Final Independent External Peer Review Report
Cherry Creek Dam, Colorado
Dam Safety Modification Report

Prepared by
Battelle Memorial Institute

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Risk Management Center
Huntington District

Contract No. W912HQ-15-D-0001
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February 20, 2019

BATTELLE
It can be done

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Prepared by

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505 King Avenue
Columbus, Ohio 43201

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Executive Summary

PROJECT BACKGROUND AND PURPOSE

The Omaha District is conducting a Dam Safety Modification Study (DSMS) and preparing a Dam Safety Modification Report (DSMR) for potential modifications to Cherry Creek Dam. The DSMR will include a baseline risk assessment, risk-based alternative development, an environmental impact statement (EIS), and other documents needed for approval. The DSMR documents the condition of the existing structure and recommended corrective actions to reduce risks to tolerable levels. The DSMR serves as the decision document authorizing remedial actions to address failure mechanisms that pose unacceptable or intolerable risks to the public or the environment downstream while delivering its authorized benefits. In order for the project to function safely and effectively, the DSMR will be prepared in compliance with the United States Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1156, Dam Safety Policy and Procedures. The DSMR will describe the alternative risk management plans.

The Cherry Creek Dam project is located on Cherry Creek, 11.4 miles above its confluence with the South Platte River, in Arapahoe County, Colorado (southeast of the City of Denver). Cherry Creek Dam was authorized by the Flood Control Acts of August 19, 1941 (Public Law 228, 77th Congress, 1st Session) and December 1944. At the time of construction, the primary purposes of the project were to protect Denver against floods from Cherry Creek and to provide storage capacity for irrigation. Later, the project use plan was modified to add recreational benefits and to exclude the irrigation storage capacity. Cherry Creek Dam was operated as a dry dam (without permanent pool) until 1958.

The project consists of a rolled earth-fill embankment with a triple-barrel outlet works and a right abutment earthcut emergency spillway that runs parallel to the axis of the dam. The dam embankment is approximately 14,300 feet long with a maximum height of 140 feet and a crest width of 30 feet. The outlet works, located in the right abutment at embankment station 105+00, consist of an approach channel, a concrete intake tower with service bridge, a triple-barrel concrete conduit, a stilling basin, and a discharge channel. The discharge channel empties into the Cherry Creek channel a short distance downstream from the dam. The earthcut emergency spillway has a 67-foot bottom width for the first 8,500 feet and a 1,000-foot transition to a 45-foot bottom width for the remaining 2,600 feet of the excavation. The spillway channel was excavated into overburden with 1V-on-2H side slopes and into bedrock with 1V-on-1H side slopes. The spillway, if used, would discharge into the Toll Gate and Sand Creek drainage basins, which are separate from the Cherry Creek drainage basin. The reservoir at the multipurpose pool (El. 5,550.0) is approximately 1.5 miles long, and the original design flood control pool (El. 5,598.0) is approximately 3.25 miles long.

Construction of the project was initiated in fiscal year 1943 and was completed in June 1953. Construction was performed as three separate efforts: construction of the cutoff trench, construction of the outlet works, and construction of the embankment and spillway. Significant development has occurred

in the metropolitan Denver area since original construction, significantly increasing the consequences of a dam failure or spillway flow. Cherry Creek Dam was initially assigned a Dam Safety Action Classification (DSAC) 2 (high urgency of action) in December 2008 following a Screening Portfolio Risk Assessment conducted in July 2005. The project was considered high risk primarily due to an overtopping failure mode during a Probable Maximum Flood (PMF) event or other extreme storm, two internal erosion potential failure modes, and consequences associated with these potential failure modes. The DSAC 2 classification was confirmed in a September 26, 2011 memorandum from the USACE Dam Safety Officer to the Northwestern Division Commander. The memorandum directed Northwestern Division to move the project into the DSMS phase. The DSMS has confirmed that risks are above tolerable risk guidelines, primarily due to the potential for extreme incremental life loss consequences that exist downstream of the dam in the Denver metropolitan area. The only actionable failure mode is the hydrologic deficiency due to overtopping of the dam during an extreme hydrologic event, referred to as HE1. HE1 represents over 99 percent of the risk at Cherry Creek Dam. No action will be taken as a result of the Cherry Creek DSMS.

Independent External Peer Review Process

Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analysis. USACE is conducting an Independent External Peer Review (IEPR) of the Cherry Creek Dam, Colorado, Dam Safety Modification Report (hereinafter: Cherry Creek Dam DSMR 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 (2018). Battelle has experience in establishing and administering peer review panels for USACE and was engaged to coordinate this IEPR. The IEPR was external to the agency and was conducted following USACE and Office of Management and Budget (OMB) guidance described in USACE (2018) and OMB (2004). This final report presents the Final Panel Comments of the IEPR Panel (the Panel). Details regarding the IEPR (including the process for selecting panel members, the panel members' biographical information and expertise, and the charge submitted to the Panel to guide its review) are presented in appendices.

Based on the technical content of the decision documents and the overall scope of the project, Battelle identified potential candidates for the Panel in the following key technical areas: consequence economist/planning, environmental biologist, hydrology and hydraulic (H&H) engineer, and geotechnical/civil engineer. Battelle screened the candidates to identify those most closely meeting the selection criteria and evaluated them for COIs and availability. USACE was given the list of all the final candidates to independently confirm that they had no COIs, and Battelle made the final selection of the four-person Panel from this list.

The Panel received electronic versions of the decision documents (2,225 pages in total), along with a charge that solicited comments on specific sections of the documents to be reviewed. Following guidance provided in USACE (2018) and OMB (2004), USACE prepared the charge questions, 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 via teleconference at the start of the review to provide the Panel an opportunity to ask questions of USACE and clarify uncertainties. Other than Battelle-facilitated teleconferences, there was no direct communication between the Panel and USACE during the peer review process.

IEPR panel members reviewed the decision documents individually and produced individual comments in response to the charge questions. The panel members then met via teleconference with Battelle to review key technical comments 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/high, medium, medium/low, or low); and (4) recommendations on how to resolve the comment. Overall, seven Final Panel Comments were identified and documented. Of these, one was identified as having medium significance, one had medium/low significance, and five had low significance.

Battelle received public comments from USACE on the Cherry Creek Dam DSMR (three individual comments, totaling three pages of comments) and provided them to the IEPR panel members. The panel members were charged with determining if any information or concerns presented in the public comments raised any additional discipline-specific technical concerns with regard to the Cherry Creek Dam DSMR review documents. After completing its review, the Panel confirmed that no new issues or concerns were identified.

Results of the Independent External Peer Review

The panel members agreed on their "assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (USACE, 2018) in the Cherry Creek Dam DSMR. Table ES-1 lists the Final Panel Comment statements by level of significance. The full text of the Final Panel Comments is presented in Section 4.2 of this report. The following summarizes the Panel's findings.

Based on the Panel's review, the report is well-written, is concise, and provides excellent supporting documentation on engineering, environmental, economic, and plan formulation issues. The report provided a balanced assessment of the economic, engineering, and environmental issues of the overall project. Each model is appropriately chosen and applied. The Panel identified one risk clarification that is currently not covered in the documents and several other elements of the report that should be clarified or documented in more detail.

Engineering: The project demonstrates a commitment to public safety tempered by fiscal responsibility on the part of the USACE. Commitment to USACE's study, analysis, design, and assessment process has produced an economical draft plan to lower the risk of Cherry Creek Dam failure to levels that meet industry standards for acceptability. The requirement that on-site surveillance begin when the reservoir begins to fill is a positive operational requirement. History has shown that initial filling of reservoirs often is the most critical time in the overall operation of a dam.

One aspect of the DSMR that is unclear is whether a potential failure mode related to the potential for uncontrolled seepage discharging through deformation cracks in the clay core was considered during the risk evaluation process. The DSMR documents the risk associated with two seepage-related failure modes but does not indicate that any other potential geotechnical-related failure modes were considered. It is unclear whether previous evaluations included other potential failure modes related to embankment seepage failure.

In addition, the description of the "no-action" alternative in the DSMR does not specify the frequency of the smallest flood event that would trigger the 7,000-cubic foot per second (cfs) dam outlet works release under the water control plan enacted in April 2017.

Environmental: The Panel found the documents well-organized, well-written, and thorough. However, with regard to excavating the bottom of the spillway, clarification on the actual species of minnows found in the spillway is needed given the potential for a species of minnow designated as threatened by the state to be present in the area.

Plan Formulation and Economics: These sections of the DSMR are exceptionally well-written, with solid graphics and tabular presentation. The methodology and presentation throughout the report are logical, complete, and nicely sequential. However, transportation infrastructure is not addressed in the economic impact analysis, potentially underestimating the total economic impact resulting from a breach of Cherry Creek Dam. In addition, the DSMR lacks information on some of the sources of economic data presented and the assumptions made related to the data's use.

Table ES-1. Overview of seven Final Panel Comments Identified by the Cherry Creek Dam DSMR IEPR Panel

No.	Final Panel Comment
Significance – Medium	
1	It is unclear whether a potential failure mode related to the potential for uncontrolled seepage discharging through deformation cracks in the clay core was considered during the risk evaluation process.
Significance – Medium/Low	
2	Clarification on the actual species of minnows found in the spillway is needed given the potential for a species of minnow designated as threatened by the state to be present in the area.
Significance – Low	
3	The description of the “no-action” alternative in the DSMR does not specify the frequency of the smallest flood event that would trigger the 7,000-cfs dam outlet works release under the water control plan enacted in April 2017.
4	The DSMR does not indicate what maintenance would be routinely employed to ensure that the capacity of the spillway is maintained in the future.
5	Transportation infrastructure is not addressed in the economic impact analysis, potentially underestimating the total economic impact resulting from a breach of Cherry Creek Dam.
6	The DSMR lacks information on some of the sources of economic data presented and the assumptions made related to the data’s use.
7	The DSMR does not describe the pre-failure alert processes that are part of the Emergency Action Plan (EAP) nor any improvements to the EAP and communications with local authorities that are expected to address any perceived deficiencies in the processes.

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Table ES-1. Overview of Seven Final Panel Comments Identified by the Cherry Creek Dam DSMR IEPR Panel. v

LIST OF ACRONYMS

BEP	Backward Erosion Piping
CAP	Continuing Authorities Program
cfs	Cubic Feet per Second
CLOMR	Conditional Letter of Map Revision
COI	Conflict of Interest
CWA	Clean Water Act
DEIS	Draft Environmental Impact Statement
DFIRM	Digital Flood Insurance Rate Map
DOE	United States Department of Energy
DrChecks	Design Review and Checking System
DSAC	Dam Safety Action Classification
DSMR	Dam Safety Modification Report
DSMS	Dam Safety Modification Study
EAP	Emergency Action Plan
EC	Engineer Circular
EIS	Environmental Impact Statement
EM	Engineer Manual
EOP	Environmental Operating Principle
ER	Engineer Regulation
ERDC	Engineer Research and Development Center
ETL	Engineer Technical Letter
FERC	Federal Energy Regulatory Commission
H&H	Hydrology and Hydraulic
HEC-FDA	Hydrologic Engineering Center-Flood Damage Reduction Analysis
HEC-FIA	Hydrologic Engineering Center-Flood Impact Analysis
HEC-HMS	Hydrologic Engineering Center-Hydrologic Modeling System
HEC-LifeSim	Hydrologic Engineering Center-Life Loss and Direct Damage Estimation
HEC-RAS	Hydrologic Engineering Center-River Analysis System
HEP	Habitat Evaluation Procedure
HSI	Habitat Suitability Index

IEPR	Independent External Peer Review
IWR	Institute for Water Resources
LOMC	Letter of Map Change
NEPA	National Environmental Policy Act
NWD	Northwestern Division
O&M	Operation and Maintenance
OEO	Outside Eligible Organization
OMB	Office of Management and Budget
OPSEC	Operations Security
PDT	Project Delivery Team
PFMA	Potential Failure Mode Analysis
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RHA	Rivers and Harbors Act
RiskMAP	Risk Mapping and Planning
RMC	Risk Management Center
USACE	United States Army Corps of Engineers

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1. INTRODUCTION

The Omaha District is conducting a Dam Safety Modification Study (DSMS) and preparing a Dam Safety Modification Report (DSMR) for potential modifications to Cherry Creek Dam. The DSMR will include a baseline risk assessment, risk-based alternative development, an environmental impact statement (EIS), and other documents needed for approval. The DSMR documents the condition of the existing structure and recommended corrective actions to reduce risks to tolerable levels. The DSMR serves as the decision document authorizing remedial actions to address failure mechanisms that pose unacceptable or intolerable risks to the public or the environment downstream while delivering its authorized benefits. In order for the project to function safely and effectively, the DSMR will be prepared in compliance with the United States Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1156, Dam Safety Policy and Procedures. The DSMR will describe the alternative risk management plans.

The Cherry Creek Dam project is located on Cherry Creek, 11.4 miles above its confluence with the South Platte River, in Arapahoe County, Colorado (southeast of the City of Denver). Cherry Creek Dam was authorized by the Flood Control Acts of August 19, 1941 (Public Law 228, 77th Congress, 1st Session) and December 1944. At the time of construction, the primary purposes of the project were to protect Denver against floods from Cherry Creek and to provide storage capacity for irrigation. Later, the project use plan was modified to add recreational benefits and to exclude the irrigation storage capacity. Cherry Creek Dam was operated as a dry dam (without permanent pool) until 1958.

The project consists of a rolled earth-fill embankment with a triple-barrel outlet works and a right abutment earthcut emergency spillway that runs parallel to the axis of the dam. The dam embankment is approximately 14,300 feet long with a maximum height of 140 feet and a crest width of 30 feet. The outlet works, located in the right abutment at embankment station 105+00, consist of an approach channel, a concrete intake tower with service bridge, a triple-barrel concrete conduit, a stilling basin, and a discharge channel. The discharge channel empties into the Cherry Creek channel a short distance downstream from the dam. The earthcut emergency spillway has a 67-foot bottom width for the first 8,500 feet and a 1,000-foot transition to a 45-foot bottom width for the remaining 2,600 feet of the excavation. The spillway channel was excavated into overburden with 1V-on-2H side slopes and into bedrock with 1V-on-1H side slopes. The spillway, if used, would discharge into the Toll Gate and Sand Creek drainage basins, which are separate from the Cherry Creek drainage basin. The reservoir at the multipurpose pool (El. 5,550.0) is approximately 1.5 miles long, and the original design flood control pool (El. 5,598.0) is approximately 3.25 miles long.

Construction of the project was initiated in fiscal year 1943 and was completed in June 1953. Construction was performed as three separate efforts: construction of the cutoff trench, construction of the outlet works, and construction of the embankment and spillway. Significant development has occurred in the metropolitan Denver area since original construction, significantly increasing the consequences of a dam failure or spillway flow. Cherry Creek Dam was initially assigned a Dam Safety Action Classification (DSAC) 2 (high urgency of action) in December 2008 following a Screening Portfolio Risk Assessment conducted in July 2005. The project was considered high risk primarily due to an overtopping failure mode during a Probable Maximum Flood (PMF) event or other extreme storm, two internal erosion potential failure modes, and consequences associated with these potential failure modes. The DSAC 2 classification was confirmed in a September 26, 2011 memorandum from the USACE Dam Safety Officer to the Northwestern Division Commander. The memorandum directed Northwestern Division to move the project into the DSMS phase. The DSMS has confirmed that risks are above tolerable risk guidelines,

primarily due to the potential for extreme incremental life loss consequences that exist downstream of the dam in the Denver metropolitan area. The only actionable failure mode is the hydrologic deficiency due to overtopping of the dam during an extreme hydrologic event, referred to as HE1. HE1 represents over 99 percent of the risk at Cherry Creek Dam. No action will be taken as a result of the Cherry Creek DSMS.

Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analysis. The objective of the work described here was to conduct an Independent External Peer Review (IEPR) of the Cherry Creek Dam, Colorado, Dam Safety Modification Report (hereinafter: Cherry Creek Dam DSMR IEPR) in accordance with procedures described in the Department of the Army, U.S. Army Corps of Engineers (USACE), Engineer Circular (EC) *Review Policy for Civil Works* (EC 1165-2-217) (USACE, 2018) and the Office of Management and Budget (OMB), *Final Information Quality Bulletin for Peer Review* (OMB, 2004). 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).

This final report presents the Final Panel Comments of the IEPR Panel (the Panel) on the existing engineering, economic, environmental, and plan formulation analyses contained in the Cherry Creek Dam DSMR IEPR documents (Section 4). Appendix A describes in detail how the IEPR was planned and conducted, including the schedule followed in executing the IEPR. Appendix B provides biographical information on the IEPR panel members and describes the method Battelle followed to select them. Appendix C presents the final charge to the IEPR panel members for their use during the review; the final charge was submitted to USACE in the final Work Plan according to the schedule listed in Table A-1. Appendix D presents the organizational COI form that Battelle completed and submitted to the Institute for Water Resources (IWR) prior to the award of the Cherry Creek Dam DSMR IEPR.

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, as described in USACE (2018).

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. IEPR provides an independent assessment of the engineering, economic, environmental, and plan formulation analyses of the project study. In particular, the IEPR addresses the technical soundness of the project study's assumptions, methods, analyses, and calculations 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 Cherry Creek Dam DSMR was conducted and managed using contract support from Battelle, which is an Outside Eligible Organization (OEO) (as defined by EC 1165-2-217). Battelle, a 501(c)(3) organization under the U.S. Internal Revenue Code, has experience conducting IEPRs for USACE.

3. METHODS FOR CONDUCTING THE IEPR

The methods used to conduct the IEPR are briefly described in this section; a detailed description can be found in Appendix A. The IEPR was completed in accordance with established due dates for milestones

and deliverables as part of the final Work Plan; the due dates are based on the award/effective date and the receipt of review documents.

Battelle identified, screened, and selected four panel members to participate in the IEPR based on their expertise in the following disciplines: consequence economist/planning, environmental biologist, hydrology and hydraulic (H&H) engineer, and geotechnical/civil engineer. The Panel reviewed the Cherry Creek Dam DSMR documents and produced seven Final Panel Comments in response to 35 charge questions provided by USACE for the review. This charge also included two overview questions and one public comment question added by Battelle, for a total of 38 questions. Battelle instructed the Panel to develop the Final Panel Comments using a standardized four-part structure:

1. Comment Statement (succinct summary statement of concern)
2. Basis for Comment (details regarding the concern)
3. Significance (high, medium/high, medium, medium/low, or low; in accordance with specific criteria for determining level of significance)
4. Recommendation(s) for Resolution (at least one implementable action that could be taken to address the Final Panel Comment).

Battelle reviewed all Final Panel Comments for accuracy, adherence to USACE guidance (EC 1165-2-217), and completeness prior to determining that they were final and suitable for inclusion in the Final IEPR Report. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The Panel's findings are summarized in Section 4.1; the Final Panel Comments are presented in full in Section 4.2.

4. RESULTS OF THE IEPR

This section presents the results of the IEPR. A summary of the Panel's findings and the full text of the Final Panel Comments are provided.

4.1 Summary of Final Panel Comments

The panel members agreed on their "assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (USACE, 2018) in the Cherry Creek Dam DSMR IEPR review documents. The following summarizes the Panel's findings.

Based on the Panel's review, the report is well-written, is concise, and provides excellent supporting documentation on engineering, environmental, economic, and plan formulation issues. The report provided a balanced assessment of the economic, engineering, and environmental issues of the overall project. Each model is appropriately chosen and applied. The Panel identified one risk clarification that is currently not covered in the documents and several other elements of the report that should be clarified or documented in more detail.

Engineering: The project demonstrates a commitment to public safety tempered by fiscal responsibility on the part of the USACE. Commitment to USACE's study, analysis, design, and assessment process has produced an economical draft plan to lower the risk of Cherry Creek Dam failure to levels that meet industry standards for acceptability. The requirement that on-site surveillance begin when the reservoir begins to fill is a positive operational requirement. History has shown that initial filling of reservoirs often is the most critical time in the overall operation of a dam.

One aspect of the DSMR that is unclear is whether a potential failure mode related to the potential for uncontrolled seepage discharging through deformation cracks in the clay core was considered during the risk evaluation process. The DSMR documents the risk associated with two seepage-related failure modes but does not indicate that any other potential geotechnical-related failure modes were considered. It is unclear whether previous evaluations included other potential failure modes related to embankment seepage failure.

In addition, the description of the “no-action” alternative in the DSMR does not specify the frequency of the smallest flood event that would trigger the 7,000-cubic foot per second (cfs) dam outlet works release under the water control plan enacted in April 2017.

Environmental: The Panel found the documents well-organized, well-written, and thorough. However, with regard to excavating the bottom of the spillway, clarification on the actual species of minnows found in the spillway is needed given the potential for a species of minnow designated as threatened by the state to be present in the area.

Plan Formulation and Economics: These sections of the DSMR are exceptionally well-written, with solid graphics and tabular presentation. The methodology and presentation throughout the report are logical, complete, and nicely sequential. However, transportation infrastructure is not addressed in the economic impact analysis, potentially underestimating the total economic impact resulting from a breach of Cherry Creek Dam. In addition, the DSMR lacks information on some of the sources of economic data presented and the assumptions made related to the data’s use.

4.2 Final Panel Comments

This section presents the full text of the Final Panel Comments prepared by the IEPR panel members.

Final Panel Comment 1

It is unclear whether a potential failure mode related to the potential for uncontrolled seepage discharging through deformation cracks in the clay core was considered during the risk evaluation process.

Basis for Comment

The DSMR documents the risk associated with two seepage-related failure modes but did not indicate that any other potential geotechnical-related failure modes had been considered. It is unclear whether previous evaluations included other potential failure modes related to embankment seepage failure. A review of the settlement data contained in the ninth periodic inspection report, Plate C – 10, indicates that a large amount of differential settlement occurred during initial construction. The large amount of measured settlement could indicate the potential for large displacements leading to cracking of the upper sections of the clay core.

The clay core for the Cherry Creek embankment lacks a drainage zone on the downstream side of the core section. Current design practice would incorporate a pervious filtered drainage zone directly downstream of the clay core. One purpose of the drain would be to provide a safe exit for seepage if the clay core developed transverse cracks due to horizontal or vertical displacements. If not intercepted, such uncontrolled seepage could lead to saturation and ultimately failure of the downstream embankment shell. Depending on the location of the crack(s), this condition may not become critical or obvious until the reservoir level reaches higher stages.

Significance – Medium

The absence of a filtered drain downstream of the clay core presents a risk that may not have been evaluated.

Recommendation for Resolution

1. Evaluate a potential failure mode related to the likelihood and risk associated with a crack extending through the upper sections of the clay core of the embankment.

Final Panel Comment 2

Clarification on the actual species of minnows found in the spillway is needed given the potential for a species of minnow designated as threatened by the state to be present in the area.

Basis for Comment

The following statement is found in the DSMR Appendix C Draft Environmental Impact Statement (DEIS), DEIS Appendix A, Draft Fish and Wildlife Coordination Act Report, Section 6.1, Fisheries:

> "Several feet of soil will be excavated from the bottom of the spillway. There is open water in the bottom of the spillway that likely contains fish *(i.e. minnows)* year-round. As such, direct, adverse impacts would occur to minnows located at the bottom of the spillway. The minnows would likely be disturbed and may be killed as a result of excavation. Such impacts would occur in the short-term or within the 12 to 18-month period estimated for restoration activities. Given that the affected minnows are a common species, such impacts would not affect the greater minnow population. Adverse impacts would not extend beyond the localized minnow population at the bottom of the spillway." (emphasis added; p. 32)

Based on habitat descriptions, the IEPR Panel recognizes that the conclusions drawn in the DEIS relative to impacts on fisheries likely are accurate. However, exact species of minnows found in the spillway are not identified. The Panel understands that there are many kinds of minnows. One of them is the Common Shiner (*Luxilus cornutus*) which, only a few pages earlier, is listed in Table 4-1 as ST (State Threatened) and S2 (State Imperiled).

Significance – Medium/Low

While the impacts on fisheries are believed to be accurate, the lack of specificity with regard to the exact fish species occurring in the spillway could result in impacts to species that may be rare.

Recommendation for Resolution

1. List the exact species of minnows (or other fish/amphibians) that could be impacted to verify that they are not threatened or endangered species.

Final Panel Comment 3

The description of the "no-action" alternative in the DSMR does not specify the frequency of the smallest flood event that would trigger the 7,000-cfs dam outlet works release under the water control plan enacted in April 2017.

Basis for Comment

Appendices D, G, I, J, and M, as well as the DSMR text itself, reference the water control plan as a critical component of the "no-action" alternative. According to the text of the DSMR, the previous Water Control Plan limited the combined discharge of the Tri-Lakes Project such that a target discharge at the Denver stream gage in Denver of 5,000 cfs was maintained.

Downstream of the dam, flood response and land use planning are based upon the previous water control plan. Additionally, the delineation of the Special Flood Hazard Area of both Cherry Creek and the South Platte River downstream of the Cherry Creek – South Platte River confluence is based upon the previous water control plan. Implementation of the April 2017 water control plan may create the possible risk of unacceptable downstream flooding in events more frequent than the frequency of a flood resulting from a Probable Maximum Precipitation (PMP) event, which could have adverse effects on flood response and land use planning downstream of the dam, as well as the delineation of the Special Flood Hazard Area.

Significance – Low

While the adverse impacts of downstream flooding due to rainfall events more frequent than the PMP event could be significant, an assessment of these impacts would likely not change the recommendations of the DSMR.

Recommendations for Resolution

1. Revise the DSMR text to clearly indicate the expected frequency of the flood event that would trigger the 7,000-cfs release under the 2017 water control plan.
2. If the annual exceedance probability of the 7,000-cfs release is 1% or greater, directly inform downstream jurisdictions.

Final Panel Comment 4

The DSMR does not indicate what maintenance would be routinely employed to ensure that the capacity of the spillway is maintained in the future.

Basis for Comment

The DSMR indicates that the spillway channel has suffered significant erosion damage due to local rainfall events since the date of spillway construction, significantly affecting the spillway crest elevation and therefore the operational characteristics of the reservoir system. In addition, the conclusions of the DSMR rely on the assumption that the spillway will be returned to and maintained at the design elevation. The DSMR does not discuss when the spillway would be returned to the design condition, nor does it describe the type and frequency of maintenance needed to maintain the spillway crest elevation. Should routine maintenance not be performed on the spillway, the chance of dam overtopping could increase to an unacceptable level.

Significance – Low

Inclusion of more a more detailed spillway maintenance program will not change the recommendations of the DSMR.

Recommendations for Resolution

1. Describe the spillway maintenance program in greater detail, to include required funding levels, in the DSMR.
2. Ensure that the spillway maintenance program becomes a part of the overall maintenance budget request legislation.

Final Panel Comment 5

Transportation infrastructure is not addressed in the economic impact analysis, potentially underestimating the total economic impact resulting from a breach of Cherry Creek Dam.

Basis for Comment

Transportation facilities are expensive public assets to repair or replace, and the damage or loss of these assets would create negative economic effects that could be significant. Paragraph 7.c. of an April 5, 2017, memorandum (subject line: *Request for Approval of Cherry Creek, Chatfield, and Bear Creek Water Control Plans as Changed by the Cherry Creek Dam WCPMS*) states that damage estimates "exclude everything else such as transportation infrastructure" (Bergman, 2017).

Each of the three Final Alternatives assumes that the 2017 water control plan would be implemented; therefore, damage to or loss of downstream transportation facilities is a potential impact common to each of the Final Alternatives.

Significance – Low

Because the impacts to transportation infrastructure would be the same under each of the Final Alternatives, including the economic effects of transportation network losses is unlikely to change the recommendations of the DSMR.

Recommendations for Resolution

1. Conduct an economic analysis of the three Final Alternatives that includes the primary and secondary economic consequences of the loss of transportation infrastructure.
2. Include the analysis results in the comparison of the three Final Alternatives and publish the information in the final DSMR.

Literature Cited

Bergman, K. (2017). Request for Approval of Cherry Creek, Chatfield, and Bear Creek Water Control Plans as Changed by the Cherry Creek Dam WCPMS, memorandum for the U.S. Army Corps of Engineers Northwest Division Commander, April 5, 2017.

Final Panel Comment 6

The DSMR lacks information on some of the sources of economic data presented and the assumptions made related to the data's use.

Basis for Comment

No errors were found in the economic analysis in the DSMR, but there was a lack of full documentation and sourcing of some tables and some assumptions in the text. Selected examples include, but are not limited to, the following:

- In Table 10, p. 35, an explanation of the assumptions for existing conditions is needed to support the validity of the tabulated data.
- No clear sourcing for the cost estimates, both structural and/or operational, is presented in the DSMR.
- The source of data in Table 12, p. 36, is not identified. The source may have been Expert Opinion Elicitations, but that is not clear.
- In the discussion of the Future Without Action Condition (Section 4.0, pp. 41 to about 45), sources for the assumptions are needed.
- The discussion of funding on p. 43 (specifically, what to do if funding is not available) states that funding "will be sought" if it cannot be procured through the Northwestern Division (NWD) Mission Critical Asset Program. This discussion warrants more definitive information and documentation.

Significance – Low

The technical quality of the report would be improved if the sources of data obtained by USACE and the assumptions made regarding the data's use were further documented.

Recommendations for Resolution

1. Review the DSMR and the Economics appendix and identify which data and assumptions are presented without full documentation and/or sourcing.

2. Include the sources/documentation in the appropriate sections of the DSMR.

Final Panel Comment 7

The DSMR does not describe the pre-failure alert processes that are part of the Emergency Action Plan (EAP) nor any improvements to the EAP and communications with local authorities that are expected to address any perceived deficiencies in the processes.

Basis for Comment

Section 6.1 of the DSMR describes the process to notify local officials of the likelihood of overtopping of Cherry Creek Dam. The description indicates that this notification would likely occur approximately 5.5 hours prior to overtopping. This section also indicates that the Omaha District is updating its EAP for Cherry Creek to reflect the conclusions of the DSMR. The DSMR does not provide any information regarding the nature or content of the anticipated modifications to the EAP or any description of the communications prior to issuance of a final overtopping warning.

It is assumed that the hydrologic conditions which have a potential for an overtopping event could be identified before a definite determination regarding overtopping could be made. The identification of such conditions would serve to trigger the nonstructural measures described in sections 2.1.1 to 2.1.5. The DSMR would be more complete if it described the improved communication and anticipated timing of communications with local officials during the entire process, rather than just the final notification to those local officials.

Significance – Low

While additional information regarding the notification procedure and EAP would make the DSMR more complete, the basis for selection of the Tentatively Selected Plan would not be affected in the absence of this information.

Recommendation for Resolution

1. Provide additional information and description of the overall communication and notification process with local officials which will likely be included in future modifications to the EAP.

5. REFERENCES

Bergman, K. (2017). Request for Approval of Cherry Creek, Chatfield, and Bear Creek Water Control Plans as Changed by the Cherry Creek Dam WCPMS, memorandum for the U.S. Army Corps of Engineers Northwest Division Commander, April 5, 2017.

OMB (2004). Final Information Quality Bulletin for Peer Review. Executive Office of the President, Office of Management and Budget, Washington, D.C. Memorandum M-05-03. December 16, 2004.

The National Academies (2003). Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports. The National Academies (National Academy of Science, National Academy of Engineering, Institute of Medicine, National Research Council). May 12, 2003.

USACE (2018). Water Resources Policies and Authorities: Review Policy for Civil Works. Engineer Circular (EC) 1165-2-217. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. February 20, 2018.

APPENDIX A

IEPR Process for the Cherry Creek Dam DSMR Project

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A.1 Planning and Conduct of the Independent External Peer Review (IEPR)

Table A-1 presents the major milestones and deliverables of the Cherry Creek Dam Safety Modification Report (DSMR) IEPR. Due dates for milestones and deliverables are based on the award/effective date listed in Table A-1. The review documents were provided by U.S. Army Corps of Engineers (USACE) on December 11, 2018. Note that the actions listed under Task 6 occur after the submission of this report. Battelle anticipates submitting the pdf printout of the USACE's Design Review and Checking System (DrChecks) project file (the final deliverable) on April 18, 2019. The actual date for contract end will depend on the date that all activities for this IEPR are conducted and subsequently completed.

Table A-1. Major Milestones and Deliverables of the Cherry Creek Dam DSMR IEPR

Task	Action	Due Date
1	Award/Effective Date	11/16/2018
	Review documents available	12/11/2018
	Public comments available	1/28/2018
	Battelle submits draft Work Plan[a]	11/27/2018
	USACE provides comments on draft Work Plan	11/29/2018
	Battelle submits final Work Plan[a]	12/14/2018
2	Battelle submits list of selected panel members[a]	12/3/2018
	USACE confirms the panel members have no COI	12/7/2018
3	Battelle convenes kick-off meeting with USACE	12/3/2018
	Battelle convenes kick-off meeting with panel members	12/19/2018
	Battelle convenes kick-off meeting with USACE and panel members	12/19/2018
4	Panel members complete their individual reviews	1/23/2019
	Panel members provide draft Final Panel Comments to Battelle	2/4/2019
	Battelle sends public comments to panel members for review	1/30/2019
	Panel confirms no additional Final Panel Comment is necessary with regard to the public comments	2/5/2019
	Panel finalizes Final Panel Comments	2/11/2019
5	Battelle submits Final IEPR Report to USACE[a]	2/20/2019
6[b]	Battelle convenes Comment Response Teleconference with panel members and USACE	4/3/2019
	Battelle submits pdf printout of DrChecks project file[a]	4/18/2019
	Contract End/Delivery Date	11/30/2019

[a] *Deliverable.*
[b] *Task 6 occurs after the submission of this report.*

At the beginning of the Period of Performance for the Cherry Creek Dam DSMR IEPR, 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., terminology to use, access to DrChecks, etc.). Any revisions to the schedule were submitted as part of the final Work Plan. The final charge consisted of 35 charge questions provided by USACE; two overview questions and one public comment question added by Battelle (all questions were included in the draft and final Work Plans); and general guidance for the Panel on the conduct of the peer review (provided in Appendix C of this final report).

Prior to beginning their review and after their subcontracts were finalized, all the members of the Panel attended a kick-off meeting via teleconference planned and facilitated by Battelle in order to review the IEPR process, the schedule, communication procedures, and other pertinent information for the Panel. Battelle planned and facilitated a second kick-off meeting via teleconference during which USACE presented project details to the Panel. Before the meetings, the IEPR Panel received an electronic version of the final charge, as well as the review documents and reference/supplemental materials listed in Table A-2.

Table A-2. Documents to Be Reviewed and Provided as Reference/Supplemental Information

Review Documents[a]	No. of Review Pages
DSMR Main Report	110
Appendix A Geotechnical/Civil Engineering	200
Appendix B Office of Counsel Opinions	22
Appendix C Environmental Impact Statement	750
Appendix E Nonstructural Assessment	35
Appendix F Plan Formulation	130
Appendix G Consequences Appendix	50
Appendix H Constructability Review	16
Appendix I Semi-Quantitative Risk Assessment	64
Appendix J Hydraulic Engineering	160
Appendix K Real Estate Assessment	6
Appendix L Cost Engineering	21
Appendix M Hydrologic Engineering	456
Appendix N Plans and Drawings for Alternatives	40
Appendix O Structural Engineering	95
Appendix P Risk Assessment for Final Alternatives	70
Total Number of Review Pages	**2,225**

Supplemental Information[b]	No. of Review Pages
Public Comments	3
Risk Estimate Report	400
Total Number of Reference Pages	**450**

[a] Appendix D was not listed in the Request for Proposal table of Review Documents. Battelle assumes this appendix is not being reviewed.

[b] Supporting documentation only. These documents are not for Panel review and should be used as information sources only. They are not included in the total page count.

In addition to the materials provided in Table A-2, the panel members were provided the following USACE guidance documents.

General

- Engineer Circular (EC) 1105-2-412, Assuring Quality of Planning Models, 31 March 2011
- EC 1165-2-217, Review Policy for Civil Works, 20 February 2018
- Engineer Regulation (ER) 500-1-1, Civil Emergency Management Program
- 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 1110-2-1156, Engineering and Design – Safety of Dams – Policy and Procedures, 31 March 2014
- ER 1110-1-8159, Engineering and Design – DrChecks, 10 May 2001
- ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies
- National Academy of Sciences, "Policy 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. Available at: http://www.nationalacademies.org/site_assets/groups/nasite/documents/webpage/na_069688.pdf
- Water Resources Development Act of 2007, Sections 2034 & 2035, Pub. L. 110-114. Privacy Act, 5 U.S.C. § 522a as amended
- Best Practices in Dam and Levee Risk Analysis: https://www.usbr.gov/ssle/damsafety/risk/methodology.html

Environmental/Planning

- ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. CECWP, 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, 29 November 1978).
- ER 200-2-2, Environmental Quality, Procedures for Implementing NEPA. CECWRE (now CECW-A), 4 March 1988
- National Environmental Policy Act of 1969
- National Historic Preservation Act of 1966
- 36 CFR 800

- Endangered Species Act
- Clean Air Act
- Clean Water Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- ER 200-1-5, Policy for Implementation and Integrated Application of the USACE Environmental Operating Principles (EOP) and Doctrine and Sustainability
- Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
- Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks

Geotechnical Engineering

- Engineer Manual (EM) 1110-2-1901, Engineering and Design – Seepage Analysis and Control for Dams, 30 April 1993
- EM 1110-2-1908, Instrumentation of Embankment Dams and Levees
- EM 1110-2-1913, Engineering and Design – Design and Construction of Levees, 30 April 2000
- EM 1110-2-1914, Engineering and Design – Design, Construction, and Maintenance of Relief Wells, 29 May 1992
- Engineer Technical Letter (ETL) 1110-2-556 (or most recent guidance), Risk-based Analysis in Geotechnical Engineering for Support of Planning Studies or more current Hydraulic Engineering
- EM 1110-2-1413, Hydrologic Analysis of Interior Areas, 15 January 1987
- EM 1110-2-1415, Hydrologic Frequency Analysis, 5 March 1993
- EM 1110-2-1416, River Hydraulics, 15 October 1993
- EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies, 1 August 1996
- EM 1110-2-2902, Engineering and Design – Conduits, Culverts, and Pipes, 31 March 1998
- MMC Production Center, Application of Simplified Physical Breach Method in HEC-RAS, 2 December 2016
- MMC Production Center, Levee Widening Erosion Rates, February 2016
- MMC Production Center, Standard operating procedures–Modeling, mapping and consequences, June 2014
- MMC Production Center, Modification of MMC Levee Analysis Standard Operation Procedure to Include Additional Overtopping Scenarios, January 2018

Peer Review

- USACE guidance, *Review Policy for Civil Works* (EC 1165-2-217), February 20, 2018
- Office of Management and Budget (OMB), *Final Information Quality Bulletin for Peer Review,* December 16, 2004.

About halfway through the review, Battelle submitted six panel member questions to USACE asking for clarification regarding different aspects of the project. USACE provided written responses to all six questions prior to the end of the review. The responses included the additional documents listed below.

- Cherry Creek Final IES Report Sep2011.pdf
- Cc_pir09 reduced.pdf

- 2007_Relief_Well_Rehab_Report_complete_2007_08.pdf
- Warning_Issuance_Time_Report.pdf
- HTRW Survey Combined.pdf.

A.2 Review of Individual Comments

The Panel was instructed to address the charge questions/discussion points within a charge question response form provided by Battelle. At the end of the review period, the Panel produced 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. At the end of the review, Battelle summarized the individual comments into a preliminary list of overall comments and discussion points. Each panel member's individual comments were shared with the full Panel.

A.3 IEPR Panel Teleconference

Battelle facilitated a 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 should 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, added any missing issues of significant importance to the findings, and merged any related individual comments. At the conclusion of the teleconference, Battelle reviewed each Final Panel Comment with the Panel, including the associated level of significance, and confirmed the lead author for each comment.

A.4 Preparation of Final Panel Comments

Following the teleconference, Battelle distributed 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 Cherry Creek Dam DSMR IEPR:

- 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 a summary email 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/high, medium, medium/low, and 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:** There is a fundamental issue within study documents or data that will influence the technical or scientific basis for selection of, justification of, or ability to implement the recommended plan.
  2. **Medium/High:** There is a fundamental issue within study documents or data that has a strong probability of influencing the technical or scientific basis for selection of, justification of, or ability to implement the recommended plan.
  3. **Medium:** There is a fundamental issue within study documents or data that has a low probability of influencing the technical or scientific basis for selection of, justification of, or ability to implement the recommended plan.
  4. **Medium/Low:** There is missing, incomplete, or inconsistent technical or scientific information that affects the clarity, understanding, or completeness of the study documents, and there is uncertainty whether the missing information will affect the selection of, justification of, or ability to implement the recommended plan.
  5. **Low:** There is a minor technical or scientific discrepancy or inconsistency that affects the clarity, understanding, or completeness of the study documents but does not influence the selection of, justification of, or ability to implement the recommended plan.
- Guidelines 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).

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. At the end of this process, seven Final Panel Comments were prepared and assembled. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The full text of the Final Panel Comments is presented in Section 4.2 of the main report.

A.5 Conduct of the Public Comment Review

Following the schedule in Table A-1, Battelle received several emails containing three pages of public comments on the Cherry Creek Dam DSMR from USACE. Battelle then sent the public comments to the panel members in addition to the following charge question:

1. **Do the public comments raise any additional discipline-specific technical concerns with regard to the overall report?**

The Panel confirmed that no new issues or concerns were identified.

A.6 Final IEPR Report

After concluding the review and preparation of the Final Panel Comments, Battelle prepared a final IEPR report (this document) on the overall IEPR process and the IEPR panel members' findings. Each panel member and Battelle technical and editorial reviewers reviewed the IEPR report prior to submission to USACE for acceptance.

A.7 Comment Response Process

As part of Task 6, Battelle will enter the seven Final Panel Comments developed by the Panel into USACE's 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 closeout, as a final deliverable and record of the IEPR results.

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APPENDIX B

Identification and Selection of IEPR Panel Members for the Cherry Creek Dam DSMR Project

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B.1 Panel Identification

The candidates for the Cherry Creek Dam, Colorado, Dam Safety Modification Report (hereinafter: Cherry Creek Dam DSMR IEPR) Panel were evaluated based on their technical expertise in the following key areas: consequence economist/planning, environmental biologist, hydrology and hydraulic (H&H) engineer, and geotechnical/civil engineer. These areas correspond to the technical content of the review documents and overall scope of the Cherry Creek Dam DSMR.

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 evaluated these candidate panel members in terms of their technical expertise and potential conflicts of interest (COIs). Of these candidates, Battelle chose the most qualified individuals, confirmed their interest and availability, and ultimately selected four experts for 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.

Candidates were screened for the following potential exclusion criteria or COIs. These COI questions were intended to serve as a means of disclosure in order to better characterize a candidate's employment history and background. Battelle evaluated whether scientists in universities and consulting firms that are receiving USACE funding have sufficient independence from USACE to be appropriate peer reviewers. Guidance in OMB (2004, p. 18) states,

> "…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."

The term "firm" in a screening question referred to any joint venture in which a firm was involved. It applied to any firm that serves in a joint venture, either as a prime or as a subcontractor to a prime. Candidates were asked to clarify the relationship in the screening questions.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Cherry Creek Dam DSMR
1. Previous and/or current involvement by you or your firm in the Cherry Creek Dam, Colorado, Dam Safety Maintenance Report (Cherry Creek Dam DSMR) and related projects.
2. Previous and/or current involvement by you or your firm in flood control or dam safety in the Denver area and surrounding communities.
3. Previous and/or current involvement by you or your firm in the conceptual or actual design, construction, or operation and maintenance (O&M) of any projects related to Cherry Creek Dam.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Cherry Creek Dam DSMR
4. Current employment by the U.S. Army Corps of Engineers (USACE).
5. Previous and/or current involvement with paid or unpaid expert testimony related to Cherry Creek Dam DSMR.
6. Past, current, or future interests or involvements (financial or otherwise) by you, your spouse, or your children related to the Denver area and surrounding communities.
7. 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 Omaha District.
8. Previous or current involvement with the development or testing of models that will be used for, or in support of, the Cherry Creek Dam DSMR project.
9. Current firm involvement with other USACE projects, specifically those projects/contracts that are with the Omaha 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 Omaha District. Please explain.
10. Any previous employment by USACE as a direct employee, notably if employment was with the Omaha District. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
11. Any previous employment by USACE as a contractor (either as an individual or through your firm) within the last 10 years, notably if those projects/contracts are with the Omaha District. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
12. Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning flood management or dam safety, and include the client/agency and duration of review (approximate dates).
13. Pending, current, or future financial interests in contracts/awards from USACE related to the Cherry Creek Dam DSMR project.
14. Significant portion of your personal or office's revenues within the last three years came from USACE contracts.
15. Any publicly documented statement (including, for example, advocating for or discouraging against) related to the Cherry Creek Dam DSMR project.

Panel Conflict of Interest (COI) Screening Questionnaire for the IEPR of the Cherry Creek Dam DSMR
16. Participation in relevant prior and/or current Federal studies related to the Cherry Creek Dam DSMR project.
17. Previous and/or current participation in prior non-Federal studies related to the Cherry Creek Dam DSMR project.
18. Has your research or analysis been evaluated as part of the Cherry Creek Dam DSMR project?
19. 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? If so, please describe.

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.

B.2 Panel Selection

In selecting the final members of the Panel, Battelle chose experts who best fit the expertise areas and had no COIs. Table B-1 provides information on each panel member's affiliation, location, education, and overall years of experience. 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 selected the final Panel.

Table B-2 presents an overview of the credentials of the final four members of the Panel and their qualifications in relation to the technical evaluation criteria. More detailed biographical information on the panel members and their areas of technical expertise is given in Section B.3.

Table B-1. Cherry Creek Dam DSMR IEPR Panel: Summary of Panel Members

Name	Affiliation	Location	Education	P.E.	Exp. (yrs)
Consequence Economist/Planning					
Ken Casavant	Independent consultant	Pullman, WA	Ph.D., Agricultural Economics	N/A	45+
Environmental Biologist					
Charles Newling	Wetland Science Applications, Inc.	Briggsville, WI	M.S., Zoology (Wildlife Ecology)	N/A	43
Hydrology and Hydraulic Engineer					
Eric Weis	Smith Environmental & Engineering	Dacono, CO	B.S., Civil Engineering	Yes	20
Geotechnical / Civil Engineer					
Douglas Spaulding	Spaulding Consultants, Inc.	Golden Valley, MN	M.S., Geotechnical Engineering	Yes	50

Table B-2. Cherry Creek Dam DSMR IEPR Panel: Technical Criteria and Areas of Expertise

Technical Criterion	Casavant	Newling	Weis	Spaulding
Consequence Economist/Planner				
Minimum 15 years of demonstrated experience in economics	X			
Bachelor's degree or higher in economics	X			
Direct experience working for or with USACE is highly preferred but not required	X			
Expertise in flood risk management evaluating and conducting complex multi-objective public works projects with high public and interagency interest	X			
Familiarity with USACE flood risk management analysis, economics calculations utilizing the Hydrologic Engineering Center's (HEC) Flood Damage Reduction Analysis software (HEC-FDA 1.4.2)	X			
Expertise in acceptable methodologies for estimating life loss via the use of HEC's LifeSim software (HEC-LifeSim 1.0 – preferred) and/or Flood Impact Analysis software (HEC-FIA 3.0 - acceptable)	X			
Familiarity with USACE plan formulation process, procedures, and standards as they relate to flood risk management	X			
Minimum five years of experience directly dealing with the USACE six-step planning process, which is governed by ER 1105-2-100, Planning Guidance Notebook	X			

Table B-2. Cherry Creek Dam DSMR IEPR Panel: Technical Criteria and Areas of Expertise (continued)

Technical Criterion	Casavant	Newling	Weis	Spaulding
Environmental Biologist				
M.S. degree or higher in a related field		X		
At least 10 years of experience directly related to environmental evaluation or review		X		
Demonstrated experience working with National Environmental Policy Act (NEPA) environmental impact statement assessments, including cumulative effects analysis, for complex projects with competing trade-offs is highly desirable		X		
Hydrology and Hydraulic (H&H) Engineer				
Registered professional engineer			X	
Minimum of 15 years of experience in hydrologic and hydraulic engineering			X	
Experience with all aspects of hydrology and hydraulic engineering, including northwest hydrology, urban hydrology and hydraulics, open channels systems, effects of management practices and low impact development on hydrology, design of earthen dams and detention ponds, use of non-structural systems as they apply to flood proofing, warning systems and evacuation			X	
Familiarity with HEC modeling computer software, or equivalent commercial software, including HEC River Analysis System (RAS) and HEC Hydrologic Modeling System (HMS)			X	
Geotechnical/Civil Engineer				
Minimum of 15 years of experience in the field of geotechnical engineering related to the analysis, design, and construction of embankment dams and levees, including rehabilitation of these structures				X
Knowledge and experience in the evaluation of backward erosion piping (BEP) potential failure modes in the foundations of embankment dams and/or levees, and in the development, design, and construction of remediation alternatives for correcting BEP issues				X
Experience in failure mode analysis, risk assessment of embankment dams and/or levees, evaluation of risk reduction measures for dam safety assurance projects				X
Familiarity with USACE dam safety guidance				X
Demonstrated experience in developing construction costs, construction methods, sequencing, and schedules, including design and construction of dams, levees, channel construction, and road removal/relocation				X
Working knowledge of all applicable USACE design criteria				X
Licensed professional engineer				X

B.3 Panel Member Qualifications

Detailed biographical information on each panel members' credentials and qualifications and areas of technical expertise are summarized in the following paragraphs.

Name	Ken Casavant, Ph.D.
Role	Consequence Economist/Planner
Affiliation	Independent Consultant

Dr. Casavant is a professor and economist at the School of Economic Sciences at Washington State University, Director of the Freight Policy Transportation Institute, and adjunct professor at North Dakota State's Upper Great Plains Transportation Institute. He earned his Ph.D. in agricultural economics from Washington State University in 1971. Dr. Casavant has nearly 50 years of experience as an economist, with expertise in flood risk management plan formulation assignments, particularly the evaluation and comparison of alternative plans for numerous flood risk management projects including Continuing Authorities Program (CAP) Section 205 projects. He has served as an economic consultant detailing the tradeoffs necessary on several multi-objective public works projects, most recently on studies of the deep-draft national and international maritime industry and flood risk management.

Dr. Casavant is familiar with USACE plan formulation processes, procedures, and standards. He has more than 15 years of experience in plan formulation, evaluation, and comparison of alternative plans for numerous flood risk projects, navigation studies (lock replacement), ecosystem restoration projects, and feasibility studies, including his technical reviews of the Lower Columbia River Channel Deepening Project, the Upper Mississippi and Illinois Navigation Study, the Barataria Basin Barrier Shoreline Restoration Study, and the Mississippi River Gulf Outlet Ecosystem Restoration Plan, many of which included flood risk management requirements. The Mississippi-Illinois system project was a navigation lock system replacement project that included coastal inland waterway system needs. For the Lower Columbia River project, Dr. Casavant analyzed the costs of deep-draft shipping and the impacts of those costs on the project. The supply chains and alternative movements of maritime steam ships were a focal point of the analyses. For the Delaware River Main Channel Deepening Project, he assessed and documented the benefits of the project. For the Upper Mississippi and Illinois Navigation Study, he examined alternative shipping flows, including shallow and deep draft, and performed benefits calculations as part of the economic evaluation.

Dr. Casavant has worked with USACE methodologies for cost effectiveness/incremental cost analysis and has a detailed knowledge of USACE standards and procedures, including the Institute for Water Resource (IWR) Planning Suite. As an economist or a combined Civil Works planner/economist for USACE IEPRs, he has studied and evaluated alternative plans for navigation lock replacement projects as well as navigation/dredging projects, such as the Savannah Harbor Expansion Project General Re-evaluation Report. Over the last 10 years, he has worked on 13 USACE projects where he has had to apply USACE standards and procedures, including the IWR Planning Suite methodologies, with a focus on effective and efficient ecological and natural sustained output per dollar of relevant expenditure for alternative project formulations. He has applied the USACE six-step planning process, which is governed by Engineer Regulation (ER) 1105-2-100, *Planning Guidance Notebook*, during his work as a technical

reviewer and peer reviewer on more than 20 projects, such as the Port of Iberia Channel Deepening Project in 2006 for USACE; the External Independent Economic Opinion on Identifying and Measuring National Economic Development Benefits: Navigation Shipping; and the Morganza to the Gulf IEPR study, a hurricane protection and storm damage risk project.

Dr. Casavant has experience identifying, reviewing, and evaluating impacts on environmental resources from structural flood risk and impacts related to hurricane and coastal storm damage risk reduction projects. As part of other IEPRs, he has reviewed assessments prepared using HEC-FDA, HEC-LifeSim, and/or HEC-FIA. Whether formulating risk assessments developed using Monte Carlo evaluations or using traditional risk models in the IWR Planning Suite, he has acquired broad and applied experience working with risk-informed approaches to decision-making. The six most recent projects he has contributed to had critical components concerning the impacts of environmental resources from flood risk and coastal storm damage. He has also been a plan formulator expert on Louisiana Water Resources Council IEPRs; several of the projects under review had a specific objective to evaluate the damage reduction and the risk associated with achieving benefits from flood risk management, and one project focused specifically on the impact on shorelines.

Dr. Casavant has published more than 70 journal articles and has contributed to hundreds of written documents, including chapters in books, books, abstracts, proceedings, professional materials, conference papers, and research bulletins, circulars, and reports. He is a member of numerous professional associations, such as the Transportation Research Board-National Research Council, the International Agricultural Economics Association, and the Logistics and Physical Distribution Association.

Name	Charles Newling, PWS, CWB, CWD
Role	Environmental Biologist
Affiliation	Wetland Science Applications, Inc.

Mr. Newling is senior wetland regulatory scientist and senior vice president of Wetland Science Applications, Inc., and the Wetland Training Institute, Inc. He earned his M.S. in zoology (wildlife ecology) from Southern Illinois University in 1975. His 43-year career has focused on environmental evaluation of water resources in both the public and private sectors for compliance with the Clean Water Act (CWA) and NEPA. Mr. Newling has specialized knowledge of a broad array of environmental laws, with a strong focus on the requirements of the CWA, NEPA, the Rivers and Harbors Act (RHA), the Fish and Wildlife Coordination Act, the Endangered Species Act, and the National Historic Preservation Act. Compliance with these laws, including evaluation under the National Historic Preservation Act, as required to secure Federal permits under Section 10 of the RHA and Section 404 of the CWA.

Mr. Newling is familiar with the habitat and the fish and wildlife species of this area, gained through experience working on projects on the Mississippi River, the Great Lakes, and the Illinois River eco-region. His consulting work spans the ecology of the Upper Midwest as far back as 1975, when he authored two studies used by the St. Louis District in preparation for its EIS for the replacement of Lock and Dam 26 on the Mississippi River: *Preliminary Report on the Floodplain Animals of the Upper Mississippi River and the Illinois Waterway Including Some Probable Impacts of Increased Commercial Traffic* (1975), and *Threatened Vertebrate Species Occurring or Believed To Occur in the Floodplains of the Mississippi River between Cairo, Illinois, and Minneapolis, Minnesota, and the Illinois Waterway between Grafton, Illinois, and Chicago, Illinois* (1975). In addition, his expertise includes evaluating

ecosystem restoration technologies for mitigation of potential impacts from proposed projects. He has a strong knowledge of the ecology of wetlands, wet prairies, streams, and interconnected habitat, having conducted functional analyses of these environments since 1975.

Mr. Newling has experience calculating average annual habitat units and applying the calculations to determine mitigation or restoration needs (or to determine whether those needs have been satisfied). He is familiar with the development and use of habitat suitability indices (HSIs) and with various assessment models, including habitat evaluation procedures (HEPs) for riparian and wetland habitats, Hydrogeomorphic Approach, Wetland Evaluation Technique, and other assessment methods. He was trained in HEP from its inception, has worked with the team that developed some of the HSIs, and is familiar with the concepts and application of Index of Biotic Integrity and Floristic Quality Assessment. He also has taught some of these methods and was contracted by the State of Washington Department of Ecology to teach the State Wetland Rating System. In addition, he contributed to the development of the USACE Wetland Delineation Manual and supported efforts to develop and standardize evaluation of wetlands and related habitat. He also is familiar with essential fish habitat procedures.

Mr. Newling has more than 13 years of experience working for the USACE New England Division Regulatory Branch and the USACE Waterways Experiment Station Environmental Laboratory (now known as ERDC). His USACE work involved evaluation and long-term monitoring of habitat development projects. From 1981 to 1989, he was the technical coordinator for USACE wetland training, including evaluation of wetland functions and values, and he has organized, conducted, and served as primary instructor in hundreds of wetland-related training courses for professionals. He has provided rapid response assistance to USACE District offices nationwide on technical matters of wetland delineation, restoration, and regulation. His consulting expertise has focused on wetland delineation, wetland construction and restoration, the assessment of wetland functions and values, mitigation monitoring, and wetland mitigation banking. He is familiar with regulating works of various kinds, notably revetments and wing dams, and is familiar with environmental issues involving their construction and maintenance.

He also has gained knowledge of USACE documentation associated with flood risk management while working on several recent projects serving on IEPR panels for USACE projects in Illinois, Wisconsin, Iowa, Missouri, Kansas, Ohio, Nevada, and Colorado.

Mr. Newling is a member of the Society of Wetland Scientists, The Wildlife Society, Association of State Wetland Managers, Society of Ecological Restoration, and Wisconsin Wetlands Association; has served on the Board of Directors for the Society of Wetland Scientists as Liaison to its National Certification Program; and serves on the Board of Directors of the G.M. Sutton Avian Research Center. He is a Professional Wetland Scientist, Certified Wildlife Biologist, and Certified Wetland Delineator.

Name	Eric Weis, P.E.
Role	Hydrology and Hydraulic (H&H) Engineer
Affiliation	Smith Environmental and Engineering

Mr. Weis holds a B.S. in civil engineering from Colorado State University and has 20 years of experience working on a variety of water resources design and construction projects. He is a registered professional engineer in Colorado. His design qualifications include shepherding water resources facilities projects and urban infrastructure retrofit projects from concept to construction. His experience also includes regulatory

administration of land development, stormwater quality, and floodplain administration at both the local and regional level. He has also led municipal programs with multidisciplinary teams charged with the administration, operation, and asset management of public stormwater infrastructure.

Mr. Weis is experienced in the design and construction of water resource projects including water distribution, sanitary sewer collection, and stormwater management ranging from large-basin hydrology to small-scale water quality best management practices. He has extensive experience in floodplain studies and Federal Emergency Management Agency floodplain management to include Conditional Letters of Map Revision (CLOMRs) and other Letters of Map Change (LOMCs), Physical Map Revisions, and Flood Insurance Studies in both the Digital Flood Insurance Rate Map (DFIRM) and Risk Mapping and Planning (RiskMAP) formats. He has led or been a team member on more than 20 stormwater basin master planning studies, many of which were taken to final design and construction.

Mr. Weis has more than six years of experience managing teams that design, build, and maintain Civil Works at levels higher than the individual project. He prepared and executed multi-year budget plans funding operations, maintenance, and capital improvement in two Colorado jurisdictions, providing stormwater management and flood control services to more than 150,000 people. Mr. Weis's technical skills include Autodesk AutoCAD, Autodesk Civil 3D, ArcGIS, USACE HEC-RAS and HEC-GeoRAS, HEC-GeoHMS and HEC-HMS, U.S. Environmental Protection Agency Storm Water Management Model, Colorado Urban Hydrograph Procedure, Bentley StormCAD, WaterCAD, and MicroStation V8.

Mr. Weis has also given the United States more than 26 years of active duty and reserve military service, retiring with multiple commendations. Mr. Weis previously worked as Stormwater Division Manager for the City of Greeley Public Works, Greeley, Colorado. Among multiple responsibilities, he oversaw the overhaul of the city's stormwater design and construction standards, and he developed and implemented workflow processes for floodplain development and stormwater quality permits.

As a senior drainage engineer, Adams County Transportation Department, Adams County, Colorado, Mr. Weis was the primary advisor to the Transportation Director regarding drainage and flood control infrastructures within the county. Among multiple tasks, he administered the county's floodplain management program, reviewed and approved floodplain use permits, and reviewed and approved CLOMR applications and LOMCs. Mr. Weis also developed and implemented protocols to prioritize storm drainage and flood control master planning studies and capital improvement projects within the county.

Name	Douglas Spaulding, P.E.
Role	Geotechnical/Civil Engineer
Affiliation	Spaulding Consultants, Inc.

Mr. Spaulding is a principal and geotechnical engineer with Spaulding Consultants, LLC, responsible for dam, levee, and floodwall design and inspection. He earned his M.S. in geotechnical engineering from Purdue University and is a registered professional engineer in Wisconsin, Minnesota, and Michigan. He has 50 years of experience in the design, evaluation, and inspection of water-retaining structures.

During his long career, Mr. Spaulding has provided geotechnical design and evaluation services for flood control levees, embankments, and hydroelectric projects in a 23-state area. His experience includes

10 years with USACE, where he served as Chief of the Levee and Channel Design Section for the St. Paul District. In that capacity, he managed the development of the Pembina levee project in North Dakota and provided geotechnical design services for over $200 million worth of local flood protection projects in Wisconsin, Minnesota, and North Dakota. The Pembina project and the Mankato and Winona flood control projects in Minnesota all included extensive sections of floodwall (both I-wall and T-wall configurations). In addition, for the Winona project, Mr. Spaulding supervised the evaluation of underseepage using a drainage trench. He also served as the Program Manager for the National Dam Safety Program in Wisconsin and Minnesota. He has experience with lock structures in Minnesota and Michigan and served on the design team for the rehabilitation of Lock and Dams No.1 and No.2 on the Mississippi River and managed the design of several hydroelectric projects at dams on the Mississippi and Red Rivers.

As part of his experience, Mr. Spaulding applied USACE risk-informed approaches to the evaluation of safety issues at USACE navigation, flood control, and hydroelectric projects. From 1988 to 2010, he also provided dam safety training for USACE operations personnel at navigation and flood control projects. Over the last 10 years, Mr. Spaulding has participated in more than 75 Potential Failure Mode Analysis (PFMA) evaluations of dams and hydroelectric projects. As a facilitator of PFMA evaluations authorized by the Federal Energy Regulatory Commission (FERC), Mr. Spaulding has directed more than 50 evaluations for embankment dams, concrete gravity structures, and arch dam structures.

Mr. Spaulding has served on IEPR review panels dealing with local flood protection projects such as levees, channels and floodwalls, dam remediation, dam replacement, and seepage control system upgrades. This experience has provided extensive background in USACE's Safety Assurance Review requirements. Mr. Spaulding has provided peer review services on two reaches of hurricane protection projects in the New Orleans area. In 2008, he peer-reviewed the geotechnical design of the New Orleans Group 1 to Group 3 pump stations. In 2010, Mr. Spaulding also served on the IEPR team reviewing the Olmsted Lock and Dam structure on the Ohio River. In 2014, he served on the IEPR evaluation team for the Pine Creek dam remediation in Oklahoma, assessing proposed methods to control internal embankment seepage around an existing conduit that had created large internal voids in the 50-year-old dam. In addition, Mr. Spaulding currently serves on two FERC-appointed Boards of Consultants reviewing the design of two major hydroelectric projects and was appointed to the United States Department of Energy (DOE) Peer Review panel to evaluate ongoing DOE-sponsored research related to dams and hydroelectric generation. He recently served on a Bureau of Reclamation review panel for the Folsom Dam spillway addition.

Mr. Spaulding is a lifetime member of the American Society of Civil Engineers. He also is a member of the Minnesota Geotechnical Society, the National Hydropower Association, and the Construction Panel for the Minneapolis section of the American Arbitration Association.

APPENDIX C

Final Charge for the Cherry Creek Dam DSMR IEPR

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Charge Questions and Guidance to the Panel Members for the Independent External Peer Review (IEPR) of the Cherry Creek Dam, Colorado Dam Safety Modification Report

This is the final Charge to the Panel for the Cherry Creek Dam DSMR IEPR. This final Charge was submitted to USACE as part of the final Work Plan, originally submitted on December 17, 2018. The dates and page counts in this document have not been updated to match actual changes made throughout the project.

BACKGROUND

The Omaha District is conducting a Dam Safety Modification Study (DSMS) and preparing a Dam Safety Modification Report (DSMR) for potential modifications to Cherry Creek Dam. The DSMR will include a baseline risk assessment, risk-based alternative development, an Environment Impact Statement (EIS) report, and other documents needed for approval. The DSMR documents the condition of the existing structure and recommended corrective actions to reduce risks to tolerable levels. The DSMR serves as the decision document authorizing remedial actions to address failure mechanisms that pose unacceptable or intolerable risks to the public or the environment downstream while delivering its authorized benefits. In order for the project to function safely and effectively, the DSMR will be prepared in compliance with the USACE Engineering Regulation, ER 1110-2-1156, Dam Safety Policy and Procedures. The DSMR will describe the alternative risk management plans.

The Cherry Creek Dam project is located on Cherry Creek, 11.4 miles above its confluence with the South Platte River, in Arapahoe County, Colorado (southeast of the City of Denver). Cherry Creek Dam was authorized by the Flood Control Acts of 19 August 1941 (Public Law 228, 77th Congress, 1st Session) and December 1944. At the time of construction, the primary purposes of the project were to protect Denver against floods from Cherry Creek and to provide storage capacity for irrigation. Later, the project use plan was modified to add recreational benefits and to exclude the irrigation storage capacity. Cherry Creek Dam was operated as a dry dam (without permanent pool) until 1958.

The project consists of a rolled earth-fill embankment with a triple-barrel outlet works and a right abutment earthcut emergency spillway that runs parallel to the axis of the dam. The dam embankment is approximately 14,300 feet in length, has a maximum height of 140 feet and a crest width of 30 feet. The outlet works is located in the right abutment at embankment station 105+00, and consists of an approach channel, concrete intake tower with service bridge, a triple barrel concrete conduit, stilling basin, and a discharge channel. The discharge channel empties into the Cherry Creek channel a short distance downstream from the dam. The emergency spillway is earthcut with a 67-foot bottom width for the first 8,500 feet and a 1,000-foot transition to a 45-foot bottom width for the remaining 2,600 feet of the excavation. The spillway channel was excavated into overburden with 1V on 2H side slopes and into bedrock with 1V on 1H side slopes. The spillway, if used, would discharge into the Toll Gate and Sand Creek drainage basins, which are separate from the Cherry Creek drainage basin. The length of the reservoir at the multipurpose pool (El. 5550.0) and the original design flood control pool (El. 5598.0) are approximately 1.5 miles and 3.25 miles, respectively.

Construction of the project was initiated in fiscal year 1943 and was completed in June 1953. Construction was performed as three separate efforts – construction of the cutoff trench, construction of the outlet works, and construction of the embankment and spillway. Significant development has occurred in the metropolitan Denver area since original construction, significantly increasing the consequences of a dam failure or spillway flow. Cherry Creek Dam was initially assigned a Dam Safety Action Classification

(DSAC) 2 (high urgency of action) in December 2008 following the Screening Portfolio Risk Assessment conducted in July 2005. The project was considered high risk primarily due to an overtopping failure mode during a Probable Maximum Flood (PMF) event or other extreme storm, two internal erosion potential failure modes, and consequences associated with these potential failure modes. The DSAC 2 classification was confirmed in a 26 September 2011 memorandum from the U.S. Army Corps of Engineers Dam Safety Officer to the Northwestern Division Commander. The memorandum directed Northwestern Division to move the project into the DSMS Phase. The DSMS has confirmed that risks are above tolerable risk guidelines, primarily due to the potential for extreme incremental life loss consequences that exist downstream of the dam in the Denver metropolitan area. The only actionable failure mode is the hydrologic deficiency due to overtopping of the dam during an extreme hydrologic event, referred to as HE1. HE1 represents over 99 percent of the risk at Cherry Creek Dam. No action will be taken as a result of the Cherry Creek DSMS.

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the Cherry Creek Dam, Colorado Dam Safety Modification Report (DSMR) (hereinafter: Cherry Creek Dam DSMR IEPR) in accordance with the Department of the Army, U.S. Army Corps of Engineers (USACE), Water Resources Policies and Authorities' *Review Policy for Civil Works* (Engineer Circular [EC] 1165-2-217, dated February 20, 2018), and the Office of Management and Budget's (OMB's) *Final Information Quality Bulletin for Peer Review* (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 and environmental assumptions and projections, project evaluation data, economic analyses, environmental analyses, engineering analyses, formulation of alternative plans, methods for integrating risk and uncertainty, models used in evaluation of economic or environmental impacts, and any biological opinions" (EC 1165-2-217; p. 39) for the decision 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) who meet the technical criteria and areas of expertise required for and relevant to the project.

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 1165-2-217 (p.41), 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. The review assignments for the panel members may vary slightly according to discipline.

Review Documents[a]	No. of Review Pages	Subject Matter Experts			
		Consequence Economist/ Planning	Environ-mental Biologist	H&H Engineer	Geotechnical/ Civil Engineer
DSMR Main Report	110	110	110	110	110
Appendix A Geotechnical/Civil Engineering	200				200
Appendix B Office of Counsel Opinions	22	22	22	22	22
Appendix C Environmental Impact Statement	750	750	750	750	750
Appendix E Nonstructural Assessment	35	35	35	35	35
Appendix F Plan Formulation	130	130	130	130	130
Appendix G Consequences Appendix	50	50	50		
Appendix H Constructability Review	16			16	16
Appendix I Semi-Quantitative Risk Assessment	64	64	64	64	64
Appendix J Hydraulic Engineering	160			160	
Appendix K Real Estate Assessment	6	6	6		
Appendix L Cost Engineering	21	21			21
Appendix M Hydrologic Engineering	456			456	
Appendix N Plans and Drawings for Alternatives	40			40	40
Appendix O Structural Engineering	95			95	95
Appendix P Risk Assessment for Final Alternatives	70	70	70	70	70
Total Number of Review Pages	**2,225**	**1258**	**1237**	**1948**	**1553**
Supplemental Information					
Public Comments	50	50	50	50	50
Risk Estimate Report	400	400	400	400	400
Total Number of Reference Pages	**450**	**450**	**450**	**450**	**450**

[a] Appendix D was not listed in the Request for Proposal table of Review Documents. Battelle assumes this appendix is not being reviewed.

Documents for Reference

General

- EC 1105-2-412, Assuring Quality of Planning Models, 31 March 2011
- EC 1165-2-217, Review Policy for Civil Works, 20 February 2018
- ER 500-1-1, Civil Emergency Management Program
- 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 1110-2-1156, Engineering and Design - Safety of Dams - Policy and Procedures, 31 March 2014
- ER 1110-1-8159, Engineering and Design - DrChecks, 10 May 2001
- ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies
- National Academy of Sciences, "Policy 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. Available at: http://www.nationalacademies.org/site_assets/groups/nasite/documents/webpage/na_069688.pdf
- Water Resources Development Act of 2007, Sections 2034 & 2035, Pub. L. 110-114. Privacy Act, 5 U.S.C. § 522a as amended
- Best Practices in Dam and Levee Risk Analysis: https://www.usbr.gov/ssle/damsafety/risk/methodology.html

Environmental/Planning

- ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. CECWP, 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, 29 November 1978).
- ER 200-2-2, Environmental Quality, Procedures for Implementing NEPA. CECWRE (now CECW-A), 4 March 1988
- National Environmental Policy Act of 1969
- National Historic Preservation Act of 1966
- 36 CFR 800
- Endangered Species Act
- Clean Air Act
- Clean Water Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- Engineer Regulation 200-1-5, Policy for Implementation and Integrated Application of the USACE Environmental Operating Principles (EOP) and Doctrine and Sustainability
- Executive Order 12898, Federal Actions to Address Environmental Justice in
- Minority Populations and Low-Income Populations
- Executive Order 13045 Protection of Children from Environmental Health Risks and Safety Risks

Geotechnical Engineering

- EM 1110-2-1901, Engineering and Design - Seepage Analysis and Control for Dams, 30 April 1993
- EM 1110-2-1908, Instrumentation of Embankment Dams and Levees
- EM 1110-2-1913, Engineering and Design - Design and Construction of Levees, 30 April 2000
- EM 1110-2-1914, Engineering and Design – Design, Construction, and Maintenance of Relief Wells, 29 May 1992
- ETL 1110-2-556 (or most recent guidance), Risk-based Analysis in Geotechnical Engineering for Support of Planning Studies or more current Hydraulic Engineering
- EM 1110-2-1413, Hydrologic Analysis of Interior Areas, 15 January 1987
- EM 1110-2-1415, Hydrologic Frequency Analysis, 5 March 1993
- EM 1110-2-1416, River Hydraulics, 15 October 1993
- EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies, 1 August 1996
- EM 1110-2-2902, Engineering and Design - Conduits, Culverts, and Pipes, 31 March 1998
- MMC Production Center, Application of Simplified Physical Breach Method in HEC-RAS, 2 December 2016
- MMC Production Center, Levee Widening Erosion Rates, February 2016
- MMC Production Center, Standard operating procedures–Modeling, mapping and consequences, June 2014
- MMC Production Center, Modification of MMC Levee Analysis Standard Operation Procedure to Include Additional Overtopping Scenarios, January 2018

Peer Review

- EC 1165-2-217, Review Policy for Civil Works, 20 February 2018
- Office of Management and Budget, Final Information Quality Bulletin for Peer Review, 16 December 2004

SCHEDULE & DELIVERABLES

This schedule is based on the receipt date of the final review documents and may be revised if review document availability changes. This schedule may also change due to circumstances out of Battelle's control such as changes to USACE's project schedule and unforeseen changes to panel member and USACE availability. As part of each task, the panel member will prepare deliverables by the dates indicated in the table (or as directed by Battelle). All deliverables will be submitted in an electronic format compatible with MS Word (Office 2003).

Task	Action	Due Date
Attend Meetings and Begin Peer Review	Subcontractors complete mandatory Operations Security (OPSEC) training	1/17/2019
	Battelle sends review documents to panel members	12/19/2018
	Battelle convenes kick-off meeting with panel members	12/20/2018
	Battelle convenes kick-off meeting with USACE and panel members	12/21/2018

Task	Action	Due Date
	Battelle convenes mid-review teleconference for panel members to ask clarifying questions of USACE	1/7/2019
Prepare Final Panel Comments	Panel members complete their individual reviews	1/23/2019
	Battelle provides talking points for Panel Review Teleconference to panel members	1/25/2019
	Battelle convenes Panel Review Teleconference	1/28/2019
	Battelle provides Final Panel Comment templates and instructions to panel members	1/29/2019
	Panel members provide draft Final Panel Comments to Battelle	2/4/2019
	Battelle provides feedback to panel members on draft Final Panel Comments; panel members revise Final Panel Comments	2/05/2019 - 2/11/2019
	Panel finalizes Final Panel Comments	2/12/2019
Review Public Comments	Battelle receives public comments from USACE	1/23/2019
	Battelle sends public comments to Panel	1/25/2019
	Panel completes its review of public comments	1/30/2019
	Battelle and Panel review the Panel's responses to the charge question regarding the public comments	1/31/2019
	Panel drafts Final Panel Comment for public comments, if necessary	2/7/2019
	Panel finalizes Final Panel Comment regarding public comments, if necessary	2/11/2019
Review Final IEPR Report	Battelle provides Final IEPR Report to panel members for review	2/14/2019
	Panel members provide comments on Final IEPR Report	2/19/2019
	*Battelle submits Final IEPR Report to USACE	2/21/2019
	USACE Risk Management Center (RMC) provides decision on Final IEPR Report acceptance	2/28/2019
Comment/ Response Process	Battelle inputs Final Panel Comments to Design Review and Checking System (DrChecks) and provides Final Panel Comment response template to USACE	3/4/2019
	Battelle convenes teleconference with USACE to review the Comment Response process	3/4/2019
	Battelle convenes teleconference with Panel to review the Comment Response process	3/4/2019
	USACE Project Delivery Team (PDT) provides draft Evaluator Responses to USACE RMC for review	3/18/2019
	USACE RMC reviews draft Evaluator Responses and works with USACE PDT regarding clarifications to responses, if needed	3/22/2019
	USACE RMC provides draft PDT Evaluator Responses to Battelle	3/25/2019

Task	Action	Due Date
	Battelle provides draft PDT Evaluator Responses to panel members	3/27/2019
	Panel members provide draft BackCheck Responses to Battelle	4/1/2019
	Battelle convenes teleconference with panel members to discuss draft BackCheck Responses	4/2/2019
	Battelle convenes Comment Response Teleconference with panel members and USACE	4/3/2019
	USACE inputs final PDT Evaluator Responses to DrChecks	4/10/2019
	Battelle provides final PDT Evaluator Responses to panel members	4/11/2019
	Panel members provide final BackCheck Responses to Battelle	4/16/2019
	Battelle inputs panel members' final BackCheck Responses to DrChecks	4/17/2019
	*Battelle submits pdf printout of DrChecks project file	4/18/2019

* Deliverables

** Battelle will provide public comments to panel members after they have completed their individual reviews of the project documents to ensure that the public comment review does not bias the Panel's review of the project documents.

CHARGE FOR PEER REVIEW

Members of this IEPR Panel are asked to determine whether the technical approach and scientific rationale presented in the decision documents are credible and whether the conclusions are valid. The Panel is asked to determine whether the technical work is adequate, competently performed, and properly documented; satisfies established quality requirements; and yields scientifically credible conclusions. The Panel is being 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 decision documents. Please focus your review on the review materials assigned to your discipline/area of expertise and technical knowledge. Some sections have no questions associated with them; however, you may still 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 that the Panel will be asked to provide an overall statement related to 2 and 3 below per USACE guidance (EC 1165-2-217).

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 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 (Lynn McLeod; mcleod@battelle.org) for requests or additional information.

3. In case of media contact, notify the Battelle Program Manager, Lynn McLeod (mcleod@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 the Project Manager, no later than 10 pm ET by the date listed in the schedule above.

Independent External Peer Review of the Cherry Creek Dam, Colorado Dam Safety Modification Report (DSMR)
Charge Questions and Relevant Sections as Supplied by USACE

The following Review Charge to Reviewers outlines the objectives of the Independent External Peer Review (IEPR) for the subject study and identifies specific items for consideration for the IEPR Review Panel.

The objective of the IEPR is to obtain an independent evaluation of whether the interpretations of analysis and conclusions based on analysis are reasonable for the subject study. The IEPR Review Panel is requested to offer a broad evaluation of the overall study decision document in addition to addressing the specific technical and scientific questions included in the Review Charge. The Review Panel has the flexibility to bring important issues to the attention of decision makers, including positive feedback or issues outside those specific areas outlined in the Review Charge. The Review Panel can use all available information to determine what scientific and technical issues related to the decision document may be important to raise to decision makers. This includes comments received from agencies and the public as part of the public review process.

The Panel review is to focus on scientific and technical matters, leaving policy determinations for USACE and the Army. The Panel should not make recommendations on whether a particular alternative should be implemented or present findings that become “directives” in that they call for modifications or additional studies or suggest new conclusions and recommendations. In such circumstances the Review Panel would have assumed the role of advisors as well as reviewers, thus introducing bias and potential conflict in their ability to provide objective review.

Panel review comments are to be structured to fully communicate the Panel’s intent by including the comment, why it is important, any potential consequences of failure to address, and suggestions on how to address the comment

The Review Panel is asked to consider the following items as part of its review of the decision document and supporting materials.

Broad Evaluation Review Charge Questions

1. Is the need for and intent of the decision document clear?
2. Does the decision document adequately address the stated problem and intent relative to scientific and technical issues?
3. Do the methodologies used to inform the risk assessment align with accepted industry and scientific practices?

Given the need for and intent of the decision document, assess the adequacy and acceptability of the following:

4. Project evaluation data used in the study analyses

5. Economic, environmental, and engineering assumptions that underlie the study analyses
6. Economic, environmental, and engineering methodologies, analyses, and projections
7. Models used in the evaluation of existing and future without-project conditions and of economic or environmental impacts of alternatives
8. Methods for integrating risk and uncertainty
9. Formulation of alternative plans and the range of alternative plans considered
10. Quality and quantity of the surveys, investigations, and engineering sufficient for conceptual design of alternative plans
11. Overall assessment of significant environmental impacts and any biological analyses.

Further:

12. Evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable.
13. Assess the considered and tentatively selected alternatives from the perspective of systems, including systemic aspects being considered from a temporal perspective, including the potential effects of climate change.

For the Tentatively Selected Plan (No Action), assess whether:

14. The models used to assess life safety hazards are appropriate.
15. The tradeoffs of protecting life safety versus accepting risk for high consequence/low probability events have been adequately evaluated, including consideration of uncertainty.
16. The assumptions made for the life safety hazards are appropriate.
17. The quality and quantity of the surveys, investigations, and engineering are sufficient for a concept design considering the life safety hazards and to support the models and assumptions made for determining the hazards.
18. The analysis adequately addresses the uncertainty and residual risk given the consequences associated with the potential for loss of life for this type of project.
19. From a public safety perspective, the proposed alternative is reasonably appropriate or are there other alternatives that should be considered.

Specific Technical and Scientific Review Charge Questions

Plan Formulation/Evaluation

20. Was a reasonably complete array of possible measures considered in the development of alternatives, including those non-structural measures?

21. Have the five required alternatives (ER 1110-2-1156) been identified and adequately discussed and considered, including identification of an alternative “Achieving only tolerable risk limit for life-safety”?

22. Does each alternative meet the formulation criteria of being effective, efficient, complete, and acceptable per USACE definitions? Do they meet the study objectives and avoid violating the study constraints? Is the evaluation and comparison of the alternative appropriate and are the results of the screening acceptable?

Civil

23. Do the drawings provide adequate detail to illustrate and describe the alternatives?

24. Are the major scope items adequately captured, described, and illustrated?

25. Are constructability issues addressed in adequate detail?

Engineering Geology

26. Does the study clearly characterize the pertinent geologic conditions of the dam’s foundation?

27. Does the study clearly describe the geological investigations and supporting studies completed to date?

28. Does the study identify the material properties of the foundation rock needed to design features such as rock anchors?

Hydrology and Hydraulics

29. 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?

30. Is the method used to develop the hydrologic loading curve appropriate to support the risk management plan selection?

31. Is the flood frequency analysis sufficient to support a decision to accept the risk of overtopping?

Environmental

32. Was the discussion of natural resources sufficient to characterize current baseline conditions and to allow for evaluation of forecasted conditions (with and without proposed actions)?

33. Are the analyses of the human environment including socio-economic and natural resources within the project area sufficient to support the estimation of impacts of the final array of alternatives?

34. Did the formulation process follow the requirement to avoid, minimize, and then mitigate adverse impacts to resources?

35. Does the EIS meet the NEPA requirements and implementing ER 200-2-2?

Battelle Summary Charge Questions to the Panel Members[1]

Summary Questions

36. Please identify the most critical concerns (up to five) you have with the project and/or review documents. These concerns can be (but do not need to be) new ideas or issues that have not been raised previously.

37. Please provide positive feedback on the project and/or review documents.

Public Comment Questions

38. Do the public comments raise any additional discipline-specific technical concerns with regard to the overall report?

[1] Questions 36 through 38 are Battelle-supplied questions and should not be construed or considered part of the list of USACE-supplied questions. These questions were delineated in a separate appendix in the final Work Plan submitted to USACE.

APPENDIX D

Conflict of Interest Form

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David Kaplan
USACE, Institute for Water Resources
November 14, 2018
C-2

Conflicts of Interest Questionnaire

Independent External Peer Review

Cherry Creek Dam, Colorado (CO), Dam Safety Modification Report (DSMR)

The purpose of this document is to help the U.S. Army Corps of Engineers identify potential organizational conflicts of interest on a task order basis as early in the acquisition process as possible. Complete the questionnaire with background information and fully disclose relevant potential conflicts of interest. Substantial details are not necessary; USACE will examine additional information if appropriate. Affirmative answers will not disqualify your firm from this or future procurements.

NAME OF FIRM: **Battelle Memorial Institute Corporate Operations**
REPRESENTATIVE'S NAME: **Courtney Brooks**
TELEPHONE: **614-424-5623**
ADDRESS: **505 King Avenue, Columbus, Ohio 43201**
EMAIL ADDRESS: **brooksc1@battelle.org**

I. INDEPENDENCE FROM WORK PRODUCT. Has your firm been involved in any aspect of the preparation of the subject study report and associated analyses (field studies, report writing, supporting research etc.) **No** Yes (if yes, briefly describe):

II. INTEREST IN STUDY AREA OR OUTCOME. Does your firm have any interests or holdings in the study area, or any stake in the outcome or recommendations of the study, or any affiliation with the local sponsor? **No** Yes (if yes, briefly describe):

III. REVIEWERS. Do you anticipate that all expert reviewers on this task order will be selected from outside your firm? No **Yes** (if no, briefly describe the difficulty in identifying outside reviewers):

IV. AFFILIATION WITH PARTIES THAT MAY BE INVOLVED WITH PROJECT IMPLEMENTATION. Do you anticipate that your firm will have any association with parties that may be involved with or benefit from future activities associated with this study, such as project construction? **No** Yes (if yes, briefly describe):

V. ADDITIONAL INFORMATION. Report relevant aspects of your firm's background or present circumstances not addressed above that might reasonably be construed by others as affecting your firm's judgment. Please include any information that may reasonably: impair your firm's objectivity; skew the competition in favor of your firm; or allow your firm unequal access to nonpublic information.

No additional information to report.

Courtney M. Brooks

Courtney Brooks — November 14, 2018
Date

Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal

BATTELLE

It can be done