

Final Independent External Peer Review Report Mohawk Dam Major Rehabilitation Report Warsaw, Ohio

Prepared by
Battelle Memorial Institute

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

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Task Control Number: 10-208
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SHORT-TERM ANALYSIS SERVICE (STAS)

on

**Final Independent External Peer Review Report
Mohawk Dam Major Rehabilitation Report
Warsaw, Ohio**

by

**Battelle
505 King Avenue
Columbus, OH 43201**

for

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Scientific Services Program

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**FINAL
INDEPENDENT EXTERNAL PEER REVIEW REPORT
for the**

**Mohawk Dam Major Rehabilitation Report
Warsaw, Ohio**

EXECUTIVE SUMMARY

Project Background and Purpose

Mohawk Dam is located in Coshocton County, Ohio, on the Walhonding River, a tributary of the Muskingum River. The project is located about 17 miles upstream of the city of Coshocton, Ohio. The purpose of the Major Rehabilitation Report is to address reliability deficiencies at Mohawk Dam. Action is needed because the excessive uncontrolled seepage is negatively affecting the structural stability of the dam, resulting in increased risks to the downstream public. Due to the history of excessive seepage through and under the dam and through the left abutment during events with frequent return periods, it was ranked by the U.S. Army Corps of Engineer's Screening for Portfolio Risk Assessment (SPRA) process as a Dam Safety Action Class II – Urgent (unsafe or potentially unsafe) project. Rehabilitation is needed to correct these seepage problems and to minimize the potential for catastrophic failure of the dam during such events.

Several alternatives were considered in the Mohawk Dam Major Rehabilitation Report (hereinafter Mohawk Dam MRR) to address the risk and reliability issues associated with the project. Three features of the project were identified as areas of concern: the main embankment, left abutment, and spillway, all of which would need separate actions in order to accomplish the rehabilitation of the complete project. Major rehabilitation guidance requires that each “separable” component be individually justified. However, in the case of Mohawk Dam, repairing the main embankment without repairing the left abutment, or vice versa, would not accomplish the goals and objectives of the study. While repair of a single feature would reduce the risk associated with that feature, it would not reduce the risk or increase the reliability of the project as a whole:

- Catastrophic failure of the main embankment could occur even if the left abutment were rehabilitated.
- Likewise, catastrophic failure of the left abutment could occur even if the main embankment was rehabilitated.

This resulted in the designation of two separable components and three features of the project. The first component consists of the left abutment and main embankment, and the second component is the spillway.

Alternatives to address planning objectives were developed in the Mohawk Dam MRR for each feature and these alternatives were combined after the initial screening to form a comprehensive

solution for the entire project. These alternatives were evaluated based on their ability to meet project objectives considering engineering, economic, and environmental feasibility.

The final array of plans is listed below:

- Main Embankment Full Depth Centerline Seepage Cutoff Wall and Left Abutment Seepage Cutoff Wall (Immediate Rehabilitation)
- Main Embankment Full Depth Centerline Seepage Cutoff Wall, Left Abutment Seepage Cutoff Wall and Spillway Gravity Monolith Section (Immediate Rehabilitation)
- No Action (as required by the National Environmental Policy Act).

For the final screening, the plans were analyzed to determine the most economic investment, as well as which alternative would reduce the most risk in terms of loss of life downstream of the dam. As the environmental effects of all of the final plans were considered minor and insignificant, all plans were considered nearly equal in terms of environmental acceptability.

As the plan with the highest net benefits, the Main Embankment Full Depth Centerline Seepage Cutoff Wall and Left Abutment Seepage Cutoff Wall plan was identified in the Mohawk Dam MRR as the National Economic Development (NED) plan. However, due to engineering considerations and life safety concerns, as well as the need for the project as a whole to be stable and perform satisfactorily for the probable maximum flood (PMF) event, the recommended alternative was the Main Embankment Full Depth Centerline Cutoff Wall, Left Abutment Seepage Cutoff Wall, and Spillway Gravity Monolith Section plan.

The critical factor in the decision to include the spillway repair in the recommended plan was the probability of failure associated with that feature. The Without Project condition probability of failure was determined to present an unacceptable level of risk to the project and the downstream community.

Methodology of the Independent External Peer Review

USACE is conducting an Independent External Peer Review (IEPR) of the Mohawk Dam MRR. Battelle, as a 501(c)(3) non-profit science and technology organization with experience in establishing and administering peer review panels for USACE, was engaged to coordinate the IEPR of the Mohawk Dam MRR. Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analyses. The IEPR was external to the agency and conducted following USACE and Office of Management and Budget (OMB) guidance described in USACE (2010), USACE (2007), and OMB (2004). This final report describes the IEPR process, describes the panel members and their selection, and summarizes the Final Panel Comments of the IEPR Panel (the Panel).

Six panel members were selected for the IEPR from more than 40 identified candidates. Based on the technical content of the Mohawk Dam MRR and the overall scope of the project, the final panel members were selected for their technical expertise in six key areas: (1) plan formulation, (2) economics, (3) hydrology and hydraulics engineering, (4) soils engineering, (5) engineering geology, and (6) NEPA and biology/ecology. Although the Panel was disclosed to USACE, Battelle made the final decision on selecting the Panel.

The Panel received electronic versions of the Mohawk Dam MRR documents, totaling more than 2,000 pages (listed in Appendix B), along with a charge that solicited comments on specific sections of the documents to be reviewed. The charge was prepared by Battelle to assist USACE in developing the charge questions that were to guide the peer review, according to guidance provided in USACE (2010) and OMB (2004). USACE was given the opportunity to provide comments and revisions, and subsequently approved the final charge questions.

The USACE Project Delivery Team briefed the Panel and Battelle during a kick-off meeting held via teleconference prior to the start of the review. There was also a one-day site visit to Warsaw, Ohio on January 19, 2011 where the Panel received a 3 hour detailed briefing on the Mohawk Dam MRR in the morning and visited the Mohawk Dam to view critical components in the afternoon. The Panel also participated in a site visit debriefing facilitated by Battelle to discuss what they had viewed at the site visit and to brief the one panel member who was not able to attend the site visit. In addition to the teleconference and site visit, a teleconference with USACE, the Panel, and Battelle was held halfway through the review period to provide the Panel an opportunity to ask questions of USACE and clarify uncertainties. The Panel produced more than 500 individual comments in response to the 103 charge questions.

IEPR panel members reviewed the Mohawk Dam MRR documents individually. The panel members then met via teleconference with Battelle to review key technical comments, discuss charge questions for which there were conflicting responses, and reach agreement on the Final Panel Comments to be provided to USACE. Each Final Panel Comment was documented using a four-part format consisting of: (1) a comment statement; (2) the basis for the comment; (3) the significance of the comment (high, medium, or low); and (4) recommendations on how to resolve the comment. Overall, 30 Final Panel Comments were identified and documented. Of these, 15 were identified as having high significance, 14 had medium significance, and 1 had low significance.

Results of the Independent External Peer Review

Table ES-1 summarizes the Final Panel Comments by level of significance. Detailed information on each comment is contained in Appendix A of this report.

Table ES-1. Overview of 30 Final Panel Comments Identified by the Mohawk Dam MRR IEPR Panel

Significance – High	
1	Potential life safety consequences due to catastrophic failures from unsatisfactory dam performance were not evaluated.
2	The rationale and justification for the identification of the NED plan and for the deviation from the NED plan have not been sufficiently supported in the report.
3	The rationale for selecting the recommended plan is not consistent with USACE guidance on project formulation.
4	The potentially viable left abutment grout curtain alternative was not adequately considered, leaving the alternative development process incomplete.

5	The screening of alternatives was abbreviated and did not include evaluations of the benefits and costs of each alternative.
6	The alternative development process for the full depth cutoff wall did not include probabilistic seepage analyses and consideration of the risks associated with construction.
7	The Expert Elicitation panel may have exceeded their charge, resulting in a recommended plan for remediation that is not adequately supported.
8	Non-structural alternatives were not fully developed and evaluated.
9	A succinct definition of the base condition was not fully developed and documented.
10	The discussion of the risk and reliability analysis methodology is confusing and does not provide sufficient information to confirm the technical adequacy or the appropriate use of the model developed to evaluate economic feasibility.
11	The results of the probabilistic seepage analyses call into question the method that was used and the consistency of the variables applied to the analyses.
12	Inconsistencies in hydraulic conductivity values presented in the Engineering Reanalysis Report (ERR) and MRR are not explained, and key variables in the seepage analyses that affect the risk analyses are not identified.
13	Relatively little data are available establishing the seepage situation in the left abutment.
14	The hydrologic models used to determine the inflow into Mohawk Dam and downstream water surface profiles were not calibrated with past storm events.
15	The abbreviated methodology used in the analysis of the road damages benefit category is not based on sound engineering principles.
Significance – Medium	
16	The assumptions behind the hydrological uncertainties leading to spillway erosion failure were not provided.
17	Adequate consideration was not given to alternatives to address rock erosion downstream of the emergency spillway.
18	Potentially viable off-site alternatives were not investigated, making the alternative development process incomplete.
19	The erodibility analysis downstream of the emergency spillway was not sufficiently supported.
20	The potential consequences and impacts of catastrophic failure, particularly the severity, intensity, and duration of such a failure, are not fully described and evaluated from an engineering, environmental, or economic perspective.
21	The public that may be affected by a possible significant catastrophic event may not have been notified through the public outreach efforts performed to date.
22	The potential for dam embankment failure due to overtopping was not discussed in the report.
23	No data were provided in the report on the <i>in situ</i> permeability values for the foundation rock.
24	Potential impacts to wildlife habitats and water quality from the No Action and Action Alternatives (Plans A and B) were not thoroughly investigated and evaluated.
25	Documentation of the commitments made to avoid, minimize, and/or reduce impacts are not consistent with Council on Environmental Quality guidelines.

26	The cumulative impacts analysis does not evaluate the impact of present and reasonably foreseeable future incremental actions at Mohawk Dam on upstream and downstream projects.
27	Supporting documentation has not been provided for the basis on which emergency repair expenditures have been estimated.
28	The use of historic reportable damages as the basis for identifying current average annual damages and as a measure of lost capacity to prevent future flood damages is not consistent with USACE guidance.
29	The documentation supporting the estimate of flood damages prevented is incomplete.
Significance – Low	
30	The analysis of recreation benefits using the Unit Day Value (UDV) method is not fully supported.

The panel members agreed amongst each other on their “assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used” (USACE, 2010; p. D-4) in the Mohawk Dam MRR document. Significantly, the Panel agreed that the extent of the seepage problem at the site, in light of unsuccessful prior attempts to correct the problem, warrants consideration of a major remediation project at Mohawk Dam. The following statements summarize the Panel’s findings, which are described in more detail in the Final Panel Comments (see Appendix A).

Plan Formulation: The MRR is in compliance with all of the typical formulation steps; however, the report does not use any of the required data inputs and formulation techniques identified in USACE regulations on plan formulation (USACE, 2000) as a basis for screening and formulating alternatives. The Panel is concerned that all reasonable alternatives were not considered, and alternatives were screened without a comparison of costs and benefits. The selection of the NED plan cannot be confirmed, and the rationale and overriding reasons for deviation from the NED plan have not been identified and justified. Therefore, the Panel has concluded that the adequacy and acceptability of the formulation of alternative plans cannot be confirmed; a reanalysis of a full range of alternatives consistent with formulation guidance is necessary to provide a sufficient analysis upon which to base a recommendation.

Economics: Although the economic portion of the MRR is abbreviated, it identifies the types of benefits appropriate for analysis. However, there are problems with the technical adequacy or validity of every category of benefits claimed. There is limited rationale given for making economic decisions, the base condition is not properly defined as a basis for calculating benefits, and there is a lack of presentation, documentation, or explanation of the methodology used to estimate average annual benefits for every category of benefits included in the MRR. In addition, average annual benefits were not estimated for each alternative considered. Evaluating alternatives and determining the alternative that maximizes net benefits is required to identify the NED plan. Based on the current analysis, the Panel cannot verify the identification of the NED plan or determine the economic feasibility of the recommended plan.

Engineering: While extensive analyses were performed for certain elements of the problem, insufficient justification has been given for the elimination of some alternatives (especially the grouting alternative) along with inadequate documentation to support parameters used in critical analyses. There are issues related to the in situ permeability of the soils and rock which have the potential to cause significant changes in construction methodology, cost, and schedule. In addition, the Panel found that the risk posed by the left abutment was not of the same magnitude as that posed by the dam, and that there was no technical justification for selecting the same cutoff method as for the dam. Finally, the Panel received insufficient documentation with the original review documents and, while USACE was responsive in providing the requested data, the Panel believes the review process would have been more efficient had all the engineering data been provided at the outset.

Environmental: The evaluation and analysis of potential effects to the human, physical, and natural environment was largely qualitative; additional detail is needed to affirm the assessments made in the MRR and EA. Insufficient detail in the description of potential direct, indirect, and cumulative impacts from off-site alternatives and from the No Action Alternative resulted in some uncertainties by the Panel of the alternative selection process, including the selection of the recommended plan. The MRR and EA did not consider the wide-reaching effects of actions in the Muskingum River basin that may result in beneficial and/or adverse effects to Mohawk Dam.

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LIST OF ACRONYMS

ATR	Agency Technical Review
COI	Conflict of Interest
DrChecks	Design Review and Checking System
EA	Environmental Assessment
ERR	Engineering Reanalysis Report
FONSI	Finding of No Significant Impact
HMR	Hydrometeorological Report
IEPR	Independent External Peer Review
Lu	lugeons
MRR	Major Rehabilitation Report
NED	National Economic Development
NEPA	National Environmental Policy Act
NTP	Notice to Proceed
OMB	Office of Management and Budget
PMF	probable maximum flood
UDV	Unit Day Value
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WRDA	Water Resources Development Act

1. INTRODUCTION

Mohawk Dam is located in Coshocton County, Ohio, on the Walhonding River, a tributary of the Muskingum River. The project is located about 17 miles upstream of the city of Coshocton, Ohio. The purpose of the Major Rehabilitation Report is to address reliability deficiencies at Mohawk Dam. Action is needed because the excessive uncontrolled seepage is negatively affecting the structural stability of the dam, resulting in increased risks to the downstream public. Due to the history of excessive seepage through and under the dam and through the left abutment during events with frequent return periods, it was ranked by the U.S. Army Corps of Engineer's Screening for Portfolio Risk Assessment (SPRA) process as a Dam Safety Action Class II – Urgent (unsafe or potentially unsafe) project. Rehabilitation is needed to correct these seepage problems and to minimize the potential for catastrophic failure of the dam during such events.

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As the plan with the highest net benefits, the Main Embankment Full Depth Centerline Seepage Cutoff Wall and Left Abutment Seepage Cutoff Wall plan was identified in the Mohawk Dam MRR as the National Economic Development (NED) plan. However, due to engineering considerations and life safety concerns, as well as the need for the project as a whole to be stable and perform satisfactorily for the probable maximum flood (PMF) event, the recommended alternative is the Main Embankment Full Depth Centerline Cutoff Wall, Left Abutment Seepage Cutoff Wall and Spillway Gravity Monolith Section plan.

The critical factor in the decision to include the spillway repair in the recommended plan was the probability of failure associated with that feature. The Without Project condition probability of failure was determined to present an unacceptable level of risk to the project and the downstream community.

The objective of the work described here was to conduct an Independent External Peer Review (IEPR) of the Mohawk Dam Major Rehabilitation Report (MRR) in accordance with procedures described in the Department of the Army, U.S. Army Corps of Engineers Engineer Circular *Civil Works Review Policy* (EC No. 1165-2-209) (USACE, 2010), USACE CECW-CP memorandum *Peer Review Process* (USACE, 2007), and Office of Management and Budget (OMB) bulletin *Final Information Quality Bulletin for Peer Review* (OMB, 2004). Battelle, as a 501(c)(3) non-profit science and technology organization with experience in establishing and administering peer review panels, was engaged to coordinate the IEPR of the Mohawk Dam MRR. Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analyses.

This final report details the IEPR process, describes the IEPR panel members and their selection, and summarizes the Final Panel Comments of the IEPR Panel on the existing environmental, economic, and engineering analyses contained in the Mohawk Dam MRR. Detailed information on the Final Panel Comments is provided in Appendix A.

2. PURPOSE OF THE IEPR

To ensure that USACE documents are supported by the best scientific and technical information, USACE has implemented a peer review process that uses IEPR to complement the Agency Technical Review (ATR), as described in USACE (2010) and USACE (2007).

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 economic, engineering, and environmental analysis of the project study. In particular, the IEPR addresses the technical soundness of the project study's assumptions,

methods, analyses, and calculations 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 Mohawk Dam MRR was conducted and managed using contract support from Battelle, which is an Outside Eligible Organization under Section 501(c)(3) of the U.S. Internal Revenue Code with experience conducting IEPRs for USACE.

3. METHODS

This section describes the method followed in selecting the members for the IEPR Panel (the Panel) and in planning and conducting the IEPR. The IEPR was conducted following procedures described by USACE (2010) and in accordance with USACE (2007) and OMB (2004) guidance. Supplemental guidance on evaluation for conflicts of interest (COIs) was obtained from the *Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports* (The National Academies, 2003).

3.1 Planning and Schedule

After receiving the notice to proceed (NTP), Battelle held a kick-off meeting with USACE to review the preliminary/suggested schedule, discuss the IEPR process, and address any questions regarding the scope (e.g., clarify expertise areas needed for panel members). During the kick off meeting potential dates for the site visit were discussed. Subsequently, the site visit was delayed until January 2011 to ensure that critical USACE PDT staff could participate. The schedule was updated to reflect the changes to the schedule as a result of delaying the site visits and distributed to USACE.

Table 1 defines the schedule followed in executing the IEPR. Due dates for milestones and deliverables are based on the NTP date of August 23, 2010. Note that the work items listed in Task 7 occur after the submission of this report. Battelle will enter the 30 Final Panel Comments developed by the Panel into USACE’s Design Review and Checking System (DrChecks), a Web-based software system for documenting and sharing comments on reports and design documents, so that USACE can review and respond to them. USACE will provide responses (Evaluator Responses) to the Final Panel Comments, and the Panel will respond (BackCheck Responses) to the Evaluator Responses. All USACE and Panel responses will be documented by Battelle.

Table 1. Mohawk Dam MRR IEPR Schedule

TASK	ACTION	DUE DATE
1	NTP	August 23, 2010
	Review Documents Available	September 1, 2010
	Battelle prepares draft Work Plan ^a	September 16, 2010
	USACE provides comments on draft Work Plan	September 28, 2010
	Battelle prepares final Work Plan ^a	October 5, 2010
2	Battelle submits list of six selected panel members ^a	September 14, 2010
	USACE provides comments on list of panel members	September 20, 2010

TASK	ACTION	DUE DATE
	Battelle completes subcontracts for panel members	October 12, 2010
3	Battelle submits draft charge ^a	September 16, 2010
	USACE provides comments on draft charge	September 28, 2010
	Battelle submits final Work Plan, including final charge ^b	October 5, 2010
	USACE approves final Work Plan, including final charge	October 6, 2010
4	Battelle convenes kick-off meeting with USACE	September 8, 2010
	Battelle convenes kick-off meeting with IEPR Panel	January 10, 2011
	Battelle convenes kick-off meeting with USACE and IEPR Panel	January 10, 2011
	USACE convenes Mohawk Dam site visit in Warsaw, Ohio	January 19, 2011
5	Battelle sends review documents and charge to IEPR Panel	January 4, 2011
	IEPR Panel completes review and provides comments to Battelle	February 1, 2011
	Battelle consolidates comments from IEPR Panel	February 3, 2011
	Battelle convenes panel review teleconference with IEPR Panel	February 7, 2011
6	IEPR Panel provides draft Final Panel Comments to Battelle	February 14, 2011
	Battelle submits final IEPR Report to USACE ^a	February 28, 2011
7 ^b	Battelle inputs Final Panel Comments to DrChecks	March 2, 2011
	USACE provides draft Evaluator Responses via e-mail (Word document)	March 7, 2011
	Battelle convenes teleconference with USACE, Battelle, and IEPR Panel to discuss Final Panel Comments	March 17, 2011 (est.)
	USACE inputs final Evaluator Responses to Final Panel Comments in DrChecks	March 24, 2011
	Battelle inputs final BackCheck responses to DrChecks	April 7, 2011
	Battelle submits pdf of DrChecks file and closes out DrChecks ^a	April 8, 2011
	Project Closeout	June 13, 2011

^a Deliverable

^b Task occurs after the submission of this report.

3.2 Identification and Selection of IEPR Panel Members

The candidates for the Panel were evaluated based on their technical expertise in the following key areas: plan formulation, economics, hydrology and hydraulics engineering, soils engineering, engineering geology, and NEPA (biology/ecology). These areas correspond to the technical content of the Mohawk Dam MRR and overall scope of the Mohawk Dam project.

To identify candidate panel members, Battelle reviewed experts in Battelle's Peer Reviewer Database, sought recommendations from colleagues, contacted former panel members, and conducted targeted Internet searches. Battelle initially identified more than 40 candidates for the Panel, evaluated their technical expertise, and inquired about potential COIs. Of these, Battelle chose 12 of the most qualified candidates and confirmed their interest and availability. Of the 12 candidates, six were proposed for the final Panel and six were proposed as backup reviewers. Information about the candidate panel members, including brief biographical information, highest level of education attained, and years of experience, was provided to USACE for

feedback. Battelle made the final selection of panel members according to the selection criteria described in the Work Plan.

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

The candidates were screened for the following potential exclusion criteria or COIs.¹ These COI questions were intended to serve as a means of disclosure, and to better characterize a potential candidate's employment history and background. Providing a positive response to a COI screening question did not automatically preclude a candidate from serving on the Panel. For example, participation in previous USACE technical peer review committees and other technical review panel experience was included as a COI screening question. A positive response to this question could be considered a benefit.

- Involvement by you or your firm² in the Mohawk Dam Muskingum River Basin, Ohio Dam Safety Assurance Program Major Rehabilitation Report.
- Involvement by you or your firm² in conceptual or actual design, construction, or O&M of flood damage reduction projects in the city of Coshocton; Coshocton County, OH; Walhonding River, Muskingum River, Muskingum River Basin, Charles Mill Lake, Pleasant Hill Lake, and North Branch of Kokosing Lake Nellie, OH; and Zanesville, OH region.
- Involvement by you or your firm² in the Mohawk Dam Muskingum River Basin, Ohio Dam Safety Assurance Program Major Rehabilitation Report related projects.
- Current employment by the U.S. Army Corps of Engineers (USACE).
- Involvement with paid or unpaid expert testimony related to Mohawk Dam Muskingum River Basin, Ohio Dam Safety Assurance Program Major Rehabilitation Report.
- Current or previous employment or affiliation with members of the cooperating agencies or local sponsors, including USACE and Muskingum Watershed Conservancy District (MWCD) (for pay or pro bono).
- Past, current or future interests or involvements (financial or otherwise) by you, your spouse or children related to the city of Coshocton; Coshocton County, OH; Walhonding River, Muskingum River, Muskingum River Basin, Charles Mill Lake, Pleasant Hill Lake, and North Branch of Kokosing Lake Nellie, OH; and Zanesville, OH region
- Current personal involvement with other USACE projects, including whether involvement was to author any manuals or guidance documents for USACE. If yes,

¹ Battelle evaluated whether scientists in universities and consulting firms that are receiving USACE-funding have sufficient independence from USACE to be appropriate peer reviewers. See OMB (2004, p. 18), "...when a scientist is awarded a government research grant through an investigator-initiated, peer-reviewed competition, there generally should be no question as to that scientist's ability to offer independent scientific advice to the agency on other projects. This contrasts, for example, to a situation in which a scientist has a consulting or contractual arrangement with the agency or office sponsoring a peer review. Likewise, when the agency and a researcher work together (e.g., through a cooperative agreement) to design or implement a study, there is less independence from the agency. Furthermore, if a scientist has repeatedly served as a reviewer for the same agency, some may question whether that scientist is sufficiently independent from the agency to be employed as a peer reviewer on agency-sponsored projects."

² Includes any joint ventures in which your firm is involved.

provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please highlight and discuss in greater detail any projects that are specifically with the Huntington District.

- Current firm² involvement with other USACE projects, specifically those projects/contracts that are with the Huntington District. If yes, provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role.
- Any previous employment by the USACE as a direct employee or contractor (either as an individual or through your firm²) within the last 10 years, notably if those projects/contracts are with the Huntington District. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
- Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning conceptual or actual design, construction, or O&M of flood control or flood risk management projects, and include the client/agency and duration of review (approximate dates).
- Pending, current or future financial interests in Mohawk Dam Muskingum River Basin, Ohio Dam Safety Assurance Program Major Rehabilitation Report related contracts/awards from USACE.
- A significant portion (i.e., greater than 50%) of personal or firm² revenues within the last 3 years came from USACE contracts.
- Any publicly documented statement (including, for example, advocating for or discouraging against) related to Mohawk Dam Muskingum River Basin, Ohio Dam Safety Assurance Program Major Rehabilitation Report.
- Participation in relevant prior Federal studies relevant to this project and/or Mohawk Dam Muskingum River Basin, Ohio Dam Safety Assurance Program Major Rehabilitation Report.
- Participation in prior non-Federal studies relevant to this project and/or Mohawk Dam Muskingum River Basin, Ohio Dam Safety Assurance Program Major Rehabilitation Report.
- 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.

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

Prior to beginning their review and within 59 days of their subcontracts being finalized, all 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, and other pertinent information for the Panel. The kickoff meeting with the panel members is normally held immediately prior to the panel members beginning their review. In this case, however, the Mohawk Dam site visit was delayed, which necessitated also delaying the kickoff meeting with the panel members for nearly three months.

3.3 Preparation of the Charge and Conduct of the IEPR

Shortly after Battelle received NTP, USACE provided the following documents and reference materials. The documents and files in bold font were provided for review and the other documents were provided for reference or supplemental information only.

- Mohawk Dam Major Rehabilitation Report
 - **Main Report**
 - Appendix A: Real Estate Design Memorandum
 - **Appendix B: Risk and Reliability/Economics**
 - **Appendix C: Environmental**
 - Appendix D: Cost Engineering
 - Appendix E: Draft Project Partnering Agreement
 - Appendix F: Change Management Plan
 - **Appendix H: Geotechnical Appendix for Dam Embankment**
 - **Appendix I: Geotechnical Analysis of Left Abutment and Emergency Spillway**
 - **Appendix J: Hydrology and Hydraulics**
 - **Appendix K: Structural and Mechanical**
 - Appendix L: Hazardous, Toxic, and Radioactive Waste
 - Appendix M: Interim Risk Reduction Measures Plans
 - Appendix N: Quality Control Plan
 - **Engineering Drawing**
 - **Construction Drawing**
- USACE guidance *Civil Works Review Policy* (EC 1165-2-209) dated January 31, 2010
- CECW-CP Memorandum dated March 31, 2007
- Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

In addition, throughout the review period, USACE provided additional documents at the request of panel members. These additional documents were provided as supplemental information only and were not part of the official review.

- Embankment Reanalysis Report, Mohawk Dam, Walhonding River, Ohio (1979)
- Design Memorandum for the Correction of the Spillway Deficiency at Mohawk Dam, Ohio, Under the Dam Safety Assurance Program (1985)
- Dam Safety Assurance Program, Justification Study, Mohawk Dam, Muskingum River Basin, Ohio
- Economics Guidance Memorandum, 09-03, Unit Day Values for Recreation, Fiscal Year 2009

- Embankment, Abutment, and Spillway Event Trees for Mohawk Dam Base Condition and Alternatives
- Data from the HMR52 (Hydrometeorological Report) computer program
- Data showing bedrock permeability from pressure testing at Mohawk Dam

Battelle prepared a draft charge document, including specific charge questions and discussion points. The charge was prepared by Battelle to assist USACE in developing the charge questions that were to guide the peer review, according to guidance provided in USACE (2010) and OMB (2004). The draft charge was submitted to USACE for evaluation as part of the draft Work Plan. USACE provided comments and revisions to the draft charge, which were used to produce the final charge. The final charge was submitted to USACE for approval. In addition to a list of 103 charge questions/discussion points, the final charge included general guidance for the Panel on the conduct of the peer review (provided in Appendix B of this final report).

Battelle planned and facilitated a final kick-off meeting via teleconference during which USACE presented project details to the Panel. Before the meeting, the IEPR Panel received an electronic version of the Mohawk Dam MRR documents (listed above) and the final charge (Appendix B). The Panel was instructed to address the charge questions/discussion points within a comment-response form provided by Battelle.

In addition, there was a one-day site visit to Warsaw, Ohio on January 19, 2011 where the Panel received a 3 hour detailed briefing on the Mohawk Dam MRR in the morning and visited the Mohawk Dam to view critical components in the afternoon. Five of the six IEPR panel members attended the site visit, which was held within 65 working days of the Panel being under subcontract. One panel member had an emergency and could not attend the site visit.

3.4 Review of Individual Comments

Prior to completion of the review of the Mohawk Dam MRR documents, a teleconference with USACE, the Panel, and Battelle was held halfway through the review period to provide the Panel an opportunity to ask questions of USACE and clarify uncertainties. At the end of the review period, the Panel produced approximately 500 individual comments in response to the charge questions/discussion points. Battelle reviewed the comments to identify overall recurring themes, areas of potential conflict, and other overall impressions. As a result of the review, Battelle was able to summarize the 500 comments into a preliminary list of 27 overall comments and discussion points. Each panel member's individual comments were shared with the full Panel in a merged individual comments table.

3.5 IEPR Panel Teleconference

Battelle facilitated a 5 hour teleconference with the Panel so that the panel experts, many of whom are from diverse scientific backgrounds, 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 IEPR report and decide which panel member would serve as the lead author for the development of each Final Panel Comment. This information exchange ensured that the final IEPR report would accurately represent the Panel's assessment of the project, including any conflicting opinions. The Panel engaged in a thorough discussion of the overall positive and

negative comments, added any missing issues of high-level importance to the findings, and merged any related individual comments. In addition, Battelle confirmed each Final Panel Comment's level of significance to the Panel.

The Panel also discussed responses to six specific charge questions where there appeared to be disagreement among panel members. The conflicting comments were resolved based on the professional judgment of the Panel, and all sets of comments were determined not to be conflicting. Each comment was either incorporated into a Final Panel Comment, determined to be consistent with other Final Panel Comments already developed, or determined to be a non-significant issue.

At the end of these discussions, the Panel identified 26 comments and discussion points that should be brought forward as Final Panel Comments. Following the teleconference, panel members determined amongst themselves that four additional Final Panel Comments were warranted, bringing the total number of Final Panel Comments to 30.

3.6 Preparation of Final Panel Comments

Following the teleconference, Battelle prepared a summary memorandum for the Panel documenting each Final Panel Comment (organized by level of significance). The memorandum provided the following detailed guidance on the approach and format to be used to develop the Final Panel Comments for the Mohawk Dam MRR 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 the merged individual comments table, a summary detailing each draft final comment statement, an example Final Panel Comment following the four-part structure described below, and templates for the preparation of each Final Panel Comment.
- **Directive to the Lead:** Each lead was encouraged to communicate directly with other IEPR 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 Comments:** Each Final Panel Comment was presented as part of a four-part structure:
 1. Comment Statement (succinct summary statement of concern)
 2. Basis for Comment (details regarding the concern)
 3. Significance (high, medium, low; see description below)
 4. Recommendation for Resolution (see description below).
- **Criteria for Significance:** The following were used as criteria for assigning a significance level to each Final Panel Comment:
 1. **High:** Describes a fundamental problem with the project that could affect the recommendation, success, or justification of the project. Comments rated as high

- indicate that the Panel analyzed or assessed the methods, models, and/or analyses and has determined that there is a “showstopper” issue.
2. **Medium:** Affects the completeness of the report in describing the project, but will not affect the recommendation or justification of the project. Comments rated as medium indicate that the Panel does not have sufficient information to analyze or assess the methods, models, or analyses.
 3. **Low:** Affects the understanding or accuracy of the project as described in the report, but will not affect the recommendation or justification of the project. Comments rated as low indicate that the Panel identified information (tables, figures, equations, discussions) that was mislabeled or incorrect or that there were data or report section not clearly described or presented.
- **Guidance for Developing the Recommendation:** The recommendation was to include specific actions that the 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).

At the end of this process, 30 Final Panel Comments were prepared and assembled. Battelle reviewed and edited the Final Panel Comments for clarity, consistency with the comment statement, and adherence to guidance on the Panel’s overall charge, which included ensuring that there were no comments regarding either the appropriateness of the selected alternative or USACE policy. There was no direct communication between the Panel and USACE during the preparation of the Final Panel Comments. The Final Panel Comments are presented in Appendix A of this report.

4. PANEL DESCRIPTION

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

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

Table 2. Mohawk Dam MRR IEPR Panel: Technical Criteria and Areas of Expertise

	Shoudy	Nelson	Molinas	Kerkes	Bruce	Young
Plan Formulation	X					
Extensive experience in the plan formulation process, particularly with the Corps' 6 step process	X	X				
Familiar with large, complex civil works projects with high public and interagency interests	X	X				
Familiar with evaluation of alternative plans for flood risk reduction projects	X	X				
Familiarity with USACE standards and procedures is required	X	X				
Degree in planning or a related field	X					
Economics		X				
Able to evaluate the appropriateness cost/benefit analysis used	X	X				
Experience dealing directly with HEC-FDA is encouraged	X	X				
Familiar with risk and uncertainty analysis (i.e. Monte Carlo type simul.)	X	X				
Experience with National Economic Development (NED) analysis procedures, particularly as they relate to flood risk management projects	X	X				
At least 5 years experience directly working for or with USACE is highly recommended	X	X				
Familiar with large, complex civil works projects with high public and interagency interests	X	X				
Degree in economics or related field	X	X				
Hydrology and Hydraulics Engineering			X			
Professional engineer having experience with engineering analysis related to flood risk management and dam safety projects			X			
Familiar with large, complex civil works projects with high public and interagency interests			X			
Familiar with standard USACE hydrologic and hydraulic computer models (HEC-RAS, HEC-HMS, & HEC-ResSim)			X			
Experience with unsteady flow dam failure analysis modeling			X			
Knowledge and experience with the routing of inflow hydrographs through multipurpose flood control reservoirs (The emphasis is focused on flood control reservoirs only. Experience should emphasize modeling spillways and outlet works related to flood control reservoirs, particularly for large dams. Demonstrate experience in dealing with discharge being utilized at the individual flood control reservoir during a large flood event.)			X			
B.S. degree or higher in civil engineering, or hydrology and hydraulics engineering			X			

	Shoudy	Nelson	Molinas	Kerkes	Bruce	Young
Soils Engineering				X		
Experience in embankment dam design and evaluation is mandatory, as well as experience in seepage and piping and seepage failure mode analysis, risk analysis of embankment dams, and familiarity with the USACE dam safety guidance				X	X	
Familiar with large, complex civil works projects with high public and interagency interests				X	X	
M.S. degree or higher in geotechnical engineering				X	X	
Engineering Geology					X	
A senior-level person with extensive experience in the type of work being performed					X	
Familiar with large, complex civil works projects with high public and interagency interests					X	
Proficient in assessing seepage through sedimentary rock					X	
Experienced in the design of seepage barriers or cutoff walls, with knowledge of spillway erodibility in sedimentary rock					X	
Seepage, piping, and seismic experience					X	
Working knowledge of all applicable USACE design criteria. Licensed Professional Geologist					X	
NEPA and Biology/Ecology						X
Familiar with large, complex civil works projects with high public and interagency interests						X
Particular knowledge of flood risk management, the National Environmental Policy Act (NEPA), and other pertinent environmental statutes and policies						X
M.S. degree or higher in ecology/biology or related science						a

^a Mr. Young does not hold an M.S. degree; however, his 17 years of experience with NEPA and in biology and ecology is commensurate with a higher degree.

Harry Shoudy

Role: This panel member was chosen primarily for his plan formulation experience and expertise.

Affiliation: Independent Consultant

Harry Shoudy, currently the Chief Executive Officer for Harry Shoudy Consulting, has more than 40 years of water resources planning, plan formulation, policy, and economics experience; more than 32 years of that experience was with the U.S. Army Corps of Engineers. He earned an M.S. in water resources planning from Colorado State University in 1980. Before forming his consulting firm in 2003, Mr. Shoudy served in a dual assignment as the Chief Economist and Senior Policy Advisor for the USACE. During Mr. Shoudy's career, he also served as a Senior Economic and Policy Advisor for the Board of Engineers for Rivers and Harbors, Chief of Economics in the South Atlantic Division of the Corps, Chief of Economics in the Buffalo District of the Corps, and an economist with the New York State Environmental Conservation Department. He was the study manager on the Cleveland Harbor navigation study responsible for formulation of plans and economic analysis. He participated in the USACE 6 step planning process for numerous district flood control studies. As Senior Policy Advisor for the USACE, he reviewed reports and participated in formulation meetings. Mr. Shoudy participated in the study or review of large complex civil works projects, including the American River flood control project, which had high public as well as interagency interest. In addition, Mr. Shoudy is a graduate of the Executive Development Program of the Corps and completed a 4-month executive development assignment as Acting Assistant Deputy Assistant Secretary of the Army (Civil Works).

Mr. Shoudy has extensive high-level coordination experience. He shared in the management of the National Water Assessment for the South Atlantic Gulf Region, and was selected to represent the Corps in providing technical advice to the U.S. State Department, the agency responsible for providing three delegates from the United States to the Commission for the Study of Alternatives to the Panama Canal. He further represented the U.S. Government and traveled to Panama on numerous occasions at the request of the State Department to provide expert planning and economic advice to the delegates from Japan, Panama, and the United States on the \$20 million international study. Mr. Shoudy has also participated in many national Corps task forces and national interagency task forces to include an interagency White House task force on floodplain management under the direction of General Galloway, formed after the 1993 mid-west flooding, and an interagency floodplain management coordinating committee under the direction of the Office of Management and Budget.

Mr. Shoudy has reviewed numerous civil works navigation, flood damage reduction, recreation, shore protection, and environmental restoration projects at the division and headquarters level. He is fully familiar with USACE standards and procedures, and developed USACE national policy guidance in planning and economics to include implementation guidance in response to Water Resources Development Act legislation. Most of the national policy guidance and procedures he developed were implementation guidance in response to Water Resources Development Act legislation, primarily for shore protection and flood control type projects. Mr. Shoudy has received many awards during his career including a Department of the Army

Meritorious Civilian Service Award and was one of three finalists for Federal Employee of the Year in the Atlanta Metropolitan area in 1990 receiving the honor of first runner-up.

Howard (Eric) Nelson

Role: This panel member was chosen primarily for his economics experience and expertise.

Affiliation: Volkert Environmental Group, Inc.

Eric Nelson is a study manager specializing in plan formulation and economics at Volkert Environmental Group, Inc. He earned his B.A. in economics from the University of Tennessee in 1975 and has 30 years of experience in water resources planning with a focus on NED procedures, particularly as they relate to flood risk management. He was a USACE plan formulator/economist for 27 years (1979–2006), and is experienced with all phases of the USACE plan formulation standards. His primary field of expertise is in flood damage reduction projects and he is familiar with the USACE ER 1105 Series regulations. Mr. Nelson is familiar with risk and uncertainty analysis, utilizing, among others, Monte Carlo simulation on past projects. His experience includes comprehensive water resource planning, deep draft navigation, and environmental restoration. He has served as both an economist and plan formulator for a number of diverse projects for state, local, and international clients. Mr. Nelson's expertise in benefit/cost analysis is reflected in his experience as lead economist on the Pearl River Flood Damage Reduction Study in Jackson, Missouri (which involved the planning of a dry dam solution for temporary flood water storage) and the Village Creek Flood Damage Reduction Study in Birmingham, Alabama. His knowledge and experience in large complex civil works projects with high public and interagency interests as well as ecosystem restoration and multipurpose planning is reflected in his role as plan formulator and contract manager of the multi-state project Comprehensive Water Resource Planning for the Apalachicola, Chattahoochee, and Flint River Basins and the Alabama, Coosa, Tallapoosa River Basins in Alabama, Georgia, and Florida. Among the projects requirements were the planning of water resource demand for inland navigation, hydropower production, municipal and industrial water supply, and other economic and social needs. He also is familiar with USACE hydrologic models and is experienced in the use of HEC-FDA, having both employed it on several projects as well as having taught the application to other users. Mr. Nelson is a graduate of the 1986-87 class of Planning Associates from the Board of Engineers for Rivers and Harbors.

Albert Molinas, Ph.D.

Role: This panel member was chosen primarily for his hydrology and hydraulics engineering experience and expertise.

Affiliation: Independent consultant and Colorado State University

Albert Molinas is a professor of civil engineering at Colorado State University (CSU) and the president of Hydrau-Tech, Inc. He earned his Ph.D. in hydraulics and civil engineering in 1982 and has more than 33 years of experience in the fields of river mechanics, open channel hydraulics and sedimentation. He has extensive experience related to flood risk management and dam safety projects. For the 100-year-old Bachman Dam, he conducted independent hydraulic and hydrologic studies and provided expert evaluations of alternatives to address the threat to downstream community and public facilities due to insufficient spillway capacity to pass the PMF design discharge. Dr. Molinas has participated in multiple large, complex civil works

projects, including Bachman Dam (Texas), Rock Creek Dam (California), Creswta Dam (California), and the Meridian Village Lake Dam (Colorado). He has extensive knowledge and expertise on numerical modeling of rivers, reservoirs, and channel networks under steady and unsteady flow conditions including basic research to develop efficient solution algorithms to solve complex channel networks with hundreds of branches under unsteady flooding conditions to computing flows through dams and reservoirs to dam-break and dam overtopping analysis. He served as a reviewer and hydraulic designer for the Valenciano Dam in Puerto Rico, critically reviewing the unsteady dam-break flow analysis and applying an unsteady flow model to establish critical tailwater elevations and flow conditions for the riprap design around critical downstream structures. He also conducted numerical modeling of spillway erosion and resulting hydraulic conditions under unsteady flow conditions for the Silver Lake Dam failure (MI).

Dr. Molinas' experience with modeling spillway and outlet works related to flood control reservoirs includes conducting independent hydraulic modeling studies for the Bachman Dam by routing PMF flows through the upstream watershed and the reservoir and then, using the existing dam structures (spillway, outlet, and dam embankment), overtopped a selected segment of the dam. For the Rock Creek Dam (California), he reviewed the hydrology to establish extreme event (PMF) floods and to optimally route water and sediment during these events. He also reviewed the spillway and low level outlet rating curves and revised the auxiliary spillway design for stilling basin flows. Dr. Molinas is very familiar with USACE's hydrologic and hydraulic computer models. In 1979-80, he worked at the USACE North Central Division to develop the "Strip" version of HEC-6 model. During his tenure at CSU (1983-2001), he assisted USACE's Waterways Experiment Station with hydraulic and hydrologic modeling efforts beyond USACE capacity and also offered short-courses at CSU for USACE models. He has recently used HEC-1, HEC-2, HEC-6, HEC-RAS, HEC-HMS, HMR-52, and GeoHEC-HMS models for a variety of consulting projects. Dr. Molinas is a professional engineer in water resources and civil engineering and is licensed in CO.

David Kerkes, Ph.D.

Role: This panel member was chosen primarily for his soils engineering experience and expertise.

Affiliation: Independent consultant

Dave Kerkes is an independent consultant in Houston, Texas, specializing in groundwater seepage analyses and drainage design, analysis and design of retaining walls and sheetpile structures, and design, construction, safety, and remediation of earth and rockfill dams. He earned his Ph.D. in civil (geotechnical) engineering from the University of Colorado at Boulder in 1990. He has more than 35 years of geotechnical and civil engineering experience and is a licensed engineer in Indiana, Texas, and Colorado. He has had major roles, including senior review consultant, in the design and construction of earth and rockfill dams for water resource development projects in the U.S., Southeast Asia, and South America. He has performed more than 50 dam safety inspections as part of the Federal Dam Safety Inspection Program, and has prepared structural behavior reports for 10 dams for the U.S. Bureau of Reclamation based on a review of design and construction records, dam safety inspection reports, and instrumentation data. Dr. Kerkes is experienced in embankment dam design and evaluation and analysis of seepage and piping and seepage failure mode analysis and risk analysis of embankment dams. In

addition to performing numerous seepage and slope stability analyses, he has taught undergraduate and graduate courses on seepage analysis and drainage design, including the mechanism of piping failure and slope stability analysis, and has presented technical seminars to the Texas Commission on Environmental Quality on the subjects of seepage analyses, dam design, and dam safety.

His experience with embankment dam design includes the Wadaslintang Dam in Indonesia and Recreta Dam in Peru, as well as many others for which his activities included development of preliminary or final designs for the dams and foundations, conducting initial site investigations, preparing final design drawings, estimates of construction quantities and costs. He consulted on a forensic evaluation of the failure of Taum Sauk Upper Dam, an 80 ft high rockfill dam in Missouri, which is the upper dam for a pump storage power generation facility. He served on the design and construction review panel for High Savery Dam in Wyoming and was the reviewer of design modifications for La Regadera Dam in Colombia. He has experience with large complex civil works projects with high public and interagency interests, having prepared reports for local, state, and federal agencies. He serves on a Technical Assistance Contract with FEMA to assess natural slopes and earth dams damaged by natural disasters.

Dr. Kerkes is also familiar with computer programs for slope stability and seepage as well as traditional methods and fundamental governing equations. He is familiar with the engineering design manuals adopted by the USACE for use on USACE projects, specifically EM 1110-2-1913 “Design and Construction of Levees” and EM 1110-2-1901 “Seepage Control in Earth Foundations”. Dr. Kerkes has authored more than 15 engineering related publications, including “Analysis and Prediction of Stresses and Pore Pressures Associated with Wet Core Construction for Embankment Dams”. He is a member of the U.S. Society on Dams.

Donald Bruce, Ph.D.

Role: This panel member was chosen primarily for his engineering geology experience and expertise.

Affiliation: Independent consultant

Donald Bruce, president of Geosystems, L.P., earned degrees in geology and civil engineering from Aberdeen University, Scotland in 1977. Dr. Bruce has 35 years of experience in engineering geology and is familiar with large, complex civil work projects; he is a current member of the six-person Peer Review Panel for the USACE’s new program conducting Safety Assessments of all the dams in its purview. To date, about 125 dams have been analyzed, and the panel is focusing on those six which top the list of concerns. Dr. Bruce is primarily responsible for geological and rehabilitation constructability issues involved in the remediation efforts for these critical structures.

Dr. Bruce has extensive experience with dam foundation engineering related to seepage concerns. Since 2005, Dr. Bruce has been a member of a Panel of Experts appointed by the U.S. Government to review the Mosul Dam in Iraq. The 370-foot-high, 14,000-foot-long embankment dam is built on a largely carbonate foundation that contains highly erodible and soluble gypsum beds. Dr. Bruce’s prime roles on this project have been to review available geological, construction, and dam performance data in relation to seepage, liquefaction potential

and quality of construction; lead “technology transfer” efforts to Iraqi forces; and develop an implementation manual for the grouting works. Dr. Bruce has published multiple papers and made multiple presentations on seepage and seepage cutoffs. He also has seismic experience, serving since 2006 as a consultant on the seepage and seismic remediation of the Tuttle Creek Dam (KS). Dr. Bruce has also served as a consultant on seepage and seepage cutoff concerns on multiple USACE dam projects, including Pakota Dam (IN), Mississinewa Dam (IN), Center Hill Dam (TN), and Clearwater Dam (MO). His participation in multiple USACE dam projects and expert panels has provided him with knowledge of the USACE design criteria.

Dr. Bruce is a Chartered Engineer in the U.K., and a licensed geologist and engineering geologist in WA. He is a member of numerous national and international committees on dams, foundations, and grouting. He has co-authored three textbooks and over 225 technical papers on geosystems and geotechnical construction. He is the immediate past Chairman of ASCE’s Grouting Committee and the International Society for Micropiles (ISM). He is the recipient of 1998 ASCE Martin Kapp Award, and the 2004 GeoInstitute Wallace Hayward Baker Award. He is a long-time Instructor for the Colorado School of Mines Grouting Short Course.

David Young

Role: This panel member was chosen primarily for his NEPA and biology/ecology experience and expertise.

Affiliation: Independent consultant

Dave Young, a senior environmental consultant with Crouch Environmental Services, Inc., earned his B.S. in marine biology from Texas A&M University at Galveston in 1993. He has more than 15 years experience in wetland delineation, environmental assessments, water quality, and NEPA, and has been directly involved with water resource evaluation and NEPA assessments for more than 10 years. Mr. Young earned an advanced certification to perform wetland delineations and has attended training courses on various aspects of NEPA, including Section 106 coordination, and state Department of Transportation (DOT) processes related to NEPA compliance (FL DOT, AZ DOT, and TX DOT). His experience includes managing, preparing, and/or providing support on numerous Programmatic Categorical Exclusions, Categorical Exclusions, Environmental Assessments/Findings of No Significant Impact and Environmental Impact Statements. His experience with complex civil works projects with high public and interagency interests includes working directly or indirectly for the USACE managing and providing support for the Houston Ship Channel - Placement Area 14 and 15 project (USACE Galveston District), and serving as technical lead for the Section 227 Demonstration Project (USACE Galveston District). Mr. Young has performed hundreds of wetland delineations in Florida, Louisiana, Texas, and Arizona throughout his career. These include jurisdictional delineations, jurisdictional determinations, forensic jurisdictional delineations, ordinary high water mark delineations, mean high tide delineations, and verifications of delineations for various USACE Regulatory Offices. He has extensive experience with developing alternative analyses, including 404(b)(1) evaluations for the least environmentally damaging practicable alternative, coordination with concerned landowners and stakeholder, coordination with various regulatory and resource agencies, and development of conceptual compensatory mitigation plans to offset unavoidable impacts to waters of the U.S.

5. SUMMARY OF FINAL PANEL COMMENTS

The panel members agreed amongst each other on their “assessment of the adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used” (USACE, 2010; p. D-4) in the Mohawk Dam MRR document. Significantly, the Panel agreed that the extent of the seepage problem at the site, in light of unsuccessful prior attempts to correct the problem, warrants consideration of a major remediation project at Mohawk Dam. The following statements summarize the Panel’s findings, which are described in more detail in the Final Panel Comments (see Appendix A).

Plan Formulation: The MRR is in compliance with all of the typical formulation steps; however, the report does not use any of the required data inputs and formulation techniques identified in USACE regulations on plan formulation (USACE, 2000) as a basis for screening and formulating alternatives. The Panel is concerned that all reasonable alternatives were not considered, and alternatives were screened without a comparison of costs and benefits. The selection of the NED plan cannot be confirmed, and the rationale and overriding reasons for deviation from the NED plan have not been identified and justified. Therefore, the Panel has concluded that the adequacy and acceptability of the formulation of alternative plans cannot be confirmed; a reanalysis of a full range of alternatives consistent with formulation guidance is necessary to provide a sufficient analysis upon which to base a recommendation.

Economics: Although the economic portion of the MRR is abbreviated, it identifies the types of benefits appropriate for analysis. However, there are problems with the technical adequacy or validity of every category of benefits claimed. There is limited rationale given for making economic decisions, the base condition is not properly defined as a basis for calculating benefits, and there is a lack of presentation, documentation, or explanation of the methodology used to estimate average annual benefits for every category of benefits included in the MRR. In addition, average annual benefits were not estimated for each alternative considered. Evaluating alternatives and determining the alternative that maximizes net benefits is required to identify the NED plan. Based on the current analysis, the Panel cannot verify the identification of the NED plan or determine the economic feasibility of the recommended plan.

Engineering: While extensive analyses were performed for certain elements of the problem, insufficient justification has been given for the elimination of some alternatives (especially the grouting alternative) along with inadequate documentation to support parameters used in critical analyses. There are issues related to the in situ permeability of the soils and rock which have the potential to cause significant changes in construction methodology, cost, and schedule. In addition, the Panel found that the risk posed by the left abutment was not of the same magnitude as that posed by the dam, and that there was no technical justification for selecting the same cutoff method as for the dam. Finally, the Panel received insufficient documentation with the original review documents and, while USACE was responsive in providing the requested data, the Panel believes the review process would have been more efficient had all the engineering data been provided at the outset.

Environmental: The evaluation and analysis of potential effects to the human, physical, and natural environment was largely qualitative; additional detail is needed to affirm the assessments

made in the MRR and EA. Insufficient detail in the description of potential direct, indirect, and cumulative impacts from off-site alternatives and from the No Action Alternative resulted in some uncertainties by the Panel of the alternative selection process, including the selection of the recommended plan. The MRR and EA did not consider the wide-reaching effects of actions in the Muskingum River basin that may result in beneficial and/or adverse effects to Mohawk Dam.

Table 3 lists the 30 Final Panel Comment statements by level of significance.

Table 3. Overview of 30 Final Panel Comments Identified by the Mohawk Dam MRR IEPR Panel

Significance – High	
1	Potential life safety consequences due to catastrophic failures from unsatisfactory dam performance were not evaluated.
2	The rationale and justification for the identification of the NED plan and for the deviation from the NED plan have not been sufficiently supported in the report.
3	The rationale for selecting the recommended plan is not consistent with USACE guidance on project formulation.
4	The potentially viable left abutment grout curtain alternative was not adequately considered, leaving the alternative development process incomplete.
5	The screening of alternatives was abbreviated and did not include evaluations of the benefits and costs of each alternative.
6	The alternative development process for the full depth cutoff wall did not include probabilistic seepage analyses and consideration of the risks associated with construction.
7	The Expert Elicitation panel may have exceeded their charge, resulting in a recommended plan for remediation that is not adequately supported.
8	Non-structural alternatives were not fully developed and evaluated.
9	A succinct definition of the base condition was not fully developed and documented.
10	The discussion of the risk and reliability analysis methodology is confusing and does not provide sufficient information to confirm the technical adequacy or the appropriate use of the model developed to evaluate economic feasibility.
11	The results of the probabilistic seepage analyses call into question the method that was used and the consistency of the variables applied to the analyses.
12	Inconsistencies in hydraulic conductivity values presented in the Engineering Reanalysis Report (ERR) and MRR are not explained, and key variables in the seepage analyses that affect the risk analyses are not identified.
13	Relatively little data are available establishing the seepage situation in the left abutment.
14	The hydrologic models used to determine the inflow into Mohawk Dam and downstream water surface profiles were not calibrated with past storm events.
15	The abbreviated methodology used in the analysis of the road damages benefit category is not based on sound engineering principles.
Significance – Medium	
16	The assumptions behind the hydrological uncertainties leading to spillway erosion failure were not provided.
17	Adequate consideration was not given to alternatives to address rock erosion downstream of the emergency spillway.
18	Potentially viable off-site alternatives were not investigated, making the alternative development process incomplete.
19	The erodibility analysis downstream of the emergency spillway was not sufficiently supported.

20	The potential consequences and impacts of catastrophic failure, particularly the severity, intensity, and duration of such a failure, are not fully described and evaluated from an engineering, environmental, or economic perspective.
21	The public that may be affected by a possible significant catastrophic event may not have been notified through the public outreach efforts performed to date.
22	The potential for dam embankment failure due to overtopping was not discussed in the report.
23	No data were provided in the report on the <i>in situ</i> permeability values for the foundation rock.
24	Potential impacts to wildlife habitats and water quality from the No Action and Action Alternatives (Plans A and B) were not thoroughly investigated and evaluated.
25	Documentation of the commitments made to avoid, minimize, and/or reduce impacts are not consistent with Council on Environmental Quality guidelines.
26	The cumulative impacts analysis does not evaluate the impact of present and reasonably foreseeable future incremental actions at Mohawk Dam on upstream and downstream projects.
27	Supporting documentation has not been provided for the basis on which emergency repair expenditures have been estimated.
28	The use of historic reportable damages as the basis for identifying current average annual damages and as a measure of lost capacity to prevent future flood damages is not consistent with USACE guidance.
29	The documentation supporting the estimate of flood damages prevented is incomplete.
Significance – Low	
30	The analysis of recreation benefits using the Unit Day Value (UDV) method is not fully supported.

6. REFERENCES

American Society for Testing and Materials. ASTM D5878 – 08, Standard Guides for Using Rock-Mass Classification Systems for Engineering Purposes. ASTM, West Conshohocken, PA. Revision issued annually.

Bruce, D. A., T. L. Dreese, and D. M. Heenan (2010). Design, construction, and performance of seepage barriers for dams on carbonate foundations. *Environ. Eng. Geosci.*, 16(3): 183-193.

Fread, D. L. (1985; rev, 1991). BREACH: An Erosion Model for Earthen Dam Failures. Report, National Weather Service, NOAA, Silver Spring, Maryland.

Froehlich, D. C. (1995). Embankment dam breach parameters revisited. In: *Water Resources Engineering*, 1995 ASCE Conference, San Antonio, Texas, August 14-18, pp. 887-891.

Froehlich, D. C. (2008). Embankment dam breach parameters and their uncertainties. *J. Hydraul. Eng.-ASCE*. 134(12): 1708-1721.

Iarossi, B., H. Van Aller, B. W. Harrington, M. Q. Taherian, G. Gopenko, R. S., Norton, B. S. Clevenger, and T. Ives (eds.) (1996). *Maryland Dam Safety Manual*. Maryland Department of the Environment, Water Management Administration, Dam Safety Division.

MacDonald, T. C., and J. Langridge-Monopolis (1984). Breaching characteristics of dam failures. *J. Hydraul. Eng.-ASCE*. 110(5): 567-586.

National Environmental Policy Act of 1969, as amended. 1982. 42 U.S.C. 4321-4347. Public Law 91-190, amended Public Law 94-52, July 3, 1975; Public Law 94-83, August 9, 1985; and Public Law 97-258 § 4(b), September 13.

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.

Rice, J. D., and M. J. Duncan (2010a). Deformation and cracking of seepage barriers in dams due to changes in the pore pressure regime. *J. Geotech. Geoenviron*, 133(1): 2-15.

Rice, J. D., and M. J. Duncan (2010b). Findings of case histories on the long-term performance of seepage barriers in dams. *J. Geotech. Geoenviron*. 133(1): 16-25.

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.

Sutley, Nancy H. Executive Office of the President. Council on Environmental Quality (2011). Memorandum for Heads of Federal Departments and Agencies. Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact. January 14.

USACE (1996). Project Operations – Partners and Support. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Pamphlet 1130-2-500. 27 December.

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

USACE (2007). Peer Review Process. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. CECW-CP Memorandum. March 30.

USACE (2010). Water Resources Policies and Authorities: Civil Works Review Policy. Department of the Army, US Army Corps of Engineers, Washington, D.C. Engineer Circular (EC) No. 1165-2-209. January 31.

Wahl, T. L. 1996. *Prediction of Embankment Dam Breach Parameters: Literature Review and Needs Assessment*. USBR, Water Resources Research Laboratory, PAP-735, Denver, Colorado.

Wahl, T. L. 1997. Predicting Embankment Dam Breach Parameters – A Needs Assessment. Presented at the 27th IAHR Congress, San Francisco, California, August.

Wahl, T. L. 1998. Prediction of Embankment Dam Breach Parameters. DSO-98-004, Dam Safety Research Report, U.S. Department of the Interior Bureau of Reclamation, Dam Safety Office.

Weaver, K. D. and D. A. Bruce. 2007. *Dam Foundation Grouting, Revised and Expanded Edition*, American Society of Civil Engineers, New York: ASCE Press, 504 p

APPENDIX A

Final Panel Comments

on the

Mohawk Dam MRR

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Final Panel Comment 1:

Potential life safety consequences due to catastrophic failures from unsatisfactory dam performance were not evaluated.

Basis for Comment:

One of the key study objectives identified in the Mohawk Dam Major Rehabilitation Report (MRR) is to increase public safety downstream of the dam by decreasing the risk of dam failure. During screening, alternatives that failed to meet the public safety objective were eliminated from further consideration without an evaluation of the costs or benefits of meeting the public safety objective. The MRR states that the recommended plan was selected based on engineering considerations and life safety concerns. However, the magnitude of the potential life safety concerns is unclear since they have not been evaluated. An analysis of potential catastrophic flooding and loss of life consequences if rehabilitation is not performed is needed to support the public safety screening rationale and the deviation from the National Economic Development (NED) plan.

Flood profiles were provided in Appendix J, but they are not translated into inundation maps showing the aerial extent of depths of flooding, times of flood wave arrivals, velocity, depth, and duration for unsatisfactory performance at various pool elevations. Since public safety is used as a screening rationale, it is imperative to document and support the uncertainty of the consequences for the potential loss of life, the potential for catastrophic flooding, and the population at risk.

ER 1105-2-100 (USACE, 2000) and EP 1130-2-500 (USACE, 1996) indicate that risk and uncertainty should be discussed for each alternative. The alternative discussions in the report indicate where there is a reduction in risk of failure and increase in reliability; however, the uncertainty of failure consequences, catastrophic flooding consequences, and potential loss of life impacts has not been evaluated.

Life safety concerns were used as the basis for selecting the recommended plan. Public safety is an important objective, but not at any cost. Analysis and evaluation are required to support the additional costs for safety when compared to the consequences of not providing the additional costs.

Significance – High:

Without documentation, evaluation, and consideration of the difference in life safety consequences between the NED plan and the recommended plan as well as the difference in costs and benefits between the two, there is insufficient justification for a deviation from the NED plan.

Recommendations for Resolution:

1. Analyze potential catastrophic flooding for each alternative in the final array of alternatives and provide a display of each alternative's accomplishments.
2. Evaluate the risk and uncertainty associated with the potential life safety consequences for each alternative in the final array of alternatives.
3. Conduct incremental analyses of the life safety consequences, as well as the costs and benefits for each alternative in the final array of alternatives.
4. Include a rationale to support a deviation from the NED plan and a justification for the recommended plan.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

USACE (1996). Project Operations – Partners and Support. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Pamphlet 1130-2-500. 27 December.

Final Panel Comment 2:

The rationale and justification for the identification of the NED plan and for the deviation from the NED plan have not been sufficiently supported in the report.

Basis for Comment:

The NED plan has not been properly identified by comparing the benefits and costs of each alternative and applying an incremental analysis of the alternatives. Further, since the main embankment rehabilitation was combined with the left abutment rehabilitation without incremental analysis of that inclusion, it cannot be confirmed that the alternative labeled the NED plan in the report is actually the NED plan. The main embankment and the left abutment have significantly different probabilities of failure; while the addition of the left abutment may be incrementally justified, that justification is not provided in the report.

The report indicates that the NED objective is to contribute to NED through the reduction of failure risks and associated increases in reliability. The NED objective should be to identify the optimum investment that reasonably maximizes net benefits (USACE, 1996; Appendix B, p. B-2) and (USACE, 2000; Chapter 2, p. 2-7).

The NED plan has not been selected as the recommended plan. The rationale for the selection of the recommended plan is limited and not consistent with the formulation requirements in ER 1105-2-100 (USACE, 2000) and EP 1130-2-500 (USACE, 1996). Annual benefits and annual costs were not provided in the MRR for the various alternatives; therefore, incremental analysis and a meaningful comparison of alternatives leading to the selection of the NED plan are not possible. There is no identification and documentation of the trade-offs to support the final recommended plan, and adequate analysis, documentation, and support has not been provided for a deviation from the NED plan. USACE guidance indicates that the alternative plan that reasonably maximizes net benefits consistent with protecting the nation's environment, the NED plan, shall be selected. The Assistant Secretary of the Army for Civil Works may grant an exception when there are overriding reasons for selecting another plan based upon other Federal, state, local, and international concerns. Normally exceptions to the NED plan are coordinated through USACE Headquarters prior to a final report recommendation by the District Engineer. There is no indication in the report that coordination regarding a deviation from the NED plan has been initiated.

Finally, formulation of the NED plan cannot be confirmed and deviation from the NED plan to the recommended plan is not documented in sufficient detail to be consistent with the formulation requirements in USACE guidance.

Significance – High:

Without sufficient analysis and evaluation of the alternatives, identification or confirmation of the NED plan, and support for the deviation from the NED plan, the basis for making a recommendation to deviate from the NED plan is questionable.

Recommendations for Resolution:

1. Estimate average annual benefits and costs for each alternative.
2. Reformulate alternatives to include applying the techniques of incremental analysis and trade-off analysis.
3. Provide additional documentation and support for the identification of the NED plan.

4. Justify the overriding reasons for deviation from the NED plan and selection of the recommended plan.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

USACE (1996). Project Operations – Partners and Support. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Pamphlet 1130-2-500. 27 December.

Final Panel Comment 3:

The rationale for selecting the recommended plan is not consistent with USACE guidance on project formulation.

Basis for Comment:

Final panel comments 3, 4, 5, and 6 are all interrelated and deal with various aspects of plan formulation. There is some redundancy in these interrelated comments, but the Panel has concluded that due to their individual significance, they should be retained as individual issues of the IEPR.

The formulation and evaluation of alternatives in the MRR is limited and is not consistent with the requirements of ER 1105-2-100, Chapter 2 (USACE, 2000) and EP 1130-2-500, Appendix B (USACE, 1996). The subsequent paragraphs describe how the guidance required by these two documents has not been followed.

Annual benefits and annual costs were not provided in the report for the various alternatives, as required by ER 1105-2-100, Chapter 2, p. 2-7 (USACE, 2000) and EP 1130-2-500, Appendix B, p. B-1 (USACE, 1996).

All alternatives are compared to a base condition when determining benefits for each alternative, yet the base condition in the MRR has not been adequately described and supported. According to EP 1130-2-500, Appendix B, p. B-3 (USACE, 1996), the base condition assumes that the project will be operated in the most efficient manner possible without the proposed rehabilitation. The base condition in the MRR assumes full operation of the dam even though current operation is restricted to avoid the risk of failures. Additional documentation is necessary to support that the base condition is the most efficient and most likely future condition without implementation of the rehabilitation project in order for alternatives to be properly compared to the base condition and evaluated. Finally, the Interim Operating Plan is clearly a Federal Action that must be fully discussed and considered in identifying the base condition.

In the comparison of alternative plans, the beneficial and adverse effects of each plan (ER 1105-2-100, Chapter 2, p. 2-6 (USACE, 2000) have not been identified and compared, as required, to include monetary and non-monetary costs and benefits ER 1105-2-100, Chapter 2, p. 2-7 (USACE, 2000). In addition, an incremental analysis of alternatives has not been included in the MRR to determine incremental costs and benefits of increments of plans or project features ER 1105-2-100, Chapter 2, p. 2-10 (USACE 2000).

Scheduled rehabilitation was the only non-structural alternative considered and was eliminated from further consideration without a detailed evaluation. According to ER 1105-2-100, pp. 2-4 and 2-5 (USACE 2000), non-structural alternatives must be given equal consideration to structural alternatives. If the costs and benefits of any non-structural alternatives are not evaluated, it does not appear that they are being given equal consideration.

Safety is identified in the MRR as the primary justification for including the spillway improvements in the recommended plan. However, the spillway improvements are not incrementally feasible as a last added increment. Therefore, inclusion of the spillway

improvements would not be part of the NED plan and would require further documentation and elaboration of the reasons for selection. There is no indication that the views and concerns of the non-Federal sponsor on including the spillway improvements in the recommended plan have been elicited.

The entire formulation and analysis of alternatives was driven by the goal of the rehabilitation project being able to pass the probable maximum flood (PMF). While it is an appropriate goal, it should not serve as a requirement at any cost. As covered in ER 11-5-2-100, Chapter 2 (USACE 2000), formulation decisions should be made on the benefits, costs, and residual impacts of any alternative. While additional safety is desired, incremental increases in safety must be justified.

The inclusion of the spillway in the recommended plan results in the plan being marginally justified. Major rehabilitation new starts have to compete with other types of new construction starts for scarce resources, and while formulation is based on net benefits, budgeting usually favors plans with higher benefit/cost ratios. To successfully compete as new starts, a level of detail and evidence of criticality commensurate with other Civil Works new starts must be demonstrated as discussed in EP 1130-2-500, Chapter 3 (USACE 1996).

Significance – High:

The recommended plan is not supported with sufficient data and analysis, nor does it follow USACE guidance on the formulation of alternative plans and plan selection.

Recommendations for Resolution:

1. Provide support showing that the base condition is the most likely future scenario without the rehabilitation project.
2. Estimate average annual benefits and costs for each alternative.
3. Reformulate alternatives to include the initial screening of alternatives and applying the techniques of incremental analysis and trade off analysis.
4. Provide a detailed justification for including the spillway improvements in the recommended plan.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

USACE (1996). Project Operations – Partners and Support. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Pamphlet 1130-2-500. 27 December.

Final Panel Comment 4:
The potentially viable left abutment grout curtain alternative was not adequately considered, leaving the alternative development process incomplete.
Basis for Comment:
<p>Final panel comments 3, 4, 5, and 6 are all interrelated and deal with various aspects of plan formulation. There is some redundancy in these interrelated comments, but the Panel has concluded that due to their individual significance, they should be retained as individual issues of the IEPR.</p> <p>The rejection of the option of a grout curtain through the left abutment appears not to have been based on factual or test data. The conclusion reached during Expert Elicitation that a curtain would have a longevity of approximately 20 years ignores important facts:</p> <ul style="list-style-type: none"> • Evidence of the original grout curtain (over 70 years old) was found in situ. • There have been very substantial changes in drilling and grouting techniques in the past 70 years (Weaver and Bruce, 2007) (specifically relating to grout durability). • There is no evidence that the rock is erodible or undergoing piping (the seepage is clear). <p>Supplemental data not included in the MRR but which were provided to the Panel separately relate to the results of permeability testing in four holes drilled from the spillway crest area in 1983. These tests were conducted in 5 foot stage lengths between Elevations 884.1 and 839.2. The permeability test values range from moderately high (18 Lugeons [Lu]) to extremely high (266 Lu) and indicate rock that is very amenable to contemporary rock fissure grouting practices. These supplemental data are inconsistent with the statement in Appendix H, Table 2, of the MRR that the rock can be assumed to be “nonpermeable”; however, the data are consistent with the fact that the abutment transmits water freely with the lake at elevations above 843 (although other estimates say 848.6 and 865). The geostructural and hydrogeological facts are inconsistent with the conclusion that a grout curtain would provide “only minimal improvement over the base condition” (p. 20) at elevations up to 914, since curtains can be engineered to a residual permeability of less than 3 Lu, if required (Weaver and Bruce, 2007).</p>
Significance – High:
The dismissal of the grout curtain from further consideration during the alternative screening and Expert Elicitation processes affects the recommendation and justification of the project.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Tabulate and review all existing permeability data and obtain new data in the area of the proposed cutoff. 2. Review all borehole logs in the vicinity and historical records of seepage through the abutment to correlate the permeability data and seepage observations with the geological logs (especially with respect to lithology and geostructure). 3. Contact counterparts in other Districts where “modern” grouting has recently been conducted (e.g., Louisville, Chicago, Nashville, Little Rock) to research contemporary grout curtain concepts, details, and performance levels.

Literature Cited:

Bruce, D. A., T. L. Dreese, and D. M. Heenan (2010). Design, construction, and performance of seepage barriers for dams on carbonate foundations. *Environ. Eng. Geosci.*, 16(3): 183-193.

Weaver, K. D. and D. A. Bruce (2007). *Dam Foundation Grouting, Revised and Expanded Edition*. American Society of Civil Engineers, New York: ASCE Press, 504 p.

Final Panel Comment 5:

The screening of alternatives was abbreviated and did not include evaluations of the benefits and costs of each alternative.

Basis for Comment:

Final panel comments 3, 4, 5, and 6 are all interrelated and deal with various aspects of plan formulation. There is some redundancy in these interrelated comments, but the Panel has concluded that due to their individual significance, they should be retained as individual issues of the IEPR.

The screening process employed in the MRR is not consistent with ER 1105-2-100 guidance (USACE, 2000) on the formulation of alternative plans. In the initial screening of alternatives in the MRR, some alternatives were not adequately analyzed to determine their economic justification prior to being eliminated from further consideration. The primary formulation criterion is to reasonably maximize net benefits to the national economy (USACE, 2000; Chapter 2, p. 2-7), which can be done by comparing plans using economic benefits and costs. Thus, annual benefits are compared to annual costs and net benefits are derived for each alternative. Alternatives are further compared by performing an incremental analysis. As long as there are positive net benefits for going from one plan to a higher level of improvement (such as increased safety), the more expensive plan is chosen and net benefits are maximized.

The abbreviated screening methodology used in the MRR results in potentially feasible alternatives being eliminated from further consideration for not totally meeting the safety objective. Incremental analysis of the increased responsiveness of varying alternatives to the safety objective was not performed. In addition, a trade-off analysis between alternatives was not performed. Finally, seemingly arbitrary decisions were made in the early alternative screening process to eliminate alternatives from further consideration based solely on the criteria of completeness, effectiveness, efficiency, and acceptability. These are appropriate criteria that should be taken into account in the screening process and the extent to which each one is achieved should be identified. However, there is no expectation that these criteria will be fully achieved, and deleting alternatives that do not meet these criteria is inappropriate. Evaluation of alternatives by applying these criteria is discussed in the USACE guidance on the formulation of alternative plans (USACE, 2000; Chapter 2, p. 2-4).

Significance – High:

Without an analysis of the benefits and costs of each alternative and a comparison of alternatives on an equal basis by applying the same criteria, there is no assurance that feasible alternatives have not been prematurely and inappropriately eliminated from further consideration; this could impact the recommended plan.

Recommendations for Resolution:

1. Estimate average annual benefits and costs for each alternative.
2. Document the plan formulation process consistent with USACE guidance.
3. Compare plans applying the same criteria of annual costs, annual benefits, and net benefits.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

Final Panel Comment 6:
The alternative development process for the full depth cutoff wall failed to include probabilistic seepage analyses and consideration of the risks associated with construction
Basis for Comment:
<p>Final panel comments 3, 4, 5, and 6 are all interrelated and deal with various aspects of plan formulation. There is some redundancy in these interrelated comments, but the Panel has concluded that due to their individual significance, they should be retained as individual issues of the IEPR.</p> <p>Little or no risk of unsatisfactory performance is assigned to the full length, full depth cutoff wall based on the apparent assumption of total, or near total, effectiveness of the wall. The following statement is made in Section 6.2.1 of Appendix H:</p> <p style="padding-left: 40px;">Seepage analyses that include a full depth cutoff are neither appropriate nor necessary, since even a 50% effective cutoff wall should lower the groundwater level at even the highest pool to elevations below the downstream toe. The safety factors against high uplift pressures and excessive exit gradients are infinity, by definition in this case.</p> <p>Considering that construction of the wall will involve excavation of a trench approximately 2,300 feet long, extending through the dam embankment and foundation to a maximum depth of 265 feet, it is overly optimistic to assume that there will be no imperfections in this construction. Therefore, the assumption of a 100% effective cutoff wall is unrealistic. In addition, it is unclear whether 50% effectiveness refers to seepage quantities, piezometric levels, or some other criteria. After defining the meaning of the term, it should be a straightforward exercise to perform a seepage analysis for a wall with 50% effectiveness, which should support the statement, "... even a 50% effective cutoff wall should lower the groundwater level at even the highest pool to elevations below the downstream toe." The seepage analysis would also provide information that could subsequently be used to assess the efficacy of the full length, full depth cutoff wall.</p> <p>There is a distinct lack of <i>in situ</i> permeability values for the foundation rock, although there are considerable data on the permeability variation in the outwash materials. In addition, the quality of the rock into which the cutoff wall will be embedded was not discussed, and no rationale was given as to why the cutoff wall would be advanced to a depth of 3 feet into the bedrock beneath the soil deposits. Construction of the cutoff wall will result in very high hydraulic gradients where the wall extends into bedrock; therefore, the integrity of this rock is an important consideration in the design and construction of the wall. These issues may affect design details and construction methods and costs.</p>
Significance – High:
The selection of the recommended plan is unsupported without a probabilistic seepage analysis for an imperfect cutoff that also considers the integrity of the rock into which the wall is set and associated underseepage.
Recommendations for Resolution:
1. Define what is meant by effectiveness (e.g., reduction in flow quantities, reduction in piezometric levels, etc.).

2. Conduct a seepage analysis for a wall with 50% effectiveness to support the statement regarding the effect on the downstream groundwater level of a 50% effective cutoff wall.
3. Provide the rationale for setting the bottom of the cutoff wall at a depth of 3 feet into the bedrock beneath the soil deposits.
4. Provide the basis for a Reliability Index with consideration given to the effectiveness of the cutoff wall in light of potential construction imperfections and potential seepage through the bedrock beneath the cutoff wall.

Final Panel Comment 7:

The Expert Elicitation panel may have exceeded their charge, resulting in a recommended plan for remediation that is not adequately supported.

Basis for Comment:

As noted in Appendices B and D of EP 1130-2-500 (USACE, 2006), Expert Elicitation is one of four accepted methods for calculating probabilities of unsatisfactory performance. The method relies on the use of expert judgment to establish subjective probabilities to measure an individual's degree of belief concerning the likelihood of the occurrence of an event. Consequently the method is highly dependent upon the experience and skill of the panel of experts selected and the procedures used to avoid biases in the probabilities. Appendix B states:

Expert Elicitation should only be used to establish subjective probabilities of unsatisfactory performance for preliminary screening purposes to determine the components or features which need further study, or when there is insufficient data to develop the probabilities from historical frequencies of occurrence or analytical procedures.

It is understandable that there would be a lack of historical data relating to the Failure Continuum described in Appendix I, Section 5.0; however, the absence of information noted in the discussion presented in Section 5.1 raises the question of whether the assessment of remediation alternatives by the panel was based on sufficient information regarding the left abutment. The phrases "unknown subsurface conditions," "limited bedrock information," and "uncertainty involved in the subsurface conditions" used in Section 5.0 reflect the fact that this was something the panel considered in arriving at its conclusions. Consequently, it seems that the first portion of the charge of Expert Elicitation would have been more appropriate at this stage, being "... to determine the components or features which need further study ..."

Since the outcome of the Expert Elicitation process is highly dependent on the experience and skill of the panel, it is important that the report state the criteria used in the selection of the panel members. Specific experience with the Failure Continuum described in Appendix I is a particularly relevant criterion, as well as experience in the remediation of seepage problems similar to the condition at Mohawk Dam. This is especially important since there appears to have been no attempt to model the problem analytically. As a minimum, it would have been very helpful if a rock mass classification had been developed for the left abutment using ASTM D5878-08, as some of these classification systems have been applied to hydraulic erodibility. In addition, as noted in Addendum E (Reviews) of Appendix I, "The EEO should have included more experts from outside of the LRH staff." As observed in that addendum, this is not a reflection on the qualifications of the panel member. A more diverse panel may well have provided guidance in numerically modeling the problem, which in turn would have further supported the panel's recommendation.

Significance – High:

Considering the lack of information and high degree of uncertainty regarding subsurface conditions, the appropriateness of the subjective probabilities subsequently applied to the risk analyses, as well as the basis for the recommended plan, may not be appropriate.

Recommendations for Resolution:

1. Provide the criteria used to select the Expert Elicitation panel.
2. Reassess the alternatives for remedial measures to the left abutment after additional geologic information has been obtained that removes some of the uncertainties associated with unknown subsurface conditions in the left abutment.
3. Incorporate additional experts outside the Huntington District for the reassessment process.
4. Develop a rock mass classification for the left abutment in accordance with ASTM D5878-08.
5. Conduct a literature search to identify sites or projects where similar conditions exist or existed to supplement the information available to the Expert Elicitation panel in the decision making process.

Literature Cited:

USACE (2006). Project Operations – Partners and Support (Work Management Policies). Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Pamphlet 1130-2-500. 1 June.

American Society for Testing and Materials. ASTM D5878 – 08, Standard Guides for Using Rock-Mass Classification Systems for Engineering Purposes. ASTM, West Conshohocken, PA. Revision issued annually.

Final Panel Comment 8:
Non-structural alternatives were not fully developed and evaluated.
Basis for Comment:
<p>ER 1105-2-100, Chapter 2, p. 2-5 (USACE, 2000) indicates that non-structural alternatives shall receive equal consideration to structural measures. A range of non-structural alternatives was not considered in the MRR. For example, a scheduled rehabilitation delay for 10 years was identified as the only non-structural alternative, but dismissed without adequate evaluation, discussion, and consideration of benefits and costs to compare with the immediate rehabilitation alternative. The MRR does state that the scheduled rehabilitation delay alternative has 40% fewer net benefits than the immediate rehabilitation alternative, but gives no specifics or documentation.</p> <p>Additional non-structural alternatives that could have been considered include modification of dam operations at Mohawk Dam and within the river basin, dam removal, redevelopment of sites to reduce the risk to flood-related damages, and alternative schedules of rehabilitation delays. The alternative schedules of rehabilitation delays are required by EP 1130-2-500, Appendix B, p. B-6 (USACE, 1996), which indicates that the optimum rehabilitation timing must be identified.</p> <p>In addition, the following could be considered non-structural alternatives that could be implemented throughout the river basin with or without a rehabilitation project for Mohawk Dam:</p> <ul style="list-style-type: none"> • Perform revised floodplain mapping and studies to more accurately reflect the current floodplain, which may result in more extensive floodplain boundaries. • Strengthen existing or developing new rules, codes, and ordinances discouraging development within low-lying and flood prone/floodplain areas. • Identify floodplain areas that may be at risk for development (current and/or future) and develop conservation plans to either manage or acquire these properties for buffers to surrounding developed areas. • Retrofit existing structures for reduced exposure to risk or remove existing structures from the floodplain.
Significance – High:
<p>Identification and evaluation of all reasonable non-structural measures is needed to confirm that the NED plan was identified and the appropriate recommended plan was selected.</p>
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Evaluate additional non-structural alternatives. 2. Evaluate alternative schedules of rehabilitation delays. 3. Identify the optimum rehabilitation timing of rehabilitation delay alternatives. 4. Identify and document the cost, benefits, net benefits, and benefit/cost ratios of the base condition and every structural and non-structural alternative identified for consideration.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

USACE (1996). Project Operations – Partners and Support. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Pamphlet 1130-2-500. 27 December.

Final Panel Comment 9:**A succinct definition of the base condition was not fully developed and documented.****Basis for Comment:**

The base condition constitutes the benchmark against which all plans are evaluated. On page E-270, ER 1105-2-100 (USACE, 2000) states, “the base condition assumes that the project will be operated in the most efficient manner possible without the proposed rehabilitation.” Without a well defined and supported base condition to compare project alternatives against, formulation of plans can lead to inappropriate decisions. Only one base condition can be selected for evaluation purposes. A sensitivity analysis of including or excluding the interim operation practices in the base condition can demonstrate the impact of that decision and provide support for selection of the base condition.

The base condition is the basis for formulation of alternative solutions as it provides the basis for establishing specific study problem and opportunity statements, which in turn aid in providing the rationale for determining the types and characteristics of the investigations that are required to support the development of those alternative rehabilitation plans as well as the resulting measurement of the effects (beneficial or adverse) associated with each alternative plan when compared to the base condition. In Appendix B, Section 2, the MRR identifies the base condition as a fully functioning dam. This is questionable since it does not include plans that would be implemented in the absence of rehabilitation, that is, the Interim Operating Plan or the repair or replacement of the gate operating equipment. The description of base condition must be sufficient to allow a comparison of the impacts associated with each alternative plan or increments thereof in order to determine the extent to which each alternative’s contribution to efficiency, effectiveness, completeness, and acceptability can be measured in accordance with the Federal objective and the problems and opportunity statements.

The Interim Operating Plan or risk reduction plan, which has apparently already been implemented, is clearly a Federal Action and as such the effects of this action must be considered, investigated, and evaluated. It is inappropriate to base the plan formulation process on a fully functioning project given the risk of dam failure with a significant flood event. Likewise, it is inappropriate to state in section 9.7 of the main report, “It is likely these interim measures would be implemented prior to completion of the recommended rehabilitation plan. However, with the exception of the interim surveillance plan and augmentation of the seepage blanket, any measures not implemented prior to construction of the recommended rehabilitation plan should be considered necessary rehabilitation plan components.” The MRR does not provide an evaluation of any of these components.

The basis for evaluating the categories of beneficial or negative effects (e.g., future flood damages prevented, provision of recreational opportunities, lost capability to provide flood damage reduction during emergency repair, lost capability to provide recreational opportunities during emergency repair, repair of damaged transportation infrastructure, and the opportunity to avoid emergency repair expenditures) are the logical extension of the definition of the base condition as the formulation of alternative plans depends on comparing the benefits and impacts of each alternative plan to the base condition. As such, the base conditions should be crafted with specific planning study objectives to facilitate comparison to the base condition as well as

calculating net benefits and benefit/cost ratios, and performing incremental, screening, and trade-off analyses. Non-monetary benefits such as risk reduction play an important role in plan formulation and selection of the recommended plan.

The description of the base condition stated in the report does not consider probable failure modes of each of the project's major components (main embankment, the transition zone between the main embankment and the left abutment, the outlet structure tunnels and gate operating equipment, and the emergency spillway) such that the effects of these failures can be properly evaluated through incremental or trade-off analyses. The assumptions that underlie breach failures should be clearly stated so that the alternative plan's accomplishments toward the goals of efficiency, effectiveness, completeness, and acceptability can be understood and fully supported. For example:

- The MRR does not enumerate the potential size of any breach so that an estimate of the time and cost for emergency repairs to all project resources can be determined.
- The description of the base condition does not consider whether recreation facilities are assumed to be damaged or destroyed by a catastrophic failure so that a cost estimate for their repair or replacement can be determined.
- The description of the base condition does not consider the duration, intensity, and severity of catastrophic failure such that the evaluation of all effects (positive and negative) can be supported.

The effects to downstream channel morphology as a result of a catastrophic failure are not considered, even qualitatively, or discussed in relationship to potential environmental impacts or the provision of future flood damage reduction.

Significance – High:

Without a comprehensive definition of the base condition, it is not possible to accurately identify the benefits of each alternative plan, determine the NED plan, or support a deviation from the NED plan.

Recommendations for Resolution:

1. Provide a comprehensive description of the base condition to include the current and the most likely future conditions without major rehabilitation.
2. Provide clear and convincing support for not including the interim operating plan or the repair or replacement of gate operating equipment in the base condition.
3. Provide appropriate problem and opportunity statements that facilitate the formulation of rehabilitation plans and the measurement of their effects to derive incremental differences.
4. Provide appropriate problem and opportunity statements that facilitate the discussion and measurement of the consequences of probable catastrophic failures with respect to other project facilities and downstream resources.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

Final Panel Comment 10:

The discussion of the risk and reliability analysis methodology is confusing and does not provide sufficient information to confirm the technical adequacy or the appropriate use of the model developed to evaluate economic feasibility.

Basis for Comment:

The risk and reliability analysis methodology is used to determine the average annual equivalency of project benefits (Appendix B, Section 4). The Panel did not find in the MRR:

- a demonstration that the average annual benefits claimed for any alternative are reasonable,
- that any alternative is economically justified, an explanation upon which to base a review of the acceptability of the model or results stemming from its use, or
- information on all of the input parameters for each of the various categories of benefits.

Without this information, the validity of the model is questionable. The following paragraphs describe the concerns and issues the Panel has with the items listed above and the results produced by this analytical technique.

The risk and reliability model uses the data displayed in the event trees (Addendum 4) as input values. Some of the values are associated with specific flood stages (flood damages, roadway damages), whereas others are gross unsubstantiated approximations (historic damages, repair costs). Annual average equivalency for flood damages has traditionally been achieved through a frequency analysis because the annual frequency values are expressed as the probability of an event being equaled or exceeded in any given year. The damage estimates associated with each flood stage are combined with the frequency associated with each flood stage to produce the relationship of damage versus frequency. The area under this resulting curve is then estimated as the average annual damages. The MRR does not state that either the values for the frequency of events, the probability of unsatisfactory performance or the values of flood damages change over time. Thus, since time is not a factor, there is no rationale for the use of discounting procedures. If, however, there is some assumed change in either the probability of unsatisfactory performance or the value of flood damages associated with each flood stage analyzed or with the frequency of each flood stage, then that change needs to be explained and supported by empirical evidence.

The MRR states that the model is used to calculate repair costs, which is inappropriate. The Panel assumes that this statement refers to the costs for emergency repairs necessitated by a catastrophic failure. The costs for emergency repair should be engineering estimates based on quantities.

The MRR does not explain how the model accounts for the timing of a failure event or the appropriate discounting techniques applied. Without such explanations, the technical adequacy of the results presented cannot be confirmed.

Guidance provided in ER 1105-2-100 (Chapter 3) requires that many of the variables used in the estimate of benefits and costs be subjected to an examination of risk and uncertainty. The HEC-FDA model provides such an examination for flood damage calculations. The MRR does

not explain how or if the risk and reliability analysis methodology deals with the issue of risk and uncertainty for any of the category of benefits.

Figure 5 is a simplified or generic form of the event trees presented in Addendum 4. Nowhere in Addendum 4 or in the text associated with Figure 5 is there an explanation of the term “reset” used in Figure 5. The meaning of this term is unclear, yet it implies the use of some mathematical technique, which also is not explained.

Significance – High:

Without the ability to confirm the appropriateness of the risk and reliability analysis methodology, the technical adequacy of the average annual benefits cannot be confirmed, and the justification of the NED plan and the recommended plan is questionable.

Recommendations for Resolution:

1. Explain the salient features of the risk and reliability analysis methodology to include all input parameters.
2. Explain all of the mathematical techniques employed by the model to estimate average annual benefits.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, DC 20314-100. Engineering Regulation 1105-2-100. 22 April.

Final Panel Comment 11:
The results of the probabilistic seepage analyses call into question the method that was used and the consistency of the variables applied to the analyses.
Basis for Comment:
<p>The probabilities of unsatisfactory performance, critical parameters in the overall risk analysis, are determined from the results of the probabilistic seepage analyses. The probability of unsatisfactory performance is a function of the results of the probabilistic seepage analyses, as well as the variables used in the seepage analyses. However, it appears that the tool used to compute the probability of unsatisfactory performance had an effect on the result as well. The results obtained from any analysis should depend entirely on the independent variables defining the problem and not on any sensitivity of the computational method to the independent variables used in the analysis. In addition, for consistency, the same set of independent variables should be applied to each set of analyses.</p> <p>Appendix H, Section 5.2, notes that the probabilistic seepage analyses had to be performed differently than the probabilistic slope stability analyses. From Section 6.2.2 it appears that the analysis for the partial depth cutoff wall was performed somewhat differently than for the base condition, which had an effect on the results. In discussing the results in Section 6.2.2.1, it is noted that the probability for unsatisfactory performance is higher for the partial depth cutoff than for the base condition, even though the safety factor for the failure mode is higher. This is counter-intuitive, and the explanation presented in the appendix is: “This is explained by looking at the Taylor Series sheet, which shows that the partial cutoff increases the sensitivity of the foundation permeability to the safety factor.” It is not clear why the foundation permeability would be sensitive to the safety factor and not vice versa, since the safety factor is the dependent variable. Nevertheless, it was not analyzed further because the probability of unsatisfactory performance was considered low for the rehabilitation alternative, and this situation occurred at an extreme event, being the PMF. However, what is somewhat alarming, given the importance of the probabilities of unsatisfactory performance to the risk analyses, is that complete trust has been placed on the results for the base condition when an anomalous result was obtained for one of the rehabilitation alternatives.</p>
Significance – High:
A consistent set of variables must be applied for all analyses given the critical importance of the probabilistic seepage analyses to the overall risk assessment and selection of the recommended plan.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Apply a consistent set of variables to the analyses for each alternative, as was applied to the analysis for the base condition. 2. Provide a more detailed discussion of how the Taylor Series approximation was used to compute probabilities of unsatisfactory performance and Reliability Indices.

Final Panel Comment 12:

Inconsistencies in hydraulic conductivity values presented in the Engineering Reanalysis Report (ERR) and MRR are not explained, and key variables in the seepage analyses that affect the risk analyses are not identified.

Basis for Comment:

The report does not present sufficient discussion to support the selection of hydraulic conductivity values, nor does it address differences in values for the same materials or zones modeled in the ERR and MRR. In addition, there are inconsistencies in hydraulic conductivities for materials and/or zones modeled in the MRR analyses that are not discussed.

The results of the seepage analyses are critical to the risk analyses, and appropriately so given the seepage problem that exists at the site. While Appendix H presents discussions of the various materials encountered on site (foundation, embankment, seepage blanket, relief wells, etc.), as well as issues relating to sampling and testing of these materials, there are some inconsistencies between the ERR and MRR hydraulic conductivity values that warrant further discussion. The use of different units in the table presented in Appendix H, Section 4.5, makes comparison of values even more difficult.

Appendix H explains that the Downstream Rock Fill contained higher percentages of fines than previously thought, which may explain why the hydraulic conductivity was reduced from the ERR to the MRR, though this was never stated in the text. However, the value in the MRR was less than the Terrace Gravel Layer and Foundation Outwash hydraulic conductivities by approximately one order of magnitude; therefore, this would seem to mitigate the concern identified in the ERR of piping of foundation material into the Downstream Rock Fill. In addition, the hydraulic conductivity of the Toe Drain was also reduced by approximately an order of magnitude from the ERR to the MRR, though no explanation is given as to why. Additionally, the hydraulic conductivity for the Toe Drain used in the MRR is less than the values for the Terrace Gravel Layer, Foundation Outwash, and Downstream Alluvium. This essentially indicates that the Toe Drain is no longer functioning as a drain, but rather impeding flow through the foundation at the location of the Toe Drain. At the same time, the likelihood of piping of foundation soil into the Toe Drain is reduced because of its higher fines content.

According to Appendix H, Section 4.5.3, “The major sources of uncertainty for through seepage reliability analyses include hydraulic conductivity...of foundation materials..., while for under seepage they include relief well and rock toe efficiencies, hydraulic conductivity...” Given the importance of the hydraulic conductivity values to the seepage analyses used to determine the probabilities for unsatisfactory performance, the MRR must clearly describe how the tabulated hydraulic conductivities were established for the materials and zones modeled in the analyses and why values were revised from the ERR to the MRR. Appendix H, Section 4.5 does not adequately describe the basis for the selection of seepage properties. In addition, the following statement is made in Section 4.5.3: “This work also helps to reveal the relative sensitivity of input variables, which is important to the identification of key random variables.” However, the key random variables are never identified and their significance in the risk analyses is never discussed.

Finally, the hydraulic conductivity values for several of the materials differ significantly between three tables in Appendix H: the unnumbered table of Historical Seepage Parameters in Section 4.5; Table 2 (Deterministic Parameters); and, Table 3 (Probabilistic Parameters). No discussion is presented to address these differences. Also, a value for the vertical hydraulic conductivity in the relief wells is given in Table 3, when it would seem that the horizontal hydraulic conductivity would be a more critical value for a relief well.

Significance – High:

Inadequate support for hydraulic conductivity values selected and inconsistent values raise questions regarding the validity of the seepage analyses, which in turn affect the risk analyses, along with associated recommendations and project justification.

Recommendations for Resolution:

1. Provide a basis for the selection of hydraulic conductivity values tabulated in three tables in Appendix H: the unnumbered table of Historical Seepage Parameters in Section 4.5; Table 2 (Deterministic Parameters); and, Table 3 (Probabilistic Parameters). This need not be a lengthy discussion, but rather a reference to specific laboratory tests, field tests, index property correlations, etc. (whatever information was specifically used to establish the values).
2. Resolve the inconsistencies between tables in Appendix H.
3. Discuss the difference between deterministic and probabilistic seepage parameters.
4. Discuss the inconsistencies between hydraulic conductivity values used in the analyses (e.g., why the value for the Downstream Alluvium and Glacial Outwash is about 10 times greater than the value for the Toe Drain).
5. Discuss the changes made in hydraulic conductivity values from the ERR to the MRR (e.g., why the hydraulic conductivity for the Toe Drain was reduced by about a factor of 10).
6. Identify the key random variables in the seepage analyses alluded to in the text, and discuss the implications on the risk analyses.
7. Use a consistent set of units for all hydraulic conductivity values (feet per second, feet per minute, or centimeters per second); do not mix units.

Final Panel Comment 13:**Relatively little data are available establishing the seepage situation in the left abutment.****Basis for Comment:**

The MRR appendices and the supplemental information provided separately contain a dearth of permeability data and little strength information:

- The structural and/or lithological control over flow characteristics is not clearly presented.
- There is no consistency in the various descriptions of the elevation at which seepage commences.
- There are no data on seepage rate versus lake elevation.
- The integrity of the embankment/abutment contact is not known.
- No testing or analysis of erodibility is described.
- No geological or hydrogeological basis is provided to justify the length or depth of the proposed cutoff wall.
- There is little information upon which to judge if a cutoff wall can be built and, if so, what degree of pregrouting would be necessary.

Despite this lack of modeling and investigation, it is apparently being assumed that the left abutment poses the same degree of risk as the embankment dam and its foundations, and therefore requires treatment to the same level of care as the embankment dam. This assumption has significant cost implications.

Significance – High:

With this lack of data in the MRR, the severity of the left abutment problem has not been proven, thereby raising questions on the need to remediate and the selection of the remedial method.

Recommendations for Resolution:

1. Tabulate and review all existing permeability data and obtain new data in the area of the proposed cutoff through the abutment.
2. Review all borehole logs in the vicinity and historical records of seepage through the abutment to correlate the permeability data and seepage observations with the geological logs (especially with respect to lithology and geostructure).
3. Contact counterparts in other Districts where “modern” grouting has recently been conducted (e.g., Louisville, Chicago, Nashville, Little Rock) to research contemporary grout curtain concepts, details, and performance levels.
4. Readdress the risk of failure occurring through the abutment and especially relative to the risks posed by other Potential Failure Modes (PFM) such as the embankment/foundation piping mode.
5. Implement a seepage analysis (and robust hydrogeological model) of the left abutment with appropriate representative parameters (especially on permeability). This will provide an engineering basis for designing the length, depth, and residual permeability of the cutoff.

Final Panel Comment 14:
The hydrologic models used to determine the inflow into Mohawk Dam and downstream water surface profiles were not calibrated with past storm events.
Basis for Comment:
<p>In general, numerical simulations involve four steps: building the model, calibrating the model, verifying the model, and making future predictions. The derivation of the PMF inflows into Mohawk Dam was not adequately conducted in that the HEC-HMS and RES-SIM models were not calibrated and verified with any past events. As presented, this modeling effort has skipped two of the four steps listed above (calibrating the model and verifying the model). Therefore, projections made by these models lack confidence and credibility.</p> <p>Similarly, in modeling unsteady open channel flows downstream from the Mohawk Dam, channel roughness coefficients, expansion, contraction and local energy loss coefficients, channel junction losses, cross section spacing, and time step durations have been assumed along the various reaches. These modeling parameters are often chosen by modelers with experience with similar systems. Models are then calibrated and verified with observed flood events to match measured water surface profiles, flood wave arrival times, etc. The hydraulic modeling effort has also skipped the two important simulation steps and therefore the water surface profile computations lack confidence and credibility.</p>
Significance – High:
Inflow projections from upstream watersheds are the driving force behind the dam failure analysis and, if they are not properly accounted for, the recommendation and justification of the project may be affected.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Calibrate the models. One of the recent flood events can be used to calibrate the various input parameters used in the models. 2. Validate the models using the 2005 flood that approached the 100-year event.

Final Panel Comment 15:

The abbreviated methodology used in the analysis of the road damages benefit category is not based on sound economic and engineering principles.

Basis for Comment:

The MRR used a method which does not rely on sound economic and engineering principles, and the methodology used is largely unexplained.

Roadway pavement damages are functions of velocities, durations, and flow depths. The methodology used to estimate these benefits does not address these variables. Without establishing criteria for when road surfaces are impacted by flood flow depths, velocity, and duration and analyzing the number of miles of roads meeting the road surface failure conditions, the methodology is arbitrary, does not adequately describe the true impacts, nor is it possible to confirm the appropriateness of the magnitude of road damages estimated. A standard for evaluation should be determined that describes the conditions that must be met to trigger the need for road resurfacing and the cost to do so. Average annual road damages avoided must be estimated for each alternative evaluated to allow the proper formulation of alternatives and identification of the NED plan.

The information provided for historic flood damages prevented does not appear to have been examined to determine if there were instances where roadways, bridges, culverts, or other drainage infrastructure suffered damages that required repairs or the costs associated with those repairs. In Section 10 of Appendix J, the following statement is found:

The results of a dam failure at Mohawk could be catastrophic at areas just downstream of the dam. A dam break with any of the eight adopted starting pool levels would cause flooding due to the large volume of water retained behind the dam. As noted above, for dam breaks of the eight adopted initial pool levels, there is large attenuation in peak flows downstream of the dam to the first index station in Coshocton, Ohio. Most attenuation of the flood wave associated with a dam break occurs in the first 15 miles downstream of the dam.

It is difficult to believe that 85 miles of roadway would need to be repaved as a result of an approximate 3-year event, even on a system-wide basis. It was estimated that approximately 500 miles of paved roads are located in the study area. In Appendix B, Addendum 6, the MRR states, “. . . through interviews with the District’s H&H staff it was concluded that . . . at least 400 miles of pavement would need replacement in the case of a dam failure under PMF circumstances.” With a cost of \$1.5 million per mile, the total cost of repaving from a PMF event would be \$600,000,000.

The areal extent of flooding was not presented. Addendum 6 has a reference to mapping (“shape files of the road networks within the basin were obtained from the Tuscarawas County GIS website”) as well as a reference to analytical techniques used to estimate the extent of roadway damages claimed for several levels of flooding. The report does not provide examples of the actual work accomplished.

The MRR states in Appendix B, Addendum 6, "An estimate for paving an average 2-lane road where minimal preparation is required was developed for this analysis by the Federal Highway Department and Nashville District's Cost Estimating Branch 12." There is no discussion of the basis for either estimate. The estimates need further support. There are several counties and municipalities within the study area that could be consulted on these costs to account for the differences of standards for city streets, county roads or state highways as well as the historical records to verify or validate the reasonableness of the estimate.

The damages to bridges, culverts and other drainage structures is in all likelihood somewhat more important than those to roadways as well as the impacts to transportation patterns, delays and detours. If the MRR wishes to use these estimates as a proxy for all transportation infrastructure damages, then it should be stated as such and a basis to demonstrate that such a proxy is a reasonable approximation technique should be provided.

Just as the lost capacity to prevent future flood damages to downstream properties is an acceptable category of benefits, that capacity also extends to the prevention of future roadway damages. Any analyses for this category of benefits should also investigate the length of time that would be required to affect the repairs. For any length of time greater than one year, similar techniques used to determine average annual benefits for the avoidance of emergency repair expenditures would need to be used to evaluate the average annual benefits of avoiding road damage repairs.

Significance – High:

Average annual equivalent benefits for road damages prevented were not estimated for each alternative, yet road damages prevented are a significant benefit category (30%) and adequate support for this category is necessary to identify the NED plan and justify the recommended plan.

Recommendations for Resolution:

1. Expand rationale for why in-depth flow, velocity, and duration analyses were not performed. Otherwise, historic data from previous floods within the watershed, other floods in the District, or flooding events throughout USACE could be used as a guide in defining the failure point conditions to support the findings. Data from municipal public works departments, county road departments, or state highway departments need to be collected and analyzed for appropriate cost estimates to account for varying standards for different types of roadways.
2. Provide rationale for using repaving costs as a proxy for all damages to transportation infrastructure. The information contained in footnote 12 to Addendum 6, p. 43, needs to be expanded to include the date on which HQUSACE approved the development of the methodology used for the Wolf Creek Major Rehabilitation Report and whether that approval was specific to the methodology employed or was subsumed as a part of an approval of the entire report.
3. Include graphics of the amount and location of infrastructure that might be damaged by various flow levels, which would help verify the extent of necessary road resurfacing.
4. Compute average annual equivalent benefits for flood damage prevented using a frequency based method and present them in the MRR, as appropriate.
5. Provide a rationale for not estimating the costs to motorists for longer travel distances and time, especially for a 7-year construction period. While it may not result in a significant

value, a qualitative assessment at the very least needs to be included in appropriate trade off analyses for plan formulation purposes and cumulative impact assessment.

5. Present average annual equivalent benefits for the lost capacity to prevent transportation infrastructure damages during emergency repair periods.

Final Panel Comment 16:

The assumptions behind the hydrological uncertainties leading to spillway erosion failure were not provided.

Basis for Comment:

The Panel identified hydrology of the Mohawk Dam watershed as the driving cause of spillway erosion failure. Proper selection of antecedent conditions and the magnitude and timing of the Probable Maximum Flood (PMF) discharges into the Mohawk Dam reservoir have major impacts on the reservoir hydrology and the duration of spillway flows. Certain assumptions are made implicitly in USACE's hydrologic computations; in the use of HMR-52's default rainfall distribution, storm orientation optimization; and in the selection of precipitation losses. The Panel reviewed the implicit hydrological assumptions:

- A. Hydrometeorological Report (HMR) – The PMF event for the hydrology of Mohawk Dam Reservoir and the Mohawk Dam failure analysis was derived in Appendix J, Exhibit 1, which states that PMF computations followed HMR-51 and HMR-52 procedures. No other details are given. The Panel verified the HMR-52 computations using the data files supplied by USACE in order to analyze the assumptions used in PMF computations.
- From the HMR 52 Manual, the Panel determined the preferred storm orientation for the Mohawk Dam area as 230 degrees. Using the HMR data files supplied by USACE, the Panel computed the optimized storm orientation from HMR-52 as 190 degrees.
 - Using the HMR-52 data files provided by USACE, the Panel computed the 6-hr precipitations are 0.36 in., 0.43 in., 0.54 in., 0.74 in., 1.13 in., 2.57 in., 10.56 in., 1.57 in., 0.89 in., 0.63 in., 0.48 in., and 0.39 in. for a total of 20.29 in. This computed rainfall distribution is in close agreement with the distribution presented in Appendix J, Exhibit 1 and Appendix J, Table 2, where the total rainfall is reported as 20.37 inches.
- B. Precipitation – The order of Panel-computed 6-hr increments based on precipitation amounts are 12-10-8-6-4-2-1-3-5-7-9-11 (where 1 is the largest 6-hr precipitation, and 12 is the smallest 6-hr precipitation). This distribution places the maximum 6-hr precipitation to 36-42 hours (center of event). There are other storm distributions accepted by HMR-52. These storm distributions place the largest four maximum 6-hour precipitation periods towards the end of the event (instead of centering). One such arrangement is given as 12-11- 10-9-7-6-5-3-1-2-4-8. As a result of a skewed distribution, the peak precipitation occurs after the ground is fully saturated and infiltration losses are at a minimum. Previous major events listed in the MRR confirm more severe conditions under saturated soil conditions. USACE takes this process into account in their simulations by applying a 30% PMF event 6 days prior to the PMF event. However, the almost constant rate of precipitation losses of 0.3 in./hr in Appendix J, Table 2 does not reflect saturated ground conditions properly, and the basis for the selection of 30% PMF event as antecedent event is not explained.
- C. Sensitivity Analysis – On page 12, Appendix J, first paragraph, it is stated, “a sensitivity analysis was performed by increasing the unit hydrograph peak by 25% and 50% and adjusting the volume to see the effects of the peak PMF elevation after routing the PMF

through the dam.” From the sensitivity analysis, the 150% PMF peak was chosen as the PMF inflow. This procedure is based on sensitivity analysis rather than the physical nature of storms. Using the recent large storm events, a physically based peak reflecting Mohawk Dam watershed conditions could have been derived without resorting to increasing the PMF peaks.

Significance – Medium

The lack of explanations for the selection of the antecedent conditions and the magnitude and timing of the PMF discharges impacts the completeness of the report and understanding of the project.

Recommendations for Resolution:

1. Explain the reasoning behind the selection of a 30% PMF event as the antecedent condition using characteristics of previous major storm events.
2. Ensure model runs do not alter the peak runoff from HMR (e.g., 150% PMF, 125% PMF, etc.), but rather rearrange the temporal distribution within the framework of HMR-52.
3. Define storm orientation as 190 degrees in Appendix J, Exhibit 1 and in the text.

Final Panel Comment 17:
Adequate consideration was not given to alternatives to address rock erosion downstream of the emergency spillway.
Basis for Comment:
<p>The Panel finds that no serious consideration was given to any alternatives apart from protecting the spillway crest structure with a massive concrete gravity structure in the event that headcut erosion progresses back over the entire length of the spillway. The recommended plan assumes that complete erosion of the spillway channel is inevitable. In Appendix I, Section 6.7, the report states, “Because of the risk of undercutting the existing weir and the extent of overburden downstream of the weir, a surface treatment such as a spillway lining or energy dissipaters were not considered effective.” However, no information is presented to support this statement.</p> <p>Any methods that could prevent the erosion of rock in the spillway channel could also effectively prevent undercutting of the existing weir. An assessment of alternatives requires an understanding of where erosion of the spillway channel is expected to start and both the rate and extent of erosion that would follow. An important part of the analysis is a figure or table that identifies specifically where headcut erosion is expected to begin and then presents the progress of headcut erosion versus time. The Panel finds that no consideration was given to any possible measures for preventing the start of headcut erosion or at least retarding the progress of erosion, rather than simply allowing it to occur.</p>
Significance – Medium:
Serious consideration needs to be given to other alternatives that would prevent the start of headcut erosion in the spillway channel, or at least mitigate the progression of erosion that might occur.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Develop a figure or table that specifically identifies where headcut erosion is expected to begin and illustrates the progress of erosion versus time. 2. Identify additional alternatives that would prevent the start of headcut erosion in the spillway channel, or at least mitigate the progression of erosion. 3. Compare alternatives on the basis of cost and effectiveness in achieving the design intent.

Final Panel Comment 18:

Potentially viable off-site alternatives were not investigated, making the alternative development process incomplete.

Basis for Comment:

ER 1105-2-100 (USACE, 2000) identifies the need to evaluate a “full range of alternatives” in exploring solutions and developing the project plan. The spirit of this analysis is not intended to be an exhaustive list; however, reasonable alternatives that would meet the purpose and need of the project should be identified. This spirit is also contained with the National Environmental Policy Act (NEPA, 1982) and its associated guidance and directives towards alternative development and analysis. All reasonable alternatives, or the reasonable range of alternatives, should be considered and discussed at a comparable level of detail to avoid any indication of a bias towards a particular alternative(s). These include off-site alternatives. All alternatives should include sufficient detail so that they may be evaluated on their comparative merits. The alternative development process developed for the Mohawk Dam project did not evaluate all reasonable alternatives, which include off-site alternatives.

The Mohawk Dam controls the outflow from four other USACE flood control dams within the drainage basin (Mohicanville, Charles Mill Lake, Pleasant Hill Lake, and North Branch of Kokosing Lake). The upstream drainage area of Mohawk Dam is approximately 1,504 square miles (821 square miles net area excluding Charles Mill, Pleasant Hill, and Mohicanville drainage areas). The Mohawk Dam and the four USACE flood control dams within the drainage basin are functionally interdependent on each other. The actions of the upstream dams have direct and indirect effects on the functioning of Mohawk Dam. Therefore, the consideration of alternatives at these four dams (i.e., off-site) that could meet the purpose and need of the project, as stated, should have been considered during the alternative analysis process.

In addition to potential alternatives that could be implemented at the four USACE flood control dams, other off-site alternatives that might reduce the physical stresses to Mohawk Dam were not considered. These alternatives could include additional flood control measures conducted immediately upstream of Mohawk Dam that might reduce the frequency and intensity of a peak event, additional dam structures and hydrologic modifications, or reasonable alternatives that are outside USACE’s jurisdiction.

As a result of the off-site analysis, the screening process might show that the on-site alternatives are the only ones that would meet the purpose and need of the project. In addition, the analysis may also conclude that these off-site alternatives reduce, minimize, and/or delay impacts to the human, physical, and natural environments at a level that is less than the proposed action, while still meeting the purpose and need. This analysis may also identify other problems within the system and provide an overall benefit to ensuring public safety, health and welfare.

Significance – Medium:

Off-site alternatives are a critical component of the process of identifying, analyzing, and screening alternatives that should have been considered and presented in the report.

Recommendations for Resolution:

1. Provide a more detailed identification and description of the off-site alternatives considered for the project that would meet the purpose and need of the project.
2. Conduct a qualitative analysis of the potential effects (adverse and/or beneficial) of these alternatives to the environment; identify the potential costs associated with implementing these alternatives; determine the significance of these alternatives; and document this analysis.
3. Re-evaluate the EA/FONSI that addresses the identification, investigation, analysis, and screening of these off-site alternatives. If the revised screening analysis shows that one of the off-site alternatives should be implemented in lieu of the proposed plan, determine the appropriate NEPA documentation.

Literature Cited:

National Environmental Policy Act of 1969, as amended (1982). 42 U.S.C. 4321-4347. Public Law 91-190, amended Public Law 94-52, July 3, 1975; Public Law 94-83, August 9, 1985; and Public Law 97-258 § 4(b), September 13.

USACE (2000). Planning -- Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

Final Panel Comment 19:

The erodibility analysis downstream of the emergency spillway was not sufficiently supported.

Basis for Comment:

Flows over the relatively steep emergency spillway channel have large velocities and depths. Corresponding shear stresses and therefore the erosive powers these flows have (which are directly related to these variables) are also very large. The strength of the surface material is the balancing force resisting the scouring action (erosion) of these flows. For alluvial material, the rate of erosion is dependent on the transport capacity of the flows versus the amount of material available in the bed and banks of the channel. For sandstone, shale, and other types of rocks, the rate of erosion is expressed in relation to the applied shear stress and to material properties. In general, scour initiates at a point in the system where shear stresses exceed a threshold value (critical shear) and advances either upstream or downstream in order to achieve balance between the driving hydrodynamic forces and resisting channel material properties. These complex interrelationships are formulated in numerical simulation models. Unfortunately, some of these processes are empirical in nature and were developed by limited field observations and laboratory studies. To make things more complicated, there are numerous theories to describe the different processes. Depending on the accuracy of these theories and the simulation models using them, projections made into future events have certain uncertainties attached to them.

One of the three major rehabilitation issues presented in the MRR is to address emergency spillway erosion in the event of PMF flows. Due to the fractured nature of surface material found along the spillway, 65 ft to 85 ft of erosion is computed along the spillway.

For the present study, spillway erosion is computed using the U.S. Department of Agriculture's SITES model. While an accepted method seems to have been applied to the erosion analysis of the spillway channel, the results seem counterintuitive as stated in the MRR's Appendix I, Section 6.7.2: "... discharge for the PMF event eroded all bedrock down to the corresponding tail water elevation for the full width of the spillway." Sandstone and shale are not the hardest rock types encountered in nature, but there is an incredible amount of erosion that is computed to take place in 1.5 days (Appendix J, Exhibit 1 and Exhibit 4 show the duration of flows in excess of 100,000 cfs in 1.5 days).

The parameters used in the SITES model are not well specified and in some instances were estimated, thereby introducing uncertainty. Model results were not calibrated or verified with any of the spillway flows that were encountered in the overall project area (or in a similar application). In nature, as scour takes place, hydraulics of flows is altered to result in less severe conditions. Since the progression of scour with time (in the form of thalweg and water surface profiles at various simulation times) is not presented, a qualitative assessment of the rate of erosion could not be made. Local scour equations are developed using limited laboratory and field data. Extending these equations beyond the data from which they are derived may result in unrealistic estimates. Unfortunately, there is no guidance in the report on the range of parameters used in SITES model development and the limitations to impose on the Mohawk Dam spillway erosion results.

Significance – Medium:

Lack of discussion on the limitations of the spillway erosion model, the uncertainties involved in the computations, and the lack of model validation weaken the findings of the spillway erosion analysis.

Recommendations for Resolution:

1. Include a section on calibration and verification of the spillway erosion model.
2. Include a section discussing the limitations of spillway erosion modeling and how this impacts the project.

Final Panel Comment 20:
The potential consequences and impacts of catastrophic failure, particularly the severity, intensity, and duration of such a failure, are not fully described and evaluated from an engineering, environmental, or economic perspective.
Basis for Comment:
<p>The MRR states on page 2 that rehabilitation is needed to “...minimize the potential for catastrophic failure of the dam” and explains that this catastrophic failure could occur when a significant pool is retained. On page 26, it further explains that the “...effects of a catastrophic dam failure on most resources are difficult to predict; however, a catastrophic dam failure scenario was included in order to provide a comparison of the potential impacts of the no action alternative to that of the proposed action alternatives.” In Section 6 the MRR provides analyses, depending on the resource, of the impacts from the no action alternative; however, it does not provide any substantive information on the severity, intensity, and duration of the catastrophic failure event. NEPA specifies that to ascertain whether an impact is significant, one must determine the severity, intensity, and duration of the potential impact, relative to the resource being analyzed.</p> <p>Engineering, environmental, and economic details of the severity, intensity, and duration of the catastrophic failure event are needed to determine the significance of the failure and to provide the basis for estimating the average annual values for reductions in these consequences for each alternative evaluated. Based on the severity of the catastrophic event and the significance of the impacts to engineering, environmental, and economic considerations, alternative plans can be formulated, evaluated, and analyzed. Given the limited documentation in the MRR of the catastrophic failure consequences, the recommended plan is not supportable.</p>
Significance – Medium:
The consequences and impact of the catastrophic failure from an environmental, engineering, and economic perspective need to be presented in the report to fully understand what role they played in the selection of the recommended plan.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Provide a detailed description, evaluation, and analysis of the catastrophic event. 2. Document the catastrophic event, providing modeling and potential impacts to various environmental constraints, including the human, physical, and biological environment. 3. Quantify the impacts of the catastrophic event. If quantification is not possible, qualify the impacts, and then document and describe them accordingly.

Literature Cited:

National Environmental Policy Act of 1969, as amended (1982). 42 U.S.C. 4321-4347. Public Law 91-190, amended Public Law 94-52, July 3, 1975; Public Law 94-83, August 9, 1985; and Public Law 97-258 § 4(b), September 13.

Final Panel Comment 21:
The public that may be affected by a possible significant catastrophic event may not have been notified through the public outreach efforts performed to date.
Basis for Comment:
<p>The MRR and EA/FONSI provide documentation regarding public outreach efforts performed for the project. These documents were made available to the public through distribution to public libraries within close proximity of the project, as well as notification through locally circulated newspapers.</p> <p>ER 1105-2-100, Appendix B (USACE, 2000), provides guidelines regarding the preparation and implementation of public involvement activities. It is not clear from the MRR that the strategy developed for public involvement considered the potential catastrophic events of not implementing any improvements needed at the Mohawk Dam. It is also not clear how USACE maximized public input for the project (ER 1105-2-100, p. B-2), how USACE identified those groups and individuals who would be potentially affected by a possible catastrophic event, what level of interest would there be regarding the project, and how it was determined which public involvement activities would be “major.”</p> <p>The Panel is concerned that public meetings were not conducted in those upstream and downstream areas of the Mohawk Dam that would be most affected by catastrophic failure.</p>
Significance – Medium:
The public outreach efforts to date seem inadequate, and many citizens within the Muskingum River basin, both upstream and downstream of the Mohawk Dam, may not be aware of the significance of a catastrophic failure of the Dam if the recommended plan is not implemented.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Provide additional documentation in the reports to describe the outreach effort performed since it is unclear how USACE developed the public involvement strategy. 2. Implement additional public outreach strategies during future development of the project for communities upstream and downstream of the Mohawk Dam within the Muskingum River basin. If public concerns require re-evaluation of potential impacts associated with the recommended plan, the EA/FONSI may have to be re-evaluated.

Literature Cited:

USACE (2000). Planning -- Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

Final Panel Comment 22:
The potential for dam embankment failure due to overtopping was not discussed in the report.
Basis for Comment:
<p>The dam failure simulations used in hydraulic analysis assume piping failures with different breach invert elevations, times to complete the breach, and breach base widths for different reservoir inflow elevations. Dam failure simulations should be extended to include other modes of failures, and the selection of breach parameters should include commonly used values as follows:</p> <p>A. Piping Failure Simulations input data from Appendix J (p. 18) are listed as breach base width = 100 ft; breach invert = 795 ft; breach side slopes = 2H: 1V; time to complete formation of breach = 0.5 hr; reservoir inflow = varies for different pool levels.</p> <p>None of the dam failure cases in the MRR or Appendix J consider failure due to overtopping. Since there is a 3.5 ft wall added to the main embankment of the dam, and since there are doubts about the age of the outlet gates, it seems that the possibility of embankment overtopping exists. Especially if a 30% PMF event (as evaluated in the MRR) is assumed to occur as an antecedent storm, the reservoir elevations may be high enough to overtop the embankment with the assumed 150% PMF discharges. Initial estimates calculated by the Panel using simple weir equations show the discharge from such events to be more than 500,000 cfs.</p> <p>B. Piping failure analysis assumes a failure time of 0.5 hr. This translates to a failure rate of 4 ft/min. This is twice the rate of 2 ft/min, commonly used to estimate failure rates for overtopping. For piping failures that occur at even a slower rate, the rate used translates into an even greater factor. As a result, peak discharges are significantly overestimated.</p> <p>C. Dam failure analysis uses a breach base width of 100 ft. For a dam height of 119.5, the width/height ratio is less than 1. In most documented instances, width depth ratio is closer to 2.</p>
Significance – Medium:
Limiting the dam failure analysis to piping cases only and selecting a subset of breach parameters may overlook an important mode of failure and may not cover some realistic failure scenarios.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Include failure due to main embankment overtopping in the dam failure analysis using overtopping elevations of 914.5 ft and 917.5 ft (with and without parapet wall failure). 2. Review breach geometry using data from past failures. Such information is available in the literature (e.g., Fread, 1985; Froehlich, 1995; Froehlich, 2008; Iarossi, Van Aller, Harrington, et al., 1996; MacDonald and Langridge-Monopolis, 1984; Wahl, 1996; Wahl, 1997; and Wahl, 1998).

Literature Cited:

Fread, D. L. (1985; rev, 1991). BREACH: An Erosion Model for Earthen Dam Failures. Report, National Weather Service, NOAA, Silver Spring, Maryland.

Froehlich, D. C. (1995). Embankment dam breach parameters revisited. In: *Water Resources Engineering*, 1995 ASCE Conference, San Antonio, Texas, August 14-18, pp. 887-891.

Froehlich, D. C. (2008). Embankment dam breach parameters and their uncertainties. *J. Hydraul. Eng.-ASCE*. 134(12): 1708-1721.

Iarossi, B., H. Van Aller, B. W. Harrington, M. Q. Taherian, G. Gopenko, R. S., Norton, B. S. Clevenger, and T. Ives (eds.) (1996). *Maryland Dam Safety Manual*. Maryland Department of the Environment, Water Management Administration, Dam Safety Division.

MacDonald, T. C., and J. Langridge-Monopolis. (1984). Breaching characteristics of dam failures. *J. Hydraul. Eng.-ASCE*. 110(5): 567-586.

Wahl, T. L. (1996). Prediction of Embankment Dam Breach Parameters: Literature Review and Needs Assessment. USBR, Water Resources Research Laboratory, PAP-735, Denver, Colorado.

Wahl, T. L. (1997). Predicting Embankment Dam Breach Parameters – A Needs Assessment. Presented at the 27th IAHR Congress, San Francisco, California, August.

Wahl, T. L. (1998). Prediction of Embankment Dam Breach Parameters. DSO-98-004, Dam Safety Research Report, U.S. Department of the Interior Bureau of Reclamation, Dam Safety Office.

Final Panel Comment 23:
No data were provided in the report on the <i>in situ</i> permeability values for the foundation rock.
Basis for Comment:
There is a shortage of permeability data in the left abutment, which affects the design and implementation of any cutoff that will be constructed in this area. The lack of permeability data in the rock under the dam, combined with the paucity of information on the mechanical properties of the rock, lead to the Panel’s conclusion that the depth of embedment of the full depth cutoff wall cannot yet be logically determined. At present, it is an “assumed” value, which is just a “rule of thumb” estimate based on prior practice in foundation materials on other projects that may or may not be similar to those at Mohawk Dam. The Panel’s concern is that insufficient toe-in into adequate rock will allow seepage to continue in the rock under and around the wall, and, due to the changes in gradients and flow paths imposed by the cutoff, may progressively damage the rock and reduce the effectiveness of the wall (Rice and Duncan, 2010a and b). The lack of data directly influences the ability to design the appropriate depth of the wall, and so affects cost and schedule. The lack of data also prevents making a forecast of the need for, and extent of, any pregrouting before cutoff wall construction to prevent catastrophic and sudden slurry loss, possibly threatening dam safety.
Significance – Medium:
The <i>in situ</i> permeability data are necessary to develop the appropriate depth of the cutoff wall, which is a critical part of the project.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Reevaluate historical logs to establish if any relevant data exist. If they do, they should be presented clearly and evaluated with care. 2. Conduct further exploration to establish the mechanical and hydraulic properties of the bedrock, especially in the zone extending 20 feet into rock below or beyond the anticipated extent of the cutoff. 3. Run tests to measure the potential erodibility of the rock under conditions equivalent to the anticipated maximum service conditions. 4. Conduct the proposed suite of rock tests designed to provide specific bidding information to potential bidders.

Literature Cited:

Rice, J. D., and M. J. Duncan (2010a). Deformation and cracking of seepage barriers in dams due to changes in the pore pressure regime. *J. Geotech. Geoenviron.* 133(1): 2-15.

Rice, J. D., and M. J. Duncan (2010b). Findings of case histories on the long-term performance of seepage barriers in dams. *J. Geotech. Geoenviron.* 133(1): 16-25.

Final Panel Comment 24:

Potential impacts to wildlife habitats and water quality from the No Action and Action Alternatives (Plans A and B) were not thoroughly investigated and evaluated.

Basis for Comment:

Section 6.3 of the MRR (Fish and Wildlife Resources) provides qualitative information on wildlife and habitat resources in the project vicinity and discusses potential impacts of the No Action and Action Alternatives to these resources.

The MRR and Environmental Assessment/Finding of No Significant Impact (EA/FONSI) do not provide any detailed analysis of the types of wildlife present or observed within the study area. It is common to provide lists of those species that would be typically expected to occur within each of the habitat types present or actually observed during field inspection. The MRR and EA/FONSI indicate that the resources present are “fairly common and generally tolerant of human disturbances such as those related to this project”; however, no documentation is provided to support this statement. The dam is located in a rural portion of Ohio and it is not clear how tolerant these resources would be to construction activities and human interaction.

The analysis performed in the MRR and EA does not provide any information regarding potential behavioral disturbances, impacts to habitat connectivity, alterations to migration patterns, fragmentation of habitat, alterations to carrying capacity of the species present, and species diversity. No documentation is provided to support how the species present are acclimated to humans and human interactions. No documentation is provided about the fish and aquatic resources present upstream and downstream of the dam and the potential effects to these resources.

Analysis and documentation of potential effects to migratory birds, outside of the bald eagle, are not discussed. While the Mohawk Dam is not located within any of the major North American migratory flyways, the MRR or EA still has to provide an analysis of potential impacts in accordance with the Migratory Bird Treaty Act. There may be birds that frequent Mohawk Dam that are protected under the Act. No information is provided regarding any migratory bird nests located on site and whether clearing and grubbing activities would adversely affect these nests.

The effect on wildlife was determined to be not significant; however, this statement was based on abundant habitats similar to those at Mohawk Dam being available for wildlife. It is not clear whether impacts to wildlife and fisheries would be deemed not significant as no information is provided to support this statement. The likelihood of this depends greatly on species and habitat.

Section 6.4 of the MRR (Endangered Species) provides information regarding potential impacts to the Indiana bat. In particular, as a result of the recommended plan, USACE will be avoiding construction during the bat’s active season, and conducting construction during its dormant season. This construction delay will most likely come at a cost to schedule and to the project. It is common to perform species-specific surveys to determine the presence of a species where habitats may be present. In the event that bats are not found during these surveys, it is

reasonable (with concurrence from the U.S. Fish and Wildlife Service) to perform construction activities year-round with no effect to this endangered species.

Section 6.5 (Wetlands) discusses the potential effects to wetlands from the construction of the proposed cutoff wall. The cutoff wall would result in the reduction of hydrologic input from the seep that feeds a floodplain wetland downstream of the dam in the remnant Walhonding River channel. This floodplain wetland provides habitat for aquatic and terrestrial wildlife; alterations in hydrology would have adverse effects on these wildlife resources, potentially including aquatic species. However, Section 6.4 of the MRR indicates that no impacts to aquatic habitat would occur under the Action Alternatives or the No Action Alternative; more information is needed to support this assertion.

No information is provided in the MRR regarding direct, indirect, and cumulative impacts to water quality. Impacts to water quality can include runoff from unstabilized areas contributing to higher levels of turbidity and suspended solids in the receiving waters downstream of Mohawk Dam. Increases in these water quality parameters could affect filter feeding organisms, fish, and other aquatic wildlife and indirectly affect terrestrial wildlife that feeds on these organisms. Although USACE is mandated to comply with the Clean Water Act, no information is provided on how water quality impacts would be avoided, minimized, or reduced during construction.

Significance – Medium:

Fish, wildlife, and aquatic resources present on site are not well-documented, resulting in an incomplete and unclear assessment of potential beneficial and detrimental effects from the No Action Alternative and Action Alternatives (Plan A and B), which includes the recommended plan.

Recommendations for Resolution:

1. Describe the resources present in more detail.
2. Describe the impacts to these resources in more detail and justify more fully why the impacts are not significant.
3. Consider alternative avoidance measures for the Indiana bat and coordinate these efforts with the U.S. Fish and Wildlife Service.
4. Revise the MRR and EA to address potential effects to water quality. Discuss best management practices used and discuss how these practices will be monitored and maintained during construction.
5. Provide a section in the MRR and EA called “Water Quality.”

Final Panel Comment 25:
Documentation of the commitments made to avoid, minimize, and/or reduce impacts are not consistent with Council on Environmental Quality guidelines.
Basis for Comment:
<p>The MRR and EA/FONSI provide information regarding avoidance, minimization, or reduction of impacts in various sections of the MRR. These measures, which are considered a part of mitigation within the context of NEPA, require certain commitments to be made that demonstrate that there will not be an adverse effect on a particular environmental resource.</p> <p>Recent guidance from the Council on Environmental Quality (January 14, 2011) directs Federal agencies to develop procedures and guidance regarding the implementation, funding, and discussion of mitigation measures and the commitments associated with those measures. Additional information is needed in the MRR to describe how these mitigation measures and commitments will be implemented and funded.</p>
Significance – Medium:
The lack of documentation regarding funding and implementation of mitigation commitments leaves some uncertainty as to how these measures will be performed and result in non-adverse effects to human, physical, and natural environments.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Provide documentation on how impacts to water quality were avoided, minimized, and reduced. 2. Provide documentation on how any unavoidable impacts to water quality would be mitigated. 3. Once guidance is developed by USACE, provide documentation on how mitigation measures and commitments will be implemented and funded.

Literature Cited:

Sutley, Nancy H. Executive Office of the President. Council on Environmental Quality (2011). Memorandum for Heads of Federal Departments and Agencies. Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact. January 14.

Final Panel Comment 26:
The cumulative impacts analysis does not evaluate the impact of present and reasonably foreseeable future incremental actions at Mohawk Dam on upstream and downstream projects.
Basis for Comment:
<p>NEPA defines cumulative impacts as those impacts that result from the incremental impact of the action on the environment added to past, present, and reasonably foreseeable future actions regardless of which agency or person undertakes them. The MRR and EA/FONSI describe some past cumulative impacts and the Interim Risk Reduction Measures (IRRM) within the project limits; however, the reports have not taken into consideration the potential environmental effects, when added to present and future projects upstream and downstream of Mohawk Dam, other actions by USACE in these watersheds, and other actions by agencies or persons.</p> <p>The MRR and EA/FONSI indicate that the inclusion of uncertainties in the analysis, as well as incomplete or unavailable information, is allowed according to the Council of Environmental Quality (CEQ) regulations. Documentation, investigation, and analysis to support this statement are not provided. The Panel is concerned that data are available to demonstrate more certainty in the cumulative impacts analysis. Forecasting and research performed with the local sponsor, local authorities, and interested parties were not provided in the MRR and EA.</p>
Significance – Medium:
NEPA requires documentation of incremental cumulative impacts to determine if they are significant. This documentation is not provided in the MRR or EA/FONSI, affecting the completeness and understanding of the project.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Document more fully the communications, research, and forecasting performed to identify those present and reasonably foreseeable actions located within the Muskingham River Basin. 2. Describe how the recommended plan, when added to these system-wide actions, will adversely affect the environment, as well as the significance of these impacts. 3. Re-evaluate the EA/FONSI to document this analysis.

Final Panel Comment 27:
Supporting documentation has not been provided for the basis on which emergency repair expenditures have been estimated.
Basis for Comment:
<p>A proper description of the base condition includes a description of the consequences of a catastrophic failure and a description of the consequences without failure, making it possible to derive these benefits. The report does not provide any information on the assumed nature, severity, or extent of a catastrophic failure or on the consequences without failure; this information is necessary to estimate both the quantities and resulting costs and the time to effect emergency repairs. The Panel does not find it reasonable to assume that these costs and time would be identical for the main embankment, left abutment, and emergency spillway. Likewise, it is unclear that emergency repairs for a catastrophic failure would be the same for all pool levels evaluated, or that they would be similar for ranges of pool levels evaluated that result in consequences without failure. It seems probable that a catastrophic failure event could result in substantial damage to recreational facilities, consideration of which should be included in the estimate of the cost of emergency repairs.</p> <p>The report does not clearly identify and describe the emergency repair costs avoided for each alternative. In addition, since average annual benefits from emergency costs avoided have not been calculated for each alternative, the effectiveness of the alternatives cannot be compared and incremental analysis, trade off analysis, and identification of the NED plan are not possible.</p>
Significance – Medium:
Without sufficient documentation of the consequences of catastrophic failure and the consequences without failure, these benefits in their current state are not supportable.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Support the estimate of with and without failure consequences for the base condition and the extent to which these would be reduced or eliminated by each alternative. 2. Provide sufficient information upon which to base appropriate estimates of costs and time for emergency repairs for each project component separately and for each pool level evaluated. Present this information fully in Appendix B and summarize it in the Main Report. 3. Compute average annual equivalent costs using pool elevation (stage) and frequency information for the base condition; present these costs in Appendix B and elsewhere in the MRR as appropriate. 4. Estimate average annual emergency repair costs avoided for each alternative. 5. Discuss the risks and uncertainties associated with this category of benefits; present the resulting computations.

Final Panel Comment 28:

The use of historic reportable damages as the basis for identifying current average annual damages and as a measure of lost capacity to prevent future flood damages is not consistent with USACE guidance.

Basis for Comment:

The test for the appropriate inclusion of the prevention of future flood damages as a category of benefits is the ability of a rehabilitated Mohawk Dam to prevent future flood damages to current downstream floodplain development. While historic information does not allow this test to be passed, the computations for flood damages prevented (as derived in Addendum 1), would. According to ER 1105-2-100, Appendix D, paragraph D-4.b (USACE, 2000), USACE policy requires flood damage estimates to be based on current information: “An analysis is considered current if it was approved within 3 fiscal years of the pertinent decision date.”

Addendum 2 uses historic average annual damages prevented to estimate the lost flood protection capabilities during repairs. The historic average annual damages for the Muskingum River System are simply a summation of annual damages prevented, updated to current dollars using price levels, and divided by the years of record. The total damages prevented by the Muskingum River Basin System are estimated to be more than \$7.5 billion, which yields an annual average of \$106 million for the 70 years the system has been in service. The average annual damages attributed to the performance of Mohawk Dam are estimated at \$26 million or 25% of the system’s total capacity. The MRR states that these estimates are based “on aggregated stage-damage and benefit data developed by Huntington District in the mid-1960s for the system.” In ER 1105-2-100, Appendix D, paragraph D-4.b.(3) (USACE, 2000) , USACE policy expressly prohibits indexing of flood damage estimates: “However, in no event will simple indexing of overall benefits be acceptable.”

Despite the clear prohibition in USACE guidance (as noted above) of using benefits that are not reasonably current, Addendum 4 estimates the event tree consequences for the base condition and various selected alternatives to the base condition for all the economic benefit categories using the indexed historic data rather than using the updated damages from Addendum 1.

The contribution from all dams in the basin should be included before calculating Mohawk Dam’s percentage share of historic flood damages prevented. The 25% share of average annual system-wide damages estimated for Mohawk Dam does not include contributions from Dillon Dam or North Branch Kokosing Dam. From information provided with the review documents, but mistakenly left out of the report (figure displaying all of the major components in the Muskingum River Basin System and their Dam Safety Action Classification), Dillon Dam’s storage capacity is marginally smaller (260,890 ac-ft) than that of Mohawk Dam (285,000 ac-ft). The MRR states, “Mohawk is credited with 25% of the total benefits attributed to the Muskingum Basin System as reported in Piedmont Lake, Dam Safety Assurance Evaluation Report, dated April 1996.” The MRR does not explain how those shares were derived. The Interim Risk Reduction Measures Plan states that Mohawk Dam’s share of system-wide flood reduction capability is 21.5% (Appendix M, Section D.1, p. 11).

The average annual historic damages are used to estimate the lost flood protection during repair

periods. A 6-month impact results in one-half of the annual damages and a 2-year impact results in twice the annual damages, and each is then multiplied by the probability of unsatisfactory performance under the base condition versus the alternative rehabilitated condition. While this approach is a simplified method, it does not account for development changes over the last 70 plus years, does not apply depth damage relationships to current development at risk, and does not use current values for affected structures in order to estimate average annual equivalent benefits. Use of current values is required by USACE guidance in the analyses of project benefits. The results for lost flood protection during repairs should use current conditions, current structure values, and current depth damage relationships to calculate damages. The average annual damages for lost flood protection during repairs should be estimated for all alternatives and compared to the base condition.

Significance – Medium:

The prevention of future flood damages constitutes approximately 8% of total benefits claimed for both the NED plan and the recommended plan. Since there are virtually no net benefits for the recommended plan, these benefits are essential to the economic justification of the recommended plan.

Recommendations for Resolution:

1. Reanalyze the lost flood protection benefits for each alternative applying the methodology and results of Addendum 1.
2. Provide a figure displaying all of the major components of the Muskingham River basin system with a listing of each component's Dam Safety Action Classification and the storage capacity for each dam.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

Final Panel Comment 29:

The documentation supporting the estimate of flood damages prevented is incomplete.

Basis for Comment:

The third paragraph of Addendum 1 to Appendix B provides information on the conduct of an inventory of the structures in the affected floodplain, the methodology employed for conducting that inventory, and the methodology used to assign first floor elevations to each structure. There is no indication that any selective “ground truthing” was performed to verify the assignment of first floor elevations. Further, it is assumed that the floodplain in question stretches from the Mohawk Dam to the Ohio River, but this is not stated nor is there a listing of the communities or damage centers through which this floodplain passes. Such basic information is necessary in order to more fully understand the nature and complexities of the project’s problems and opportunities and is a USACE requirement (USACE, 2000; paragraph 2-3,b).

The paragraph at the top of page 29 in Appendix B, Addendum 1, states that structural depth damage curves were selected from Economic Guidance Memoranda 01-03 and 04-01 for residential structures. It also states that the utilized depth damage curves for commercial structures were the “New Orleans” depth damages curves. There is no explanation given for the appropriateness of transferring such information from one region of the country to another, or whether there are considerations in the “New Orleans” curves for such things as mold and/or hydrocarbon contamination, which would be appropriate for the Gulf location but would not necessarily be applicable to other U.S. regions. There is no mention of the derivation of the values for the contents of any type of structure, or of any depth damage relationships for those contents.

It is not clear whether the information presented in Appendix B, Addendum 1, Table 1-2 (With Failure Damages) is the same as would be expected for the “without project” evaluation of a new start project, or whether the information presented in Table 1-3 (Without Failure Damages) would be similar to residual damages. Since residual damages would not be prevented by a rehabilitated or status quo Mohawk Dam, the use of residual damages as a basis for project benefits is inappropriate. However, a display of residual damages is required by ER 1105-2-100, paragraph 3-3.b (USACE, 2000): “The analysis of any proposed flood damage reduction project shall include an estimate of the residual expected annual damages that would occur with the project in place.”

Since the HEC-FDA model was devised for the express purpose of computing average annual equivalent damages for any condition (as well as giving full consideration to the factors that constitute risk and uncertainty), it is unclear why the results of the application of the HEC-FDA model were not provided for the base condition and alternatives for this category of benefits.

Addendum 5 is mislabeled; the information it presents deals strictly with the issue of double counting flood damages prevented and not with incremental benefits. Further, the text in the second paragraph is confusing with respect to what was actually accomplished. The expression “only the basis did so” is not clear. The stub items included in Table 5-1 are confusing and unclear. Additionally, the conclusion that there is only 2.1% of joint benefits or double counting

appears to contradict the information provided in paragraph 5.1 of Appendix B. According to the data provided in Tables 13 and 14 to which paragraph 5.1 refers, the amount of double counting is considerably greater than 2.1%. As a result, the Panel cannot determine the extent of possible double counting of flood damages prevented or whether appropriate measures were used to avoid double counting.

Significance – Medium:

Without the ability to confirm the technical adequacy of the flood damages prevented benefits (56.5% of total benefits), the justification of the NED plan and the recommended plan is questionable.

Recommendations for Resolution:

1. Verify the validity of the inventory of the floodplain and the methodology employed to obtain flood damage data with some selective field work.
2. Annotate Figure 1 in Appendix B with the place names of the principal damage centers and the amount of the expected flood damages in the base condition to display the aerial extent of the floodplain and the location of severe damages as well as a table displaying damages attributable to each significant damage center.
3. Provide the rationale for the transfer and use of “New Orleans” commercial structure depth damage curves.
4. Explain the derivation of the value of contents for all types of structures used as input to the HEC-FDA model.
5. Provide stage damage information for the “without Mohawk Dam” condition.
6. Provide stage damage information for residual damages with Mohawk Dam in place in order to confirm that residual damages were not used as a basis for claiming benefits for the without failure damages shown in Table 1-3 of Addendum 1.
7. Provide a table of the average annual and residual damages for the base condition and each alternative.
8. Explain in Addendum 5 the procedures and terms used to avoid double counting and resolve the conflicts between the values displayed in Addendum 5 text and tables and those displayed in Appendix B, paragraph 5.1 and Tables 13 and 14.

Literature Cited:

USACE (2000). Planning – Planning Guidance Notebook. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. Engineer Regulation 1105-2-100. 22 April.

Final Panel Comment 30:
The analysis of recreation benefits using the Unit Day Value (UDV) method is not fully supported.
Basis for Comment:
<p>While the Panel agrees that the UDV method is appropriate for evaluating recreation under the circumstances of the MRR, there are several items in the evaluation that are not fully explained or were not provided.</p> <ul style="list-style-type: none"> • The difference between the data displayed in Appendix B and Addendum 3 with respect to visitor hours and visitor days and the resulting relationship between them is not explained. • The value of \$6.06 is characterized as appropriate, but no basis is provided for its derivation. This value has to be interpolated from information provided in the annual Economic Guidance Memorandum for the dollar values associated with a number of points assigned to a project's general recreation facilities. For example, \$5.49 for 30 points and \$6.73 for 40 points. This was not done for the MRR. • No rationale is provided for assigning specific points from a range of points to Mohawk Dam's general recreation facilities for each of the six criteria. • The computations for average annual equivalent benefits for the base condition and each alternative are not provided. • Addendum 3 calculates recreation benefits that would be forgone during emergency repair periods resulting from catastrophic failure or consequences without failure. No rationale for these estimates is provided. A proper description of the base condition should indicate the extent to which the recreation facilities are damaged or destroyed under either failure scenario. Determining appropriate costs for their repair or replacement could then be developed and presented. The extent to which access to recreation facilities would be curtailed, whether to repair or replace them or as a result of repair to other project features, can also be determined. • The report does not consider the negative benefit to recreation for any alternative plan, depending upon its construction period. It is not appropriate to include recreation benefits forgone during emergency repair periods as a project benefit without including the impacts to recreation during construction of each alternative.
Significance – Low:
The resolution of the issues surrounding the recreation benefits would result in a more thorough and credible planning document.
Recommendations for Resolution:
<ol style="list-style-type: none"> 1. Explain any meaningful relationship between visitor hours and visitor days; extraneous or potentially confusing information should be deleted. 2. In the citation of the Economic Guidance Memorandum, state the UDVs associated with general recreation facilities assessed with a total of 30 points and with 40 points. 3. Provide the point ranges and the rationale used in assigning a specific point to Mohawk Dam's general recreation facilities for each criterion. 4. Compute Average Annual Equivalent Recreation benefits under the base condition and each alternative. 5. Provide appropriate consideration of annual recreation benefits not realized for the

construction period of each alternative.

APPENDIX B

Final Charge to the Independent External Peer Review Panel

as

Submitted to USACE on October 5, 2010

on the

Mohawk Dam MRR

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**Final Charge Questions and Guidance to the Peer Reviewers
for the
Mohawk Dam Major Rehabilitation Report, Warsaw, Ohio**

BACKGROUND

Mohawk Dam is located in Coshocton County, Ohio, on the Walhonding River, a tributary of the Muskingum River. The project is located about 17 miles upstream of the city of Coshocton, Ohio. The purpose of the Major Rehabilitation Report is to address reliability deficiencies at Mohawk Dam. Action is needed because the excessive uncontrolled seepage is negatively affecting the structural stability of the dam, resulting in increased risks to the downstream public. Due to the history of excessive seepage through and under the dam and through the left abutment during events with frequent return periods, it was ranked by the U.S. Army Corps of Engineer's Screening for Portfolio Risk Assessment (SPRA) process as a Dam Safety Action Class II – Urgent (unsafe or potentially unsafe) project. Rehabilitation is needed to correct these seepage problems and to minimize the potential for catastrophic failure of the dam during such events.

Several alternatives were considered in the Mohawk Dam Major Rehabilitation Report (hereinafter Mohawk Dam MRR) to address the risk and reliability issues associated with the project. Three features of the project were identified as areas of concern. These features include the main embankment, left abutment, and spillway – all of which would need separate actions in order to accomplish the rehabilitation of the complete project. Major rehabilitation guidance requires that each “separable” component be individually justified. However, in the case of Mohawk Dam, repairing the main embankment without repairing the left abutment, or vice versa, would not accomplish the goals and objectives of the study. While repair of a single feature would reduce the risk associated with that feature, it would not reduce the risk or increase the reliability of the project as a whole:

- Catastrophic failure of the main embankment could occur even if the left abutment were rehabilitated.
- Likewise, catastrophic failure of the left abutment could occur even if the main embankment was rehabilitated.

This resulted in the designation of two separable components and three features of the project. The first component consists of the left abutment and main embankment, and the second component is the spillway.

Alternatives to address planning objectives were developed in the Mohawk Dam MRR for each feature and these alternatives were combined after the initial screening to form a comprehensive solution for the entire project. These alternatives were evaluated based on their ability to meet project objectives considering engineering, economic, and environmental feasibility.

The final array of plans is listed below:

- Main Embankment Full Depth Centerline Seepage Cutoff Wall and Left Abutment Seepage Cutoff Wall (Immediate Rehabilitation)

- Main Embankment Full Depth Centerline Seepage Cutoff Wall, Left Abutment Seepage Cutoff Wall and Spillway Gravity Monolith Section (Immediate Rehabilitation)
- No Action (as required by the National Environmental Policy Act)

For the final screening, the plans were analyzed to determine the most economic investment, as well as to determine which alternative would reduce the most risk in terms of loss of life downstream of the dam. As the environmental effects of all of the final plans are considered minor and insignificant, all plans were considered nearly equal in terms of environmental acceptability.

As the plan with the highest net benefits, the Main Embankment Full Depth Centerline Seepage Cutoff Wall and Left Abutment Seepage Cutoff Wall plan was identified in the Mohawk Dam MRR as the National Economic Development (NED) plan. However, due to engineering considerations and life safety concerns, as well as the need for the project as a whole to be stable and perform satisfactorily for the probable maximum flood (PMF) event, the recommended alternative is the Main Embankment Full Depth Centerline Cutoff Wall, Left Abutment Seepage Cutoff Wall and Spillway Gravity Monolith Section plan.

The critical factor in the decision to include the spillway repair in the recommended plan was the probability of failure associated with that feature. The Without Project condition probability of failure was determined to present an unacceptable level of risk to the project and the downstream community.

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the Mohawk Dam Major Rehabilitation Report in accordance with the Department of the Army, U.S. Army Corps of Engineers (USACE), Water Resources Policies and Authorities' *Civil Works Review Policy* (EC 1165-2-209) dated January 31, 2010, and the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

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

The purpose of the IEPR is to assess the "adequacy and acceptability of the economic, engineering, and environmental methods, models, and analyses used" (EC 1165-2-209; p. D-4) for the Mohawk Dam Major Rehabilitation Report. The IEPR will be limited to technical review and will not involve policy review. The IEPR will be conducted by subject matter experts (i.e., IEPR panel members) with extensive experience in engineering, economics, plan formulation, and environmental issues relevant to the project. They should also have experience applying their subject matter expertise to flood risk management.

The IEPR Panel will be “charged” with responding to specific technical questions as well as providing a broad technical evaluation of the overall project. Per EC 1165-2-209, Appendix D, review panels should identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods. Review panels should be able to evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable. Reviews should focus on assumptions, data, methods, and models. The panel members may offer their opinions as to whether there are sufficient analyses upon which to base a recommendation.

DOCUMENTS PROVIDED

The following is a list of documents and reference materials that will be provided for the review. **The documents and files presented in bold font are to be reviewed.** All other documents are provided for reference.

- Mohawk Dam Major Rehabilitation Report
 - **Main Report**
 - Appendix A: Real Estate Design Memorandum
 - **Appendix B: Risk and Reliability/Economics**
 - **Appendix C: Environmental**
 - Appendix D: Cost Engineering
 - Appendix E: Draft Project Partnering Agreement
 - Appendix F: Change Management Plan
 - **Appendix H: Geotechnical Appendix for Dam Embankment**
 - **Appendix I: Geotechnical Analysis of Left Abutment and Emergency Spillway**
 - **Appendix J: Hydrology and Hydraulics**
 - **Appendix K: Structural and Mechanical**
 - Appendix L: Hazardous, Toxic, and Radioactive Waste
 - Appendix M: Interim Risk Reduction Measures Plans
 - Appendix N: Quality Control Plan
 - **Engineering Drawing**
 - **Construction Drawing**
- USACE guidance *Civil Works Review Policy* (EC 1165-2-209) dated January 31, 2010
- CECW-CP Memorandum dated March 31, 2007
- Office of Management and Budget’s *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

SCHEDULE

TASK	ACTION	DUE DATE
Conduct Peer Review	Battelle sends review documents to panel members	1/3/2011
	Battelle/IEPR Panel kick-off meeting	1/10/2011
	USACE/Battelle/Panel kick-off meeting	1/10/2011
	USACE/Battelle/Panel site visit	1/19/2011
	Panel members complete their review	2/1/2011
Prepare Final Panel Comments and Final IEPR Report	Battelle provides Panel merged individual comments and talking points for Panel review teleconference	2/4/2011
	Battelle convenes Panel review teleconference	2/7/2011
	Battelle provides Final Panel Comments directive to Panel	2/7/2011
	Panel members provide draft Final Panel Comments to Battelle	2/14/2011
	Battelle provides feedback to Panel members on draft Final Panel Comments; Panel provides revised draft Final Panel Comments per Battelle feedback (iterative process)	2/14/11-2/22/11
	Panel members finalize Final Panel Comments	2/22/2011
	Battelle provides final IEPR Report to Panel for review	2/23/2011
	Panel provides comments on final IEPR Report	2/25/2011
	*Battelle submits final IEPR Report to USACE	2/28/2011
Comment/ Response Process	Battelle inputs Final Panel Comments to DrChecks; Battelle provides Final Panel Comment response template to USACE	3/2/2011
	USACE PDT provides draft Evaluator Responses and clarifying questions to Battelle	3/7/2011
	Battelle provides the Panel the draft Evaluator Responses and clarifying questions	3/9/2011
	Panel members provide Battelle with draft comments on draft Evaluator Responses (i.e., draft BackCheck Responses)	3/15/2011
	Battelle convenes teleconference with Panel to discuss draft BackCheck Responses	3/16/2011
	Battelle convenes teleconference between Panel and USACE PDT to discuss Final Panel Comments, draft responses, and clarifying questions	3/17/2011
	USACE inputs final Evaluator Responses in DrChecks	3/24/2011
	Battelle provides Evaluator Responses to Panel	3/29/2011
	Panel members provide Battelle with final BackCheck Responses	4/1/2011
	Battelle inputs the Panel's BackCheck Responses in DrChecks	4/7/2011
*Battelle submits pdf printout of DrChecks project file	4/8/2011	

CHARGE FOR PEER REVIEW

Members of this IEPR Panel are asked to determine whether the technical approach and scientific rationale presented in the Mohawk Dam Major Rehabilitation Report are credible and whether the conclusions are valid. The Panel is asked to determine whether the technical work is adequate, competently performed, properly documented, satisfies established quality requirements, and yields scientifically credible conclusions. The Panel is 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 Mohawk Dam Major Rehabilitation Report. Please focus on your areas of expertise and technical knowledge. Even though there are some sections with no questions associated with them, that does not mean that you cannot comment on them. Please feel free to make any relevant and appropriate comment on any of the sections and appendices you were asked to review. In addition, please note the following guidance. Note that the Panel will be asked to provide an overall statement related to 2 and 3 below per USACE guidance (EC 1165-2-209; Appendix D).

1. Your response to the charge questions should not be limited to a “yes” or “no.” Please provide complete answers to fully explain your response.
2. Assess the adequacy and acceptability of the 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 evaluation of 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 Independent Technical Review.
2. Please contact the Battelle deputy project manager (Corey Wisneski, wisneskic@battelle.org) or project manager (Karen Johnson-Young, johnson-youngk@battelle.org) for requests or additional information.
3. In case of media contact, notify the Battelle project manager 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 Corey Wisneski, wisneskic@battelle.org, no later than October 27, 2010, COB EDT.

**Independent External Peer Review
Mohawk Dam Major Rehabilitation Report, Warsaw, Ohio**

Final Charge Questions

GENERAL QUESTIONS

1. Do the main report and appendices form an integrated and consistent product upon which to base a recommendation?
2. Please comment on the soundness of engineering evaluation as applicable and relevant to your area of expertise. Comment on whether the data presented explain past events and how engineering decisions will be validated.
3. Please comment on whether all dam safety issues and opportunities have been identified.
4. Please comment on the clarity of the description of project maintenance, including previous rehabilitations and dam safety modifications.
5. Is there sufficient information presented to identify, explain, and comment on assumptions that underlie engineering analyses? Why or why not?
6. Has the condition of the structure been adequately described with regards to:
 - a. the risk to the structure;
 - b. the economic impacts, environmental impacts, and life safety consequences posed by the structure; and
 - c. the benefits provided by the structure?
7. Are the methods used to evaluate the condition of the structure adequate and appropriate given the circumstances?
8. Have the hazards that affect the structure been adequately described?
9. Have the appropriate alternatives been considered and adequately described for this project?
10. Do the alternatives and their associated costs appear reasonable?
11. Do the benefits and consequences appear reasonable?
12. Are there any additional analyses or information available or obtainable that would affect decisions regarding the structure?

13. Has anything significant been overlooked in the development of the assessment of this structure or the alternatives?
14. Have appropriate considerations been made to support the decisions regarding this structure?
15. For the selected alternative:
 - a. Are the quality and quantity of the surveys, investigations, and engineering sufficient for a conceptual design?
 - b. Are the models used to assess hazards appropriate?
 - c. Are the assumptions made for the hazards appropriate?
 - d. Does the analysis adequately address the uncertainty given the consequences associated with the potential for loss of life for this type of project?

1. PROJECT BACKGROUND

16. Please comment on the adequacy of the discussion pertaining to the design and construction of the dam and appurtenant features. What, if any, key factors are missing from this discussion?
17. Please comment on the dam's performance over time in relationship to previous and current safety concerns.
 - a. Does the physical data and observed data provide adequate information to characterize the project and its performance?
 - b. Are there any other performance or safety concerns that should be considered and addressed?

2. PROJECT LOCATION AND DESCRIPTION

No questions

3. PROBLEM IDENTIFICATION

18. Based on your experience, have all characteristics, conditions, and scenarios leading to failure, along with the potential consequences, been identified?
19. Please comment on whether the study objectives and constraints have been adequately characterized.
20. Please comment on whether all pertinent factors have been considered in the estimation of risk for the baseline condition.

21. Have all dam safety risk management measures been considered, including structural and non-structural measures, for (a) individual significant failure modes and (b) multiple significant failure modes?
22. Please comment on the adequacy and comprehensiveness of the dam break analysis completed to estimate flood characteristics for dam failure.
23. Do you concur that the range of problem definition statements in Section 3 adequately and appropriately defines, discusses and documents the root causes of potential concern?
24. In the specific case of the Mohawk Dam, please comment on whether sufficient evidence exists to conclude that downstream seepage threatens the integrity of the dam that could lead to dam failure (Section 3.1.1).
25. Please comment on whether seepage at the left abutment is significant (Section 3.1.2 and 3.2.2).
26. How critical is the lack of verification of the extent of the seepage path through the bedrock relative to abutment/embankment contact integrity; do you consider that any other studies should be performed to evaluate this factor (Section 3.1.2)?
27. Please comment on whether the inadequacies described in the relief well system are sufficient to lead to dam failure (Section 3.1.3).
28. Please comment on whether the piping of the seepage blanket will lead to downstream face slope failures and breach of the dam (Section 3.1.4).
29. Please comment on the statements regarding the operating equipment and gates (Section 3.1.5).
30. Please comment on whether the any one or combination of the above factors leading to dam failure is sufficiently likely to warrant major rehabilitation.
31. Are there any implications from the observation that seepage occurs from the pervious fill at all times, even when the dam is “dry” (Section 3.2.1)?
32. Please comment on whether the magnitude of the underseepage observed in 1969 was sufficient to question the stability of the embankment (Section 3.2.2).

4. PROJECT HISTORY AND SUMMARY OF PREVIOUS WORK

4.1 Original Design Philosophy

33. Does this section adequately describe the original design of the dam? If not, what additional items should be included so that the alternatives can be adequately evaluated?

4.2 History

No questions

4.3 Repairs and Modifications

34. Does the text in this section adequately describe the repairs and modifications to the dam structure? If not, what types of descriptions are missing?

4.4 Interim Risk Reduction Measures Plan (IRRMP)

No questions

4.5 Summary of Historic Maintenance Costs

No questions

5. ECONOMIC CONSIDERATIONS

35. Please comment on the components included in the calculation of the economic benefits of the rehabilitation project.
36. Is the period of analysis used in the economic analysis justified? Please discuss.
37. Please comment on the characterization or binning of performance measures into satisfactory and unsatisfactory including the criteria used for classification.

6. ENVIRONMENTAL CONSIDERATIONS

6.1 Land Use

38. Please comment on whether the proposed changes to the area's land use are described clearly and completely.
39. Please comment on the accuracy of the assessment that no permanent change in land use would be expected under the proposed action.

6.2 Physiography, Geology, Soils and Prime Farmland

40. Please comment on the accuracy of the assessment that the disposal of the fill would not be expected to significantly alter the topographic setting.

6.3 Fish and Wildlife Resources

41. Please comment on the accuracy of the assessment that the impacts to forest and field habitat would not be significant.

6.4 Endangered Species

42. Please comment on whether the list of endangered species in Coshocton County is complete and accurate.
43. Please comment on the mitigatory decision to clear trees only during the Indiana bat's dormant season.

6.5 Wetlands

44. Please comment on the accuracy of the assessment that little change to the ecological function and value of the downstream wetlands would be expected to occur from the project-related reduction of discharge.

6.6 Floodplain

No questions

6.7 Regulated Hazardous Contaminants

No questions

6.8 Cultural Resources

No questions

6.9 Scenic Rivers

No questions

6.10 Air Quality

45. Please comment on the accuracy of the assessment that no significant impacts to air quality would be expected from the proposed action.

6.11 Noise

No questions

6.12 Socioeconomic Impacts

46. Have potential socioeconomic impacts been considered for all project activities (benefits, costs, construction, etc.)? Please comment.

6.13 Aesthetics

No questions

6.14 Transportation and Traffic

47. Please comment on the anticipated transportation and traffic impacts from the project.

6.15 Cumulative Effects

48. Please comment on whether all potential cumulative effects have been discussed.

7. ENGINEERING CONSIDERATIONS

49. Please comment on the soundness of the hydraulic and flow models used in the hydrology and hydraulics analysis.
50. Please comment on the suitability of the models used for the reliability analyses.
51. Are the results of the base condition analysis adequately summarized so that alternatives can be evaluated accordingly? If not, what additional results should be included?
52. Please comment on the suitability of the criteria established for unsatisfactory performance of the embankment and abutment.

8. ALTERNATIVE DEVELOPMENT AND EVALUATION

53. Please comment on the formulation and evaluation of alternatives.
54. Please comment on whether adequate consideration has been given to the non-structural and structural alternative plans and their potential to address the significant dam safety issues.
55. Please comment on whether the “with project condition” associated with each alternative plan is clearly presented and compared against the “without project condition” or baseline risk, including the cost of each alternative.
56. Please comment on whether the potential impacts of each alternative plan, and potential mitigation measures for each are adequately presented?
57. Have risk and reliability been appropriately quantified in the study process in conformance with EP 1130-2-500 (Section 8.1.2)?
58. Please comment on the statement that past efforts have turned out to be piecemeal solutions and that a comprehensive solution is warranted (Section 8.2).
59. Please comment on whether you consider the project objectives to be reasonable, appropriate and justified (Section 8.3).
60. Is the initial array of alternatives applicable, appropriate and comprehensive (Section 8.5.1)? Do you concur with the planning criteria used in the initial screening?

61. Please comment on whether you support the methodology used in the intermediate screening process (Section 8.5.2).
62. Please comment on rationale behind the selection of the recommended alternative. Is sufficient data provided to justify the selection?
63. Are the net benefits assigned associated with the recommended alternative reasonable and well justified?

9. RECOMMENDED PLAN

64. Are all dam safety issues addressed by the recommended plan? Why or why not?
65. Will the recommended alternative revise the Dam Safety Action Classification (DSAC) of the dam? Why or why not?
66. Please comment on whether the effect of delaying implementation of the recommended plan is clearly outlined?
 - a. What, if any, additional consequences of not implementing, or delaying implementation of the recommended risk management plan should be included?
67. Please comment on the suitability of the assumptions and costs associated with maintenance of the relief wells.
68. Based on your experience, are the assumptions used in estimating construction costs consistent with similar projects?
69. Please comment on the assumptions associated with operation and maintenance of the constructed seepage barrier.
70. Based on your experience and industry knowledge, please comment on how effective the choice of cutoff wall type and construction methods will be in achieving a continuous barrier (Section 9.6)?

10. MAJOR REHABILITATION CLASSIFICATION

No questions

11. PROJECT COST ESTIMATE

No questions

12. COST SHARING CONSIDERATIONS

No questions

13. REAL ESTATE REQUIREMENTS

No questions

14. SUMMARY AND CONCLUSIONS

No questions

APPENDIX B: RISK AND RELIABILITY ANALYSIS/ECONOMICS

71. Have the flood damage reduction benefits specifically attributable to Mohawk Dam been adequately characterized, ensuring that potential downstream benefits for other dams/projects in the Muskingum River Basin are not being double counted? Please comment.
72. Is the basis or calculation of the \$6.06 unit day value clear and well defined? Please comment.
73. Please comment on the characterization or binning of performance measures into satisfactory and unsatisfactory including the criteria used for classification.
74. Is the period of analysis used in the economic analysis justified? Please discuss.
75. Please comment on the depth-damage curves used for the flood damage estimation.
76. Please comment on the assumption that 100% of the recreational benefits would be lost, and the amount of time they would be lost for, in the case of dam failure.
77. Is the methodology for estimating road damages clear and based on sound engineering principles and guidelines? Please discuss.

APPENDIX C: ENVIRONMENTAL

78. Please comment on the finding that the proposed project will have no significant impact on the quality of the human and natural environment.

APPENDIX H: GEOTECHNICAL APPENDIX FOR DAM EMBANKMENT

79. Please comment on the increased piezometric levels that indicate seepage pathways through the foundation outwash; does the recommended rehabilitation solution take into account any implications of this occurrence (Section 2.5.2).
80. Please comment on whether the passage of water and emergence of springs in the bedrock might affect the reliability of the recommended rehabilitation project (Section 3).
81. Please comment on any potential repercussions due to the quality of the historic and recent subsurface investigations being called into question (Section 4.3.1).

82. Please comment on the lack of expected revelation of a highly pervious zone, and relative homogeneity of foundation outwash, relative to the wide variations in relief well flows and slow drop in piezometer levels observed (Section 4.3.1).
83. Please comment on the hydraulic conductivity data from the pump tests indicating aquifer heterogeneity, the difference between the results obtained from the pump tests compared with the data obtained from laboratory tests, and the selection of soil parameters used for seepage modeling (Section 4.5.3).
84. Please comment on the selection of soil parameters used in the slope stability analysis (Section 4.6).
85. Please comment on the methods used for probabilistic seepage and slope stability analyses for the base condition and on the results of the analysis (Section 5).
86. Please comment on whether the results of the base condition analyses conducted indicate that rehabilitation recommendation of the Mohawk Dam is well justified (Section 5.3).
87. Please comment on the methods used for probabilistic seepage and slope stability analyses for the rehabilitation alternatives and recommended plan and the results of the analysis (Section 6).
88. Please comment on whether sufficient documentation and justification were provided to determine if the “no action” alternative is unacceptably high, and that the reliability of the Mohawk Dam will continue to decrease with time absent the rehabilitation project (Section 6.1.1).
89. Please comment on the statement and its implications, if any, that a 50% cutoff wall should lower the groundwater level at even the highest pool to elevations below the downstream toe (Section 6.2.1).
90. Please comment on the annual probability results relative to the rehabilitation alternatives (Section 6.2.4).
91. Please comment on the conclusions reached in Section 7.

APPENDIX I: GEOTECHNICAL ANALYSIS OF LEFT ABUTMENT AND EMERGENCY SPILLWAY

92. Is sufficient information known concerning the left abutment geology, hydrogeology and outlet works construction, upon which to confidently develop a rehabilitation concept; if not, what additional studies would you suggest?
93. Please comment on the process used to develop probabilities of unsatisfactory performance levels and how the process was applied (Section 5.0).
94. Please comment on the results of the expert elicitation.

- a. What additional studies, if any, would you suggest might be conducted to reduce uncertainty (Section 5.1)?
- 95. Please comment on the recommended rehabilitation plan (Section 5.3).
- 96. Please comment on the methods used in the spillway erodability analysis; please comment on the results of the analysis (Section 6).
- 97. Please comment on the spillway erodability rehabilitation plan (Section 6.7).

APPENDIX J: HYDROLOGY AND HYDRAULICS ANALYSIS

- 98. Please comment on the suitability of the model input parameters.
- 99. Based on your experience and the information contained in this appendix, please comment on the reasonableness of the assumed dam break conditions.
- 100. Please comment on the range of parameters selected for the sensitivity analysis.
- 101. Please comment on whether the modeling results support the conclusions presented in the Appendix.

APPENDIX K: OPERATING EQUIPMENT AND GATES

- 102. Based on your experience and the information contained in Appendix K, please comment on whether the recommended scope of gate rehabilitation is justified.

FINAL OVERVIEW QUESTION

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