IEPR COMMENTS

March 15, 2013

Mr. Thomas W. Bishop, P.E.
Senior Review Manager
U.S. Army Corps of Engineers
Risk Management Center
12596 W. Bayaud Avenue, Suite 400
Lakewood, CO 80228

CONTRACT NO. W912HQ-10-D-0002
Task Order: 0036
SUBMITTAL OF DELIVERABLE: *Final Independent External Peer Review Report for Dam Safety Modification Report for Pine Creek Lake, Mc Curtain County, Oklahoma*

Dear Mr. Bishop:

This letter accompanies the submission of the Final Independent External Peer Review Report for *Dam Safety Modification Report for Pine Creek Lake, Mc Curtain County, Oklahoma*. This deliverable is being submitted electronically in PDF format.

Please contact me at 561.598.6506 or strayerp@battelle.org if you have any technical questions regarding this submittal.

Sincerely,

Patricia Strayer

Patricia Strayer
Project Manager

encl.

cc: Kathryn White, USACE Tulsa District
Scott Morris, USACE Tulsa District

Battelle
The Business of Innovation

March 15, 2013

Final Independent External Peer Review Report Dam Safety Modification Report (DSMR) for Pine Creek Lake, McCurtain County, Oklahoma

Prepared by
Battelle Memorial Institute

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Risk Management Center (RMC)
for the Tulsa District

Contract No. W912HQ-10-D-0002
Task Order: 0036

Final Independent External Peer Review Report
Dam Safety Modification Report (DSMR) for
Pine Creek Lake, McCurtain County, Oklahoma

by

Battelle
505 King Avenue
Columbus, OH 43201

for

Department of the Army
U.S. Army Corps of Engineers
Risk Management Center (RMC)
for the Tulsa District

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Final Independent External Peer Review Report for the

Dam Safety Modification Report (DSMR) for Pine Creek Lake, McCurtain County, Oklahoma

EXECUTIVE SUMMARY

Project Background and Purpose

Pine Creek Lake was authorized for construction by the Flood Control Act of July 3, 1958. The Pine Creek Dam is located on the Little River at river mile 145.3, which is about 5 miles northwest of Wright City in McCurtain County, Oklahoma. Pine Creek Lake was built for the purposes of flood control, water supply, water quality, fish and wildlife, and recreation. Construction of the dam began in February 1963, and the project became operational in June 1969. The conservation pool filled to elevation 438.0 on January 7, 1970. The embankment is a rolled impervious earth fill, 7,510 feet long rising 124 feet above the streambed. The dike extends southwest from the right side of the spillway and is 14,150 feet long, 38 feet in maximum height, with a crest width of 10 feet. The embankment includes a spillway weir with a gross width of 608 feet. The outlet works include an intake structure, a 13-foot conduit, a 48-inch water supply and water quality bypass, and a 36-inch water supply static head line. Flow through the conduit is controlled by two 5-foot 8-inch by 13-foot hydraulic slide gates operating in tandem.

There is an existing water supply storage agreement, DACW56-71-C-0033, that went into effect on August 21, 1970, between the United States of America and the Weyerhaeuser Company. The total cost of the construction of the Pine Creek Lake project was $5,119,307. The actual construction costs were finalized in 1978, but for some reason were not applied to this agreement until 2006. The Weyerhaeuser Company chose to put 14,700 acre-feet into immediate use (Space No. 1), activated 2,940 acre-feet soon after (Space No. 2), and has 11,160 acre-feet of future use storage. The costs are $1,523,505.76 for Space No. 1 and $307,579.78 for Space No. 2. The Weyerhaeuser Company transferred and assigned water supply storage agreement DACW56-71-C-0033 to the International Paper Company on August 10, 2009. The International Paper Company continues to make payments on Space No. 1 and Space No. 2, and has not yet activated their future use storage.

The Pine Creek Dam is currently classified as Dam Safety Action Classification (DSAC) I (urgent and compelling). A primary reason for the DSAC I classification was concern over the seepage and piping along and into the outlet conduit. Internal erosion of embankment materials into or along the outlet conduit appears to pose unacceptably high risks at the Pine Creek Dam. The outlet conduit was constructed in a trench with steep side slopes, which raises the possibility that low-stress areas may exist within the embankment due to arching action along the outlet conduit. Low-stress areas can result in embankment cracking and the development of seepage paths. Seepage emanates from the downstream toe near the outlet work outfall structure. Seepage through the joints in the outlet conduit has been observed. Voids up to 10 cubic yards have been discovered in an area surrounding the conduit, and dye tests have shown a fairly rapid response. Seepage carrying material has been observed at the downstream end of the outlet conduit. The physical evidence suggests that relatively open and continuous seepage paths likely exist along the outlet conduit.

The objective of the Dam Safety Modification Report (DSMR) Study is to reduce risk at Pine Creek Lake to below tolerable risk guidelines or as low as reasonably practicable and to provide adequate information to determine what permanent dam modifications are necessary for the U.S. Army Corps of Engineers (USACE) to operate Pine Creek Lake Dam for the foreseeable future. The purpose of the DSMR is to identify structural and non-structural risk reduction measures to (1) formulate and evaluate alternatives for varying degrees of permanent risk reduction, and (2) ultimately recommend a cost-effective, technically feasible alternative that minimizes adverse environmental, economic, and social effects and will allow the project to operate for the foreseeable future as originally authorized within tolerable risk guidelines. Primary evaluation factors of annual probability of failure, life safety tolerable risk guidelines, as low as reasonably practicable considerations, and essential USACE guidelines form the basis for plan selection.

Non-structural measures considered are advanced warning systems, real estate buyout within inundation areas, and permanent pool restriction. Structural measures considered are a new chimney filter, cutoff wall, permanent downstream filter, upstream-to-downstream embankment and filter replacement, downstream embankment replacement, and permanent joint repair.

The DSMR serves as the decision document for the Pine Creek Lake project.

Independent External Peer Review Process

USACE is conducting an Independent External Peer Review (IEPR) of the DSMR for Pine Creek Lake, McCurtain County, Oklahoma (hereinafter Pine Creek Lake IEPR). As a 501(c)(3) non-profit science and technology organization, Battelle is independent, is free from conflicts of interest (COIs), and meets the requirements for an Outside Eligible Organization (OEO) per guidance described in USACE (2012a, 2012b). Battelle has experience in establishing and administering peer review panels for USACE and was engaged to coordinate the IEPR of Pine Creek Lake. Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analyses. The IEPR was external to the agency and conducted following USACE and Office of Management and Budget (OMB) guidance described in USACE (2012a, 2012b) and OMB (2004). This final report describes the IEPR process, describes the panel members and their selection, and summarizes the Final Panel Comments of the IEPR Panel (the Panel).

Based on the technical content of the Pine Creek Lake review documents and the overall scope of the project, Battelle identified candidates for the Panel in the following key technical areas: environmental planning/National Environmental Policy Act (NEPA) impact assessment, hydraulic and hydrology engineering, geotechnical engineering, economics/planning, civil/structural engineering, and engineering geology. Six panel members were selected for the IEPR from more than 26 candidates identified. USACE was given the list of candidate panel members, but Battelle made the final selection of the Panel.

The Panel received an electronic version of the Pine Creek Lake review documents (approximately 3,000 pages), along with a charge that solicited comments on specific sections of the documents to be reviewed. USACE prepared the charge questions following guidance provided in USACE (2012a, 2012b) and OMB (2004), which were included in the draft and final Work Plans.

The USACE Project Delivery Team (PDT) briefed the Panel and Battelle during a kick-off meeting held at the Pine Creek Lake project office prior to the start of the review to provide the Panel an opportunity to ask questions of USACE and clarify uncertainties. As part of this meeting, USACE led Battelle and the Panel on a visit of the Pine Creek Lake dam facilities, including the uncontrolled spillway, intake tower and bridge, stilling basin and conduit outfall, 36 inch discharge pipe and bypass channel, and dike/tieback levee. A mid-review teleconference was held between the PDT, Battelle, and Panel to provide an opportunity for the Panel to ask clarifying questions of the PDT to assist in the Panel's review of the documents. Other than these meetings, there was no direct communication between the Panel and USACE during the peer review process. The Panel produced more than 170 individual comments in response to the 26 charge questions.

IEPR panel members reviewed the Pine Creek Lake documents individually. The panel members then met via teleconference with Battelle to review key technical comments, discuss charge questions for which there were conflicting responses, and reach agreement on the Final Panel Comments to be provided to USACE. Each Final Panel Comment was documented using a four-part format consisting of: (1) a comment statement; (2) the basis for the comment; (3) the significance of the comment (high, medium, or low); and (4) recommendations on how to resolve the comment. Overall, 15 Final Panel Comments were identified and documented. Of these, two were identified as having high significance, eight had medium significance, and five had low significance.

Results of the Independent External Peer Review

The panel members agreed among one another on their "assessment of the adequacy and acceptability of the engineering, economic, and environmental methods, models, and analyses used" (USACE, 2012a, 2012b; p. D-4) in the DSMR and Baseline Risk Assessment (BLRA) Report review documents. Table ES-1 lists the Final Panel Comment statements by level of significance. The full text of the Final Panel Comments is presented in Appendix A of this report. The following statements summarize the Panel's findings.

The DSMR and BLRA Report provide a well thought-out and thorough presentation of USACE's approach to risk assessment for the project and the need for urgency. From a planning standpoint, it is apparent that USACE explored a reasonable set of alternatives. In general, the DSMR, BLRA Report, Draft Environmental Assessment (EA), Hydrology Report, and other technical appendices and supporting documents provide substantial data regarding the investigations conducted to support the project. However, in some cases, key information is not provided, which prevents the Panel from fully and accurately assessing the project.

Plan Formulation – The problems, needs, constraints, and opportunities associated with the recommended dam improvements are primarily civil, structural, and geotechnical in nature. Overall, the Panel found that the multiple investigations and analyses conducted for this project provide sufficient basis for the recommendation. The screening of proposed alternatives was based on reduction of risk as discussed in the tolerable risk guideline, which includes loss-of-life risk reduction. The project directly addressed the following primary system flaws: hydraulic fracturing or other defect in embankment; potential for material loss through conduit joints; deficient filters; and the potential for an unfiltered seepage flow around the interim downstream filter (as detailed as PFMOW 1, Conduit Piping). The Panel acknowledges that additional elements and plans were considered but not formulated because they were determined not to be technically viable in design or construction.

Hydrology and Hydraulics – The Panel found the hydrology and hydraulics discussion sufficient to characterize current baseline conditions and to allow for evaluation of forecasted conditions. In terms of the hydrology and hydraulics analyses, risk and uncertainty were sufficiently considered by flood routing and inundation mapping of the Probable Maximum Flood (PMF) event. The analyses performed for the DSMR are appropriate for risk and consequence determination. The dam failure analysis and inundation mapping were performed utilizing Hydrologic Engineering Center-River Analysis System (HEC-RAS) and HEC-Geographic RAS (HEC-GeoRAS) tools. Likely bankfull stages of reaches downstream caused by simultaneous releases from neighboring dams could increase inundation consequences, but not significantly. While there are concerns about the topographic resolution, the hydrology and hydraulics analyses performed for the DSMR are appropriate for risk and consequence determination.

Engineering – The Panel found that, in general, the engineering analyses appear consistent with generally accepted methodologies. The investigations of the seepage conditions surrounding the conduit appear well-devised and well-analyzed, with rational conclusions leading to the recommended repairs. There are several instances where additional information would be helpful in understanding and providing confidence in the conclusions. For example: there was no discussion of the significance of the response of PZ17 in 2012 to changes in headwater; there is insufficient information presented to assess the evaluation of seepage at main dam station 30+00; and the ability of the uncontrolled spillway to safely discharge the PMF is not addressed.

Geotechnical/Geology – The Panel found that the geotechnical evaluation of the existing conditions and the development of remedial measures for the observed seepage conditions along the outlet works as described in the DSMR did not follow sufficiently rigorous analytical procedures. The voids and seepage along the conduit are assumed to be due to "hydraulic fracturing" or other defects related to the initial construction and compaction of backfill and subsequent settlement. No analytical methods to evaluate the potential occurrence of hydraulic fracturing – or more importantly, to assess the limits of the zone of fracturing – have been performed. The Panel recognizes that these types of analyses are difficult and often provide somewhat uncertain results, but they could provide a useful tool during final design stages to evaluate the limits of the cutoff component of the remedial actions, as defined in Structural Alternative 7 repair program. Finally, the Panel is concerned with the length of the concrete cutoff wall and its ability to block harmful seepage. The Panel believes an extended cutoff wall would make the overall solution redundant, resilient, and robust.

Economics – The Panel found that the economic analyses were consistent with generally accepted methodologies. Some components of the economic analysis have not been adequately explained. Specifically, depth-damage percentage losses, dam rebuilding costs, and impacts to agriculture cannot be confirmed because the level of detail in the analysis is not consistent with USACE Engineer Regulation (ER) 1110-2-1156, Section 18.4 (USACE, 2011). There were also inconsistencies between the main report and appendices. Benefits forgone (described as flood risk management) do not appear to represent existing condition values. Finally, depth-damage inputs for structures, content, and vehicles do not coincide with guidance presented in Corps of Engineers Civil Works (CECW) memoranda.

Environmental – The Panel found that the affected environment and environmental consequences of all alternatives have been adequately described. However, although 11 threatened and endangered species were reported, the description of the specific species is incomplete; therefore, all potential impacts on these species may not be provided. Measures needed to ensure that potential impacts to these species do not occur should be included in the DSMR, including potential impacts on costs. In addition, water quality monitoring is recommended if grouting is implemented.

Table ES-1. Overview of 15 Final Panel Comments Identified by the Pine Creek Lake IEPR Panel

No.	Final Panel Comment
Significance – High	
1	The length of the proposed cutoff wall of 44 feet may not be long enough to cover the area of potential hydraulic fracturing or embankment defects.
2	The current schedule for completing remediation does not correspond to the apparent urgency of actions needed to prevent failure as implied by Dam Safety Action Classification (DSAC) I.
Significance – Medium	
3	Pertinent hydrologic and hydraulic calculations, modeling, and mapping are not fully presented in Appendix 12 of the Baseline Risk Assessment (BLRA) Report; therefore, the full extent of the breach routing and resulting downstream flood hazards could not be determined.
4	The breach formation time of three hours, associated with each of the six antecedent pool elevations, may not be in accordance with dam breach analysis guidelines and criteria.
5	Coincidental flood releases from Broken Bow and DeQueen Lakes were not considered during hydraulic modeling, which could result in increased flood stage and the inundation area on the Little River in the vicinity of the subject tributaries.

Table ES-1. Overview of 15 Final Panel Comments Identified by the Pine Creek Lake IEPR Panel (Cont'd)

No.	Final Panel Comment
6	There are discrepancies between reported maximum high pool elevations associated with the Probable Maximum Flood (PMF), which could significantly increase the flood volumes, flow depths, and inundation area.
7	Standard Penetration Tests (SPTs) do not appear to correspond to the shear strength parameters used for the stability analysis conducted in USACE's 2003 Seismic Safety Review, which could constitute a change in the stability of the critical dam cross section.
8	Bedrock erosion and embankment foundation stability due to uncontrolled spillway discharge under Probable Maximum Flood (PMF) conditions have not been addressed, and their importance as a credible failure mode cannot be evaluated.
9	The cause of the minor pin-boils observed at Station 30+00 under higher pool levels has not been fully evaluated and could pose a long-term concern for the integrity of the dam, especially under high-pool conditions.
10	Eleven threatened and endangered species were reported, yet a description of the specific species, the probability of them being found in the project boundary area, and potential impacts on these species were not provided.
	Significance – Low
11	The U.S. Geological Survey (USGS) 10-meter Digital Elevation Model (DEM) topographic data used to develop hydraulic models, map downstream flood hazards, and ultimately determine dam breach consequences may not be commensurate with the vertical accuracy as stated in the Baseline Risk Assessment (BLRA).
12	The operation, maintenance, repair, replacement and rehabilitation (OMRR&R) efforts are not adequately described, and it could not be determined if the proposed costs are reasonable.
13	Piezometer PZ17 appears to be very responsive to high pool conditions and may indicate an undesirable seepage condition.
14	Various key inputs to the economic analysis, such as the cost of repairing the damage to the dam as a potential direct loss, were not provided or explained and could result in an inaccurate final cost analysis.
15	The chemical composition of the grouting material and sealant is not described, and the potential for short-term impacts on aquatic species has not been considered.

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LIST OF ACRONYMS

ASCE	American Society of Civil Engineers
ATR	Agency Technical Review
BA	Biological Assessment
BLRA	Baseline Risk Assessment
CECW	Corps of Engineers Civil Works
COI	Conflict of Interest
DEM	Digital Elevation Model
DrChecks	Design Review and Checking System
DSA	Dam Safety Assurance
DSAC	Dam Safety Action Classification
DSM	Dam Safety Modification
DSMR	Dam Safety Modification Report
EA	Environmental Assessment
EC	Engineer Circular
EID	El Dorado Irrigation District
EA	Environmental Assessment
EM	Engineer Manual
ER	Engineer Regulation
ERDC	Engineer Research and Development Center
FERC	Federal Emergency Management Agency
GIS	Geographic Information System
HEC-DSS	Hydrologic Engineering Center-Data Storage System
HEC-FDA	Hydrologic Engineering Center-Flood Damage Reduction Analysis
HEC-FIA	Hydrologic Engineering Center-Flood Impact Analysis
HEC-GeoRAS	Hydrologic Engineering Center-Geographic River Analysis Center
HEC-HMS	Hydrologic Engineering Center-Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center-River Analysis Center
IEPR	Independent External Peer Review
MW	Megawatt
NED	National Economic Development

NEPA	National Environmental Policy Act
O&M	Operation and Maintenance
OEO	Outside Eligible Organization
OMB	Office of Management and Budget
OMRR&R	Operation, Maintenance, Repair, Replacement and Rehabilitation
PDT	Project Delivery Team
PFM	Potential Failure Mode
PMF	Probable Maximum Flood
SAME	Society of American Military Engineers
SPT	Standard Penetration Test
USACE	United States Army Corps of Engineers
USGS	U.S. Geological Survey

1. INTRODUCTION

Pine Creek Lake was authorized for construction by the Flood Control Act of July 3, 1958. The Pine Creek Dam is located on the Little River at river mile 145.3, which is about 5 miles northwest of Wright City in McCurtain County, Oklahoma. Pine Creek Lake was built for the purposes of flood control, water supply, water quality, fish and wildlife, and recreation. Construction of the dam began in February 1963,and the project became operational in June 1969. The conservation pool filled to elevation 438.0 on January 7, 1970. The embankment is a rolled impervious earth fill, 7,510 feet long rising 124 feet above the streambed. The dike extends southwest from the right side of the spillway and is 14,150 feet long, 38 feet in maximum height, with a crest width of 10 feet. The embankment includes a spillway weir with a gross width of 608 feet. The outlet works include an intake structure, a 13-foot conduit, a 48-inch water supply and water quality bypass, and a 36-inch water supply static head line. Flow through the conduit is controlled by two 5-foot 8-inch by 13-foot hydraulic slide gates operating in tandem.

There is an existing water supply storage agreement, DACW56-71-C-0033, that went into effect on August 21, 1970, between the United States of America and the Weyerhaeuser Company. The total cost of the construction of the Pine Creek Lake project was $5,119,307. The actual construction costs were finalized in 1978, but for some reason were not applied to this agreement until 2006. The Weyerhaeuser Company chose to put 14,700 acre-feet into immediate use (Space No. 1), activated 2,940 acre-feet soon after (Space No. 2), and has 11,160 acre-feet of future use storage. The costs are $1,523,505.76 for Space No. 1 and $307,579.78 for Space No. 2. The Weyerhaeuser Company transferred and assigned water supply storage agreement DACW56-71-C-0033 to the International Paper Company on August 10, 2009. The International Paper Company continues to make payments on Space No. 1 and Space No. 2, and has not yet activated their future use storage.

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The objective of the Dam Safety Modification Report (DSMR) Study is to reduce risk at Pine Creek Lake to below tolerable risk guidelines or as low as reasonably practicable and to provide adequate information to determine what permanent dam modifications are necessary for the U.S.

Army Corps of Engineers (USACE) to operate Pine Creek Lake Dam for the foreseeable future. The purpose of the DSMR is to identify structural and non-structural risk reduction measures to (1) formulate and evaluate alternatives for varying degrees of permanent risk reduction; and (2) ultimately recommend a cost-effective, technically feasible alternative that minimizes adverse environmental, economic, and social effects and will allow the project to operate for the foreseeable future as originally authorized within tolerable risk guidelines. Primary evaluation factors of annual probability of failure, life safety tolerable risk guidelines, as low as reasonably practicable considerations, and essential USACE guidelines form the basis for plan selection.

Non-structural measures considered are advanced warning systems, real estate buyout within inundation areas, and permanent pool restriction. Structural measures considered are a new chimney filter, cutoff wall, permanent downstream filter, upstream-to-downstream embankment and filter replacement, downstream embankment replacement, and permanent joint repair.

The DSMR serves as the decision document for the Pine Creek Lake project.

The objective of the work described here was to conduct an Independent External Peer Review (IEPR) of the DSMR for Pine Creek Lake, McCurtain County, Oklahoma (hereinafter Pine Creek Lake Dam) in accordance with procedures described in the Department of the Army, USACE Engineer Circular (EC) *Civil Works Review*, *Change 1* (EC 1165-2-209, Change 1) (USACE, 2012a), *Civil Works Review* (EC 1165-2-214) (USACE, 2012b), and Office of Management and Budget (OMB) bulletin *Final Information Quality Bulletin for Peer Review* (OMB, 2004).[1] Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analyses.

This final report details the IEPR process, describes the IEPR panel members and their selection, and summarizes the Final Panel Comments of the IEPR Panel on the existing environmental, economic, and engineering analyses contained in the Pine Creek Lake review documents. The full text of the Final Panel Comments is presented in Appendix A.

2. PURPOSE OF THE IEPR

To ensure that USACE documents are supported by the best scientific and technical information, USACE has implemented a peer review process that uses IEPR to complement the Agency Technical Review (ATR), as described in USACE (2012a, 2012b).

In general, the purpose of peer review is to strengthen the quality and credibility of the USACE decision documents in support of its Civil Works program. For the purpose of this IEPR, USACE has been directed by Congress to evaluate USACE dams for safety assurance and seepage/stability correction. IEPR provides an independent assessment of the economic, engineering, and environmental analysis of the project study. In particular, the IEPR addresses the technical soundness of the project study's assumptions, methods, analyses, and calculations

[1] On December 15, 2012, USACE issued *Civil Works Review Policy* (EC 1165-2-214), which supersedes *Civil Works Review Policy* EC 1165-2-209. However, all tasks under this contract, including development of this IEPR report, were performed under EC 1165-2-209.

and identifies the need for additional data or analyses to make a good decision regarding implementation of alternatives and recommendations.

In this case, the IEPR of the Pine Creek Lake was conducted and managed using contract support from Battelle, which is an Outside Eligible Organization (OEO) (as defined by EC Nos. 1165-2-209, Change 1, and 1165-2-214) under Section 501(c)(3) of the U.S. Internal Revenue Code with experience conducting IEPRs for USACE.

3. METHODS

This section describes the method followed in selecting the members for the IEPR Panel (the Panel) and in planning and conducting the IEPR. The IEPR was conducted following procedures described by USACE (2012a, 2012b) and in accordance with OMB (2004) guidance. Supplemental guidance on evaluation for conflicts of interest (COIs) was obtained from the *Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports* (The National Academies, 2003).

3.1 Planning and Schedule

At the beginning of the Period of Performance, Battelle held a kick-off meeting with USACE to review the preliminary/suggested schedule, discuss the IEPR process, and address any questions regarding the scope (e.g., clarify expertise areas needed for panel members). Any revisions to the schedule were submitted as part of the final Work Plan.

Table 1 presents the schedule followed in executing the IEPR. Due dates for milestones and deliverables are based on the award/effective date of February 1, 2013. The review documents were provided by USACE on February 1, 2013. Note that the work items listed in Task 7 occur after the submission of this report. Battelle will enter the 15 Final Panel Comments developed by the Panel into USACE's Design Review and Checking System (DrChecks), a Web-based software system for documenting and sharing comments on reports and design documents, so that USACE can review and respond to them. USACE will provide responses (Evaluator Responses) to the Final Panel Comments, and the Panel will respond (BackCheck Responses) to the Evaluator Responses. All USACE and Panel responses will be documented by Battelle. Battelle will provide USACE and the Panel a pdf printout of all DrChecks entries, through comment closure, as a final deliverable and record of the IEPR results.

Table 1. Pine Creek Lake IEPR Schedule

Task	Action	Due Date
1	**Award/Effective Date**	2/1/2013
	Review documents available	2/1/2013
	Battelle submits draft Work Plan[a]	2/8/2013
	USACE provides comments on draft Work Plan	2/12/2013
	Battelle convenes teleconference	2/12/2013
	Battelle submits final Work Plan[a]	2/15/2013
2	Battelle requests input from USACE on the COI questionnaire	2/1/2013
	USACE provides comments on COI questionnaire	2/4/2013
	Battelle submits list of selected Panel[a]	2/5/2013
	USACE confirms the Panel has no COIs	2/6/2013
	Battelle completes subcontracts for Panel	2/11/2013
3	USACE provides charge to be included in Work Plan	2/8/2013
4	USACE/Battelle hold kick-off meeting	2/8/2013
	Battelle sends review documents to Panel	2/11/2013
	Battelle/Panel hold kick-off meeting	2/12/2013
	USACE/Battelle/Panel hold kick-off meeting	2/13/2013
	USACE convenes site visit with Panel and Battelle	2/13/2013
5	Battelle convenes mid-review teleconference for Panel to ask clarifying questions of USACE	2/19/2013
	Panel completes individual reviews	2/27/2013
	Battelle provides Panel merged individual comments and talking points for Panel Review Teleconference	2/28/2013
	Battelle convenes Panel Review Teleconference	3/1/2013
	Battelle provides Final Panel Comments directive to Panel	3/1/2013
	Panel provides draft Final Panel Comments to Battelle	3/7/2013
	Battelle provides feedback to Panel on draft Final Panel Comments; Panel provides revised draft Final Panel Comments per Battelle feedback (iterative process)	3/7/2013
	Final Panel Comments finalized	3/13/2013
6	Battelle provides Final IEPR Report to Panel for review	3/14/2013
	Panel provides comments on Final IEPR Report	3/14/2013
	Battelle submits Final IEPR Report to USACE[a]	**3/15/2013**

Table 2. Pine Creek Lake IEPR Schedule (Cont'd)

Task	Action	DUE DATE
7[b]	Battelle inputs Final Panel Comments to DrChecks; Battelle provides Post-Final Panel Comment Response Process template to USACE	3/15/2013
	Battelle convenes teleconference with USACE to review the Post-Final Panel Comment Response Process	3/18/2013
	Battelle convenes teleconference with Panel to review the Post-Final Panel Comment Response Process (if necessary)	3/18/2013
	USACE provides draft PDT Evaluator Responses to Battelle	3/21/2013
	Battelle provides the Panel the draft PDT Evaluator Responses	3/21/2013
	Panel provides Battelle with draft comments on draft PDT Evaluator Responses (i.e., draft BackCheck Responses)	3/22/2013
	Battelle convenes teleconference with Panel to discuss draft BackCheck Responses	3/22/2013
	Battelle convenes teleconference with Panel and USACE to discuss Final Panel Comments, and draft responses	3/25/2013
	USACE inputs final PDT Evaluator Responses in DrChecks	3/26/2013
	Battelle provides PDT Evaluator Responses to Panel	3/26/2013
	Panel provides Battelle with final BackCheck Responses	3/27/2013
	Battelle inputs the Panel's BackCheck Responses in DrChecks	3/28/2013
	Battelle submits pdf printout of DrChecks project file[a]	**3/29/2013**

[a] *Deliverable.*
[b] *Task 7 occurs after the submission of this report*

3.2 Identification and Selection of IEPR Panel Members

The candidates for the Panel were evaluated based on their technical expertise in the following key technical areas: environmental planning/National Environmental Policy Act (NEPA) impact assessment, hydraulic and hydrology engineering, geotechnical engineering, economics/planning, civil/structural engineering, and engineering geology. These areas correspond to the technical content of the Pine Creek Lake review documents and the overall scope of the Pine Creek Lake project.

To identify candidate panel members, Battelle reviewed the credentials of the experts in Battelle's Peer Reviewer Database, sought recommendations from colleagues, contacted former panel members, and conducted targeted Internet searches. Battelle initially identified more than 26 candidates for the Panel, evaluated their technical expertise, and inquired about potential COIs. Of these, Battelle chose the most qualified candidates and confirmed their interest and availability, and ultimately selected six experts for the final Panel.

The six selected reviewers constituted the final Panel. The remaining candidates were not proposed for a variety of reasons, including lack of availability, disclosed COIs, or lack of the precise technical expertise required.

The candidates were screened for the following potential exclusion criteria or COIs.[2] These COI questions were intended to serve as a means of disclosure and to better characterize a candidate's employment history and background. Providing a positive response to a COI screening question did not automatically preclude a candidate from serving on the Panel. For example, participation in previous USACE technical peer review committees and other technical review panel experience was included as a COI screening question. A positive response to this question could be considered a benefit.

- Previous and/or current involvement by you or your firm[3] in the DSMR for Pine Creek Lake, Oklahoma.
- Previous and/or current involvement by you or your firm[3] in the DSMR studies or any work related to the Pine Creek Lake, Little River and Wright City, McCurtain, Oklahoma, region.
- Previous and/or current involvement by you or your firm[3] in projects related to the DSMR for Pine Creek Lake, Oklahoma.
- Previous and/or current involvement by you or your firm[3] in the conceptual or actual design, construction, or operation and maintenance (O&M) of any projects in the DSMR for Pine Creek Lake, Oklahoma, related projects.
- Current employment by USACE.
- Previous and/or current involvement with paid or unpaid expert testimony related to the DSMR for Pine Creek Lake, Oklahoma.
- Previous and/or current employment or affiliation with the non-federal sponsors or any of the following cooperating federal, state, county, local and regional agencies, environmental organizations, and/or interested groups (for pay or pro bono): Weyerhaeuser Company, International Paper Company.
- Past, current or future interests or involvements (financial or otherwise) by you, your spouse or children related to Pine Creek Lake, Little River and Wright City, McCurtain, Oklahoma, region.
- Current personal involvement with other USACE projects, including whether involvement was to author any manuals or guidance documents for USACE. If yes, provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters, Engineer Research and Development Center [ERDC], etc.), and position/role. Please highlight and discuss in greater detail any projects that are specifically with the Tulsa District.

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[2] Battelle evaluated whether scientists in universities and consulting firms that are receiving USACE-funding have sufficient independence from USACE to be appropriate peer reviewers. See OMB (2004, p. 18), "….when a scientist is awarded a government research grant through an investigator-initiated, peer-reviewed competition, there generally should be no question as to that scientist's ability to offer independent scientific advice to the agency on other projects. This contrasts, for example, to a situation in which a scientist has a consulting or contractual arrangement with the agency or office sponsoring a peer review. Likewise, when the agency and a researcher work together (e.g., through a cooperative agreement) to design or implement a study, there is less independence from the agency. Furthermore, if a scientist has repeatedly served as a reviewer for the same agency, some may question whether that scientist is sufficiently independent from the agency to be employed as a peer reviewer on agency-sponsored projects."

[3] Includes any joint ventures in which a panel member's firm is involved and if the firm serves as a prime or as a subcontractor to a prime.

- Previous or current involvement with the development or testing of models that will be used for or in support of the DSMR for Pine Creek Lake, Oklahoma, project.
- Current firm[3] involvement with other USACE projects, specifically those projects/contracts that are with the Tulsa District. If yes, provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please also clearly delineate the percentage of work you personally are currently conducting for the Tulsa District. Please explain.
- Any previous employment by the USACE as a direct employee or contractor (either as an individual or through your firm[3]) within the last 10 years, notably if those projects/contracts are with the Tulsa District. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
- Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning Dam Safety Modification (DSM), and include the client/agency and duration of review (approximate dates).
- Pending, current or future financial interests in the DSMR for Pine Creek Lake, Oklahoma, related contracts/awards from USACE.
- A significant portion (i.e., greater than 50%) of personal or firm[3] revenues within the last 3 years came from USACE contracts.
- A significant portion (i.e., greater than 50%) of personal or firm[3] revenues within the last 3 years from contracts with any non-federal sponsor.
- Any publicly documented statement (including, for example, advocating for or discouraging against) related to the DSMR for Pine Creek Lake, Oklahoma.
- Participation in relevant prior federal studies relevant to this project and/or DSMR for Pine Creek Lake, Oklahoma.
- Previous and/or current participation in prior non-federal studies relevant to this project and/or the DSMR for Pine Creek Lake, Oklahoma.
- Is there any past, present or future activity, relationship or interest (financial or otherwise) that could make it appear that you would be unable to provide unbiased services on this project?

In selecting the final members of the Panel, Battelle chose experts who best fit the expertise areas and had no COIs. The six final reviewers were either affiliated with consulting companies or were independent engineering consultants. Battelle established subcontracts with the panel members when they indicated their willingness to participate and confirmed the absence of COIs through a signed COI form. USACE was given the list of candidate panel members, but Battelle made the final selection of the Panel. Section 4 of this report provides names and biographical information on the panel members.

Prior to beginning their review and within 5 days of their subcontracts being finalized, all members of the Panel attended an in-person kick-off meeting on February 12, 2013, facilitated by Battelle, in Idabel, OK. Battelle reviewed the IEPR process, the schedule, communication procedures, and other pertinent information for the Panel.

3.3 Preparation of the Charge and Conduct of the IEPR

Charge questions were provided by USACE and included in the draft and final Work Plans. In addition to a list of 26 charge questions/discussion points, the final charge included general guidance for the Panel on the conduct of the peer review (provided in Appendix B of this final report).

At the start of the review, the IEPR Panel received an electronic version of the final charge as well as the Pine Creek Lake documents and reference materials listed below. The documents and files in bold font were provided for review; the other documents were provided for reference or supplemental information only. In addition, throughout the review period, USACE provided additional documents at the request of panel members. These documents were provided to Battelle and then disseminated to the Panel as additional information only and were not part of the official review. A list of these additional documents requested by the Panel is provided below.

- **Pine Creek Lake Main Dam Safety Modification Report (300 pages)**
- **Appendix I – Baseline Risk Assessment Report W/Appendices (2,000 pages)**
- **Appendix II – Economic Consequences (31 pages)**
- **Appendix III – Formulation of Risk Management Plans (200 pages)**
- **Appendix IV – Engineering Design Drawings (172 pages)**
- **Appendix V – Final Risk Assessment Breakdown (15 pages)**
- **Appendix VI – Cost Estimating Breakdown (200 pages)**
- **Appendix VII – Draft Environmental Assessment (EA) (100 pages)**
- **Appendix VIII – Real Estate Breakdown (6 pages)**
- EC 1105-2-410, Review of Decision Documents, 22 August 2008
- EC 1105-2-412, Assuring Quality of Planning Models, 31 March 2011
- EC 1165-2-209, Water Resources Policies and Authorities - Civil Works Review Policy,
- Change 1, 31 January 2012
- EC 1165-2-210, Water Resources Policies and Authorities - Water Supply Storage and
- Risk Reduction Measures for Dams, 9 April 2010
- EP 1110-2-13, Dam Safety Preparedness, 28 June 1996
- ER 1110-1-12, Engineering and Design - Quality Management, 31 March 2011 (change2)
- ER 1110-2-1150, Engineering and Design - Engineering and Design for Civil Works
- Projects, 31 August 1999

- ER 1110-2-1155, Engineering and Design - Dam Safety Assurance Program, 12 September 1997
- ER 1110-2-1156, Engineering and Design - Safety of Dams - Policy and Procedures, 28
- October 2011
- ER 1110-1-8159, Engineering and Design - DrChecks, 10 May 2001.
- National Academy of Sciences, "Policy and Procedures on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports," May 2003 for General Scientific and Technical Studies and Assistance: General Scientific and Technical Studies and Assistance. Available at:
- http://www.nationalacademies.org/coi/index.html
- Water Resources Development Act of 2007, Sections 2034 & 2035, Pub. L. 110-114. Privacy
- Act, 5 U.S.C. § 522a as amended
- Risk-Reduction Evaluation DAMRAE Workshop Institute for Water Resources Risk Management Center Denver, Colorado, June 2012 – Power Point Presentation
- Pine Creek DSME Table Definitions and Formulas
- Earth Dam Criteria Report 63 Pine Creek Dam and Lake Little River, Oklahoma, Feb. 1974
- Pine Creek Lake PMF 2011
- Pine Creek Lake PMF revised 22 May 2012
- Water Quality Report, Pine Creek Lake (2000)

Documents Requested by Panel

During the review process, the Panel requested the following additional information from USACE:

- Risk-Reduction Evaluation DAMRAE Workshop Institute for Water Resources Risk Management Center, Denver, Colorado, June 2012 – Power Point Presentation
- Pine Creek DSMR Table Definitions and Formulas
- Earth Dam Criteria Report 63 Pine Creek Dam and Lake Little River, Oklahoma, Feb. 1974
- Pine Creek Lake PMF 2011
- Pine Creek Lake PMF revised 22 May 2012
- Water Quality Report, Pine Creek Lake (2000)
- Seismic Safety Review – Pine Creek Dam, Little River Oklahoma, 2003

About halfway through the review of the Pine Creek Lake review documents, a teleconference was held with USACE, the Panel, and Battelle so that USACE could answer any questions the

Panel had concerning either the review documents or the project. Prior to this teleconference, Battelle submitted 28 panel member questions to USACE. USACE was able to provide responses to all of the questions during the teleconference.

3.4 Site Visit

An in-person meeting to discuss the Pine Creek Lake project was held at the USACE Pine Creek Lake Project Office in Valiant, Oklahoma, on February 12, 2013; all six panel members and two Battelle staff members attended this meeting. The meeting was conducted in two parts. The first part involved a detailed briefing of the project history, issues, actions, and DSMR. Panel members had several questions during the presentation, and open discussion occurred. At the conclusion of the presentation, USACE, Battelle staff members, and the panel members convened for the second part of the meeting, which included a site visit. USACE led Battelle and the Panel on a tour of the Pine Creek Lake Dam uncontrolled spillway, intake tower and bridge, stilling basin and conduit outfall, 36-inch discharge pipe and bypass channel, and associated dike. USACE, Battelle, and panel members stopped at these various points to observe the key structural components, including a tour inside the intake tower.

Throughout the site visit, USACE staff pointed out specific project features to help the panel members better comprehend previous events, repairs and issues associated with the existing project features, and intent of the project modification features, then answered questions posed by the panel members. This tour provided an opportunity for the panel members to see the project area and project features and to ask clarifying questions of the PDT.

Battelle prepared and submitted a meeting summary, which was delivered to USACE on February 22, 2013. The summary provided a detailed documentation of the discussions and panel questions, as well as highlights from the site visit.

3.5 Review of Individual Comments

The Panel was instructed to address the charge questions/discussion points within a comment-response form provided by Battelle. At the end of the review period, the Panel produced 170 individual comments in response to the charge questions/discussion points. Battelle reviewed the comments to identify overall recurring themes, areas of potential conflict, and other overall impressions. As a result of the review, Battelle summarized the 170 comments into a preliminary list of 19 overall comments and discussion points. Each panel member's individual comments were shared with the full Panel in a merged individual comments table.

3.6 IEPR Panel Teleconference

Battelle facilitated a 5-hour teleconference with the Panel so that the panel members could exchange technical information. The main goal of the teleconference was to identify which issues should be carried forward as Final Panel Comments in the Final IEPR Report and decide which panel member would serve as the lead author for the development of each Final Panel Comment. This information exchange ensured that the Final IEPR Report would accurately represent the Panel's assessment of the project, including any conflicting opinions. The Panel engaged in a thorough discussion of the overall positive and negative comments on the Pine Creek Lake Project, added any missing issues of high-level importance to the findings, and merged related individual comments. In addition, Battelle confirmed each Final Panel Comment's level of significance to the Panel.

The Panel also discussed responses to one specific charge question where there appeared to be disagreement among panel members. The conflicting responses to this charge question were resolved based on the professional judgment of the Panel, and the Panel agreed to develop a Final Panel Comment based on this charge question.

At the end of these discussions, the Panel identified 17 comments and discussion points that should be brought forward as Final Panel Comments.

3.7 Preparation of Final Panel Comments

Following the teleconference, Battelle prepared a summary memorandum for the Panel documenting each Final Panel Comment (organized by level of significance). The memorandum provided the following detailed guidance on the approach and format to be used to develop the Final Panel Comments for the Pine Creek Lake:

- Lead Responsibility: For each Final Panel Comment, one panel member was identified as the lead author responsible for coordinating the development of the Final Panel Comment and submitting it to Battelle. Battelle modified lead assignments at the direction of the Panel. To assist each lead in the development of the Final Panel Comments, Battelle distributed the merged individual comments table, a summary detailing each draft final comment statement, an example Final Panel Comment following the four-part structure described below, and templates for the preparation of each Final Panel Comment.
- Directive to the Lead: Each lead was encouraged to communicate directly with the other panel members as needed and to contribute to a particular Final Panel Comment. If a significant comment was identified that was not covered by one of the original Final Panel Comments, the appropriate lead was instructed to draft a new Final Panel Comment.
- Format for Final Panel Comments: Each Final Panel Comment was presented as part of a four-part structure:
  1. Comment Statement (succinct summary statement of concern)
  2. Basis for Comment (details regarding the concern)
  3. Significance (high, medium, low; see description below)
  4. Recommendation(s) for Resolution (see description below).
- Criteria for Significance: The following were used as criteria for assigning a significance level to each Final Panel Comment:
  1. High: Describes a fundamental problem with the project that could affect the recommendation, success, or justification of the project. Comments rated as high indicate that the Panel analyzed or assessed the methods, models, and/or analyses and determined that there is a "showstopper" issue.
  2. Medium: Affects the completeness of the report in describing the project, but will not affect the recommendation or justification of the project. Comments rated as medium

indicate that the Panel does not have sufficient information to analyze or assess the methods, models, or analyses.

3. Low: Affects the understanding or accuracy of the project as described in the report, but will not affect the recommendation or justification of the project. Comments rated as low indicate that the Panel identified information (tables, figures, equations, discussions) that was mislabeled or incorrect or data or report sections that were not clearly described or presented.

- Guidance for Developing Recommendations: The recommendation section was to include specific actions that USACE should consider to resolve the Final Panel Comment (e.g., suggestions on how and where to incorporate data into the analysis, how and where to address insufficiencies, areas where additional documentation is needed).

During the Final Panel Comment development process, the Panel felt that two of the Final Panel Comments could either be dropped, or merged into other Final Panel Comments; therefore, the total Final Panel Comment count was reduced to 15. Battelle reviewed and edited the Final Panel Comments for clarity, consistency with the comment statement, and adherence to guidance on the Panel's overall charge, which included ensuring that there were no comments regarding either the appropriateness of the selected alternative or USACE policy. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The Final Panel Comments are presented in Appendix A of this report.

4. PANEL DESCRIPTION

Candidates for the Panel were identified using Battelle's Peer Reviewer Database, targeted Internet searches using key words (e.g., technical area, geographic region), searches of websites of universities or other compiled expert sites, and referrals. Battelle prepared a draft list of primary and backup candidate panel members (who were screened for availability, technical background, and COIs), and provided it to USACE for feedback. Battelle made the final selection of panel members.

An overview of the credentials of the final six members of the Panel and their qualifications in relation to the technical evaluation criteria is presented in Table 2. More detailed biographical information regarding each panel member and his or her area of technical expertise is presented in the text that follows the table.

Table 2. Pine Creek Lake IEPR Panel: Technical Criteria and Areas of Expertise

Technical Criterion	Rein	Schalk	Spaulding	Bastian	Powell	Jermstad
Environmental Planning / NEPA Impact Assessment						
Minimum 10 years of experience directly related to water resource environmental evaluation or review	X					
Experience with programs having high public and interagency interests	X					
Minimum 10 years of experience with Endangered Species Act requirements	X					
Minimum 10 years of experience with the implementation of the NEPA compliance process	X					
Experience in the EA process with knowledge of the NEPA compliance process	X					
Experience in evaluating and conducting NEPA impact assessments, including cumulative effects analyses, for complex multi-objective public works projects with competing trade-offs	X					
Experience with cultural surveys	X					
Experience with biological assessments	X					
Experience with endangered species	X					
Experience working with inland lakes, lakes and river ecosystems	X					
Familiar with USACE calculation and application of environmental impacts and benefits	X					
Experience determining the scope and appropriate methodologies for impact assessment and analyses for a variety of projects and the potential project impacts to nearby sensitive habitats	X					
Minimum M.S. degree in an appropriate field of study	X					
Hydraulic and Hydrology Engineering						
Registered P.E. with a minimum 10 years of demonstrated experience in hydraulic engineering with an emphasis on large public works projects, and with extensive background in hydraulic theory and practice and river geomorphology		X				
Demonstrated ability to coordinate, interpret, and explain testing results with other engineering disciplines, particularly structural engineers, geotechnical engineers, and geologists		X				

Table 2. Pine Creek Lake IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Rein	Schalk	Spaulding	Bastian	Powell	Jermstad
Experience associated with flood risk management projects and the analysis and design of hydraulic structures related to flood control projects, including the design of hydraulic structures such as:		X				
-Outlet works		X				
-Spillways and stilling basins		X				
-Flood control channels, levees, and diversion channel design		X				
-Large river control structures		X				
Experience performing work in hydrologic analysis		X				
Experience performing work in floodplain analysis		X				
Experience performing work in hydraulic design of channels and levees using various channel and bank protection works		X				
Experience performing work in river sedimentation		X				
Demonstrated knowledge and experience with physical modeling and the application of data from physical model testing to the design of stilling basins and scour protection		X				
Demonstrated knowledge and experience with the routing of inflow hydrographs through multipurpose flood control lakes utilizing multiple discharge devices, including gated sluiceways and gated spillways		X				
Familiar with USACE application of risk and uncertainty analyses in flood damage reduction studies		X				
Familiar with standard USACE hydrologic and hydraulic computer models (including but not limited to HEC-1, HEC-HMS, HEC-2, HEC-RAS, FLO-2D, and HEC-DSS) used in drawdown studies, dam break inundation studies, and hydrologic modeling and analysis for dam safety investigations		X				
Familiar with preparing plans and specifications for USACE projects		X				
Knowledge of USACE design and construction procedures and policies		X				
Familiar with USACE dam safety assurance (DSA) policy and guidance and experience in evaluating risk reduction measures for DSA projects		X[a]				
Minimum M.S. degree in engineering		X				

Table 2. Pine Creek Lake IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Rein	Schalk	Spaulding	Bastian	Powell	Jermstad
Geotechnical Engineering						
Minimum 20 years of demonstrated experience in the specific field of dams engineering in evaluating, designing, and constructing large embankment dams (>100 feet high) for water storage			X			
Minimum 15 years of experience in the general field of geotechnical engineering			X			
Recognized expert in cutoff wall design and construction and soil improvement, including experience with various methods of cutoff wall construction			X			
Familiar with field and laboratory testing and the determination of in-situ material properties			X			
Experience in subsurface investigations			X			
Experience in soil compaction and earthwork construction			X			
Experience in soil mechanics			X			
Experience in seepage and piping			X			
Experience in bearing capacity and settlement			X			
Experience in dewatering			X			
Experience in design and construction of foundations on alluvial soils			X			
Experience in foundation inspection and assessment			X			
Experience in foundation grouting and other foundation treatment methods including construction of foundation seepage barriers			X			
Experience in the design, installation and assessment of instrumentation			X			
Experience in preparing plans and specifications for USACE projects			X			
Knowledge of USACE design and construction procedures and policies			X			
Knowledge of and experience in the forensic investigation of seepage, settlement, stability, and deformation problems associated with embankments constructed on alluvial soils			X			
Familiar with USACE DSA policy and guidance and with evaluation of risk reduction measures for DSA projects			X			
Active participation in related professional societies			X			

Table 2. Pine Creek Lake IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Rein	Schalk	Spaulding	Bastian	Powell	Jermstad
Minimum M.S. degree in engineering			X			
Economics / Planning						
Minimum 10 years of experience directly related to water resource economic evaluation or review				X		
Demonstrated experience in public works planning				X		
Minimum of 5 years of experience directly dealing with the USACE six-step planning process governed by ER 1105-2-100, Planning Guidance Notebook				X		
Direct experience working for or with USACE				X		
Familiar with the USACE plan formulation process, procedures, standards, guidance, and economic evaluation techniques				X		
Familiar with the USACE flood risk and hurricane/coastal storm damage risk reduction analysis				X		
Experience identifying and evaluating impacts to environmental resources from structural flood risk management and hurricane and coastal storm damage risk reduction projects				X		
Familiar with economic benefit calculations, including use of standard USACE computer programs such as HEC Flood Damage Reduction Analysis (FDA)				X		
Experience with National Economic Development (NED) analysis procedures, particularly as they relate to hurricane and coastal storm damage risk reduction				X		
Demonstrated experience working with project teams to identify and evaluate measures and alternatives using appropriate planning methodologies to reduce life safety risk				X		
Extensive experience reviewing the analysis with which the measures and alternatives were evaluated and determining whether they are sufficiently comprehensive and complete to result in approval of a recommended alternative				X		
Active participation in related professional societies				X		
Minimum B.S. in economics				X[a]		
Civil / Structural Engineering						
Registered P.E. with a minimum 15 years of experience in civil/structural engineering					X	

Table 2. Pine Creek Lake IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Rein	Schalk	Spaulding	Bastian	Powell	Jermstad
Extensive experience in the design and construction of hydraulic structures for large and complex Civil Works projects, including outlet works and spillways					X	
Extensive experience in the stability analysis and structural design of mass concrete scour protection and stilling features, including the design of baffles, end sills, and training walls					X	
Practical knowledge of construction methods and techniques as they relate to structural portions of projects					X	
Familiarity with preparing plans and specifications for USACE projects					X	
Knowledge of USACE design and construction procedures and policies					X	
Demonstrated knowledge in a variety of construction-related activities, including:					X	
-Site layout and surveying					X	
-Three-dimensional modeling					X	
-Construction techniques					X	
-Grading					X	
-Hydraulic structures					X	
-Erosion control					X	
-Interior drainage					X	
-Earthwork					X	
-Concrete placement					X	
-Design of access roads					X	
-Retaining wall design					X	
-Relocation of underground utilities					X	
Knowledge of USACE DSA policy and guidance and experience in evaluating risk reduction measures for DSA projects					X	
Active participation in related professional societies					X	
Minimum M.S. degree in engineering					X[a]	

Table 2. Pine Creek Lake IEPR Panel: Technical Criteria and Areas of Expertise (Cont'd)

Technical Criterion	Rein	Schalk	Spaulding	Bastian	Powell	Jermstad
Engineering Geology						
20 years or more of demonstrated experience in the general field of engineering geology						X
Registered professional geologist						X
Proficient in assessing seepage and piping through and beneath dams constructed on or within various geologic environments, including, but not limited to, alluvial soils, colluviums, and other geological formations						X
Familiar with and knowledgeable of identification of geological hazards						X
Familiar with exploration techniques, including soil and rock logging, geologic mapping, geophysical investigations, and air photo interpretation						X
Familiar with field and laboratory testing and the determination of in-situ material properties						X
Familiar with geomorphology						X
Familiar with foundation inspection and assessment						X
Familiar with foundation grouting and other foundation treatment methods, including construction of foundation seepage barriers						X
Familiar with the design, installation, and assessment of instrumentation						X
Familiar with preparation of factual data and interpretative geology reports, including the preparation of geotechnical baseline reports for USACE projects						X
Familiar with the preparation of plans and specifications for USACE projects						X
Knowledge of USACE design and construction procedures and policies						X
Knowledge of USACE DSA policy and guidance						X
Active participation in related professional societies						X

[a] *Waiver statement presented as part of Task 2 deliverable and approved by USACE*

Felicia Orah Rein, Ph.D.

Role: Environmental Planning/NEPA Impact Assessment
Affiliation: Watershed Solutions, Inc.

Dr. Rein is owner and senior scientist at Watershed Solutions, Inc., a Florida State certified small business enterprise specializing in ecological restoration, environmental assessment and impact analyses, ecological monitoring, water resource management, and erosion control. She is also an affiliate professor at Florida Atlantic University in the Geosciences Department. She earned her Ph.D. in ecosystem science/restoration ecology from the University of California at Santa Cruz in 2000. She has 25 years of experience conducting water resource and environmental evaluations in a variety of water systems (lakes, rivers, ports, estuaries) and 18 years of experience in the NEPA compliance process, which has included writing environmental impact statements and environmental impact reports and ensuring NEPA compliance on all levels. She has 20 years of experience working with Endangered Species Act requirements, including a recent project on Moores Lake in Carmel Valley, California, for which she worked closely with local, state, and federal government as well as lawyers, environmentalists, and community groups on a complex water rights assessment. For this project, she analyzed environmental tradeoffs for threatened species, water resources, and other land uses; conducted biologic and hydrologic assessments with sensitive species analyses; worked extensively with wetlands, sediment transport, and watershed science; developed a mitigation plan for long-term lake management; and conducted wetland delineations. Dr. Rein also contributed to the Moores Lake Biological Assessment (BA); her familiarity with BAs includes reviewing many BAs for California Environmental Quality Act and NEPA studies. Most of the projects Dr. Rein has worked on over the past 10 years have high public and interagency interest, including the Jamaica Bay, Marine Park and Plumb Beach, New York, Environmental Restoration Project Feasibility Report, which involved nearly a dozen agencies and was partially driven by public interest. Dr. Rein's experience with cultural surveys includes the USACE Site One Impoundment project, where the project archaeologist identified some human remains and pottery shards, made appropriate notifications, and protected the site from flooding impacts while it was being assessed. Dr. Rein is experienced in determining the scope and appropriate methodologies for impact assessment of sensitive habitats. She has conducted many environmental impact analyses for a variety of projects, including having served as an expert witness for impact assessments, for which she investigated a site, reviewed relevant documents, and prepared expert reports for an environmental damage dispute. She is familiar with USACE's calculation and application of environmental impact and benefits, having served on other IEPR panels involving the review of relevant documents and methods. Dr. Rein is a member of Sigma Xi National Scientific Research Society.

Brian Schalk, P.E., CFM

Role: Hydraulic and Hydrology Engineering
Affiliation: JE Fuller Hydrology & Geomorphology, Inc.

Mr. Schalk is a hydraulic and hydrologic engineer at JE Fuller/Hydrology & Geomorphology, Inc. He earned his M.S. in Civil Engineering from the University of Alaska in Fairbanks in 2005; is a registered professional engineer in California, Arizona, and Alaska; and is a registered Certified Floodplain Manager by the Association of State Floodplain Managers. He has 12 years of experience in hydraulic engineering with an emphasis on large public works projects, with an extensive background in hydraulic theory and river geomorphology. He has served as project engineer and manager for a variety of small- and large-scale projects that have involved hydrologic and hydraulic analyses of urban and rural watersheds, Federal Emergency Management Agency (FEMA)-based flood hazard delineations, levee assessment/certification, design of flood-control structures and storm water facilities (plans, specifications, etc.), watershed management planning, and evaluation of scour and sedimentation impacts to fluvial systems. Mr. Schalk's demonstrated ability to coordinate, interpret, and explain testing results with other engineering disciplines is reflected in his management and work on large-scale, multi-discipline projects that necessitate coordination and strong communication between team members on projects such as the USACE-sponsored Va Shly'ay Akimel-Salt River Restoration Project. This project involved working with experts from the fields of environmental science, geotechnical engineering, planning, permitting, structural engineering, material mining, and public utility coordination.

Mr. Schalk's experience with flood risk management projects and the analysis and design of hydraulic structures related to flood control projects includes the study and design of flood control channels, stilling and flood control basins, various types and degrees of bank protection, and the hydraulic modeling and evaluation of flood control/drainage structures such as bridges, culverts, dams, and regional drainage channels. Relevant studies include his engineering support for the Spook Hill Levee Flood Inundation Study, which assessed downstream flood hazard risk and included the hydraulic re-evaluation of existing facilities. His experience with large river control structures includes hydrologic and hydraulic modeling for evaluation and/or design of river training structures and/or bridge crossings on the Salt River in Arizona and the Tanana River in Alaska. The Tanana River Bridge design included review and utilization of National Cooperative Highway Research Program Effects of Debris on Bridge Pier Scour. His knowledge of spillways and stilling basins includes project engineering and management on studies requiring the design and/or evaluation of regional, in-line and off-line, retention/detention basins and associated spillways (both primary and emergency). Outlets for regional basins typically included culvert/pipe primary outlets and concrete emergency spillways. His experience with flood control channels and levees includes serving as project manager/engineer for the assessment, certification, and/or rehabilitation design of six levee structures, such as the Little Colorado River Levee Certification for Holbrook, Arizona. His involvement on the Scottsdale Road Corridor Drainage Master Plan for Scottsdale, Arizona, reflects his experience with design of diversion channels, which includes the hydrologic evaluation of flow splits (both natural and constructed) and the hydraulic routing of estimated design discharges/hydrographs from regional flood control facilities.

Mr. Schalk is knowledgeable in the following areas of flood hazard mitigation: hydrologic and hydraulic analyses; floodplain mapping; hydraulic design of channels and levees using various types of bank protection; and sedimentation impacts on fluvial systems. Mr. Schalk has participated in floodplain delineation studies for FEMA, flood control infrastructure design for local municipalities, USACE ecosystem restoration projects, area drainage master plans for local governments, and levee certifications for FEMA accreditation. His significant experience with hydrologic and hydraulic analyses is reflected in the preparation of area drainage master plans, FEMA flood insurance studies, and dam inundation studies, all of which typically require the hydrologic analysis of rural and/or urban watersheds. Experience with floodplain analysis includes FEMA flood inundation studies that required mapping for the 10-, 25-, 50-, 100-, and 500-year events and projects such as Mohave Valley Risk Monitoring and Assessment Plan (MAP) Study for Mohave County, Arizona, and FEMA that require flood hazard assessment based on area of inundation and flow depth and velocity. In addition to FEMA-based levee certification, Mr. Schalk's experience with the design of channels and levees using channel and bank protection works include the Natural Resources Conservation Service-sponsored Emergency Watershed Protection along Cave Creek Wash in Cave Creek, Arizona, which entailed the evaluation of various bank protection treatments (riprap, spurs, and gabions). He is familiar with typical federal design guidelines for bank protection, such as the Federal Highway Administration Hydraulic Engineering Circular No. 11 publication and National Cooperative Highway Research Program Report 568 for riprap design. Projects associated with river sedimentation and sediment yield estimation have been performed by Mr. Schalk for levee certification projects, including the Equestrian Levee Certification Project for Clark County, Nevada, and FEMA. His familiarity with physical modeling and application of data associated with the physical model testing to the designing of stilling basins and scour protection has been acquired through academic studies associated with culvert modeling with laboratory flume instrumentation. His involvement on projects such as the Sonoqui Wash Channel and Flood Control Facilities Design (Maricopa County, Arizona) and the Tahchevah and Wide Canyon Dams Inundation Study (Riverside County, Arizona) reflects his experience with routing of inflow hydrographs though multipurpose flood control basins utilizing multiple discharge devices. He is also familiar with the principles of flow routing through gated sluiceways and spillways and has modeled basins that include pipes and culverts as primary outlets and concrete weir emergency spillways.

Mr. Schalk is familiar with the USACE application of risk and uncertainty analyses in flood damage reduction studies, including experience in the identification of the extent, frequency, and magnitude of flood hazards and the determination of risk based on known community infrastructure. Projects such as the Mohave Valley and Munds Park Risk MAP Studies are examples of collecting risk-based data and providing this data to FEMA for generation of regulatory Digital Flood Insurance Rate Maps and non-regulatory risk maps. In addition, the Little Colorado River Levee Certification Project in Holbrook, Arizona, required familiarity with the application of USACE risk and uncertainty as it applies to levee certification and FEMA accreditation.

Mr. Schalk is proficient with the use of standard USACE hydrologic and hydraulic models including the USACE Hydrologic Engineering Center (HEC) software HEC-1, HEC-2, HEC-HMS (Hydrologic Modeling System), HEC-RAS (River Analysis System), HEC-DSS (Data Storage System) and FLO-2D, as well as other modeling software. He has reviewed and interpreted results from the models to determine regional flood control facility inflow and outflow hydrographs associated with multiple spillways and to route downstream hydrographs to determine potential areas of inundation, magnitude of flow depth, velocity, and flood wave travel time. He used both one- and two-dimensional modeling on projects such as the Willow Creek Levee Evaluation and Floodplain Delineation for Prescott, Arizona. His involvement in USACE Va Shly'Ay Akimel-Salt River Ecosystem Restoration and Tres Rios Ecosystem Restoration projects demonstrates his familiarity with the preparation of plans and specification for USACE projects and knowledge of USACE design and constructions procedures and policies. His experience implementing his knowledge of, and experience in, USACE dam safety assurance

(DSA) policy and guidance includes flood inundation studies and levee certification projects based on FEMA and/or USACE policy. He is a member of the Arizona Floodplain Management Association, Arizona Association of County Engineers, and American Council of Engineering Companies of Arizona.

Douglas Spaulding, P.E.

Role: Geotechnical Engineering
Affiliation: Spaulding Consultants, LLC

Mr. Spaulding is a Principal and geotechnical engineer with Spaulding Consultants, LLC, where he is responsible for a variety of water resource projects, including dam, levee, and floodwall design and inspection and flood control structures. Mr. Spaulding received his M.S. in geotechnical engineering in 1968 and has been practicing in the geotechnical area for 45 years. He is a registered professional engineer in the states of Arizona, Michigan, Minnesota, North Dakota, and Wisconsin, and served as the Chief of the Levee and Channel Design Section for USACE National Dam Safety Program in Wisconsin and Minnesota from 1973 to 1978. He has worked on the design, inspection, and evaluation of numerous earth dam structures throughout his career. This experience includes the Highway 75 Dam, a 25-foot-high, 3.5-mile long flood control dam in western Minnesota. Mr. Spaulding provided the stability analysis, wrote the specifications, and assembled the design drawings for this USACE flood control structure.
Mr. Spaulding also participated in the final design for the Spring Valley Dam, a 120-foot-high zoned earth embankment located on the Eau Galle River in Wisconsin. Subsequent work included periodic inspection and facilitating a potential failure mode evaluation. Other projects included a remedial seepage design for the High Falls and Eau Pleine reservoirs located in Wisconsin. These designs involved evaluation of existing drain systems and design of a new toe drain and stability berm for the two 100-year-old, 50-foot-high embankments. In addition to these structures, Mr. Spaulding has facilitated potential failure mode (PFM) analyses for many earth embankments, including the remediation of the Hebgen Dam in Montana. This 85-foot-high earth structure survived the Yellowstone earthquake of 1959. Recent analyses indicated that the original intake structure constructed in 1915 would not resist seismic loading. Mr. Spaulding facilitated the PFM analyses evaluating the proposed remediation and construction.
Mr. Spaulding also supervised the seepage analysis of a drainage blanket repair for the 75-foot-high Dead Colt Creek Dam in North Dakota. This analysis utilized finite element evaluation to design an abutment blanket to provide seepage control for the structure. His geotechnical engineering experience includes 10 years with the USACE St. Paul District in the Dams and Special Studies Section. In this capacity, he supervised the implementation of the National Dam Safety Program in the states of Wisconsin and Minnesota. He has served as a Federal Energy Regulatory Commission (FERC) facilitator for PFM evaluations on over 60 structures and has conducted over 75 independent consultant inspections for hydroelectric dams throughout the United States. In addition to these activities, Mr. Spaulding has provided dam safety training for dam operators for the USACE St. Paul District and utilities for the last 35 years. He is very familiar with both FERC and USACE dam safety policies.

Mr. Spaulding's cutoff wall design, construction, and soil improvement expertise includes supervising the preliminary design of slurry trench cutoffs for three hydroelectric developments at Lock & Dam No. 3, 4, and 5 in the USACE Vicksburg District. These projects were done for private development at federal projects. In 2011, Mr. Spaulding served on the Board of Consultants for the Prairie du Sac Hydroelectric Project in southern Wisconsin. This 100-year-old, 30-megawatt (MW) hydroelectric project consists of an Ambursen dam founded on timber piles. Due to tailwater regression, the condition of the timber piling was in doubt and the remediation involved soil densification using compaction grouting.

Additionally, Mr. Spaulding recently served as the geotechnical expert on the IEPR Panel for the East St. Louis seepage remediation project. This $180 million project involved rehabilitation of seepage control structures over 30 miles of levee system. Remediation activities involved slurry trench cutoffs, cutoff trenches, relief well design, and seepage berms. Mr. Spaulding ran a field laboratory testing program for an earthwork contractor early in his career. He has also prepared numerous exploration plans for evaluation of new structures and remediation of existing dams. These activities have included identification and exploration of boring locations, evaluation of in-situ testing, and laboratory and testing programs. Mr. Spaulding's in-situ testing experience includes conducting test grouting programs, vane shear testing, pressure meter testing, and long-term pump testing of deep wells. His experience in subsurface investigations includes the design, monitoring, and modification of numerous subsurface exploration programs to evaluate new designs and remediation projects. His involvement included monitoring day-by-day results of exploration programs in order to modify the program to obtain the best information possible. The subsurface exploration activities for these programs included obtaining rock cores, conducting undisturbed sampling, and obtaining block samples of shale for undisturbed laboratory testing. In his role as principal geotechnical engineer, Mr. Spaulding was responsible for reviewing soil compaction and earthwork data for the Spring Valley Dam, the Highway 75 Dam, and the High Falls and Eau Pleine construction projects.

Mr. Spaulding's experience with seepage and piping includes utilizing finite element techniques to evaluate the design of seepage berms at several major dams. These included the design of both seepage berms and drain systems. His experience includes evaluating contractor claims related to the USACE core trench construction for the Spring Valley Dam in the St. Paul District. He has specified and evaluated dewatering systems, including deep wells, cutoffs, and sump systems. Mr. Spaulding was the owner's representative for the 30-day deep well pump test to evaluate the groundwater impacts for the Lorella Pumped Storage Project located near Klamath Falls, Oregon. Early in his career, Mr. Spaulding independently derived the equations for uplift and seepage included in the report titled *Evaluation of Underseepage-TM-424* (published by the USACE Waterways Experiment Station). These equations are used to evaluate uplift on the land side of various levee structures based upon pervious and semi-pervious subsurface confining conditions. The evaluation of settlement and bearing capacity has been required for numerous geotechnical designs over Mr. Spaulding's career. His settlement computations have included evaluations of the settlement for the Calumet levee located in southern Chicago and the pedestrian bridge at the Grand Forks local flood protection project in Grand Forks, North Dakota. This structure was founded on over 60 feet of soft lacustrine clay. He has conducted extensive evaluations of dewatering systems, including the core trench for the Spring Valley Dam in response to contractor claims and evaluations of deep well systems for interior drainage structures and for the construction of deep excavations for hydroelectric projects located on the Red River in Louisiana.

Mr. Spaulding's experience includes design and construction of foundations on alluvial soils. His design of water retaining and levee structures in the Upper Midwest has involved the evaluation of foundation conditions for alluvial soils which always exist in the river valleys. He has reviewed both onsite testing and laboratory exploration information for numerous foundations for levees, dams, and other types of structures over his 45-year career. These include structures for the Mankato Flood Control Project, the English Coulee channel, the Highway 75 Dam, and other structures in the Midwest. His experience with foundation grouting includes the Seneca Falls Hydroelectric Project, located on the New York State Canal System. This project was constructed in 1913 and the dam and navigation lock sections failed twice due to solutioning of the bedrock formations below the dam. In 2001, FERC requested that the hydroelectric project owner evaluate the foundation below the powerhouse structure to assess the integrity of the rock formation. Mr. Spaulding supervised a trial grouting and water level monitoring program that demonstrated the integrity of this portion of the project foundation. Mr. Spaulding has developed and monitored numerous instrumentation programs for earth embankments. He developed plotting capability for the USACE St. Paul District to monitor existing instrumentation at structures. Mr. Spaulding's instrumentation experience includes open tube and pneumatic piezometers in addition to pressure cells, survey movement points, and settlement gauges.

Mr. Spaulding's experience in the forensic investigation of problems associated with alluvial soil embankment includes his role as the facilitator for the forensic evaluation of the failure of the 40-foot-high Thomson Hydroelectric forebay embankment. This embankment, which failed in June 2012, is located on the St. Louis River near Duluth, Minnesota. At the request of FERC, the owner convened a panel to evaluate the cause of failure of this structure. He has provided engineering services to USACE as a geotechnical consultant for nine design and construction projects for several USACE Districts. He has conducted extensive studies to evaluate the failure of levees and earth structures founded on the 100-foot-deep lacustrine clay deposits in the Red River of the North. Mr. Spaulding also recently served as an expert witness to evaluate the cause of an embankment failure founded on these treacherous deposits. Mr. Spaulding is an active member of the American Society of Civil Engineers (ASCE), the Society of American Military Engineers (SAME), the Minnesota Geotechnical Society, and the National Hydro Power Association.

David Bastian, P.E.

Role: Economics/Planning
Affiliation: Independent Consultant

Mr. Bastian is an independent consultant and professional engineer, specializing in USACE compliance and policy review, plan formulation and incremental cost analysis, dredging and flood risk reduction, and hydraulic and river engineering. He is a registered professional engineer in Mississippi, and earned his M.S. in river engineering from Delft University, Holland. He has more than 40 years of experience in navigation, dredging, and water resource-related activities, most of which have been with USACE. His career has focused on both practical research and water resource-related project implementation, including serving for 15 years as a hydraulic engineer for the USACE Waterways Experiment Station. Mr. Bastian's employment at USACE included positions as Deputy Chief of Staff for Support, Office Chief of Engineers; Assistant Director of Civil Works, Office Chief of Engineers; technical and policy compliance review expert, Washington Level Review Center; and navigation research, USACE Institute for Water Resources. He served at the USACE Washington Level Review Center as a technical and policy compliance review expert and managed interdisciplinary reviews of over 70 feasibility reports. His experience directly related to water resources economic evaluation and review includes the review of USACE water resources feasibility reports for technical and economic evaluation for 20 years. Since 1975, he has been involved with public works planning and working with project teams to identify and evaluate measures and alternatives using appropriate planning methodologies to reduce life safety risk, particularly as a Headquarters reviewer where he evaluated dam safety rehabilitation studies centering on loss of life. He has extensive experience reviewing the analyses used to evaluate measures and alternatives to determine whether they are sufficiently comprehensive and complete to result in approval of recommended alternatives. He provided technical and policy compliance to all aspects of the Corpus Christi channel-deepening project report such that the feasibility report met Headquarters requirements for project authorization. Mr. Bastian is proficient in the USACE plan formulation process, procedures, standards, guidance, and economic evaluation techniques, having worked in the USACE planning function for over 25 years. He is intimately familiar with and experienced in the application of the USACE six-step planning process and USACE policy Engineer Regulation (ER) 1105-2-100 as a reviewer, instructor, and study leader for the last 20 years. He is familiar with the USACE flood risk and hurricane/coastal damage risk reduction analysis, as demonstrated by his 5 years working on post-Katrina studies for the New Orleans District as well as having reviewed numerous USACE flood risk and hurricane damage risk reduction studies while serving at the Headquarters review center. As both a USACE reviewer and participant, he identified and evaluated impacts to environmental resources from this structural flood risk management and risk reduction project. As part of his post-Katrina studies, he utilized his familiarity with the NED analysis procedures, where he conducted economic evaluation of the post-Katrina levee rebuild and of other Louisiana hurricane and storm damage risk reduction studies. His management and/or review of numerous studies involving HEC-FDA (Flood Damage Reduction Analysis) and other computer programs demonstrates his familiarity with economic benefit calculations. He has prepared feasibility reports and provided independent technical review of flood and hurricane damage reduction, ecosystem restoration, navigation, major rehabilitation, post-authorization, and DSA for Alaska, Galveston, Huntington, Jacksonville, Kansas City, Little Rock, Mobile, New Orleans, Tulsa, Vicksburg, and Norfolk Districts. Mr. Bastian's participation in related professional societies includes the ASCE and the American Association of Port Authorities.

Rex Powell, P.E.

Role: Civil / Structural Engineering
Affiliation: Bergmann Associates

Mr. Powell is a senior discipline specialist, structural engineer, and project manager with Bergmann Associates. He earned his B.S. in Civil Engineering from the Rensselaer Polytechnic Institute in 1981 and is a registered professional engineer in New York. He has over 30 years of experience in design and analysis of structures as well as mechanical, geotechnical, and hydraulics design. He has extensive experience in the design and construction of hydraulic structures for large and complex Civil Works project, including outlet works and spillways. Mr. Powell is trained in FERC PFM analysis and facilitation. He has been the independent consultant on several FERC Part 12 dam safety inspections as well as a number of state-regulated dam safety inspections, and was a member of the IEPR team for the Herbert Hoover Dike Culvert Replacement project. Mr. Powell is a member of the SAME and has published and presented technical papers to the United States Society on Dams, USACE Infrastructure Systems Conference, and Association of State Dam Safety Officials.

Mr. Powell's practical knowledge of construction methods is demonstrated through his involvement in the planning, design, and construction of numerous new, repair, and rehabilitation projects for hydraulic structures using a variety of construction techniques. He is experienced in using construction techniques such as precast concrete, steel, masonry, roller-compacted concrete, in-the-dry and in-the wet construction, post-tensioning, shoring, various pile types, compaction, and jet grouting. Throughout his career, Mr. Powell has been involved with cast-in-place concrete placements from small, specially placed pours to large, nearly 1,000-cubic-yard lifts.

Mr. Powell has designed, analyzed, and constructed numerous low-head gravity dams and weirs, ranging in size from 12 inches to greater than 25 feet. He has been responsible for the design of virtually all structural aspects of hydropower plants and dams. He is experienced in the design of concrete gravity dams and structures, including pre-stressed and post-tensioned elements, structural steel, timber, masonry, and cofferdam design. He has extensive experience in the stability analysis and structural design of mass concrete scour protection and stilling features, with functional knowledge of stilling basin design standards, rehabilitation design and review, and spillway training wall design.

As project engineer for the Hudson Falls Hydroelectric Project (Hudson River, New York), Mr. Powell was responsible for the preparation of project arrangements, construction specifications, and structural criteria and design for a 1,300-foot spillway and non-overflow dam, downstream fish passage, trash rack structure, intake, and powerhouse with an installed capacity of 36 MW. He was responsible for detail design, drawing production, specifications, and construction for of the New York State Dam on the Mohawk River, which included various retaining wall designs. His work on a 2,400-MW U.S. Hydroelectric Power Plant in New York included three-dimensional geometric modeling, and stability and finite element analysis.

Mr. Powell also worked on the Canyon del Pato hydroelectric expansion project, Rio Santa, Peru. There, Mr. Powell designed a complementary intake structure that joined to the existing intake tunnel upstream of the common underground de-sander. Improvements also included enlargement of the existing rock sluice and discharge tunnel. He was also part of the team that performed the field inspection of the surface and underground features and coordinated the structural evaluation of the existing works. Other tunnel liner designs include a new reinforced concrete liner for the Station 5 power tunnel (Genesee River, New York) for Rochester Gas & Electric. The tunnel, 16 feet wide and horseshoe-shaped, had a roughly horizontal alignment transitioning to a 20-foot-diameter intake shaft.

Mr. Powell has prepared plans and specifications for a number of USACE projects within the last 6 years, including canal walls, locks, tainter gates, and pump stations, and he understands USACE design and construction procedures and policies. He was Senior Structural Engineer and/or Technical Design Manager for the St. Paul District Devils Lake City Embankments Creel

Bay and East Ditch Pump Station Replacement projects (Devils Lake, North Dakota); the Pittsburgh District Montgomery Locks and Dam project (Monaca, Pennsylvania), and the Rock Island District Lockport Pool Roller-Compacted Concrete Replacement Wall project (Lockport, Illinois), among others. For the USACE Nashville District Chickamauga Lock Replacement project (Chattanooga, Tennessee), he was responsible for the design of the integral landward lock wall monoliths, which involved integration of innovative segmental concrete cofferdam monoliths into the completed lock wall structures. The new 110-foot by 600-ft lock chamber will be constructed riverward of the existing lock while it remains in operation, ultimately replacing the smaller lock. Design of the lock involved non-linear two- and three-dimensional finite element analyses of the integrated structures. He also managed Engineering During Construction of the segmental cofferdam installation, which involved lifting precast concrete box sections into position onto drilled shafts and filling them with mass concrete.

Mr. Powell has functional knowledge of typical erosion control measures used in heavy Civil Works projects during construction and in the final condition. He has also evaluated the erosion potential of jointed bedrock subjected to dam discharges. Mr. Powell's work on the Erie Canal Lock E-10 Overflow Spillway Replacement (Cranesville, New York) included designing reinforced concrete aprons and mitigation measures for future erosion. Mr. Powell has been involved in the arrangement and monitoring of drainage for concrete dams and has developed flow nets for dams with drains. He has working knowledge of earthwork typically associated with large Civil Works projects. He has demonstrated experience in developing site arrangements and identifying survey requirements. He has performed basic grading and drainage associated with site development for large hydraulic projects. His experience includes the design of access road arrangements to suit grades and turning radii for heavy equipment, and using typical design sections. His experience with retaining wall design includes inverted T- and L-walls, cantilever and tied-back sheets, braced walls, and master-pile retaining walls. Mr. Powell is also experienced in the relocation of underground utilities, including permanent moving and temporary relocation for construction and abandoning pipes.

David Jermstad P.G., CEG, REA II

Role: Engineering Geology
Affiliation: Carlton Engineering, Inc.

Mr. Jermstad is a principal engineer and technical manager at Carlton Engineering, Inc. He has over 35 years of experience in engineering geology, earning his B.S. in geology from California State University in 1984. He is a registered professional geologist (California), a certified engineering geologist (California), a registered environmental assessor II (California), and a certified environmental manager (Nevada). Mr. Jermstad is highly experienced in the western states region with technical rock mechanics, slope stability, subsurface investigations, soil mechanics, retaining wall design criteria, seepage and piping, erosion protection design, and earthwork construction. He is extremely proficient in assessing seepage and piping through and beneath dams, including work at Cameron Park Lake earthen dam, Aloha Lake Dams, Caples Lake Dams, Echo Lake Dam, El Dorado Forebay Dam, Silver Lake Dam, Murphys Forebay and Afterbays Dams, and Hunters Dam. Mr. Jermstad is knowledgeable in the identification of geological hazards, having prepared geohazard reports for numerous development and improvement projects in challenging terrain and high-wind areas, most recently for the

California Department of General Services. He is familiar with all types of exploration techniques, including soil and rock logging, geologic mapping, geophysical investigations, and air photon interpretation. Much of Mr. Jermstad's work involves subsurface exploration; his most recent challenge was on the award-winning Alpine County Hawkins Peak Telecommunications project, for which he evaluated subsurface conditions and provided foundation recommendations for two structures. This effort involved pinning foundation concrete to rock substrate and addressing complex rock fracturing.

Mr. Jermstad oversees Carlton Engineering’s National Institute of Standards and Technology/Cement and Concrete Reference Laboratory Compliant Soils and Materials Testing Laboratory. He is familiar with field and laboratory testing and the determination of in-situ materials properties. He understands the importance of observing and qualifying the properties of in-situ materials, as displayed during the award-winning El Dorado Irrigation District’s Flume 51 Replacement project. This project included the assessment and mitigation of a landslide, stability analysis, drainage design, seepage mitigation, earthwork and foundation criteria, rock mechanics, and erosion control. Mr. Jermstad is familiar with geomorphology and seeks to understand the history and dynamics of landform(s) to predict future changes that may affect project goals. One example is the Flume Conditions Assessment, a FERC project that consisted of a geotechnical evaluation of all elevated and at-grade flume structures along a 22-mile water conveyance system. Since its completion, the findings of this Flume Conditions Assessment have been used to develop a capital improvement program, prioritize flume replacement projects, and schedule ongoing maintenance for this critical water and power infrastructure. Mr. Jermstad is also familiar with foundation inspection and assessment for embankments, levees, and dams; he has assessed more than 20 dam foundations and has been involved in more than 10 FERC Part 12 Dam Safety Inspections. His experience includes investigating facility foundations and conducting subsurface studies to evaluate the soil engineering properties at sites such as the El Dorado Irrigation District (EID) El Dorado Powerhouse, and the EID Echo Lake Tunnel pipeline,.

Mr. Jermstad’s familiarity with foundation grouting and other seepage prevention methods includes the design of subsurface drains, grout curtains, and cutoff walls. He has a working knowledge of grout rheology, concrete mix designs, and other materials used in foundation seepage barriers. He is familiar with the design, installation, and assessment of instrumentation, including piezometers, monitoring wells, and slope inclinometers, having provided a geotechnical site evaluation for the construction of a multi-level temperature control device for a large lake on the American River.

Mr. Jermstad has experience with the preparation of factual data, interpretive geology reports, and plans specific to USACE projects, including his current work on the USACE Lava Cap Mine Waterline project. For that project, he is leading a multi-discipline team providing services for waterline infrastructure installation. The project includes the construction and installation of approximately 8,000 linear feet of distribution line and 3,000 linear feet of service lines to various properties in Nevada County, California. This project demonstrates his knowledge of current USACE design and construction procedures and policies. He also is familiar with USACE DSA policy and guidance He has provided engineering services on several dams under USACE’s jurisdiction, including serving as the independent consultant providing Dam Safety Engineering Services per 18 CFR Part 12D for FERC 2019 dam projects such as Hunters Dam, Murphys Forebay South and West Dams, and Murphys Afterbay Dam. Mr. Jermstad has been an active participant in the ASCE, Association of Engineering Geologists, and American Council of Engineering Companies.

5. SUMMARY OF FINAL PANEL COMMENTS

The panel members agreed among one another on their "assessment of the adequacy and acceptability of the engineering, economic, and environmental methods, models, and analyses used" (USACE, 2012a, 2012b; p. D-4) in the DSMR and Baseline Risk Assessment (BLRA) Report review documents. Table 3 lists the Final Panel Comment statements by level of significance. The full text of the Final Panel Comments is presented in Appendix A of this report. The following statements summarize the Panel's findings.

The DSMR and BLRA Report provide a well thought-out and thorough presentation of USACE's approach to risk assessment for the project and the need for urgency. From a planning standpoint, it is apparent that USACE explored a reasonable set of alternatives. In general, the DSMR, BLRA Report, Draft Environmental Assessment (EA), Hydrology Report, and other technical appendices and supporting documents provide substantial data regarding the investigations conducted to support the project. However, in some cases, key information is not provided, which prevents the Panel from fully and accurately assessing the project.

Plan Formulation – The problems, needs, constraints and opportunities associated with the recommended dam improvements are primarily civil, structural, and geotechnical in nature. Overall, the Panel found that the multiple investigations and analyses conducted for this project provide sufficient basis for the recommendation. The screening of proposed alternatives was based on reduction of risk as discussed in the tolerable risk guideline, which includes Loss of Life risk reduction. The project directly addressed the following primary system flaws: hydraulic fracturing or other defect in embankment; potential for material loss through conduit joints; deficient filters; and the potential for an unfiltered seepage flow around the interim downstream filter as detailed as PFMOW 1 Conduit Piping. The Panel acknowledges that additional elements and plans were considered, but not formulated because they were determined not to be technically viable in design or construction.

Hydrology and Hydraulics – The Panel found the hydrology and hydraulics discussion sufficient to characterize current baseline conditions and to allow for evaluation of forecasted conditions. In terms of the hydrology and hydraulics analyses, risk and uncertainty were sufficiently considered by flood routing and inundation mapping of the Probable Maximum Flood (PMF) event. The analyses performed for the DSMR are appropriate for risk and consequence determination. The dam failure analysis and inundation mapping were performed utilizing Hydrologic Engineering Center-River Analysis System (HEC-RAS) and HEC-Geographic RAS (HEC-GeoRAS) tools. Likely bankfull stages of reaches downstream caused by simultaneous releases from neighboring dams could increase inundation consequences, but not significantly. While there are concerns about the topographic resolution, the hydrology and hydraulics analyses performed for the DSMR are appropriate for risk and consequence determination.

Engineering – The Panel found that, in general, the engineering analyses appear consistent with generally accepted methodologies. The investigations of the seepage conditions surrounding the conduit appear well-devised and well-analyzed, with rational conclusions leading to the recommended repairs. There are several instances where additional information would be helpful in understanding and providing confidence in the conclusions For example: there was no discussion of the significance of the response of PZ17 in 2012 to changes in headwater; there is insufficient information presented to assess the evaluation of seepage at main dam station 30+00; and the ability of the uncontrolled spillway to safely discharge the PMF is not addressed.

Geotechnical/Geology – The Panel found that the geotechnical evaluation of the existing conditions and the development of remedial measures for the observed seepage conditions along the outlet works as described in the DSMR did not follow sufficiently rigorous analytical procedures. The voids and seepage along the conduit are assumed to be due to "hydraulic fracturing" or other defects related to the initial construction and compaction of backfill and subsequent settlement. No analytical methods to evaluate the potential occurrence of hydraulic fracturing – or more importantly, to assess the limits of the zone of fracturing – have been performed. The Panel recognizes that these types of analyses are difficult and often provide somewhat uncertain results, but they could provide a useful tool during final design stages to evaluate the limits of the cutoff component of the remedial actions, as defined in Structural Alternative 7 repair program. Finally, the Panel is concerned with the length of the concrete cutoff wall and its ability to block harmful seepage. The Panel believes an extended cutoff wall would make the overall solution redundant, resilient, and robust.

Economics – The Panel found that the economic analyses were consistent with generally accepted methodologies. Some components of the economic analysis have not been adequately explained. Specifically, depth-damage percentage losses, dam rebuilding costs, and impacts to agriculture cannot be confirmed because the level of detail in the analysis is not consistent with USACE Engineer Regulation (ER) 1110-2-1156, Section 18.4 (USACE, 2011). There were also inconsistencies between the main report and appendices. Benefits forgone (described as flood risk management) do not appear to represent existing condition values. Finally, depth-damage inputs for structures, content, and vehicles do not coincide with guidance presented in Corps of Engineers Civil Works (CECW) memoranda.

Environmental – The Panel found that the affected environment and environmental consequences of all alternatives have been adequately described. However, although 11 threatened and endangered species were reported, the description of the specific species is incomplete; therefore, all potential impacts on these species may not be provided. Measures needed to ensure that potential impacts to these species do not occur should be included in the DSMR, including potential impacts on costs. In addition, water quality monitoring is recommended if grouting is implemented.

Table 3. Overview of 15 Final Panel Comments Identified by the Pine Creek Lake IEPR Panel

No.	Final Panel Comment
	Significance – High
1	The length of the proposed cutoff wall of 44 feet may not be long enough to cover the area of potential hydraulic fracturing or embankment defects.
2	The current schedule for completing remediation does not correspond to the apparent urgency of actions needed to prevent failure as implied by Dam Safety Action Classification (DSAC) I.
	Significance – Medium
3	Pertinent hydrologic and hydraulic calculations, modeling, and mapping are not fully presented in Appendix 12 of the Baseline Risk Assessment (BLRA) Report; therefore, the full extent of the breach routing and resulting downstream flood hazards could not be determined.
4	The breach formation time of three hours, associated with each of the six antecedent pool elevations, may not be in accordance with dam breach analysis guidelines and criteria.
5	Coincidental flood releases from Broken Bow and DeQueen Lakes were not considered during hydraulic modeling, which could result in increased flood stage and the inundation area on the Little River in the vicinity of the subject tributaries.
6	There are discrepancies between reported maximum high pool elevations associated with the Probable Maximum Flood (PMF), which could significantly increase the flood volumes, flow depths, and inundation area.
7	Standard Penetration Tests (SPTs) do not appear to correspond to the shear strength parameters used for the stability analysis conducted in USACE's 2003 Seismic Safety Review, which could constitute a change in the stability of the critical dam cross section.
8	Bedrock erosion and embankment foundation stability due to uncontrolled spillway discharge under Probable Maximum Flood (PMF) conditions have not been addressed, and their importance as a credible failure mode cannot be evaluated.
9	The cause of the minor pin-boils observed at Station 30+00 under higher pool levels has not been fully evaluated and could pose a long-term concern for the integrity of the dam, especially under high-pool conditions.
10	Eleven threatened and endangered species were reported, yet a description of the specific species, the probability of them being found in the project boundary area, and potential impacts on these species were not provided.

	Significance – Low
11	The U.S. Geological Survey (USGS) 10-meter Digital Elevation Model (DEM) topographic data used to develop hydraulic models, map downstream flood hazards, and ultimately determine dam breach consequences may not be commensurate with the vertical accuracy as stated in the Baseline Risk Assessment (BLRA).
12	The operation, maintenance, repair, replacement and rehabilitation (OMRR&R) efforts are not adequately described, and it could not be determined if the proposed costs are reasonable.
13	Piezometer PZ17 appears to be very responsive to high pool conditions and may indicate an undesirable seepage condition.
14	Various key inputs to the economic analysis, such as the cost of repairing the damage to the dam as a potential direct loss, were not provided or explained and could result in an inaccurate final cost analysis.
15	The chemical composition of the grouting material and sealant is not described, and the potential for short-term impacts on aquatic species has not been considered.

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APPENDIX A

Final Panel Comments

on the

Pine Creek Lake Review Documents

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Final Panel Comment 1

The length of the proposed cutoff wall of 44 feet may not be long enough to cover the area of potential hydraulic fracturing or embankment defects.

Basis for Comment

The remedial plan for seepage control includes four elements which, if properly implemented, will provide a robust and redundant solution. The installation of an appropriately sized plastic concrete cutoff wall is perhaps the most important element of the proposed plan. It is the Panel's opinion that the 44-foot-long wall is not long enough to cut off the entire leakage area and potentially could compromise the effectiveness of this element of the remedial measures. The following factors support this opinion:

a) Section B-B, page 7, of the Formulation of Risk Management Plans Report (Dam Safety Modification Report [DSMR] Appendix III) indicates that the width of the top of the concrete plug in the area of the core trench is 50 feet. If this dimension is correct, the proposed 44-foot-long core wall will not span the entire width of the concrete plug section, nor will it cover the postulated zone of hydraulic fracturing as shown in Figure 5.
b) Conversely, the Cutoff Wall Detail on Sheet 145 of 173 of the 65% Design Drawings (DSMR Appendix IV) shows the top of the concrete plug only slightly narrower than the cutoff wall.
c) The length of the cutoff wall appears to have been evaluated and determined based mainly upon engineering judgment after review of the subsurface exploration and other investigations. There were no engineering analyses or rationale provided in the report to support the selection of the 44-foot length.
d) In order to achieve a robust design, the cutoff wall should extend well past the limits of the concrete plug in order to incorporate all of the areas that potentially have been subjected to hydraulic fracturing and provide adequate overlap with the competent portions of the impervious core.
e) Aerial photographs of the outlet works construction taken on October 6, 1966, clearly show that there are relatively steep rock excavation slopes extending upward on either side from the top of the concrete plug. This is consistent with the Cutoff Wall Detail on Sheet 145 of 173 of the 65% Design Drawings (DSMR Appendix IV), which shows the rock excavation surface extending above the concrete plug at a 1H:1V slope or steeper. This type of bedrock configuration potentially could have resulted in hydraulic fracturing well beyond the proposed limits of the cutoff wall.
f) Federal Emergency Management Agency (FEMA) 484 Section 5.1 recommends that the "side slopes of the excavation must be flat enough to avoid differential settlement of the embankment dam near the conduit"; Section 5.1.1 goes on to recommend that the rock "foundation line, grade, and density should be uniform." (FEMA, 2005) Furthermore, FEMA P 675 Section 2.1 recommends that to "avoid installing a negative projecting embankment conduit, use a trench with at least 2 to 1 (horizontal to vertical) or flatter side slopes (figure 31)." (FEMA, 2007) This suggests that arching action could extend to the top of the rock excavation trench.

Significance – High

The limited 44-foot length of the cutoff wall has not been justified, and there is evidence that this length will not fully span the entire zone of fractured or defective material. This could allow seepage to flow along the outlet works downstream of the concrete plug and create a potential for piping, resulting in dam failure.

Recommendations for Resolution

1. Conduct an analysis during final design of the stresses within the embankment overlying and adjacent to the concrete plug to evaluate the possibility that hydraulic fracturing has occurred and to define the zone of fracturing. The limits of the analysis should be sufficient to define the limits of any potential hydraulic fracturing and thereby provide a basis for the length of the cutoff wall.
2. Consider extending the limits of the cutoff wall to incorporate the entire length of the embankment fill, which was placed and compacted against the steep, irregular surface of the sloping excavated sidewalls of the trench for the outlet works. Consideration should be given regardless of the results of the analysis described above in the previous recommendation and occur during the final design phase.

Literature Cited

FEMA (2005). Technical Manual: Conduits through Embankment Dams. Federal Emergency Management Agency. FEMA 484. September.

FEMA (2007). Technical Manual: Plastic Pipe Used in Embankment Dams. Federal Emergency Management Agency. FEMA P 675. November.

Final Panel Comment 2

The current schedule for completing remediation does not correspond to the apparent urgency of actions needed to prevent failure as implied by Dam Safety Action Classification (DSAC) I.

Basis for Comment

The current schedule as shown in Appendix VI-F of the Dam Safety Modification Report (DSMR) indicates that on-site construction to remediate the seepage conditions will not begin until October 2014 and will not be substantially complete until August 2016. The DSMR indicated that the seepage condition around the outlet works was reclassified as a DSAC I in April 2011. The current schedule therefore will result in over a five-year period to resolve a critical dam safety issue. This appears to be reflected in DSMR Table 50, which indicates a six-year estimated time to implement, though the beginning of the estimated period of construction is not defined. The Panel is concerned that any delay in implementing the remedial work increases the threat of failure, particularly if there are unforeseen high reservoir levels.

The Panel has the following observations related to the urgency of the remedial work:

a) The seepage issues related to the outlet conduit surrounding backfill have been an ongoing source of concern since the initial filling of the reservoir in 1969. Over the last four years, there has been increasing visual and physical evidence that the seepage conditions have increased in severity. The Tulsa District has undertaken multiple types of investigations, including dye testing, standard penetration testing, and ground penetrating radar, among other methodologies. The District is to be complimented on the thoroughness of its evaluation and investigations in identifying the serious nature of this problem. The formation of internal voids within the embankment and the emergence of seepage flow carrying sediment are classic indications of an embankment nearing a failure condition that warrants remedial action on an expedited schedule.

b) The rate of progression of the seepage condition cannot be predicted. As stated in Section 4.2.2.1 of the DSMR, critical piping may occur at increased pool levels of 438 feet (only five feet above the current conservation pool). This imposes a serious immediate risk to the integrity of the dam, which has been correctly identified in the report.

c) Many areas in the country have recently experienced storm events with increased intensity and frequency and with substantial increases in precipitation resulting from a single storm event, which may be attributable to climate change. The project area has been undergoing a long-term drought condition, which fortunately has resulted in reservoir elevations remaining very low. The possibility of one severe storm event in the future causing a rapid increase in pool elevation, resulting in increased seepage conditions or sudden failure, is a plausible scenario that should be considered as part of unforeseen conditions or climate change considerations.

d) The remedial plan for seepage control includes four elements, which if properly implemented will provide a robust and redundant solution. These include a cutoff wall, a chimney drain, a downstream drain and a liner system As indicated in DSMR Section 4.4.3, Non-Structural/Structural Plan 4 was eliminated from consideration for the selected risk management plan because it delays the implementation of the structural plan and resolution of the issues within the embankment. However, each of the various structural elements is currently presented as separate, requiring separate contracts, resulting in a drawn-out duration for complete implementation.

Significance – High

Investigations to date have provided evidence of critical seepage conditions, and the potential time for internal seepage and piping to progress to a failure condition under either normal or higher pool levels cannot be predicted. The immediate risk would be exacerbated under higher reservoir levels. Any delay in implementing the remedial measures increases the likelihood of dam failure prior to completion of the project.

Recommendations for Resolution

1. Clarify the starting time for the estimated construction period durations of the risk management alternatives listed in Table 50.
2. Include Structural/Non-Structural Plan 4 in Tables 50 and 51.
3. Make every effort to expedite required reviews, funding, and finalization of repair procedures and contracts in order to begin remedial construction at the earliest possible date.
4. Modify the sequencing to expedite the installation of the most critical remedial measures involving the drain and cutoff wall. The construction of the cutoff wall and installation of the new drain will require specialized equipment and contractor expertise. The installation of the steel liner and downstream drain system will involve more-routine type construction that does not require significant specialized equipment. Consider utilizing a separate contract to install the secant wall and chimney filter before implementing the downstream filter and conduit liner system. This sequencing may expedite the installation of the most critical remedial measures involving the chimney drain and cutoff wall.

Final Panel Comment 3

Pertinent hydrologic and hydraulic calculations, modeling, and mapping are not fully presented in Appendix 12 of the Baseline Risk Assessment Report; therefore, the full extent of the breach routing and resulting downstream flood hazards could not be determined.

Basis for Comment

The determination of dam breach consequences is highly dependent on the hydrologic and hydraulic analyses completed for the Baseline Risk Assessment Report. Although general discussion was provided regarding these analyses, Hydrologic Engineering Center-River Analysis System (HEC-RAS) modeling and mapping of the downstream inundation areas were not included with Appendix 12 of the Baseline Risk Assessment Report. The current level of discussion in Appendix 12 limits the Panel's ability to analyze the mapped flood hazards used to determine dam breach consequences.

In addition, supporting hydrologic assumptions and calculations, such as development of the Pine Creek Lake storage curve, are not fully provided with the Baseline Risk Assessment Report. According to the Baseline Risk Assessment Report, Appendix 12, Section C.3.7.2, level pool routing of the reservoir was modeled for dam failure analysis. The Pine Creek Lake storage curve from the Water Control Manual (as referenced in the Baseline Risk Assessment Report, Appendix 12) was the basis for this level pool routing. It is assumed that the storage curve used for level pool routing was developed at the time of dam construction. Unsteady HEC-RAS model results are flood-volume dependent; therefore, the computed downstream flood depths and inundation area are dependent on the stored volume within the reservoir at the time of failure.

Significance – Medium

Because the current Dam Safety Modification Report (DSMR) documents do not fully provide the supporting information associated with the hydrologic and hydraulic calculations, modeling, and mapping, the completeness of the report and overall understanding of the results are affected.

Recommendations for Resolution

1. Provide more information on HEC-RAS modeling and mapping in Appendix 12 in order to understand the mapped flood hazards used to determine dam breach consequences.
2. Include the storage curve calculation used for level pool routing and incorporate this information in Appendix 12 of the Baseline Risk Assessment Report.
3. Verify that physical changes within the storage/reservoir area (i.e., sediment accumulation, vegetation growth) that have occurred since dam construction do not necessitate an update of the Pine Creek Lake storage curve that is provided in the Water Control Manual. If significant reservoir storage has been lost, develop a revised Pine Creek Lake storage curve.

Final Panel Comment 4

The breach formation time of three hours, associated with each of the six antecedent pool elevations, may not be in accordance with dam breach analysis guidelines and criteria.

Basis for Comment

According to the U.S. Army Corps of Engineers (USACE) *Safety of Dams – Policy and Procedures*, Appendix O, Section O.3, a short-term risk reduction strategy for mitigating a breach under a seepage failure mode scenario usually involves some form of reservoir drawdown or modified reservoir operations under reduced storage levels (USACE, 2011). This suggests that the breach formation time may vary depending on the antecedent pool elevation.

Table 13 of the Baseline Risk Assessment Report shows a breach formation time of three hours for each of the six pool elevations (437.53’, 446.93’, 471.33’, 480.13’, 485’ and 503.5’). However, it is reasonable that the breach formation time associated with a 437.53’ pool elevation is longer than a breach formation time associated with higher pool elevations.

The downstream peak flood stage is dependent on breach parameters, which include the breach formation time. Use of a standard breach formation time for all pool elevations is highly significant given that an unsteady HEC-RAS model was used to map downstream flood inundation. Unsteady model results are driven by flood volume, which is dependent on how quickly a breach forms during dam failure. It is likely that a decrease in the breach formation time will result in an increase in flood depths in the vicinity of the Pine Creek Lake Dam.

In addition, according to Ackerman and Brunner (2006) of the USACE Hydrologic Engineering Center (HEC), a breach matrix of possibilities is recommended when simulating a hypothetical dam failure. The matrix would include estimates of varying breach sizes and formation times. Breach parameters can be estimated based on historic data or numerical models; however, given the uncertainty associated with dam failure, modeling of several breach sizes and formation times is recommended. Breach parameter data, including methods for predicting dam breach properties, have been summarized by the National Weather Services, National Oceanic Atmospheric Administration (NOAA) (Fread, 1988, revised 1991).

Furthermore, according to the Federal Energy Regulatory Commission (FERC) (1993), the Time of Failure (TFH) for engineered, earthen dams should be between 0.1 hour and 1 hour (page 2-A-9). This time line also encompasses the 0.5 hour +/- flood wave release time for the 1997 piping failure of the Bureau of Reclamation’s Teton Dam, a large earth dam similar to Pine Creek.

Decreasing the breach formation time will likely result in a local increase of downstream flow depths and inundation area, possibly increasing loss of life and economic consequences; however, it is unlikely that this change in downstream flood impacts will prompt a reconsideration of the selected dam remediation alternatives.

Significance – Medium

Adequate discussion regarding a fixed breach formation time associated with varying pool elevations is not provided in the Baseline Risk Assessment Report; therefore, a complete understanding of the study is not possible.

Recommendations for Resolution

1. Provide rationale for the use of a fixed three-hour breach formation time within the Baseline Risk Assessment Report.
2. Update hydraulic modeling and flood hazard mapping, if it is decided that a breach matrix of possibilities is appropriate for use.
3. As a quality control check, model breach characteristics with the BREACH model and compare results.

Literature Cited

Ackerman, C., and Brunner, G. (2006). Dam Failure Analysis Using HEC-RAS and HEC-GeoRAS. Third Federal Interagency Hydrologic Modeling Conference, Reno, Nevada. April. Available at http://acwi.gov/hydrology/mtsconfwkshops/conf_proceedings/3rdFIHMC/11F_Ackerman.pdf. Accessed March 8, 2013.

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USACE (2011). Safety of Dams – Policy and Procedures. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation (ER) No. 1110-2-1156. October 28.

Final Panel Comment 5

Coincidental flood releases from Broken Bow and DeQueen Lakes were not considered during hydraulic modeling, which could result in increased flood stage and the inundation area on the Little River in the vicinity of the subject tributaries.

Basis for Comment

According to the Dam Safety Modification Report (DSMR), Section 3.2.2, the Pine Creek Lake Dam is one dam in a three-dam flood-control system that also includes Broken Bow Lake and DeQueen Lake Dams. However, coincidental flood releases from Broken Bow and DeQueen Lakes were not considered during the hydraulic modeling. Coincidental flood releases from Broken Bow and DeQueen Lakes increase the discharge, stage, and velocities downriver from those two reservoirs. A flood wave resulting from a potential failure mode at Pine Creek Lake Dam would add to the discharge, stage, and velocities and could impact loss of life and economic consequences in the reaches below these two structures. Since they were not addressed in the DSMR, the Panel has no basis to evaluate flood impacts.

Flood releases are to be made in accordance with releases from Broken Bow Lake and DeQueen Lake Dams, predicted runoff, allowable stage from downstream control points, and allowable reservoir storage within the system. Each of the three reservoirs is regulated to retain balanced flood-control facilities. However, prioritization of flood releases is based on available storage and inflow into each reservoir.

As discussed in Section C.2.4 of the Baseline Risk Assessment Report, Appendix 12, coincidental downstream discharges were not developed during the update of the Probable Maximum Flood (PMF) analysis. In addition, flood release information for Broken Bow Lake and DeQueen Lake Dams is not available for lesser hypothetical events. The hydraulic modeling initial conditions for the Broken Bow Lake Dam and DeQueen Lake Dam tributaries were set to low-flow conditions for the study.

As discussed in Section IV.A.3 of the Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams (FEMA, 1998), for flood routing computations, releases are typically limited to maximum values determined from operating protocol, tailwater conditions, and downstream conveyance capacities. This suggests that the modeling of coincidental flood releases from Broken Bow Lake and DeQueen Lake Dams under operational conditions is an appropriate approach for assessment of Little River flood hazards.

Hydraulic modeling was based on the low-flow downstream boundary conditions associated with the Broken Bow Lake and DeQueen Lake Dams. Using low-flow boundary conditions does not account for regional high-precipitation events and the subsequent flood releases at Broken Bow Lake Dam and DeQueen Lake Dam. In the event that Broken Bow Lake Dam and/or DeQueen Lake Dam are required to release flood waters coincidental with the failure of Pine Creek Lake Dam, flood impacts in the vicinity of these two tributaries would likely exceed those modeled under low-flow conditions. Under this scenario, this modeling approach would likely underestimate the downstream stage and potential for consequences.

Significance – Medium

It is unclear if coincidental flood releases from the Broken Bow Lake and DeQueen Lake Dams would result in an increase in Little River flood depth and inundation area in the vicinity of these tributary streams.

Recommendations for Resolution

1. Discuss and, if necessary, fully evaluate the downstream boundary conditions associated with the Broken Bow Dam and DeQueen Lake Dam tributaries.
2. Revise the dam breach modeling and map associated flood hazards, if downstream boundary conditions other than low-flow conditions are deemed appropriate.
3. Re-evaluate consequences based on remapped flood hazards.

Literature Cited

FEMA (1998). Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams. U.S. Department of Homeland Security, Interagency Committee on Dam Safety. Reprinted April 2004.

Final Panel Comment 6

There are discrepancies between reported maximum high pool elevations associated with the Probable Maximum Flood (PMF), which could significantly increase the flood volumes, flow depths, and inundation area.

Basis for Comment

Notable discrepancies with regard to the maximum high pool elevation have been identified within the review documents (see Table 1 below).

Table 3. Notable Discrepancies for Maximum High Pool Elevation.

Document	Section/Page	Maximum High Pool Elevation (feet)
Baseline Risk Assessment Report	2.2.1	503.0
Baseline Risk Assessment Report	6.3.4.6	503.6
Baseline Risk Assessment Report	6.3.4.9	503.5
Baseline Risk Assessment Report, Appendix 12 – H&H	Table C.1, C2.2.2, C.3.8.1,	503.6
Baseline Risk Assessment Report, Appendix 12 – H&H	Table C.4, Table C.5, C.3.8.3.1, C.3.8.3.7	503.5
Baseline Risk Assessment Report, Appendix 13 - Consequences	Throughout	503
PMF Analysis for Dam Safety Report (May 2011)	Page 16	503.47
PMF Analysis (May 2012)	Page 29	503.56

Given that the maximum pool elevation of 503.6 feet is reported in the latest PMF Analysis (May 2012), it is assumed that this pool elevation is the most appropriate for use in the unsteady Hydrologic Engineering Center-River Analysis System (HEC-RAS) modeling of the dam breach. Unsteady HEC-RAS model results are dependent on the volume of flow being routed. If there are 26,600 acres of storage at a pool elevation of 503.0 feet (Baseline Risk Assessment Report, Section 2.2.1), an increase of the pool elevation to 503.6 feet results in about 16,000 acre-feet of additional flood volume to be routed downstream. This additional flood volume will likely increase the flow depths and enlarge the inundation area used for the risk and consequence analysis.

Significance – Medium

Discrepancies among reported maximum high pool elevations indicate a potential inaccuracy of calculated flow depths and inundation area and limits confidence in the conclusions that may have been drawn based on those analyses.

Recommendations for Resolution

1. Verify breach modeling use of 503.6 feet as maximum high pool elevation.
2. If the modeled pool elevation of 503.6 feet was not used as the maximum high pool elevation, perform revised modeling of the breach and map the resulting downstream flood hazards.
3. Use remapped flood hazards as the basis for determining breach consequences.

Final Panel Comment 7

Standard Penetration Tests (SPTs) do not appear to correspond to the shear strength parameters used for the stability analysis conducted in the Seismic Safety Review (USACE, 2003), which could constitute a change in the stability of the critical dam cross section.

Basis for Comment

The remedial plan for seepage control includes four elements which, if properly implemented, will provide a robust and redundant solution. The elements have not been quantitatively evaluated to ensure that slope stability is adequately improved to achieve the minimum required Safety Factors. Extensive field work and monitoring performed since the Seismic Safety Review (USACE, 2003) reveal differing site conditions than originally analyzed. The critical dam cross section modeled in the Seismic Safety Review (USACE, 2003) was at Station (Sta) 40+00 and the outlet works are located at Sta 35+00. Field work along the outlet works revealed zones of soft/loose material that merit reanalysis.

The Panel observes the following:

1. Section 2.5.2, Stability, of the Baseline Risk Assessment (BLRA) Report identifies adopted shear strengths used to evaluate the stability of the embankment. The safety factors presented exceed the minimum factors required. However, the existing filter sand is described as saturated and loose based on the extensive data. Additional loose/soft material was encountered above the filter (approximate top of filter is Elevation [El.] 405 feet) within portions of the embankment material. Some of the SPT results from studies performed after the 2003 stability analysis suggest that variable and lower shear strengths than those analyzed exist in areas including the filter and portions of the embankment. The following address low SPT results above El. 405 feet.
   a. Phase I performed in 2010 and summarized in Table 1 of the BLRA identifies very soft soil above the filter and within the embankment in P-20- El. 474-476 feet. P-20 is located approximately 100 feet upstream of the crest.
   b. Phase I performed in 2010 and summarized in Table 1 of the BLRA identifies very soft soil above the filter and within the embankment in P-21- El. 497-498 feet and at El. 492-493 feet. P-21 was not sampled between El. 497 and 493 feet, nor was it sampled between El. 492-488.5 feet. SPT counts remain soft until El. 487.0 feet. It is reasonable to interpret that this entire zone from El. 498.5 feet to El. 487.5 feet is very soft clay with SPT counts from 2 to 4 blows per foot. P-21 is located approximately 40 feet upstream of the crest.
   c. Phase III performed in 2011 included three borings in the vicinity of P-20 and P-21. A review of the boring logs for B-9L and B-9R reveals that no SPT testing was performed above El. 413.4 feet. A review of the boring

logs for C-3L reveals that no testing was performed above El. 407.7 feet.

2. Section 11.2.1, Embankment Piping at Conduit, of the BLRA states:
   "A slight depression was observed on the upstream slope directly over the conduit during the September 2009 Periodic Inspection".

   A trench was excavated in the vicinity of the depression and did not reveal any obvious signs of distress. The Panel observes that the described location of the depression appears to be in the vicinity of the very soft clay described in 1(a) and 1(b) above.

Significance – Medium

The elements of the selected alternative have not been quantitatively evaluated to ensure that slope stability is adequately improved to achieve the minimum required Safety Factors. There is insufficient information to assess the current and future stability of the dam in the vicinity of the outlet works.

Recommendations for Resolution

1. Perform a revised stability analysis using data correlated from the SPT testing from Phases I through IV. Specifically, model the localized loose and soft filter material below approximately El. 405 feet and model the localized soft zone described in items 1 (a) and 1(b) above.
2. Iterate the layer and shear strength to achieve a Safety Factor between 1.0 and the previously calculated 1.6 (steady seepage) to reflect current embankment conditions in the model.
3. Modify the model to verify the interim construction conditions for the planned alternative to confirm that the improvements result in a Safety Factor exceeding the minimum required factors shown in Table 3-1 of the U.S. Army Corps of Engineers' Engineer Manual (EM) 1110-2-1902 (USACE, 1992).
4. Modify the model with the final recommended alternative improvements and analyze to confirm that the improvements result in a Safety Factor exceeding the minimum required factors shown in Table 3-1 of USACE's EM 1110-2-1902 (USACE, 1992).

Literature Cited

USACE (1992). Slope Stability. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Manual (EM) No. 1110-2-1902. October 31.

USACE (2003). Seismic Safety Review – Pine Creek Dam, Little River Oklahoma, Department of the Army, U.S. Army Corps of Engineers, Tulsa District. November.

Final Panel Comment 8

Bedrock erosion and embankment foundation stability due to uncontrolled spillway discharge under Probable Maximum Flood (PMF) conditions have not been addressed, and their importance as a credible failure mode cannot be evaluated.

Basis for Comment

The Baseline Risk Assessment Report (BLRA) and Dam Safety Modification Report (DSMR) are silent on the subject of the ability of the uncontrolled spillway to safely discharge the PMF design flow. Under PMF conditions, there is 23 feet of head across the 608-foot-long spillway, resulting in a discharge of 246,600 cubic feet per second (cfs) (BLRA Section 2.2.2 Hydrologic Data). There is no erosion protection (other than grass) along the channel downstream of the stilling basin sill.

DSMR Section 3.4.2.1 states that:

1. "In general, the valley section is founded on the hard sandstone beds with minor amounts of shale, whereas the upper embankment is located on the narrow sandstone ridge. The average depth of soil cover is about 4 feet, with a maximum of 15 feet. Soil types range from non-plastic to low plasticity sandy materials (SM, SC, or CL) on the abutment walls. The upland portion of the abutments consists of highly plastic clays (CH)."
2. "The Paluxy Sand forms the foundation for the dike to the right side of the spillway. These sediments are primarily soft, fine to medium-grained, poorly cemented, friable, shaly sandstone and soft, clayey shale and are often indistinguishable from the overburden in drilling operations…. The majority of these deposits are lean clay (CL) clay underlain or inter-lensed by substantial amounts of silty sand (SM) and clayey sands (SC)."

DSMR Section 3.4.2.3 states that:

> "Shale bedrock downstream of the stilling basin begins about 100 feet from the end sill. The shale is moderately hard to very hard below the base of weathering and contains occasional sandstone seams and sandy zones. Excavation for the foundation carried to the fresh gray rock below the secondary weathered zone. The only major construction problem involved a rock slide in the right non-overflow section, as a result of the attitude of the synclinal fold in relation to the excavation limits. The rock wedge slid into the excavation area from the downstream face on a weathered bedding plane along the synclinal folds."

The susceptibility of these materials to erosion is not described.

Typical Embankment Section "A" on as-built drawing 1800-C6-12/1 (of the Supplemental Information provided) shows that the embankment adjacent to the spillway is founded on overburden.

There is no information provided regarding discharge velocities, the susceptibility of foundation soils and bedrock to erosion, and the likelihood of head-cutting that could undermine the existing embankment.

While such a potential failure mode would not affect conclusions regarding the failure modes associated with the outlet works, the ability of the project to safely pass the design flood without additional dam modifications has not been demonstrated.

Significance – Medium

Without a discussion, demonstration, or analysis regarding whether the uncontrolled spillway can safely pass the PMF, the evaluation of credible failure modes is incomplete.

Recommendations for Resolution

1. Provide additional information with regard to uncontrolled spillway discharge velocities, susceptibility of foundation soils and bedrock to erosion under spillway design conditions, and the potential effects of erosion and head-cutting to embankment foundation stability.
2. Provide a copy of the full Potential Failure Modes Analysis Report as an appendix to the BLRA Report to document what failure modes have been considered and evaluated.

Final Panel Comment 9

The cause of the minor pin-boils observed at station 30+00 under higher pool levels has not been fully evaluated and could pose a long-term concern for the integrity of the dam, especially under high-pool conditions.

Basis for Comment

Baseline Risk Assessment Report (BLRA) Section 9.1.2.2.2 on Potential Failure Mode E3 (PFME3) – *Foundation-Embankment interface piping in the vicinity of Station 30+00* – describes minor seepage and pin-boils observed near station 30+00 during high pools and indicate that there is a saddle in the top of rock in this area that tends to concentrate seepage flows in the blanket drain. Dam Safety Modification Report (DSMR) Section 3.2.2 notes that the Pool of Record was El. 475.10 in May 2009. As-built drawing 1800-C6-2/2 shows the assumed top of rock at the dam axis at approximately El. 460 near station 30+00A. As-built drawing 1800-C6-12/1 (Typical Embankment Section "E") shows that the blanket drain is constructed on native soil in this area.

Therefore, the Pool of Record was not more than about 15 feet above the bedrock foundation and even less above native soils. With the Probable Maximum Flood (PMF) pool at approximately El. 503, the gross head over top of rock and native foundation soils would be roughly three times greater than previously experienced.

The Panel agrees with the recommendation in the BLRA Section 9.1.2.2.2 that seepage collection be improved such that quantities of seepage can be monitored, collected, measured, and evaluated for the presence of sediments. However, the statement in Section 9.1.2.2.2 that the "design of the dam appears to have addressed this failure mode adequately given the chimney/blanket filter and the favorable geologic conditions" does not seem consistent with either that recommendation or the observation of pin-boils under relatively low head. Additionally, further detail on the evaluation of this potential failure mode (PFM) is not provided in BLRA Section 5.0, while details are provided for other cited PFMs.

The annual probability of failure for this PFM as presented in BLRA Figure 90 seems very low considering the information provided. Additionally, it is not clear whether the likelihood of failure at the design head (the PFM for this critical structure) is based on seepage analysis (2D or 3D) and whether the system response probability reported in BLRA Table 31 accurately reflects the supporting analyses. Given the conclusion that the saddle near station 30+00 tends to concentrate seepage flows in the blanket drain in that area, a three-dimensional seepage analysis may be warranted to accurately evaluate the probability of this PFM occurring at maximum design head.

This issue does not affect conclusions relative to the most critical failure mode (PFMOW1/2/3), but it raises a concern as to whether the evaluation of PFME3 supports the very low probability estimated for this PFM.

Significance – Medium

Sufficient information is not provided in the report to assess whether the methods, models, or analyses used to evaluate PFME3 are sufficient to support a conclusion that this PFM was adequately addressed by the original design.

Recommendations for Resolution

1. Provide quantitative evaluation (seepage analysis) in the supporting documentation that supports the probability estimates for PFME3.
2. Monitor the outflow of the pin-boils for flow and transported sediment when flowing under high-pool conditions.

Final Panel Comment 10

Eleven threatened and endangered species were reported, yet a description of the specific species, the probability of them being found in the project boundary area, and potential impacts on these species were not provided.

Basis for Comment

Section 4.5.3 Terrestrial Resources of Appendix VII states that Pine Creek Lake is situated in the western Ouachita Mountains of southeastern Oklahoma and that this area contains one of the greatest concentrations of imperiled or critically imperiled, aquatic and terrestrial species in mid-North America (Woods et al., 2005). No additional information is provided, and the species are not defined. The Draft EA in Appendix VII does not identify any imperiled species within the project study. This statement requires clarification.

The Dam Safety Modification Report (DSMR) states that there are 11 threatened or endangered species, but only two species were mentioned in the main document: the American burying beetle and an endangered mussel (not named). The Draft EA in Appendix VII discusses the state- and county-listed species and their habitats, but not in terms of potential presence in the project boundary area.

When discussing the current pool restriction, the DSMR (p. 133) states that “Lowering the pool also impacts the fishery in the lake, the endangered mussels downstream of the dam,…”. Potential impacts are not defined. This mussel is not discussed elsewhere in the document and is not named under the environmental resources section. Overall, Section 4.2.4.5.8 of the main report, Threatened and Endangered Species, does not adequately describe the existing conditions; therefore, potential impacts to these species cannot be evaluated.

The Draft EA, Appendix VII (p. 55) notes that soil disturbance associated with construction-related activities implemented under the recommended plan could adversely impact the American burying beetle, if the species is present in the project area. The document reports that no American burying beetle surveys have been conducted in 2012 in or near the vicinity of Pine Creek Lake Dam. More information is required regarding the American burying beetle, its habitat, and specifically what impacts may occur. The document also does not provide information on when the most recent American burying beetle survey was conducted in or near the project area.

In addition, Harperella (*Ptilimnium nodosum*) is an annual herb listed in the Draft EA under threatened and endangered species. McCurtain County, Oklahoma, is within the documented range of the American burying beetle, and there is potential habitat within the project area that may support Harperella (p. 38). While the presence of both of these species has not been confirmed within the project area, suitable habitat may exist. Ground disturbance and decreased lake water levels associated with the proposed actions may impact areas with potentially suitable habitat. Impacts to the American burying beetle, Harperella, and the endangered mussel are possible. If impacts will occur and mitigation is needed, potential impacts need to be defined to take into account construction scheduling and costs and the benefits forgone if construction time is extended.

According to the most current 2012 American burying beetle survey results available from the U.S Fish and Wildlife Service (USFWS) Oklahoma Ecological Services Field Office, no beetles were found to be present (USFWS, 2012). Appendix VII (p. 63) states that

> "Prior to initiation of soil disturbing activities along the dike and the embankment, the Tulsa District will coordinate [American burying beetle] survey efforts and data collection under the conditions of the most current Biological Opinion in effect at that time."

At present, no surveys have been conducted for Harperella on federal lands managed at Pine Creek Lake. Before maintenance activities associated with the dam safety modification are started and woody vegetation is removed, the Panel understands that the U.S. Army Corps of Engineers (USACE) will consult with the USFWS in accordance with Section 7 of the Endangered Species Act and in compliance with the most recent Biological Opinion in effect at that time. Yet, no mitigation measure was defined to make sure this recommendation goes forward.

The DSMR (p. 150) states that a "No Action" decision would not reduce the likelihood of dam failure that could result in substantial adverse impacts to terrestrial resources on project lands and lands downstream of Pine Creek Lake Dam. The impacts to these species have not been adequately described.

Significance – Medium

Without an evaluation of potential impacts to threatened and endangered species that may occur in the project area, the report's overall analysis of the environmental impacts to terrestrial resources is incomplete.

Recommendations for Resolution

1. Include a list of individual threatened and endangered species and their potential to occur within the project area in Section 4.2.4.5.8 Threatened and Endangered Species of the document, including identifying the unnamed endangered mussel.
2. Define the species of concern with regard to the statement in the DSMR that "this area contains one of the greatest concentrations of imperiled or critically imperiled, aquatic and terrestrial species in mid-North America."
3. Identify potential impacts to the endangered mussel, and include impacts on construction scheduling and costs and the benefits forgone if construction time is extended due to the presence of the mussel or Harperella.
4. Define mitigation measures for these species if needed. For example, a mitigation measure for this project may read: "Prior to initiation of soil-disturbing activities

along the dike and the embankment, the Tulsa District will coordinate survey efforts and data collection under the conditions of the most current Biological Opinion in effect at that time for the American burying beetle, Harperella and endangered mussel. All avoidance measures within the USFWS biological opinion should be implemented."

Final Panel Comment 11

The U.S. Geological Survey (USGS) 10-meter Digital Elevation Model (DEM) topographic data used to develop hydraulic models, map downstream flood hazards, and ultimately determine dam breach consequences may not be commensurate with the vertical accuracy as stated in the Baseline Risk Assessment (BLRA).

Basis for Comment

Calculations for loss of life and economic consequences are a direct function of inundation depths, and these, in turn, are based on the topography of the downstream study area. The USGS 10-meter DEM topographic data used for the study is considered low resolution when loss of life and economic consequences are based upon flood depths of two feet. Lack of topographic resolution implies uncertainty with regard to the calculation/computation of loss of life and economic consequences resulting from interpolation of flood elevations.

According to the Baseline Risk Assessment Report, Appendix C, Section C.3.5, USGS 10-meter DEM topographic data were used to develop the hydraulic models, post-process results, map inundation boundaries, generate depth grids, and assess consequences. As discussed in the report, these topographic data were considered the best available. In addition, as stated in the Baseline Risk Assessment Report (draft), Appendix 13, Section C.2.6, the hazard area used to identify the population at risk (PAR) is defined as the boundary within which the flood depth is greater than two feet. These hazard areas were defined by inundation grids using a Geographic Information System (GIS) based on USGS topographic data.

It is common for USGS DEMs to be derived from the elevation contours provided on USGS 1:24,000-scale topographic maps. One-half a contour interval is standard industry practice for estimating the vertical accuracy of USGS 1:24,000-scale topographic maps. Examples of applicable USGS topographic maps include the USGS Wright City and Idabel Quadrangles (7.5-Minute Series, 1:24,000-scale), which have contour intervals (c.i.) of 20 feet and 10 feet, respectively. In order to accurately determine flood depths of two feet, a vertical accuracy of one foot (c.i. = two feet) may be required.

With regard to Hydrologic Engineering Center-River Analysis System (HEC-RAS) model development using USGS topographic data, according to the Baseline Risk Assessment Report, Appendix C, Section C.3.7.4, the utilized USGS DEM showed limited channel detail; therefore, the channel Design/Modification editor in HEC-RAS was utilized to “cut” the Little River channel into each cross-section. These “cut” cross-sections were based on templates created from channel measurements estimated from aerial photography. Inverts for channel templates were based on information provided in the Water Control Manual.

As suggested by Ackerman and Brunner (2006) of the U.S. Army Corps of Engineers

(USACE) HEC in Davis, California:

> "If the cross-sectional data came from a low resolution terrain model the channel data will not be represented in the cross section. For a large flood wave resulting from a dam break, the channel data may not be significant. The importance of the channel portion of the total cross-sectional conveyance will need to be evaluated: if the channel conveyance is rather small compared with the total conveyance, for instance, the peak stage of the flood wave may not be significantly affected. To perform the dam breach analysis, however, RAS will need a channel for the low-flow portion of the simulation."

Significance – Low

Given the conservative nature of the probable dam failure modes that were modeled in HEC-RAS (see dam failure mode *PFMOW_503* as described in the Baseline Risk Assessment Report, Appendix C), the resultant flow depths and inundation area used to determine potential life safety issues and economic consequences – which are based on low-level resolution topography – are likely conservative in nature, but would not affect the recommended plan.

Recommendations for Resolution

1. Discuss the potential impacts of the low resolution mapping on the study results.
2. Investigate potential sources of additional mapping data (for example, mapping used for Federal Emergency Management Agency [FEMA] detailed studies).
3. If deemed necessary after further consideration, obtain detailed channel cross-section(s) for each reach of the Little River conveying a significant portion of the flood flow. The number of cross-sections could be limited to the number necessary to verify that the templates used to "cut" the river channel in the HEC-RAS model were representative of the existing channel conditions.

Literature Cited

Ackerman, C., and Brunner, G. (2006). *Dam Failure Analysis Using HEC-RAS and HEC-GeoRAS*. Third Federal Interagency Hydrologic Modeling Conference, Reno, Nevada. April. Available at http://acwi.gov/hydrology/mtsconfwkshops/conf_proceedings/3rdFIHMC/11F_Ackerman.pdf. Accessed March 8, 2013.

Final Panel Comment 12

The operation, maintenance, repair, replacement and rehabilitation (OMRR&R) efforts are not adequately described, and it could not be determined if the proposed costs are reasonable.

Basis for Comment

The term “operation, maintenance, repair, replacement and rehabilitation (OMRR&R)” is not adequately described, which prevents the Panel from assessing whether all of the life-cycle costs for maintaining the various alternatives have been considered.

In Table 50 (ALARP Summary Table) of the Dam Safety Modification Report (DSMR), the difference in annual O&M costs for the baseline condition and the various structural alternatives is not more than $33,316, and there is no difference in annual O&M costs between “Make IRRM Permanent,” “Non-Structural Plan 1,” and many of the structural alternatives. One could expect the O&M costs for most, if not all, of the alternatives to be less than the baseline, since the alternatives would be new and built to better criteria while the existing condition represents a 43-year-old structure. However, there is no further detail regarding the breakdown of O&M costs in the DSMR.

Repair costs appear to be a line-item apart from the “repair” in OMRR&R (Tables 50 and 51) because it addresses “repair” in a fix-as-fails situation costing an estimated $40 million (DSMR, p. 13 and Table 3; section 6 of Appendix II). Section 6 of Appendix II states:

> “Costs to repair or rebuild Pine Creek Dam in the event of failure were based on the original cost of the dam brought to current price levels…”

Regardless of classification, it would seem that the repair cost would be equal to or greater than the cost given for Alternative 5 – close to $100 million.

It is the Panel’s interpretation that costs to date for the various investigations, studies, and grouting and backfilling operations for the outlet works would be extrapolated to estimate the future O&M costs for the baseline condition. However, with little or no apparent cost difference indicated in Table 50 (O&M) and Table 51 (OMRR&R), it is not clear whether they are captured in the economic analysis.

Significance – Low

This issue affects the technical clarity of the DSMR and completeness of the economic comparison of alternatives.

Recommendations for Resolution

1. Provide details supporting the O&M costs associated with the various risk reduction alternatives that clearly support the reported values and document the differences.

Final Panel Comment 13

Piezometer PZ17 appears to be very responsive to high pool conditions and may indicate an undesirable seepage condition.

Basis for Comment

Baseline Risk Assessment Report Figure 52 shows an atypical response of piezometer PZ17 relative to the reservoir pool. Furthermore, the plots of PZ17 readings in Baseline Risk Assessment (BLRA) Appendix 9 show a substantial scatter of response since the occurrence of maximum pool. This information is presented without providing any analysis or discussion in the review documents of its significance to seepage. This particular piezometer was not sampled during dye testing to identify whether there is a potential seepage path from headwater to this location. Given its proximity to the toe of the dam and its location between the outlet works and the seepage identified at Station 30+00A, some assessment appears warranted.

The rise of pressure at PZ17 in Figure 52 is actually shown to precede the rise in pool elevation, leading the Panel to suspect that either (1) it could be reacting to local runoff or possibly to preemptive discharge through the outlet works, rather than to pool, or (2) there are problems with the data collection. However, no analysis or other evaluation is presented in the review documents to explain these unusual readings, and it cannot be ascertained whether they are indicative of an alternate or branch seepage path.

Significance – Low

This issue does not affect conclusions presented in the review documents with regard to seepage along the conduit, but the report needs to clarify other potential failure modes or seepage paths.

Recommendations for Resolution

1. Provide an evaluation of the PZ17 readings that establishes the significance of its response to high pool conditions and its relevance to dam safety.

Final Panel Comment 14

Various key inputs to the economic analyses, such as including the cost of repairing damage to the dam as a potential direct loss, were not provided or explained and could result in an inaccurate final cost analysis.

Basis for Comment

Some components of the economic analysis have not been adequately explained. Specifically, depth-damage percentage losses, dam rebuilding costs, and impacts to agriculture cannot be confirmed.

Depth-Damage Percentage Losses

Application of the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center-Flood Impact Analysis (HEC-FIA) software and its input is the basis for the Pine Creek Lake Dam Safety Modification (DSM) dam failure economic loss results. The largest category of losses for higher-elevation failure event cost (Dam Safety Modification Report [DMSR], Table 34, p. 147,) covers structures and their contents and vehicles. The report appears to use the Federal Emergency Management Agency's (FEMA) Hazus dataset without clarification (p. 18 of Appendix II). Based on a single reference to depth-damage input being the 100% loss of a vehicle at a submergence of three feet, the Panel is concerned that depth-damage percentage losses do not coincide with USACE guidance for vehicles (USACE, 2009) and, by extension, to content and structures provided in USACE (2003). In the case of vehicle damage, the report appears to indicate much greater loss than would result from the USACE guidance.

Dam Rebuilding Costs

The Panel has two concerns related to the category labeled "dam repairs" in Table 34. The first is whether it is appropriate to include dam repairs in the analysis. Section 5.3.9.1 of USACE (2011) states:

> "(NOTE: one potential direct loss is the cost of repairing the damage to the dam. This is a complicated issue and to some degree depends on the extent of damage to the dam. If the dam can be repaired, these repair costs could be counted as an economic cost. In the case of catastrophic failure, these rebuilding costs should not be included in the direct costs, as the decision to rebuild the dam depends on the post-failure benefits which would be a separate analysis.)"

Section 4.2.4.4 of the DSMR and p. 5 of Appendix II include dam repair in association with a fail event having a three-year repair period. It is classified as a piping failure.

If the dam failure qualifies for a direct loss, the second concern is that the estimated cost of $40 million (based on updating original construction costs) seems low because the alternative appearing to be closest to the repair is Alternative 5, and its comparative cost to implement is estimated at $99.8 million. Further, the repair cost would have to incorporate current design standards, which would increase the costs. Thus, the economic benefits for any of the alternatives would be considerably understated.

Forgone Benefits
Table 34 contains a category of damages by fail event labeled “flood risk management” and represents the forgone benefits during the three-year dam repair. The estimated $5 million was derived using an accounting of damages prevented over a 43-year period with costs brought to a 2012 price level. This appears to be understated because it represents past populations and their belongings.

Impacts to Agriculture
Agriculture losses are not included in the cost-benefit analysis, and the discussion of the economic contribution of agriculture is not consistent within the document. In the description of existing conditions, Wright City is reported to have a mix of industrial, commercial, and residential land uses, and surrounding areas that also support agriculture. DSMR Section 4.2.4.5.13 states that

> “Land use adjacent to the project area is primarily agricultural…”

However, DSMR Section 1.4.2.2 states that

> “…the inundation area below the dam has a minimal amount of agriculture… [and] crop damages would not be significant…”

This appears incongruous with the previously quoted statement.

As a result of the inconsistency, potential impacts to agriculture cannot be determined. “Since the inundation area below the dam has a minimal amount of agriculture, it was determined that crop damages would not be significant in comparison with other direct damages and therefore were not evaluated”. Moreover, no explanation is given for eliminating potential impacts to agricultural resources from consideration. The report does not provide the basis for determining that crop damages are not significant and does not provide a justification for this determination.

Further, there is no mention of economic impacts related to livestock. It is unclear whether such impacts would occur, whether they are relevant, and, if so, whether they are factored into the estimate of consequences.

Significance – Low

Components of the economic analysis and input data used have not been adequately explained and analysis shows that the considerable predicted damage could be underestimated and may subsequently affect the benefit cost ratios of the alternatives but probably not affect the rank order.

Recommendations for Resolution

1. Provide a concise description of how HEC-FIA works as applied to this study, defining the inputs and the uncertainties associated with the input data and output data.
2. Clarify the importance of agriculture in the project area and justify eliminating agricultural impacts from evaluation.
3. Evaluate dam costs for repair, assess the forgone benefits during the three-year dam repair, and provide revised estimates.
4. Calculate depth-damage percentage losses based on USACE guidance for vehicles.

Literature Cited

USACE (2011).Safety of Dams – Policy and Procedures. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation (ER) No. 1110-2-1156. October 28.

USACE (2009). Generic Depth-Damage Relationships for Vehicles. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Economic Guidance Memorandum (EGM) No. 09-04. June 22. Available at http://planning.usace.army.mil/toolbox/library/EGMs/egm09-04.pdf. Accessed February 28, 2013.

USACE (2003). Generic Depth-Damage Relationships for Residential Structures with Basements. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Economic Guidance Memorandum (EGM) No. 04-01. October 10. Available at http://planning.usace.army.mil/toolbox/library/EGMs/egm04-01.pdf. Accessed February 28, 2013.

Final Panel Comment 15

The chemical composition of the grouting material and sealant is not described, and the potential for short-term impacts on aquatic species has not been considered.

Basis for Comment

Grout is applied to reduce leaks during maintenance activities, and grouting was considered in the alternatives evaluated. The chemical composition of the grouting material and sealant has not been presented. Due to the method of implementation (pumping under pressure), it is possible that this material will end up in downstream resources either from excess material oozing out while semi-fluid or from degradation of the material over time.

In the Dam Safety Modification Report (DSMR) (p. 158), in order to justify eliminating element 1, one concern defined is “contamination of the filters with grout”. This suggests that some material does become mobilized and trapped in filters. The report does not discuss potential impacts resulting from mobilization of this material into downstream natural resources or potential short-term impacts on aquatic species. Therefore, it is uncertain what impacts (if any) these applications may have. Potential impacts to water resources and downstream aquatic species are required to be evaluated by the National Environmental Policy Act (NEPA).

Significance – Low

Because the chemical composition of the grout and sealant has not been adequately described, potential short-term impacts to downstream natural resources resulting from mobilization of grout cannot be evaluated.

Recommendations for Resolution

1. Provide information regarding the chemical composition of grout and sealant.
2. Identify potential impacts on downgradient natural resources from grout mobilization or from degradation over time, or demonstrate that no impacts are likely to occur.
3. Prepare and implement a water quality monitoring program, including pH and electrical conductivity (EC), immediately prior to and during grouting. Continue monitoring through initial set of the grout.

APPENDIX B

Final Charge to the Independent External Peer Review Panel as Submitted to USACE on February 15, 2013

on the

Pine Creek Lake IEPR

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Charge Questions and Guidance to the Peer Reviewers
for the
Independent External Peer Review
of the
Dam Safety Modification Report (DSMR) Report for
Pine Creek Lake, Oklahoma

Background

The Tulsa District's Project Delivery Team (PDT) is preparing a decision document, the Dam Safety Modification Report (DSMR), for the remediation of the Pine Creek Dam. The DSMR will be comprised of the main report and supported by technical appendices and other documents as needed for approval. The DSMR documents the deficiency issues of embankment internal erosion and seepage and piping along and into the outlet conduit and the recommended corrective actions to resolve these deficiencies.

The DSMR serves as the decision document authorizing remediation of the related seepage and piping deficiencies in order for the project to function safely and effectively and in compliance with the USACE Engineering Regulation, ER 1110-2-1156, Dam Safety Policy and Procedures. The DSMR describes the alternative risk management plans considered and the plan recommended for remediation of the seepage and piping deficiencies. Following HQUSACE approval of the DSMR and Appendices and the EA with a signature of the Finding of No Significant Issues (FONSI), the PDT will proceed into preconstruction engineering and design activities for the Pine Creek Dam Safety Modification Project.

Study Description

Pine Creek Lake was authorized for construction by the Flood Control Act approved July 3, 1958, House Document 170, 85th Congress, 1st Session. The Pine Creek Dam is located on the Little River at river mile 145.3, which is about 5 miles northwest of Wright City in McCurtain County, Oklahoma. Pine Creek Lake was built for the purposes of flood control, water supply, water quality, fish and wildlife, and recreation. Construction of the dam began in February 1963. The project became operational in June 1969. The conservation pool filled to elevation 438.0 on January 7, 1970. The embankment is a rolled impervious earth fill, 7,510 feet long rising 124 feet above the streambed. The dike extends southwest from the right side of the spillway and is 14,150 feet long, 38 feet in maximum height, with a crest width of 10 feet. The embankment includes a spillway weir with a gross width of 608 feet. The outlet works include an intake structure, 13-foot conduit, a 48-inch water supply and water quality bypass, and a 36-inch water supply static head line. Flow through the conduit is controlled by two 5 feet 8 inch by 13 feet hydraulic slide gates operating in tandem.

There is an existing water supply storage agreement, DACW56-71-C-0033, that went into effect on August 21, 1970 between the United States of America and the Weyerhaeuser Company. The total cost of the construction of the Pine Creek Lake project was $5,119,307. The actual construction costs were finalized in 1978, but for some reason were not applied to this agreement until 2006. The Weyerhaeuser Company chose to put 14,700 acre-feet into immediate use (Space No.1), activated 2,940 acre-feet soon after (Space No.2), and has 11,160 acre-feet of future use storage. The costs for Space No. 1 are $1,523,505.76, and for Space No. 2 $307,579.78. The

Weyerhaeuser Company transferred and assigned water supply storage agreement DACW56-71-C-0033 to the International Paper Company on August 10, 2009. The International Paper Company continues to make payments on Space No. 1 and Space No. 2, and has not yet activated their future use storage.

A primary reason for the DSAC I classification was concern over the seepage and piping along and into the outlet conduit. Internal erosion of embankment materials into or along the outlet conduit appears to pose unacceptably high risks at the Pine Creek Dam. The outlet conduit was constructed in a trench with steep side slopes, which raises the possibility those low stress areas, may exist within the embankment due to arching action along the outlet conduit. Low stress areas can result in embankment cracking and the development of seepage paths. Seepage emanates from the downstream toe near the outlet work outfall structure. Seepage through the joints in the outlet conduit has been observed. Voids up to ten cubic yards have been discovered in an area surrounding the conduit, and dye tests have shown a fairly rapid response. Seepage carrying material has been observed at the downstream end of the outlet conduit. The physical evidence suggests that relatively open and continuous seepage paths likely exist along the outlet conduit.

The objective of the DSMR Study is to reduce risk at Pine Creek Lake to below tolerable risk guidelines or as low as reasonably practicable and to provide adequate information to determine what permanent dam modifications are necessary for the Corps to operate Pine Creek Lake for the foreseeable future. Structural and non-structural risk reduction measures will be identified and used to formulate and evaluate alternatives for varying degrees of permanent risk reduction; and to ultimately recommend a cost effective, technically feasible alternative that minimizes adverse environmental, economic and social effects, which will allow the project to operate for the foreseeable future as originally authorized within tolerable risk guidelines. Primary evaluation factors of annual probability of failure, life safety tolerable risk guidelines, As Low as reasonable Practicable considerations, and essential USACE guidelines form the basis for plan selection. This study will incorporate, where available, Corps methodology to confirm these findings.

Non- Structural measures to be considered are advanced warning systems, real estate buyout within inundation areas, and permanent pool restriction. Structural measures to be considered are new chimney filter, cutoff wall, permanent downstream filter, upstream to downstream embankment and filter replacement, downstream embankment replacement, and permanent joint repair.

The Dam Safety Modification Report (DSMR) serves as the Decision Document.

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the technical basis for the economic, engineering, and environmental methods, models, data and analyses, and assumptions supporting the Dam Safety Modification Report (DSMR) for the Pine Creek Lake, Oklahoma (hereinafter: Pine Creek Lake IEPR) in accordance with the Department of the Army, USACE, Water Resources Policies and Authorities' *Civil Works Review* (EC 1165-

2-214) dated December 15, 2012, and the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

Peer review is one of the important procedures used to ensure that the quality of published information meets the standards of the scientific and technical community. Peer review typically evaluates the clarity of hypotheses, validity of the research design, quality of data collection procedures, robustness of the methods employed, appropriateness of the methods for the hypotheses being tested, extent to which the conclusions follow from the analysis, and strengths and limitations of the overall product.

The purpose of the IEPR is to assess the "adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (EC 1165-2-214; p. D-4) for the Pine Creek Lake documents. The IEPR will be limited to technical review and will not involve policy review. The IEPR will be conducted by subject matter experts (i.e., IEPR panel members) with extensive experience in geotechnical engineering, engineering geology, civil/structural engineering, hydraulic and hydrology engineering, economics/planning and environmental planning/NEPA issues relevant to the project. They will also have experience applying their subject matter expertise to flood risk management.

The Panel will be "charged" with responding to specific technical questions as well as providing a broad technical evaluation of the overall project. Per EC 1165-2-214, Appendix D, review panels should identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods. Review panels should be able to evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable. Reviews should focus on assumptions, data, methods, and models. The panel members may offer their opinions as to whether there are sufficient analyses upon which to base a recommendation.

DOCUMENTS PROVIDED

The following is a list of documents, supporting information, and reference materials that will be provided for the review.

Review Document	Estimated Pages	Required Disciplines
Main Dam Safety Modification Report (300 pages)	226	All
Appendix I – Baseline Risk Assessment Report W/Appendices (2,000 pages)	1,611	Geotechnical Engineer, Engineering Geologist, Civil/Structural, Hydraulic and Hydrology Engineer
Appendix II – Economic Consequences (31 pages)	33	Economics/Planning
Appendix III – Formulation of Risk Management Plans (200 pages)	128	All

Review Document	Estimated Pages	Required Disciplines
Appendix IV – Engineering Design Drawings (172 pages)	176	Geotechnical Engineer, Civil/Structural, Hydraulic and Hydrology Engineer
Appendix V – Final Risk Assessment Breakdown (15 pages)	104	All
Appendix VI – Cost Estimating Breakdown (200 pages)	65	Geotechnical Engineer, Engineering Geologist, Civil/Structural, Hydraulic and Hydrology Engineer, Economic/Planning
Appendix VII – Final Environmental Assessment (EA) (100 pages)	109	Engineering Geologist, Economic/Planning, Environmental Planner/NEPA
Appendix VIII – Real Estate Breakdown (6 pages)	6	Engineering Geologist, Economic/Planning, Environmental Planner/NEPA

Supporting Information
The following are supplemental documents (shown as file names found on the CD) that may provide additional information for the review of Appendix IV- Engineering Design Drawings:

- PineCreek-Embankment-Closure-Photos-2.pdf
- PineCreek-Fdn-Rpt-1-Photos_With Caps.pdf
- Foundation Report #4 Photos.pdf
- Foundation Report #3 Photos.pdf
- Pine Creek Aerial Photos.pdf
- PineCreek OverviewMap_01April2011.pdf
- Pine_Creek_Outlet_works_as_builts.pdf
- Pine_Creek_embankment_as-builts.pdf

Documents for Reference
The following USACE regulations shall be followed in conducting the IEPR. The most recent Engineer Circulars (EC), Manuals (EM), Pamphlets (EP), and Regulation (ER) shall be used, which are available at http://140.194.76.129/publications/ or http://www.hnd.usace.army.mil/techinfo/engpubs.htm

General
- EC 1105-2-410, Review of Decision Documents, 22 August 2008
- EC 1105-2-412, Assuring Quality of Planning Models, 31 March 2011
- EC 1165-2-209, Water Resources Policies and Authorities - Civil Works Review Policy, Change 1, 31 January 2012
- EC 1165-2-210, Water Resources Policies and Authorities - Water Supply Storage and Risk Reduction Measures for Dams, 9 April 2010
- EP 1110-2-13, Dam Safety Preparedness, 28 June 1996

- ER 1110-1-12, Engineering and Design - Quality Management, 31 March 2011 (change 2)
- ER 1110-2-1150, Engineering and Design - Engineering and Design for Civil Works Projects, 31 August 1999
- ER 1110-2-1155, Engineering and Design - Dam Safety Assurance Program, 12 September 1997
- ER 1110-2-1156, Engineering and Design - Safety of Dams - Policy and Procedures, 28 October 2011
- ER 1110-1-8159, Engineering and Design - DrChecks, 10 May 2001.
- National Academy of Sciences, "Policy and Procedures on Committee Composition and
- Balance and Conflicts of Interest for Committees Used in the Development of Reports," May 2003 for General Scientific and Technical Studies and Assistance: General Scientific and Technical Studies and Assistance. Available at: http://www.nationalacademies.org/coi/index.html
- Water Resources Development Act of 2007, Sections 2034 & 2035, Pub. L. 110-114. Privacy Act, 5 U.S.C. § 522a as amended.

Environmental/Planning

- ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. CECW-P, 28 December 1990
- Council on Environmental Quality. 1978. Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. 40 CFR Parts 1500-1508. Washington, DC: U.S. Government Printing Office (November 29, 1978).
- ER 200-2-2, Environmental Quality, Procedures for Implementing NEPA. CECWRE (now CECW-A), 4 March 1988.

Engineering Geology

- EM 1110-1-1804, Engineering and Design - Geotechnical Investigations, 01 January 2001
- ER 1110-1-1807, Engineering and Design - Procedures for Drilling in Earth Embankments, 01 March 2006
- EM 1110-1-1802, Geophysical Exploration for Engineering and Environmental Investigations, 31 August 1995.

Geotechnical Engineering

- EM 1110-2-1901, Engineering and Design - Seepage Analysis and Control for Dams, 30 April 1993
- EM 1110-2-1902, Engineering and Design - Slope Stability, 31 October 2003
- EM 1110-2-2300, Engineering and Design - General Design and Construction Considerations For Earth and Rock-Fill Dams, 30 July 2004
- EM 1110-2-1908, Engineering and Design - Instrumentation of Embankment Dams and Levees, 30 June 1995
- ER 1110-2-110, Engineering and Design - Instrumentation for Safety Evaluations of Civil Works Projects, 8 July 1985.

Materials Engineering

- ER 1110-1-1901, Project Geotechnical and Concrete Materials Completion Report for Major USACE Project, 22 February 1999
- EM 1110-2-1906, Laboratory Soils Testing, 20 August 1986
- ER 1110-2-1911, Engineering and Design - Construction Control for Earth and Rock-Fill Dams, 30 September 1995
- EM 1110-2-2000, Engineering and Design - Standard Practice for Concrete for Civil Works Structures, 31 March 2001.

Structural Engineering

- EM 1110-2-2002, Evaluation and Repair of Concrete Structures, 30 June 1995
- EM 1110-2-2100, Engineering and Design - Stability Analysis of Concrete Structures, 1 December 2005
- EM 1110-2-2102, Waterstops and Other Preformed Joint Materials for Civil Works Structures, 30 September 1995
- EM 1110-2-2104, Engineering and Design - Strength Design for Reinforced-Concrete Hydraulic Structures, 20 August 2003
- EM 1110-2-2400, Engineering and Design - Structural Design and Evaluation of Outlet Works, 02 June 2003
- EM 1110-2-4300, Instrumentation for Concrete Structures, 30 November 1987
- ER 1110-2-100, Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures, 15 February 1995.

Hydraulic Engineering

- EM 1110-2-1602, Engineering and Design - Hydraulic Design of Reservoir Outlet Works, 15 October 1980
- EM 1110-2-1603, Engineering and Design - Hydraulic Design of Spillways, 16 January 1990
- EM 1110-2-2902, Engineering and Design - Conduits, Culverts, and Pipes, 31 March 1998
- EM 1110-2-3600, Engineering and Design - Management of Water Control Systems, 30 November 1987
- ER 1110-8-2 (FR), Inflow Design Floods for Dams and Reservoirs, 1 March 1991
- ER 1110-2-240, Water Control Management, 8 October 1998
- ER 1130-2-530, Flood Control Operations and Maintenance Policies, 30 October 1996
- ER 1110-2-8156, Preparation of Water Control Manuals, 31 August 1995.

SCHEDULE

This final schedule is based on the February 1, 2013 receipt of the final review documents. The schedule will be revised upon receipt of final review documents.

Task	Action	Due Date
Conduct Peer Review	Battelle sends review documents to IEPR Panel	2/11/2013
	Battelle convenes kickoff meeting with Panel	2/11/2013
	USACE convenes kickoff meeting with Battelle and Panel	2/12/2013
	Battelle convenes mid-review teleconference for Panel to ask clarifying questions of USACE	2/19/2013
	USACE convenes site visit with Battelle and Panel	2/11/2013
	*Panel members complete their individual reviews	2/25/2013
Prepare Final Panel Comments	Battelle provides Panel merged individual comments and talking points for Panel Review Teleconference	2/28/2013
	Battelle convenes Panel Review Teleconference	3/1/2013
	*Panel members provide Final Panel Comments to Battelle	3/13/2013
	Battelle provides Final IEPR Report to Panel for Review	3/14/2013
	*Panel provides comments on Final IEPR Report	3/14/2013
	Battelle submits Final IEPR Report to USACE	3/15/2013
Comment/ Response Process	Battelle convenes teleconference with Panel to review the Post-Final Panel Comment Response Process (if necessary)	3/18/2013
	USACE provides final PDT Evaluator Responses to Battelle	3/21/2013
	Battelle provides the Panel the final PDT Evaluator Responses	3/21/2013
	*Panel members provide Battelle with final comments on final PDT Evaluator Responses (i.e., final BackCheck Responses)	3/22/2013
	Battelle convenes teleconference with Panel to discuss final BackCheck Responses	3/22/2013
	Battelle convenes teleconference with Panel and USACE to discuss Final Panel Comments and final responses	3/25/2013
	USACE inputs final PDT Evaluator Responses in DrChecks	3/26/2013
	Battelle provides PDT Evaluator Responses to Panel	3/26/2013
	*Panel members provide Battelle with final BackCheck Responses	3/27/2013
	Battelle inputs the Panel's BackCheck Responses in DrChecks	3/28/2013
	Battelle submits pdf printout of DrChecks project file	3/29/2013

**indicates deliverables*

CHARGE FOR PEER REVIEW

Members of this IEPR Panel are asked to determine whether the technical approach and scientific rationale presented in the Pine Creek Lake IEPR documents are credible and whether the conclusions are valid. The Panel is asked to determine whether the technical work is adequate, competently performed, properly documented, satisfies established quality requirements, and yields scientifically credible conclusions. The Panel is asked to provide feedback on the economic, engineering, environmental resources, and plan formulation. The panel members are not being asked whether they would have conducted the work in a similar manner.

Specific questions for the Panel (by report section or Appendix) are included in the general charge guidance, which is provided below.

General Charge Guidance

Please answer the scientific and technical questions listed below and conduct a broad overview of the Pine Creek Lake IEPR documents. Please focus your review on the review materials assigned to your discipline/area of expertise and technical knowledge. Even though there are some sections with no questions associated with them, that does not mean that you cannot comment on them. Please feel free to make any relevant and appropriate comment on any of the sections and appendices you were asked to review. In addition, please note the following guidance. Note that the Panel will be asked to provide an overall statement related to 2 and 3 below per USACE guidance (EC 1165-2-214; Appendix D).

1. Your response to the charge questions should not be limited to a "yes" or "no." Please provide complete answers to fully explain your response.
2. Assess the adequacy and acceptability of the engineering, economic and environmental assumptions and projections, project evaluation data, and any biological opinions of the project study.
3. Assess the adequacy and acceptability of the economic analyses, environmental analyses, engineering analyses, formulation of alternative plans, methods for integrating risk and uncertainty, and models used in evaluating economic or environmental impacts of the proposed project.
4. If appropriate, offer opinions as to whether there are sufficient analyses upon which to base a recommendation.
5. Identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods.
6. Evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable
7. Please focus the review on assumptions, data, methods, and models.

Please **do not** make recommendations on whether a particular alternative should be implemented, or whether you would have conducted the work in a similar manner. Also, please **do not** comment on or make recommendations on policy issues and decision-making. Comments should be provided based on your professional judgment, **not** the legality of the document.

1. If desired, panel members can contact one another. However, panel members **should not** contact anyone who is or was involved in the project, prepared the subject documents, or was part of the USACE Agency Technical Review (ATR).

2. Please contact the Battelle Project Manager Patricia Strayer (strayerp@battelle.org) for requests or additional information.
3. In case of media contact, notify the Battelle Program Manager, Karen Johnson-Young (johnson-youngk@battelle.org) immediately.
4. Your name will appear as one of the panel members in the peer review. Your comments will be included in the Final IEPR Report, but will remain anonymous.

Please submit your comments in electronic form to Patricia Strayer (strayerp@battelle.org)**, no later than February 25, 2013, COB ET.**

Independent External Peer Review
of the
Dam Safety Modification Report (DSMR) Report for
Pine Creek Lake, Oklahoma
Charge Questions and Relevant Sections As Supplied By USACE

General (3)

1. Were risk and uncertainty sufficiently considered?
2. Are potential life safety issues accurately and adequately described under existing, future-without-project, and future-with-project conditions?
3. In your opinion, are there sufficient analyses upon which to base the recommendation?

Problem, Needs, Constraints, and Opportunities (1)

4. Are the problems, needs, constraints, and opportunities adequately and correctly defined?

Existing and Future-Without-Project Resources (3)

5. Do you agree with the general analyses of the existing social, financial, and natural resources within the study area?
6. Was the hydrology discussion sufficient to characterize current baseline conditions and to allow for evaluation of how forecasted conditions (with and without proposed actions) are likely to affect hydrologic conditions.
7. Please review the discussion of the future conditions expected to exist in the absence of a federal project. Are those conditions logical and adequately described and documented?

Plan Formulation / Evaluation (4)

8. Was a reasonably complete array of possible measures considered in the development of alternatives?
9. Are future operation, maintenance, repair, replacement, and rehabilitation efforts adequately described, and are the estimated costs of those efforts reasonable for each alternative?
10. Please comment on the screening of the proposed alternatives. Are the screening criteria appropriate? In your professional opinion, are the results of the screening acceptable? Were any measures or alternatives screened out too early?
11. Were the engineering, economic, and environmental analyses used for this study consistent with generally accepted methodologies? Why or why not?

Recommended Plan (2)

12. Comment on whether you agree or disagree with how the selected alternative was formulated and selected. Comment on the plan formulation. Does it meet the study objectives and avoid violating the study constraints?
13. Please comment on the completeness of the recommended plan (i.e., will any additional efforts, measures, or projects be needed to realize the expected benefits)?

Dam Safety (5)

14. Has the condition of the dam (including the design and construction of the dam and appurtenant features, project maintenance, previous major rehabilitations and dam safety modifications, and the dam's performance over time) been clearly described?
15. Is there sufficient information presented to identify, explain, and comment on assumptions that underlie engineering analyses? Why or why not?
16. Were the characteristics, conditions, and scenarios leading to failure, along with the potential consequences, adequately identified? Were pertinent factors, including population at risk, considered in the estimation of risk for the baseline condition? Were all the dam safety issues and opportunities identified?
17. Have all alternatives received sufficient consideration, including those involving repairing, replacing, or removing the dam?
18. Have the potential impacts of each alternative been clearly and adequately presented?

Project Specific Questions (3)

19. Are the methods used to evaluate the condition of Pine Creek Dam adequate and appropriate given the circumstances?
20. Have the hazards that affect the structure been adequately described for Pine Creek Dam?
21. Has anything significant been overlooked in the development of the assessment of Pine Creek Dam or the alternatives?

Environmental Assessment Questions (4)

22. Have the affected environment and environmental consequences of all alternatives been adequately described? If not, please elaborate.
23. Should any other resources be considered for the affected environment? If yes, please elaborate.
24. Under the proposed mitigation, would the project meet the threshold of negligible adverse impact on significant environmental resources? If not, please elaborate.
25. Have all pertinent federal acts, regulations, and executive orders been considered and compliance demonstrated? If not, please elaborate.

Final Overview Question (1)

26. What is the most important concern you have with the document or its appendices that was not covered in your answers to the questions above?

Final Compiled Comments and Responses
on the
Independent External Peer Review of the
Dam Safety Modification Report (DSMR) for
Pine Creek Lake, McCurtain County, Oklahoma

Final Panel Comment 1

The length of the proposed cutoff wall of 44 feet may not be long enough to cover the area of potential hydraulic fracturing or embankment defects.

Basis for Comment

The remedial plan for seepage control includes four elements which, if properly implemented, will provide a robust and redundant solution. The installation of an appropriately sized plastic concrete cutoff wall is perhaps the most important element of the proposed plan. It is the Panel's opinion that the 44-foot-long wall is not long enough to cut off the entire leakage area and potentially could compromise the effectiveness of this element of the remedial measures. The following factors support this opinion:

a) Section B-B, page 7, of the Formulation of Risk Management Plans Report (Dam Safety Modification Report [DSMR] Appendix III) indicates that the width of the top of the concrete plug in the area of the core trench is 50 feet. If this dimension is correct, the proposed 44-foot-long core wall will not span the entire width of the concrete plug section, nor will it cover the postulated zone of hydraulic fracturing as shown in Figure 5.

b) Conversely, the Cutoff Wall Detail on Sheet 145 of 173 of the 65% Design Drawings (DSMR Appendix IV) shows the top of the concrete plug only slightly narrower than the cutoff wall.

c) The length of the cutoff wall appears to have been evaluated and determined based mainly upon engineering judgment after review of the subsurface exploration and other investigations. There were no engineering analyses or rationale provided in the report to support the selection of the 44-foot length.

d) In order to achieve a robust design, the cutoff wall should extend well past the limits of the concrete plug in order to incorporate all of the areas that potentially have been subjected to hydraulic fracturing and provide adequate overlap with the competent portions of the impervious core.

e) Aerial photographs of the outlet works construction taken on October 6, 1966, clearly show that there are relatively steep rock excavation slopes extending upward on either side from the top of the concrete plug. This is consistent with the Cutoff Wall Detail on Sheet 145 of 173 of the 65% Design Drawings (DSMR Appendix IV), which shows the rock excavation surface extending above the concrete plug at a 1H:1V slope or steeper. This type of bedrock configuration potentially could have resulted in hydraulic fracturing well beyond the proposed limits of the cutoff wall.

f) Federal Emergency Management Agency (FEMA) 484 Section 5.1 recommends that the "side slopes of the excavation must be flat enough to avoid differential settlement of the embankment dam near the conduit"; Section 5.1.1 goes on to recommend that the rock "foundation line, grade, and density should be uniform." (FEMA, 2005) Furthermore, FEMA P 675 Section 2.1 recommends that to "avoid installing a negative projecting embankment conduit, use a trench with at least 2 to 1 (horizontal to vertical) or flatter side slopes (figure 31)." (FEMA, 2007) This suggests that arching action could extend to the top of the rock excavation trench.

Significance – High

The limited 44-foot length of the cutoff wall has not been justified, and there is evidence that this length will not fully span the entire zone of fractured or defective material. This could allow seepage to flow along the outlet works downstream of the concrete plug and create a potential for piping, resulting in dam failure.

Recommendations for Resolution

1. Conduct an analysis during final design of the stresses within the embankment overlying and adjacent to the concrete plug to evaluate the possibility that hydraulic fracturing has occurred and to define the zone of fracturing. The limits of the analysis should be sufficient to define the limits of any potential hydraulic fracturing and thereby provide a basis for the length of the cutoff wall.
2. Consider extending the limits of the cutoff wall to incorporate the entire length of the embankment fill, which was placed and compacted against the steep, irregular surface of the sloping excavated sidewalls of the trench for the outlet works. Consideration should be given regardless of the results of the analysis described above in the previous recommendation and occur during the final design phase.

Literature Cited

FEMA (2005). Technical Manual: Conduits through Embankment Dams. Federal Emergency Management Agency. FEMA 484. September.

FEMA (2007). Technical Manual: Plastic Pipe Used in Embankment Dams. Federal Emergency Management Agency. FEMA P 675. November.

PDT Final Evaluator Response (FPC#1):

X Concur __Non-Concur

Explanation:

Based on comments made in previous reviews and further evaluation.

Recommendation #1: X Adopt __Not adopt
Explanation:

Further analysis will be conducted during Planning, Engineering, and Design Phase.

Recommendation #2: X Adopt __Not adopt
Explanation:

Based on comments made in previous reviews and further evaluation, the length of the Element 5A Modified Cutoff Wall have been revised to 64 feet. Additional analyses will be performed at Planning, Engineering and Design Phase.

Dam Safety Modification Report (DSMR):

Section 1.4.3.5.7 Structural Plan 7:

Replace:

“Element 5a is 44 feet long versus the 406 feet length of Element 5.”

With:

“Element 5a is **64** feet long versus the 406 feet length of Element 5.”

Section 1.5 Decision and Section 4.6 Recommended Risk Management Plan:

Replace:

“The additional cost Structural Plan 7 of $700,000 for the cutoff wall provides a reduction in risk two orders of magnitude greater than Structural Plan 6 from an annual probability of failure of 4.89E-5 to 4.48E-7.”

With:

“The additional cost Structural Plan 7 of **$997,000** which is for the cutoff wall provides a reduction in risk two orders of magnitude greater than Structural Plan 6 from an annual probability of failure of 4.89E-5 to 4.48E-7.”

Section 2.0 Executive Summary:

Replaced:

"The additional cost Structural Plan 7 of **$700,000** for the cutoff wall provides a reduction in risk two orders of magnitude greater than Structural Plan 6 from an annual probability of failure of 4.89E-5 to 4.48E-7."

With:

"The additional cost Structural Plan 7 of $**997,000** for the cutoff wall provides a reduction in risk two orders of magnitude greater than Structural Plan 6 from an annual probability of failure of 4.89E-5 to 4.48E-7."

Section 4.3.5.1 Structural Measures (Elements), Element 5a Modified E-5 Cutoff

Wall (Hydraulic Fracture or Other Defect):

Replace Figures 84 and 85.

Section 4.3.5.1 Structural Measures (Elements), Element 5a Modified E-5 Cutoff Wall (Hydraulic Fracture or Other Defect):

Replace:

"The lateral extent of this wall is narrower than Element 5 with a width of approximately 44 feet as shown in Figure 85. The wall will serve as to cutoff embankment and rock trench which has shown evidence of a hydraulic fracture or other defect in the embankment."

With:

"The lateral extent of this wall is narrower than Element 5 with a width of approximately **64** feet as shown in Figure 85. **The excavation into rock around the middle of the conduit consists of a 1H:4V slope from the bottom of the excavation to approximately 5 feet above the conduit transitioning to a 3H:1V to the natural rock surface as shown in Appendix IV, As-Built Drawings, Outlet Works, Drawing 1800-C4-2/1.4, Section B-B. As discussed in Section 3.5.5.1 Presence of a Hydraulic Fracture or Other Defect, the hydraulic fracture would have occurred at the point of greatest stress differential where the slope changes from 1H:4V to 3H:1V as shown in Figures 71 and 78. The width of the wall is based on extending the wall beyond greatest stress differential past the transition to the 3H:1V slope.** The wall will serve as to cutoff embankment and rock trench which has shown evidence of a hydraulic fracture or other defect in the embankment."

Section 4.3.5.2 Structural Risk Management Plans (Alternatives), Table 49:

Replace:

"Install Modified Full-Depth Cutoff Wall – 4 feet diameter, 44 feet wide Secant Pile Wall (versus 406 feet width of Element 5)"

With:

"Install Modified Full-Depth Cutoff Wall – 4 feet diameter, **64** feet wide Secant Pile Wall (versus 406 feet width of Element 5)"

Section 4.4 Comparison of Risk Reduction, Table 50:

Replace existing values in Alt. 7 column with new values.

Section 4.4 Comparison of Risk Reduction, Table 51:

Replace existing values in Alt. 7 column with new values.

Section 4.5 Selection of the Recommended Risk Management Plan, Table 53:

Replace existing values in Annual Prob Failure (APF) and Comparative Cost to Implement ($M) column for 7 (Element 4, 5a, 9a, and 11) row with new values.

Section 4.5 Selection of the Recommended Risk Management Plan, Table 54:

Replace existing values in 7 (Element 4, 5a, 9a, and 11) row with new values.

Section 4.6 Recommended Risk Management Plan

Replaced:

"The additional cost Structural Plan 7 of **$700,000** for the cutoff wall provides a reduction in risk two orders of magnitude greater than Structural Plan 6 from an annual probability of failure of 4.89E-5 to 4.48E-7."

With:

"The additional cost Structural Plan 7 of $**997,000** for the cutoff wall provides a reduction in risk two orders of magnitude greater than Structural Plan 6 from an annual probability of failure of 4.89E-5 to 4.48E-7."

<u>Appendix III, Formulation of Risk Management Plans:</u>

Section 2.3.3 Element 5a – Construct Modified Cutoff Wall:

Replace Figures 14 and 15.

Section 2.3.3 Element 5a – Construct Modified Cutoff Wall:

Replace:

“The lateral extent of this wall is narrower than Element 5 with a width of approximately 44 feet as shown in **Error! Reference source not found.** (Appendix IV - 65% Engineering Design Drawings – Sheet 145). The plastic concrete portion will serve as a cutoff wall for the rock trench which has shown evidence of a hydraulic fracture or other defect in the embankment. The CSB will be designed to maintain a k-value of 10-8 and utilize slurry for construction of approximately 75 pounds per cubic yards to maintain stability along the walls. Consideration will be given in final design to use one material rather than the two materials.”

With:

“The lateral extent of this wall is narrower than Element 5 with a width of approximately **64** feet as shown in Figure 15 (Appendix IV - 65% Engineering Design Drawings – Sheet 145). **The excavation into rock around the middle of the conduit consists of a 1H:4V slope from the bottom of the excavation to approximately 5 feet above the conduit transitioning to a 3H:1V to the natural rock surface as shown in Appendix IV, As-Built Drawings, Outlet Works, Drawing 1800-C4-2/1.4, Section B-B. The hydraulic fracture would have occurred at the point of greatest stress differential where the slope changes from 1H:4V to 3H:1V. The width of the wall is based on extending the wall beyond greatest stress differential past the transition to the 3H:1V slope.** The plastic concrete portion will serve as a cutoff wall for the rock trench which has shown evidence of a hydraulic fracture or other defect in the embankment. The CSB will be designed to maintain a k-value of 10-8 and utilize slurry for construction of approximately 75 pounds per cubic yards to maintain stability along the walls. Consideration will be given in final design to use one material rather than the two materials.”

Section 4.2.3.5 Meeting risk reduction objectives for the DSAC class of the dam – Table 25:

Replaced:

“4 foot diameter, 44 foot wide Secant Pile Wall (versus 406 foot width of Element 5)"

With:

“4 foot diameter, **64** foot wide Secant Pile Wall (versus 406 foot width of Element 5)"

Section 4.3.3 Alternative Risk Reduction Element Combinations:

Replaced:

"4 foot diameter, 44 foot wide Secant Pile Wall (versus 406 foot width of Element 5) + Construct Modified Downstream Filter (less robust design than Element 9) + Permanent Joint Repair – Steel Pipe Sleeve"

With:

"4 foot diameter, **64** foot wide Secant Pile Wall (versus 406 foot width of Element 5) + Construct Modified Downstream Filter (less robust design than Element 9) + Permanent Joint Repair – Steel Pipe Sleeve"

Appendix IV, 65% Engineering Design Drawings, As-Built Drawings, and Construction

Photographs:

65% Engineering Design Drawings:

Replace Drawings 144 and 145.

Appendix VI, Cost Estimating Breakdown:

Section 7 Pine Creek Dam Selected Plan, Table:

Replace existing value for Total Construction Cost for Alt 7 with new value.

Section 7 Pine Creek Dam Selected Plan, Table 7.1:

Replace existing values with new value.

Section 7 Pine Creek Dam Selected Plan, Element 5A – Cut-Off Wall:

Replace:

"The final wall design should be approximately 44 feet wide with a minimum auger design of 48 inches."

With:

"The final wall design should be approximately **64** feet wide with a minimum auger design of 48 inches."

Cost Estimate Alternative Comparison:

Replace existing values with new values for Element 5a and Alternative 7 all cost graphics

Structural Plan 7 Detailed Cost Breakdown:

Replace existing cost breakdown with new cost breakdown.

Panel Final BackCheck Response (FPC#1):

_X_Concur __Non-Concur

Final Panel Comment 2

The current schedule for completing remediation does not correspond to the apparent urgency of actions needed to prevent failure as implied by Dam Safety Action Classification (DSAC) I.

Basis for Comment

The current schedule as shown in Appendix VI-F of the Dam Safety Modification Report (DSMR) indicates that on-site construction to remediate the seepage conditions will not begin until October 2014 and will not be substantially complete until August 2016. The DSMR indicated that the seepage condition around the outlet works was reclassified as a DSAC I in April 2011. The current schedule therefore will result in over a five-year period to resolve a critical dam safety issue. This appears to be reflected in DSMR Table 50, which indicates a six-year estimated time to implement, though the beginning of the estimated period of construction is not defined. The Panel is concerned that any delay in implementing the remedial work increases the threat of failure, particularly if there are unforeseen high reservoir levels.

The Panel has the following observations related to the urgency of the remedial work:

a) The seepage issues related to the outlet conduit surrounding backfill have been an ongoing source of concern since the initial filling of the reservoir in 1969. Over the last four years, there has been increasing visual and physical evidence that the seepage conditions have increased in severity. The Tulsa District has undertaken multiple types of investigations, including dye testing, standard penetration testing, and ground penetrating radar, among other methodologies. The District is to be complimented on the thoroughness of its evaluation and investigations in identifying the serious nature of this problem. The formation of internal voids within the embankment and the emergence of seepage flow carrying sediment are classic indications of an embankment nearing a failure condition that warrants remedial action on an expedited schedule.

b) The rate of progression of the seepage condition cannot be predicted. As stated in Section 4.2.2.1 of the DSMR, critical piping may occur at increased pool levels of 438 feet (only five feet above the current conservation pool). This imposes a serious immediate risk to the integrity of the dam, which has been correctly identified in the report.

c) Many areas in the country have recently experienced storm events with increased intensity and frequency and with substantial increases in precipitation resulting from a single storm event, which may be attributable to climate change. The project area has been undergoing a long-term drought condition, which fortunately has resulted in reservoir elevations remaining very low. The possibility of one severe storm event in the future causing a rapid increase in pool elevation, resulting in increased seepage conditions or sudden failure, is a plausible scenario that should be considered as part of unforeseen conditions or climate change considerations.

d) The remedial plan for seepage control includes four elements, which if properly implemented will provide a robust and redundant solution. These include a cutoff wall, a chimney drain, a downstream drain and a liner system As indicated in DSMR Section 4.4.3, Non-Structural/Structural Plan 4 was eliminated from consideration for the selected risk management plan because it delays the implementation of the structural plan and resolution of the issues within the embankment. However, each of the various structural elements is currently presented as separate, requiring separate contracts, resulting in a drawn-out duration for complete implementation.

Significance – High

Investigations to date have provided evidence of critical seepage conditions, and the potential time for internal seepage and piping to progress to a failure condition under either normal or higher pool levels cannot be predicted. The immediate risk would be exacerbated under higher reservoir levels. Any delay in implementing the remedial measures increases the likelihood of dam failure prior to completion of the project.

Recommendations for Resolution

1. Clarify the starting time for the estimated construction period durations of the risk management alternatives listed in Table 50.
2. Include Structural/Non-Structural Plan 4 in Tables 50 and 51.
3. Make every effort to expedite required reviews, funding, and finalization of repair procedures and contracts in order to begin remedial construction at the earliest possible date.
4. Modify the sequencing to expedite the installation of the most critical remedial measures involving the drain and cutoff wall. The construction of the cutoff wall and installation of the new drain will require specialized equipment and contractor expertise. The installation of the steel liner and downstream drain system will involve more-routine type construction that does not require significant specialized equipment. Consider utilizing a separate contract to install the secant wall and chimney filter before implementing the downstream filter and conduit liner system. This sequencing may expedite the installation of the most critical remedial measures involving the chimney drain and cutoff wall.

PDT Final Evaluator Response (FPC#2):

__X_ Concur _Non-Concur

Explanation:

The urgency of the project was applied immediately upon notice of DSAC I with direction to start DSMS process rather than completing an Issue Evaluation Study (IES) which is required to evaluate both confirmed and unconfirmed issues related to concerns of the dam. Consideration was given to both remediating the dam expeditiously and meeting "As-Low-As-Reasonably-Possible" (ALARP) considerations. The construction sequence for the risk reduction plans allow for each measure to be constructed in a manner which reduces the risk as each subsequent measure is constructed by reducing the flow of water and pressure through the system. In addition, risk reduction measures, Element 5A (modified cut-off wall) and Element 4 (chimney filter) installed prior to Element 9A (modified downstream filter) allow for a reduction of head in design subsequently making the Element 9A much smaller in comparison to Element 9 (downstream filter) for a cost savings of $600,000. Finally, Interim Risk Reduction Measures (IRMMS) have been implemented to immediately address the concerns at the project until the permanent risk reduction measures can be designed. The most significant measures included installation of a downstream inverted filter and operational changes including a pool and release restriction.

Recommendation #1: X Adopt __Not adopt
Explanation:

Currently the project starts upon approval of the Dam Safety Modification Study by Chief of Engineering Construction Community of Practice project in June 2013 with Plan and Specification Development, and Solicitation and Selection of Contractor. Construction is planned to start in October 2014.

Dam Safety Modification Study

Revised Estimated Time to Implement (Years) for Alternatives 6 and 7 in Table 50 from 6 to 4 years. Detailed construction schedules are included in DSMR, Appendix VI.

Section 4.4 Comparison of Risk Reduction:

Replace:

"Table 50 is a summary of the ALARP Table as formulated by the SWD Dam Safety Production Center. The alternative risk management plans were then compared according to the tolerable risk guidelines and P&G guidance as shown in Table 51. The SWD Dam Safety Production Center chose to evaluate and then compare the Non-Structural Alternatives and the mandated alternatives further into the risk analysis to identify potential combinations of risk reductions prior to performing a cost estimate and comparing against each risk management plan, alternative. A Cost Engineering Report including a detailed breakdown and summary of the cost estimate for each structural risk management plans as well as the construction schedules formulated is included in

Appendix VI. The shaded alternatives in Table 50 and Table 51 do not meet tolerable risk guidelines. It should be noted in Table 50 that the "(A) Risk Cost per annum ($)" for Alternative 6 is much larger than the other alternatives because the Annualized Probability of Failure (APF) of 4.89E-05 as shown in Table 51 just meets the tolerable risk guideline of an APF of 1E-4."

With:

"Table 50 is a summary of the ALARP Table as formulated by the SWD Dam Safety Production Center. The alternative risk management plans were then compared according to the tolerable risk guidelines and P&G guidance as shown in Table 51. The SWD Dam Safety Production Center chose to evaluate and then compare the Non-Structural Alternatives and the mandated alternatives further into the risk analysis to identify potential combinations of risk reductions prior to performing a cost estimate and comparing against each risk management plan alternative. A Cost Engineering Report including a detailed breakdown and summary of the cost estimate for each structural risk management plans as well as the construction schedules formulated is included in Appendix VI. **The Estimated Time to Implement (years) indicated in Table 50 currently starts upon approval of the Dam Safety Modification Study by Chief of Engineering Construction Community of Practice project in June 2013 with Plan and Specification Development, and Solicitation and Selection of Contractor. Construction is planned to start in October 2014.** The shaded alternatives in Table 50 and Table 51 do not meet tolerable risk guidelines. It should be noted in Table 50 that the "(A) Risk Cost per annum ($)" for Alternative 6 is much larger than the other alternatives because the Annualized Probability of Failure (APF) of 4.89E-05 as shown in Table 51 just meets the tolerable risk guideline of an APF of 1E-4.

Recommendation #2: __Adopt X Not adopt
Explanation:

As indicated by Panel, Non-Structural/Structural Plan 4 was eliminated from consideration for the selected risk management plan because it delays the implementation of the structural plan and resolution of the issues within the embankment. In addition, Structural Plan/Non-Structural Plan 4 was not shown further in DSMR, including Tables 50 and 51. Risk may appear to meet tolerable guidelines before completion of all of the Risk Management Measures (Elements), due to assumptions made in the evaluation of baseline risk and depending on the construction sequence. In order to be considered robust and redundant, and to meet ALARP criteria, all measures of Structural Plan 4 would need to be constructed.

Recommendation #3: X Adopt __Not adopt
Explanation:

The Pine Creek Dam DSMR, PED, and construction is following an expedited process, but still meet USACE Policy. In the meantime, IRRMS are in place to manage the risks until the final modification.

Dam Safety Modification Study (DSMR):

Section 4.6 Recommended Risk Management Plan:

Add Bullet:

“4. Consideration will be given to expedite implementation and sequencing of the risk management plan in planning, engineering , design, and construction phases.“

Recommendation #4: X Adopt __Not adopt
Explanation:

Dam Safety Modification Study (DSMR):

Section 4.6 Recommended Risk Management Plan:

Add Bullet:

“5. Consideration will be given in planning, engineering and design to adjusting sequence of construction of risk management measures (elements) to expedite project completion and provide additional risk reduction.“

Panel Final BackCheck Response (FPC#2):

_X_Concur __Non-Concur

Based on the Evaluator Response provided, it appears that the PDT understands that the current embankment condition may be at a critical state and that any means to expedite the remedial actions should be pursued.

Final Panel Comment 3

Pertinent hydrologic and hydraulic calculations, modeling, and mapping are not fully presented in Appendix 12 of the Baseline Risk Assessment Report; therefore, the full extent of the breach routing and resulting downstream flood hazards could not be determined.

Basis for Comment

The determination of dam breach consequences is highly dependent on the hydrologic and hydraulic analyses completed for the Baseline Risk Assessment Report. Although general discussion was provided regarding these analyses, Hydrologic Engineering Center-River Analysis System (HEC-RAS) modeling and mapping of the downstream inundation areas were not included with Appendix 12 of the Baseline Risk Assessment Report. The current level of discussion in Appendix 12 limits the Panel's ability to analyze the mapped flood hazards used to determine dam breach consequences.

In addition, supporting hydrologic assumptions and calculations, such as development of the Pine Creek Lake storage curve, are not fully provided with the Baseline Risk Assessment Report. According to the Baseline Risk Assessment Report, Appendix 12, Section C.3.7.2, level pool routing of the reservoir was modeled for dam failure analysis. The Pine Creek Lake storage curve from the Water Control Manual (as referenced in the Baseline Risk Assessment Report, Appendix 12) was the basis for this level pool routing. It is assumed that the storage curve used for level pool routing was developed at the time of dam construction. Unsteady HEC-RAS model results are flood-volume dependent; therefore, the computed downstream flood depths and inundation area are dependent on the stored volume within the reservoir at the time of failure.

Significance – Medium

Because the current Dam Safety Modification Report (DSMR) documents do not fully provide the supporting information associated with the hydrologic and hydraulic calculations, modeling, and mapping, the completeness of the report and overall understanding of the results are affected.

Recommendations for Resolution

1. Provide more information on HEC-RAS modeling and mapping in Appendix 12 in order to understand the mapped flood hazards used to determine dam breach consequences.
2. Include the storage curve calculation used for level pool routing and incorporate this information in Appendix 12 of the Baseline Risk Assessment Report.
3. Verify that physical changes within the storage/reservoir area (i.e., sediment accumulation, vegetation growth) that have occurred since dam construction do not necessitate an update of the Pine Creek Lake storage curve that is provided in the Water Control Manual. If significant reservoir storage has been lost, develop a revised Pine Creek Lake storage curve.

PDT Final Evaluator Response (FPC#3):

___Concur _X_Non-Concur

Explanation:

A detailed report on the hydrologic and hydraulic calculations was developed and provided to the IEPR panel. All information describing the analysis and specific to the comment recommendations #1 through #3 are included. The report also details information concerning the inundations developed by the Modeling, Mapping and Consequences (MMC).

Action Taken:

Appendix I, Baseline Risk Assessment:

Table C.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace in Inflow Hydrograph Column:

"Prelim PMF"

With:

"PMF"

Section C.3.6.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"Initial model layout was created with reference to roughly estimated inundation boundaries that were developed by the USACE MMC Production Team. Initial cross-section and flow path spacing, width, and shape were largely based on standard modeling practice. Storage areas were used for the simulation of Pine Creek Lake reservoir and for tributary valleys not modeled by separate routing reaches."

With:

"Initial model layout was created with reference to roughly estimated inundation boundaries that were developed by the USACE MMC Production Team. Initial cross-section and flow path spacing, width, and shape were largely based on standard modeling practice. Storage areas were used for the simulation of Pine Creek Lake reservoir and for tributary valleys not modeled by separate routing reaches. **Figure C.5 presents a schematic of the HEC-RAS model**."

Section C.3.6.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Add: Figure C.5: HEC-RAS Model Schematic

Section C.3.7.5, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"Generally, a Manning's roughness coefficient of 0.04 was assumed for the channel of the Little River and 0.04-0.06 for the tributary channels. For the overbank areas roughness values were visually estimated for each cross section using GIS and National Land Cover Data, along with recommended roughness coefficient values from the HEC-RAS hydraulic reference manual. Once the model was developed and refined during preliminary simulation efforts, the model simulation results were compared with rating curves established for the Little River at Wright City, Idabel and Horatio. The simulated ratings compare reasonably well to the actual rating curve within the flow range of observed events."

With:

"**Overbank n-values were estimated from 2006 national land cover data and referenced to suggested Manning's n-values provided in the HEC-RAS hydraulic appendix. A single, composite n-value was used for each overbank. The values used in this model range between 0.05 and 0.14. Table C.4 shows the Manning's n-values referenced for overbanks. Little River cross sections channel n-values were adjusted to a uniform value of 0.04, based on a comparison between rating curves computed by RAS and those presented in the Water Control manual for three gage locations at Wright City, Idabel and Horatio. Manning's n-values along the Little River were increased for the cross sections immediately downstream of Pine Creek Lake Dam to account for sediment and turbulence associated with a breaching dam. The n-values were doubled for the first model cross section downstream of the dam and then transitioned back to normal n-values ten river miles downstream. Tributary channel n-values were generally set at 0.045 for all cross sections with slope less than 10 ft./mile. For slopes greater than 10 ft./mile, channel n-values were estimated with the assistance of Jarrett's equation, up to a maximum value of 0.06.**

Table C.4: Reference Manning's N-values for Overbank Areas

Landcover	N-Value
Open Water	0.025
Barren Land	0.028
Open Space/Turf Grass	0.030
Pasture/Hay	0.031
Cultivated Crops	0.035
Grassland/Herbaceous	0.036
Emergent Herbaceous Wetlands	0.045
Shrub/Scrub	0.060
Evergreen Forest	0.080
Mixed Forest	0.081
Woody Wetlands	0.100
Deciduous Forest	0.110
Developed, Low Intensity	0.120
Developed, Medium Intensity	0.130
Developed, High Intensity	0.150

"

Section C.3.8.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"Modeling for the risk analysis included model simulations for the inflow hydrographs determined as a baseline for risk assessment. These inflow events produced a maximum high pool (503.6') that corresponds to a PMF inflow hydrograph with a starting condition equal to the top of the flood pool, a top of flood control pool (480.13') corresponding to the spillway crest elevation and an intermediate pool (485') between the top of flood control pool and the PMF pool. For the top of flood control and intermediate pool elevations, a scaled PMF inflow hydrograph was routed from an antecedent pool equal to the 10% duration pool to achieve the desired peak pool elevation. Residual flow hydrographs were not available for downstream inflow reaches. Minimum steady flows were used as boundary conditions for those reaches."

With:

"Modeling for the risk analysis included model simulations for the inflow hydrographs determined as a baseline for risk assessment. These inflow events produced a maximum high pool (503.6') that corresponds to a PMF inflow hydrograph with a starting condition equal to the top of the flood pool, a top of flood control pool (480.13') corresponding to the spillway crest elevation and an intermediate pool (485') between the top of flood control pool and the PMF pool. For the top of flood control and intermediate pool elevations, a scaled PMF inflow hydrograph was routed from an antecedent pool equal to the 10% duration pool to achieve the desired peak pool elevation. Residual flow hydrographs were not available for downstream inflow reaches. Minimum steady flows were used as boundary conditions for those reaches. **Peak Stages and Discharges are shown in Table C.5.**

Table C.5: Hydraulic Model Output for Non-Failure Simulations

Community Name or Flooding Location	River Station	Simulation	Peak Discharge (cfs)	Time to Peak Stage (hours)**	Max Water Surface Elevation (NAVD 88)
Pine Creek Lake Dam	**145.3**	**PMF Pool**	**254,100**	**55.4**	**503.6**
		Intermediate Pool	**27,600**	**74.3**	**485**
Wright City, OK	**141**	**PMF Pool**	**253,800**	**56.4**	**398**
		Intermediate Pool	**27,400**	**78.5**	**381**
Idabel, OK	**111**	**PMF Pool**	**228,900**	**71.6**	**357.9**
		Intermediate Pool	**25,600**	**100.7**	**343.8**
Horatio, AR	**71**	**PMF Pool**	**180,600**	**99.8**	**308.1**
		Intermediate Pool	**24,500**	**127**	**296.5**

****Time from start of Simulation"**

Section C.3.8.2.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"As agreed upon during the PFMA, Tables C.4 and C.5 show the breach characteristics for each flood event and breach scenario used in this study."

With:

"As agreed upon during the PFMA, Tables **C.6** and **C.7** show the breach characteristics for each flood event and breach scenario used in this study."

Section C.3.8.2.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"Table C.4: Breach Parameters (PFMOW 1, 2, 3 and PFME 3)"

With:

“Table **C.6**: Breach Parameters (PFMOW 1, 2, 3 and PFME 3)”

Section C.3.8.2.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

“Table C.5: Breach Parameters (PFMOW 1, 2, 3 and PFME 3)”

With:

“Table **C.7**: Breach Parameters (PFMOW 1, 2, 3 and PFME 3)”

Section C.3.8.3.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

“This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 480.13’ (top of active storage) followed by the PMF inflow hydrograph, reaching a maximum pool elevation of 503.5’ prior to dam failure. All elevations are in NAVD 88.”

With:

“This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 480.13’ (top of active storage) followed by the PMF inflow hydrograph, reaching a maximum pool elevation of **503.6**’ prior to dam failure. All elevations are in NAVD 88. **Peak Stages and Discharges are shown in Table C.8.**

Table C.8: Hydraulic Model Output for PFMOW_503

Community Name or Flooding Location	River Station	Peak Discharge (cfs)	Time to Peak Stage (hours)*	Max Water Surface Elevation (NAVD 88)
Pine Creek Lake Dam	145.3	1,625,100	0	503.6
Wright City, OK	141	1,549,500	3.7	414.6
Idabel, OK	111	869,900	14.1	372.9
Horatio, AR	71	530,600	32.8	316.4

***Time from initiation of breach”**

Section C.3.8.3.2, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

“This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 446.93’ (10% pool exceedance duration) followed by a scaled PMF inflow hydrograph, reaching a maximum pool elevation of 485' prior to dam failure. The pool elevation of 485' represents an intermediate pool, added simply to give more definition to the relationship between pool level and consequences in the range of elevations between top of active storage and PMF pool. This elevation of 485 is not related to any specific frequency or duration. All elevations are in NAVD 88.'

With:

"This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 446.93' (10% pool exceedance duration) followed by a scaled PMF inflow hydrograph, reaching a maximum pool elevation of 485' prior to dam failure. The pool elevation of 485' represents an intermediate pool, added simply to give more definition to the relationship between pool level and consequences in the range of elevations between top of active storage and PMF pool. This elevation of 485 is not related to any specific frequency or duration. All elevations are in NAVD 88. **Peak Stages and Discharges are shown in Table C.9**

Table C.9: Hydraulic Model Output for PFMOW_485

Community Name or Flooding Location	River Station	Peak Discharge (cfs)	Time to Peak Stage (hours)*	Max Water Surface Elevation (NAVD 88)
Pine Creek Lake Dam	145.3	958,100	0	485
Wright City, OK	141	920,900	3.6	408.8
Idabel, OK	111	452,000	15.5	363.5
Horatio, AR	71	221,400	39.8	309.4

***Time from initiation of breach"**

Section C.3.8.3.3, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 446.93' (10% pool exceedance duration) followed by a scaled PMF inflow hydrograph, reaching a maximum pool elevation of 480.13' (top of active storage) prior to dam failure. All elevations are in NAVD 88."

With:

"This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 446.93' (10% pool exceedance duration) followed by a scaled PMF inflow hydrograph, reaching a maximum pool elevation of 480.13' (top of active storage) prior to dam failure. All elevations are in NAVD 88. **Peak Stages and Discharges are shown in Table C.10**

Table C.10: Hydraulic Model Output for PFMOW_480

Community Name or Flooding Location	River Station	Peak Discharge (cfs)	Time to Peak Stage (hours)*	Max Water Surface Elevation (NAVD 88)
Pine Creek Lake Dam	145.3	842,400	0	480.1
Wright City, OK	141	806,300	3.7	407.6
Idabel, OK	111	374,700	16	361.4
Horatio, AR	71	176,400	41.3	307.9

***Time from initiation of breach"**

Section C.3.8.3.4, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 446.93' (10% pool exceedance duration) followed by a scaled PMF inflow hydrograph, reaching a maximum pool elevation of 471.33' (1% pool exceedance duration) prior to dam failure. All elevations are in NAVD 88."

With:

"This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 446.93' (10% pool exceedance duration) followed by a scaled PMF inflow hydrograph, reaching a maximum pool elevation of 471.33' (1% pool exceedance duration) prior to dam failure. **All elevations are in NAVD 88. Peak Stages and Discharges are shown in Table C.11**

Table C.11: Hydraulic Model Output for PFMOW_471

Community Name or Flooding Location	River Station	Peak Discharge (cfs)	Time to Peak Stage (hours)*	Max Water Surface Elevation (NAVD 88)
Pine Creek Lake Dam	145.3	671,600	0	471
Wright City, OK	141	609,100	4.1	401.7
Idabel, OK	111	277,800	16.4	358.5
Horatio, AR	71	126,200	43.6	305.9

***Time from initiation of breach"**

Section C.3.8.3.5, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

“This scenario simulates a piping failure with initiation beginning at the outlet works. This scenario uses a constant pool elevation of 446.93’ (10% pool exceedance duration) prior to dam failure. Lake inflow is set equal to outflow to maintain pool level prior to failure. All elevations are in NAVD 88. Peak Stages and Discharges are shown in Table C.12”

With:

“This scenario simulates a piping failure with initiation beginning at the outlet works. This scenario uses a constant pool elevation of 446.93’ (10% pool exceedance duration) prior to dam failure. Lake inflow is set equal to outflow to maintain pool level prior to failure. **All elevations are in NAVD 88. Peak Stages and Discharges are shown in Table C.12**

Table C.12: Hydraulic Model Output for PFMOW_447

Community Name or Flooding Location	River Station	Peak Discharge (cfs)	Time to Peak Stage (hours)*	Max Water Surface Elevation (NAVD 88)
Pine Creek Lake Dam	145.3	313,400	0	446.9
Wright City, OK	141	282,300	3.7	398.5
Idabel, OK	111	73,500	19.1	350.2
Horatio, AR	71	43,300	45.9	300.2

***Time from initiation of breach”**

Section C.3.8.3.6, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

“This scenario simulates a piping failure with initiation beginning at the outlet works. This scenario uses a constant pool elevation of 437.53’ (90% pool exceedance duration) prior to dam failure. Lake inflow is set equal to outflow to maintain pool level prior to failure. All elevations are in NAVD 88.”

With:

“This scenario simulates a piping failure with initiation beginning at the outlet works. This scenario uses a constant pool elevation of 437.53’ (90% pool exceedance duration) prior to dam failure. Lake inflow is set equal to outflow to maintain pool level prior to failure. All elevations are in NAVD 88. **Peak Stages and Discharges are shown in Table C.13.**

Table C.13: Hydraulic Model Output for PFMOW_437

Community Name or Flooding Location	River Station	Peak Discharge (cfs)	Time to Peak Stage (hours)*	Max Water Surface Elevation (NAVD 88)
Pine Creek Lake Dam	145.3	208,700	0	437.5
Wright City, OK	141	175,700	3.8	395

Idabel, OK	**111**	**35,900**	**19.8**	**345.6**
Horatio, AR	**71**	**23,000**	**41.8**	**295.6**

***Time from initiation of breach"**

Section C.3.8.3.7, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"This scenario simulates a piping failure with initiation beginning along the dike at elevation 482', two feet above the roughly estimated existing ground elevation of 480'. The scenario starts with an antecedent pool elevation of 480.13' (top of active storage) followed by the PMF inflow hydrograph, reaching a maximum pool elevation of 503.6' prior to dam failure. All elevations are in NAVD 88."

With:

"This scenario simulates a piping failure with initiation beginning along the dike at elevation 482', two feet above the roughly estimated existing ground elevation of 480'. The scenario starts with an antecedent pool elevation of 480.13' (top of active storage) followed by the PMF inflow hydrograph, reaching a maximum pool elevation of 503.6' prior to dam failure. All elevations are in NAVD 88. **Peak Stages and Discharges are shown in Table C.14**

Table C.14: Hydraulic Model Output for PFMD_503

Community Name or Flooding Location	River Station	Peak Discharge (cfs)	Time to Peak Stage (hours)*	Max Water Surface Elevation (NAVD 88)
Pine Creek Lake Dam	**145.3**	**316,100**	**0**	**503.6**
Wright City, OK	**141**	**312,800**	**2.8**	**399.5**
Idabel, OK	**111**	**263,100**	**16.3**	**359**
Horatio, AR	**71**	**200,200**	**42.9**	**308.8**

***Time from initiation of breach"**

Section C.3.8.3.8, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"This scenario simulates a piping failure with initiation beginning along the dike at elevation 482', two feet above the roughly estimated existing ground elevation of 480'. The scenario starts with an antecedent pool elevation of 446.93' (10% pool exceedance duration) followed by a scaled PMF inflow hydrograph, reaching a maximum pool elevation of 485' prior to dam failure. The pool elevation of 485' represents an intermediate pool, added simply to give more definition to the relationship between pool level and consequences in the range of elevations between top of active storage and PMF pool. This elevation of 485 is not related to any specific frequency or duration. All elevations are in NAVD 88."

With:

"This scenario simulates a piping failure with initiation beginning along the dike at elevation 482', two feet above the roughly estimated existing ground elevation of 480'. The scenario starts with an antecedent pool elevation of 446.93' (10% pool exceedance duration) followed by a scaled PMF inflow hydrograph, reaching a maximum pool elevation of 485' prior to dam failure. The pool elevation of 485' represents an intermediate pool, added simply to give more definition to the relationship between pool level and consequences in the range of elevations between top of active storage and PMF pool. This elevation of 485 is not related to any specific frequency or duration. All elevations are in NAVD 88. **Peak Stages and Discharges are shown in Table C.15**

Table C.15: Hydraulic Model Output for PFMD_485

Community Name or Flooding Location	River Station	Peak Discharge (cfs)	Time to Peak Stage (hours)*	Max Water Surface Elevation (NAVD 88)
Pine Creek Lake Dam	145.3	31,700	0	485
Wright City, OK	141	31,000	8.7	382.3
Idabel, OK	111	27,900	31.1	344.4
Horatio, AR	71	26,300	57.9	297.1

***Time from initiation of breach"**

Section C.3.9, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"Requirements for estimating consequences for risk analysis include export of hydraulic model results into the GIS environment for development of inundation boundaries and depth grids. The maximum water surface profile representing each dam failure and non-failure scenario was exported from *HEC-RAS* into the GIS environment. *ArcGIS* 9.3 and *HEC-GeoRAS* were used to develop the GIS products from the exported model results. A flood depth grid and the associated inundation boundary were developed for every dam failure and non-failure scenario. This GIS data, along with flood wave hydrograph data and pertinent model geometry data, was provided for use in consequence analyses."

With:

"Requirements for estimating consequences for risk analysis include export of hydraulic model results into the GIS environment for development of inundation boundaries and depth grids. The maximum water surface profile representing each dam failure and non-failure scenario was exported from *HEC-RAS* into the GIS environment. *ArcGIS* 9.3

and *HEC-GeoRAS* were used to develop the GIS products from the exported model results. A flood depth grid and the associated inundation boundary were developed for every dam failure and non-failure scenario. This GIS data, along with flood wave hydrograph data and pertinent model geometry data, was provided for use in consequence analyses. **Figure C.6 presents computed inundation for the HEC-RAS failure and non-failure simulations for the PMF Pool. Figure C.7 presents computed inundation near Wright City, OK, the only significantly populated area inundated from dam failure at Pine Creek Lake**."

Section C.3.9, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Add: Figure C.6: HEC-RAS Model Inundations

Section C.3.9, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Add: Figure C.7: HEC-RAS Model Inundations near Wright City, OK

Recommendation #1: __Adopt X Not adopt
Explanation:

Pertinent data related to hydrologic and hydraulic calculations, including hydraulic models and computed inundations were posted on RADSII for transfer to the IEPR panel on 21Feb2013.

Recommendation #2: __Adopt X Not adopt
Explanation:
The referenced report in Recommendation #1 includes the adopted storage curve calculations used in the event routings.

Recommendation #3: __Adopt X Not adopt
Explanation:

A bathymetric study was conducted in late 2011 and adopted in June 2012. No resurvey was conducted for the flood pool. Based on this the extreme event routings were not expected to have any difference with pool routing.

Panel Final BackCheck Response (FPC#3):

_X_ Concur __Non-Concur

The intent of FPC No. 3 was to recommend that supplemental hydrologic and hydraulic modeling information be included as appendix material to Appendix 12 of the Baseline

Risk Assessment Report, which would provide the Panel with an opportunity to more fully understand the more detailed aspects of the hydrologic and hydraulic modeling and flood hazard mapping efforts. **The supplemental modeling information was provided in mid-review, which only provided 2 working days before panel review comments were due; therefore**, given the scope and duration of the review process, a thorough review was not able to be performed. The issues, needs, constraints and opportunities associated with the recommended dam improvements are primarily civil structural/geotechnical in nature; and considering this, the initially provided and reviewed hydrologic and hydraulic analyses and flood hazard mapping approaches are adequate for assessment of the Pine Creek Dam flood hazards.

Final Panel Comment 4

The breach formation time of three hours, associated with each of the six antecedent pool elevations, may not be in accordance with dam breach analysis guidelines and criteria.

Basis for Comment

According to the U.S. Army Corps of Engineers (USACE) *Safety of Dams – Policy and Procedures*, Appendix O, Section O.3, a short-term risk reduction strategy for mitigating a breach under a seepage failure mode scenario usually involves some form of reservoir drawdown or modified reservoir operations under reduced storage levels (USACE, 2011). This suggests that the breach formation time may vary depending on the antecedent pool elevation.

Table 13 of the Baseline Risk Assessment Report shows a breach formation time of three hours for each of the six pool elevations (437.53', 446.93', 471.33', 480.13', 485' and 503.5'). However, it is reasonable that the breach formation time associated with a 437.53' pool elevation is longer than a breach formation time associated with higher pool elevations.

The downstream peak flood stage is dependent on breach parameters, which include the breach formation time. Use of a standard breach formation time for all pool elevations is highly significant given that an unsteady HEC-RAS model was used to map downstream flood inundation. Unsteady model results are driven by flood volume, which is dependent on how quickly a breach forms during dam failure. It is likely that a decrease in the breach formation time will result in an increase in flood depths in the vicinity of the Pine Creek Lake Dam.

In addition, according to Ackerman and Brunner (2006) of the USACE Hydrologic Engineering Center (HEC), a breach matrix of possibilities is recommended when simulating a hypothetical dam failure. The matrix would include estimates of varying breach sizes and formation times. Breach parameters can be estimated based on historic data or numerical models; however, given the uncertainty associated with dam failure, modeling of several breach sizes and formation times is recommended. Breach parameter data, including methods for predicting dam breach properties, have been summarized by the National Weather Services, National Oceanic Atmospheric Administration (NOAA) (Fread, 1988, revised 1991).

Furthermore, according to the Federal Energy Regulatory Commission (FERC) (1993), the Time of Failure (TFH) for engineered, earthen dams should be between 0.1 hour and 1 hour (page 2-A-9). This time line also encompasses the 0.5 hour +/- flood wave release time for the 1997 piping failure of the Bureau of Reclamation's Teton Dam, a large earth dam similar to Pine Creek.

Decreasing the breach formation time will likely result in a local increase of downstream flow depths and inundation area, possibly increasing loss of life and economic consequences; however, it is unlikely that this change in downstream flood impacts will prompt a reconsideration of the selected dam remediation alternatives.

Significance – Medium

Adequate discussion regarding a fixed breach formation time associated with varying pool elevations is not provided in the Baseline Risk Assessment Report; therefore, a complete understanding of the study is not possible.

Recommendations for Resolution

1. Provide rationale for the use of a fixed three-hour breach formation time within the Baseline Risk Assessment Report.
2. Update hydraulic modeling and flood hazard mapping, if it is decided that a breach matrix of possibilities is appropriate for use.
3. As a quality control check, model breach characteristics with the BREACH model and compare results.

Literature Cited

Ackerman, C., and Brunner, G. (2006). Dam Failure Analysis Using HEC-RAS and HEC-GeoRAS. Third Federal Interagency Hydrologic Modeling Conference, Reno, Nevada. April. Available at http://acwi.gov/hydrology/mtsconfwkshops/conf_proceedings/3rdFIHMC/11F_Ackerman.pdf. Accessed March 8, 2013.

Fread, D.L. (1988, revised 1991). BREACH: An Erosion Model for Earth Dam Failures. National Weather Services, National Oceanic Atmospheric Administration (NOAA), Silver Springs, Maryland.

FERC (1993). Engineering Guidelines for Evaluation of Hydropower Projects. Chapter II - Selecting and Accommodating Inflow Design Floods for Dams. 0119-2. Federal Energy Regulatory Commission. October. Available at http://www.ferc.gov/industries/hydropower/safety/guidelines/eng-guide.asp. Accessed March 8, 2013.

USACE (2011). Safety of Dams – Policy and Procedures. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation (ER) No. 1110-2-1156. October 28.

PDT Final Evaluator Response (FPC#4):

___Concur _X_Non-Concur

Explanation:

Current USACE guidance recommends an average breach width between 0.5 and 3 times the height of the dam and breach formation times between 0.5 and 4 hours. The initial breach parameters were within these limits. During the risk assessment discussion, the multi-discipline team decided to alter the parameters. This Expert Elicitation process is reasonable for all risk evaluations and takes into account the knowledge of the local project with the expertise of the evaluators.

Recommendation #1: __Adopt X Not adopt
Explanation:

The three hour breach formation time was established by Expert Elicitation after discussion of the value produced using the Von Thun and Gillette regression equation.

Recommendation #2: __Adopt X Not adopt
Explanation:

A breach parameters sensitivity was conducted as part of the base model development and the Von Thun parameters were deemed the best fit for the hypothetical analysis. Risk team discussions included all parameter assessments before adopting the noted parameters.

Recommendation #3: __Adopt X Not adopt
Explanation:

Current USACE guidance recommends an average breach width between 0.5 and 3 times the height of the dam and breach formation times between 0.5 and 4 hours. The adopted parameters fit this range of values and were considered satisfactory when compared to the range of parameters considered during the base model development and the expert elicitation.

Panel Final BackCheck Response (FPC#4):

__X_Concur ___Non-Concur

The Evaluator Response provided by the PDT implies a high level of consideration of breach parameters through the breach parameter sensitivity analysis performed by the USACE's multi-discipline team of experts. Furthermore, USACE guidance and local project knowledge were used in the development of the dam breach parameters.

Final Panel Comment 5

Coincidental flood releases from Broken Bow and DeQueen Lakes were not considered during hydraulic modeling, which could result in increased flood stage and the inundation area on the Little River in the vicinity of the subject tributaries.

Basis for Comment

According to the Dam Safety Modification Report (DSMR), Section 3.2.2, the Pine Creek Lake Dam is one dam in a three-dam flood-control system that also includes Broken Bow Lake and DeQueen Lake Dams. However, coincidental flood releases from Broken Bow and DeQueen Lakes were not considered during the hydraulic modeling. Coincidental flood releases from Broken Bow and DeQueen Lakes increase the discharge, stage, and velocities downriver from those two reservoirs. A flood wave resulting from a potential failure mode at Pine Creek Lake Dam would add to the discharge, stage, and velocities and could impact loss of life and economic consequences in the reaches below these two structures. Since they were not addressed in the DSMR, the Panel has no basis to evaluate flood impacts.

Flood releases are to be made in accordance with releases from Broken Bow Lake and DeQueen Lake Dams, predicted runoff, allowable stage from downstream control points, and allowable reservoir storage within the system. Each of the three reservoirs is regulated to retain balanced flood-control facilities. However, prioritization of flood releases is based on available storage and inflow into each reservoir.

As discussed in Section C.2.4 of the Baseline Risk Assessment Report, Appendix 12, coincidental downstream discharges were not developed during the update of the Probable Maximum Flood (PMF) analysis. In addition, flood release information for Broken Bow Lake and DeQueen Lake Dams is not available for lesser hypothetical events. The hydraulic modeling initial conditions for the Broken Bow Lake Dam and DeQueen Lake Dam tributaries were set to low-flow conditions for the study.

As discussed in Section IV.A.3 of the Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams (FEMA, 1998), for flood routing computations, releases are typically limited to maximum values determined from operating protocol, tailwater conditions, and downstream conveyance capacities. This suggests that the modeling of coincidental flood releases from Broken Bow Lake and DeQueen Lake Dams under operational conditions is an appropriate approach for assessment of Little River flood hazards.

Hydraulic modeling was based on the low-flow downstream boundary conditions associated with the Broken Bow Lake and DeQueen Lake Dams. Using low-flow boundary conditions does not account for regional high-precipitation events and the subsequent flood releases at Broken Bow Lake Dam and DeQueen Lake Dam. In the event that Broken Bow Lake Dam and/or DeQueen Lake Dam are required to release flood waters coincidental with the failure of Pine Creek Lake Dam, flood impacts in the vicinity of these two tributaries would likely exceed those modeled under low-flow conditions. Under this scenario, this modeling approach would likely underestimate the downstream stage and potential for consequences.

Significance – Medium

It is unclear if coincidental flood releases from the Broken Bow Lake and DeQueen Lake Dams would result in an increase in Little River flood depth and inundation area in the vicinity of these tributary streams.

Recommendations for Resolution

1. Discuss and, if necessary, fully evaluate the downstream boundary conditions associated with the Broken Bow Dam and DeQueen Lake Dam tributaries.
2. Revise the dam breach modeling and map associated flood hazards, if downstream boundary conditions other than low-flow conditions are deemed appropriate.
3. Re-evaluate consequences based on remapped flood hazards.

Literature Cited

FEMA (1998). Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams. U.S. Department of Homeland Security, Interagency Committee on Dam Safety. Reprinted April 2004.

PDT Final Evaluator Response (FPC#5):

___Concur X Non-Concur

Explanation:

The release interactivity between Pine Creek, Broken Bow and DeQueen is unknown and varies greatly since these are controlled reaches. A sensitivity analysis was conducted to account for the inconsistency of the coincident discharges. Sensitivity of PMF pool non-failure and failure simulations at Pine Creek Lake with discharges from Broken Bow Dam and DeQueen Dam increased from low flow to high, but controlled, flood discharges commensurate with very infrequent flood events resulted in little change in computed stage and inundation along the Little River.

Recommendation #1: __Adopt X Not adopt
Explanation:

Sensitivity of PMF pool non-failure and failure simulations at Pine Creek Lake with discharges from Broken Bow Dam and DeQueen Dam increased from low flow to high, but controlled, flood discharges commensurate with very infrequent flood events resulted in little change in computed stage and inundation along the Little River. DeQueen Dam discharge was raised from a low flow of 200 cfs to the SPRA-identified 300-year annual chance event discharge of 6,850 cfs. Broken Bow Dam discharge was raised from 300 cfs to 11,000 cfs, which is the highest discharge supported by the current model geometry for the Mountain Fork.

Recommendation #2: __Adopt X Not adopt
Explanation:

The current conditions are appropriate. Sensitivity of PMF pool non-failure and failure simulations at Pine Creek Lake with discharges from Broken Bow Dam and DeQueen Dam increased from low flow to high, but controlled, flood discharges commensurate with very infrequent flood events resulted in little change in computed stage and inundation along the Little River.

Recommendation #3: __Adopt X Not adopt
Explanation:

The differences in computed stage and inundation showed little change along the Little River, therefore reevaluating consequences is not necessary.

Panel Final BackCheck Response (FPC#5):

__X_Concur __Non-Concur

The sensitivity analysis discussed in the Evaluator Response is an adequate approach to determine the necessity of coincidental flood release modeling.

Final Panel Comment 6

There are discrepancies between reported maximum high pool elevations associated with the Probable Maximum Flood (PMF), which could significantly increase the flood volumes, flow depths, and inundation area.

Basis for Comment

Notable discrepancies with regard to the maximum high pool elevation have been identified within the review documents (see Table 1 below).

Table 1. Notable Discrepancies for Maximum High Pool Elevation.

Document	Section/Page	Maximum High Pool Elevation (feet)
Baseline Risk Assessment Report	2.2.1	503.0
Baseline Risk Assessment Report	6.3.4.6	503.6
Baseline Risk Assessment Report	6.3.4.9	503.5
Baseline Risk Assessment Report, Appendix 12 – H&H	Table C.1, C2.2.2, C.3.8.1,	503.6
Baseline Risk Assessment Report, Appendix 12 – H&H	Table C.4, Table C.5, C.3.8.3.1, C.3.8.3.7	503.5
Baseline Risk Assessment Report, Appendix 13 - Consequences	Throughout	503
PMF Analysis for Dam Safety Report (May 2011)	Page 16	503.47
PMF Analysis (May 2012)	Page 29	503.56

Given that the maximum pool elevation of 503.6 feet is reported in the latest PMF Analysis (May 2012), it is assumed that this pool elevation is the most appropriate for use in the unsteady Hydrologic Engineering Center-River Analysis System (HEC-RAS) modeling of the dam breach. Unsteady HEC-RAS model results are dependent on the volume of flow being routed. If there are 26,600 acres of storage at a pool elevation of 503.0 feet (Baseline Risk Assessment Report, Section 2.2.1), an increase of the pool elevation to 503.6 feet results in about 16,000 acre-feet of additional flood volume to be routed downstream. This additional flood volume will likely increase the flow depths and enlarge the inundation area used for the risk and consequence analysis.

Significance – Medium

Discrepancies among reported maximum high pool elevations indicate a potential inaccuracy of calculated flow depths and inundation area and limits confidence in the conclusions that may have been drawn based on those analyses.

Recommendations for Resolution

1. Verify breach modeling use of 503.6 feet as maximum high pool elevation.
2. If the modeled pool elevation of 503.6 feet was not used as the maximum high

pool elevation, perform revised modeling of the breach and map the resulting downstream flood hazards.
3. Use remapped flood hazards as the basis for determining breach consequences.

PDT Final Evaluator Response (FPC#6):

___Concur X Non-Concur

Explanation:

The reasons for having “discrepancies” throughout the report resulted from several factors including the context of when analysis was performed and the level of accuracy used. Our opinion is that we need to remain within the context of when the PFMA was performed as well as where we were at that point in time with the development of the PMF (May 2011 report vs May 2012 report).

Action Taken:

Dam Safety Modification Report

Section 4.2.3 Dam Break Analysis and Inundation Maps

Add to end of section:

“**The elevation value associated with the Probable Maximum Flood (PMF) Pool, also known as Maximum Pool, for Pine Creek Lake varies in the report. Values between 503 feet and 503.6 feet are reported based the vintage of PMF study referenced and the elevation’s associated vertical datum. The PMF pool elevation of 503.6 ft. NAVD88 is the most current value and used for hydraulic breach modeling and consequence assessment in this report.**”

Appendix I, Baseline Risk Assessment:

Section C.3.8.2.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace in Tables C.6 and C.7 in Pool Elevation row:

“503.5”

With:

“**503.6**”

Section C.3.8.3.1, Appendix 12 Initiating Event: Hydrologic and Hydraulic Analysis

Replace:

"This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 480.13' (top of active storage) followed by the PMF inflow hydrograph, reaching a maximum pool elevation of 503.5' prior to dam failure. All elevations are in NAVD 88."

With:

"This scenario simulates a piping failure with initiation beginning at the outlet works. The scenario starts with an antecedent pool elevation of 480.13' (top of active storage) followed by the PMF inflow hydrograph, reaching a maximum pool elevation of **503.6**' prior to dam failure. All elevations are in NAVD 88.

Recommendation #1: __Adopt X Not adopt
Explanation:

The current PMF analysis conducted in May 2012 resulting in the Maximum Pool of 503.6 is the most current value and has been included in the hydraulic breach modeling and consequence analyses.

Recommendation #2: __Adopt X Not adopt
Explanation:

Per Recommendation #1, the most current PMF data is reflected in the hydraulic breach modeling and consequence assessment.

Recommendation #3: __Adopt X Not adopt
Explanation:

Per Recommendation #1, the inundations were computed with the most recent PMF data (May 2012) and used for development of the consequence assessment model.

Panel Final BackCheck Response (FPC#6):

_X_Concur __Non-Concur

FPC#6 was prepared primarily to confirm that the maximum pool elevation of 503.6 feet was used for hydraulic breach modeling and downstream hazard assessment. The above responses from the Corps confirm the use of this water surface elevation.

Final Panel Comment 7

Standard Penetration Tests (SPTs) do not appear to correspond to the shear strength parameters used for the stability analysis conducted in the Seismic Safety Review (USACE, 2003), which could constitute a change in the stability of the critical dam cross section.

Basis for Comment

The remedial plan for seepage control includes four elements which, if properly implemented, will provide a robust and redundant solution. The elements have not been quantitatively evaluated to ensure that slope stability is adequately improved to achieve the minimum required Safety Factors. Extensive field work and monitoring performed since the Seismic Safety Review (USACE, 2003) reveal differing site conditions than originally analyzed. The critical dam cross section modeled in the Seismic Safety Review (USACE, 2003) was at Station (Sta) 40+00 and the outlet works are located at Sta 35+00. Field work along the outlet works revealed zones of soft/loose material that merit reanalysis.

The Panel observes the following:

1. Section 2.5.2, Stability, of the Baseline Risk Assessment (BLRA) Report identifies adopted shear strengths used to evaluate the stability of the embankment. The safety factors presented exceed the minimum factors required. However, the existing filter sand is described as saturated and loose based on the extensive data. Additional loose/soft material was encountered above the filter (approximate top of filter is Elevation [El.] 405 feet) within portions of the embankment material. Some of the SPT results from studies performed after the 2003 stability analysis suggest that variable and lower shear strengths than those analyzed exist in areas including the filter and portions of the embankment. The following address low SPT results above El. 405 feet.
    a. Phase I performed in 2010 and summarized in Table 1 of the BLRA identifies very soft soil above the filter and within the embankment in P-20- El. 474-476 feet. P-20 is located approximately 100 feet upstream of the crest.
    b. Phase I performed in 2010 and summarized in Table 1 of the BLRA identifies very soft soil above the filter and within the embankment in P-21- El. 497-498 feet and at El. 492-493 feet. P-21 was not sampled between El. 497 and 493 feet, nor was it sampled between El. 492-488.5 feet. SPT counts remain soft until El. 487.0 feet. It is reasonable to interpret that this entire zone from El. 498.5 feet to El. 487.5 feet is very soft clay with SPT counts from 2 to 4 blows per foot. P-21 is located approximately 40 feet upstream of the crest.
    c. Phase III performed in 2011 included three borings in the vicinity of P-20

and P-21. A review of the boring logs for B-9L and B-9R reveals that no SPT testing was performed above El. 413.4 feet. A review of the boring logs for C-3L reveals that no testing was performed above El. 407.7 feet.

2. Section 11.2.1, Embankment Piping at Conduit, of the BLRA states:

   "A slight depression was observed on the upstream slope directly over the conduit during the September 2009 Periodic Inspection".

   A trench was excavated in the vicinity of the depression and did not reveal any obvious signs of distress. The Panel observes that the described location of the depression appears to be in the vicinity of the very soft clay described in 1(a) and 1(b) above.

Significance – Medium

The elements of the selected alternative have not been quantitatively evaluated to ensure that slope stability is adequately improved to achieve the minimum required Safety Factors. There is insufficient information to assess the current and future stability of the dam in the vicinity of the outlet works.

Recommendations for Resolution

1. Perform a revised stability analysis using data correlated from the SPT testing from Phases I through IV. Specifically, model the localized loose and soft filter material below approximately El. 405 feet and model the localized soft zone described in items 1 (a) and 1(b) above.
2. Iterate the layer and shear strength to achieve a Safety Factor between 1.0 and the previously calculated 1.6 (steady seepage) to reflect current embankment conditions in the model.
3. Modify the model to verify the interim construction conditions for the planned alternative to confirm that the improvements result in a Safety Factor exceeding the minimum required factors shown in Table 3-1 of the U.S. Army Corps of Engineers' Engineer Manual (EM) 1110-2-1902 (USACE, 1992).
4. Modify the model with the final recommended alternative improvements and analyze to confirm that the improvements result in a Safety Factor exceeding the minimum required factors shown in Table 3-1 of USACE's EM 1110-2-1902 (USACE, 1992).

Literature Cited

USACE (1992). Slope Stability. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Manual (EM) No. 1110-2-1902. October 31.

USACE (2003). Seismic Safety Review – Pine Creek Dam, Little River Oklahoma, Department of the Army, U.S. Army Corps of Engineers, Tulsa District. November.

PDT Final Evaluator Response (FPC#7):

X Concur ___Non-Concur
Explanation:

Parameters used in stability analyses during development of the Risk Management Plans (Alternatives) provided in Appendix III, Formulation of Risk Management Plans of DSMR were adopted from Earth Dam Criteria Report 63, Pine Creek Dam and Lake, Little River Oklahoma, February 1974, by U.S. Army Engineer District, Tulsa, published by U.S. Army Engineer Waterways Experiment Station Corps of Engineers. Additional analyses will be conducted in the Planning, Engineering, and Design phase of the project using information provided in the Pine Creek Dam, Seismic Safety Review, November 2003, U.S. Army Corps of Engineers, Tulsa District as well as laboratory testing performed for geotechnical explorations performed after the November 2003 Seismic Review.

Formulation of Risk Management Plans:

Section 2.6 Element 8 – Downstream (DS) Embankment Replacement (Deficient Filters and Unfiltered Downstream Exit:

Replace:

"The shear strengths and unit weights used in the analyses are outline in Table 5:"

With:

"The shear strengths and unit weights used in the analyses are outline**d** in Table 5. **The parameters were adopted directly from Earth Dam Criteria Report 63, Pine Creek Dam and Lake, Little River Oklahoma, February 1974, by U.S. Army Engineer District, Tulsa, published by U.S. Army Engineer Waterways Experiment Station Corps of Engineers. Additional analyses will be conducted in the PED phase of the project using information provided in the Pine Creek Dam, Seismic Safety Review, November 2003, U.S. Army Corps of Engineers, Tulsa District as well as laboratory testing performed for geotechnical explorations performed after the November 2003 Seismic Review.**"

Recommendation #1: X Adopt __Not adopt
Explanation:

Dam Safety Modification Study Report:

4.6 Recommended Risk Management Plan:

See Final Panel Comment 2 Recommendation #3 and 4 Response for additional information concerning revision.

Replace:

“The following are construction considerations that would need addressed during final design of the chosen alternative:

1. Required work platform of at least 60 feet in length for secant pile construction
2. Evaluation of low frequency damage to conduit if phased construction chosen
3. Evaluation of storm design event for construction of chosen alternative
4. Consideration will be given to expedite implementation of risk management plan in planning, engineering, design, and construction phases.
5. Consideration will be given in planning, engineering and design to adjusting sequence of construction of risk management measures (elements) to expedite project completion and provide additional risk reduction”

With:

“The following **engineering, design, and construction considerations will need to be addressed during planning, engineering, and design phase of the chosen alternative:**

1. **Complete stability analyses of the embankment and excavation slopes to ensure that they meet the required Factors of Safety. Analyses will be performed using data correlated from the SPT testing from Phases I through IV. Model the localized soft zone, specifically below and any soft zones above approximately El. 405 feet**
2. Required work platform of at least 60 feet in length for secant pile construction
3. Evaluation of low frequency damage to conduit if phased construction chosen
4. Evaluation of storm design event for construction of chosen alternative
5. Consideration will be given to expedite implementation of risk management plan in planning, engineering, design, and construction phases.
6. Consideration will be given in planning, engineering and design to adjusting sequence of construction of risk management measures (elements) to expedite project completion and provide additional risk reduction”

Recommendation #2: X Adopt __Not adopt
Explanation:

See Recommendation #1 Response

Recommendation #3: X Adopt __Not adopt
Explanation:

See Recommendation #1 Response

Recommendation #4: X Adopt __Not adopt
Explanation:

See Recommendation #1 Response

Panel Final BackCheck Response (FPC#7):

__X_Concur ___Non-Concur

Based on the Evaluator Responses provided, it appears that the PDT understands that the current embankment condition may be at a critical state and that the PDT will provide quantitative analysis to confirm the remedial actions will meet the required Safety Factors.

Final Panel Comment 8

Bedrock erosion and embankment foundation stability due to uncontrolled spillway discharge under Probable Maximum Flood (PMF) conditions have not been addressed, and their importance as a credible failure mode cannot be evaluated.

Basis for Comment

The Baseline Risk Assessment Report (BLRA) and Dam Safety Modification Report (DSMR) are silent on the subject of the ability of the uncontrolled spillway to safely discharge the PMF design flow. Under PMF conditions, there is 23 feet of head across the 608-foot-long spillway, resulting in a discharge of 246,600 cubic feet per second (cfs) (BLRA Section 2.2.2 Hydrologic Data). There is no erosion protection (other than grass) along the channel downstream of the stilling basin sill.

DSMR Section 3.4.2.1 states that:

1. "In general, the valley section is founded on the hard sandstone beds with minor amounts of shale, whereas the upper embankment is located on the narrow sandstone ridge. The average depth of soil cover is about 4 feet, with a maximum of 15 feet. Soil types range from non-plastic to low plasticity sandy materials (SM, SC, or CL) on the abutment walls. The upland portion of the abutments consists of highly plastic clays (CH)."
2. "The Paluxy Sand forms the foundation for the dike to the right side of the spillway. These sediments are primarily soft, fine to medium-grained, poorly cemented, friable, shaly sandstone and soft, clayey shale and are often indistinguishable from the overburden in drilling operations…. The majority of these deposits are lean clay (CL) clay underlain or inter-lensed by substantial amounts of silty sand (SM) and clayey sands (SC)."

DSMR Section 3.4.2.3 states that:

> "Shale bedrock downstream of the stilling basin begins about 100 feet from the end sill. The shale is moderately hard to very hard below the base of weathering and contains occasional sandstone seams and sandy zones. Excavation for the foundation carried to the fresh gray rock below the secondary weathered zone. The only major construction problem involved a rock slide in the right non-overflow section, as a result of the attitude of the synclinal fold in relation to the excavation limits. The rock wedge slid into the excavation area from the downstream face on a weathered bedding plane along the synclinal folds."

The susceptibility of these materials to erosion is not described.

Typical Embankment Section "A" on as-built drawing 1800-C6-12/1 (of the Supplemental Information provided) shows that the embankment adjacent to the spillway is founded on overburden.

There is no information provided regarding discharge velocities, the susceptibility of foundation soils and bedrock to erosion, and the likelihood of head-cutting that could undermine the existing embankment.

While such a potential failure mode would not affect conclusions regarding the failure modes associated with the outlet works, the ability of the project to safely pass the design flood without additional dam modifications has not been demonstrated.

Significance – Medium

Without a discussion, demonstration, or analysis regarding whether the uncontrolled spillway can safely pass the PMF, the evaluation of credible failure modes is incomplete.

Recommendations for Resolution

1. Provide additional information with regard to uncontrolled spillway discharge velocities, susceptibility of foundation soils and bedrock to erosion under spillway design conditions, and the potential effects of erosion and head-cutting to embankment foundation stability.
2. Provide a copy of the full Potential Failure Modes Analysis Report as an appendix to the BLRA Report to document what failure modes have been considered and evaluated.

PDT Final Evaluator Response (FPC#8):

___Concur _X_Non-Concur

Explanation:

In accordance to USACE ER 1110-2-1156 Appendix X, potential failure modes were classified as not credible or credible and significant. The cadre determined potential failure modes that were credible and significant, and carried those forward through the risk assessment process. PFMS3 Erosion Downstream of Spillway was not considered to be credible nor carried forward through the risk assessment process by cadre for the following reasons as indicated in Section A.4.4 PFMS3 Erosion Downstream of Spillway in BLRA Appendix 13:

1. Would require PMF.
2. Bedrock is composed or erosion resistant quartzitic sandstone with softer shale seams as indicated in Stratigraphy section, Appendix I, BLRA
3. Bedrock bedding is parallel to the spillway axis, thus shale seams to not form transverse features relative to spillway or stilling basin. Same bedrock exposed in outlet works has been exposed to flows similar to expected PMF without eroding."

Recommendation #1: __Adopt _X_Not adopt
Explanation:

Action Taken:

Dam Safety Modification Report:

Section 4.2.1 Baseline Condition:

Replace:

"Five Potential Failure Modes (PFM) were considered to be Significant and Credible and estimated during risk analysis process. These five failure modes are:"

With:

"Five Potential Failure Modes (PFM) were considered to be Significant and Credible and estimated during risk analysis process. **All other potential failure modes required to be evaluated in accordance to EM 1110-2-1156 were not considered by Risk Cadre to be Significant and Credible.** The five failure modes **considered by Risk Cadre to be Significant and Credible** are:"

Recommendation #2: X Adopt __Not adopt
Explanation:

Appendix I, Baseline Risk Assessment Report:

List of Appendices:
Replace:

APPENDIX 13 - RISK ASSESSMENT CONSEQUENCE
With:

APPENDIX 13 - **POTENTIAL FAILURE MODE DISCUSSION**
APPENDIX 14 - RISK ASSESSMENT CONSEQUENCE

Section 5.2.4 PFMOW4A, B Failure to Operate Outlet Gates:

Replace:

Impacts of Failure

The consequences of failure include loss of life and economic damages. These consequences are discussed in detail in Chapter 8 of this report. The develop of the consequences were discussed in the PFMA and Risk Estimation sessions including the location of the potential failure modes and an estimation of times for the various failure modes to develop were made for use in estimating the failure mode warning time.

With:

“Impacts of Failure

The consequences of failure include loss of life and economic damages. These consequences are discussed in detail in Chapter 8 **and Appendix 14** of this report. Develop**ment** of the consequences **was** discussed in the PFMA and Risk Estimation sessions including the location of the potential failure modes and an estimation of times for the various failure modes to develop were made for use in estimating the failure mode warning time.”

Section 8.1 Consequence Assessment Overview:

Replace:

Dollar values for estimated costs are in the 2012 price level; discounting from future costs and benefits was done at 4%. Population and loss of life estimates are based on 2010 Census Bureau data. Both the PAR and Loss of Life have been updated since the Baseline Risk Assessment was performed.

With:

Dollar values for estimated costs are in the 2012 price level; discounting from future costs and benefits was done at 4%. Population and loss of life estimates are based on 2010 Census Bureau data. Both the PAR and Loss of Life have been updated since the Baseline Risk Assessment was performed. **The consequences are discussed in detail in Appendix 14 of this report.”**

Appendices:

Add discussion in Appendix 13 Potential Failure Mode Discussion

Panel Final BackCheck Response (FPC#8):

_X_Concur __Non-Concur

Bedrock is massive enough and overburden is shallow enough that the Panel is satisfied that this issue has been addressed.

Final Panel Comment 9

The cause of the minor pin-boils observed at station 30+00 under higher pool levels has not been fully evaluated and could pose a long-term concern for the integrity of the dam, especially under high-pool conditions.

Basis for Comment

Baseline Risk Assessment Report (BLRA) Section 9.1.2.2.2 on Potential Failure Mode E3 (PFME3) – *Foundation-Embankment interface piping in the vicinity of Station 30+00* – describes minor seepage and pin-boils observed near station 30+00 during high pools and indicate that there is a saddle in the top of rock in this area that tends to concentrate seepage flows in the blanket drain. Dam Safety Modification Report (DSMR) Section 3.2.2 notes that the Pool of Record was El. 475.10 in May 2009. As-built drawing 1800-C6-2/2 shows the assumed top of rock at the dam axis at approximately El. 460 near station 30+00A. As-built drawing 1800-C6-12/1 (Typical Embankment Section "E") shows that the blanket drain is constructed on native soil in this area.

Therefore, the Pool of Record was not more than about 15 feet above the bedrock foundation and even less above native soils. With the Probable Maximum Flood (PMF) pool at approximately El. 503, the gross head over top of rock and native foundation soils would be roughly three times greater than previously experienced.

The Panel agrees with the recommendation in the BLRA Section 9.1.2.2.2 that seepage collection be improved such that quantities of seepage can be monitored, collected, measured, and evaluated for the presence of sediments. However, the statement in Section 9.1.2.2.2 that the "design of the dam appears to have addressed this failure mode adequately given the chimney/blanket filter and the favorable geologic conditions" does not seem consistent with either that recommendation or the observation of pin-boils under relatively low head. Additionally, further detail on the evaluation of this potential failure mode (PFM) is not provided in BLRA Section 5.0, while details are provided for other cited PFMs.

The annual probability of failure for this PFM as presented in BLRA Figure 90 seems very low considering the information provided. Additionally, it is not clear whether the likelihood of failure at the design head (the PFM for this critical structure) is based on seepage analysis (2D or 3D) and whether the system response probability reported in BLRA Table 31 accurately reflects the supporting analyses. Given the conclusion that the saddle near station 30+00 tends to concentrate seepage flows in the blanket drain in that area, a three-dimensional seepage analysis may be warranted to accurately evaluate the probability of this PFM occurring at maximum design head.

This issue does not affect conclusions relative to the most critical failure mode (PFMOW1/2/3), but it raises a concern as to whether the evaluation of PFME3 supports the very low probability estimated for this PFM.

Significance – Medium

Sufficient information is not provided in the report to assess whether the methods, models, or analyses used to evaluate PFME3 are sufficient to support a conclusion that this PFM was adequately addressed by the original design.

Recommendations for Resolution

1. Provide quantitative evaluation (seepage analysis) in the supporting documentation that supports the probability estimates for PFME3.
2. Monitor the outflow of the pin-boils for flow and transported sediment when flowing under high-pool conditions.

PDT Final Evaluator Response (FPC#9):

X Concur _Non-Concur

Explanation:

Appendix I, Baseline Risk Assessment Report incorrectly indicates PFME3 Foundation/Embankment Interface Piping at Station 30+00 of the Main Embankment as a possible failure mode. The risk cadre initially considered PFME3 as a possible failure mode. In addition to the reasons cited in Section 9.1.2.2.2 SRP Estimate for PFME 3 – Foundation-Embankment interface piping in the vicinity of Station 30+00, the cadre concluded that the pin boils were a result of a low point in the blanket drain, where water would naturally drain and exit. Possible silting at the exterior face of the blanket drain would not allow for drainage to occur prior to the point contributing to the increase in pressure at that point. The Risk Cadre concluded the probability of failure caused by erosion at Station 30+00 was relatively low and within tolerable risk guidelines. Further discussion of PFME3 and the reasons for discounting as significant and credible potential failure modes are included in Baseline Risk Assessment Report, Appendix 13, Potential Failure Mode Discussion.

Recommendation #1: __Adopt X Not adopt
Explanation:

Action Taken:

Appendix I, Baseline Risk Assessment Report

Section 5.2 Significant and Credible Failure Modes:

See Final Panel Comment 8, Recommendation #1 Response for additional information concerning revision.

Replace:

Five failure modes were considered to be Significant and Credible and were included in the Risk model. These five failure modes are:

1. PFMD1: Overtopping induced failure of the Dike
2. PFME1: Overtopping induced failure of the Main Embankment
3. PFMOW1: Conduit Piping
4. PFMD3: Soil Foundation Piping below the Dike
5. PFME3: Foundation/Embankment Interface Piping at Station 30+00 of the Main Embankment

With:

“Five Potential Failure Modes (PFM) were considered to be Significant and Credible and estimated during risk analysis process. **All other potential failure modes required to be evaluated in accordance to EM 1110-2-1156 were not considered by Risk Cadre to be Significant and Credible.** The five failure modes **considered by Risk Cadre to be Significant and Credible** are:”

1. PFMD1: Overtopping induced failure of the Dike
2. PFME1: Overtopping induced failure of the Main Embankment
3. PFMOW1: Conduit Piping
4. PFMD3: Soil Foundation Piping below the Dike
5. **PFMOW4A, B: Failure to Operate Outlet Gates**

Section 9.1 Methodology, Description of Methodology, and Risk Estimating Tools:

Replace:

The following five Flood and Flood-Internal failure modes were included in the Flood event tree for Pine Creek dam:

- PFMD1 – Overtopping induced failure of the Dike
- PFME1 – Overtopping induced failure of the Main Embankment
- PFMOW1 – Conduit Piping
- PFMD3 – Soil Foundation Piping below the Dike
- PFME3 – Foundation/Embankment Interface Piping at Station 30+00 of the Main Embankment

With:

The following five Flood and Flood-Internal failure modes were included in the Flood event tree for Pine Creek dam:

- PFMD1 – Overtopping induced failure of the Dike
- PFME1 – Overtopping induced failure of the Main Embankment
- PFMOW1 – Conduit Piping
- PFMD3 – Soil Foundation Piping below the Dike
- **PFMOW4A, B – Failure to Operate Outlet Gates**

9.1.2.2.2 SRP Estimates for PFME 3 – Foundation-Embankment interface piping in the vicinity of Station 30+00:

Replace:

The design of the dam appears to have addressed this failure mode adequately given the chimney/blanket filter and the favorable geologic conditions. The top of rock in this area tends to form a saddle and concentrate seepage flows in the blanket drain. Minor seepage and pin-boils have been noted at the toe of the dam in this area during high pools. Piezometers have been added in this area to confirm water levels in the blanket drain. It is recommended that seepage collection be improved such that quantities of seepage can be collected quantified and trapped for sediments.

With:

The design of the dam appears to have addressed this failure mode adequately given the chimney/blanket filter and the favorable geologic conditions. The top of rock in this area tends to form a saddle and concentrate seepage flows in the blanket drain. Minor seepage and pin-boils have been noted at the toe of the dam in this area during high pools. **As a result, the probability of failure was relatively low and within tolerable guidelines. Additional information concerning the development of this potential failure mode is located in Appendix 13 Potential Failure Mode Discussion.** Piezometers have been added in this area to confirm water levels in the blanket drain. It is recommended that seepage collection be improved such that quantities of seepage can be collected quantified and trapped for sediments. **In addition, the outflow of the pin-boils will be monitored for flow and transported sediment when flowing under high-pool conditions which is particularly important due to the presence of dispersive soils encountered within the embankment. Additional information concerning dispersive soils is located in Section 3.5.4.3.4 Laboratory Test Results (Phase I, II, III).**

Recommendation #2: _X_ Adopt Not adopt
Explanation:

See last Action Taken in Response for Recommendation #1.

Panel Final BackCheck Response (FPC#9):

__X_Concur ___Non-Concur

Dispersion is still a concern of the Panel and the monitoring will be important to provide further analysis as the project moves forward.

Final Panel Comment 10

Eleven threatened and endangered species were reported, yet a description of the specific species, the probability of them being found in the project boundary area, and potential impacts on these species were not provided.

Basis for Comment

Section 4.5.3 Terrestrial Resources of Appendix VII states that Pine Creek Lake is situated in the western Ouachita Mountains of southeastern Oklahoma and that this area contains one of the greatest concentrations of imperiled or critically imperiled, aquatic and terrestrial species in mid-North America (Woods et al., 2005). No additional information is provided, and the species are not defined. The Draft EA in Appendix VII does not identify any imperiled species within the project study. This statement requires clarification.

The Dam Safety Modification Report (DSMR) states that there are 11 threatened or endangered species, but only two species were mentioned in the main document: the American burying beetle and an endangered mussel (not named). The Draft EA in Appendix VII discusses the state- and county-listed species and their habitats, but not in terms of potential presence in the project boundary area.

When discussing the current pool restriction, the DSMR (p. 133) states that "Lowering the pool also impacts the fishery in the lake, the endangered mussels downstream of the dam,…". Potential impacts are not defined. This mussel is not discussed elsewhere in the document and is not named under the environmental resources section. Overall, Section 4.2.4.5.8 of the main report, Threatened and Endangered Species, does not adequately describe the existing conditions; therefore, potential impacts to these species cannot be evaluated.

The Draft EA, Appendix VII (p. 55) notes that soil disturbance associated with construction-related activities implemented under the recommended plan could adversely impact the American burying beetle, if the species is present in the project area. The document reports that no American burying beetle surveys have been conducted in 2012 in or near the vicinity of Pine Creek Lake Dam. More information is required regarding the American burying beetle, its habitat, and specifically what impacts may occur. The document also does not provide information on when the most recent American burying beetle survey was conducted in or near the project area.

In addition, Harperella (*Ptilimnium nodosum*) is an annual herb listed in the Draft EA under threatened and endangered species. McCurtain County, Oklahoma, is within the documented range of the American burying beetle, and there is potential habitat within the project area that may support Harperella (p. 38). While the presence of both of these species has not been confirmed within the project area, suitable habitat may exist. Ground disturbance and decreased lake water levels associated with the proposed actions may impact areas with potentially suitable habitat. Impacts to the American burying beetle, Harperella, and the endangered mussel are possible. If impacts will occur and mitigation is needed, potential impacts need to be defined to take into account construction scheduling and costs and the benefits forgone if construction time is extended.

According to the most current 2012 American burying beetle survey results available from the U.S Fish and Wildlife Service (USFWS) Oklahoma Ecological Services Field Office, no beetles were found to be present (USFWS, 2012). Appendix VII (p. 63) states that

> "Prior to initiation of soil disturbing activities along the dike and the embankment, the Tulsa District will coordinate [American burying beetle] survey efforts and data collection under the conditions of the most current Biological Opinion in effect at that time."

At present, no surveys have been conducted for Harperella on federal lands managed at Pine Creek Lake. Before maintenance activities associated with the dam safety modification are started and woody vegetation is removed, the Panel understands that the U.S. Army Corps of Engineers (USACE) will consult with the USFWS in accordance with Section 7 of the Endangered Species Act and in compliance with the most recent Biological Opinion in effect at that time. Yet, no mitigation measure was defined to make sure this recommendation goes forward.

The DSMR (p. 150) states that a "No Action" decision would not reduce the likelihood of dam failure that could result in substantial adverse impacts to terrestrial resources on project lands and lands downstream of Pine Creek Lake Dam. The impacts to these species have not been adequately described.

Significance – Medium

Without an evaluation of potential impacts to threatened and endangered species that may occur in the project area, the report's overall analysis of the environmental impacts to terrestrial resources is incomplete.

Recommendations for Resolution

1. Include a list of individual threatened and endangered species and their potential to occur within the project area in Section 4.2.4.5.8 Threatened and Endangered Species of the document, including identifying the unnamed endangered mussel.
2. Define the species of concern with regard to the statement in the DSMR that "this area contains one of the greatest concentrations of imperiled or critically imperiled, aquatic and terrestrial species in mid-North America."
3. Identify potential impacts to the endangered mussel, and include impacts on construction scheduling and costs and the benefits forgone if construction time is extended due to the presence of the mussel or Harperella.
4. Define mitigation measures for these species if needed. For example, a mitigation

measure for this project may read: “Prior to initiation of soil-disturbing activities along the dike and the embankment, the Tulsa District will coordinate survey efforts and data collection under the conditions of the most current Biological Opinion in effect at that time for the American burying beetle, Harperella and endangered mussel. All avoidance measures within the USFWS biological opinion should be implemented.”

PDT Final Evaluator Response (FPC#10):

X Concur __Non-Concur

Explanation:
A description of each of the 11 T&E species potentially present within the project area is included in Section 4.6 of the Draft EA. Likely impacts to T&E species is presented in Section 5.2.8 of the Draft EA and indicates that no T&E species would be significantly adversely impacted by the IRRM pool restriction to 433.00 feet. Section 5.2.8 indicates the only T&E species likely to be impacted by DSM activities and vegetation removal along the dike is the American burying beetle due to soil disturbing activities. Section 5.2.8 additionally states that "Prior to start of maintenance activities associated with the DSM and removal of woody vegetation the USACE will consult with the USFWS in accordance with Section 7 of the Endangered Species Act and in compliance with the most recent Biological Opinion in effect at that time." The probability of encountering ABB in the project area is low based upon a review of the most recent ABB survey results reported to the USFWS. While the Ouachita Mountains area of southeastern Oklahoma is an area with great concentrations of imperiled or critically imperiled aquatic and terrestrial species (i.e., numerous T&E freshwater mussel species), there are no currently or historically documented T&E mussel populations in the immediate vicinity of the Pine Creek Project. The nearest documented T&E mussel populations are well downstream of the Dam and are located in the Little River, downstream of the Pine Creek confluence. Consultation with the USFWS is ongoing and will continue through public and agency review of the Draft EA. If necessary, a mitigation plan would be developed and incorporated into the Final EA following completion of coordination with the USFWS in compliance with the Fish and Wildlife Coordination Act.

Recommendation #1: X Adopt __Not adopt
Explanation:

Appendix VII, Draft Environmental Assessment (EA):

Section 4.6 Threatened and Endangered Species

Add: Listing of the 11 T&E species in Table 4.6

Recommendation #2: X Adopt __Not adopt
Explanation:

Appendix VII, Draft Environmental Assessment (EA):

Section 4.6 Threatened and Endangered Species

Add: A description of each T&E species with a potential to be present within the project area, as well as the more generally defined “Ouachita Mountains of southeastern Oklahoma

Recommendation #3: __Adopt X Not adopt
Explanation:

No significant impact to T&E plant and mussel species will result from DSM activities associated with the selected alternative (Alternative 7). Surveys for the American burying beetle will be conducted in accordance with USFWS guidelines prior to soil disturbing activities associated with the DSM and woody vegetation removal along the dike. The District will comply with requirements of the Biological Opinion in effect at the time construction activities start and prudent avoidance measures would be implemented.

Recommendation #4: __Adopt X Not adopt
Explanation:

At present, the environmental assessment concludes there would be no significant impacts to T&E species with a potential to be present on federally managed lands adjacent to Pine Creek Reservoir and Pine Creek Dam or downstream of the Project. Coordination with the USFWS is ongoing and, if necessary, this recommendation may be adopted in the future based upon additional recommendations provided in compliance with the Fish and Wildlife Coordination Act.

Panel Final BackCheck Response (FPC#10):

_X_Concur __Non-Concur

Final Panel Comment 11

The U.S. Geological Survey (USGS) 10-meter Digital Elevation Model (DEM) topographic data used to develop hydraulic models, map downstream flood hazards, and ultimately determine dam breach consequences may not be commensurate with the vertical accuracy as stated in the Baseline Risk Assessment (BLRA).

Basis for Comment

Calculations for loss of life and economic consequences are a direct function of inundation depths, and these, in turn, are based on the topography of the downstream study area. The USGS 10-meter DEM topographic data used for the study is considered low resolution when loss of life and economic consequences are based upon flood depths of two feet. Lack of topographic resolution implies uncertainty with regard to the calculation/computation of loss of life and economic consequences resulting from interpolation of flood elevations.

According to the Baseline Risk Assessment Report, Appendix C, Section C.3.5, USGS 10-meter DEM topographic data were used to develop the hydraulic models, post-process results, map inundation boundaries, generate depth grids, and assess consequences. As discussed in the report, these topographic data were considered the best available. In addition, as stated in the Baseline Risk Assessment Report (draft), Appendix 13, Section C.2.6, the hazard area used to identify the population at risk (PAR) is defined as the boundary within which the flood depth is greater than two feet. These hazard areas were defined by inundation grids using a Geographic Information System (GIS) based on USGS topographic data.

It is common for USGS DEMs to be derived from the elevation contours provided on USGS 1:24,000-scale topographic maps. One-half a contour interval is standard industry practice for estimating the vertical accuracy of USGS 1:24,000-scale topographic maps. Examples of applicable USGS topographic maps include the USGS Wright City and Idabel Quadrangles (7.5-Minute Series, 1:24,000-scale), which have contour intervals (c.i.) of 20 feet and 10 feet, respectively. In order to accurately determine flood depths of two feet, a vertical accuracy of one foot (c.i. = two feet) may be required.

With regard to Hydrologic Engineering Center-River Analysis System (HEC-RAS) model development using USGS topographic data, according to the Baseline Risk Assessment Report, Appendix C, Section C.3.7.4, the utilized USGS DEM showed limited channel detail; therefore, the channel Design/Modification editor in HEC-RAS was utilized to “cut” the Little River channel into each cross-section. These “cut” cross-sections were based on templates created from channel measurements estimated from aerial photography. Inverts for channel templates were based on information provided in the Water Control Manual.

As suggested by Ackerman and Brunner (2006) of the U.S. Army Corps of Engineers

(USACE) HEC in Davis, California:

> "If the cross-sectional data came from a low resolution terrain model the channel data will not be represented in the cross section. For a large flood wave resulting from a dam break, the channel data may not be significant. The importance of the channel portion of the total cross-sectional conveyance will need to be evaluated: if the channel conveyance is rather small compared with the total conveyance, for instance, the peak stage of the flood wave may not be significantly affected. To perform the dam breach analysis, however, RAS will need a channel for the low-flow portion of the simulation."

Significance – Low

Given the conservative nature of the probable dam failure modes that were modeled in HEC-RAS (see dam failure mode *PFMOW_503* as described in the Baseline Risk Assessment Report, Appendix C), the resultant flow depths and inundation area used to determine potential life safety issues and economic consequences – which are based on low-level resolution topography – are likely conservative in nature, but would not affect the recommended plan.

Recommendations for Resolution

1. Discuss the potential impacts of the low resolution mapping on the study results.
2. Investigate potential sources of additional mapping data (for example, mapping used for Federal Emergency Management Agency [FEMA] detailed studies).
3. If deemed necessary after further consideration, obtain detailed channel cross-section(s) for each reach of the Little River conveying a significant portion of the flood flow. The number of cross-sections could be limited to the number necessary to verify that the templates used to "cut" the river channel in the HEC-RAS model were representative of the existing channel conditions.

Literature Cited

Ackerman, C., and Brunner, G. (2006). *Dam Failure Analysis Using HEC-RAS and HEC-GeoRAS*. Third Federal Interagency Hydrologic Modeling Conference, Reno, Nevada. April. Available at http://acwi.gov/hydrology/mtsconfwkshops/conf_proceedings/3rdFIHMC/11F_Ackerman.pdf. Accessed March 8, 2013.

PDT Final Evaluator Response (FPC#11):

___Concur _X_ Non-Concur

Explanation:

The modeling used for the risk assessment incorporates the best available topographic data available for this reach. Extensive searches by the district and MMC have not shown the availability of more refined elevation data. Even thought the 10m DEM is a standard base layer for model development within the MMC for risk models, the models do include checks to verify the legitimacy of the results. These checks have been included into the Pine Creek model and include: 1) a flow calibration of discharges below the dam at representative locations to verify that channel capacity flows do not cause flooding outside of the channel bounds, 2) Sensitivity test on breach parameters and resulting flow hydrographs to determine if downstream water surfaces vary greatly based on extreme inundation levels, and 3) sensitivity of roughness values to determine sensitivities of immediate overbank areas. The checks generally will expose DEM inconsistencies which may cause varied results.

Recommendation #1: __Adopt X Not adopt
Explanation:

The model was calibrated to channel capacity discharges based on downstream gage data and real time water control management.

Recommendation #2: __Adopt X Not adopt
Explanation:

No FIS study data was available in the area. Standard procedures include searches for supplemental topographic data in the region.

Recommendation #3: __Adopt X Not adopt
Explanation:

The model was calibrated to channel capacity discharges based on downstream gage data and real time water control management.

Panel Final BackCheck Response (FPC#11):

__X_Concur __Non-Concur

The Panel understands that the PDT attempted to identify other topographic data sources to supplement the USGS 10-meter topographic data. Because no additional topographic data was available the modeling which utilized this topography was then calibrated based on stage gage data which provided a more accurate relationship between the modeling output and the topographic data.

Final Panel Comment 12

The operation, maintenance, repair, replacement and rehabilitation (OMRR&R) efforts are not adequately described, and it could not be determined if the proposed costs are reasonable.

Basis for Comment

The term "operation, maintenance, repair, replacement and rehabilitation (OMRR&R)" is not adequately described, which prevents the Panel from assessing whether all of the life-cycle costs for maintaining the various alternatives have been considered.

In Table 50 (ALARP Summary Table) of the Dam Safety Modification Report (DSMR), the difference in annual O&M costs for the baseline condition and the various structural alternatives is not more than $33,316, and there is no difference in annual O&M costs between "Make IRRM Permanent," "Non-Structural Plan 1," and many of the structural alternatives. One could expect the O&M costs for most, if not all, of the alternatives to be less than the baseline, since the alternatives would be new and built to better criteria while the existing condition represents a 43-year-old structure. However, there is no further detail regarding the breakdown of O&M costs in the DSMR.

Repair costs appear to be a line-item apart from the "repair" in OMRR&R (Tables 50 and 51) because it addresses "repair" in a fix-as-fails situation costing an estimated $40 million (DSMR, p. 13 and Table 3; section 6 of Appendix II). Section 6 of Appendix II states:

> "Costs to repair or rebuild Pine Creek Dam in the event of failure were based on the original cost of the dam brought to current price levels…"

Regardless of classification, it would seem that the repair cost would be equal to or greater than the cost given for Alternative 5 – close to $100 million.

It is the Panel's interpretation that costs to date for the various investigations, studies, and grouting and backfilling operations for the outlet works would be extrapolated to estimate the future O&M costs for the baseline condition. However, with little or no apparent cost difference indicated in Table 50 (O&M) and Table 51 (OMRR&R), it is not clear whether they are captured in the economic analysis.

Significance – Low

This issue affects the technical clarity of the DSMR and completeness of the economic comparison of alternatives.

Recommendations for Resolution

1. Provide details supporting the O&M costs associated with the various risk reduction alternatives that clearly support the reported values and document the differences.

PDT Final Evaluator Response (FPC#12):

X Concur ___Non-Concur

Explanation:

Additional information has been included in Dam Safety Modification Report, Section 4.4.1 Operations, Maintenance, Repair, Replacement, Rehabilitation (OMRR&R) to explain how OMRR&R was determined.

Recommendation #1: X Adopt __Not adopt
Explanation:

Dam Safety Modification Report:

Add:

Section 4.4.1 Operations, Maintenance, Repair, Replacement, Rehabilitation (OMRR&R)

All risk management plans (alternatives) assume the same level of Operations, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) as current conditions. OMRR&R for all plans were estimated for 50 years. The present value was then annualized over 50 years to determine an annual OMRR&R cost. Non-Structural Alternatives 2, 3, and 4, Structural Alternatives 3 and 4, and No Action (baseline condition) have additional OMRR&R amounts For the Non-Structural Alternatives 2, 3, and 4, an additional $100,000 per year was included to account for additional table top exercises, additional public meetings, testing of sirens and O&M on existing sirens. Additional OMRR&R for the No Action (baseline) was estimated to be $400,000 every ten years. The additional OMRR&R would be for joint resealing efforts based on similar rehabilitation projects in the district. For structural alternatives 3 and 4, additional OMRR&R of $250,000 was projected every ten years for recoating the steel pipe. Similar rehabilitation projects in the district have recoating efforts at the approximate cost of $20 a square foot and this cost was then projected for the size and length of the Pine Creek Conduit.

Panel Final BackCheck Response (FPC#12):

__X_Concur ___Non-Concur

Final Panel Comment 13

Piezometer PZ17 appears to be very responsive to high pool conditions and may indicate an undesirable seepage condition.

Basis for Comment

Baseline Risk Assessment Report Figure 52 shows an atypical response of piezometer PZ17 relative to the reservoir pool. Furthermore, the plots of PZ17 readings in Baseline Risk Assessment (BLRA) Appendix 9 show a substantial scatter of response since the occurrence of maximum pool. This information is presented without providing any analysis or discussion in the review documents of its significance to seepage. This particular piezometer was not sampled during dye testing to identify whether there is a potential seepage path from headwater to this location. Given its proximity to the toe of the dam and its location between the outlet works and the seepage identified at Station 30+00A, some assessment appears warranted.

The rise of pressure at PZ17 in Figure 52 is actually shown to precede the rise in pool elevation, leading the Panel to suspect that either (1) it could be reacting to local runoff or possibly to preemptive discharge through the outlet works, rather than to pool, or (2) there are problems with the data collection. However, no analysis or other evaluation is presented in the review documents to explain these unusual readings, and it cannot be ascertained whether they are indicative of an alternate or branch seepage path.

Significance – Low

This issue does not affect conclusions presented in the review documents with regard to seepage along the conduit, but the report needs to clarify other potential failure modes or seepage paths.

Recommendations for Resolution

1. Provide an evaluation of the PZ17 readings that establishes the significance of its response to high pool conditions and its relevance to dam safety.

PDT Final Evaluator Response (FPC#13):

__X Concur ___Non-Concur

Explanation:

The significance of the response of PZ17 is noted in Dam Safety Modification Report is noted in Section 3.5.4.6.2 Pool Rise Versus Piezometer Response Time in 2012. However, USACE concluded that PZ17 is likely influenced by a groundwater source unrelated to pool. A rise in piezometer level in PZ17 prior to rise in pool is also noted in Figure 61, indicating that the piezometer is likely influenced by other groundwater sources unrelated to pool. A revised plot is attached in Baseline Risk Assessment Report, Additional Geotechnical Explorations and Studies, Instrumention, "Piezometer

Plots”. PZ17 will continue to be monitored and evaluated as part of the USACE Dam Safety Program.

Recommendation #1: X Adopt __Not adopt
Explanation: Dam Safety Modification Study Report (DSMR):

Section 3.5.4.6.2 Pool Rise Versus Piezometer Response Time in 2012:

Replace: “Piezometer 17 that is installed away from the conduit responded equally. Figure 61 shows the rise in pool, Piezometer 17 and 19. Piezometer 19 had no effect of pool changes.

Conclusion: Most piezometers installed around conduit responded immediately with negligible lag in pool changes indicating rapid movement of seepage that may be attributed to the existence of soft material and void. This seepage path may lead to more material loss and ultimately lead to break if embankment is not repaired.”

With: “Piezometer 17 that is installed away from the conduit responded equally. Figure 61 shows the rise in pool in Piezometer 17 and 19. **A rise in piezometer level in PZ17 prior to rise in pool is also noted in Figure 61, indicating that the piezometer is likely influenced by pool as well as other groundwater sources unrelated to pool.** Piezometer 19 had no effect of pool changes.

Panel Final BackCheck Response (FPC#13):

__X_Concur __Non-Concur

Final Panel Comment 14

Various key inputs to the economic analyses, such as including the cost of repairing damage to the dam as a potential direct loss, were not provided or explained and could result in an inaccurate final cost analysis.

Basis for Comment

Some components of the economic analysis have not been adequately explained. Specifically, depth-damage percentage losses, dam rebuilding costs, and impacts to agriculture cannot be confirmed.

Depth-Damage Percentage Losses

Application of the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center-Flood Impact Analysis (HEC-FIA) software and its input is the basis for the Pine Creek Lake Dam Safety Modification (DSM) dam failure economic loss results. The largest category of losses for higher-elevation failure event cost (Dam Safety Modification Report [DMSR], Table 34, p. 147,) covers structures and their contents and vehicles. The report appears to use the Federal Emergency Management Agency's (FEMA) Hazus dataset without clarification (p. 18 of Appendix II). Based on a single reference to depth-damage input being the 100% loss of a vehicle at a submergence of three feet, the Panel is concerned that depth-damage percentage losses do not coincide with USACE guidance for vehicles (USACE, 2009) and, by extension, to content and structures provided in USACE (2003). In the case of vehicle damage, the report appears to indicate much greater loss than would result from the USACE guidance.

Dam Rebuilding Costs

The Panel has two concerns related to the category labeled "dam repairs" in Table 34. The first is whether it is appropriate to include dam repairs in the analysis. Section 5.3.9.1 of USACE (2011) states:

> "(NOTE: one potential direct loss is the cost of repairing the damage to the dam. This is a complicated issue and to some degree depends on the extent of damage to the dam. If the dam can be repaired, these repair costs could be counted as an economic cost. In the case of catastrophic failure, these rebuilding costs should not be included in the direct costs, as the decision to rebuild the dam depends on the post-failure benefits which would be a separate analysis.)"

Section 4.2.4.4 of the DSMR and p. 5 of Appendix II include dam repair in association with a fail event having a three-year repair period. It is classified as a piping failure.

If the dam failure qualifies for a direct loss, the second concern is that the estimated cost of $40 million (based on updating original construction costs) seems low because the alternative appearing to be closest to the repair is Alternative 5, and its comparative cost to implement is estimated at $99.8 million. Further, the repair cost would have to incorporate current design standards, which would increase the costs. Thus, the economic benefits for any of the alternatives would be considerably understated.

Forgone Benefits
Table 34 contains a category of damages by fail event labeled “flood risk management” and represents the forgone benefits during the three-year dam repair. The estimated $5 million was derived using an accounting of damages prevented over a 43-year period with costs brought to a 2012 price level. This appears to be understated because it represents past populations and their belongings.

Impacts to Agriculture
Agriculture losses are not included in the cost-benefit analysis, and the discussion of the economic contribution of agriculture is not consistent within the document. In the description of existing conditions, Wright City is reported to have a mix of industrial, commercial, and residential land uses, and surrounding areas that also support agriculture. DSMR Section 4.2.4.5.13 states that

> “Land use adjacent to the project area is primarily agricultural…”

However, DSMR Section 1.4.2.2 states that

> “…the inundation area below the dam has a minimal amount of agriculture… [and] crop damages would not be significant…”

This appears incongruous with the previously quoted statement.

As a result of the inconsistency, potential impacts to agriculture cannot be determined. “Since the inundation area below the dam has a minimal amount of agriculture, it was determined that crop damages would not be significant in comparison with other direct damages and therefore were not evaluated”. Moreover, no explanation is given for eliminating potential impacts to agricultural resources from consideration. The report does not provide the basis for determining that crop damages are not significant and does not provide a justification for this determination.

Further, there is no mention of economic impacts related to livestock. It is unclear whether such impacts would occur, whether they are relevant, and, if so, whether they are factored into the estimate of consequences.

Significance – Low

Components of the economic analysis and input data used have not been adequately explained and analysis shows that the considerable predicted damage could be underestimated and may subsequently affect the benefit cost ratios of the alternatives but probably not affect the rank order.

Recommendations for Resolution

1. Provide a concise description of how HEC-FIA works as applied to this study, defining the inputs and the uncertainties associated with the input data and output data.
2. Clarify the importance of agriculture in the project area and justify eliminating agricultural impacts from evaluation.
3. Evaluate dam costs for repair, assess the forgone benefits during the three-year dam repair, and provide revised estimates.
4. Calculate depth-damage percentage losses based on USACE guidance for vehicles.

Literature Cited

USACE (2011).Safety of Dams – Policy and Procedures. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation (ER) No. 1110-2-1156. October 28.

USACE (2009). Generic Depth-Damage Relationships for Vehicles. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Economic Guidance Memorandum (EGM) No. 09-04. June 22. Available at http://planning.usace.army.mil/toolbox/library/EGMs/egm09-04.pdf. Accessed February 28, 2013.

USACE (2003). Generic Depth-Damage Relationships for Residential Structures with Basements. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Economic Guidance Memorandum (EGM) No. 04-01. October 10. Available at http://planning.usace.army.mil/toolbox/library/EGMs/egm04-01.pdf. Accessed February 28, 2013.

PDT Final Evaluator Response (FPC#14):

X Concur __Non-Concur

Explanation:

Additional text has been included to describe how HEC-FIA works and why agricultural benefits were not calculated in Dam Safety Modification Report, Section 4.1 Identify Dam Safety Issues and Opportunities and Section 9 of Appendix II - Economic Consequences.

Recommendation #1: X Adopt __Not adopt

Explanation:

The recommendation is to provide a concise description of how the models employed to analyze potential economic consequence work, discuss the models, input data and explained the uncertainties associated with input and output data. If the concern is the minimal explanation of the model in the DSM Report, additional information is presented in Appendix II, Economic Consequences.

Section 4.1 discusses how the model was used in the study. In addition to the information presently in this section the following additional text will be included: "Property damage assessment was also performed using HEC-FIA. The model estimates flood impacts based on data from HAZards U.S. (HAZUS). HAZUS is a software program developed for the Federal Emergency Management Agency (FEMA) by the National Institute of Building Sciences (NIBS). The program uses mathematical formulas and information about building stock, geology, economic data, and other information to estimate losses. The program generates economic and population data for the study area using census blocks and computes urban and agricultural flood damages based on the input event. Agricultural damages were not computed for dam-failure or non-failure conditions in this study. Property damage assessment includes structure, content, and automobile damages."

The uncertainty in the model, in regards to life loss, is located in Section 3 Model Sensitivity Analysis of Appendix II, Economic Consequences. Since the input for structures is from Census data, the uncertainty in regards to Economic Consequences (dollar damages) would be mostly due to the accuracy of the hydrology (i.e. inundation and depths of flooding) that is modeled for each event but this uncertainty is covered in the hydrology sections of the report.

Recommendation #2: X Adopt __Not adopt
Explanation:

Appendix II, Economic Consequences

Section 9, Agriculture:

The recommendation is to clarify the importance of agriculture in the project area and justify eliminating agricultural impacts from evaluation.

Add: Land use affected by a dam failure at Pine Creek is primarily forests with minimal impacts to agriculture. Acreage information was obtained from the United States Department of Agriculture National Agricultural Statistics Services (NASS). The acreage was broken up into four categories: Cleared, Woods, Water, and Developed. Farmable crops were classified as cleared. At the PMF event, just under 25 percent of the inundated area is cleared acres with the rest being woods, water, and developed. Just over 68 percent of the acres inundated are considered woods. In addition, according to NASS, between 2010-2012, cattle have seen a decrease in numbers in the affected counties. Comparing land use and aerial imagery, most of the cattle operations are located outside of the inundated area. Inclusion of agriculture benefits could potentially be adopted in the future if a planning study is needed (e.g. during PED) to justify project alternatives with a benefit-cost analysis, but currently it is not adopted.

Recommendation #3: __Adopt X Not adopt
Explanation:

The recommendation is to reassess dam repair costs, and forgone benefits. The inclusion of dam repairs was included because the cadre did not think a dam failure would be deemed catastrophic. The cadre estimated a dam fix would take three years and estimated the cost to be $40 million. This estimated amount is within the range of the various structural alternatives examined by the PDT. Historical flood damages prevented were used to determine Flood Risk Management benefits. This value is considered conservative in nature. The area downstream of Pine Creek has seen limited growth and development over the years. Between 2000 - 2010, the area saw a population decline.

The following revisions have been made:

Appendix II, Economic Consequences:

Section 6 Repair Costs:

Replace:

Costs to repair or rebuild Pine Creek Dam in the event of failure were based on the original cost of the dam brought to current price levels and approximate time duration to repair or rebuild the dam. For Pine Creek, a piping failure along the outlet works had estimated repair costs of $40,000,000 based on the risk cadre discussion.

With:

Cost to repair Pine Creek Dam in the event of a breach was based on original costs of the dam brought to current price levels and approximate time duration to repair the dam. The risk cadre assumed current building practices would be implemented. For Pine Creek, a piping failure along the outlet works was assumed to cost $40,000,000. **The risk cadre assumed the fix would be approximately 25 percent of the updated construction cost. The risk cadre estimate is considered conservative. The risk cadre estimated this value before alternatives were determined. As the study moved forward, the alternative closest to the repair (alternative 5), had a construction cost of approximately $96.3 million dollars.**

Recommendation #4: __Adopt X Not adopt
Explanation:

The recommendation is to calculate depth-damage percentage losses based on USACE guidance (USACE, 2003) for vehicles. Updating the depth-damage percentage losses in the report could potentially be adopted in the future if a planning study is needed (e.g. during PED) to justify project alternatives with a benefit-cost analysis, but currently it is not adopted. USACE EGM No. 04-01 and EGM No. 09-04 are guidance for studies dealing in Flood Risk Management (i.e Flood damage reduction studies). These studies deal with justifying the level of protection for a storm event (e.g. 100 year and 500 year event or 1% and 0.2% exceedance event) and these curves would be used in a flood damage reduction analysis model such as HEC-FDA. The DSM report is not a flood reduction study where the project alternatives are assessed on the level of protection it provides. The DSM project alternatives are rather assessed on how they lower the probability of failure of the dam. Therefore, in the without project condition the assumption is a failure at a certain pool level and the consequence of it (i.e. a singular event). The reason is the HAZUS dataset that the HEC-FIA model used had its own specific occupancy type with predefine depth damage curves for the different types of structures. These depth damage curves for structure, content, and vehicle were assumed to be sufficient to capture the estimated economic consequence resulting from a dam failure which is a singular event.

Panel Final BackCheck Response (FPC#14):

__X_Concur __Non-Concur

Revisions to the report will not change the rank order of the alternatives or the priority of the dam safety modification but could delay the urgency of completing the report. However, the Panel believes that the report would benefit from some explanation of why the USACE does not believe that the “dam failure would be catastrophic as described by Section 5.3.9.1 of USACE (2011) which states:

> “(NOTE: one potential direct loss is the cost of repairing the damage to the dam. This is a complicated issue and to some degree depends on the extent of damage to the dam. If the dam can be repaired, these repair costs could be counted as an economic cost. In the case of catastrophic failure, these rebuilding costs should not be included in the direct costs, as the decision to rebuild the dam depends on the post-failure benefits which would be a separate analysis.)”

The Panel envisions a dam failure to be where the outlet works are located. Even if the culverts were not washed out, they could not be reused or replaced in kind as they would not meet current design criteria. Such a repair or replacement would more closely match alternative 5 and increase the benefit to cost ratio.

Final Panel Comment 15

The chemical composition of the grouting material and sealant is not described, and the potential for short-term impacts on aquatic species has not been considered.

Basis for Comment

Grout is applied to reduce leaks during maintenance activities, and grouting was considered in the alternatives evaluated. The chemical composition of the grouting material and sealant has not been presented. Due to the method of implementation (pumping under pressure), it is possible that this material will end up in downstream resources either from excess material oozing out while semi-fluid or from degradation of the material over time.

In the Dam Safety Modification Report (DSMR) (p. 158), in order to justify eliminating element 1, one concern defined is “contamination of the filters with grout”. This suggests that some material does become mobilized and trapped in filters. The report does not discuss potential impacts resulting from mobilization of this material into downstream natural resources or potential short-term impacts on aquatic species. Therefore, it is uncertain what impacts (if any) these applications may have. Potential impacts to water resources and downstream aquatic species are required to be evaluated by the National Environmental Policy Act (NEPA).

Significance – Low

Because the chemical composition of the grout and sealant has not been adequately described, potential short-term impacts to downstream natural resources resulting from mobilization of grout cannot be evaluated.

Recommendations for Resolution

1. Provide information regarding the chemical composition of grout and sealant.
2. Identify potential impacts on downgradient natural resources from grout mobilization or from degradation over time, or demonstrate that no impacts are likely to occur.
3. Prepare and implement a water quality monitoring program, including pH and electrical conductivity (EC), immediately prior to and during grouting. Continue monitoring through initial set of the grout.

PDT Final Evaluator Response (FPC#15):

X Concur ___Non-Concur

Explanation:

Currently impacts to aquatic resources due to additives included in grout mix design are unknown and not quantified. Any additives incorporated into grout mix designs for grouting purposes included in the selected alternative will be assessed, with regard to aquatic resources impacts, during the design and specifications phase prior to initiation of construction. If additives incorporated into grout mix designs during construction are shown to result in impacts to aquatic resources, a supplement to the existing Environmental Assessment will be prepared by the Tulsa District at that time.

Recommendation #1: __Adopt X Not adopt
Explanation:

Information regarding the chemical composition of grout and sealant is not currently known.

Recommendation #2: X Adopt __Not adopt
Explanation:

Appendix VII, Environmental Assessment (EA):

Section 5.2.2.2 Aquatic Resources:

Add: Information regarding the general impacts of associated with grouting activities on water quality and aquatic resources.

Recommendation #3: __Adopt X Not adopt
Explanation:

While a Section 404 permit has been issued by the Tulsa District Regulatory Office (NWP 3), coordination with the Oklahoma Department of Environmental Quality is still ongoing. If chemical additives used in grouting and sealant mixes are determined to result in possible significant impacts to aquatic resources, requirements for water quality monitoring would be incorporated into a Section 401 Permit issued by ODEQ (if required). Alternatively, this recommendation could be adopted by the District in the future following assessment of chemical additives used in grouting and sealant mix designs.

Panel Final BackCheck Response (FPC#15):

_X_Concur __Non-Concur

Comment Report: All Comments
Project: Pine Creek Reservoir - Dam Safety Modification Study (DSMS)
Review: IEPR
Displaying 15 comments for the criteria specified in this report.

Id	Discipline	Section/Figure	Page Number	Line Number
5086665	Geotechnical	n/a	FPC 1	n/a

Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - High)

The length of the proposed cutoff wall of 44 feet may not be long enough to cover the area of potential hydraulic fracturing or embankment defects.

(Attachment: Pine_Creek_Lake_IEPR_FPC_1.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

Revised Mar 15 2013.

1-0 Evaluation **Concurred**
CONCUR

Explanation:

Based on comments made in previous reviews and further evaluation.

Recommendation #1: Adopt
Recommendation #2: Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_1.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-3 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013
Current Comment Status: **Comment Closed**

5086724 Geotechnical n/a FPC 2 n/a
Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - High)

The current schedule for completing remediation does not correspond to the apparent urgency of actions needed to prevent failure as implied by Dam Safety Action Classification (DSAC) I.

(Attachment: Pine_Creek_Lake_IEPR_FPC_2.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Concurred**
Concur

Explanation:

The urgency of the project was applied immediately upon notice of DSAC I with direction to start DSMS process rather than completing an Issue Evaluation Study (IES) which is required to evaluate both confirmed and unconfirmed issues related to concerns of the dam. Consideration was given to both remediating the dam expeditiously and meeting "As-Low-As-Reasonably-Possible" (ALARP) considerations. The construction sequence for the risk reduction plans allow for each measure to be constructed in a manner which reduces the risk as each subsequent measure is constructed by reducing the flow of water and pressure through the system. In addition, risk reduction measures, Element 5A (modified cut-off wall) and Element 4 (chimney filter) installed prior to Element 9A (modified downstream filter) allow for a reduction of head in design subsequently making the Element 9A much smaller in comparison to Element 9 (downstream filter) for a cost savings of $600,000. Finally, Interim Risk Reduction Measures (IRMMS) have been implemented to immediately address the concerns at the project until the permanent risk reduction measures can be designed. The most significant measures included installation of a downstream inverted filter and operational changes including a pool and release restriction.

Recommendation #1: Adopt
Recommendation #2: Not Adopt
Recommendation #3: Adopt
Recommendation #4: Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_2.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur
From the responses provided it appears that the PDT understands that the current embankment condition may be at a critical state and that any means to expedite the remedial actions should be pursued.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

Current Comment Status: **Comment Closed**

5086734	Hydrology	n/a	FPC 3	n/a

Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Medium)

Pertinent hydrologic and hydraulic calculations, modeling, and mapping are not fully presented in Appendix 12 of the Baseline Risk Assessment Report; therefore, the full extent of the breach routing and resulting downstream flood hazards could not be determined.

(Attachment: Pine_Creek_Lake_IEPR_FPC_3.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

Revised Mar 15 2013.

1-0 Evaluation **Non-concurred**
Non-Concur

Explanation:

A detailed report on the hydrologic and hydraulic calculations was developed and provided to the IEPR panel. All information describing the analysis and specific to the comment recommendations #1 through #3 are included. The report also details information concerning the inundations developed by the Modeling, Mapping and Consequences (MMC).

See attached for additional Action Taken.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 27 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_3.docx)

1-1 Backcheck Recommendation **Open Comment**
Concur
The intent of FPC No. 3 was to recommend that supplemental hydrologic and hydraulic modeling information be included as appendix material to Appendix 12 of the Baseline Risk Assessment Report, which would provide the reader with an opportunity to more fully understand the more detailed aspects of the hydrologic and hydraulic modeling and flood hazard mapping efforts. The supplemental modeling information was provided in mid-review, which only provided 2 working days before panel review comments were due; therefore, given the scope and duration of the review process, a thorough review was not able to be performed. The issues, needs, constraints and opportunities associated with the recommended dam improvements are primarily civil structural/geotechnical in nature; and considering this, the initially provided and reviewed hydrologic and hydraulic analyses and flood hazard mapping approaches are adequate for assessment of the Pine Creek Dam flood hazards.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013
Current Comment Status: **Comment Closed**

5087250 Hydrology n/a FPC 4 n/a
Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Medium)

The breach formation time of three hours, associated with each of the six antecedent pool elevations, may not be in accordance with dam breach analysis guidelines and criteria.

(Attachment: Pine_Creek_Lake_IEPR_FPC_4.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Non-concurred**
Non-Concur

Explanation:

Current USACE guidance recommends an average breach width between 0.5 and 3 times the height of the dam and breach formation times between 0.5 and 4 hours. The initial breach parameters were within these limits. During the risk assessment discussion, the multi-discipline team decided to alter the parameters. This Expert Elicitation process is reasonable for all risk evaluations and takes into account the knowledge of the local project with the expertise of the evaluators.

Recommendation #1: Not Adopt
Recommendation #2: Not Adopt
Recommendation #3: Not Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_4.pdf)

1-1 Backcheck Recommendation **Open Comment**

Concur

The explanation provided above implies a high level of consideration of breach parameters through the breach parameter sensitivity analysis performed by the USACE's multi-discipline team of experts. Furthermore, USACE guidance and local project knowledge were used in the development of the dam breach parameters.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

Current Comment Status: **Comment Closed**

5087252 Hydrology n/a FPC 5 n/a

Comment Classification: **For Official Use Only (FOUO)**

(Document Reference: Significance - Medium)

Coincidental flood releases from Broken Bow and DeQueen Lakes were not considered during hydraulic modeling, which could result in increased flood stage and the inundation area on the Little River in the vicinity of the subject tributaries.

(Attachment: Pine_Creek_Lake_IEPR_FPC_5.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Non-concurred**

Non-Concur

Explanation:

The release interactivity between Pine Creek, Broken Bow and DeQueen is unknown and varies greatly since these are controlled reaches. A sensitivity analysis was conducted to account for the inconsistency of the coincident discharges. Sensitivity of PMF pool non-failure and failure simulations at Pine Creek Lake with discharges from Broken Bow Dam and DeQueen Dam increased from low flow to high, but controlled, flood discharges commensurate with very infrequent flood events resulted in little change in computed stage and inundation along the Little River.

Recommendation #1: Not Adopt
Recommendation #2: Not Adopt
Recommendation #3: Not Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_5.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur
The sensitivity analysis discussed above is an adequate approach to determine the necessity of coincidental flood release modeling.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

Current Comment Status: **Comment Closed**

5087259 Hydrology n/a FPC 6 n/a

Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Medium)

There are discrepancies between reported maximum high pool elevations associated with the Probable Maximum Flood (PMF), which could significantly increase the flood volumes, flow depths, and inundation area.

(Attachment: Pine_Creek_Lake_IEPR_FPC_6.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

Revised Mar 15 2013.

1-0 Evaluation **Non-concurred**
Non-Concur

Explanation:

The reasons for having "discrepancies" throughout the report resulted from several factors including the context of when analysis was performed and the level of accuracy used. Our opinion is that we need to remain within the context of when the PFMA was performed as well as where we were at that point in time with the development of the PMF (May 2011 report versus May 2012 report).

See attached for additional Action Taken.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 27 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_6.pdf)

Backcheck not conducted

2-0 Evaluation **Non-concurred**
Non-Concur

Explanation:

The reasons for having "discrepancies" throughout the report resulted from several factors including the context of when analysis was performed and the level of accuracy used. Our opinion is that we need to remain within the context of when the PFMA was performed as well as where we were at that point in time with the development of the PMF (May 2011 report versus May 2012 report).

See attached for additional Action Taken.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 27 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_61.pdf)

2-1 Backcheck Recommendation **Open Comment**
Concur
FPC#6 was prepared primarily to confirm that the maximum pool elevation of 503.6 feet was used for hydraulic breach modeling and downstream hazard assessment. The above replies from the Corps confirm the use of this water surface elevation.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

2-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013
Current Comment Status: **Comment Closed**

5087272 Geotechnical n/a FPC 7 n/a
Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Medium)

Standard Penetration Tests (SPTs) do not appear to correspond to the shear strength parameters used for the stability analysis conducted in the Seismic Safety Review (USACE, 2003), which could constitute a change in the stability of the critical dam cross section.

(Attachment: Pine_Creek_Lake_IEPR_FPC_7.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

Revised Mar 15 2013.

1-0 Evaluation **Concurred**
Concur

Explanation:

Parameters used in stability analyses during development of the Risk Management Plans (Alternatives) provided in Appendix III, Formulation of Risk Management Plans of DSMR were adopted from Earth Dam Criteria Report 63, Pine Creek Dam and Lake, Little River Oklahoma, February 1974, by U.S. Army Engineer District, Tulsa, published by U.S. Army Engineer Waterways Experiment Station Corps of Engineers. Additional analyses will be conducted in the Planning, Engineering, and Design phase of the project using information provided in the Pine Creek Dam, Seismic Safety Review, November 2003, U.S. Army Corps of Engineers, Tulsa District as well as laboratory testing performed for geotechnical explorations performed after the November 2003 Seismic Review.

Formulation of Risk Management Plans:

Section 2.6 Element 8 – Downstream (DS) Embankment Replacement (Deficient Filters and Unfiltered Downstream Exit:

Replace:

"The shear strengths and unit weights used in the analyses are outline in Table 5:"

With:

"The shear strengths and unit weights used in the analyses are outlined in Table 5. The parameters were adopted directly from Earth Dam Criteria Report 63, Pine Creek Dam and Lake, Little River Oklahoma, February 1974, by U.S. Army Engineer District, Tulsa, published by U.S. Army Engineer Waterways Experiment Station Corps of Engineers. Additional analyses will be conducted in the PED phase of the project using information provided in the Pine Creek Dam, Seismic Safety Review, November 2003, U.S. Army Corps of Engineers, Tulsa District as well as laboratory testing performed for geotechnical explorations performed after the November 2003 Seismic Review."

Recommendation #1: Adopt
Recommendation #2: Adopt
Recommendation #3: Adopt
Recommendation #4: Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_7.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur
From the comments provided it appears that the PDT understands that the current embankment condition may be at a critical state and that the PDT will provide quantitative analysis to confirm the remedial actions will meet the required Safety Factors.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013
Current Comment Status: **Comment Closed**

5087282	Geotechnical	n/a	FPC 8	n/a

Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Medium)

Bedrock erosion and embankment foundation stability due to uncontrolled spillway discharge under Probable Maximum Flood (PMF) conditions have not been addressed, and their importance as a credible failure mode cannot be evaluated.

(Attachment: Pine_Creek_Lake_IEPR_FPC_8.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Non-concurred**
Non-Concur

In accordance to USACE ER 1110-2-1156 Appendix X, potential failure modes were classified as not credible or credible and significant. The cadre determined potential failure modes that were credible and significant, and carried those forward through the risk assessment process. PFMS3 Erosion Downstream of Spillway was not considered to be credible nor carried forward through the risk assessment process by cadre for the following reasons as indicated in Section A.4.4 PFMS3 Erosion Downstream of Spillway in BLRA Appendix 13:
1. Would require PMF.
2. Bedrock is composed or erosion resistant quartzitic sandstone with softer shale seams as indicated in Stratigraphy section, Appendix I, BLRA
3. Bedrock bedding is parallel to the spillway axis, thus shale seams to not form transverse features relative to spillway or stilling basin. Same bedrock exposed in outlet works has been exposed to flows similar to expected PMF without eroding."

Recommendation #1: Not Adopt
Recommendation #2: Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_8.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur
Bedrock is massive enough and overburden is shallow enough that the Panel is satisfied that this issue has been addressed.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

Current Comment Status: **Comment Closed**

5087290 Geotechnical n/a FPC 9 n/a

Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Medium)

The cause of the minor pin-boils observed at station 30+00 under higher pool levels has not been fully evaluated and could pose a long-term concern for the integrity of the dam, especially under high-pool conditions.

(Attachment: Pine_Creek_Lake_IEPR_FPC_9.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Concurred**
Concur

Explanation:

Appendix I, Baseline Risk Assessment Report incorrectly indicates PFME3 Foundation/Embankment Interface Piping at Station 30+00 of the Main Embankment as a possible failure mode. The risk cadre initially considered PFME3 as a possible failure mode. In addition to the reasons cited in Section 9.1.2.2.2 SRP Estimate for PFME 3 – Foundation-Embankment interface piping in the vicinity of Station 30+00, the cadre concluded that the pin boils were a result of a low point in the blanket drain, where water would naturally drain and exit. Possible silting at the exterior face of the blanket drain would not allow for drainage to occur prior to the point contributing to the increase in pressure at that point. The Risk Cadre concluded the probability of failure caused by erosion at Station 30+00 was relatively low and within tolerable risk guidelines. Further discussion of PFME3 and the reasons for discounting as significant and credible potential failure modes are included in Baseline Risk Assessment Report, Appendix 13, Potential Failure Mode Discussion.

Recommendation #1: Not Adopt
Recommendation #2: Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_9.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur
Dispersion is still a concern and the monitoring is important to provide furhter analysis as the project moves forward.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

Current Comment Status: **Comment Closed**

5087298	Environmental	n/a	FPC 10	n/a

Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Medium)

Eleven threatened and endangered species were reported, yet a description of the specific species, the probability of them being found in the project boundary area, and potential impacts on these species were not provided.

(Attachment: Pine_Creek_Lake_IEPR_FPC_10.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Concurred**
Concur

Explanation:

A description of each of the 11 T&E species potentially present within the project area is included in Section 4.6 of the Draft EA. Likely impacts to T&E species is presented in Section 5.2.8 of the Draft EA and indicates that no T&E species would be significantly adversely impacted by the IRRM pool restriction to 433.00 feet. Section 5.2.8 indicates the only T&E species likely to be impacted by DSM activities and vegetation removal along the dike is the American burying beetle due to soil disturbing activities. Section 5.2.8 additionally states that "Prior to start of maintenance activities associated with the DSM and removal of woody vegetation the USACE will consult with the USFWS in accordance with Section 7 of the Endangered Species Act and in compliance with the most recent Biological Opinion in effect at that time." The probability of encountering ABB in the project area is low based upon a review of the most recent ABB survey results reported to the USFWS. While the Ouachita Mountains area of southeastern Oklahoma is an area with great concentrations of imperiled or critically imperiled aquatic and terrestrial species (i.e., numerous T&E freshwater mussel species), there are no currently or historically documented T&E mussel populations in the immediate vicinity of the Pine Creek Project. The nearest documented T&E mussel populations are well downstream of the Dam and are located in the Little River, downstream of the Pine Creek confluence. Consultation with the USFWS is ongoing and will continue through public and agency review of the Draft EA. If necessary, a mitigation plan would be developed and incorporated into the Final EA following completion of coordination with the USFWS in compliance with the Fish and Wildlife Coordination Act.

Recommendation #1: Adopt
Recommendation #2: Adopt
Recommendation #3: Not Adopt
Recommendation #4: Not Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_10.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

Current Comment Status: **Comment Closed**

5087308 Hydrology n/a FPC 11 n/a

Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Low)

The U.S. Geological Survey (USGS) 10-meter Digital Elevation Model (DEM) topographic data used to develop hydraulic models, map downstream flood hazards, and ultimately determine dam breach consequences may not be commensurate with the vertical accuracy as stated in the Baseline Risk Assessment (BLRA).

(Attachment: Pine_Creek_Lake_IEPR_FPC_11.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Non-concurred**
Non-Concur

Explanation:

The modeling used for the risk assessment incorporates the best available topographic data available for this reach. Extensive searches by the district and MMC have not shown the availability of more refined elevation data. Even thought the 10m DEM is a standard base layer for model development within the MMC for risk models, the models do include checks to verify the legitimacy of the results. These checks have been included into the Pine Creek model and include: 1) a flow calibration of discharges below the dam at representative locations to verify that channel capacity flows do not cause flooding outside of the channel bounds, 2) Sensitivity test on breach parameters and resulting flow hydrographs to determine if downstream water surfaces vary greatly based on extreme inundation levels, and 3) sensitivity of roughness values to determine sensitivities of immediate overbank areas. The checks generally will expose DEM inconsistencies which may cause varied results.

Recommendation #1: Not Adopt
Recommendation #2: Not Adopt
Recommendation #3: Not Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_11.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur
The Panel understands that the PDT attempted to identify other topographic data sources to supplement the USGS 10-meter topographic data. Because no additional topographic data was available the modeling which utilized this topography was then calibrated based on stage gage data which provided a more accurate relationship between the modeling output and the topographic data.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013
Current Comment Status: **Comment Closed**

5087316 Other n/a FPC 12 n/a
Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Low)

The operation, maintenance, repair, replacement and rehabilitation (OMRR&R) efforts are not adequately described, and it could not be determined if the proposed costs are reasonable.

(Attachment: Pine_Creek_Lake_IEPR_FPC_12.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Concurred**
Concur

Explanation:

Additional information has been included in Dam Safety Modification Report, Section 4.4.1 Operations, Maintenance, Repair, Replacement, Rehabilitation (OMRR&R) to explain how OMRR&R was determined.

Recommendation #1: Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_12.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013
Current Comment Status: **Comment Closed**

5087333 Geotechnical n/a FPC 13 n/a
Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Low)

Piezometer PZ17 appears to be very responsive to high pool conditions and may indicate an undesirable seepage condition.

(Attachment: Pine_Creek_Lake_IEPR_FPC_13.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Concurred**
Concur

Explanation:

The significance of the response of PZ17 is noted in Dam Safety Modification Report is noted in Section 3.5.4.6.2 Pool Rise Versus Piezometer Response Time in 2012. However, USACE concluded that PZ17 is likely influenced by a groundwater source unrelated to pool. A rise in piezometer level in PZ17 prior to rise in pool is also noted in Figure 61, indicating that the piezometer is likely influenced by other groundwater sources unrelated to pool. A revised plot is attached in Baseline Risk Assessment Report, Additional Geotechnical Explorations and Studies, Instrumention, "Piezometer Plots". PZ17 will continue to be monitored and evaluated as part of the USACE Dam Safety Program.

Recommendation #1: Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_13.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

Current Comment Status: **Comment Closed**

5087345 Economics n/a FPC 14 n/a

Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Low)

Various key inputs to the economic analyses, such as including the cost of repairing damage to the dam as a potential direct loss, were not provided or explained and could result in an inaccurate final cost analysis.

(Attachment: Pine_Creek_Lake_IEPR_FPC_14.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Concurred**
Concur

Explanation:

Additional text has been included to describe how HEC-FIA works and why agricultural benefits were not calculated in Dam Safety Modification Report, Section 4.1 Identify Dam Safety Issues and Opportunities and Section 9 of Appendix II - Economic Consequences.

Recommendation #1: Adopt
Recommendation #2: Adopt
Recommendation #3: Not Adopt
Recommendation #4: Not Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_14.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur
The Panel concurs because revisions to the report will not change the rank order of the alternatives or the priority of the dam safety modification but could delay the urgency of completing the report. However the panel believes that the report would benefit from some explanation of why the USACE does not believe that the "dam failure would be catastrophic as described by Section 5.3.9.1 of USACE (2011) which states:

"(NOTE: one potential direct loss is the cost of repairing the damage to the dam. This is a complicated issue and to some degree depends on the extent of damage to the dam. If the dam can be repaired, these repair costs could be counted as an economic cost. In the case of catastrophic failure, these rebuilding costs should not be included in the direct costs, as the decision to rebuild the dam depends on the post-failure benefits which would be a separate analysis.)"

The Panel envisions a dam failure to be where the outlet works are located. Even if the culverts were not washed out, they could not be reused or replaced in kind as they would not meet current design criteria. Such a repair or replacement would more closely match alternative 5 and increase the benefit to cost ratio.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

Current Comment Status: **Comment Closed**

5087351	Environmental	n/a	FPC 15	n/a

Comment Classification: **For Official Use Only (FOUO)**
(Document Reference: Significance - Low)

The chemical composition of the grouting material and sealant is not described, and the potential for short-term impacts on aquatic species has not been considered.

(Attachment: Pine_Creek_Lake_IEPR_FPC_15.doc)

Submitted By: Patricia Strayer (561-598-6506). Submitted On: Mar 15 2013

1-0 Evaluation **Concurred**
Concur

Explanation:

Currently impacts to aquatic resources due to additives included in grout mix design are unknown and not quantified. Any additives incorporated into grout mix designs for grouting purposes included in the selected alternative will be assessed, with regard to aquatic resources impacts, during the design and specifications phase prior to initiation of construction. If additives incorporated into grout mix designs during construction are shown to result in impacts to aquatic resources, a supplement to the existing Environmental Assessment will be prepared by the Tulsa District at that time.

Recommendation #1: Not Adopt
Recommendation #2: Adopt
Recommendation #3: Not Adopt

See attached for additional details.

Submitted By: Kathryn White (918-669-7651) Submitted On: Mar 26 2013 (Attachment: Pine_Creek_Lake_IEPR_Comment_Response_Form_USACE_Comment_15.pdf)

1-1 Backcheck Recommendation **Open Comment**
Concur

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Patricia Strayer (561-598-6506) Submitted On: Mar 28 2013

Current Comment Status: **Comment Closed**
