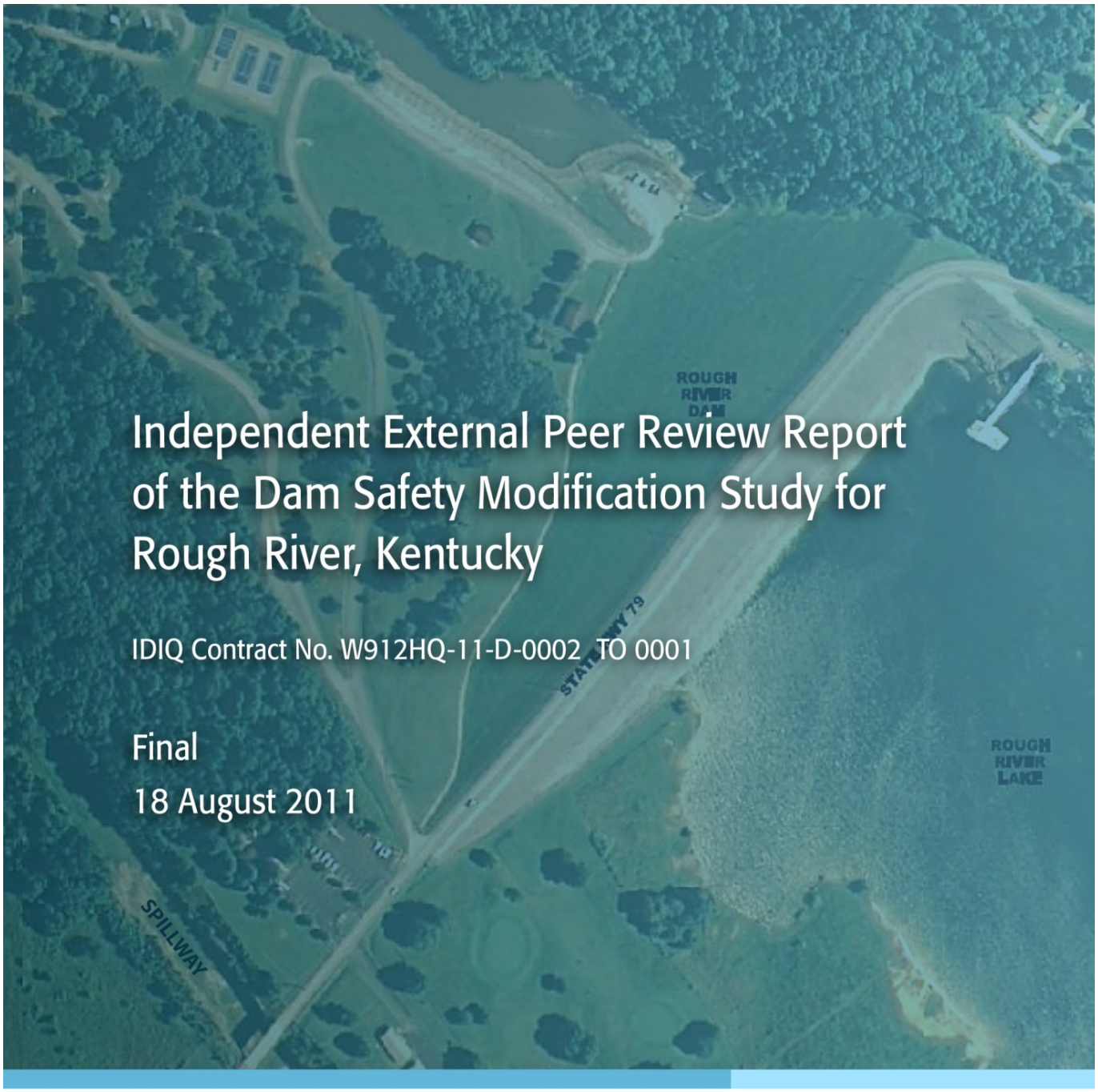

Independent External Peer Review Report of the Dam Safety Modification Study for Rough River, Kentucky

IDIQ Contract No. W912HQ-11-D-0002 TO 0001

Final

18 August 2011

noblis

For the best of reasons

This page intentionally blank.

Table of Contents

List of Figures

List of Tables

List of Acronyms

AFB	Air Force Base
ASCE	American Society of Civil Engineers
COI	conflict of interest
DSAC	Dam Safety Action Classification
DSMS	Dam Safety Modification Study
EC	Engineer Circular
FDA	Flood Damage Assessment
GIS	Geographic Information System
HEC	Hydrologic Engineering Center
IEPR	Independent External Peer Review
ISO	International Organization for Standardization
NEPA	National Environmental Policy Act
OMB	Office of Management and Budget
RAS	River Analysis System
RCC	roller-compacted concrete
SPRA	Screening Portfolio Risk Assessment
SOW	Statement of Work
UC	University of California
USACE	U.S. Army Corps of Engineers
yr	year

Executive Summary

The Rough River Dam Safety Modification Study (DSMS) was prepared in 2009 in response to a Dam Safety Action Classification (DSAC) ranking of II for Rough River Dam, Kentucky, which is described as "Urgent" (unsafe or potentially unsafe). The main objective of the DSMS was to evaluate dam safety issues or conditions that could result in unacceptable life safety, economic, and environmental risks, and consider various dam safety modifications to reduce the project risk below current U.S. Army Corps of Engineers (USACE) tolerable risk guidelines. The objective of this Task Order was for Noblis to conduct an Independent External Peer Review (IEPR) of the DSMS Report and related documents for Rough River Dam in accordance with procedures described in the Department of the Army USACE Engineer Circular (EC) No. 1165-2-209, *Civil Works Review Policy*. The IEPR performed a technical assessment of the adequacy and acceptability of economic, engineering, and environmental methods, models, data, and analyses. The review was conducted by a panel of experts with extensive experience in engineering, economic, and environmental issues associated with flood protection feature design. The panel was "charged" with responding to specific technical questions as well as providing a broad technical (engineering, economic, and environmental) evaluation of the overall DSMS.

Since Noblis has no commercial interests to advance, no vendor alliances to protect, and no sponsors or shareholders to represent, it is fully independent. Noblis provides impartial, conflict of interest (COI)-free, independent assistance to organizations throughout the federal government and has extensive experience with peer review oversight. Noblis and the selected IEPR panel have not been involved in any capacity with the Rough River Dam or the DSMS. In addition, Noblis has not performed or advocated for or against any federal water resources projects. For these reasons, Noblis was suitable for upholding the principles of independence in all aspects of managing the IEPR.

Noblis performed the requirements of this contract in accordance with its Quality Management System, which is compliant with International Organization for Standardization (ISO) 9000. Specifically, Noblis prepared a Work Plan to define and manage the process for conducting the IEPR, including the screening and selection of peer reviewers, communication and meetings with the USACE project team, project schedule and quality control, and compilation and dissemination of peer reviewers' comments. The USACE required completing the IEPR as efficiently as possible, and Noblis developed a schedule that would meet this goal. Some aspects of the task were initiated before the task award date at no expense to the USACE, and certain phases of the project were carried out concurrently to enhance the project efficiency and meet the project schedule.

Reaching out to its various pools of experts, Noblis initially identified 16 potential peer reviewers, confirmed their availability, evaluated their technical expertise, and inquired about potential COI issues. Subsequently, Noblis selected nine peer reviewers for the IEPR panel providing expertise in the areas of geotechnical, hydraulic, and structural engineering; geology; National Environmental Policy Act (NEPA) impact assessment; engineering cost estimation; economics; and plan formulation. Although it was later established that a panel of seven experts would suffice for this Task Order, Noblis formed a panel consisting of nine experts with expertise in all relevant areas with particular emphasis on critical areas of review (i.e., four members covering the three areas of geotechnical engineering, geology and hydraulic engineering) as well as a member with structural engineering expertise. The panel represented a

well-balanced mix of individuals from academia, large companies and small consulting firms, and individual consultants.

Noblis set up a secure online collaboration site to provide IEPR panel members with electronic copies of the charge and the documents to be reviewed. Noblis held a kickoff meeting outlining the steps of the IEPR process and identifying the overall schedule and deadlines. Noblis served as the conduit for information exchange between the panel and USACE in order to ensure a truly independent IEPR. Noblis conducted periodic meetings with the panel members during the IEPR to discuss their progress and current observations/comments. These meetings ensured an exchange of technical information among the panel experts and reflected their diverse scientific backgrounds.

After the IEPR review period ended and comments were developed, Noblis consolidated and collated the panel comments and ensured they were complete and responsive to the charge. Noblis reviewed a draft of the consolidated IEPR panel comments with USACE and the IEPR panel for factual accuracy. Subsequent to this discussion, minor updates were made to the IEPR draft panel comments as necessary resulting in 39 final comments included in this report and submitted to the USACE as a separate IEPR deliverable. Of the final 39 comments, 16 were identified as having high significance, 13 were identified as having medium significance, and ten comments were identified as having a low level of significance. Table ES-1 summarizes the final comments by level of significance. Details on each comment and response are contained in Appendix A of this report. Editorial comments were also captured and are included in this report but are not included in the final list of IEPR comments.

The 39 final IEPR comments submitted to the USACE were focused on recommended changes to the DSMS Report to identify and clarify specific key analyses and factors of stability, safety, environmental impact, and the evaluation of alternatives that should be considered in the selection of the preferred alternative. At a later date, the Louisville District Project Delivery Team (PDT) will review the panel members' comments and provide responses, which will be followed by the panel's concluding "backcheck" comments to indicate agreement or non-agreement (on whether the USACE's responses addressed the stated concern). All issues will be subsequently closed. In accordance with procedures described in USACE guidance (EC No. 1165-2-209), the formal record of USACE responses to comments and the panel's backcheck comments will be captured in a separate deliverable and not included in this IEPR report.

Table ES-1. Overview of Final Comments Identified by IEPR Panel.

Significance – High
The panel is concerned about proper application of the U.S. Army Corps of Engineers (USACE) plan formulation process in the Rough River Dam Safety Modification Study (DSMS). (Comment #1)
The annualized probability of failure of 28.1% seems high and inconsistent with the Statement of Issues in the Project Fact Sheet, which indicates that the dam is classified as Dam Safety Action Classification (DSAC) II and that "[u]nacceptable foundation conditions and associated seepage required investigation and analysis to remove uncertainty and lower project risk." (Comment #2)

A deterministic seismic hazard evaluation would be needed to estimate the earthquake ground motions for the Maximum Credible Earthquake (MCE). The MCE used in the DSMS Report is for an earthquake with a 2% chance of being exceeded in 50 years (or a return period of 2,475 years). This probability is too low and the return period too short for the MCE. As indicated in the report, some agencies have suggested that a return period of 5,000 or 10,000 years should be considered for the MCE. A longer return period would seem to be more appropriate if a probabilistic assessment is used to determine the MCE for the project. (Comment #5)
The panel is concerned about the seismic performance of the dam, particularly the risk of liquefaction of the sand layer underlying the dam. (Comment #6)
The data indicates that slope stability and heave potential are possibly affected by piezometer levels across the cutoff wall that are installed to facilitate the toe drain rehabilitation. (Comment #9)
The Willowstick contour plot shows two seepage “sinks” under the toe of the dam, one adjacent to the left side of the cutoff wall and one larger sink further to the left. There also appears to be a “sink” further to the left of the cutoff wall at elevation 455 ft. The panel is concerned that these “sinks” may be downward solution feature “drains” that could eventually impact the dam. (Comment #10)
There are inconsistencies in the DSMS regarding the intake tower failure mode and the reported probability of failure from the analysis. There are also contradictory statements regarding the probability of shear failure. (Comment #11)
The alternatives considered in the DSMS Report are not consistently evaluated. Additionally, the DSMS Report lacks a logic trail within the Alternative 6 evaluation concluding with a Roller Compacted Concrete (RCC) Structure as the elected “Remove and Replace Structure.” (Comment #13)
Although the borings have not been extended deeper than the Sample Sandstone, USACE intends to use this stratum as the base of the cutoff wall. (Comment #14)
The panel is concerned about the possibility of solution paths (open or gouge filled) on the untreated conduit excavation sidewalls. The description of Alternative Plan #4 seems to indicate that grouting from the conduit is only planned through the bottom of the conduit. The grouting might bypass potential defects/seepage windows to the sides and above the conduit. (Comment #15)
Consideration of cumulative impacts is incomplete within the DSMS Report and alternatives therein. (Comment #22)
Impacts to endangered species have not been sufficiently addressed within the Environmental Assessment (EA) and DSMS Report. (Comment #23)
No qualified review comments were possible regarding the accuracy of the damages prevented and the benefits of the project alternatives. (Comment #28)
Written documentation should be included in Appendix G to describe the tower failure analysis using the Structural Toolbox. (Comment #32)

Written documentation should be included in the main report or appendix to explain how the probabilities were determined using the Mechanical and Electrical Toolbox. (Comment #33)
The cost estimate for the RCC dam alternative should include the same level of detail as the cost estimate for the cutoff wall alternative in order for a reasonable (and unbiased) comparison to be made. (Comment #34)
Significance – Medium
The panel is concerned with the risk of using geotextile as part of an emergency reverse filter over a boil, especially if the boil is carrying dirty water (fines transport). (Comment #8)
Environmental impacts of the cutoff wall have been dismissed; however, if construction requires significant lowering of the reservoir, there could be associated environmental impacts. Also, in constructing the cutoff wall, even with grouting of the adjacent rock, there is a potential for grout plumes or slurry wall loss to downstream areas. (Comment #16)
The panel is concerned that the conclusions presented in Chapter 9 (Comparison of Alternative Risk Management Plans) are not justified by the data presented. (Comment #18)
Figures 9.1 and 9.2 do not support the conclusion that the cutoff wall plan reflects the most significant risk reduction. (Comment #19)
Work necessary to resolve the foundation rock underlying the embankment problem should be treated as an allowance in the cost estimate as opposed to a contingency. (Comment #20)
EA and Finding of No Significant Impact (FONSI) should be integrated into the main document. Also, reconcile inconsistencies between the DSMS Report and EA in alternative presentation. (Comment #21)
It is not clear from the DSMS Report whether there are alternatives that may allow for the partial recovery of endangered mussel species and their associated ecologic communities downstream of the project. (Comment #24)
The Public Involvement and Coordination section should highlight comments received from public. (Comment #25)
The assumption that structures have a first floor elevation of 3-ft above grade (Appendix E, p. 18) may result in significantly underestimating the flood damages/benefits and the benefit/cost ratios. (Comment #29)
The SEEP/W Analysis (Appendix G) does not adequately consider possible high permeability flow paths in rock foundation. (Comment #31)
Specified tasks in the Project Direct Costs Report have no assigned cost. (Comment #35)
The hydrologic analysis of the Rough River Dam historical record does not include the period from December 1960 to 1983. (Comment #37)
The Willowstick Report does not adequately discuss the method's ability to locate seepage targets in presence of embankment and foundation materials consisting of clay or large percentages of clay that have very high electrical conductivity. (Comment #39)

Significance – Low
The panel agrees with the DSMS conclusion that the installation of a complete cutoff wall with foundation grouting and the construction of a conduit filter are required to mitigate the risk of piping and potential dam breach as a result of the rock defects. (Comment #3)
A summary description of the Emergency Action Plan (EAP) should be provided somewhere in the introductory sections of the report. (Comment #4)
The DSMS Report does not adequately explain the project purposes that would be negatively impacted by Reservoir Restriction as an Interim Risk Reduction Measure (IRRM). (Comment #7)
Although it will not change the result, the maximum annualized loss of life on p. 136 of the DSMS Report should be 6.14E-09 as shown in Table 5.11. (Comment #12)
The DSMS Report contains no discussion regarding the amount of permanent loss (or gain) of wetlands associated with dam removal (Alternative 5). (Comment #17)
Appendix E, Table 1 shows the number of structures flooded and the population at risk for the nine considered scenarios reflecting a number of persons per structure that ranges from 1.05 to 1.11. (Comment #26)
Additional information is needed in the DSMS Report regarding damages and benefits used to justify the project. (Comment #27)
The assumed elevation for initial flood damage to vehicles is not indicated. (Comment #30)
Specified tasks in the Project Direct Costs Report have assigned costs that are too low. (Comment #36)
Both documents (*Dam Failure Analysis Toolbox [Draft] 2007* and *Inflow Flood Hydrographs Toolbox [Draft] 2007*) are in draft form and are not publically available. (Comment #38)

In general, the panel was unable to verify that the DSMS Report assembled all viable alternatives because the input data for the applicable evaluation models were unavailable for review. The DSMS Report did identify the analyses, methods, and models used in evaluating each alternative. However, the level of alternative analysis was inconsistently applied amongst the alternatives. The panel comments reflect concern over application of the plan formulation process while performing the DSMS. The panel identified several issues affecting costs and technical assumptions used in selecting the preferred alternative. The importance of involving different stakeholders as part of the planning process is reflected in the DSMS Report, yet the public comments were excluded. These considerations are essential for the DSMS to sufficiently demonstrate to the public that the selection of the preferred alternative was both appropriate and unbiased.

Economics. The DSMS economic evaluation included appropriate analyses for evaluating the benefits and costs associated with each alternative. The methodology and approach of the benefits and costs analysis were adequate for properly evaluating and comparing the alternatives; however, all of the information used in the analysis was not provided for review by the panel. Specifically, the Hydrologic Engineering Center's Flood Impact Analysis (HEC-FIA) input and output data were not provided and the cost estimate for each alternative was not provided with

the same level of detail. Consequently, no qualified statements can be made regarding the accuracy of the results of the benefits and costs analyses. The panel members offered comments based on professional experience and standard industry practices.

Engineering. The panel focused on subsurface conditions in the Rough River Dam area that have been identified and on the design of the proposed cutoff wall as a means of remediation to address the identified deficiencies with regard to the stability of the dam and dam safety. Overall, the panel concurs that the selection of a cutoff wall to rehabilitate the structure is appropriate to address the seepage deficiencies of the project and finds that the engineering principles and methods used in conducting design analysis and developing the conceptual design of the preferred alternative are sound. For the selected alternative, the DSMS Report included several detailed drawings and analyses. The panel's comments primarily relate to the lack of sufficient data and important considerations needed to improve the analyses, such as the need for deeper exploration for final design, slope stability associated with seepage conditions at the existing toe drain cutoff, investigation of anomalies identified by geophysical investigations that have been made, and approaches to seepage analysis under the dam. The panel also identified other deficiencies such as site-specific seismic characterization and liquefaction analysis. Some inconsistencies in the risk assessment with regard to classification of the dam's overall risk were pointed out, which should be addressed. The panel recognizes that this is not the final design and that additional field investigations and detailed analyses still need to be performed to address the identified concerns. Some general suggestions regarding this additional investigation and design have also been provided.

Environmental. The DSMS presented specific environmental benefits associated with the preferred alternative; but, these benefits were presented insufficiently with respect to the other alternatives considered. The DSMS does not adequately address alternatives analyses, cumulative impacts, and other critical issues required by the NEPA and other relevant federal laws and regulations. The panel identified certain environmental considerations that were not included in the DSMS Report pertaining to negative environmental impacts that could result from the project. The panel also recognizes that revised consideration of environmental impacts and additional measures to avoid, minimize, and mitigate these impacts will be addressed in later phases of the project.

1 Introduction

1.1 Report Introduction and Overview

This Independent External Peer Review (IEPR) Report provides a description of the IEPR conducted of the Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, and Economic Aspects of the Dam Safety Modification Study (DSMS) Report for Rough River Dam, Kentucky, for the U.S. Army Corps of Engineers (USACE). This IEPR Report includes a description of the IEPR objectives and process, overview of the DSMS, summary of the IEPR panel members' expertise, and discussion of observations and comments by the IEPR panel.

Section 1 of the IEPR Report provides a description of the objectives of this effort and general background information on the IEPR, as well as a brief introduction to Noblis, the contractor leading this effort. Section 2 provides an overview of the Rough River project and the DSMS. Section 3 presents the overall process followed in performing the IEPR. Section 4 describes the panel composition and the panel members' expertise. Section 5 discusses the conclusions and observations of the IEPR, including a description of the panel comments. Finally, Section 6 includes a list of references for the materials used throughout the IEPR process. Appendix A of this Final IEPR Report lists the final IEPR comments, as well as editorial comments provided by the IEPR panel. Appendix B provides a description of the IEPR panel and the panel members' résumés. Appendix C includes the "charge" and list of documents provided to the panel for the IEPR of the DSMS for Rough River Dam, Kentucky.

1.2 IEPR Overview

The USACE lifecycle review strategy for Civil Works products provides for a review of all Civil Works projects from initial planning through design, construction, and Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R). It provides procedures for ensuring the quality and credibility of USACE decision, implementation, and operations and maintenance (O&M) documents and work products. 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, the validity of the research design, the quality of data collection procedures, the robustness of the methods employed, the appropriateness of the methods for the hypotheses being tested, the extent to which the conclusions follow from the analysis, and the strengths and limitations of the overall product.

1.3 IEPR Objective

The objective of the work was to conduct an IEPR of the DSMS Report and related documents for Rough River Dam, Kentucky, in accordance with procedures described in the Department of the Army USACE Engineer Circular (EC) No. 1165-2-209, *Civil Works Review Policy*, dated 31 January 2010, and the Office of Management and Budget's (OMB's) *Final Information Quality Bulletin for Peer Review*, released 16 December 2004. The Rough River Dam IEPR involved conducting an independent technical peer review to analyze the adequacy and acceptability of economic, engineering, and environmental methods, models, data, and analyses. The independent review was limited to a technical review of the DSMS Report and was not involved in policy issues. The peer review was conducted by experts with extensive experience in

engineering, economic, and environmental issues associated with flood protection feature design. The experts were "charged" with responding to specific technical questions as well as providing a broad technical (engineering, economic, and environmental) evaluation of the overall DSMS.

The independent expert reviewers identified, recommended, and commented upon assumptions underlying the analyses as well as evaluated the soundness of models and planning methods. They evaluated data, the use of models, analyses, assumptions, and other scientific and engineering methodologies. The reviewers offered opinions as to whether there are sufficient technical analyses upon which to base the ability to implement the project.

1.4 Noblis is Conflict-Free in Water Resources Projects

Noblis, the contractor leading this effort, is a nationally recognized leader in systems analysis and analytical support to the federal government. As a nonprofit science, technology, and strategy organization, Noblis solves complex systems, process, and infrastructure problems in ways that truly benefit the public. Noblis staff includes accomplished engineers, scientists, analysts, researchers, technical specialists, and management experts with extensive multi-disciplinary and multi-sector experience. Since Noblis has no commercial interests to advance, no vendor alliances to protect, and no sponsors or shareholders to represent, it is fully independent. Noblis provides impartial, conflict of interest (COI)-free, independent assistance to organizations throughout the federal government. Noblis has documented experience with peer review oversight. Noblis and the selected IEPR panel have not been involved in any capacity with the Rough River Dam project or the DSMS. In addition, Noblis has not performed or advocated for or against any federal water resources projects.

Noblis has been recognized as one of the 2011 World's Most Ethical Companies by the Ethisphere Institute. This award honors companies that demonstrate "real and sustained ethical leadership in their industries." Noblis was one of three companies worldwide to be listed in the Business Services category. The Ethisphere Institute, a think-tank dedicated to the creation, advancement, and sharing of best practices in business ethics, corporate social responsibility, anti-corruption, and sustainability, reviewed nominations from companies in more than 100 countries and 38 industries before naming 110 companies to their 2011 list.

Noblis clients and the public deserve nothing less than work that meets the highest standards of excellence, conducted in an environment where objectivity and integrity are the hallmarks. Noblis achieves this through the development, implementation, maintenance, and continual improvement of its International Organization for Standardization (ISO) 9001:2008 Compliant Quality Management System.

2 Rough River Project Description

The Rough River DSMS Report was prepared in 2009 in response to a Dam Safety Action Classification (DSAC) ranking of II for Rough River Dam, which is described as "Urgent" (unsafe or potentially unsafe). A dam with this classification is considered to have failure initiation foreseen or at very high risk. This ranking was established by the Senior Oversight Group subsequent to an evaluation through the Screening Portfolio Risk Assessment (SPRA) program conducted in 2005. The SPRA identified seepage and piping through the soil foundation and embankment as the major contributor to project risk; however, the DSMS Report identified seepage and piping through the foundation bedrock as the major risk contributor.

The main objective of the DSMS was to evaluate dam safety issues or conditions that could result in unacceptable life safety, economic, and environmental risks, and consider various dam safety modifications to reduce the project risk below current USACE tolerable risk guidelines. The principal risk driver identified from the risk assessment performed in support of the DSMS is seepage and piping through untreated, solutioned, and/or excavation-damaged bedrock beneath the dam. A secondary component of the risk is associated with the potential seepage paths through the embankment along the conduit due to the lack of a proper filter around the conduit. USACE seepage and piping guidance (Internal Erosion Toolbox – A Method for Estimating Probabilities of Failure of Embankment Dams due to Internal Erosion, *Best Practices Guidance Document*, August 2009) was used to select best estimate values for various input parameters in evaluating critical failure paths. Structural and non-structural risk reduction measures were identified and evaluated to formulate alternative plans associated with varying degrees of permanent risk reduction, and to ultimately recommend a cost effective, technically feasible alternative plan that minimizes adverse environmental, economic, and social effects. The intent of the selected alternative plan is to allow the project to operate within current USACE tolerable risk guidelines for the foreseeable future. An evaluation of the modified annual probability of failure, reduced life safety risks, As-Low-As-Reasonably-Practicable considerations, and current USACE tolerable risk guidelines form the basis for plan selection. Figure 1 shows the project location, dredge areas, and disposal areas.

Figure 1. Rough River Dam

3 IEPR Process

3.1 Planning and Schedule

Noblis developed a schedule that would meet the USACE's goal of completing the task as efficiently as possible and proposed a project duration based on the schedule set forth in the Statement of Work (SOW) (USACE 2011). Certain aspects of the task were initiated before the task award date at no expense to the USACE, and certain phases of the project were carried out concurrently to enhance the project efficiency. Figure 2 shows the overall process highlighting the major activities of the IEPR conducted of the DSMS for Rough River Dam, Kentucky.

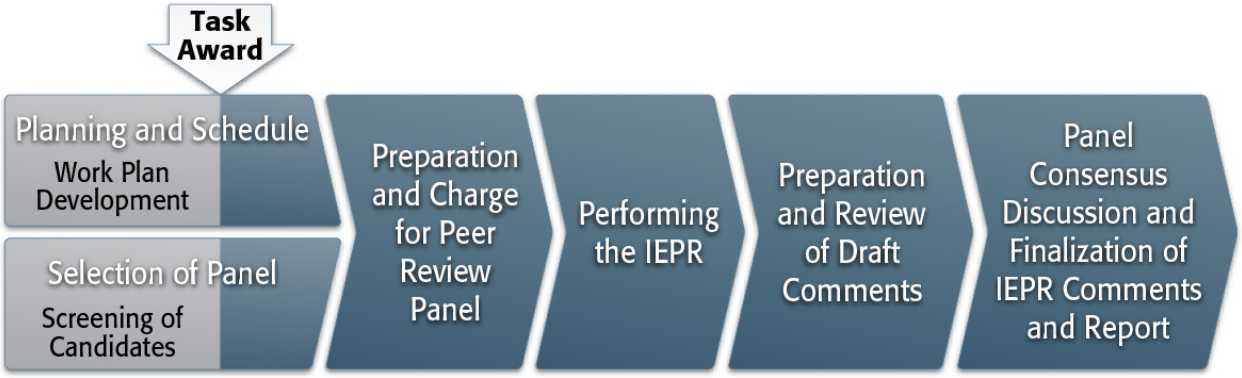

Figure 2. Rough River Dam IEPR Process

Although the project initially assumed a Notice to Proceed date of 28 February 2011, project schedule was extended because of the delayed project start (i.e., initial kickoff meeting and provision of project documents). Noblis prepared a Work Plan to define and manage the process for conducting the IEPR, including the screening and selection of peer reviewers, communication and meetings with the USACE project team, project schedule and quality control, and compilation and dissemination of peer reviewers' comments. Upon scheduling the review of draft IEPR panel comments, the overall schedule was further extended by 14 days at the request of the USACE to allow appropriate time for USACE to assess the factual accuracy of the draft IEPR panel comments and provide responses, extending the project completion date to 18 August 2011. A summary table showing the final schedule is presented in Table 1.

Noblis provided USACE with Project Status Reports on a biweekly basis to communicate the current status of the project. The Project Status Reports included details of each task and noted any schedule changes. Noblis performed the requirements of this contract in accordance with its Quality Management System, which is compliant with ISO 9000.

Table 1. Rough River Dam IEPR Project Schedule

Activity and Output	Completion Date
Planning and Schedule Output: Final Work Plan	21 April 2011
Selection of Panel Output: Final Panel Members	21 April 2011
Preparation and Charge for Peer Review Panel Output: Final Charge	10 May 2011
Performing the IEPR Output: Panel Member Comments	31 May 2011
Preparation and Review of Draft Comments Output: Draft IEPR Panel Comments	16 June 2011
Panel Consensus Discussion and Finalization of IEPR Comments and Report Output: Final IEPR Comments and Final IEPR Report	18 August 2011

3.2 Selection of Panel

Reaching out to its various pools of experts, Noblis identified experts who met and exceeded the technical expertise and requirements of this IEPR. Noblis provided potential candidates with a copy of the SOW, including the required expertise and project schedule, and conducted informal and formal discussions to identify any technical competency concerns or potential COI issues. Consistent with the guidelines of the OMB, the following were considered in the screening of the candidates:

- Expertise: Ensuring the selected reviewer has the knowledge, experience, and skills necessary to perform the review.
- Independence: The reviewer was not involved in producing the documents to be reviewed.
- COI: Any financial or other interest that conflicts with the service of an individual on the review panel because it could impair the individual's objectivity or could create an unfair competitive advantage for a person or organization.
- Availability: Candidates' availability to meet the project schedule.

After screening candidates to exclude those with inadequate expertise or potential COI issues in accordance with the requirements and guidelines of the National Academy of Sciences and OMB, 16 candidates were selected for further screening and evaluation to ensure they met or exceeded the requirements of this task. Noblis provided the list of candidates along with their detailed résumés to USACE to identify any outliers who may have a potential COI based on USACE knowledge of the individual's past involvement with the Rough River Dam project. Also, USACE acknowledged the proposed panel members' experience relative to the requirements of the IEPR. The list was then narrowed down to identify the most qualified candidates that would be available to serve on the Rough River Dam IEPR panel. Although an

eight-member panel would have met the minimum requirements of the SOW, Noblis decided to add a ninth member to ensure a thorough review of the DSMS. A description of the panel is provided in Section 4.

3.3 Preparation and Charge for Peer Review Panel

USACE made available necessary project documents (listed in Appendix C) to Noblis, which were placed on Noblis' secure online collaboration site set up for this effort in order to provide IEPR panel members with electronic copies of relevant documents. Noblis communicated via email and held a kickoff meeting outlining the steps of the IEPR process, identifying the overall schedule and deadlines, and instructing the IEPR panel members how to access the documentation and undertake the review. Noblis requested all panel members review the DSMS Report for which USACE had requested comments, as well as additional supporting documents as background material for their reference.

Subsequent to a cursory review of the documents by the panel but prior to the actual detailed IEPR, a kickoff meeting was held at the project site with the USACE concurrent with a teleconference/WebEx to familiarize the IEPR panel members with the technical aspects of the project and the specific objectives of the review. As part of this meeting, USACE provided a detailed project briefing, reviewed project features and requirements, and provided the opportunity for the exchange of technical information between the panel and USACE technical staff. Noblis met with the panel members following the meeting with USACE to refine roles and responsibilities of the IEPR panel members to ensure proper coverage of all important issues. From this point on, Noblis was the conduit for information exchange between the panel and USACE in order to ensure a truly independent IEPR.

During the USACE kickoff meeting, discussions took place regarding USACE plans to revise the DSMS throughout the progress of the IEPR. At that time, it was acknowledged that the review of the updated documents by the IEPR panel was not within the scope of this Task Order. Consequently, it was decided that the IEPR panel would focus on the documents that had already been developed. The final Charge Questions developed and approved by USACE established the general boundaries for the IEPR and are summarized in Table 2.

Table 2. Rough River Dam IEPR Charge Questions

Rough River Dam IEPR Charge Questions
1. 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?
2. Are the methods used to evaluate the condition of the structure adequate and appropriate given the circumstances?
3. Have the hazards that affect the structure been adequately described?

Rough River Dam IEPR Charge Questions
4. Have the appropriate alternatives, including removal of the dam, been considered and adequately described for this project?
5. Do the alternatives and their associated costs appear reasonable?
6. Do the benefits and consequences appear reasonable?
7. Are there any additional analyses or information available or obtainable that would affect decisions regarding the structure?
8. Has anything significant been overlooked in the development of the assessment of this structure or the alternatives?
9. Have appropriate considerations been made to support the decisions regarding this structure?
10. 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?

3.4 Performing the IEPR

After the panel was oriented with the general scope and background information of the project, the panel initiated a detailed review of the DSMS Report and supporting documents. The Rough River Dam IEPR involved conducting an independent technical peer review to analyze the adequacy and acceptability of economic, engineering, and environmental methods, models, data, and analyses presented in the DSMS. The review was limited to a technical review and was not involved with policy issues. The IEPR panel identified, recommended, and commented on assumptions underlying the analyses as well as evaluated the soundness of models and planning methods presented in the DSMS relative to the charge.

Noblis conducted periodic teleconferences with the panel members during the IEPR to discuss progress and current observations/comments. These meetings ensured an exchange of technical information among the panel experts and reflected their diverse scientific backgrounds. This information exchange provided additional context to the reviewers, ensured that the scope of the review remained responsive to the charge, and was crucial in the development of the comprehensive peer review report. Schedule details were also discussed and panel members were made aware of upcoming activities and deadlines. Any identified information or documents that the panel required to support its review were noted. Noblis facilitated discussions between the panel and USACE in order for the group to agree on reasonable solutions to address the major technical issues raised during the course of the effort.

Noblis used internal tools to track comments, issues, and information requests by the panel members during the evaluation process. This enabled Noblis to request additional information

and documentation from USACE that closed out some of the comments during the review process to the satisfaction of the panel.

3.5 Preparation and Review of Draft Comments

By the conclusion of the IEPR review period, all panel comments had been consolidated and each comment formatted into four parts: (1) a clear statement of the concern ("Comment"), (2) the basis for the concern ("Basis for Comment"), (3) the significance of the concern (the importance of the concern with regard to project implementability) ("Significance"), and (4) the recommended actions necessary to resolve the concern to include a description of any additional research that would appreciably influence the conclusions ("Recommendation for Resolution"). Noblis ensured the panel comments were complete and responsive to the charge, identified overall themes that were presented by multiple peer reviewers or repeated by one reviewer, identified comments that indicated conflicting peer review opinions, and identified other noteworthy comments. Noblis ensured the panel focused on performing a technical review of the documents and avoided commenting on policy-related issues. The panel discussions resulted in 39 draft comments that were sent to USACE for discussion.

Noblis provided a draft of the consolidated IEPR panel comments to the USACE and held a teleconference with the USACE and the IEPR panel to review the draft comments. The teleconference provided the forum to assess the factual accuracy of the panel comments, seek any needed clarification, and discuss specific technical positions. Based on verbal discussions with USACE, the panel comments contained no factual inaccuracies.

3.6 Panel Consensus Discussion and Finalization of IEPR Comments and Report

Subsequent to the discussion with the USACE, minor adjustments were made to the IEPR draft panel comments as necessary resulting in the 39 final comments included in this report and submitted to the USACE as a separate IEPR deliverable. The final IEPR panel comments are presented in Appendix A.

Noblis will track the development of USACE responses to those comments (to be completed at a later date), and the panel's concluding "backcheck" comments. All subsequent responses provided by USACE and the panel will indicate agreement or non-agreement on whether the concerns identified by the panel need to be addressed in the body of the DSMS Report. In accordance with procedures described in USACE guidance (EC No. 1165-2-209), the formal record of the USACE's responses to comments and panel's backcheck comments will be captured in a separate deliverable and not included in this IEPR report.

In developing the responses to the IEPR panel comments, the Louisville Project Delivery Team (PDT) members, as well as Division and Headquarters representatives, will review the comments and responses and determine the significance of the issue.

After the USACE submits responses to the IEPR comments, Noblis will meet with the panel to discuss the responses and the approach for preparing the concluding backcheck comments, which will indicate agreement or non-agreement on whether the identified concerns have been adequately addressed. After Noblis documents the panel backcheck comments to the USACE responses to comments in the separate IEPR panel comments deliverable, the issue will be closed. Once all issues are closed, Noblis will provide a formal record of the final IEPR panel

comments, the USACE's responses to comments, and panel's backcheck comments as a Portable Document Format (PDF) file.

Minor editorial changes were not included in the final set of comments unless they affected the technical understanding of the documents. A listing of the editorial comments is included in Table A-2 of Appendix A.

4 Panel Organization

Noblis assembled a panel of experts to conduct the IEPR, responsible for reviewing and providing comments on the DSMS for the Rough River Dam, Kentucky, project. Noblis guided communications between the panel and USACE to complete the IEPR project.

4.1 Panel Description

Noblis selected nine panel members providing expertise in the areas of geotechnical, hydraulic, and structural engineering; geology; National Environmental Policy Act (NEPA) impact assessment; engineering cost estimation; economics; and plan formulation. All panel members met and exceeded the minimum requirements for each of the specified areas of expertise. The panel represented a well-balanced mix of individuals from academia, large companies and small consulting firms, and individual consultants.

Prior to the onset of the IEPR, it was established that: (a) the structural engineering position could be eliminated, (b) the level of effort required by the NEPA impact professional and the plan formulator would be limited, and (c) a panel made up of seven individuals meeting all requirements would suffice. Subsequent to a review of relevant project documents and considering the availability of nominees, Noblis formed a panel consisting of nine experts with expertise in all relevant areas with particular emphasis on critical areas of review (i.e., four members covering the three areas of geotechnical engineering, geology, and hydraulic engineering), as well as a member with structural engineering expertise.

Figure 3 outlines the members of the IEPR Team. Table 3 presents the list of IEPR panel members and associated qualifications to participate in this IEPR. Panel member résumés are included in Appendix B.

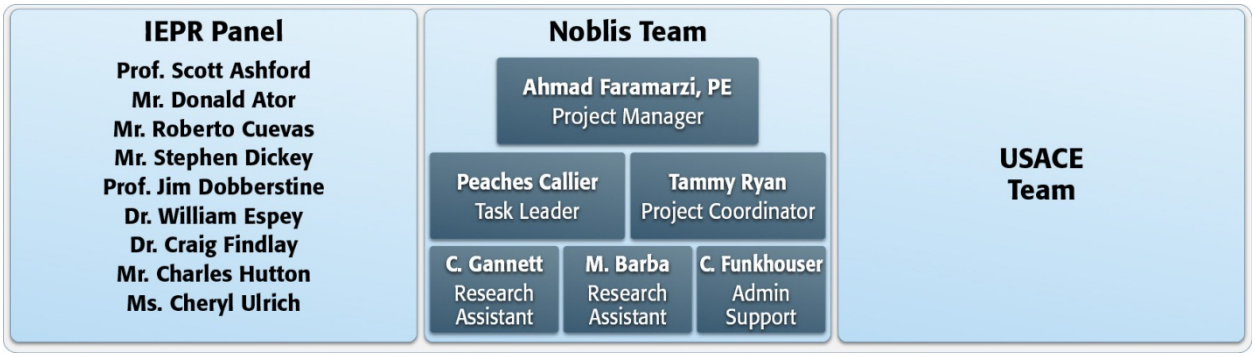

Figure 3. IEPR Team

4.2 IEPR Panel Members

Scott Ashford, PhD, PE
Role: Geotechnical Engineer/ Geologist
Affiliation: Oregon State University

Prof. Ashford is co-founder of Ashford Engineering, Inc., and has over 25 years' experience in geotechnical engineering. He spent seven years in private industry before earning his PhD from University of California (UC) Berkeley in 1994. He then served on the faculty at the Asian Institute of Technology in Bangkok, 1994–1996, and at UC San Diego, 1996–2007. He is currently Professor and Head of the School of Civil and Construction Engineering at Oregon State University. His research works to enhance public safety and reduce potential economic loss worldwide from earthquake and coastal hazards through cross-disciplinary research. His specialty is geotechnical earthquake engineering, in particular liquefaction, lateral spreading, seismic slope stability, and the performance of deep foundations.

Donald Ator
Role: Economist
Affiliation: Atkins

Mr. Ator has over 30 years' experience conducting economic analyses for more than 450 water resources planning projects nationwide. He has specialized experience conducting the economic analysis that determines a project's benefits. The large capital investment projects he has worked on have required the economic analysis of benefits and costs on a common time basis. He has discounted the economic value of the project's benefits and costs over the period of analysis using the appropriate interest rate to develop benefits to costs ratios indicating the project's economic efficiency.

Mr. Ator has worked as an economist for the USACE Vicksburg District, Gulf South Research Institute, and three Architect-Engineer firms conducting water resources economic evaluations. He has extensive experience with the USACE planning process as outlined in ER-1105-2-100, *Planning Guidance Notebook*, especially with regard to flood risk management studies, and has worked with the USACE Hydrologic Engineering Center Flood Damage Reduction Analysis (HEC-FDA), Computerized Agricultural Crop Flood Damage Assessment System (CACFDAS), @RISK, and IWR-PLAN software programs.

Roberto Cuevas
Role: Engineering Cost Estimator
Affiliation: Atkins

Mr. Cuevas is a cost engineer with over 40 years' experience in cost estimating, project management, and project engineering, and has provided estimating services for commercial, military, and industrial projects from the conceptual phase to construction documents. He worked in coordination with the architectural, civil, and mechanical trade's estimators to provide a complete computerized estimate and attended reconciliation meetings to discuss and agree on price differences with the contractor.

Mr. Cuevas had worked for the last two years at the USACE Hurricane Protection Office in New Orleans in various levees and storm proofing pump station projects providing cost estimates, estimate reviews, cost analysis, and source selection services.

Mr. Cuevas provide facility condition assessment and quality ratings (Q-ratings) to bring facilities to construction standards for USACE at Fort Dix, Lakehurst, and McGuire Air Force Base (AFB) in New Jersey, and Fort Eustis and Langley AFB in Virginia. USACE will use the assessments as a primary tool to evaluate upcoming major renovations, capital improvements budgets, facility utilization, and maintenance requirements.

Mr. Cuevas is a registered professional engineer in Puerto Rico with a BS in electrical engineering.

Stephen Dickey, RG, CEG, CHG
Role: Geologist
Affiliation: Dudek and Associates

Mr. Dickey has 35 years project experience in the areas of engineering geology, hydrogeology, and applied geophysics. He has completed projects for electrical utilities, government agencies, the military, private industry, and individuals. This work has included investigation of foundation conditions for repairs to dams, dewatering and depressurizing of soil and rock slopes, landslide investigation and stabilization, groundwater seepage studies, installation of relief wells at dams and levees, and conducting geophysical surveys in the course of groundwater and engineering investigations.

Recent experience has been with water resource exploration and development of fractured rock aquifers with vertical and horizontal wells. He has worked on USACE projects at Porterville, Yuba City, and Boulevard, California.

Jim Dobberstine
Role: NEPA Impact Assessment Professional
Affiliation: Lee College

Prof. Dobberstine is a long-time advocate of Galveston Bay and his 15-year professional career is increasingly focused on strengthening the connections between science, policy, and public awareness. He currently teaches Environmental Science and Biology at Lee College, in Baytown, Texas. He has extensive experience as an environmental scientist and regulatory specialist, focusing on wetlands and other aquatic habitats. Prof. Dobberstine has enjoyed working on a number of successful projects linking science to policy. He has experience developing and evaluating USACE permits, and is experienced with the complex regulatory framework affecting projects that potentially impact coastal habitat. He has also worked in the area of habitat conservation, and has experience with conservation easements, fee-simple acquisitions, and development of habitat assessments, project cost models, and easement contracts. He has leadership experience on aquatic habitat restoration projects aiding in project development, permit acquisition, safety and toxicity issues, fundraising/grant development, and project implementation. Prof. Dobberstine has served on subcommittees of the Galveston Bay Council of the Galveston Bay Estuary Program, formerly as Vice-Chair of the Public Participation and Education Subcommittee, and currently as a member of the Monitoring and Research Subcommittee. He also serves on the Boards of Directors of the Texas Association of Environmental Professionals (as President 2010–2011), the South Central Regional Chapter of Society of Environmental Toxicology and Chemistry (SETAC), and the Galveston Bay Foundation.

William Espey, PhD, PE, DWRE
Role: Hydraulic Engineer
Affiliation: Espey Consultants, Inc.

Dr. Espey has over 50 years of private consulting experience primarily in the fields of water resources and hydrologic engineering. His research has been concerned with problems in the areas of flooding, urban hydrology, drainage, and sedimentation. Dr. Espey has directed both research and consulting engineering projects under contract for numerous industrial and public clients. Dr. Espey has extensive experience modeling water surface profiles for flood risk management projects, a thorough understanding of the dynamics of open channel flow systems, floodplain hydraulics, and interior flood control systems. Dr. Espey is familiar with USACE application of risk and uncertainty analyses in flood risk management studies and standard USACE hydrologic and hydraulic computer models including Hydrologic Engineering Centers (HEC)-1, HEC-HMS, HEC-2, HEC-River Analysis System (HEC-RAS), FLO-2D, HEC-FDA, and HEC-DSS.

Dr. Espey's Doctoral thesis (1965) concerning the hydrology of small urban watersheds, *"Urban Unit Hydrograph Equations,"* formed the basis for the Austin Drainage Criteria Manual-Austin Standard Method for flood determination. Subsequently, at the request of the American Society of Civil Engineers (ASCE) (Urban Water Resources Research Program), urban unit hydrograph equations (ten minutes) were developed (ASCE, Espey, et al., July 1977). The Espey urban unit hydrograph method has been further documented in various textbooks and design manuals.

Craig Findlay, PhD, PE, GE
Role: Geotechnical Engineer
Affiliation: Findlay Engineering, Inc.

Dr. Findlay's 33 years in the dam safety, water resources, and geotechnical engineering profession include a broad variety of consulting and project engineering experience, more that 28 years of which have included involvement with dams and hydroelectric projects. He has served as technical lead or lead geotechnical engineer on hundreds of dam-related projects.

Dr. Findlay has worked on several hydroelectric greenfield design and remediation projects, which have given him broad experience with water resources projects including earth dam and embankment design and instrumentation; powerhouse, spillway, and headworks foundations; stability, liquefaction, and deformation analysis; seepage and piping assessments; finite element analysis of stresses in embankments, gravity dams, arch dams, and radial gates; finite element analysis of earthquake response of embankments, gravity dams, and arch dams; unlined canal design; water retaining structure remediations; cement-bentonite cutoffs and slurry walls; grouting; anchor design; and dam safety inspections.

Dr. Findlay has been a Federal Energy Regulatory Commission (FERC)-approved Independent Consultant on almost 250 Part 12 Inspections and/or served as a Potential Failure Modes Analysis Facilitator for numerous clients. He has also conducted numerous dam structural stability analyses for gravity, embankment, and/or arch dams for many of the above clients, as well as Central Vermont Public Service, Progress Energy, and EGE Fortuna, S.A. in Panama.

Dr. Findlay has presented and/or published several technical papers on seismic analysis of dams and rehabilitation, dam seepage, dam remediation, dam stability, reservoir erosion, and *in situ* soil property measurement for technical societies including United States *Committee on Large*

Dams (USCOLD), Association of State Dam Safety Officials (ASDSO), ASCE, the Canadian Geotechnical Society, American Society of Testing and Materials (ASTM), and the Transportation Research Board.

Charles Hutton, PE
Role: Structural Engineer
Affiliation: GENTERRA Consultants, Inc.

Mr. Hutton is a civil/structural engineer with over 40 years' experience in the design and management of water resource projects involving dams, hydropower, pumping plants, hydraulic structures, intakes, outlet works, gates, and water conveyance facilities in the United States and overseas. His expertise includes preparing feasibility studies, designs, drawings, and specifications for roller-compacted concrete (RCC) and gravity dams, hydropower and pumped storage plants, pumping plants, pipelines, canals and hydraulic structures; performing dam safety inspections; conducting condition assessments and evaluation of existing dams, hydropower facilities, hydraulic structures, intakes, outlet works, gates, and water conveyance systems; developing designs for rehabilitation; technical review; project management; and construction management. He spent the first 15 years of his career with the Bureau of Reclamation in Denver, Colorado, followed by 23 years with the international water resource engineering firm ECI Consultants (now known as AECOM).

Mr. Hutton has completed training for the Sandia National Laboratories Risk Assessment Methodology for Dams (RAM-D) and performed vulnerability and risk assessments for nine concrete and earth dams and their appurtenant facilities. He also has completed training for the FERC Dam Safety Performance Monitoring Program and Potential Failure Mode Analysis methodology and has been involved in three projects that required application of this methodology. He has served as a FERC-qualified independent consultant for the safety inspection of 25 dam and hydroelectric projects.

Mr. Hutton has served as an IEPR panel structural engineer specialist for several U.S. Army Corps of Engineers dams with a DSAC ranking of II, including Bluestone Dam in West Virginia, and Dover Dam in Ohio, which involved extensive dam safety modification and stabilization.

Mr. Hutton is the author or co-author of 13 technical papers presented at national conferences, seminars, and workshops and published in national engineering publications. In addition to his strong technical background in water resource engineering, he has been a successful project team leader and technical designer and/or reviewer on domestic and international water resource projects. He also has conducted seminars on dam design and dam safety engineering.

Cheryl Ulrich, PE
Role: Plan Formulator
Affiliation: Weston Solutions, Inc.

Ms. Ulrich currently works for Weston Solutions, Inc., and is the leader of the Southern Division's Natural Resource Management Team. Previously she worked with USACE, with the last decade at USACE Jacksonville in a senior leadership position on the Everglades Ecosystem Restoration Program. Ms. Ulrich is a registered professional engineer, with a BS and MS in civil engineering.

Ms. Ulrich has more than 20 years' experience managing large, complex civil works projects for the USACE; over eight years of civil works plan formulation experience on watershed studies,

flood damage reduction, beach nourishment, deep draft navigation, water supply reallocation, and long-term drought management; over seven years of civil works project management experience in ecosystem restoration, flood damage reduction, beach nourishment, deep draft navigation, and hydropower rehabilitation; and over five years of senior civil works program experience on the South Florida Everglades Ecosystem Restoration Program. Ms. Ulrich is currently teaching a Civil Works plan formulation and leadership development course for USACE Jacksonville.

Ms. Ulrich has familiarity with the economic evaluation of flood risk management alternatives including the development of average annual costs and benefits, calculation of net benefits, and identification of the National Economic Development (NED) plan.

While working for USACE Jacksonville District, Ms. Ulrich was the project manager for the Modified Water Deliveries to Everglades National Park 8.5 Square Mile Area flood mitigation project, which was the lynchpin to moving Everglades restoration forward. The 8.5 Square Mile Area involved the largest buy-out within the Everglades Restoration program.

While working for USACE Mobile District, Ms. Ulrich was the planning technical lead for watershed studies for Atlanta, Georgia; Birmingham, Alabama; and Cahaba River, Georgia—all involved flood risk management alternatives. Ms. Ulrich performed Water Supply Reallocation Reports for Lake Lanier, Carters Lake, and Allatoona Lake, which involved an analysis of flood control impacts due to the water reallocation within the reservoirs. She was the planning technical lead for the Panama City Beaches Hurricane and Storm Damage Reduction Project, which resulted in an 18.5 mile beach nourishment project (the largest in the US.)

While working for USACE Sacramento District, Ms. Ulrich prepared plans and specifications for the San Pablo and Wildcat Creeks, California, Flood Control Project and PL84-99 East Levee (Left Bank) Sacramento River emergency work, which protected the Sacramento Regional Airport.

As a USACE Civil Works planner, she has incorporated non-structural measures such as flood proofing and land acquisitions for flood damage reduction alternatives. She has also prepared several USACE planning feasibility studies that incorporated HEC-FDA, Micro-Computer Aided Cost Estimating System (MCACES), and HEC-RAS models.

Table 3. Rough River Dam IEPR Panel

		Prof. Scott Ashford	Mr. Donald Ator	Mr. Roberto Cuevas	Mr. Stephen Dickey	Prof. Jim Dobberstine	Dr. William H. Espey, Jr.	Dr. Craig Findlay	Mr. Charles Hutton	Ms. Cheryl Ulrich
	Highest Degree	Ph.D.	M.B.A	B.S.	B.A.	M.S.	Ph.D.	Ph.D.	M.S.	M.S.
	Years of Experience	28	32	34	35	10	50	36	40	20
	Past Experience with USACE Projects		●	●	●	●	●	●	●	●
	Affiliation (e.g., academia, consulting firm, government, etc)	Academia	Private	Private	Private	Academia	Consulting	Consulting	Private	Private
Geotechnical Engineer	≥20 years of experience in soils engineering or related field	●						●		
	Dam safety experience through participation in expert panels, risk evaluation/mitigation studies or similar experience with hydraulic retaining structures	●						●		
	Several years of direct experience with hydraulic retaining structure rehabilitation projects as either designer or construction project engineer	●						●		
	Adroit with risk informed approach to dam risk decision making	●						●		
	Design experience with seepage and piping, embankment stability, filter criteria, and foundation preparation	●						●		
	Design or construction experience evaluating slope sufficiency under a seismic load using geological analysis provided	●						●		
	Education and design or construction management experience with embankment dams and foundations and underground concrete structures including necessary worksite earthwork preparation and workflow management	●						●		
	Familiar with USACE application of risk and uncertainty analysis in flood damage reduction studies	●						●		

		Prof. Scott Ashford	Mr. Donald Ator	Mr. Roberto Cuevas	Mr. Stephen Dickey	Prof. Jim Dobberstine	Dr. William H. Espey, Jr.	Dr. Craig Findlay	Mr. Charles Hutton	Ms. Cheryl Ulrich
	Highest Degree	Ph.D.	M.B.A	B.S.	B.A.	M.S.	Ph.D.	Ph.D.	M.S.	M.S.
	Years of Experience	28	32	34	35	10	50	36	40	20
	Past Experience with USACE Projects		●	●	●	●	●	●	●	●
	Affiliation (e.g., academia, consulting firm, government, etc)	Academia	Private	Private	Private	Academia	Consulting	Consulting	Private	Private
Geologist	15–20 years' experience or combination of equivalent education and experience with karstic features, solution cavities, and weathered joints	●			●					
	Dam safety experience through participation in expert panels, risk evaluation/mitigation studies, projects or similar experience with assessment techniques of complex geologies	●			●					
	Experience with deep ground modification methods to include deep soil mixing, cut off walls, grouting, and related construction techniques	●			●					
	Several years' experience evaluating the results of ground water models using computer aided techniques	●			●					
	Familiar with USACE application of risk and uncertainty analysis in flood damage reduction studies	●								
Structural Engineer	15 years' experience and graduate study in the structural engineering field								●	
	Experience evaluating dam structural elements such as towers, spillway and regulating gates								●	
	Education and design experience evaluating reinforced concrete structures with emphasis on seismic analysis and design for industry codes standards and USACE design regulations, and dynamic site specific spectra analysis								●	
	Familiar with USACE application of risk and uncertainty analysis in flood damage reduction studies								●	
NEPA Impact Assessment Professional	≥10 years of experience working with the assessment of impacts on regional aquatic and terrestrial species, including lifecycles and habitat needs					●				
	Experience working on design or construction teams that work in or around fresh water lakes, streams and reservoirs					●				
	Detailed knowledge of the National Environmental Policy Act, Endangered Species Act with regional knowledge of specific regulatory requirements and Federal Services regulations					●				

		Prof. Scott Ashford	Mr. Donald Ator	Mr. Roberto Cuevas	Mr. Stephen Dickey	Prof. Jim Dobberstine	Dr. William H. Espey, Jr.	Dr. Craig Findlay	Mr. Charles Hutton	Ms. Cheryl Ulrich
	Highest Degree	Ph.D.	M.B.A	B.S.	B.A.	M.S.	Ph.D.	Ph.D.	M.S.	M.S.
	Years of Experience	28	32	34	35	10	50	36	40	20
	Past Experience with USACE Projects		●	●	●	●	●	●	●	●
	Affiliation (e.g., academia, consulting firm, government, etc)	Academia	Private	Private	Private	Academia	Consulting	Consulting	Private	Private
Engineering Cost Estimator	≥10 years' experience or combined equivalent of education and experience working with estimating complex, phased costing of multi-year civil construction projects			●						
	Direct experience working with hydraulic retention structures in a design or construction management capacity			●						
Hydraulic Engineer	10–15 years' experience or combined equivalent of education and experience in water management especially with managing water outflows from a reservoir and assessing hydraulic retention structures						●			
	Experience with characterizing surface water flows in a watershed using inundation mapping software and other water flow scenario development techniques and direct design experience with dam rehabilitation projects especially with regard to spillways, stilling basins and drainage pipes and tunnels						●			
	5–10 years' experience working with numerical modeling applications such as FLAC v6 software and familiarity with USACE standard hydrologic and hydraulic computer models						●			
	Familiar with USACE application of risk and uncertainty analysis in flood damage reduction studies						●			
Economist	5–10 years' experience or combined equivalent of education and experience in applied economics related to water resource economic evaluation or review		●							
	Experience working with risk informed approaches to decision making, risk models and disaster scenarios with regard to economic impact		●							
	≥2 years' experience working with HEC-FIA modeling software		●							
Plan Formulator	15–20 years' experience as a plan formulator who has worked with project teams, to identify and evaluate measures and alternatives using appropriate planning methodologies to reduce life safety risk									●
	Extensive experience reviewing the analysis with which the measures and alternatives were evaluated and that they are sufficiently comprehensive and complete to result in approval of a recommended alternative									●

4.3 Noblis Team

The Noblis Project Management Team (as outlined in Figure 3) included the following members:

Mr. Ahmad Faramarzi, PE, Project Manager, supervised project personnel and communicated policies, procedures, and goals to these employees, and maintained regular contact with the USACE. Mr. Faramarzi was responsible for the overall project plan, project performance, and client satisfaction on project tasks.

Ms. M.R. "Peaches" Callier, PG, RPG, Task Leader, developed the Work Plan and Report and provided technical leadership in managing the IEPR activities.

Ms. Tammy Ryan, Project Coordinator, supported the Project Manager on all IEPR tasks, including the identification and recruitment of candidates for the expert panel. Ms. Ryan also supported Ms. Callier in coordinating Rough River Dam IEPR activities.

Mr. Michael Barba and Ms. Christina Gannett served as Research Assistants and supported the IEPR activities on an as-needed basis.

Ms. Carolina Funkhouser provided Administrative Support for the project.

5 Conclusions and Observations

The Rough River Dam IEPR resulted in several comments on the adequacy of the information presented in the DSMS, as well as the information that was not found and recommended for inclusion. In general, the comments identify shortcomings and offer considerations that would improve the technical adequacy and overall quality of the DSMS. The comments also include a number of issues that should be addressed so the DSMS can be comprehensive in its representation of all factors that should be considered in determining and implementing the preferred alternative.

The general themes of the technical comments cover issues that are instrumental in being able to fully understand the technical information and rationale for the selected alternatives discussed in the DSMS. There are also a few comments regarding limitations in the overall design and approach of the preferred alternative that were not identified in the DSMS. Many of the comments include proposed measures to more accurately evaluate and account for risks to dam performance caused by seismic and solution features. Some issues presented in the IEPR pertain to environmental impacts from the preferred alternative that have not been considered. Many of the comments relate to the clarifications of cost and engineering factors that were considered in the evaluation of alternatives. Comments were rated as "high," "medium," or "low" to indicate the general significance the comment has to the sufficiency of the DSMS.

In general, the panel was unable to verify that the DSMS Report assembled all viable alternatives because the input data for the applicable evaluation models were unavailable for review. The DSMS Report did identify the analyses, methods, and models used in evaluating each alternative. However, the level of alternative analysis was inconsistently applied amongst the alternatives. The panel comments reflect concern over application of the plan formulation process while performing the DSMS. The panel identified several issues affecting costs and technical assumptions used in selecting the preferred alternative. The importance of involving different stakeholders as part of the planning process is reflected in the DSMS Report, yet the public comments were excluded. These considerations are essential for the DSMS to sufficiently

demonstrate to the public that the selection of the preferred alternative was both appropriate and unbiased.

Economics. The DSMS economic evaluation included appropriate analysis for evaluating the benefits and costs associated with each alternative. The methodology and approach of the benefits and costs analysis were adequate for properly evaluating and comparing the alternatives; however, all of the information used in the analysis was not provided for review by the panel. Specifically, the HEC-FIA input and output data were not provided and the cost estimate for each alternative was not provided with the same level of detail. Consequently, no qualified statements can be made regarding the accuracy of the results of the benefits and costs analyses. The panel members offered comments based on professional experience and standard industry practices.

Engineering. The panel focused on the Rough River Dam area subsurface conditions that have been identified and on the design of the cutoff wall as a means of remediation to address the identified deficiencies with regard to the stability of the dam and dam safety. Overall, the panel concurs that the selection of a cutoff wall to rehabilitate the structure is appropriate to address the seepage deficiencies of the project and finds that the engineering principles and methods used in conducting design analysis and developing the conceptual design of the preferred alternative are sound. For the selected alternative, the DSMS Report included several detailed drawings and analyses. The panel's comments primarily relate to the lack of sufficient data and important considerations needed to improve the analyses, such as the need for deeper exploration for final design, slope stability associated with seepage conditions at the existing toe drain cutoff, investigation of anomalies identified by geophysical investigations that have been made, and approaches to seepage analysis under the dam. The panel also identified other deficiencies such as site-specific seismic characterization and liquefaction analysis. Some inconsistencies in the risk assessment with regard to classification of the dam's overall risk were pointed out, which should be addressed. The panel recognizes that this is not the final design and that additional field investigations and detailed analyses still need to be performed to address the identified concerns. Some general suggestions regarding this additional investigation and design have also been provided.

Environmental. The DSMS presented specific environmental benefits associated with the preferred alternative; but, these benefits were presented insufficiently with respect to other alternatives considered. The DSMS does not adequately address alternatives analyses, cumulative impacts, and other critical issues required by the NEPA and other relevant federal laws and regulations. The panel identified certain environmental considerations that were not included in the DSMS Report pertaining to negative environmental impacts that could result from the project. The panel also recognizes that revised consideration of environmental impacts and additional measures to avoid, minimize, and mitigate these impacts will be addressed in later phases of the project.

A number of editorial comments were also provided. Although they should be addressed to improve the overall quality of the DSMS, they are not included in the final list of IEPR comments. These editorial comments are provided in Appendix A.3 of the report.

6 References Used During the IEPR Process

Ashford, S.A., R.W. Boulanger, and S.J. Brandenberg. 2011. *Recommended Practice for the Design of Pile Foundations in Laterally Spreading Soils,* PEER Report 5/2011, Pacific Earthquake Engineering Research Center. May.

Bray, J.D. and R.B. Sancio, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils," *Journal of Geotechnical and Geoenvironmental Engineering,* ASCE, September 2006, Vol. 132, No. 9, pp. 1165-1177, doi: 10.1061/(ASCE)1090-0241(2006)132:9(1165).

Council on Environmental Quality: Regulations for Implementing NEPA. Title 40 C.F.R., Chapter V, Part 1500 through 1518.

Department of the Army. 2002. 32 CFR Part 651. *Environmental Analysis of Army Actions; Final Rule.* March 29.

Department of the Army. 2010. USACE Engineer Circular (EC) No. 1165-2-209, *Civil Works Review Policy.* 31 January.

"Ecosystem Valuation." http://www.ecosystemvaluation.org/default.htm. Site accessed June 2011.

Endangered Species Act of 1973. 16 U.S.C. 1531.

Fritiofson v Alexander, 772 F.2d 1225 (5th Cir. 1985).

Galveston Beach to Bay Preserve v USACE, Civil Action No. G-07-0549, WL 689884 (S.D.Tex 2009).

Krchnak et al. 2009. "Integrating Environmental Flows into Hydropower Dam Planning, Design, and Operations." *Water Working Notes*; Note No. 22. November.

Mahan, Brent. USACE Portland District. 1997. *Valuing Urban Wetlands; A Property Pricing Approach.* IWR Report 97-R-1. Prepared for the Evaluation of Environmental Investments Research Program (USACE). March. Viewable at http://www.iwr.usace.army.mil/docs/iwrreports/97r01.pdf.

The Nature Conservancy Sustainable Rivers Project. 2010. www.nature.org/ourinitiatives/habitats/riverslakes/sustainable-rivers-project.xml. Site accessed June 21.

NOAA Coastal Services Center. 2011. "Environmental Valuation: Principles, Techniques, and Applications." http://www.csc.noaa.gov/coastal/economics/envvaluation.htm. Site accessed June.

Office of Management and Budget (OMB). 2004. *Final Information Quality Bulletin for Peer Review,* released 16 December.

USACE Louisville District. 2009. *Dam Safety Modification Report, Rough River Dam, Green River Basin, Falls of Rough, Kentucky.* September.

USACE Louisville District. 2011. *Statement of Work, Rough River Dam, KY, Dam Safety Modification Study*. February.

Operation and Maintenance Manual. Rough River Lake. Provided by USACE Louisville District, *1987 Revisions. USACE Institute for Water Resources. 2010. QCC Out-brief for Rough River Dam. May.

Postel, S. and Richter, B. 2003. *Rivers for life: Managing water for people and nature*. Washington, DC, US: Island Press.

Quinn, et al. 2006. "Noise, predation risk compensation and vigilance in the chaffinch *Fringilla coelebs*." *Journal of Avian Biology*.

Richter et al. 2010. "Lost in Development's Shadow: The Downstream Human Consequences of Dams." *Water Alternatives* 3[2].

Shaub, et al. 2008. "Foraging Bats Avoid Noise." *Journal of Experimental Biology*.

Willowstick Technologies, LLC. 2007. *Aquatrack Geophysical Investigation of: Rough Rivr Dam (Delineation of Water Seepage Through Earthen Dam) for Fuller, Mossbarger, Scott and May Engineers, Inc.* December.

Appendix A – IEPR Comments

A.1 Final IEPR Comments

This Appendix provides the IEPR comments on the DSMS and related documents for the Rough River Dam, Kentucky. The comments cover a range of issues that pertain to the technical aspects of the DSMS.

Each comment is formatted into four parts that include the following: (1) a clear statement of the concern ("Comment"), (2) the basis for the concern ("Basis for Comment"), (3) the significance of the concern (the importance of the concern with regard to project implementability) ("Significance"), and (4) the recommended actions necessary to resolve the concern to include a description of any additional research that would appreciably influence the conclusions ("Recommendation for Resolution"). Comments were rated as "high," "medium," or "low" to indicate the general significance the comment has to the sufficiency of the DSMS. The significance ratings are applied using the following criteria:

- High = Comment describes a fundamental problem with the project that could affect the recommendation or justification of the project
- Medium = Comment affects the completeness or understanding of the recommendation or justification of the project
- Low = Comment affects the technical quality of the reports but will not affect the recommendation or justification of the project

A.2 Summary of Comments

Following is a listing of the final comments.

Table A-1. Overview of Final Comments Identified by IEPR Panel

Significance – High
The panel is concerned about proper application of the U.S. Army Corps of Engineers (USACE) plan formulation process in the Rough River Dam Safety Modification Study (DSMS). (Comment #1)
The annualized probability of failure of 28.1% seems high and inconsistent with the Statement of Issues in the Project Fact Sheet, which indicates that the dam is classified as Dam Safety Action Classification (DSAC) II and that "[u]nacceptable foundation conditions and associated seepage required investigation and analysis to remove uncertainty and lower project risk." (Comment #2)
A deterministic seismic hazard evaluation would be needed to estimate the earthquake ground motions for the Maximum Credible Earthquake (MCE). The MCE used in the DSMS Report is for an earthquake with a 2% chance of being exceeded in 50 years (or a return period of 2,475 years). This probability is too low and the return period too short for the MCE. As indicated in the report, some agencies have suggested that a return period of 5,000 or 10,000 years should be considered for the MCE. A longer return period would seem to be more appropriate if a probabilistic assessment is used to determine the MCE for the project. (Comment #5)

The panel is concerned about the seismic performance of the dam, particularly the risk of liquefaction of the sand layer underlying the dam. (Comment #6)
The data indicates that slope stability and heave potential are possibly affected by piezometer levels across the cutoff wall that are installed to facilitate the toe drain rehabilitation. (Comment #9)
The Willowstick contour plot shows two seepage “sinks” under the toe of the dam, one adjacent to the left side of the cutoff wall and one larger sink further to the left. There also appears to be a “sink” further to the left of the cutoff wall at elevation 455 ft. The panel is concerned that these “sinks” may be downward solution feature “drains” that could eventually impact the dam. (Comment #10)
There are inconsistencies in the DSMS regarding the intake tower failure mode and the reported probability of failure from the analysis. There are also contradictory statements regarding the probability of shear failure. (Comment #11)
The alternatives considered in the DSMS Report are not consistently evaluated. Additionally, the DSMS Report lacks a logic trail within the Alternative 6 evaluation concluding with a Roller Compacted Concrete (RCC) Structure as the elected “Remove and Replace Structure.” (Comment #13)
Although the borings have not been extended deeper than the Sample Sandstone, USACE intends to use this stratum as the base of the cutoff wall. (Comment #14)
The panel is concerned about the possibility of solution paths (open or gouge filled) on the untreated conduit excavation sidewalls. The description of Alternative Plan #4 seems to indicate that grouting from the conduit is only planned through the bottom of the conduit. The grouting might bypass potential defects/seepage windows to the sides and above the conduit. (Comment #15)
Consideration of cumulative impacts is incomplete within the DSMS Report and alternatives therein. (Comment #22)
Impacts to endangered species have not been sufficiently addressed within the Environmental Assessment (EA) and DSMS Report. (Comment #23)
No qualified review comments were possible regarding the accuracy of the damages prevented and the benefits of the project alternatives. (Comment #28)
Written documentation should be included in Appendix G to describe the tower failure analysis using the Structural Toolbox. (Comment #32)
Written documentation should be included in the main report or appendix to explain how the probabilities were determined using the Mechanical and Electrical Toolbox. (Comment #33)
The cost estimate for the RCC dam alternative should include the same level of detail as the cost estimate for the cutoff wall alternative in order for a reasonable (and unbiased) comparison to be made. (Comment #34)

Significance – Medium
The panel is concerned with the risk of using geotextile as part of an emergency reverse filter over a boil, especially if the boil is carrying dirty water (fines transport). (Comment #8)
Environmental impacts of the cutoff wall have been dismissed; however, if construction requires significant lowering of the reservoir, there could be associated environmental impacts. Also, in constructing the cutoff wall, even with grouting of the adjacent rock, there is a potential for grout plumes or slurry wall loss to downstream areas. (Comment #16)
The panel is concerned that the conclusions presented in Chapter 9 (Comparison of Alternative Risk Management Plans) are not justified by the data presented. (Comment #18)
Figures 9.1 and 9.2 do not support the conclusion that the cutoff wall plan reflects the most significant risk reduction. (Comment #19)
Work necessary to resolve the foundation rock underlying the embankment problem should be treated as an allowance in the cost estimate as opposed to a contingency. (Comment #20)
EA and Finding of No Significant Impact (FONSI) should be integrated into the main document. Also, reconcile inconsistencies between the DSMS Report and EA in alternative presentation. (Comment #21)
It is not clear from the DSMS Report whether there are alternatives that may allow for the partial recovery of endangered mussel species and their associated ecologic communities downstream of the project. (Comment #24)
The Public Involvement and Coordination section should highlight comments received from public. (Comment #25)
The assumption that structures have a first floor elevation of 3-ft above grade (Appendix E, p. 18) may result in significantly underestimating the flood damages/benefits and the benefit/cost ratios. (Comment #29)
The SEEP/W Analysis (Appendix G) does not adequately consider possible high permeability flow paths in rock foundation. (Comment #31)
Specified tasks in the Project Direct Costs Report have no assigned cost. (Comment #35)
The hydrologic analysis of the Rough River Dam historical record does not include the period from December 1960 to 1983. (Comment #37)
The Willowstick Report does not adequately discuss the method's ability to locate seepage targets in presence of embankment and foundation materials consisting of clay or large percentages of clay that have very high electrical conductivity. (Comment #39)
Significance – Low
The panel agrees with the DSMS conclusion that the installation of a complete cutoff wall with foundation grouting and the construction of a conduit filter are required to mitigate the risk of piping and potential dam breach as a result of the rock defects. (Comment #3)
A summary description of the Emergency Action Plan (EAP) should be provided somewhere in the introductory sections of the report. (Comment #4)

The DSMS Report does not adequately explain the project purposes that would be negatively impacted by Reservoir Restriction as an Interim Risk Reduction Measure (IRRM). (Comment #7)
Although it will not change the result, the maximum annualized loss of life on p. 136 of the DSMS Report should be 6.14E-09 as shown in Table 5.11. (Comment #12)
The DSMS Report contains no discussion regarding the amount of permanent loss (or gain) of wetlands associated with dam removal (Alternative 5). (Comment #17)
Appendix E, Table 1 shows the number of structures flooded and the population at risk for the nine considered scenarios reflecting a number of persons per structure that ranges from 1.05 to 1.11. (Comment #26)
Additional information is needed in the DSMS Report regarding damages and benefits used to justify the project. (Comment #27)
The assumed elevation for initial flood damage to vehicles is not indicated. (Comment #30)
Specified tasks in the Project Direct Costs Report have assigned costs that are too low. (Comment #36)
Both documents (*Dam Failure Analysis Toolbox [Draft] 2007* and *Inflow Flood Hydrographs Toolbox [Draft] 2007*) are in draft form and are not publically available. (Comment #38)

The following pages outline the Comments in detail, including the four-part analysis of each. The comments are presented chronologically (starting with general comments and then in order of occurrence in the DSMS).

Comment 1
The panel is concerned about proper application of the U.S. Army Corps of Engineers (USACE) plan formulation process in the Rough River Dam Safety Modification Study (DSMS).
Basis for Comment:
There are inconsistencies in the level of detail provided in the evaluation of alternatives. Failure to demonstrate evaluation consistency could lead the public to perceive that the USACE selected an alternative prior to the plan formulation process. Examples include assumptions regarding the immediate selection of Roller Compacted Concrete (RCC) Structure for Alternative 6 "Remove and Replace Structure," and lack of documentation regarding the National Environmental Policy Act (NEPA) process comments and resolution.
Significance:
HIGH
Recommendation for Resolution:
The panel has recommended various resolutions. See comments 13, 16–19, 21, 22, 24–30, and 34.

Comment 2
The annualized probability of failure of 28.1% seems high and inconsistent with the Statement of Issues in the Project Fact Sheet, which indicates that the dam is classified as Dam Safety Action Classification (DSAC) II and that "[u]nacceptable foundation conditions and associated seepage required investigation and analysis to remove uncertainty and lower project risk."
Basis for Comment:
The baseline probability of failure is estimated at an annualized probability of 2.81E-01 and expected annualized loss of life is approximately 2. Figure 1.2 of the DSMS Report indicates a corresponding life loss estimate of approximately 7 for baseline conditions and approximately the same for restrictive pool operations. Yet, the probability of experiencing failure at Rough River Dam for a number of consecutive years is as follows, 3yr - 62.8%, 5yr - 80.8%, and 10yr 96.6%, which suggests a possible DSAC I classification.
Significance:
HIGH
Recommendation(s) for Resolution:
Provide justification and supporting analysis for the DSAC II classification of the dam, which appears to be solely based on loss of life estimates.

Comment 3
The panel agrees with the DSMS conclusion that the installation of a complete cutoff wall with foundation grouting and the construction of a conduit filter are required to mitigate the risk of piping and potential dam breach as a result of the rock defects.
Basis for Comment:
All data and engineering aspects of the project presented in the DSMS Report support this conclusion.
Significance:
LOW
Recommendation for Resolution:
Resolution not required.

Comment 4
A summary description of the Emergency Action Plan (EAP) should be provided somewhere in the introductory sections of the report.
Basis for Comment:
A summary description has been provided in Section 3.4.3 (IRRM Alternatives Considered) of the DSMS Report but should also be included in the Recommended Future Project Monitoring and Surveillance section of the Executive Summary. Additionally, documentation of the actual plan should be included in the DSMS Report.
Significance:
LOW
Recommendation for Resolution:
The EAP is currently being revised based on additional information. Upon completion of the EAP revision, include a summary/description of the EAP in the introductory section of the report.

Comment 5
A deterministic seismic hazard evaluation would be needed to estimate the earthquake ground motions for the Maximum Credible Earthquake (MCE). The MCE used in the DSMS Report is for an earthquake with a 2% chance of being exceeded in 50 years (or a return period of 2,475 years). This probability is too low and the return period too short for the MCE. As indicated in the report, some agencies have suggested that a return period of 5,000 or 10,000 years should be considered for the MCE. A longer return period would seem to be more appropriate if a probabilistic assessment is used to determine the MCE for the project.
Basis for Comment:
ER 1110-2-1806 and *EM 1110-2-2100* specify that the MCE should be established based on a deterministic seismic hazard assessment. A deterministic seismic hazard evaluation was completed for the *1997 Phase I Seismological/Geological Evaluation,* but not for the latest study. Some references in the DSMS indicate that the MCE can be estimated from a probabilistic seismic hazard evaluation, but must be linked with a very long return period (with a 50% or higher probability of not being exceeded over an extended number of years).
Significance:
HIGH
Recommendation for Resolution:
Complete a deterministic seismic hazard evaluation or provide the following in the report: 1. Detailed rationale for using a probabilistic seismic hazard assessment; 2. Basis for selection of the return period for the MCE; and 3. Justification for not performing a deterministic seismic hazard assessment in accordance with the requirements of the USACE engineering regulations and manuals.

Comment 6
The panel is concerned about the seismic performance of the dam, particularly the risk of liquefaction of the sand layer underlying the dam.
Basis for Comment:
This concern arises due to the presence of very loose sand under the dam, the heavy reliance on the 1997 seismic study, and the apparent inconsistent treatment of seismic risk compared to other hazards. Specifically, the panel is concerned about the presence of the very loose to loose clean sand underlying the dam as noted on the boring logs (e.g., Boring AD-106 in Appendix G, p. 1441) and statistical blow count analysis (Appendix G, p. 2022) where very low N1(60) are noted in the sand layers. While the potential for liquefaction is mentioned for Potential Failure Modes (PFM) 17 and 18, they are deemed in the DSMS Report (pp. 66–67) to be less likely due to the "relatively dense" nature of the materials and the "firm foundation." The panel is less concerned with the liquefaction potential of the embankment soils when the plasticity index (PI) is 10–24, although current practice recommends laboratory testing to determine the cyclic strength of loose soils with PI's between 7 and 20 *(Bray and Sancio 2006, Ashford et al. 2011)*. The panel is also concerned about the reliance on data from the 1997 Seismic Evaluation Report. Over the last 14 years, the U.S. Geological Survey (USGS) has increased their estimates of ground motions at the site, and significant advances in the profession have been made with regard to residual strengths and the effect of fines content on liquefaction potential.
Significance:
HIGH
Recommendation for Resolution:
Complete an updated detailed study on the seismic performance of the dam, including liquefaction and seismic slope stability analyses, using the most current ground motion estimates available consistent with USACE policies. If deficiencies in the anticipated performance are identified, they should be remediated.

Comment 7
The DSMS Report does not adequately explain the project purposes that would be negatively impacted by Reservoir Restriction as an Interim Risk Reduction Measure (IRRM).
Basis for Comment:
The DSMS Report indicates that other project purposes will also be negatively impacted, but does not identify the other project purposes (p. 76). Additionally, no explanation is given for the effect of Reservoir Restriction on utilities.
Significance:
LOW
Recommendation for Resolution:
Provide further clarification of the evaluation of Reservoir Restriction to adequately describe the consideration of IRRM alternatives to the reader.

Comment 8
The panel is concerned with the risk of using geotextile as part of an emergency reverse filter over a boil, especially if the boil is carrying dirty water (fines transport).
Basis for Comment:
Geotextiles tend to “blind” and blinding could result in the development of additional problems such as the occurrence of a blowout adjacent to the filter blanket (p. 8 of DSMS Report).
Significance:
MEDIUM
Recommendation for Resolution:
It is important to use only appropriately graded soils in a reverse filter blanket (meeting filter criteria). The USACE could consider using a coarser geogrid as a base mat as it does not blind.

Comment 9
The data indicates that slope stability and heave potential are possibly affected by piezometer levels across the cutoff wall that are installed to facilitate the toe drain rehabilitation.
Basis for Comment:
The Willowstick results show water "piling up" in the embankment soils upstream of the cutoff wall, with about a 15–20 ft differential (see the results in Figure 4.1 on p. 91; piezometers PZ 29 in Figure 2-13 and PZ 28 in Figure 2-14, located upstream of the wall; and PZ 31 in Figure 2-13 and PZ 32 in Figure 2-14, located downstream of the wall). This differential pressure is represented by water levels in the embankment piezometers from elevation 456–457 ft upstream of the wall, and elevations 442–444 ft downstream of the wall. The four piezometers are in the embankment soils and horizontal drain, with piezometer tip elevations between 421–433 ft. Interestingly, Piezometer PZ 18B (Figure 2-15) located downstream of the wall, but in the foundation clays below the embankment (tip at elevation 409 ft) shows water levels 10–20 ft higher than the upstream piezometers (water level from 470–480 ft, according to the Figure 2-15 plot), suggesting a strong upward gradient compared to the downstream piezometers, which indicates 28–38 ft differential between the foundation piezometer PZ 18B and downstream embankment piezometers PZ 31 and PZ 32 (DSMS Figures 2-13 through 2-15).
Significance:
HIGH
Recommendation for Resolution:
Consider additional analysis of slope stability and heave potential for a cross section across the cutoff wall using the post-cutoff wall phreatic conditions.

Comment 10
The Willowstick contour plot shows two seepage "sinks" under the toe of the dam, one adjacent to the left side of the cutoff wall and one larger sink further to the left. There also appears to be a "sink" further to the left of the cutoff wall at elevation 455 ft. The panel is concerned that these "sinks" may be downward solution feature "drains" that could eventually impact the dam.
Basis for Comment:
Figure 4.1, p. 91 of Willowstick results indicates flow paths down to elevation 431 ft and 440 ft (old datum) on both sides of the cutoff wall, and Site Plan Drawings R89-12, 3/2 and R89-12, 3/4 indicate the bottom of the base of the dam is at about elevation 450 ft (old datum) in this vicinity. Therefore, the Willowstick results indicate downward flow (or "drains") into the foundation on both sides of the cutoff wall. There also appears to be a "sink" further to the left of the cutoff wall with elevation 455 ft, but this might be just drainage into the horizontal drain layer.
Significance:
HIGH
Recommendation for Resolution:
Consider additional site investigation of possible "sink" areas. It may be beneficial to place nested piezometers in these areas to assess any future changes in gradient, which could portend a developing problem.

Comment 11
There are inconsistencies in the DSMS regarding the intake tower failure mode and the reported probability of failure from the analysis. There are also contradictory statements regarding the probability of shear failure.
Basis for Comment:
Page 134, para. 5.5.3 indicates the probability of failure of the tower is controlled by a single failure mode, which is fracturing of the vertical reinforcement leading to collapse of the tower. Para. 5.5.6 indicates the total probability of shear failure of the tower given an earthquake coincident with pool is 1.47E-05. Para. 5.5.4 indicates shear failure is not likely. Para. 5.5.6 does not give the probability of failure due to fracturing of the vertical reinforcement. The probabilities of failure given in Table 5.10 do not agree with the probability of failure given in para. 5.5.6.
Significance:
HIGH
Recommendation for Resolution:
Resolve inconsistencies and contradictory statements.

Comment 12
Although it will not change the result, the maximum annualized loss of life on p. 136 of the DSMS Report should be 6.14E-09 as shown in Table 5.11.
Basis for Comment:
The last paragraph on p. 136 of the DSMS Report indicates the annualized loss of life shown in Table 5.11 is less than 5.7E-09. This is an inconsistency that should be clarified.
Significance:
LOW
Recommendation for Resolution:
Clarify inconsistency.

Comment 13
The alternatives considered in the DSMS Report are not consistently evaluated. Additionally, the DSMS Report lacks a logic trail within the Alternative 6 evaluation concluding with an RCC as the elected "Remove and Replace Structure."
Basis for Comment:
ER 1105-2-100 defines the USACE six-step planning process. Step 5 - Comparing Alternative Plans requires that plans (including the no action plan) are compared against each other. A comparison of the outputs of the various plans as well as beneficial and adverse effects of each plan must be compared. The identification and documentation of tradeoffs are required to support the final recommendation.
Significance:
HIGH
Recommendation for Resolution:
Make the alternatives in the DSMS Report consistent by either presenting each alternative with the same level of detail or adding a preliminary screening section. For Alternative 6, document all structures considered (e.g., whether or not considerations included construction of an earth-filled dam or an RCC replacement dam downstream). This would eliminate the annual foregone benefits listed in 8.6.3.2 and reduce the environmental consequences listed in 8.6.3.3.

Comment 14
Although the borings have not been extended deeper than the Sample Sandstone, USACE intends to use this stratum as the base of the cutoff wall.
Basis for Comment:
During the site meeting with the USACE, it was indicated that there have not been any explorations deeper than the Sample Formation. The two deepest exploration borings extend to an elevation of 390 ft above mean sea level (MSL), yet the cutoff wall as described in Section 8.4 (Alternative Plan #4 – Cutoff Wall with Foundation Grouting, Conduit Grouting and Conduit Filter) is proposed to extend to an elevation of 380 ft, and each grout curtain extends deeper to an elevation of 350 ft (elevation 300 ft being about 150 ft below the valley bottom, and about 300 ft below the crest). This raises a question with regard to whether extending the cutoff wall to the Sample Sandstone is deep enough or not. Based on the exploration drilling, we do not know if there are deeper significant solution susceptible layers that could cause problems in the future. The SEEP/W Analysis assumes there are no features with significant hydraulic conductivity in the rock foundation; in other words, the seepage analysis assumes the top of the foundation rock is an effective hydraulic boundary. It is noted that the Mammoth Caves are in the same geological province and extend much deeper than 150 ft. A depth of 150 ft is probably shallow enough to at least bridge over any larger solution voids that are deeper, assuming solution activity above Sample Sandstone is limited; however, a deep boring or two (with packer testing and deep piezometer) may be prudent considering the geology and hydrogeologic vertical pressure gradients.
Significance:
HIGH
Recommendation for Resolution:
Consider additional site investigation with deeper borings to determine subsurface conditions below the proposed cutoff wall base level (Sample Sandstone). Geophysical borehole testing techniques should be considered that could be used to “see” solution features that may exist. The panel suggests evaluating the use of borehole imaging (optical and acoustic televiewer), borehole ground-penetrating radar, temperature logging, borehole resistivity, and borehole caliper logging in addition to coring. Piezometer nests would help to understand vertical gradients.

Comment 15
The panel is concerned about the possibility of solution paths (open or gouge filled) on the untreated conduit excavation sidewalls. The description of Alternative Plan #4 seems to indicate that grouting from the conduit is only planned through the bottom of the conduit. The grouting might bypass potential defects/seepage windows to the sides and above the conduit.
Basis for Comment:
Based on original construction pictures, USACE has indicated that the conduit excavation walls are a rock cut that was untreated, and still represent potential piping paths from the conduit soil backfill into the solution-prone rock. This is supported by the description of Alternative Plan #4 and the drawings of remediation in Appendix K of the DSMS Report. Also, the cutoff wall across the conduit location is proposed to be implemented using secant piles and grouting through the bottom of the conduit. This has the potential to leave "windows" for seepage on the sides and top of the conduit.
Significance:
HIGH
Recommendation for Resolution:
Consider grouting the bedrock on both sides of the conduit to seal potential untreated solution paths in the untreated conduit excavation sidewalls. In addition, a more comprehensive grouting plan from the conduit should be considered to make sure seepage "windows" between the proposed cutoff wall and conduit do not result.

Comment 16
Environmental impacts of the cutoff wall have been dismissed; however, if construction requires significant lowering of the reservoir, there could be associated environmental impacts. Also, in constructing the cutoff wall, even with grouting of the adjacent rock, there is a potential for grout plumes or slurry wall loss to downstream areas.
Basis for Comment:
The discussion in Section 8.4.3.3 (Environmental Consequences), which summarizes the discussions in the Environmental Assessment (EA), concludes that environmental impacts are not relevant in consideration of the Alternative 4 without considering all potential environmental impacts. This panel concern is further discussed in comment 22.
Significance:
MEDIUM
Recommendation for Resolution:
Add additional discussion in the DSMS Report to include consideration of these potential environmental impacts, as appropriate.

Comment 17
The DSMS Report contains no discussion regarding the amount of permanent loss (or gain) of wetlands associated with dam removal (Alternative 5).
Basis for Comment:
It is possible that the total acreage, functions, and services of wetlands following ecologic succession coupled to a large disturbance like dam removal might not match the existing wetlands. Total wetland acreage would probably be reduced, but net loss or gain of functions and services would need to be considered. The discussion present in the DSMS Report is not sufficient to assess the effects of dam removal in this regard, as detailed in 32 CFR Subpart E, 651.34(f).
Significance:
LOW
Recommendation for Resolution:
This consequence should be discussed more thoroughly in the DSMS Report than it is currently, particularly regarding functions and services, as that is the basis for USACE wetland impact analysis and mitigation requirements. The panel does not think a detailed analysis (i.e., hydrogeomorphic [HGM]) would need to be completed at this point, since the dam removal alternative is not likely a viable option based on the USACE risk estimates, and an HGM analysis would be completed for an environmental impact statement (EIS) in the event this alternative was chosen. However, reasonable estimates of acreage impacts and wetland types impacted (and by extension functions and services altered) could be made using GIS overlays of aerial photos incorporating data from the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) and other data sets.

Comment 18
The panel is concerned that the conclusions presented in Chapter 9 (Comparison of Alternative Risk Management Plans) are not justified by the data presented.
Basis for Comment:
The data presented in Figures 9.1 and 9.2 do not appear to be consistent (it may be that the RCC Dam in Figure 9.2 is incorrectly plotted). As currently presented, the data seems to support that the RCC Dam shows the lowest life safety risk, contrary to the conclusion in Section 9.2.1. Furthermore, no data is specifically referenced in Section 9.1 to support that the cutoff wall shows the most significant risk reduction.
Significance:
MEDIUM
Recommendation for Resolution:
To resolve these concerns, modify Chapter 9 of the DSMS Report so that the conclusions are clearly justified by the data presented.

Comment 19
Figures 9.1 and 9.2 do not support the conclusion that the cutoff wall plan reflects the most significant risk reduction.
Basis for Comment:
The annualized probability and annualized loss of life appear to be less for the RCC alternative. It is not clear why the cutoff wall plan shows the lowest individual life risk. Further explanation and clarification are required to understand which alternative will provide the most significant risk reduction.
Significance:
MEDIUM
Recommendation for Resolution:
Provide additional explanation and clarification.

Comment 20
Work necessary to resolve the foundation rock underlying the embankment problem should be treated as an allowance in the cost estimate as opposed to a contingency.
Basis for Comment:
This directly affects cost estimate accuracy.
Significance:
MEDIUM
Recommendation for Resolution:
The cost estimate should treat the work as an allowance. The cost estimate has sufficient detail to minimize contingency.

Comment 21
EA and Finding of No Significant Impact (FONSI) should be integrated into the main document. Also, reconcile inconsistencies between the DSMS Report and EA in alternative presentation.
Basis for Comment:
The Agency Technical Review (ATR) comment submitted by Ray Hedrick (5 May 2009) expressed a similar concern. ATR resolution was that the EA and FONSI would be reproduced as a section within the report. This was not completed even though the comment was closed out and it was stated that the issue was resolved.
Significance:
MEDIUM
Recommendation for Resolution:
Include the EA and FONSI in the DSMS Report.

Comment 22
Consideration of cumulative impacts is incomplete within the DSMS Report and alternatives therein.
Basis for Comment:
Cumulative impacts are seemingly dismissed in the EA in the first three sentences, culminating in, "…cumulative impacts are not a significant issue in consideration of the proposed action or any of the other alternatives considered except for no action." This determination is based on an incomplete analysis of the impacts (noise, light, etc.), and does not fully consider the RCC alternative (see comment 13). Additionally, the EA continues on to describe some of the cumulative impacts of the no action alternative in the event of a failure of the dam, but does not consider other past, present, or foreseeable future actions by the USACE or any other parties, and only addresses the no action alternative (again omitting other alternatives including the RCC alternative). While the cumulative impacts from the preferred alternative may turn out to be minor, NEPA and the USACE regulations are clear regarding what must be considered when assessing cumulative effects in a NEPA analysis: ▪ *32 CFR Subpart B*, 651.16: "Cumulative Impacts: (a) NEPA analyses must assess cumulative effects, which are the impact on the environment resulting from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Actions by federal, non-federal agencies and private parties must be considered (40 CFR 1508.7)." ▪ Referring to the *EA, 32 CFR Subpart E*, 651.34(f) specifies that "...The document must state and assess the effects (direct, indirect, and cumulative) of the proposed action and its alternatives on the environment, and what practical mitigation is available to minimize these impacts. Discussion and comparison of impacts should provide sufficient analysis to reach a conclusion regarding the significance of the impacts, and is not merely a quantification of facts." ▪ See also 32 CFR Subpart C, 651.20, "Environmental Assessment." Failure to fully consider and document cumulative impacts could expose the project to legal challenge. There is a fair amount of case law regarding insufficient consideration and documentation of cumulative impacts in NEPA analyses, which may also provide guidance (i.e., *Fritiofson v Alexander, 772 F.2d 1225* (5th Cir. 1985); *Galveston Beach to Bay Preserve v USACE*, Civil Action No. G-07-0549, WL 689884 (S.D.Tex 2009).
Significance:
HIGH
Recommendation for Resolution:
Cumulative effects need to be more fully considered (or better documented) within the alternatives analysis and treated more equally among the alternatives considered, consistent with regulatory requirements.

Comment 23
Impacts to endangered species have not been sufficiently addressed within the EA and DSMS Report.
Basis for Comment:
Noise, light, vibration, and air pollutants should be considered as potential impacts when considering alternatives in the DSMS Report, particularly as applied to endangered bat species. Insectivorous bats, including Gray and Indiana bats, are ecologically important species, and are declining rapidly in population size, reducing their ability to fill their ecologic niche. Research has been conducted examining noise impacts on bats and birds. This research indicates these organisms are sensitive to noise and are often displaced as a result (Shaub, et al. "Foraging Bats Avoid Noise." *Journal of Experimental Biology*. 2008.; Quinn, et al. "Noise, predation risk compensation and vigilance in the chaffinch *Fringilla coelebs*." *Journal of Avian Biology*. 2006.; many others). Noise can disrupt forage patterns and activity, and may alter roost selection and gestation success. According to the USFWS, disturbance of bats in winter caves greatly decreases their chances of survival; disturbance of maternity (summer) caves can cause large-scale mortality to flightless young. Bats can range 10–12 miles from their colony to feed. The bat species of concern in this project currently suffer significant losses annually from white-nose syndrome (linked to the fungus *Geomyces destructans*), habitat disturbance, and pesticides. As these species are already in decline, they are likely more vulnerable to other environmental stressors. Conditions and population values may have declined substantially even since 2004 when the last work to the dam was scoped. Temporary direct effects can lead to permanent secondary and cumulative effects such as displacement and habitat fragmentation. Generally, threatened/endangered species are keystone species within their ecologic communities. Protection of these species can greatly benefit the community overall through the fulfillment of the species ecologic niches. According to the US Forest Service, these bats feed on nuisance and pest species, including alfalfa weevil and gypsy moth (pests that inflict significant economic and environmental damage nationally). Avoiding impacts to local bat populations could provide economic and environmental benefits not considered in the current DSMS Report (and likewise avoid localized costs such as increasing insect populations and subsequent pesticide applications to compensate for lost bat feeding activity also not considered in the DSMS Report). There is a substantial amount of information about how to calculate the economic value of the environmental services provided within local ecologic systems (i.e., www.ecosystemvaluation.org/default.htm, www.csc.noaa.gov/coastal/economics/envvaluation.htm, www.iwr.usace.army.mil/docs/iwrreports/97r01.pdf). Mitigation for impacts might include timing or phasing the project to occur when the animals have undertaken their seasonal migration to other locations, or structural sound and vibration attenuation during construction.
Significance:
HIGH

Recommendation for Resolution:
Include additional information in the DSMS Report in order to determine if impacts to endangered bats might be significant, and to identify: 1. Whether the adjacent habitat is critical habitat as defined in Section 2 of the ESA (16 USC 1531). 2. Whether noise and vibration (i.e., blasting associated with the installation of the proposed secant wall) and other construction activities (i.e., lights, extended shifts, etc.) might displace these species either temporarily or permanently. 3. Whether noise or other impacts may be significant as defined at 32 CFR Subpart E, 651.39, and whether any impacts to bats might represent a taking as defined by the ESA. 4. Whether mitigation might be necessary to avoid impacts as required under 32 CFR Subpart B, 651.15 “Monitoring and Mitigation.”

Comment 24
It is not clear from the DSMS Report whether there are alternatives that may allow for the partial recovery of endangered mussel species and their associated ecologic communities downstream of the project.
Basis for Comment:
While the preferred alternative does not appear to worsen instream conditions, the project alternatives analysis offers the opportunity to consider whether options exist that might improve those conditions. There is significant literature suggesting environmental flows (water and sediment) downstream of dams are of significant value to downstream communities (Richter et al. "Lost in Development's Shadow: The Downstream Human Consequences of Dams." *Water Alternatives* 3[2]. 2010). Efforts are being made throughout the United States and globally to assess environmental flow requirements and initiate water management strategies to this end. The USACE has partnered in these initiatives previously with noted success, including in the Green River system in Kentucky (Postel, S. and Richter, B. *Rivers for life: Managing water for people and nature*. Washington, DC, US: Island Press. 2003.; see also The Nature Conservancy Sustainable Rivers Project. Accessed June 21, 2010. www.nature.org/ourinitiatives/habitats/riverslakes/sustainable-rivers-project.xml). Endangered species of mussels endemic to Rough River were noted in the DSMS Report. Frequently, threatened/endangered species are keystone species within their ecologic communities. Recovery of these species, even to relatively low population values, can greatly benefit the ecologic community overall through the fulfillment of important, open ecologic niches. It is not clear whether there are alternatives that might allow for partial recovery of these species and their habitats to conditions more similar to those prior to the initial dam construction. Alternatives might consider either design or operational features that reflect consideration of natural environmental flows (Krchnak et al. "Integrating Environmental Flows into Hydropower Dam Planning, Design, and Operations." *Water Working Notes*; Note No. 22. November 2009). As much of the economic benefits noted in the DSMS Report are related to recreation (including fishing), even partial recovery of mussels and related habitat could provide economic and environmental benefits not considered in the DSMS Report. There is a substantial amount of information about how to calculate the economic value of the environmental services provided within local ecologic systems such as the Rough River watershed (i.e., www.csc.noaa.gov/coastal/economics/envvaluation.htm, www.iwr.usace.army.mil/docs/iwrreports/97r01.pdf, www.ecosystemvaluation.org/default.htm). For example, considering the RCC alternative, the DSMS Report does not consider whether design or management options coupled to a modern structure might allow for restoration of environmental flows to better resemble natural, seasonal flows, accommodate better movement of fish within the river system (important to the lifecycle and reproduction of the mussels), and open up spawning areas currently not available. This might in turn provide economic and environmental benefits (through recreation associated with an improved fishery and recovery of endangered species and associated habitats) not considered in the current alternatives analysis. Consideration of these benefits may alter the economic analysis, potentially affecting alternative viability and subsequent alternative selection.

Significance:
MEDIUM
Recommendation for Resolution:
Amend the alternative(s) in the DSMS Report to reflect consideration of instream ecologic conditions, opportunities for recovery of aquatic habitats and endangered species historically endemic to Rough River, and potential economic benefits associated with recovery of these species (and habitats) not currently considered in the DSMS Report.

Comment 25
The Public Involvement and Coordination section should highlight comments received from public.
Basis for Comment:
The agency comments are included as attachments to the EA but there are no public comments presented or how they were addressed; thus, it is not clear whether public involvement in development of the EA was sought by the USACE. It is not clear whether any public notice has been conducted beyond interagency coordination. Please refer to *NEPA 40 CFR 1506.6. USACE 32 CFR Subpart E, 651.36* for public notice requirements pertaining to federal actions for NEPA.
Significance:
MEDIUM
Recommendation for Resolution:
Include or summarize public comments (if any) in the document (possibly in the appendices). If no comments were received, or if public notice has not been conducted, this should also be specified plainly in the DSMS Report.

Comment 26
Appendix E, Table 1 shows the number of structures flooded and the population at risk for the nine considered scenarios reflecting a number of persons per structure that ranges from 1.05 to 1.11.
Basis for Comment:
This seems extremely low even considering that total structures include non-residential categories. The average number of persons per household for Kentucky in the 2000 Census was 2.47 and the average for the study area counties is 2.49.
Significance:
LOW
Recommendation for Resolution:
Describe how the population at risk was determined.

Comment 27
Additional information is needed in the DSMS Report regarding damages and benefits used to justify the project.
Basis for Comment:
The DSMS should include additional information beyond the "summary" numbers for the annualized damages and benefits. DSMS Report, Vol. 3, Appendix E contains very detailed information on the annualized damages without the project, and annualized loss of service without the project.
Significance:
LOW
Recommendation for Resolution:
Bring forward into the DSMS Report some of the detailed, valuable information on annualized damages and benefits rather than just displaying the summary table in Section 9.2.

Comment 28
No qualified review comments were possible regarding the accuracy of the damages prevented and the benefits of the project alternatives.
Basis for Comment:
Inputs to the HEC-FIA model were not available for review. The model inputs provide the basis for identifying the benefits of the alternatives. The absence of the input data is a documentation issue that limited the panel's ability to assess the adequacy and acceptability of the DSMS evaluation and selection of alternatives.
Significance:
HIGH
Recommendation for Resolution:
Resolution is not possible as the input data was not provided prior to completion of the IEPR.

Comment 29
The assumption that structures have a first floor elevation of 3-ft above grade (Appendix E, p. 18) may result in significantly underestimating the flood damages/benefits and the benefit/cost ratios.
Basis for Comment:
All structures in the affected area were assumed to have a first floor elevation of 3-ft above this ground elevation.
Significance:
MEDIUM
Recommendation for Resolution:
Run the HEC-FIA Program using a more realistic assumption of the average structure first floor elevations.

Comment 30
The assumed elevation for initial flood damage to vehicles is not indicated.
Basis for Comment:
Appendix E, p. 19 states, “The flood depth at each structure, as estimated above (in the section on structures), is applied to the HAZUS vehicle depth damage function to estimate vehicle damages for every flood/failure event.” The report does not indicate the assumed elevation for initial flood damage to vehicles.
Significance:
LOW
Recommendation for Resolution:
Provide the assumed elevation for initial flood damage to vehicles.

Comment 31
The SEEP/W Analysis (Appendix G) does not adequately consider possible high permeability flow paths in rock foundation.
Basis for Comment:
Page G-1268 indicates the permeability of the underlying bedrock was not included in the analysis. On p. G-1279 the permeability summary chart for foundation rock lists K values from borehole pressure tests in the range of E-5, similar in magnitude to values measured for cohesionless soil foundation. The SEEP/W analysis assumes that top of rock is essentially a horizontal no-flow hydraulic boundary. The possible limestone solution features in the foundation rock under the dam may have large K values, with connectivity unknown at this time. The selected cutoff wall depth and grouting depth assumes these potential solution features cannot "short circuit" with pathways extending below elevation 350 ft, perhaps due to assumed presence of one or more continuous horizontal shale and weathered shale strata at formation transition.
Significance:
MEDIUM
Recommendation for Resolution:
Perform exploration drilling and testing to depths greater than elevation 390 ft to determine rock foundation characteristics with respect to presence or absence of problem features with high hydraulic conductivity.

Comment 32
Written documentation should be included in Appendix G to describe the tower failure analysis using the Structural Toolbox.
Basis for Comment:
Software used for this analysis was unavailable for panel review. The DSMS Report includes a brief description of the analysis, which is difficult to follow due to the lack of documentation.
Significance:
HIGH
Recommendation for Resolution:
Provide written documentation of analysis, methodology, and approach.

Comment 33
Written documentation should be included in the main report or appendix to explain how the probabilities were determined using the Mechanical and Electrical Toolbox.
Basis for Comment:
Software used for analysis was unavailable for panel review. Additional documentation would be helpful in understanding the analysis.
Significance:
HIGH
Recommendation for Resolution:
Provide written documentation of analysis.

Comment 34
The cost estimate for the RCC dam alternative should include the same level of detail as the cost estimate for the cutoff wall alternative in order for a reasonable (and unbiased) comparison to be made.
Basis for Comment:
It is unclear how an estimate could be prepared for the RCC dam alternative (for comparison with the cutoff wall alternative) without at least conceptual level sketches of the proposed scheme. The cost for RCC placement (as shown in Appendix H) is very high. Grouting of the foundation is not included in the estimate for the RCC dam alternative but will likely be required.
Significance:
HIGH
Recommendation for Resolution:
Provide costs estimates to the same level of detail for valid comparison of alternatives. Include the cost of foundation grouting in cost estimate.

Comment 35
Specified tasks in the Project Direct Costs Report have no assigned cost.
Basis for Comment:
Rough grading activity in Appendix H, p. 4 of the Project Direct Costs Report was assigned a quantity of 45,380 BCY but lacked associated cost. Similarly, shape embankment in Appendix H, p. 11 of the same report has a quantity of 10,000 SY with no associated cost.
Significance:
MEDIUM
Recommendation for Resolution:
Assign a cost to every activity in the Project Direct Cost Report.

Comment 36
Specified tasks in the Project Direct Costs Report have assigned costs that are too low.
Basis for Comment:
The costs representing Maintenance task, Repair task, and Standby task in Appendix H, p. 7 of the Project Direct Costs Report are too low.
Significance:
LOW
Recommendation for Resolution:
Verify the costs assigned to these tasks in accordance with the task and number of hours assigned.

Comment 37
The hydrologic analysis of the Rough River Dam historical record does not include the period from December 1960 to 1983.
Basis for Comment:
Hydrologic analysis of the complete period of record from December 1960 to 2008 would contribute to reducing the uncertainty of the hydrologic statistical analysis with regard to extreme flood probability estimates. Analysis of this historical record was not performed because the record was not in digital form. The importance and significance of re-analyzing the hydrologic data and the associated cost of that analysis in light of the project remediation cost and associated project risk seems justified.
Significance:
MEDIUM
Recommendation for Resolution:
Analyze the historical hydrologic record at Rough River Dam. A possible alternative would be selection of some historical record (e.g., Rainfall) that would suggest additional Rough River Dam hydrologic analysis of the historical record would not significantly change the results and the associated uncertainty in the hydrologic analysis of extreme flood events.

Comment 38
Both documents (*Dam Failure Analysis Toolbox [Draft] 2007* and *Inflow Flood Hydrographs Toolbox [Draft] 2007*) are in draft form and are not publically available.
Basis for Comment:
These two draft documents, both dated 2007, have had extensive revisions since 2007. Because of their draft status, they are not official USACE documents and therefore inappropriately used as references in the DSMS Report. Since these documents are essentially an accumulation of a number of technical points that are addressed in official USACE documents, necessity for inclusion is uncertain.
Significance:
LOW
Recommendation for Resolution:
Provide justification reflecting acceptable USACE protocol for the use of these draft documents to support the Rough River DSMS Report or alternatively modify the list of references.

Comment 39
The Willowstick Report does not adequately discuss the method's ability to locate seepage targets in presence of embankment and foundation materials consisting of clay or large percentages of clay that have very high electrical conductivity.
Basis for Comment:
The Willowstick electromagnetic survey maps subsurface electrical conductivity and interpretation of the survey for the USACE assumes that zones of water seepage will be zones with the highest electrical conductivity compared to surrounding ground (Willowstick white paper). Exploration borings indicate that embankment and some foundation materials such as cohesive alluvium and shale/weathered shale bedrock consist of or contain large percentages of clay. Such materials may have electrical resistivities below 20 ohm-meters (very good electrical conductor), while clean cohesionless sand channels, or open rock solution channels—which could be efficient water seepage conduits—could have resistivities above 50 ohm-meters (moderately efficient electrical conductors compared to clay).
Significance:
MEDIUM
Recommendation for Resolution:
Evaluate targets identified by Willowstick, but do not assume the method has found all seepage targets. Include the results of this evaluation in the DSMS.

A.3 Editorial Comments on the DSMS

Editorial comments are provided below as a reference for USACE. Some of the comments listed do have some significance to the technical understanding of the project; however, the actions necessary to address the comments only involve editorial changes.

Table A-2. Editorial Comments

No.	Comment
1	On page 8, the fifth bullet should be amended to read, "Perform additional grouting from within…"
2	The wording in Figure 2.2 on page 10 is illegible. Improve the scale and resolution of the figure or replace with a figure that better illustrates the cross-section of Rough River Dam.
3	On page 11, amend the second sentence of the first full paragraph by removing the second occurrence of the word "was." In the third sentence, the meaning of the phrase "...drilled 20 degrees into the abutment..." is not clear. Indicating that grouting holes were drilled 20 degrees from some reference point (e.g., 20 degrees from vertical) will help the reader visualize the placement of the grouting holes.
4	The economic value of recreation at Rough River Lake is presented for the year 2006 on page 13 and for fiscal year 2005 on page 77, both with the *USACE Value to the Nation* website listed as the source of information. This is confusing because the resulting numbers differ (significantly in some cases). Presenting the numbers from the same year in both locations (pages 13 and 77) would help eliminate confusion.
5	The number of additional borings drilled in 2003 as part of the Dam Safety Assurance Program (DSAC) is shown as 17 on page 46, 21 on page 84, and 17 plus four on page 87. This presents an inconsistency in the report.
6	The third sentence on page 47 refers to an evaluation of construction records. The first sentence on page 107 indicates there are no construction records. The existence of construction records should be clarified. Note: Construction photographs are included in the report, which implies that construction records are available.
7	On page 138, typographical errors were identified in line five, "…for a series of individual zones with for an area 30 miles…" and in line six, "Both daytime and nighttime estimates of for loss of life…" Eliminate typographical errors for clarity.
8	The second paragraph on page 160 indicates the cutoff wall must penetrate to a minimum elevation of 380 to intercept the transition from the Beech Creek Limestone to the underlying Reelsville Limestone. The Elwren Shale layer is depicted between the Beech Creek Limestone and the Reelsville Limestone in Figure 2.5 (geologic section) but not in the grouting profile in Figure 5.19. Clarify whether or not the layer of Elwren Shale is significant in deciding the depth of the cutoff wall.
9	Appendix E contains very detailed information on the annualized damages without the project and the annualized loss of service without the project. For the reader, bringing some of this valuable information forward to page 175 (Section 9.2, Economic Consequences) rather than just displaying the summary table will better demonstrate reasonableness of consequences and benefits.
10	On page 175, the sixth bullet should be amended to read, "Perform additional grouting from within…"

No.	Comment
11	On page C-2 of Appendix C, the fourth sentence in the first paragraph states, "The project reduces flood damages along approximately 89 miles along of the Rough River, approximately 71 miles on the Green River, and to a lesser extent on the Ohio and Mississippi Rivers." Correct the typographical error(s) to make this sentence clear to the reader.
12	In Appendix E, the Introduction states the dam was completed and placed in full operation in 1961; yet, in several locations in the main body of the DSMS Report, 1960 is listed as the year the dam was completed and placed in full operation. The same year should be used throughout the main body of the report and the appendices to eliminate confusion.
13	The page numbers listed in the Appendix G Table of Contents, List of Figures, and List of Tables are not consistent with the G-1, G-2, G-3, etc., page numbering system.

Appendix B – IEPR Panel Members

Noblis selected nine panel members to conduct an IEPR of the DSMS for Rough River Dam, Kentucky. Consistent with the requirements of the USACE SOW, the panel members provided expertise in eight areas: geotechnical, hydraulic, and structural engineering; geology; NEPA impact assessment; engineering cost estimation; economics; and plan formulation. All panel members met and exceeded the minimum requirements for each specified area of expertise as outlined in Table 3 of this report. The panel represented a well-balanced mix of individuals from academia, large companies and small consulting firms, and individual consultants providing expertise in all required technical areas.

Prior to the onset of the IEPR, it was established that: (a) the structural engineering position could be eliminated, (b) the level of effort required by the NEPA professional and the plan formulator would be limited, and (c) a panel made up of seven individuals meeting all requirements would suffice. Subsequent to a review of relevant project documents and considering the availability of nominees, Noblis formed a panel consisting of nine experts with expertise in all relevant areas with particular emphasis on critical areas of review (i.e., four members covering the three areas of geotechnical engineering, geology and hydraulic engineering), as well as a member with structural engineering expertise.

B.1 Résumés of panel members

The résumés of the panel members follow.

Scott A. Ashford, P.E., Ph.D.

Qualifications Summary

- 28 years of experience with a Ph.D. in geotechnical engineering.
- Geotechnical engineering working to enhance public safety and reduce potential economic loss worldwide from earthquake and coastal hazards through cross-disciplinary research in earthquake and coastal engineering, focusing on seismic site response, modeling of soil-foundation-structure interaction, liquefaction and lateral spreading, design of bridges and port facilities, sea cliff erosion, and slope stability.
- Dam safety experience through participation in dam safety expert panels, risk evaluation/mitigation studies or similar experience with hydraulic retaining structures.
- Several years of direct experience with hydraulic retaining structure rehabilitation projects as either designer or construction project engineer.
- Adroit with risk informed approach to dam risk decision making.
- Design or construction experience evaluating slope sufficiency under a seismic load using geological analysis provided.
- Education and design or construction management experience with embankment dams and foundations and underground concrete structures including necessary worksite earthwork preparation and workflow management.
- Familiar with USACE application of risk and uncertainty analysis in flood damage reduction studies.

Education

- Ph.D., Geotechnical Engineering, University of California at Berkeley, 1994
- M.S., Geotechnical Engineering, University of California at Berkeley, 1986
- B.S., Civil Engineering, Oregon State University, 1983

Certifications and Licenses

- Licensed Professional Engineer, State of California, (No. C41723, 1987)
- Licensed Professional Engineer, State of Oregon (applying for reciprocity)

Summary of Professional Experience

Ashford Engineering, Corvallis —*Co-Founder, CFO, Geotechnical Engineer*

Oregon State University, Corvallis — *Professor and Head*

University of California, San Diego — *Professor, Associate Professor, Assistant Professor*

Ashford Engineering Inc., Encinitas, Calif. — *CFO and Geotechnical Engineer*

Asian Institute of Technology, Bangkok, Thailand — *Assistant Professor*

University of California at Berkeley — *Graduate Student Researcher*

CH2M HILL, Emeryville, Calif. — *Project Engineer*

McClelland Engineers, Houston, Tex. — *Geotechnical Engineer*

- Technical Advisor, Seismic Hazards Evaluation for Kaeng Sua Ten Dam Project, Thailand, for Woodward-Clyde

Federal Services, Oakland, California

- Technical Advisor, Sri Lanka Landslide Hazard Mitigation Project, Colombo, for Asian Disaster Preparedness Center, Bangkok, Thailand
- Peer Reviewer, Preliminary Design of I5/I805 Improvement Project, for California Department of Transportation
- Peer Reviewer, Del Mar Bluff Geotechnical Study, for North County Transit District, Oceanside, Calif.
- Technical Advisory Panel Member, Seismic Design of Route 30 Improvement Project, San Bernardino Associated Governments
- Consultant, Port of Long Beach Expansion, Diaz-Yourman & Associates, Long Beach
- Consultant, West City Center School Project, Geotechnics, San Diego, Calif.
- Member, Expert Review Panel, Columbia River Crossing Project, Portland, Ore.
- "Amplification of Earthquake Ground Motions in Bangkok," Royal Thai Government, 1995–1997.
- "Kobe Earthquake Reconnaissance," Pathum Thani Concrete Company, 1995.
- "Solid Waste Management for Environmental Sustainability," The Nederlands Government, 1996–1999, (Co-PI with C. Visvanathan).
- "Earthquake Induced Loss of Lifeline Facilities in Southeast Asia Risks, Socio-Economic Impacts, and Mitigation," UC Pacific Rim Project, 1997–1998.
- "Effect of Pile Diameter on Modulus of Subgrade Reaction," California Department of Transportation (Co-PI with M.J.N. Priestley and F. Seible), 1997–2001.
- "Shake Table Testing of Pile-supported Twin-Column Bents," California Department of Transportation (Co-PI with M.J.N. Priestley and F. Seible), 1997–2001.
- "Pilot Liquefaction Study," California Department of Transportation, 1998.
- "Supplemental Field Laboratory Development," Alaska Department of Transportation and Public Resources, 1998.
- "Effect of Large Velocity Pulses on Bridge Columns," Pacific Earthquake Engineering Research Center/National Science Foundation, 1998–1999.
- "Behavior of Laterally Loaded Deep Foundations in Liquefied Sand," Federal Highways Administration Pooled Funds (Caltrans-Lead Agency, Missouri DOT, New York DOT, Oregon DOT, Utah DOT, and Washington State DOT) 1998–2001.
- Royal Thai Government for General Support of Research on Dynamic Response of Soft Bangkok Clay. 1998.
- Hayward Baker, Inc., General Support of the Treasure Island Liquefaction Test, 1999.
- "Performance of Bridge Components Subjected to a Large Velocity Pulse," PEER/NSF, 1999–2001.
- "Substation Equipment Interaction – Right and Flexible Conductor Studies," 1998–1999, (Co-PI with A. Filiatrault, A. Elgamal, and F. Seible).
- "Characterization of Ground Motions from Special Source Zones," PEER/NSF, 1998, (Co-PI with A. Elgamal).
- "Ravenal Bridge Load Testing Program," South Carolina DOT, 2000.
- "Powell Faculty Fellowship," Powell Foundation, 2000–2002.
- "Mitigation of Coastal Bluff Instability in San Diego County," California Sea Grant, 2001–2004.
- Royal Thai Government for General Support of Research on Dynamic Response of Soft Bangkok Clay, 2001.
- "Assessment/Completion of the NEES Experimental Infrastructure," NSF, 2001, (Co-PI with F. Seible, A. Filiatrault, and A. Elgamal).
- "Performance of Lifelines Subjected to Lateral Spreading: Full-Scale Field Experiment," California Energy Commission, Caltrans, and Pacific Gas & Electric through PEER Lifelines Program, 2001–2002.
- "Axial and Lateral Behavior of Full-Scale CIDH Piles in Soft Clay and Liquefied Sand," Caltrans, 2001–2003.

- "Full-Scale Testing at Port of Long Beach," National Sea Grant, 2001–2003.
- General Support of Research on Dynamic Response of Soft Bankok Clay, Donation from Royal Thai Government, 2001.
- Seismic Performance of Port Facilities: Full-Scale Testing at Port of Long Beach, Calif., 2002–2003
- Rapidly Deployable Composite Bridge Project, Office of Naval Research, 2002–2003 (Co-PI with John Kosmatka).
- NEES: Large High Performance Outdoor Shake Table, NSF, 2002–2004, Co-investigator (PI - Jose Restrepo)
- Response Assessment of Bridge Systems, Caltrans, 2002–2005
- Large Diameter Piles and Pile Systems, Caltrans, 2002–2005
- Performance of Lifelines Subjected to Lateral Spreading, PEER, 2002–2005
- Performance of PierG Seismic Fuse, Port of Long Beach, 2004–2005
- Load Capacity, Failure Mode, and Design Criteria of Sand Jacks, Caltrans, 2004–2005
- Data Acquisition System and Instrumentation for NEES LHPOST, NSF, 2004–2005, Co-Principal Investigator (PI - Jose Restrepo)
- Coastal Bluff Erosion: Causes, Mechanisms, and Implications for Coastal Protection and Restoration, UC Office of the President, 2004–2006
- Development of Reliable Methods to Analyze Batter Piles and Piles in Sloping Ground, Caltrans, 2006–2009
- Relationship between Bluff Erosion and Beach Sand Supply in the Oceanside Littoral Cell, California Sea Grant, 2006–2008
- Structural Capacity Confirmation Testing of the Modular Hybrid Pier Test Bed, BERGER/ABAM and US Navy, 2006

Related Publications

- Ashford, S.A., Roth, L.H., Madsen, S.L., and Anderson, D.G., "FS=1.5: Is it Appropriate for Embankment Design?" Proceedings, Stability and Performance of Slopes and Embankments – II, ASCE, Berkeley, California, June 1992, pp. 1112-1125
- Ashford, S.A., Sitar, N., Lysmer, J., and Deng, N., "Topographic Effects on the Seismic Response of Steep Slopes," Bulletin of the Seismological Society of America, 87(3), 1997, pp.701-709.
- Ashford, S.A., Rollins, K.M., Bradford V, S.C., Weaver, T.J., Baez, J.I., "Liquefaction Mitigation Using Stone Columns Around Deep Foundations: Full Scale Test Results," Transportation Research Record No. 1736, Journal of the Transportation Research Board, 2001, pp. 110-118.
- Ashford, S.A., Juirnarongrit, T., "Evaluation of Force Based and Displacement Based Analysis for Responses of Single Piles to Lateral Spreading", Proceedings, 11th International Conference on Soil Dynamics and Earthquake Engineering and the 3rd International Conference on Earthquake Geotechnical Engineering, 2004, pp.752-759.
- Ashford S.A., Rollins, K.M., Lane, D., "Blast-Induced Liquefaction for Full-Scale Foundation Testing," Journal of Geotechnical and Geoenvironmental Engineering, ASCE, August 2004, pp. 798-806.
- Juirnarongrit, T., Ashford, S.A., "Analysis of Pile Responses Based on Results from Full-Scale Lateral Spreading Test: Tokachi Blast Experiment," Proceedings, 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, August 1-6, 2004, Paper #1642, 14p.
- Weaver, T.S., Ashford, S.A., Rollins, K.M., "Response of Liquefied Sand to a 0.6-m CISS Pile under Lateral Loading", Journal of Geotechnical & Geoenvironmental Engineering, ASCE, Vol. 131, No.1, January 2005, pp.94-102.
- Rollins, K.M., Gerber, Lane, D., Ashford, S.A. "Lateral Resistance of a Full-Scale Pile Group in Liquefied Sand, " Journal of Geotechnical & Geoenvironmental Engineering, ASCE, Vol. 131, No. 1, January 2005, pp.115-125.
- Ashford, S.A., Juirnarongrit, T., Sugano, T. and Hamada, M., "Soil-Pile Response to Blast-Induced Lateral

Spreading. I: Field Test," Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 132(2), 2006, pp.152-162.

- Juirnarongrit, T., and Ashford, S.A., "Soil-Pile Response to Blast-Induced Lateral Spreading. II: Analysis and Assessment of the P-Y Method," Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 132(2), 2006, 163-172.

Professional Associations

- American Society of Civil Engineers (ASCE), Geo-Institute; Coasts, Oceans, Ports, and Rivers Institute
- Earthquake Engineering Research Institute (EERI)
- Network for Earthquake Engineering Simluation (NEES)
- Seismological Society of America (SSA)
- American Society of Civil Engineers, Continuing Education Committee, 1986–1989
- Earthquake Engineering Research Institute, Traditional Education Committee, 1992–1996
- Engineering Institute of Thailand, Committee on Wind and Earthquake Effects, 1995–1996
- Pacific Earthquake Engineering Research Center, Education Committee, 1998–Present
- Chair, K-12 Outreach Subcommittee, 1998–1999
- Chair, Special Projects Subcommittee, 1999–2000
- Session Chair, Planning Committee, EERI Annual Meeting, 1999
- Transportation Research Board, University Representative, 2000–Present
- Planning Committee, American Seismological Society Annual Meeting, 2000
- American Society of Civil Engineering/TCLEE, Ports and Harbors Lifeline Committee, 2004–Present
- International Society for Soil Mechanics and Geotechnical Engineering TC-4, Earthquake Geotechnical Engineering, 2004–Present
- Earthquake Engineering Research Institute, Learning from Earthquakes Advisory Committee, 2005–Present
- American Society of Civil Engineers, Standards Committee on Seismic Design of Piers and Wharves, 2005–Present
- American Society of Civil Engineers/COPRI, Ports and Harbors Committee, 2005–Present

Awards

- Faculty Representative, Transportation Research Board, 2000-2007
- Outstanding Early Career Engineer, College of Engineering, OSU, 1998
- Oliver Merwin Memorial Scholarship, University of California at Berkeley, 1985
- Otto Herman Memorial Scholarship, Oregon State University, 1982
- Tau Beta Pi National Engineering Honor Society, Oregon State University, 1981

Donald W. Ator

Qualifications Summary

- Economist, Plan Formulator, and NEPA Impact Assessment Professional with 32 years of experience conducting more than 500 economics, water resources planning, and National Environmental Policy Act (NEPA) projects nationwide.
- Senior planner for PBS&J's integrated water resources division.
- Conducted one of the first studies by USACE with risk informed approaches to decision making, risk models and disaster scenarios with regard to economic impact in 1981, The study was "Sensitivity of Benefit and Cost Evaluation Criteria to Uncertainty and Risk associated with Study Parameters, Passaic River Basin, New Jersey and New York for the New York District.
- Has extensive experience with applying HEC-FDA and other Hydrologic Engineering Center (HEC) Programs (HEC).
- Uniquely skilled in the identification of problems and opportunities and the development of objectives in the planning process. Demonstrated the ability to characterize problems and opportunities in a way that meaningful levels of achievement are identified. Identified problems and opportunities for both existing and future conditions in a manner that permits the formulation and evaluation of alternatives in a systematic manner that ensures all reasonable alternatives are fully considered.
- Specialized experience conducting the economic analysis that determines a project's benefits. The large capital investment projects have required the economic analysis of benefits and costs on a common time basis, accomplished by discounting their economic value over the period of analysis using the appropriate interest rate. Analyses typically result in the development of a ratio of benefits to costs (B/C ratio) indicating the project's economic efficiency.
- Was embedded with the New Orleans District as a team leader in the Plan Formulation Branch, responsible for managing the plan formulation activities of three plan formulators. This involved project oversight and review to ensure compliance with Corps of Engineers guidelines and the six steps of the planning process.

Education

- M.B.A., Finance and Accounting, Louisiana State University, 1984
- M.S., Agriculture Economics, Louisiana State University, 1978
- B.S., Agribusiness, Tarleton State University, 1976

Summary of Professional Experience

Water Resources Planning

Feasibility Study and Environmental Impact Statement (EIS), General Reevaluation Report, L-8 Basin, U.S. Army Corps of Engineers (USACE) Jacksonville District, West Palm Beach, Fla. —*Project Manager*

- For this flood control feasibility study and EIS, managed a team of 14 professionals to conduct formulation of nine different project alternatives and the performance of quantitative and qualitative screening of the alternatives to identify the three best alternatives for more detailed evaluation. This work included development of a structure inventory of flood plain properties, application of the Corps of Engineers HECFDA flood damage assessment model and development of benefits and costs for each alternative.
- Managed the development of the cost proposal, negotiations, and actual conduct of the work and quality

assurance/quality control (QA/QC) in addition to making monthly presentations to the project's local sponsor and the South Florida Water Management District for the 18-month duration of the project.

- The client benefited from completion of the benefits/cost analysis, which indicated that further funding at the federal level would not be likely with the project alternatives under study, more than six months ahead of schedule. This permitted the local sponsor to pursue reformulation of the measures in another project with better potential for federal funding.
- Other agencies involved included the Environmental Protection Agency (EPA), Fish and Wildlife Service (USFWS), Natural Resources Conservation Service (NRCS) at the federal level and the Departments of Agriculture, Environmental Protection, Fish and Wildlife Conservation, and Transportation and the State Historic Preservation Office at the state level. This project was completed ahead of schedule and on budget.

Preparation of a Section 905 (b) Reconnaissance Report, USACE Little Rock District, Springfield, Mo. —*Project Manager*

- For this project, investigated the problems associated with flooding along Jordan Creek in Springfield, Missouri.
- Directed the efforts that produced a report that included a summary of prior studies, reports and existing water resources projects, identified problems and opportunities, formulated alternative plans and presented engineering, environmental, and economic evaluations of those alternatives. The report culminated with the determination that there was a federal interest in proceeding to the feasibility phase and presented a financial analysis of the non-federal sponsor's willingness and ability to pursue the feasibility study, feasibility study milestones and cost estimates by line item, and the views of other agencies.
- The client benefited from the development of a feasible flood control project for the City of Springfield, Missouri, that had been plagued by chronic flooding of the downtown commercial areas.
- The project identified several alternatives with National Environmental Restoration (NER) benefits that were carried forward in the feasibility study.

Formulation of Alternatives

Reconnaissance Report, Feasibility Study, and Revitalization Study Report, USACE Buffalo District, Buffalo Harbor, Buffalo, N.Y. —*Lead Economist*

- Study to assess the viability for navigation improvements. The navigation improvements were being considered due to changing commercial activity and attendant facilities, including bulk commodity transshipment facilities. Required modifications to the Buffalo River to accommodate the larger ships operating on the Great Lakes were also formulated.
- Work included identification of public concerns and desires; a description of existing and future socioeconomic and environmental conditions; and the formulation, assessment and evaluation of alternative navigation improvements. Eighteen alternatives and B/C ratios were developed to assist in identifying the selected plan.
- During the course of the Reconnaissance Report study process, redevelopment of the harbor area for recreational or mixed use emerged as a major public interest. As a result, a separate Revitalization Study Feasibility Report was prepared that developed various recreation and environmental alternatives within the context of three growth scenarios identified for the harbor area. Sixty-six waterfront measures were assigned to alternative growth scenarios and conflicting and compatible land uses were identified. Ultimately, economic evaluations were conducted on 12 potential recreation and environmental measures were subjected to identify the preferred plan.
- Participated in the public meetings process, described existing and future conditions, participated in plan formulation, and conducted the economic evaluations. The client benefited from the identification of economically feasible alternatives that resulted in increased economic activity at the port and land use compatible with public desires for increased recreational activity as a result of innovative thinking in the plan formulation phase of the project.

Reconnaissance Investigation of the Red River of the North Basin, USACE St. Paul District, Minn., N.D., and S.D. —*Lead Agricultural Economist*

- Flood control study of a 40,000-square mile drainage basin plagued by chronic flooding.

- Responsible for collecting detailed data on existing and future land use including crop distributions, crop yields, and production costs in order to calculate expected benefits from measures formulated to reduce the magnitude and frequency of flooding in the 22 sub-basins and along the main stem of the Red River of the North.
- The greatest difficulty in this study was calculating flood damages under without- and with-project conditions so that average annual flood damage reduction benefits could be determined for the alternatives formulated to reduce the flooding. Alternatives were formulated using structural and non-structural measures to reduce flood damages. Specifically, the alternatives included levees, channel modifications, channel clearing and snagging, flood walls, relocations, and flood water storage reservoirs. The small flood water storage reservoirs were also evaluated for multipurpose feasibility, including water supply and hydroelectric power generation.
- Calculated B/C ratios for the various alternatives and assisted in the selection of the recommended plan for flood damage reduction.

Deep Draft and Inland Navigation Studies

Savannah Harbor Expansion Project Economic Analysis, Phase III Benefits Calculation Methodology and Model, Multiport Analysis and Regional Port Analysis, USACE Savannah District —*Project Manager, Senior Economist*

- For the Savannah Harbor Expansion Project Economic Analysis that was completed in three phases. Phase I involved developing a comprehensive technical work plan for performing the navigation economic analysis. The work plan described the components of the analysis and what was required to complete them. The components included commodity forecasts, vessel fleet forecasts, National Economic Development (NED) benefits calculation, a multiport analysis, and a regional port analysis. Phase II was the actual development of the commodity and fleet forecasts in 10-year increments over the 50-year project life. Commodity forecasts are one of the major inputs to harbor improvement studies and have a direct effect on the NED benefits based on the growth and timing of future benefiting cargo volumes. Vessel fleet forecasts are analogous to commodity forecasts in that they project the number and size of vessels and related sailing drafts that are expected to call Savannah Harbor under without and with project conditions. Phase III included the development of the benefits calculation methodology and model, the multiport analysis, and the regional port analysis.
- The benefits calculation methodology and model were developed to calculate the NED benefits associated with the deepening of Savannah Harbor from 42 to 48 feet. The methodology and model captured the vessel transportation cost savings of this deepening for each 1-foot interval of additional depth.

Finalization of 42 Preliminary Project Assessments for Navigation Projects, USACE Galveston District, Tex. —*Project Manager*

- Responsible for the completion of 42 preliminary project assessments (PA) in accordance with the guidance provided in EC 1165-2-200, A National Harbors Program: Dredged Material Management Plans (DMMP).
- The purpose of the PAs was to establish whether a more detailed DMMP study was required, to prepare a project summary to provide information necessary to permit the prioritization of the District's budget and work plan. Completion of the PAs required review of project authorization documents; compilation of channel maintenance dredging frequencies and quantities from the Corps' Dredging Database; assessment of the remaining capacity of existing disposal areas; comparison of forecasted annual channel maintenance costs and traffic levels with current trends; and preparation of reports documenting the analysis complete with summary tables for the 42 PAs.

Panama City Harbor Limited Reevaluation Report, Feasibility Report, Economic Appendix, USACE Mobile District, Panama City, Fla. —*Project Manager*

- Project included a thorough analysis of the economic feasibility of deepening the navigation channel at Port Panama City U.S.A., Fla. The economic evaluation investigated historic and existing conditions at the port as well as future conditions without the proposed project and with two proposed channel deepening alternatives in place.
- The period of analysis for the project was from 2003, the estimated effective date of the project, through 2053. A commodity forecast was developed that identified all goods expected to be transported into and out of the economic study area via ocean transportation during the period of analysis and included specific origin and destination information. Current and future transportation facilities, including cargo loading, unloading, and

handling facilities, as well as storage facilities and interconnections with rail, truck, and barge transportation were also identified. A vessel fleet forecast was developed that identified the vessel types, dimensions, and loading characteristics of ships expected to use the ports facilities during the period of analysis. Itineraries of vessels using the Port of Panama City were identified as well as the amount of commerce carried per vessel and the cost per ton to transport those goods by ocean carrier under the future without- and with-project conditions.

- The client benefited from the project being found economically justified and subsequently recommended to Congress for funding. Construction of the project has been completed and it is currently fully operational.

Chocolate Bayou Channel, Dredge Material Management Plan (DMMP), USACE Galveston District, Tex. —*Project Manager*

- Project began with the identification of the shippers using the channel and the commodities being shipped. Origin-to-destination data for the year 2000 were compiled from Waterborne Commerce data and interviews. During the interview process potential alternative modes to continued use of the navigation channel were identified.
- Following determination that Office of Management and Budget (OMB) survey rules applied, coordinated the selection of specific questions to be asked potential shippers during the interviews with Galveston District personnel. Worked closely with the Institute for Water Resources (IWR) in the selection of interview questions to insure that adequate data on barge elasticity was obtained during the interviews with shippers and others. The Reebie Transportation Model was used to identify comparative transportation costs for the existing barge mode and alternative modes. The alternative modes evaluated included rail, truck, and pipeline. The most likely alternative mode was determined from the cost analysis using the Reebie Model and information gathered during the interviews.
- Prepared a detailed narrative report documenting the analysis that included an assessment matrix table for each alternative mode of transportation.

Forecast of Commodity Flows, Northern Sea Route Reconnaissance Study, USACE Alaska District, Alaska —*Project Manager*

- Project that projected potential commodity flows by cargo types and volumes by origin and destination that could potentially use the Northern Sea Route (NSR). The NSR is a shipping route through the Arctic Ocean along the Eurasian coastline that connects the North Pacific and North Atlantic oceans. The route extends in excess of 3,000 nautical miles and is currently navigable from June to October. In recent years, Russia, which controls the waters of the NSR, offered the route to foreign interests for through-transit of commodities as a shorter alternative to using the Suez or Panama canals. This analysis projected cargo types and volumes that could potentially use the route assuming differing lengths of seasons that the route would be navigable, and estimated transportation costs for these commodities using conventional (non-NSR) trade routes. The forecast focused on commodity movements between the North Pacific and North Atlantic regions, with particular interest paid to movements through individual ports in Alaska and was intended to allow evaluation of potential port or harbor improvements that may be needed for Alaskan ports to benefit from using the NSR.

Initial Appraisal of Rock Removal at San Francisco Bar Channel, USACE San Francisco District, San Francisco, Calif. —*Project Manager*

- Directed the evaluation of the economic feasibility of deepening the bar at the entrance of the San Francisco Harbor Navigation Channel. The current depth of the Bar Channel restricted inbound deep-draft oil tankers calling at ports in the bay to a draft of 50 feet.
- The analysis included an evaluation of deepening the Bar Channel at incremental alternative depths, identifying the physical and economic constraints to the Bar Channel deepening, and assessing the operational and environmental impacts that would result from the proposed deepening project.

Navigation Economic Feasibility Report, San Diego Harbor, USACE San Francisco District, San Diego, Calif. —*Project Manager*

- Team prepared the study to determine if there was a Federal interest in dredging San Diego Harbor from the Navy Turning Basin to the 10th Avenue Marine Terminal from the current depth of 40 feet to a depth of 45 feet.

- To determine the economic feasibility of dredging the harbor, the project team identified the types and volumes of commodity flows that could potentially benefit from a deeper channel. The definition of the economic study area was based on the origins and destinations of these commodities. Future waterborne commerce at the harbor was projected, and the current and future composition of the fleet serving the harbor was determined. Vessel operating costs for current and projected fleet composition were estimated and used to determine with- and without project commodity movement costs for various dredging alternatives. NED benefits and costs for each dredging alternative were calculated and the alternative with the highest net NED benefits was identified.

National Environmental Protection Act (NEPA)

Fort Bliss Army Growth and Force Structure Realignment EIS, Texas and New Mexico, Army Environmental Command, Aberdeen Proving Ground, Md. —*Project Manager*

- This EIS evaluated alternatives at Fort Bliss for the use of stationing and training capacity, land use changes, and training infrastructure improvements. These alternatives supported the stationing decisions and the continued mobilization and pre-deployment training mission, and reasonably foreseeable future stationing decisions at Fort Bliss. Alternatives to the proposed action were developed in internal scoping meetings with the Fort Bliss Garrison, Installation Management Command - West Region (IMCOMW), and U.S. Army Environmental Command (USAEC) staff. Alternatives comprising the proposed action were grouped into three categories. Category 1, stationing and training alternatives, Category 2, alternatives that required land use changes, and Category 3, alternatives that involved training infrastructure improvements. All three categories included a No Action alternative.

Individual Environmental Report (IER), Inner Harbor Navigation Canal (IHNC), USACE New Orleans District, New Orleans, La. —*Project Manager, Socioeconomic Lead*

- $1.4 million NEPA compliance IER, project was completed on a hyper fast track schedule through special arrangements with the Council on Environmental Quality in order to permit the provision of hurricane protection to the Greater New Orleans area as soon possible. Due to the emergency nature of providing hurricane protection to New Orleans following the devastation of Hurricane Katrina, a project that normally requires 18 months was completed in 10 months. The project included all of the requirements of a standard EIS and Record of Decision.
- Successfully managed the project team's work efforts including those of a Joint Venture partner and subcontractors. The process included twice-monthly public meetings and monthly interagency meetings.
- Responsible for the socioeconomic analysis that documented existing and future conditions with and without the hurricane protection and the direct, indirect, and cumulative impacts.

Kane Springs Valley, Ground Water Development Project EIS, U.S. Department of the Interior, Bureau of Land Management (BLM), Las Vegas, Nev. —*Socioeconomic Lead*

- Completed the socioeconomic sections of the EIS for this groundwater development project to construct and operate infrastructure required to pump and convey groundwater requiring a 30-foot wide permanent easement (60 feet during construction) 13 miles long.
- Described the affected environment and environmental consequences and the direct, indirect, and cumulative impacts of the proposed action and alternatives on population and housing, economy and employment, and public utilities and services. Described the historic and existing conditions and projected future conditions throughout the project's life.

Lincoln County Land Act (LCLA) Groundwater Development and Utility Right-of-Way Project EIS, U.S. Department of the Interior, BLM, Mesquite, Nev. —*Socioeconomic Lead*

- Prepared the socioeconomic sections of the EIS required to construct and operate the infrastructure to pump and convey groundwater resources in the Clover Valley and Tule Desert Hydrographic Basins to help meet current and future municipal water needs in urbanizing areas in southeastern Lincoln County; specifically, the LCLA development area, north of Mesquite, Nevada. The socioeconomic sections: (1) described the data collection methods used and the social and economic characteristics of the area and (2) documented the direct, indirect, and cumulative impacts expected to occur from construction and operation of the well field and 75-mile-long

transmission pipeline with a 60-foot-wide permanent easement (100-foot during construction).

Darlington Reservoir EIS, Louisiana Department of Transportation (LDOT), Southeast La. —*Socioeconomic Lead*

- Directed the socioeconomic portion of this EIS for the DOT and development's Darlington Reservoir project. The proposed 15,000-acre multipurpose reservoir's primary purpose was flood control while secondary uses included recreation, hydropower, and water supply.
- Responsibilities included the description and assessment of existing socioeconomic conditions in the study area and evaluation of the direct, indirect, and cumulative impacts that would result from implementation of the various alternatives under consideration. Specific parameters evaluated included population displacement, additional demands on public infrastructures, real estate values, and loss of access to mineral deposits.

Environmental Assessment (EA) for Base Realignment and Closure (BRAC), USACE Savannah District, Fort Jackson, S.C. —*Project Manager*

- Required to evaluate the impacts of the BRAC decision to relocate the Chaplain Center and School (CHCS) from Fort Monmouth, N.J., to Fort Jackson, S.C. Realigning the CHCS and associated activities involved approximately 100 permanent party soldiers, 50 civilian employees, and an average daily student load of 165. The purpose of this project was to analyze the environmental impacts of this action.
- Directed an interdisciplinary team of engineers, biologists, economists, archaeologists, historians, military tacticians, and other experts in this analysis of the environmental and socioeconomic effects of the proposed action upon the existing baseline and expected future conditions.

EIS for the Proposed Regional Water Supply System, U.S. Department of Commerce, Economic Development Administration, Hope, Ark. —*Lead Economist*

- Documented existing and expected future conditions with an emphasis on the water supply and water quality aspects of the project area.
- Responsible for coordination with appropriate federal, state, and local agencies to evaluate the probable impacts on all land use, social, and economic parameters for six alternatives. Regulatory agencies involved included the EPA, USFWS, and NRCS at the federal level and the Departments of Agriculture, Environmental Protection, Fish and Wildlife Conservation, and the Arkansas Department of Transportation and the SHPO at the state level.

EIS for U.S. Navy Home Porting Projects, USACE Galveston District, Corpus Christi and Galveston, Tex. —*Lead Economist*

- Documented existing conditions and probable impacts to land use, social, and economic parameters in both communities. Direct, indirect, and cumulative impacts evaluated were those expected to result from both the construction of the necessary facilities as well as the introduction of the thousands of new personnel and their families to the areas. The regulatory agencies involved included the EPA, USFWS, and USCG at the federal level and the Environmental Protection, Fish and Wildlife Conservation, Texas Department of Transportation (TxDOT), and the SHPO at the state level.

Social Impact Studies Social Impact Assessment, Little Colorado River, USACE Los Angeles District, Holbrook, Ariz. —*Project Manager*

- Project involved construction of a levee along the north side of the river to provide 100-year flood protection allowing for long-term development and redevelopment of the town’s historic business area. The primary impacts of the project were the dislocation of 46 low-income households and five businesses located on the south side of the river.
- The study team interviewed each of the households to determine basic demographics and the place residents worked, shopped, and went to school in an attempt to quantify the impacts of dislocation. Businesses that would be dislocated were surveyed to identify the impacts that would be felt and how these impacts would affect their businesses. The study team also conducted a housing availability analysis in Holbrook to determine if there was affordable, decent, safe, and sanitary housing available for the households that would be relocated and to determine if there would be housing available for the temporary workforce required to build the levee. The expected impacts on facilities, services, community cohesion, and other factors required by Section 122 of Public

Law 91-611 were also addressed. In addition, community capacity to absorb change and take advantage of the opportunities afforded by the project was evaluated.

Socioeconomic Impacts from Flooding and Flood Control Measures, USACE Vicksburg District, Yazoo Delta, Miss. —*Project Manager*

- Study that identified, described, and assessed social and economic impacts associated with flooding and the prevention of flooding in the Yazoo Delta area. The principal study area for the effort was defined as that portion of the Yazoo Basin that would be inundated by a flood event equivalent to the Mississippi River Flood of 1927. Portions of the Yazoo Backwater Area were the focus of this very detailed evaluation.
- Areas were delineated by flood frequency zones and characterized by selected socioeconomic variables. The effects of flooding on the lives, future, economic, and physical well-being of various social and economic groups within the zones were assessed.

Socioeconomic Impact Analysis and Recreation Analysis for the Final EIS, USACE Galveston District, Neches River and Tributaries, Texas, Saltwater Barrier at Beaumont, Tex. —*Project Manager*

- Project consisted of an overflow dam in the Neches River about 30 miles upstream of the mouth, a sector gate navigation channel west of the river, and tainter gate barrier structures located in a diversion channel west of the navigation channel.
- Identified, described, and assessed significant social, economic, and recreational issues associated with existing conditions in the study area and the possible social, recreational, and local economic effects that could be experienced in the future, if actions to permanently respond to the threat of saltwater intrusion in the lower Neches River were taken.
- The purpose of the project was to prevent saltwater from moving upstream during low river flow conditions (drought) and contaminating freshwater supplies for agricultural, industrial, and municipal consumption while maintaining free and reasonably unobstructed use of the river by existing and future navigation.

Social Impact Assessment for the Kissimmee River Upper Basin Restoration Project, USACE Jacksonville District, Kissimmee River Basin, Fla. —*Project Manager*

- Project to assess the impacts of periodic increases in lake levels that would cause flooding of riparian agricultural, residential, and recreation areas. The programmed increases in water levels in the lakes of the Upper Kissimmee River Basin were to require the acquisition of land in fee or flowage rights. This impact assessment required personal interviews of 100 affected respondents to identify and describe the impacts they would experience from the higher water levels in the basin.

Economic Impact Analyses

Analysis of Economic Development Benefits that would Occur from the Construction of a Floodwall and Levee System along the Greenbrier River and Knapp Creek, USACE Huntington District, Marlinton, W.Va. —*Project Manager*

- Prepared the grant application to the state of West Virginia for economic development, capital improvements, and infrastructure projects for submission within 30 days on behalf of the Town of Marlinton, W.Va. The grant application required a detailed project description, breakdown of project costs, financing, alternate funding sources, and job creation/retention information. The job creation information required included specific information on categories and duration of employment, salaries/wages, and health benefits associated with employment during and after construction.
- The data necessary for completion of the grant application was collected through interviews with local businesses and public officials. The data collected was then used as inputs for the IMPLAN computer model to calculate the local economic benefits that would result from the completion of the flood control project. Information developed from the IMPLAN model along with other required information collected during the interviews was used to complete the grant application.
- The application text placed particular emphasis on the retention of existing jobs, the leveraging of over $80 million in federal funds and the short and long term benefits to local businesses. Mr. Ator assisted the City of

Marlinton, the Region 4 Planning and Development Council, and the Economic Development Grant Committee members in planning meetings associated with the application process.

Regional Economic Impact, Financial and Cost Recovery Analysis for Gulfport Harbor Deepening and Container Yard Expansion, USACE Mobile District, Gulfport, Miss. — *Project Manager*

- Project required a survey of area firms utilizing the port and other port related industries to gather information on the costs associated with commodity movements through the port and impacts on area businesses. A Maritime Administration input-output model (MARAD Port Kit) designed for use by ports was employed to assess direct, indirect, and induced impacts in the three county regions and the state of Mississippi.

Memphis Riverfront Development Project, Regional Economic Benefit Study, USACE Memphis District, Memphis, Tenn. —*Project Manager*

- Study to gather information and provide estimates of the economic impacts for the City of Memphis from a proposed Riverfront Development project. The report included a description of the data sources, assumptions, and methodologies employed in estimating these impacts. Tangible economic benefits were identified and documented. Secondary or multiplier effects were also estimated for each tangible benefit category. These included jobs, personal income, increased tax base, and increased tax revenues. Intangible benefits were described and listed separately.
- The study was initiated by identifying the area of influence or benefited area (study area). This was followed by estimating the economic impacts resulting from project construction, project operation, tourism, and recreation related expenditures and induced private sector investments due to increased residential and commercial development. The comprehensive report presented the analyses and described the techniques and procedures applied.

Grand and White Lakes Water Management Study, USACE New Orleans District, La. — *Project Manager, Lead Economist*

- Project to assess the economic impacts of the quantity and quality of water under several different management plans in the Grand and White Lakes system in the southwestern coastal area of Louisiana. The different management plans under consideration would affect water levels in the lakes and as a result have economic impacts on coastal and shoreline erosion, commercial fisheries, wildlife (hunting and trapping industry), the quality of irrigation water (rice industry), and water levels in the Gulf Intracoastal Waterway (shipping industry).
- Conducted 160 interviews with farmers, navigation interests, irrigation companies, commercial fishermen, hunters, trappers, and federal, state, and local government officials to collect the information necessary to assess the economic impacts of land loss due to erosion and the factors causing erosion and affecting water quality (primarily salinity levels). Regulatory agencies involved included EPA, USFWS, USCG, NRCS, and FEMA at the federal level and the Louisiana Office of Public Works, Department of Environmental Quality, Department of Wildlife and Fisheries, SHPO, and the Office of Emergency Management at the state level.

Regional Economic Impact, Financial, and Cost Recovery Analysis for the Proposed Deepening and Neobulk Expansion Project, USACE Mobile District, Pascagoula, Miss. —*Project Manager, Senior Economist*

- Study of the direct, indirect, and induced impacts expected to result from harbor improvements and the addition of a neobulk terminal at the Port of Pascagoula. Impacts were estimated for sales, income, employment, and taxes using the MARAD Port Kit Model. Port marketing strategies were described and project financial feasibility was analyzed.
- Regional environmental benefits from improvements to oyster habitat were also projected. The results of this study were used by the local sponsor to inform the public about the length of time required to recover the investment required to undertake the project.

Flood Control Studies

Update Benefits for the Portugues Dam and Reservoir, USACE Jacksonville District, Ponce, Puerto Rico —*Project Manager*

- The benefits were updated and stated in current price levels discounted over a 100-year project life, using both the authorized interest rate and the current water resources evaluation interest rate. The flood control benefit categories that were updated included damages to residential structures and contents, non-residential structures and contents, automobiles, transportation, infrastructure, reduced emergency costs, and loss of income. Recreation benefits that were updated were based on unit day value methodology.
- The client benefited from being able to submit remaining cost/remaining benefits (RCRB) information in time to get Congressional authorization and funding for the project.

Analysis of Economics and Reevaluation Report, Dark Hollow Reevaluation Report, USACE Little Rock District, North Little Rock, Ark. —*Project Manager*

- Project directed by the Water Resources Development Act of 1999, Section 576 to review a report prepared by the City of North Little Rock concerning flood protection for the Dark Hollow area of North Little Rock, Ark. The objectives of this project were to determine whether or not the proposed Dark Hollow Flood Damage Reduction project was economically justified, technically sound, and environmentally acceptable.
- The first purpose of the project was to review the files of the economic evaluation already performed by the Little Rock District and develop additional economic data and stage-damage functions through surveys of local business owners. The second purpose of the project was to review the files of the engineering evaluation already performed by the Little Rock District and produce an executive summary report with appropriate appendices. This was accomplished in spite of a three-year stoppage of work during the middle of the study due to additional work that had to be done to formulate and evaluate a new tunnel alternative.
- The report documented conclusively that tunneling alternatives were not an economically viable option for providing flood protection to the City of North Little Rock.

Arkansas River Levees Rehabilitation Study (Van Buren Levee and Floodwall, Fort Smith Levee and Floodwall, McLean Bottoms Levee District No. 3, Crawford County Levee System), USACE Little Rock District, Ark. —*Project Manager*

- Responsible for developing the cost and technical proposal, scheduling and directing the field work, report preparation, and making a presentation to the client on the study findings. The project required an economic analysis of the Van Buren Levee and Floodwall System, Fort Smith Levee and Floodwall, the McLean Bottoms Levee District No. 3, Levee System and the Crawford County Levee System in Arkansas to ensure the accuracy of data used in previous studies. The project area lies along the Arkansas River from approximately 123 miles to 153 miles west of Little Rock.
- The problems and opportunities in the study area were identified and addressed by a project team of economists, civil engineers, hydrologists, cost engineers, and planners. The three major components of the study included an update of the economics on the identified levee systems; a comparison of the updated economics to the most recently used Corps of Engineers' economics; recommendations for repairs as needed and a presentation of study findings.

Inundation Reduction Benefit Report, USACE Los Angeles District, Imperial Valley, Calif. —*Project Manager*

- Study began with the delineation of land use into agricultural and urban categories. For the agricultural category, crop inundation losses were determined through an evaluation of crop distribution and production budget analyses to determine crop production losses. Non-crop flood damages included damages to farm houses, equipment, and facilities and were determined through the use of the Urban Flood Damage Computer Program. Properties in the urban category were visually identified and assigned elevations through the use of topographic maps and hand levels. Depreciated replacement values of residential and commercial structure values were determined through use of Marshall and Swift valuation procedures, and verified through contacts with local real estate agents. Damages were calculated for various frequency flood events under with- and without project conditions. These damages were then used to generate estimated annual damages. Annual damages were not

large enough to justify potential engineering flood damage reduction measures and the study was terminated to avoid further study costs.

Residential and Commercial Structure Inventory, Jefferson Parish (East Bank), USACE New Orleans District, La. —*Project Manager*

- Directed the collection of pertinent information to form a statistically significant sample of the residential and commercial structures selected by the Corps of Engineers from within the 500 year floodplain in the Jefferson Parish (east bank of the Mississippi River). The sample list supplied by the Corps of Engineers contained 3,203 residential structures, 1,035 commercial structures, and 3,812 miscellaneous structures. These sample structures were distributed over 110 hydrologic storage areas.
- Information collection was accomplished through extensive field surveys conducted by project teams. Information was gathered regarding a number of characteristics for each structure surveyed including, elevation of first floor, estimate of depreciated replacement value, and category of structure use. Data collected was entered into a computerized database for use in calculating average annual flood damages.

Depth/Damage Relationships, Flood of 1993, Lower River Des Peres Watershed, USACE St. Louis District, Mo. —*Project Manager*

- Study to develop the relationship between structure value (replacement cost less depreciation) to depth of flooding over the first floor and damage (as a percent of structure value). Data elements for each structure were drawn from databases provided by the St. Louis District, the county appraiser, the city engineer, insurance records, a field survey, subsequent valuation of all structures using Marshall & Swift Valuation service programs and extensive personal interviews. The Best Fit distribution analysis program was used to typify the distribution(s) about the points on the curves. Values for selected points were calculated using both average and summation methods. These curves were compared to each other and to curves resulting from regression analysis. Curves were generated for single and multiple story residential, public, commercial and industrial properties.

Recreation Studies

Moonshine Beach Park and Table Rock Lake Market Feasibility Analysis, USACE Little Rock District, Branson, Mo. —*Project Manager*

- Conducted this analysis that determined the feasibility of recreational facilities and related services in the vicinity of Moonshine Beach Park on Table Rock Lake, near Branson, Mo. The analysis included interviewing recreational users to determine the type of services required, developing two recreational facility development scenarios, and projecting visitation, income and cash flows, and net present values for each alternative.

Economic Impact of Reducing Services at Starkey Park and Relocation of Starkey Marina, USACE Little Rock District, Beaver Lake, Ark. —*Project Manager*

- Conducted recreational use surveys of users of the Corps of Engineers Starkey Park and the leased Starkey Marina at Beaver Lake on the White River. The recreational user surveys were conducted during the three peak use weekends of Memorial Day, Fourth of July, and Labor Day. The benefits and costs of keeping the park open were calculated and financial and market analyses were developed for the existing and alternative locations for the marina.

Beaver Lake Marina Recreation and Market Analysis, USACE Little Rock District, Ark. — *Lead Economist,* Project Manager

- Investigation to determine the demand for additional marina services at the dam site of Beaver Lake and the feasibility of a new marina at the dam site to satisfy those demands. Demand for marina services was determined through a survey of recreation participants and their willingness to pay for additional facilities. Feasibility for the overall project was determined by converting future demand into cash flows for a 15-year period of analysis and computing payout time, net present value, and internal rates of return.

Coastal Erosion/Beach Re-nourishment Studies

Economic Evaluation of Benefits from Beneficial Use Disposal Alternatives of Dredged Material for Consistency with State of Texas Coastal Management Plan, USACE

Galveston District, Tex. —*Principal Investigator*

- Analysis that documented two extensive literature reviews to determine whether any accepted methodologies had been developed to quantify the monetary value of beneficial use of dredge material. None were found. The work effort then focused on the qualitative assessment of the existing dredge disposal plans compared to alternative beneficial disposal plans.

Tybee Island Re-Evaluation Study Economic Analysis, USACE Savannah District, Savannah, Ga.

- Performed without- and with-project comparisons of proposed beach nourishment alternatives along the Back River west of Tybee Island. The storm damage model was used to estimate expected annual damages to shorefront property, land loss, and armor from annual and storm induced beach recession. Without- and with-project recreation usage was estimated and associated parking needs and availability were determined.
- As part of this project, benefits from a previous Corps of Engineers study of nourishment of the ocean side beach were updated to current dollars.

Special and/or Unique Projects

Geographic Information System (GIS), USACE New Orleans District, Livingston Parish, La. —*Project Manager*

- Project conducted under the New Orleans District's Planning Assistance to the States (PAS) program and involved providing technical assistance to Livingston Parish to create a Geographic Information System (GIS) to coordinate the Parish's delivery of governmental services. The first task was to assess the geographic data needs and mapping capabilities of the Parish; identify, cost, and prioritize necessary spatial data; and develop a feasibility plan for implementation of the parish-wide system. The project then developed the GIS layers using highresolution aerial photography as a base for all layers. The development of the system included road centerlines, railroads, building footprints, parcels, jurisdictional boundaries, voter precincts, and an Interactive Map Service (IMS).
- Additional activities included development GIS layers of lots, utilities, hydrology, and land use for the Parish-wide system.

Licking River Watershed and Dillon Lake Ecosystem Restoration Project, USACE Huntington District, Ohio —*Project Manager*

- Study to develop, evaluate, and recommend alternatives to restore the aquatic ecosystem of the Licking River Watershed (LRW) and Dillon Lake. Trends in economic growth in the watershed had critically impaired the aquatic and riparian ecosystem in the watershed and resulted in excessive sediment in the reservoir.
- Developed and implemented the Quality Control Plan and conducted the Internal Technical Review (ITR) and Incremental Cost Analysis (ICA) of the proposed ecosystem restoration measures for the project.

Development of Project Study Plan (PSP) for Dredged Material Management Plan (DMMP) for Gulf Intracoastal Waterway (GIWW), USACE Galveston District, GIWW, High Island to Brazos River, Tex. —*Project Manager*

- Developed the PSP for the Dredged Material Management Plan for the GIWW from High Island to the Brazos River for the Galveston District. The PSP identified the estimated level of effort, contingencies, work assignments, and schedules associated with preparation of the DMMP. The DMMP required a description of all relevant dredged material management information including dredged quantities and quality of material for this portion of the GIWW along the Texas coast. This included dredged material management information on contamination, economic and environmental considerations, and disposal management activities for the current dredging practices. It also required identification of specific measures necessary to manage the volume of material expected to be dredged over the next 20 years for construction and maintenance of dredged material placement areas for all federal and non-federal permitted dredging within the geographic area.
- Alternative plans and a scope of work for preparing this DMMP were developed as part of this effort. The PSP considered the full range of measures for dredged materials management, including management of existing

disposal sites to extend their life; various combinations of new disposal sites including different disposal methods, disposal locations, and periods of use; and measures to reduce dredging requirements, including reduced dimensions and reduced sediment from upstream sources.

Projection of Study Area Involvement in Present and Future Petroleum Industry Activities on the Outer Continental Shelf (OCS) , Channel Deepening Study, USACE New Orleans District, Port of Iberia, New Iberia, La. —*Project Manager*

- For the reconnaissance phase of this study, identified the NED benefits that would accrue to study area firms from a deeper navigation channel. The fundamental assumption that the need for a deeper channel was that the oil and gas industry's future growth is on the OCS. The exploration, production, and servicing of these OCS facilities will require larger deeper draft equipment. The biggest beneficiaries were firms engaged in fabrication of offshore oil and gas related equipment.
- This study was a detailed market analysis of this industry to determine the likelihood that these firms would produce the claimed NED benefits. This analysis was required for the increased production opportunities benefit category for both with- and without project conditions. The initial phase of this project was an analysis of the global demand for petroleum and the identification of the fabricators of these rigs and their production cost, including transportation costs. Then an analysis of regional markets was conducted. This included identification of the regions (markets) of the world where Port of Iberia fabricators have the highest potential for winning contracts for new components. In addition, the fabricators meeting existing demand and their cost of production were identified to determine competitive cost advantages. The last phase of this project was to identify the fabricators of offshore rig components by industry segment, which included not only the Port of Iberia, but also Morgan City and the Houma Navigation Canal.
- The NED project benefits were the increases in net income to U.S. fabricators from additional fabrication work due to the incremental foot-by-foot deepening of the navigation channel.

Development of Initial Job Training Program, Community Impact Mitigation Plan, Inner Harbor Navigation Canal (IHNC) Lock Replacement, USACE New Orleans District, New Orleans, La. —*Project Manager*

- Project had two separate phases that unavoidably had some overlap in terms of both subject matter and timing. Phase I focused on an analysis of the labor market characteristics in the study area while the objective of Phase II was the development of a viable job training program.
- The primary purpose of the project was to draw the necessary labor force to perform the construction of the IHNC Lock from the impacted community. The study area consisted of the entire New Orleans metropolitan area SMSA, but was primarily focused on the communities immediately adjacent to actual project construction. Specifically, this included the area bounded by Press Street on the west, the Mississippi River on the south, the Orleans/St. Bernard Parish line on the east, and Florida Avenue to the north. The neighborhoods involved included Holy Cross, Lower Ninth Ward, Bywater, and St. Claude.

Preparation of a Financial Resources Handbook, USACE Portland District, Ore. —*Project Manager*

- Project required the preparation of a financial resources handbook for use by the Corps of Engineers and nonfederal partners seeking technical or financial assistance on a water resource problem or project. The handbook covered sources of technical assistance for water resources projects, provided information on the programs available and contact information for the federal, state, and local programs for financing these projects. Monetary instruments, such as bonds, used for private sector financing were also presented.

Roberto Cuevas

Qualifications Summary

- Engineering cost estimator with 34-year background in cost estimating, project management, and project engineering and has provided estimating services for commercial, military, and industrial projects including project takeoffs and pricing from the conceptual phase to construction documents.
- Excellent skills in detailed cost estimating and in-depth conceptual and parametric cost estimating based on a solid understanding of the electrical engineering and related disciplines gained from his electrical engineering background and 20 years in the construction industry.
- Extensive experience in the preparation and analysis of change orders. PC-based estimating software experience includes Composer Gold, Cost Link, Success Estimator and MII.
- Current general responsibilities include providing estimating and scheduling support on projects from the conceptual design stage through to construction, to help meet contract schedules and budgets; assisting project managers in troubleshooting scheduling and budgeting problems prior to occurrence; and providing support to clients in the research, review, and analysis of construction claims.

Education

- B.S., Electrical Engineering, University of Puerto Rico, 1966

Summary of Professional Experience

PBS&J—*Senior Estimator/Scheduler*

Preparation of construction cost estimates for U. S. Army Corps of Engineers project using MII Estimating Software at the Hurricane Protection Office in New Orleans, Louisiana. Also work with Estimate Reviews, Cost Analysis and Source Selection.

Representative Projects:

- JSP-05 Storm proofing Interior Pump Stations, Jefferson Parish, Louisiana
- LPV 105.02 East Reach Lakefront Airport T-walls, Orleans Parish, Louisiana
- LPV 107 Lincoln Beach Levee & Floodgate, Orleans Parish, Louisiana

Estimating services for Stratcom Offutt Air Force Base, Omaha, Nebraska

- Responsible to provide estimating services for this facility which includes retrofit of the mechanical and electrical systems. Worked with preliminary information gather during site visits to prepare a complete estimate.

Construction Management and Cost Estimating Services for the Education and Administration Center at Fort McHenry National Monument and Historical Shrine, Baltimore, Md. (National Park Service [NPS])

- Responsible for preparation of the electrical estimate. As part of PBS&J's ongoing work for the NPS, will provide class "A" cost estimating services for the new education and administration center at the Fort McHenry National Monument and Historical Shrine.

Additions and Architectural Services to the Swimming and Fitness Center – University of Texas, El Paso (Moody Nolan, Inc.)

- Responsible for providing electrical estimate services. PBS&J, in association with Moody-Nolan, Inc., will provide architectural services for an addition and renovation of the existing swimming and fitness center at the University of Texas in El Paso. The initial scope of work includes preparing and coordinating a comprehensive facility program in accordance with the University's facilities programming guidelines, and

involves meeting with various departments, completing building evaluation, preparing space analyses, space adjacency diagrams, conceptual cost estimates, code analyses, Texas Accessibility Standards evaluation, and room data sheets. Will also provide architectural design services.

U.S. Air Force McGuire Air Force Base (AFB) TO03-Facility Condition Assessments and Q-Ratings for the Joint Base; Fort Dix, Navy Lakehurst, and McGuire AFB, N.J. (Ewing Cole Cherry Brott)

- Responsible for building assessment and survey to bring the facilities up to electrical standards. As a subconsultant, PBS&J is currently providing facility assessments for the U.S. Army Corp of Engineers (USACE) at Fort Dix, Navy Lakehurst, and McGuire AFB in New Jersey. These assessments consist of a review of 400 facilities by a four-man team of discipline experts – architect, structural, electrical, and mechanical.
- Overall assessments include structural and envelope review for deficiencies, major system (HVAC, fire sprinkler, plumbing, electrical power, lighting) review, and recommendations for capital improvements, environmental betterments, and energy efficiency initiatives.
- Estimated that the 400 buildings assessment will conclude by November 2008. USACE will use the assessments as a primary tool to evaluate upcoming major renovations, capital improvement budgets, facility utilization, and maintenance requirements.

U.S. Property & Fiscal Office (USPFO) Security/Communications Facilities, Lincoln, Nebr.

- Responsible for preparation of the electrical estimate. Project involves adding/altering the security and communications facilities.

Campbell Drive Middle School, Miami-Dade County, Fla. (Miami-Dade County Public Schools [MDCPS])

- Responsible for a complete estimate to include the air handling units electrical and controls work. Project involves the replacement of HVAC controls and air handling units for the Campbell Drive Middle School located in Miami.

Middle School Prototypes, Miami-Dade County, Florida (MDCPS)

- Responsible for change order review to reconcile the estimate with the electrical contractor. Project involves a review of the construction manager's request for change orders (RCO) proposal.

Faithful and Gould, Miami, Fla.—*Senior Electrical Cost Estimator*

- Provided estimating services for commercial, military, and industrial projects including takeoff and pricing from the conceptual phase to the construction documents. Worked in coordination with the architectural, civil, and mechanical trades estimators to provide a complete computerized estimate. Attended reconciliation meetings to discuss and agree on price differences with the contractor. Representative projects included:
  - Honda Engine Plant, Lincoln, Ala.
  - Memorial Regional Hospital Central Energy Plant (CEP) Expansion, Hollywood, Fla.
  - Hangar Building 890/891 Repair and Remodeling, Miami, Fla.
  - Diego Garcia Island Wharf Upgrade, Diego Garcia Island, British Indian Ocean Territory
  - Miami-Dade County Children's Courthouse, Miami, Fla.
  - SRI International Marine Science Research Center, St. Petersburg, Fla.

Hanscomb, Inc., Orlando, Fla.—***Senior Electrical Cost Estimator***

- Provided cost estimating services for numerous airport, entertainment, hotel, hospital, military, and other projects. Representative projects included:
  - Vanderbilt Hotel, La Concha & Convention Center at the Condado Trio Complex, Puerto Rico
  - BMW Assembly Plant, Spartanburg, S.C.
  - Conway Water Treatment Plant Upgrade, Orlando, Fla.
  - Ben Gurion 2000 Airport, Tel Aviv, Israel
  - Blizzard Beach, Walt Disney World, Lake Buena Vista, Orlando, Fla.
  - AFS Launch Tower 17B, Cape Canaveral, Fla.
  - MCI Building, Pompano Beach, Fla.

RC Electrical and Controls Corp., San Juan, Puerto Rico—*Project Manager*

- In charge of business development and project management for electrical and controls work.
- Complete management of electrical construction work including estimating, purchasing, scheduling, and field operations supervision.
- Worked with new and remodeling projects including office buildings, hospitals, and pharmaceutical buildings.

Sam P. Wallace Corp., San Juan, Puerto Rico —*Project Engineer*

- Performed design, estimating, purchasing, scheduling, cost control, and field operation supervision for electrical and controls work primarily for pharmaceutical buildings.

Professional Associations

- AACE International

Stephen Dickey, RG, CEG, CHG

Qualifications Summary

- Senior Engineering Geologist and Hydrogeologist with over 35 years' experience performing engineering geologic, groundwater supply, contaminant hydrogeology, seismic risk, and geophysical work for industrial, government, and private clients. Project experience in California, the Southwest and Midwest regions, Montana, and Alaska. Work has included supervising geotechnical drilling operations, geologic aspects of heavy construction, construction dewatering, earthwork, seismic hazard, municipal well construction, and geophysical surveys.
- Field experience conducting emergency repair and safety upgrade projects for dams and hydraulic structures.
- Experience with evaluating geologic aspects of slope sufficiency for soil engineers, including providing estimate of potential seismic loads.
- Familiarity with risk assessment approach to hazards by assessing risk of earthquake vibration hazard and fault rupture hazard for critical electrical utility facilities in Southern California.
- Familiarity with USACE facilities and procedures from project work constructing safety upgrades to Success Lake flood control dam and Feather River levee at Yuba City.
- Project experience with complex and unfavorable dam foundation materials, including talc schist bearing Franciscan Assemblage metamorphic rocks.
- Project experience with in-situ deep ground modification (stone columns, wick drains, soil cement walls) in coastal environment, including assessing impact on groundwater hydrology.
- Extensive experience with application of groundwater model codes to projects in complex hydrologic and geologic environments.
- Extensive field and office experience conducting and interpreting geophysical surveys as applied to engineering problems and projects.

Education

- Graduate Work, Geophysics and Geology, University of Riverside, 1988–1990
- B.A., Geology, Occidental College, 1971

Certifications and Licenses

- Registered Geologist, State of California (#3615, 1980)
- Certified Engineering Geologist, State of California (#1070, 1980)
- Certified Hydrogeologist, State of California (#386, 1996)

Summary of Professional Experience

Southern California Edison (SCE)

- Worked within the Geotechnical Group, which provided in-house engineering, geotechnical, seismic hazard, and groundwater consulting services to the steam generation, research and development, hydro generation, transmission/substation, environmental affairs, and customer service departments.

ARCO Transportation—*Hydrogeologic and Environmental Consultant*

- In-house consultant for several petroleum pipeline/transportation operating companies including Four Corners

Pipeline, ARCO Pipeline, ARCO Transportation Alaska, Kenai Pipeline Company, ARCO Terminal Services, and ARCO Marine.

Lockheed Aeronautical Systems

- Technical management of groundwater Superfund work at Burbank, Calif.
- Assembled and managed a team of groundwater specialists in contaminant hydrogeology, groundwater modeling, geochemistry, and remedial design. The team addressed solvent contamination of a municipal groundwater aquifer underlying several square miles of Burbank, Calif., caused by aircraft manufacturing.
- Project included extensive groundwater investigation over a large area of Burbank and North Hollywood, operating a 1000 gpm groundwater treatment and aquifer reinjection system, and providing remedial design and engineering for a 6000 gpm groundwater extraction wellfield. The project required frequent interface with USEPA, the ULARA Watermaster, the Los Angeles Regional Water Quality Control Board, and City of Burbank municipal water supply executives.

Project Experience Related to Dam Safety

Investigation/Repair of Storm Damage to Thompson Dam Spillway, Santa Catalina Island, Los Angeles County, Calif.

- The Reservoir impounded by Thompson Dam provides more than 90% of the water supply for Avalon, Calif. During intense storms, a three foot spill caused the spillway flip bucket to fail and move downstream, and then scoured off the spillway concrete structure to bedrock more than halfway up to the spillway crest. The following response work was done under full reservoir conditions:
  - Supervised demolition of concrete structures and debris removal with Connelly Pacific and Union Engineering to clear the site for geotechnical investigation.
  - Supervised and logged exploration coreholes of underlying bedrock to determine foundation conditions for new flip bucket and spillway structure.
  - Inspection of foundation conditions during construction
  - Supervised slope deformation monitoring by survey and earth deformation recorder (slope inclinometer borings) when portions of bedrock slope began to creep in response to over-excavation for construction of new flip bucket.
  - Supervised installation of horizontal wells (hydraugers) into metamorphic foundation rock of spillway slope and side slopes to relieve seepage pressure and stop slope movement while construction completed.

Big Creek Dam 7, Water Stop Replacement.

- Dam 7 is part of the SCE Big Creek hydroelectric system on the San Joaquin River, Calif.
- Supervised air percussion drilling of vertical holes up to 250 ft deep which had to follow concrete monolith joints from crest of dam through concrete dam, and into foundation rock for water stop replacement.
- Part of inspection team verifying proper installation of flexible water stops in the boreholes by In-Situ Form, Inc.

Safety Upgrades to Success Lake Dam, Porterville, Calif.

- Supervised exploration drilling, design, installation, and testing of relief wells at toe of Success Lake Dam under USACE contract.
- Supervised excavation and re-grading at toe of dam, then installation of 5000 cubic yards rip rap stone.
- Supervised drilling, construction, testing of relief wells at toe of dam.

Installation of Relief Wells, Safety Upgrade to Feather River Levee, Shanghai Bend, Levee District 1, Yuba City, Calif.

- Used downhole induction logs of pilot exploration holes to construct geophysical cross section of subsurface to identify potential seepage paths under levee and aid design of pressure relief wells.

- Supervised drilling, construction and testing of approximately 50 relief wells.

Portal Forebay Dam Rapid Drawdown Assessment

- Performed groundwater modeling to estimate transient embankment water pressures under various rapid drawdown conditions. Portal Forebay is intake basin for Ward Tunnel and Ward Powerhouse, Southern California Edison Big Creek Project. Work product used as input by geotechnical engineer for embankment stability assessment.

Ash Canyon Dam, Mohave Generating Station, Laughlin, Nev.

- Supervised CSAMT electromagnetic and cross borehole electrical resistivity surveys by Zonge Engineering and University of California Berkeley to explore for possible seepage pathways for contaminated groundwater under earth fill dam to Colorado River.

Representative Professional Assignments

- Supervised investigation, monitoring, and groundwater modeling of cooling water contaminant plume, Mohave Generating Station, Laughlin, Nev.
- Geophysical survey followed by Cone Penetrometer and Hydropunch groundwater sampling to track offsite solvent plume migration for electronic manufacturer in Newport Beach.
- Exploration drilling, hydraulic testing/analysis, design and construction supervision for installation of deep well dewatering system, fuel oil tank farm at Redondo Beach Generating Station, CA.
- Design, installation of construction dewatering system to suppress high groundwater and facilitate over-excavation for school building foundations at Winchester, CA.
- Installation and testing of pilot dewatering system wells with Griffin Dewatering for Bart Extension project, Milbrae and San Bruno, San Francisco Bay area, CA.
- Supervised drilling, construction and testing of three 2500 to 4000 gpm water supply wells for San Gabriel Valley Water Company, CA.
- Supervised drilling, construction, and testing of two 2500 gpm water supply wells for Valley County Water Company, Irwindale, Calif.
- Supervised drilling and construction of five 2000 to 4000 gpm water supply wells for Suburban Water Systems in West Covina, Pico Rivera, and La Mirada, Calif.
- Supervised drilling, construction, and testing of two 1000+ construction water wells for E. L. Yeager Construction, Riverside, Calif.
- Supervised drilling, construction, and testing of two municipal supply wells for Santa Ynez Water Conservation District, Santa Ynez, Calif.
- Performed fault rupture hazard in coastal shallow groundwater area of Newport-Inglewood Fault Zone in Long Beach, CA using cone-penetrometer soundings to generate three-dimensional image of layering within soft lagoonal sediments.
- Supervised drilling, construction, and testing of two 1000+ industrial water supply wells for Robertson's Materials, Riverside, Calif.
- Supervised drilling, construction, and testing of five alluvial and hardrock municipal supply wells for SCE water system at Santa Catalina Island.
- Investigated mining subsidence damage to six story brick apartment building built over extensive underground mineworks, Butte, MT. Project included monitoring of building deformation, re-constructing history of subsidence deformation in surrounding area from historical records, interpreting stope book mining maps.
- Supervised drilling, construction, and testing of three golf course irrigation wells for City of Victorville, Calif.
- Supervision of drilling, zone testing, construction of four municipal wells for Los Angeles County Public Works Division at Lancaster, Calif.
- Investigation of subsurface groundwater conditions, interaction of surface water and groundwater for Mill Creek Diversion 3 for FERC hydro relicensing Joint Flow Recommendation Subcommittee process, SCE Hydro

Generation Division. Similar work was done for SCE FERC licensing projects for Santa Ana River and Lytle Creek.

- Installation of groundwater monitoring instrumentation for hydrology/riparian vegetation monitoring at Rush Creek and Lee Vining Creek for SCE Hydro Generation, Eastern Division, Sierra Nevada Mountains, Calif.
- Hydrogeologic evaluation, well siting, and installation supervision of horizontal wells in granitic rock for private land owners at Palomar Mountain, Sawpit Canyon and Waterman Canyon in San Bernardino Mountains.
- Seismic survey to determine subsurface rock conditions for realignment of sewer main adjacent to Santa Rosa Creek for Cambria Community Services.
- Microgravity and electrical resistivity survey of beach areas at Cambria, California to delineate subsurface topography of canyons under beach sand for location of desalinization plant seawater intake and brine rejection wells, Cambria Community Services District.
- Prepared updated Alquist-Priolo fault rupture hazard investigation for property within Newport-Inglewood Fault Zone on Reservoir Hill in Long Beach, Calif.
- Geophysical survey of sixteen springs at U. S. Navy China Lake Air Weapons Station to support long term project to site and develop groundwater supplies for remote test facilities.
- Magnetometer survey at Pismo Beach to determine “as constructed” bottom depth of embedment for foundation caissons in eroded seaside cliff during slope reinforcement/grade beam construction.
- Performed inclinometer (“Slope Indicator”) deformation monitoring surveys for landslide investigations at Palos Verdes, Whittier Hills, Laguna Niguel, San Clemente, and San Fernando Valley.
- Evaluation of groundwater resources for long term industrial water supply, Soda Lake Basin, Upper Johnson Valley, Ivanpah Valley, Danby Lake, and Bristol Lake valleys, Calif. Work scope included drilling test wells, aquifer testing, and research of historical water levels and water production.
- Provided groundwater resources evaluation and well site selection for Vineyard development at Escondido Ranch, Santa Catalina Island, Calif.
- Well siting and construction supervision for granite water supply wells up to 1100 feet in depth for private ranch, Escondido, Calif.
- Horizontal borehole camera survey to locate source of primary liner leak, cyanide heap leach facility, Viceroy Mine, Nipton, Calif.
- Monitored and inspected removal of Otto fuel tanks, and installation of new double lined Otto fuel tanks, Point Loma Submarine Base Torpedo Shop, San Diego, Calif.
- Downhole logging of bucket auger exploration holes in landslides at Whittier Hills, Palos Verdes, Laguna Niguel, Goleta.
- Resistivity survey for groundwater resources, Casa De Las Pobres, Rosarito, Baja Norte, Mexico.

Jim Dobberstine

Qualifications Summary

- Extensive experience as a biologist and environmental scientist (since 1993), and with development, evaluation, and review of NEPA impact and cumulative affects assessments (since 2002) on complex, multi-objective projects including port/shipping terminal, rail, drilling and pipeline, commercial and residential development, and aquatic habitat restoration projects. The projects involved coordination with agencies including the USACE, NOAA-NMFS, EPA, USFWS, and numerous state, local, and private entities. Experience in research of many aspects of aquatic and riparian habitats, including water and sediment characterization (toxicity, biotic community, chemistry).
- M.S. in Environmental Management (NEPA, CWA, ESA and other regulatory), an M.S. in Environmental Science (Biology and Environmental Toxicology), and a B.A. in Life Sciences (Biology/Chemistry). Certificates in USACE wetland delineation (Texas A&M) and water quality improvement using constructed wetlands (Clemson).
- Experience with NEPA impact and cumulative affects assessments on projects with high public and interagency interest within sensitive aquatic habitats, including wetlands and riparian systems. Examples include habitat restoration featuring beneficial uses of dredge material to restore estuarine marsh and sea grass beds, coupled to coastal marsh preservation. Also habitat restoration in mixed urban/industrial riparian areas where there were potential toxicant/exposure concerns contrasted with significant cultural and environmental benefits including community education and recreation opportunities, and ecosystem enhancement.
- Extensive experience developing and evaluating USACE permits applications and related documents for the Galveston Bay Foundation. Experienced with the complex regulatory framework affecting projects that potentially impact aquatic habitat (NEPA, ESA, CWA, etc.).
- Ongoing research in benthic habitats, ecotoxicology, and ecosystem function in aquatic estuarine communities.
- Board member of the Texas Association of Environmental Professionals (TAEP): President of the Board (2010-11) and Education Director (2007-11).
- Board Member of the South Central Regional Chapter of the Society of Environmental Toxicology and Chemistry (SETAC) 2010-11.
- Galveston Bay Council: current member of the Monitoring and Research Subcommittee, former Vice-Chair of the Public Participation and Education Subcommittee.
- Served on the Independent External Peer Review of the Engineering, Economic, and Environmental Evaluation of the Geotechnical, Hydrological, Hydraulic, and Economic Aspects of the Dam Safety Modification Study Report for Rough River Dam, Kentucky.

Education

- M.S., Environmental Science, University of Houston Clear Lake
- M.S., Environmental Management, University of Houston Clear Lake
- B.A., Life Sciences, Concordia University Portland

Certifications and Licenses

- Certificate: 40 hour USCOE Wetland Delineation Course. Texas A&M, Texas Seagrant, and the Texas Coastal Watershed Program, 2007.
- Certificate: Constructed Wetlands for Water Quality Improvement. Entrix, Clemson University, and University of Houston Clear Lake, 2004.
- Certificate: Management Development at the American Zoo and Aquarium Association School for Zoo and

Aquarium Personnel conducted by North Carolina State University, 1999.

- Completed: GIS Techniques in Environmental Assessment. SETAC short course conducted by the University of North Texas, 2011.
- Completed: Probabilistic Ecological Risk Assessment. SETAC short course conducted by Texas Tech University, 2010.
- Completed: Application of Adaptive Management to Address Climate Change Related Challenges. Restore America's Estuaries (RAE) Special Program conducted by the NOAA Coastal Service Center and the PBS&J Ecosystem Restoration Division, 2010.
- Completed: Predicting the Toxicity of Metals to Aquatic Organisms: An Introduction to the Biotic Ligand Model. SETAC short course conducted by Aquatic Ecological Risk Assessment L.L.C., HydroQual, Inc., and the Copper Development Association, 2009.
- Completed: Benthic Mapping Techniques aboard the Alletta Morris. Benthic mapping techniques including sidescan sonar, underwater video, sediment profile cameras, and soil cores. RAE Special Program conducted by the EPA, USDA-NRCS, and the University of Rhode Island, 2008.
- Completed: Sampling Benthic Sediments: Methods, Analyses, and Judgments. SETAC short course conducted by the University of North Texas Institute of Applied Sciences, 2006.
- Completed: Conserving Land with Conservation Easements short course, a program of the National Land Trust Alliance's 2006 Land Conservation Leadership Program.

Summary of Professional Experience

Lee College, Environmental Science and Biology—*Faculty*

- Lead instructor in the environmental science program. Includes development of new courses and textbook/lab manual selection. Courses often focus on Galveston Bay as a model for concepts discussed, and incorporate practical experience and research in aquatic ecosystem function of estuarine communities. Courses also cover many aspects of environmental regulation, including the National Environmental Policy Act, the Clean Water Act, the Clean Air Act, and the Endangered Species Act.
- Has worked to foster research opportunities for students through partnerships with local universities, the results of which have been featured through organizations including Restore America's Estuaries (RAE) and the Society of Environmental Toxicology and Chemistry (SETAC).
- Ongoing research in benthic habitats, ecotoxicology, and ecosystem function in aquatic estuarine communities.
- Editor and contributor to Laboratory and Field Exercises in Environmental Science (Lehmberg, 2010).
- Member on the Professional Development Committee (a subcommittee of the Lee College Faculty Assembly).
- Member of the Faculty Learning Community of Lee College, working to develop improved teaching methods for critical thinking.
- Member of the Instructional Learning Outcomes Committee, developing program assessments for student learning.
- External Advisor for the University of Houston Environmental Management Program Curriculum Review, April 2007.
- Grant development for program development, student research, and student support.
- 2007-2008: Member of the Technical Advisory Committee of the Chambers (TX) Greenprint Project of the Trust for Public Land.
- 2010: Session Chair at the Restore America's Estuaries Conference (Galveston, TX) session titled "Opportunities, Challenges, and Lessons Learned with the Use of Dredged Materials".
- 2009: Session Chair at the Galveston Bay Estuary Program's Ninth Biennial State of the Bay Symposium (Galveston, TX) session titled "The Science of Estuarine Wetlands".

The Galveston Bay Foundation—*Environmental Scientist*

- Land Programs Manager, working as an environmental scientist and regulatory specialist, focusing on wetlands and other aquatic habitats. Experienced team member on numerous aquatic habitat restoration projects aiding in project design, funding development, safety and toxicity issues, and habitat quality/needs. Projects included numerous aquatic habitat (stream/river, estuarine wetland) restoration projects, stream bank erosion protection, and stream/estuarine aquatic habitat assessments, including lifecycle and habitat needs. Extensive experience developing and evaluating U.S. Army Corps of Engineers permits applications and related documents for the Galveston Bay Foundation. Experienced with the complex regulatory framework affecting projects that potentially impact coastal habitat (NEPA, ESA, CWA, etc.).
- Worked in the area of habitat conservation, overseeing the Foundation's Land Conservation program managing more than 2,500 acres of protected coastal habitat (terrestrial and aquatic). Included conservation easements, fee-simple acquisition, and development of habitat assessments, project cost models, and easement contracts.
- Habitat restoration experience at all phases, including project development, permit acquisition, fundraising/grant development, and project implementation. Projects include:
  - Emergent estuarine marsh and seagrass habitat beneficially using dredge material from onsite, coupled to preservation (conservation easement) of associated coastal high marsh and prairie (buffer) habitat in west Galveston Bay and Galveston Island.
  - Emergent estuarine and palustrine marsh within riparian corridors of lower Galveston Bay.
  - Estuarine marsh and correction of erosional losses upland in high wave energy areas of east Galveston Bay.
  - Subsided marsh within mixed urban/industrial areas of upper Galveston Bay where potential toxicant/exposure concerns contrasted with significant cultural and environmental benefits including community education and recreation opportunities, and ecosystem enhancement.
- Project manager for a number of federal grant funded habitat research and educational projects at all phases. This includes fund raising, project design and implementation, reporting, and public outreach. Example projects include:
  - "Science Based Monitoring of Created Wetlands and Restored Habitat within the Galveston Bay System", a joint project in partnership with the University of Houston Clear Lake. This research project provided stipends for student research focused on the functional aspects of multiple wetland habitat restoration sites, generating data regarding the vegetation and faunal uses of created marshes relative to natural ones. Funding partners included NOAA, the Texas General Land Office Texas Coastal Management Program (TCMP), and the Galveston Bay Estuary Program (GBEP). Data collected is anticipated to aid habitat restoration managers with the design and implementation of future projects in the lower Galveston Bay watershed.
  - "Discover Galveston Bay Interpretive Sign Project": Two-tier grant funded project placing educational signs on the natural history specific to 40 locations around the Galveston Bay watershed in cooperation with multiple private and public agency partners. Funded by NOAA and the TCMP.
- Project manager for a number of successful projects linking science to policy, including:
  - The Galveston Bay Foundation's Wetland Permit Review Program working proactively with citizens, local business, and federal, state and regional policy makers to affect positive change to both individual actions and the underlying policies affecting the Galveston Bay watershed. Coordinated with federal, state, and local agencies to review project proposals within the lower Galveston Bay watershed, providing comments on impacts, alternatives analysis, mitigation requirements, and project design, aimed at reducing any given project's adverse impacts to Galveston Bay. Also conducted rulemaking reviews and comment development, and worked to establish clear links between the relevant science and policy affecting aquatic habitat management within the bay system.
  - The federally funded (USFWS) Living Shorelines programs, assisting local landowners with permitting, fundraising, and project implementation for shoreline restoration and alternative shoreline stabilization on private lands within the bay system.
- GBF representative on citizen advisory panels (CAPs) facilitating communication between local petrochemical industry and neighboring communities, including the Bay Area Citizens Advisory Panel (Baycap) and the Seashore Area Citizens Advisory Panel (Seacap).

The Houston Advanced Research Center (HARC)—*Contract Consultant*

- Assisted information management, technical communications, and stakeholder facilitation related to the Galveston Bay Freshwater Inflows Group, a program of the Galveston Bay Estuary Program. Required extensive knowledge of stream and estuarine ecology, water quality, and research methods, including familiarity with ongoing research regarding environmental flows in Texas.

The University of Houston Clear Lake (UHCL)—*Graduate Research Assistant*

- Research assistant to Dr. Cindy Howard, working on estuarine habitat assessments (water, sediment, benthic community), sediment toxicity, and sediment contaminants (heavy metals, organics). This position included an internship completed with the PBS&J Environmental Toxicology Laboratory, Houston under Dr. Jim Horne, learning protocols and procedures for bioassays related to sediment toxicity characterization and whole effluent toxicity in accordance with USEPA and USACE guidelines.

Public zoo and aquarium field—*Senior Biologist, Aquatic Habitat Specialist*

- Extensive experience working with aquatic organisms, water quality, and aquatic habitats with organisms including fish, birds, and marine mammals. Included developing protocols and managing water system maintenance, repair, analytical schedules and procedures for aquatic animal life support, ensuring compliance with all local, state and federal regulations that relate to water quality and animal welfare, staff supervision and training, developing work schedules. Also budget development and staff training protocols related to animal care. Developed in-depth knowledge of wildlife, ecology, and habitat preservation. Includes field experience such as assisting Texas Marine Mammal Stranding Network with stranded sperm whale calf as part of first response team responsible for locating and initial treatment of animal at the treatment site in 1989. Also includes participating in successful captive breeding programs for North American river otters (*Lutra canadensis*) and endangered brown pelicans (*Pelicanus occidentalis*), and assisting with the care of several species of sea turtles, including Kemp's Ridley held for the National Marine Fisheries Head Start Project at Sea-Arama Marineworld from 1984-1990.

Related Publications

- 2009/10: Editor and section contributor to Laboratory and Field Exercises in Environmental Science (Lehmberg, 2010; ISBN978-0-578-05921-1).
- 2008: Platform presentation at the 4th National Restore America's Estuaries Conference (Providence, RI) on ongoing research titled "*Comparing salt marsh ecosystem responses to different restoration techniques*". Also presented at the 2009 Texas Coastal Conference hosted by the Texas General Land Office (Galveston, TX).
- 2007: Co-author of a research poster presented at the Eighth Biennial State of the Bay Symposium (Galveston, TX) titled "*Identifying suitable reference sites for impacted sites along the Houston Ship Channel*" (J. Dobberstine, J. Horne, L. Brzuzy, C. Howard). Full paper in the conference proceedings, viewable at http://gbic.tamug.edu/gbeppubs/sobviii/sobviii_rpr.htm#Dobberstine. This work was also presented as a platform at the 2006 Society of Environmental Toxicology and Chemistry National Conference (Montreal, Canada) and at the American Association for the Advancement of Science (AAAS) Southwestern and Rocky Mountain Division Annual Meeting (Clear Lake, TX), April 2007, where it was awarded "Honorable Mention" for outstanding student paper presentation.
- (2007) "*Sediment Triad Approach to Finding a Suitable Reference Bayou for Patrick Bayou and Similar Sites Located on the Houston Ship Channel*". Master's Thesis, UHCL.
- 2007: Presenter at the Texas Association of Environmental Professionals Environmental Challenges and Innovations Conference; presented a platform titled "*Public Comments and the role of an NGO in the NEPA process; an overview of the Galveston Bay Foundation's volunteer Permit Review Committee*." Also presented at the Society for Wetland Scientists annual conference in June 2007.
- 2007: Co-author of two research posters, "*Functional Assessment of Plant Communities at Four Restored Sites in a Lower Galveston Bay Estuarine Marsh Complex*" (L. Ray, J. Dobberstine, J.C. Whitney, C. Howard) and "*Comparison of Benthic Macroinvertebrate Communities among Native, Restored, and Impacted Salt Marshes in the Galveston Bay System*" (K. Farmer, J. Dobberstine, C. Howard), presented at the Society of Environmental Toxicology and Chemistry National Conference (Milwaukee, WI).

- 2006: Round Table presenter and panelist at the Texas A&M University Chapter of Sigma Xi's Spring Symposium (College Station, TX) on "Sea-level rise, hurricanes, and the future of our coasts".
- 2006: Platform presentation titled "*Successes and Challenges: An overview of community-based coastal marsh restoration in Galveston Bay*" at the 3rd National Restore America's Estuaries National Conference (New Orleans, LA).
- 2005: Co-author of a platform presentation, "*PAHs Environmental Overview: Occurrence in Houston Area Sediments*" (I. Rhodes, J. Dobberstine, L. Brzuzy), presented at the SETAC SW Regional Meeting (Marble Falls, TX).
- 2005: Public Participation and Education Plenary Session moderator at the GBEP "State of the Bay" Symposium, January 25th, Houston TX.
- 1996: Co-authored paper titled "Hand-rearing Scarlet Ibis (*Eudocimus ruber*) at Moody Gardens". Published in the Animal Keepers' Forum, October 1996. Awarded Certificate of Excellence in Journalism at the American Association of Zookeepers National Conference in October 1997.
- 1993: Co-authored a research paper concerning behavioral tendencies and enrichment with Spectacled Bears (*Tremarctos ornatus*) and American Black Bears (*Ursus americanus*), titled "Food-Scattering Enrichment for Zoo Bears: Does It Really Work?" Published in the Shape of Enrichment, February 1994. Presented the same research in poster format at the First Conference on Environmental Enrichment, Portland, Oregon.

Research manuscripts in progress:

- "*An Assessment of Restored Wetlands in the Lower Galveston Bay Watershed*". Co-Author: Cynthia L. Howard, University of Houston Clear Lake.

Professional Associations

- Texas Association of Environmental Professionals (TAEP): Board member since 2008.
  - *President (2010-11)*
  - *Education Director (2008- present; oversees the association's Chuck Glore Memorial Scholarship program, which awards $1000 scholarships to environmental science and engineering students at several southeast Texas universities)*
- South Central Regional Chapter of the Society of Environmental Toxicology and Chemistry (SETAC):
  - Board Member (2010 to present)
- The Galveston Bay Foundation:
  - Board member since 2009
  - Delegate Trustee representing TAEP
  - Advisor for the Land Committee working with conservation land holdings
  - Advisor for the Wetland Permit Review Committee reviewing regulatory notices and advising on actions
- Galveston Bay Council (Galveston Bay Estuary Program):
  - Vice-Chair of the Public Participation and Education Subcommittee (2003-2006)
  - Member of the Monitoring and Research Subcommittee (2007-present)
- Member of the Council on Undergraduate Research (2010 to present)

Awards

- 2009 Phi Theta Kappa "Certificate of Appreciation" in recognition of valuable contributions to the 2009 student inductees.

W.H. Espey, Jr., Ph.D., P.E., D.WRE

Qualifications Summary

- Registered professional engineer
- Over 40 years experience in environmental and water resources engineering with particular emphasis in the areas of, water resources (water availability, water rights), industrial and municipal waste management, treatment, and disposal. Specifically has extensive experience in the use of various and numerical hydrologic models
- HEC 1. HEC 2, HEC-RAS, HEC-HMS, HEC-DSS, SWMM, STWAVE, ADCIRC
- Dr. Espey has over 40 years of private consulting experience primarily in the field of hydrologic engineering. His research has been concerned with problems in the areas of coastal and inland flooding, urban hydrology, drainage, and sedimentation. Dr. Espey has directed both research and consulting engineering projects under contract for numerous industrial and public clients. Dr. Espey has also been involved in various flood control projects concerning industrial/public facilities and land development projects. Dr. Espey's engineering experience covers a broad range of environmental, planning and engineering services. Dr. Espey has been involved in many flood control projects in the Southwest. He has also served on various review panels regarding proposed flood control projects (channel improvements, storage, and levees)
- Ph.D. in Civil Engineering.

Education

- Ph.D., Civil Engineering, The University of Texas at Austin, Texas, 1965
- M.S., Civil Engineering, The University of Texas at Austin, Texas, 1963
- B.S., Civil Engineering, The University of Texas at Austin, Texas, 1960
- USGS, Management, Short Course, Washington D.C., 1963
- Manhattan College, June 1969, Stream and Estuarine Analysis Course
- American Society of Civil Engineers Continuing Education Program, "Effective Marketing of Professional Services," 1977

Certifications and Licenses

- Registered Professional Engineer, State of Texas (#25586, 1966)
- Registered Professional Engineer, State of Oklahoma (#12149, 2003)
- Registered Professional Engineer, State of Louisiana (#18349, 1979)
- Registered Professional Engineer, State of New Mexico (#7709, 1987)

Summary of Professional Experience

Espey Consultants, Inc.—*President*

Resource Management International, Inc.—*Vice President/Regional Manager*

W. H. Espey, Inc., Austin, Texas—*President*

Espey, Huston & Associates, Inc., Austin, Texas—*President, Chairman, Board of Directors*

The University of Texas at Austin, Texas—*Visiting Professor, Department of Civil Engineering, Water Resources Course, Summer 1978; Fluid Mechanics Course, Spring 1980*

The University of Texas at Austin, Texas—*Guest Lecturer, Short Course in "Flood Plain Hydrology, HEC-1"*

Espey, Huston & Associates, Inc., Austin, Texas—*Sr. Partner*

Ocean Sciences and Water Resources Department, TRACOR, Inc. —*Sr. Scientist and Director*

TRACOR, Austin, Tex.—*Engineer/Scientist*

The University of Texas at Austin—*Research Associate, Civil Engineering, Hydraulic Engineering Laboratory*

- Teaching and research experiences principally in the fields of water resources and oceanography.
- Has taught course in hydraulics and hydrology, mechanics of materials, and fluid mechanics.
- Research has been concerned with problems in the areas of flood frequency, urban hydrology, cohesive sediments, mixing and diffusion in estuary systems, free surface flow, and photogrammetry.
- Concerned with the development of a laminar flow apparatus for cohesive sediments. This research project was concerned with the development of a new testing apparatus for the determination of incipient shear stress for cohesive sediments.
- In his 1965 doctoral thesis concerning the hydrologic of small urban watersheds, developed *"Urban Unit Hydrograph Equations,"* which formed the basis for the Austin Drainage Criteria Manual-Austin Standard Method for flood determination.
- Subsequently, at the request of the ASCE (*Urban Water Resources Research Program*), urban unit hydrograph equations (ten minutes) were developed (ASCE, Espey, et al, July 1977). The urban unit hydrograph methodology has found application not only in the USA (Tucker, 1978, Per Com), but also in Australia (Mann, 1980). The Espey urban unit hydrograph method has been further documented in textbooks and design manuals by A. Oshman Akan, *Urban Stormwater Hydrology* (1993); Bedient and Huber, *Hydrology and Floodplain Analysis* (1989); *Applied Hydrology*, Chow/Maidment/Mays McGraw-Hill (1988); *Civil Engineering Reference Manual, 2nd Edition* by Michael R. Lindeburg, PE (1998); and *Recommended Hydrologic Procedures for Computing Urban Runoff from Small Watersheds in Pennsylvania*, Commonwealth of Pennsylvania (1982).

U.S. Geological Survey, Water Resources Division, Austin, Texas—*Hydraulic Engineer*

- Concerned with the collection, processing and evaluation of water resources records of the State of Texas.
- Field work experience included both maintenance and operation of various stream gauging stations located in Texas. This field experience included flow measurements using various field equipment such as the price, pygmy meters, and supporting equipment such as truck-mounted power, boat equipment, and cable car systems as well as portable four-wheel base systems.
- Combining field experience and engineering design, was involved in the design and construction of various gauging stations including low water concrete controls. The design of the concrete low water controls included indirect measurements and theoretical development of rating curves.
- Directed a research project concerned with the effects of urbanization on the hydrologic response of small urban watersheds. The USGS project was one of the first reports by the USGS on the subject. The project was basically concerned with the effects of urban development on the volume of runoff, flood flow rates, and flood frequency.
- Field data collection and record processing of the gauging stations in the Colorado basin.
- Was selected by the USGS to conduct an urban watershed study of Waller Creek watershed (Espey 1963, *USGS Open File Report*). This initial USGS urban watershed study on Waller Creek formed the basis of the subsequent Waller Creek urban study (*A Study of Some Effects of Urbanization of Storm Runoff from a Small Watershed*), which was partially funded and published by the Texas Water Commission (TWC, July 1965).

Private Consulting *Engineer*

- Dr. Espey was appointed by the USACE, Chicago District to serve as chairman of the First (1981), Second (1987), Third (1994), Fourth (2001), Fifth (2004), and Sixth (2007) Technical Committees, "For the Review of Lake Michigan Diversion Flow Measurements and Accounting Procedures," which were mandated by the

modified Supreme Court Decree of December 1980.

- The ASCE convened an External Review Panel, requested by Secretary of Army to review the work by the Interagency Performance Evaluation Task Force (IPET) on Katrina/New Orleans. Dr. W.H. Espey, Jr. was selected (Oct 2005) as team leader for the Internal Urban Drainage Review which included review of the hydrologic models, including HEC-RAS, and HEC-HMS, and analysis of associated mode of failure conditions.
- Member of the IEPR review panel – Clear Lake Creek Flood Control Project – Review included hydrologic models, HEC-RAS and HMS, and associated floodplain delineation, and evaluation of engineering alternatives.
- Member of the IEPR Review Panel – White Oak Bayou Flood Control Project Project – Review included hydrologic models, HEC-RAS and HMS, and associated floodplain delineation, and evaluation of engineering alternatives.
- Guadalupe River Dam Rehabilitation Project, Guadalupe Blanco River Authority, Kerrville, TX
- Elm Fork of the Trinity, City of Dallas, Dam and Overflow Spillway Rehabilitation – flood damage. Trinity River Authority and City of Dallas.
- Dr. Espey served as project principal for the preparation of plans and specifications for a Breakwater at the Bonnabel Pumping Station in Jefferson Parish in 2007.
- In 2008, as part of the Lake Pontchartrain and Vicinity, New Orleans, Louisiana Hurricane Protection Project, Espey Consultants, Inc. is preparing plans and specifications for Pile Load Testing for the Breakwaters at the Bonnabel, Suburban, and Duncan Pumping Stations in Jefferson Parish. Dr. Espey is the Project Principal.
- Dr. Espey served as Project Principal in 2008 to review hydraulic information and provide storm-induced hydraulic loadings leading to design of a closure structure for the Mississippi River – Gulf Outlet (MRGO) located south of Bayou La Loutre in St. Bernard Parish.
- Dr. Espey was appointed to the Independent Technical Review Panel (ITR) in 2008 for the USACE/FEMA Joint Coastal Surge Project (Arcadis/USACE New Orleans District) for the Texas Coast. The Independent Technical Review Panel (ITR) consists of broad membership from the University of Texas, Texas A&M University, the Water Development Board, the General Land Office, Harris County Flood Control District, private consultants, and other entities.
- In 2008, Dr. Espey was appointed as a member of the IEPR for the Inner Harbor Navigation Canal (IHNC)-02 Lake Borgne Protection Project. The IHNC-02 Borgne Protection project consists of a hurricane barrier extending from the Gulf Intracoastal Waterway (GIWW) levee near Bayou Bienvenue.
- Recently, Dr. Espey was elected as the Chair of the Bay and Basin Expert Science Team, as mandated by Senate Bill 3 (80th Texas Legislature) for the Trinity and San Jacinto River Basins and Galveston Bay System. (2008-present)
- Dr. Espey was appointed to the National Committee on Levee Safety (NCLS) Review Panel of the American Council of Engineering Companies (2009-present)
- Project Principal – FIA Contract – Hurricane Modeling of lower Texas Coast, Cameron to Matagorda Counties.
- Project principal for the Houston ship Channel Aeration project for the Texas Water Development Board. Water quality modeling designed to evaluate differing alternative reaeration systems for the Houston Ship Channel to improve water quality.
- 1993 – Great Missouri River Flood. Howard Bend levee District/Sverdrup Inc., Lower Missouri River, 1993. Directed a major hydrologic investigation to assess the impact of the devastation Great Flood of August 1993 on the lower Missouri River. The focus of the analysis was the impact on flood frequency characteristics and Federal Emergency Management Agency flood criteria.
- Proposed Superport/Galveston, Texas. – Project principal on the proposed superport located at Pelican Island, Galveston, Texas. The project consisted of preliminary engineering design and supporting environmental studies of the proposed superport located at Pelican Island Ship channel improvements included widening and deepening (60 feet) of the Houston Ship Channel and Galveston Harbor area.
- Dr. Espey has specifically been involved in a number of Water Resources projects concerned with flood plain and floodway delineation, master drainage studies, water supply, water conservation, return flows and several major water reservoir projects. Many of these projects use basic analytical tools, computer models such as HEC-I and HEC-II. In addition, he was involved in the design of major drainage improvements concerning land

development and major channel rectification projects in various urban areas. A major urban hydrology research project for HEC (USCE) was concerned with the effects of urbanization on flood discharges as modeled by SCS-TR-55 computer model. Dr. Espey directed this research which consisted of compilation of urban hydrologic data and the application of the SCS model to urban watersheds. Another significant hydrologic research project that dr. Espey directed was the expansion and application of SWMM water quality computer model to a large land development projects, the Woodlands, Title VII, New Town. The SWMM model was applied to this 18,000-acre development and expanded to model nutrient loading and the effects of porous pavement. He was also involved in projects concerning the allocation and water rights associated with flow diversions for both municipal and industrial use.

- Dr. Espey has specific technical training in the Water Resources Engineering including the following disciplines: flood control, drainage, water distribution/storage systems, erosion, hurricane surge, hydrology and sedimentation. His specific background in hydraulic/fluid mechanics also include various pipe network models such as KYPIPE and EPANET. His experience includes various hydraulic machinery such as pumps, impulse turbines, surge tanks, booster pumps and associated cavatation. He has taught course fluid mechanics dealing with laminar and turbulent flow in pipes, drag forces, turbo machinery, dimensional analysis energy and momentum principles.
- Dr. Espey lead a team of engineers to conduct a due diligence review of the Rio Rancho Utilities Corporation (RRUC) water and wastewater systems. This review included technical analysis, interviews, examination of RRUC books and records, field observation of system facilities. All of the water supplied to customers of the RRUC water system is obtained from groundwater pumped from the Middle Rio Grande Basin. The Water System includes 16 active wells varying in age from new to just over 30 years, with the average age of the well facilities approximating 15 years. In addition, two wells are under construction. The total capacity of wells numbered 1 through 16 is approximately 15,400 gpm if all well facilities are in operation. These wells produced approximately 12,800 acre-feet of water in 1994. The water system relies on a variety of pumping facilities to distribute water supplies. The average age of these pumping facilities is approximately 15 years. Included with each well pumping facility are station piping, electrical controls, and ancillary well and pump equipment. The water system utilizes a supervisory control and data acquisition (SCADA) system. The control function of this equipment enables the simplified transfer of water through the water system to meet increased demands. Total storage capacity of the water system approximates 18.7 million gallons. In addition, two tanks with an aggregate storage capacity of 2.0 mg are under construction. These storage facilities are located at 11 different well sites and include 14 tanks, three of which are surge tanks. These surge tanks provide a means of releasing the build-up of hydraulic pressures in the water system. The water system's conveyance facilities include approximately 190,000 feet of transmission mains and over 1,050,000 feet of distribution mains. The total combined length of the transmission and distribution mains is approximately 235 miles.
- Dr. Espey was project manager for the evaluation and assessment of condition and capacity of Sangre De Cristo Water System. The system consisted of four components: (1) Santa Fe Canyon Treatment System, (2) Santa City Well System, (3) Buckman Well System, and (4) distribution system. Assessment included evaluation of well capacity (Buckman and Santa Fe), Canyon Treatment Plant capacity and City Well system capacity. The Buckman transmission main and Booster Stations is a critical part of the water distribution system. Detailed analysis utilizing the pipe-network model KYPIPE was performed on the system. Three alternative improvement scenarios were implemented. A new (30") parallel line to the existing Buckman Transmission main and supporting Booster Stations were evaluated (scenario 1). Paralleling the Buckman Transmission Main and Booster Stations (Buckman) from the well field to the 10 million gallon (MG) ground storage facility (tank). SDWC is delivering 1,000 gpm (on peak) to Las Campanas. The analysis assumes new sources to bring the existing Buckman to capacity (6,100 gpm) and to supply the new Buckman up to 5,000 gpm. The 10 MG tank outlet pumpage is doubled from 8,000 to 16,000 gpm. A new 30" transmission main TM out of 10 MG tank into an existing "good" network location in Zone 4 is included. The 6 MG tank in Zone 2 (the tank for which the SDWC is attempting to get zoning approval) is presumed to exist. The computer analysis (run) presumes 5,000 gpm per Buckman line gets to 10 MG tank. The balance (1,100 gpm) is diverted to Las Campanas from the existing line and that an additional 5,000 gpm from the new line gets to the tank.
- Dr. Espey was involved for the City of Austin on a project to develop system design criteria and engineering specifications for stormwater pumping systems and stormwater irrigation systems. The criteria developed will be included in the City of Austin – Drainage Criteria Manual and associated City of Austin – Standard Specifications.

- Dr. Espey also has experience in developing water quality models/sampling programs/management plans for numerous lakes (Cedar Creek, Texas; Town Lake [Austin, Texas and Dallas, Texas]; Cross Lake, Shreveport, Louisiana; Lake Austin, Texas; Toledo Bend Reservoir, Texas; Lake Houston, Texas; Tributary Lakes/Red River, Louisiana; Lake Travis, Texas; Lewis Creek; Lake Texoma, Texas; Martin Lake Mine, Texas; Big Cajun/Oxbon Lignite Mine Lake, Louisiana; Moticello Mine Lake, Texas; Lake Amistad, Texas; Coleto Creek, Texas; Eagle Mountain; Lake Dunlap, Texas.
- Dr. Espey has also has experience in water quality modeling for the following rivers and streams in Texas: San Antonio, Cedar Creek, Guadalupe, Blanco, Pedernales, Houston Ship Channel, San Marcos, Colorado, Nueces, Neches, Trinity, Sabine, Brazos and Red.
- Dr. Espey's water resources experience include numerous projects concerned with Texas Water Rights (prior appropriation doctrine) and the associated hydrologic modeling reflecting reservoir/system operations, recharge/channel losses, water rights evaluation, naturalized flows, estuary fresh-water inflow requirements, reservoir/stream water quality modeling, and surface water hydrology

Related Publications

- Discussion of Paper 3069, Journal Hydraulics Division, ASCE, pp. 181-184, November 1962.
- Discussion of Paper 3071, Journal Hydraulics Division, ASCE, pp. 191-192, Nov. 1962 (with S. P. Sauer).
- "A New Test to Measure the Scour of Cohesive Soils", Tech. Rep. HYD 01-6301, Hydraulics laboratory, Department of Civil Engineering, The University of Texas at Austin, April 1963.
- "Measurements of the Shear Resistance of Cohesive Sediments", Proceedings, Federal Inter-Agency Sedimentation Conference, Agricultural Research Service, Miscellaneous Publication No. 970, pp. 151-155, 1963 (with F. d. Masch, Jr., and w. L. Moore).
- Discussion of paper 3462, Journal Hydraulics Division, ASCE, pp. 262-264, November 1963.
- "The Effects of Urbanization on the Unit Hydrograph Characteristics of Small Watersheds", WRO Bulletin, pp. 33-36, November 1963.
- "The Effects of Urbanization of the Unit Yield of a Small Watershed Located in Austin, Texas", Fourth Western National Meeting of the American Geophysical Union, Seattle, Washington, December 1964 (with C. W. Morgan).
- "A Study of Some Effects of Urbanization on Storm Runoff from a Small Watershed", Tech. Rep. HYD 06-6501, Hydraulics Laboratory, Department of Civil Engineering, The University of Texas at Austin, April 1965.
- "Some Factors that Influence the Erosion Resistance of Cohesive Sediments", ASCE Hydraulics Division, Sedimentation Sessions, Tucson, Arizona, August 1965.
- "General Unity Hydrograph Relationships for Both Urban and Rural Watersheds", Paper Presented at Fifth Western National Meeting of the American Geophysical Union, Dallas, Texas, Sept. 1-3, 1965 (with F. D. Masch Jr., and C. W. Morgan).
- "Study of some Effects of Urbanization on Storm Runoff from a Small Watershed", Texas Water Development Board, Rep. 23, 110 pp., August 1966 (with F. D. Masch, Jr., and C. W. Morgan).
- "Some Effects of Urbanization on Design Flood Criteria for Small Watersheds", Symposium on Consideration of Some Aspects of Storms and Floods in Water Planning, Texas Water Development Board, Rep. 33, pp. 137-154, November 1966 (with F. D. Masch, Jr., and C. W. Morgan).
- "Shell Dredging - A Factor in Sedimentation in Galveston Bay, Texas", Center for Research in Water Resources, Tech. Rep., HYD 06-6702, CRWR-7, 1967 (with F. D. Masch, Jr.).
- "Computer Simulation of the Propagation of Surface Waves", Paper Presented at the 63rd National Meeting of American Institute of Chemical Engineers, February 1968; also published in Proceedings (with R. J. Huston and J. E. Stover).
- "Evaluation of Hydrologic Effects of Urbanization", Paper Presented at the 49th Annual Meeting of the American Geophysical Union, Washington, D.C., April 1968 (with D. E. Winslow).

- "Computer simulation of the Propagation of Surface Waves" (for USCE-CERC), TRACOR Document No. 68-544-U, April 29, 1968 (with R. J. Huston and J. E. Stover).
- "The Effects of Urbanization in Unit Hydrographs for Small Watersheds, Houston, Texas, 1967-1967", (for Office of Water Resources Research), TRACOR Document No. 68-975-U and 68-1006-U, October 1968 (with D. E. Winslow).
- "The Effects of Urbanization on Peak Discharge", Water Resources Symposium No. 2 on the Effects of Watershed Changes on Streamflow, The University of Texas at Austin, October 1968 (with D. E. Winslow and C. W. Morgan).
- "Galveston Bay Study Phase 1, Technical Report Summary", (for TWQB), TRACOR Document No. 68-567-U, October 1968 (with R. J. Huston, G. H. Ward, Jr., J. E. Stover, and W. D. Bergman).
- "Proposed Model Structure for the Galveston Bay Water Quality Management Study", Paper Presented at ASCE National Meeting on Water Resources Engineering, new Orleans, February 3-7, 1967 (with F. D. Masch, Jr.).
- "Computer Simulation of Gravity Water Waves", Paper Presented at Texas Section ASCE Spring Meeting, April 10-12, 1969, Tyler, Texas (with J. E. Stover and R. J. Huston).
- Discussion of Paper 5891, Journal Sanitary Engineering Division, ASCE, pp. 675-678, June 1969 (with J. E. Stover).
- "Water Quality Analysis of the Sabine Power Plant", (for Gulf State Utilities Company), TRACOR Document No. T-70-AU-7368-U, July 13, 1970 (with J. E. Stover).
- "Water Quality Analysis of the Nueces Bay Plant", (for Central Power and Light Company), TRACOR Document No. T70-AU-7203-U, April 9,, 1970 (with J. E. Stover, R. J. Huston, W. D. Bergman, and G. H. Ward, Jr.).
- "Water Quality Analysis of the Cedar Bayou Generating Station", (For Houston Lighting and Power Company) TRACOR Document No. T70-AU-7525, Rev. 1, July 1, 1970 (with R. J. Huston, J. E. Stover, W. D. Bergman and G. H. Ward, Jr.)
- "Anaerobic Modeling for the Houston Ship Channel", Paper presented at the 9th Texas Water Pollution Control Association Conference, University of Houston, Houston, Texas, July 9-10, 1970 (with A. J. Hays, Jr. and G. H. Ward, Jr.).
- "Hydraulic Studies of Thermal Discharge in Shallow Estuaries", Paper presented at the ASCE Joint Meeting Texas-New Mexico, El Paso, Texas, October 8-10, 1970 (with R. J. Huston and D. R. Betterton).
- "Galveston Bay Project Water Quality Modeling and Data Management, Phase II Technical Progress Report", TRACOR Document No. T70-AU-7636-U (for TWQB) January 1971 (with A. J. Hays, Jr., W. D. Bergman, J. P. Buckner, R. J. Huston, and G. H. Ward Jr.).
- "Modeling of Thermal Discharges in Shallow Estuaries, Proceedings of the American Power Conference, Volume 33, pp. 4;57-464, 1971 (with D. R. Betterton, A. J. Mary and W. M. Mayer).
- "Storm Water Runoff Volume and Recharge Analysis for the San Antonio Ranch", TRACOR Document No. T720AU-9544-U, June 19, 1972 (with D. E. Winslow).
- "Preliminary Analysis of the Detention Time for the Cedar Bayou Cooling Pond", EH&A Document No. 7201, August 1972 (with W. D. Bergman).
- "Storm Runoff Analysis of Residential Settings for The Woodlands", TRACOR Document No. T72-AU-9585-U, Sept. 15, 1972 (with D. E. Winslow).
- "Urban Parameters Affecting the Runoff Response of Small Urban Watersheds", Paper presented at the 1972 ASCE National Environmental Engineering Meeting, October 16-22, 1972, Houston, Texas (with D. E. Winslow).
- "Estuarine Modeling: An Assessment", Water Pollution Control Research Series, Report No. 16070 DZV, Stock No. 5501-0129, U. S. Government Printing Office, Washington, D. C., 1971 (with G. H. Ward, Jr.).
- "Estuarine Water Quality Models", Water Research, Paragon Press, 1972, Vol. 6, pp. 1117-1131 (with G. H.

Ward, Jr.).

- "Ecological and Engineering Assessment of the University of Houston Clear Lake Campus Phase I", EH&A Document No. 7205, November 1972 (with W. D. Bergman and H. B. Sharp).
- "Storm Water Quality Analysis - Phase I - The Woodlands", EH&A Document No. 7302-R1, May 1, 1973 (with D. E. Winslow).
- "Statement Concerning Deepwater Port Location in the Corpus Christi, Texas Area". prepared for the Texas Environmental Coalition and presented to the Department of the Army Galveston District, Corps of Engineers, May 25, 1973 (with D. E. Winslow, H. B. sharp, and Dr. B. Maguire).
- "Environmental Considerations of the Proposed Medical Center Plaza Waste Treatment Facility", EH&A Document No. 7312, October 9, 1973 (with W. D. Bergman and J. M. Wiersema).
- "Flood Plain Analysis in the Area of the Proposed and Alternative Locations of Harmony Hills Substation and Transmission Easements", EH&A Document No. 7322-R1, December 12, 1973 (with W. D. Bergman).
- "Preliminary Analysis of Proposed Drainage Improvements in City of Cities Municipal Utility District", EH&A Document No. 7425, September 4, 1974 (with D. E. Winslow).
- "Estuarine Resources", presented at Short Course, Analysis and Control of Water Resource Systems, June 20, 1969.
- "Urban Flood Frequency Characteristics", Journal of Hydraulics Division, February 1974 (with M. ASCE and D. E. Winslow).
- "Natural Drainage Systems: An Alternative to Conventional Drainage Systems," March 29, 1974 (with D. E. Winslow and Veltman).
- "Quantity Aspects of Urban Storm Water Runoff," A Short Course Application of Storm Water Management Models, University of Massachusetts, Department of Civil Engineering, August 23, 1974 (with D. E. Winslow).
- "Residential Storm Water Management Objectives, Principles & Design Considerations," Cooperative Publication of ASCE, NAHB, and ULI, Library of Congress Catalog Number LC75-34759, 1975.
- "Use of the 30-Minute Unit Hydrograph for Sewered and Partially Sewered Catchments," ASCE Urban Water Resources Research Program, July 1975.
- "Maximum Utilization of Water Resources in a Planned Community, Application of the Storm Water Management Model (SWMM)," EPA Report, with E. Diniz, September 1976 (reprinted July 1979).
- "Drainage Criteria Manual" for the City of Austin, January 1977 (with D. G. Altman, C. Carter, R. porter and M. Wright).
- "Hydrologic Transport of Radionuclides, An Assessment of Modeling Practices," Presented at a Workshop on the Evaluation of Models Used for the Environmental Assessment of Radionuclides sponsored by Oakridge National Laboratory, Gatlinburg, Tennessee, September 9, 1977 (with E. Gloyna)
- "A Standard Methodology for Drainage Criteria in Austin, Texas," 1977 Tri-Sectional Fall Meeting in Mexico, New Mexico and Texas Sections of the ASCE, presented at Albuquerque, New Mexico, October 8, 1977 (with C. B. Graves and D. G. Altman).
- "Nomographs for Ten-Minute Unit Hydrographs and Small Urban Watersheds," ASCE Urban Water Resources Research Program, Technical Memorandum No. 32, December 1977 (with C. B. Graves).
- "Nomographs Address", American Water Resources Association Symposium, Austin, Texas, Dec. 7, 1979.
- "Stormwater Analysis and Prediction in Houston," Discussion, Journal of the Environmental Engineering Division, ASCE, December 1979 (with E. Diniz).
- "Investigation of Soil Conservation Service Urban Hydrology Techniques," American Geophysical Union 1980 Spring Meeting (with D.G. Altman).
- "Hydrologic Design Criteria for Gulf Coast Lignite Mines," Second Gulf Coast Lignite Conference, Houston, Texas, October 3, 1980 (with G.M. Pettit).
- "The 24-25 May 1981 Flood along Shoal Creek, Austin, Texas - Was It Predictable?" Presentation at the

American Geophysical Union 1981 Fall Meeting, San Francisco, California, Dec. 1981 (with D.G. Altman).

- “Lake Michigan Diversion: Findings of the First Technical Committee for Review of Diversion Flow Measurements and Accounting Procedures,” Prepared for the Chicago District U.S. Army Corps of Engineers, April 1982 (with H.H. Barnes, Jr. and S. Vigander).
- “Evaluation of Engineering Feasibility of Hydropower at Lock and Dam No. 2 Red River Project,” Prepared for the Vicksburg District, U.S. Army Corps of Engineers, August 1985.
- “Lake Michigan Diversion: Findings of the Second Technical Committee for Review of Diversion Flow Measurements and Accounting Procedures,” Presentation to the Chicago District, U.S. Army Corps. of Engineers, November 1987 (with H.H. Barnes, Jr. and David E. Westfall).
- "Shoal Creek Flood Control Plan, Austin, Texas," Proceedings of the First Symposium on Engineering Hydrology, ASCE, Hydraulics Division, August 3-7, 1987.
- "Sediment Management of the Red River Waterway Navigation Project," Proceedings of 17th Annual National Conference and Infrastructure Symposium, Water Resources Planning and Management Division, ASCE, April 18, 1990 (with Phil Combs, Vicksburg District, U.S. Army Corps. of Engineers).
- "Stormwater Management Planning for the Rush Creek Watershed, Arlington, Texas," Proceedings of 17th Annual National Conference and Infrastructure Symposium, Water Resources Planning and Management Division, ASCE, April 18, 1990 (with Duke G. Altman and David D. Gieber, Espey, Huston & Associates, Inc., and Jerome F. Ewen, City of Arlington, Texas).
- "Water Measurement and Accounting of Lake Michigan Diversion," Planning and Management Division, ASCE, April 19, 1990 (with Harry H. Barnes and David Westfall).
- "Industrial Stormwater Permitting - Application Requirements," Presentation to the Industrial Stormwater Permitting Symposium, University of Houston, Department of Civil and Environmental Engineering and the Texas Water Commission, Houston, Texas, February 27, 1991.
- "Impact of New EPA Storm Water Discharge Regulations on the Gas Processing Industry," Presentation to the 70th Annual Gas Processors Association Convention, San Antonio, Texas, March 11-12, 1991 (with Duke G. Altman and M.A. Vivona).
- "FAA Storm Water Program," Proceedings of the ASCE Hydraulic Engineering Sessions at Water Forum, August 2-6, 1992 (with R.R. Rose and George I. Legarreta).
- "Storm Water Regulations - Aircraft Deicer/Anti-icers Operations," Presentation at the ASCE National Hydraulics Division Conference in San Francisco, California, July 1993 (with George I. Legarreta).
- "Probability and Impact of an Observed Rare Sequence of Floods," Presentation to the American Society of Civil Engineers (ASCE) National Hydraulics Division Conference in San Francisco, California, 1993 (with Leo Beard, Phil Combs, and Ben M. Littlepage).
- “Lake Michigan Diversion: Findings of the Third Technical Committee for Review of Diversion Flow Measurements and Accounting Procedures,” Presentation to the Chicago District, U.S. Army Corps. Of Engineers July 1994. (O.G. Lara, and Dr. R.L.Barkau)
- “Lake Michigan Diversion at Chicago,” Hydraulic Engineering Conference ‘94, Buffalo, N.Y. August 1-5, 1994, p.175, (with Oscar G. Lara and Robert L. Barkau).
- “The Summer of 1993 Floods, Lower Missouri River,” Hydraulic Engineering Conference ‘94, Buffalo, NY August 1-5, 1994, p. 628, (with Leo R. Beard and John E. Reinfurt).
- “Management of Sediments on the Red River Waterway Project,” Hydraulic Engineering Conference ‘94, Buffalo, NY August 1-5, 1994, p. 1125, (with Phil G. Combs, C. Fred Pinkard, Jr. and Ben Littlepage).
- “Austin Standard Method: Re-Visited After 20 Years,” Water Resources Engineering-Volume I, Proceedings of the First International Conference, 1995, (with Tom Hegimeir).
- “Comparison of General vs. Multi-Sector NPDES Storm Water Permits,” 1996, (Presentation at the North American Water and Environment Congress ‘96, June 22-28, 1996, Anaheim, California), (with John Whitescarver and Michael Ports)
- “Comparison of Hydrologic Modeling and Flood Frequency Analysis for a Small Urban Watershed Located in

Austin, Texas," (Presentation at the North American Water and Environment Congress '96, June 22-28, 1996, Anaheim, California.)

- "Flood Frequency Analysis of an Urban Watershed in Central Texas with Consideration of Significantly Large Historical Events." Texas Section AWRA, November 1999. (With Brian Reis)
- "Lake Michigan Diversion: Findings of the Fourth Technical Committee for Review of Diversion Flow Measurements and Accounting Procedures," Prepared for the Chicago District U.S. Army Corps. Of Engineers, May 2001 (with A.R. Schmidt, and Dr. R.L. Barkau
- "Comprehensive Frequency Analysis on the Llano River in the Colorado River Basin of Texas." Second Interagency Hydrologic Conference, July/August 2002. (With Brian Reis)
- Floodplain Mapping, Technology & Tools: Shoal Creek ReStudy, Austin, Texas." ASFPM, May 2004. (With Brian Reis and Travis Wilson)
- "Lake Michigan Diversion: Findings of the Fifth Technical Committee for Review of Diversion Flow Measurements and Accounting Procedures," Prepared for the Chicago District U.S. Army Corps. Of Engineers, July 2004 (with Dr. Charles Melching, and Dean Mades)
- "What went wrong and Why" – A report by the American Society of Civil Engineers, Hurricane Katrina External Review Panel. W.H. Espey (co – author) Draft November 2006
- "Hurricane Katrina: One Year Later – What must we do Next?" Report Findings – Press Release, New Orleans, August 25, 2006
- "The New Orleans Levees: The Worst Engineering Disaster in U.S. History – What Went Wrong and Why?, Report to the ASCE Board of Directors, July 23, 2006

Professional Associations

- American Society of Civil Engineers
- National Society of Professional Engineers
- Texas Society of Professional Engineers
- Council of Consulting Engineers
- Bausch & Lom Photogrammetric Award, First Place in Graduate Division, 1961
- One-year Scholarship from the U. S. public Health Department, Water Resources, for Ph.D. program at The University of Texas at Austin, Texas, 1963–1964
- Vice Chairman of ASCE Waterways and Harbors, Texas Section, 1968, 1970
- Chairman of ASCE Waterways and Harbors, Texas Section, 1969, 1971
- American Men of Science, 1969
- 5-Year Certificate of Appreciation, TRACOR, 1970
- Member of ASCE Ad Hoc Task Committee on NAHB Residential Drainage Storm Water Management, 1973–1974
- 5-Year, 10-Year, 15-Year, 20-Year Certificate of Appreciation, Espey, Huston & Associates, Inc., 1978, 1982, 1987, 1992
- Contact Member ASCE/Student Chapter, The University of Texas at Austin, Texas, 1978-1979
- Member of ASCE Waterways and Harbors Committee, 1978–82
- Award for Outstanding Service, ASCE, 1979
- Member of ASCE Task Committee on the Estimation of Runoff Time Characteristics, 1980-present
- Chi Epsilon; Sigma Tau, Sigma Xi
- Chi Epsilon, Special Honor Award, November 1992

- Distinguished Graduate of the College of Engineering, The University of Texas at Austin, Texas, 1986
- Dean's Executive Committee, College of Engineering, The University of Texas at Austin, Texas, 1986
- Civil Engineering Visiting Committee, College of Engineering, Department of Civil Engineering, The University of Texas at Austin, Texas, 1986
- Programs Committee Hydraulics Division, ASCE, 1992-Present
- Chairman of the 1995 American Society of Civil Engineers (ASCE) 1st International Water Resources Engineering and International Groundwater Management Symposium; Watershed Management Symposium; and Texas Water '95 held in San Antonio, Texas, August 14-18, 1995
- Charter Member, Civil and Architectural Engineering Academy of Distinguished Alumni, University of Texas, at Austin, Texas, November 2003
- Award for Outstanding Planning Achievement, Lower Colorado River Basinwide Project, USACE, 2001
- Founding Diplomat of the American Academy of Water Resource Engineers (ASCE), Treasurer of the Board of Trustees
- ABET – Senior Civil Engineering Program Evaluator (1966 – Present)

R. Craig Findlay, Ph.D., P.E., G.E.

Qualifications Summary

- Geotechnical engineer with 33 years experience in the dam safety, water resources, and geotechnical engineering profession including a broad variety of consulting and project engineering experience, more than 28 years of which have included involvement with dams and hydroelectric projects.
- Served as technical lead or lead geotechnical engineer on hundreds of dam related projects.
- Worked on several hydroelectric greenfield design and remediation projects which have given him broad experience with water resources projects including earth dam and embankment design and instrumentation; powerhouse, spillway and headworks foundations; stability, liquefaction and deformation analysis; seepage and piping assessments; finite element analysis of stresses in embankments, gravity dams, arch dams and radial gates; finite element analysis of earthquake response of embankments, gravity dams, and arch dams; unlined canal design; water retaining structure remediations; cement-bentonite cutoffs and slurry walls; grouting; anchor design; and dam safety inspections.
- FERC approved Independent Consultant on almost 250 Part 12 Inspections and/or served as a Potential Failure Modes Analysis Facilitator for multiple clients.
- Conducted numerous dam structural stability analyses for gravity, embankment, and/or arch dams for multiple clients.
- Presented and/or published several technical papers on seismic analysis of dams and rehabilitation, dam seepage, dam remediation, dam stability, reservoir erosion and in situ soil property measurement for many technical societies.

Education

- Ph.D., Engineering, University of New Hampshire, 1991
- M.S., Civil Engineering, University of New Hampshire, 1981
- B.S., Civil Engineering, University of New Hampshire, 1976

Certifications and Licenses

- Licensed Professional Civil Engineer, State of Alabama
- Licensed Professional Civil Engineer, State of California
- Licensed Professional Civil Engineer, State of Georgia
- Licensed Professional Civil Engineer, State of Idaho
- Licensed Professional Civil Engineer, State of Maine
- Licensed Professional Civil Engineer, State of Montana
- Licensed Professional Civil Engineer, State of New Hampshire
- Licensed Professional Civil Engineer, State of New York
- Licensed Professional Civil Engineer, State of Vermont
- Licensed Professional Civil Engineer, State of Washington
- Licensed Professional Geotechnical Engineer, State of California

Summary of Professional Experience

Findlay Engineering, Inc.—*Independent Consultant and Principal*

Duke Engineering & Services, Inc. (formerly Northrop, Devine & Tarbell, Inc.)—*Director of Geotechnical Engineering*

ABB- Environmental Services (during completion of Ph.D. Dissertation)—*Manager of Geotechnical, Civil and Solid Waste Engineering*

Findlay Geotechnical Consulting, Inc. (geotechnical engineering consultant during Ph.D. research)—*Principal Engineer*

E. C. Jordan Company and Jordan Gorrill Associates, Inc.—*Senior Geotechnical Engineer*

New Hampshire Department of Transportation—*Assistant Roadway Foundation Engineer*

- Served on the Board of Consultants for Vermilion Dam as the geotechnical engineer, owned and operated by Southern California Edison for about ten years. Vermilion Dam is a 165-foot-high, 4,234-foot-long zoned embankment dam located at about elevation 7,650 feet in the Sierra Nevada Mountains of California. The dam is founded on a complex soil foundation of glacial moraine and interbedded alluvial materials. Seepage is controlled by numerous drainage systems, some of which were originally designed under the review of Dr. Karl Terzaghi. Current work involves a long term drainage improvement program as a result of two seepage incidents.
- On the Board of Consultant's for rehabilitation of two dams in Maine for Florida Power & Light (NextEra). Completed rehabilitation (as the engineer of record) of a hydraulic fill dam with seepage and seismic inadequacies for FPL.

Army Corps of Engineers, Independent External Peer Review Panel

- Selected to participate in the independent external peer review panel to review the East Branch Dam, Elk County Pennsylvania Dam Safety Modification Study for the USACE Flood Risk Management Planning Center of Expertise as a subcontractor to Battelle. One of three panel members of a multidiscipline team for this work.

Swinging Bridge Dam

- The Part 12 Independent Consultant for the 2009 Part 12 Inspection of Swinging Bridge Dam, which underwent a high profile rehabilitation for development of a large sinkhole just upstream of the crest in 2005.
- Participated in the post-remediation PFMA and prepared the PFMA Report. The PFMA was conducted concurrent with the final Board of Consultants Meeting for the rehabilitation.

Saluda Dam Part 12 Inspection

- Assisted on the first (2010) Part 12 Inspection of Saluda Dam following its high profile seismic rehabilitation.
- Responsible for geotechnical and instrumentation review of the project. The dam is a semi-hydraulic fill structure located in Columbia, S.C., and underwent construction of a downstream secondary dam in the mid 2000s as part of a seismic rehabilitation.

Mammoth Pool Dam Fragility Analysis

- Southern California Edison Company is embarking on a risk assessment program of their portfolio of dams.
- Currently conducting a detailed seismic stability "fragility" analysis of the 400 foot high Mammoth Pool zoned embankment dam located on the Sam Joaquin River, about 50 miles northeast of Fresno, Calif. A fragility analysis is an analysis that focuses on a potential failure mode of the dam, and investigates the resulting factor of safety under various levels of loading probability of recurrence. Review of the available project data and boring logs indicated that liquefaction was not anticipated to be an issue at the dam, leaving the potential seismic deformation as the key question to be investigated. For seismic loading, return periods of 1000, 2500, 5000 and 10000 years were considered. Seismic time histories (horizontal and vertical) were selected by another consultant for each of these return periods, along with appropriate scaling factors. With 24 sets of time histories for each

return period, and four different distance/magnitude models, on the order of almost 100 analysis runs are required. Due to the very high number of time histories that must be considered, an approach to analysis that streamlines the data handling problems was critical. Because of their seemless integration, the GeoStudio (GeoSlope Inc, Alberta Canada) suite of computer programs (SEEPW, SIGMAW, QUAKEW, and SLOPEW is being used. These programs conduct a seepage and initial stress finite element analysis, an equivalent linear finite element response analysis (similar to QUAD4M), and a double integrated Newmark analysis. Work to be completed in 2009.

Diversion Dam Seismic Issues, Beaver River, Niagara Mohawk Power Corporation

- A consultant to Erie Boulevard Hydroelectric, LP (now Brascan and formerly Niagara Mohawk Power Corporation) regarding seismic stability issues and assessment of the need for and approaches for remediation of Diversion Dam.
- The dam is an 80-foot-high hydraulic fill structure, which is part of the Beaver River Project, located in New York State. Work included a major field investigation program using energy calibrated standard penetration testing on both the upstream (barge) and downstream slopes of the dam.
- The field investigation was conducted in the summer of 1998 to assess the relative density of a construction cofferdam observed on the upstream side of the dam in old 1924 construction photographs. The borings were also conducted using carefully controlled methods, in accordance with the published recommendations of Seed and others. The drilling procedure including prevention of the development of unbalanced hydrostatic head on the sample zone during drilling rod removal. The controlled drilling methods facilitated measurement of standard penetration test blow count values which were improved over those from previous field investigations made at the site.
- Because of the sensitivity of the field work, spent a significant amount of time in the field overseeing the drilling procedures and energy calibration of the SPT test equipment. The field work is the subject of a paper co-authored and presented at the 1999 USCOLD Annual Lecture in Atlanta.
- Carried out an extensive seismic stability analysis on the existing dam and later on the designed remediation cross section. Seismic analysis included liquefaction analysis, post-earthquake, and deformation analysis components of three separate cross sections of the dam. For the liquefaction analysis, seepage analysis (SEEP/W), static finite element analysis (SIGMA/W), dynamic response finite element (QUAD4M), and liquefaction triggering analyses (spreadsheet based) were conducted. Post-earthquake residual strengths and strengths reduced by seismically induced pore pressures were assessed and post-earthquake slope stability analyses were conducted. Finally, QUAD4M acceleration time histories for selected potential sliding blocks were double integrated (Newmark-type deformation analysis method) to determine potential movement of the dam during seismic shaking.
- Analyses of existing conditions indicated a need to improve seismic stability. Involved in developing a remedial approach, which consisted of a foundation drainage system and downstream seismic berm. The work was conducted under review of the FERC and their consultant's A. J. Hendron and I.M. Idriss. Rehabilitation of the dam included construction of a downstream stability berm and toe drainage system, and was completed in the fall of 2002.
- Project is the subject of papers co-authored and presented at the 2003 USSD and Waterpower Conferences. A paper summarizing the work was also published in the summer 2004 issue of the Journal of Dam Safety.

Post-Earthquake Analysis, West Embankment, Sinclair Dam, Georgia Power Company

- Conducted a detailed seismic analysis of the 90-foot-high West Embankment of Sinclair Dam, located on the Oconee River, near Milledgeville, Ga., and assisted in addressing follow-on questions and analyses requested by the FERC. The dam has lower upstream core sections consisting of semi-hydraulic fill, and exhibited in old construction photographs (circa 1920s) and as determined by low SPT "N" values measured in test borings. The FERC has requested several dam owners in the southeast to re-evaluate the seismic stability of their semi-hydraulic fill dams, based on potentially loose conditions that could exist and the proximity of some of the dams to the 1886 Charleston, S.C earthquake epicenter.
- Conducted the seismic assessment. The assessment included assessing liquefaction potential based on SPT "N"-values, assessment of post-earthquake residual strength, and post-earthquake and seismic deformation analysis.

The post-earthquake analysis was conducted using the program UTEXAS4, which required extensive review and assessment of drained and undrained triaxial test data to develop strength parameters for the two-step Lowe and Karafiath type undrained strength approach incorporated into the program. The analysis indicated adequate seismic stability. Deformation was computed using the Makdisi-Seed approach, and indicated that seismic deformation under the maximum credible earthquake would be tolerable. The analyses have been accepted by the FERC in 2007, and no rehabilitation of the West Embankment has been required.

Abbott Brook Dike Seismic Stability Assessment and Rehabilitation, Skelton Project, Florida Power & Light

- Conducted an assessment of post-earthquake stability and deformation analysis for this 700-foot-long, 40-foot-high hydraulic fill dam located in Northern Maine. The analysis was based on SPT blow counts and the methods of Seed and Idriss, recently updated as summarized by Youd and Idriss.
- Determined that the downstream lower core of the structure potentially susceptible to liquefaction, and the downstream slope had minimum computed factors of safety less than would be desirable, under the maximum credible earthquake loading event. As an additional complicating factor, the foundation soils for the dam (glacial till interlayered with sand) contained artesian pressure in excess of the ground surface at the toe of the dam. As a result, rehabilitation has been proposed, consisting of toe drainage and a stability berm to improve the post-earthquake stability of the dam as well as mitigating the potential of heave at the toe of the embankment. The rehabilitation scheme was completed in 2010.

Review of Embankment Instrumentation, Relief Wells, and Seismic Stability, Skelton Project, Florida Power & Light

- Providing ongoing assistance to Florida Power & Light (FPL Energy Maine Hydro LLC) regarding the instrumentation and monitoring of a relief well system for its 75-foot-high Skelton Embankment on the Saco River in Southern Maine. The dam is founded above a confined sand deposit which has experienced increasing artesian pressure since construction in the 1940s.
- Initial work included re-assessment of stability with regard to heave at the toe as well as general slope stability. Work has included a historic review of construction and maintenance records, review of historic monitoring data, slope stability analysis, post-earthquake analysis and planning and observing a program of video inspection and redevelopment of the existing system of 15 relief wells.
- Rehabilitation has included re-screening structurally deficient well screens, and design and installation of two new 80-foot-deep, 12-inch diameter permanent pumped relief wells. A network of 50-year old metal standpipe piezometers was replaced with vibrating wire piezometers (in part, to prevent winter freezing/artesian water level problems) that are monitored from centralized locations. The rehabilitation and improvements have decreased confined foundation pressures well within acceptable levels.
- At the request of the FERC, FPL has had to review the seismic stability of the project. Conducted that assessment, including liquefaction triggering, post-earthquake, and deformation analyses of the embankment dam. Analyzed the post-earthquake stability of the gravity structure, including the post earthquake adequacy of the spillway piers if damaged by the MCE event.

Chittenden Dam Detailed Slope, Gravity and Seismic Stability Analyses – Central Vermont Public Service

- Updated stability analyses on selected interpretive cross sections of Chittenden Dam. The dam is located in central Vermont, about eight miles northwest of the city of Rutland at the head of East Creek. The analyses included consideration of the west (main) embankment cross section, an east embankment cross section, and a concrete spillway section founded over a portion of the embankment dam.
- The cases of normal full pool loading, flood loading, normal plus seismic, and rapid drawdown were analyzed. The embankment slope stability analyses were conducted using the program SLOPE/W, licensed by FEI from GEOSLOPE International, Calgary Alberta, Canada. The analysis was completed using the Spencer Method. Analyses of the concrete gravity ogee spillway were made using the two-dimensional gravity analysis method, and the normal, PMF and post-earthquake loading cases were considered. The tailwater elevation at the spillway is an important consideration with regard to assessing uplift under the concrete gravity spillway. No previous analysis of the PMF tailwater elevation has been made for the project. For this analysis, a simple HECRAS model of the spillway discharge using the inline spillway feature of HECRAS. Three cross sections upstream of the spillway were developed to model the reservoir and three cross sections downstream of the dam were developed to model tailwater conditions. The upstream boundary condition of the model was a constant head

elevation of the reservoir, and the downstream boundary condition (900 feet downstream of the spillway) was critical flow depth. The steady state model used downstream cross sections developed from interpretation of USGS topographic mapping, and the available near-dam project topography.

- The analyses found the structures were adequately stable under all considered loading conditions.

Upper and Middle Dam Remedial Measures, Androscoggin River Drainage, FPL Energy-Maine Hydro LLC

- Responsible for the geotechnical aspects of the remediation of the embankments for Upper and Middle Dams located in the Western Mountains of Maine. This work was under review of the Federal Energy Regulatory Commission (FERC). The dams are owned and operated by FPL Energy and regulated by the FERC. The embankments were constructed in the early 1900s and in recent years were identified to have seepage, artesian pressure and slope stability problems that the FERC had directed the owner to remediate. The FERC had also directed the owner to assess if the embankments had any seismic stability/liquefaction issues.
- Planned an extensive geotechnical investigations conducted by Findlay Engineering, Inc. to assess subsurface conditions for planning the remediations. Engineering evaluation included assessment of existing slope stability, seismic and liquefaction stability, and design analyses of several potential remedial approaches. The subsurface investigations determined that sections of the embankments are founded on pervious alluvial soils underlain by relatively impervious, dense glacial till. The pervious alluvial soils were assessed to be responsible for the artesian conditions identified at the toe of the embankments in at least one locations.
- To remediate the embankments, a 500-foot-long sheet pile cutoff wall was installed at one embankment, and a downstream filter berm is planned at the other. The sheet pile approach was used where the alluvial layer was at a low elevation, to avoid the need to have a prolonged drawdown of the storage reservoir retained by the embankment or expensive dewatering measures which would otherwise been needed for other remediation approaches which would have required excavation of the downstream toe or slope. At other locations where the alluvial soils are at a higher elevation and would only be a problem with regard to embankment stability during extreme flood scenarios, a filter berm will be constructed. At present, the sheet pile cutoff has been completed, and design of the other remedial measures is underway.

Slope and Seismic Stability Analyses, Lake Robinson Dam, Lake Robinson Nuclear Station, Progress Energy

- Conducted slope and seismic stability assessments of the embankment dam retaining Lake Robinson, which is adjacent to Robinson Nuclear Plant near Hartsville, S.C. The earth dam about 4,300 feet long and up to 50 feet in height. The dam and power plant are owned and operated by Progress Energy of Raleigh, NC.
- The analyses were prepared as required by the Nuclear Regulatory Commission (NRC) for inclusion in the plant's Facility Description and Safety Report on file with the NRC. The potential for foundation liquefaction needed to be assessed and embankment deformation was to be assessed using a Newmark approach. The original analysis details could not be found, and the analysis was required to be redone.
- Reviewed available subsurface investigation information, soil profiles, geology reports and construction specifications to develop properties for use in the analyses and to characterize the appropriate seismicity of the project locations. The slope and seismic stability analysis was conducted using the Programs SEEP/W and SLOPE/W, which were developed by GeoSlope International, of Calgary, Alberta, Canada. Since phreatic surface conditions at the embankments are not known by the analyst, a finite element seepage analysis using SEEP/W was conducted to define the steady state phreatic surface through the embankment, based on assumed hydraulic conductivity values. The results of the seepage analysis were then imported into the slope stability analysis program (SLOPE/W), and slope stability analyses, using the Spencer Method were conducted.
- The analyses found the embankment had adequate stability under all considered loading cases, that foundation liquefaction was not anticipated under the regional seismicity (as indicated by standard penetration test results), and that embankment deformation would be minimal under the operating basis earthquake.

Silver Lake and Sugar Hill Dams, Central Vermont Public Service

- Served as an owner's representative for review of a field investigation and stability assessment for the two dams which are owned and operated by Central Vermont Public Service. The analyses and field work were conducted by another consultant retained by the owner.
- The field investigation encountered relatively loose, saturated soils under the upstream slope of one of the dams,

triggering a more detailed assessment of liquefaction and potential seismic deformation under a maximum credible seismic event.

- Reviewed and commented on the analyses performed by the other consultant and participated in discussions between the owner and the Federal Energy Regulatory Commission as a technical expert.

Seepage and Slope Stability Analysis of Vermilion Dam, Southern California Edison

- Vermilion Dam is a 165-foot-high, 4,234-foot-long zoned embankment dam located at about elevation 7,650 feet in the Sierra Nevada Mountains of California. The dam is founded on a complex soil foundation of glacial moraine and interbedded alluvial materials. Seepage is controlled by numerous drainage systems, some of which were originally designed under the review of Dr. Karl Terzaghi. One of the key monitoring piezometers for a section of Vermilion Dam had elevated readings that were above the phreatic surface assumed in previous slope stability analyses, bringing the minimum computed factor of safety for slope stability into question. The previous analyses used a phreatic surface model consisting of a single phreatic surface. However, the piezometers at the dam are nested in sets of three piezometers each at various depths. Threshold values for each of the piezometers had not been established, and using phreatic surface assumptions of the previous slope stability analyses would not properly account for the flownet-like distribution of phreatic conditions actually indicated by the piezometer readings. Because the foundation layer was relatively thick, it was postulated that the single phreatic surface assumption of the previous analyses was overly conservative with regard to slope stability compared to the flownet-like conditions that actually exist.
- Used the program SEEP/W to model the seepage through and within the foundation below the dam, calibrated using the piezometer readings. The resulting seepage model was then imported into the slope stability program SLOPE/W, and slope stability analysis was conducted. The dam was found to be adequately stable even with the elevated piezometer water level observed. An additional important aspect of the finite element seepage analysis and associated slope stability analyses conducted was that they allowed a rational approach to developing threshold piezometer readings for the several sets of nested piezometers at the dam, satisfying requirements for the Performance Monitoring Plan for the dam.

Annual Inspections (2001 through 2006) and Seismic Stability Assessment, Fortuna Dam, EGE Fortuna SA

- Conducted several annual inspections and analysis reviews of Fortuna Dam, as mandated by the government of Panama (the next scheduled for February, 2005). The project is located near David Panama, adjacent to the Costa Rican border which is a relatively active seismic area. The project was completed in 1994 and includes a 341-foot-high concrete face rockfill dam, over 10 kilometers of tunnels and an underground powerhouse. The project has a total generation capacity of 300 MW, and provides about 40 percent of the generation capacity of the country.
- The project included slope stability, post-earthquake slope stability and seismic deformation analyses that were conducted using simplified approaches as a first cut. Stability of the dam was found to be adequate.

Post-Earthquake Analysis, Lundy Lake and Vermilion Dams, Southern California Edison

- Conducted post-earthquake analyses of these two dams for Southern California Edison. The analysis approach included the assumption of liquefaction of suspected relatively looser zones of the embankment cross sections, assessment of appropriate post-earthquake residual strength values, and post-earthquake slope stability analysis using the program SLOPEW.
- The embankments were found to be adequately stable with regarding the loading under the maximum credible earthquake.

Post-Earthquake Analysis, Gulf Island Dam, Florida Power & Light

- Conducted post-earthquake analyses of this dam for FPL Energy Maine Hydro, LCC at their Gulf Island Project located on the Androscoggin River, in Lewiston, Maine. The analysis approach included the assumption of liquefaction of suspected relatively looser zones of the embankment cross sections, assessment of appropriate post-earthquake residual strength values, and post-earthquake slope stability analysis using the program SLOPE/W.
- The embankment was found to be adequately stable with regarding the loading under the maximum credible earthquake.

Supplemental Seismic and Flood Analyses of Tioga Lake Dams, Southern Calif.

- Conducted slope stability analysis of the timber crib rockfill dam and small concrete arch dam at Tioga Lake, located in Tioga Pass, California. The slope stability analysis was conducted using the program SLOPE/W, and the arch analysis was conducted using SAP2000 NL, using a response spectrum approach.
- Both dams were found to be adequately stable to resist the maximum credible earthquake loading case.

FERC Part 12 Dam Safety Inspection and Slope Stability Analysis, Oswegatchie Project, Orion Power

- Conducted the 2000 Part 12 inspection of the Oswegatchie Project on the Oswegatchie River in upstate New York. The project includes four developments, including concrete gravity dams and earthen and concrete saddle dikes and sections.
- Follow-up work conducted in 2002 included slope stability analysis of a previously unanalyzed embankment structure. The program SLOPE/W was used. The analysis considered the normal, pseudostatic, and flood cases.

Soil Founded Ambersun Dam Stability and Seepage FEM Analysis, Sugar River Dam 1, Sugar River, Newport, N.H.

- Conducted a gravity analysis of a concrete Ambursen structure founded on alluvial soil. The analysis included finite element flow net analysis (using SEEP/W) to assess uplift on the base of the structure, HECRAS analysis to develop a tailwater curve (calibrated from flood observations), and a finite element stress analysis of the stability of the face slab under flood and seismic loading.
- The latter analysis was conducted using the finite element program SAP2000NL. The gravity analyses of several intermediary flood cases were conducted to find out the critical loading condition for the dam. An intermediate flood case (significantly less than the PMF) was found to be the critical loading case, and the dam was found to be adequately stable for all loading cases.

Penstock Replacement Geotechnical Issues and Slope Stability Analyses, Schaghticoke Project, Hoosic River, N.Y., Niagara Mohawk Power Corporation

- Retained by Orion Power, N.Y., (and formerly Niagara Mohawk Power Company) to serve as their liaison and peer reviewer of the geotechnical aspects for the design and replacement of the aging 1,100-foot-long penstock. The penstock ruptured during the spring of 1998 under full hydrostatic load. The penstock traverses a pipe bridge across the Hoosic River, and steep slopes which have had historic slope stability problems. To complicate geotechnical issues, a confined zone of artesian pressure was identified by Niagara Mohawk under the penstock alignment, which is being considered in the review of slope stability.
- Work conducted by FEI includes independent laboratory testing and review of significant subsurface investigations by both the designer and Niagara Mohawk, independent detailed slope stability analysis conducted with SLOPE/W, participating in weekly design review meetings, and detailed review and comment on the design criteria, drawings and specifications.
- Presented a paper summarizing the work at the 2000 ASDSO conference in Providence, R.I., and published in the conference proceedings.

Big Creek Dam 4, Dam 5 and Dam 6 Abutment Rock Slope Stability Analyses, Big Creek, Calif., Southern California Edison Co.

- The Federal Energy Regulatory Commission was concerned with the abutment slope stability of these 50 and 75 foot high concrete arch dams supported by exfoliated granite abutments. To address this issue, FEI completed a detailed analysis of the stability of the granite abutments of Big Creek Dams 4 and 5. The developments are part of Southern California Edison's historic Big Creek Project located in the Sierra Nevada Mountains of California. Dr. Findlay first mapped the bedrock features of both abutments, involving access by technical climbing.
- The mapping identified the critical blocks of the exfoliating granite for analysis, as well as the strikes and dips of the joints defining the blocks. Joint roughness was estimated by measuring the asperities of an exposed surface of the potential sliding plane of the most critical block. The analyses were made using the sliding block approach as outlined by Hoek and Bray as well as by using a spreadsheet coding of the two plane wedge (with tension crack) approach, also outlined by Hoek and Bray.
- Analyses found the abutments to be stable under normal gravity and seismic loading (0.15g) and PMF flooding, except on the left abutment of Dam 4. At that abutment, a large block was found to be marginally unstable if the

tension crack was surcharged with water (such as might occur under PMF overtopping during an extreme flood). A recommendation is that the vertical and near vertical joints defining the left abutment block of dam 4 be dry pack grouted to mitigate surcharging with water.

- Project was the subject of a paper presented at the 2000 ASDSO Annual Conference and in a recent ASDSO (winter 2000-2001) news letter article.

Slope Stability Analyses and FERC Part 12 Dam Safety Inspections, Upper Raquette River Project, New York, Niagara Mohawk Power Corporation

- Independent Consultant for conducting the FERC Part 12 Inspections for the Upper Raquette River Project, which includes five developments and a mix of concrete gravity dams and earthfill dikes up to about 70 feet in height.
- Inspection identified that the numerous dike structures on the project had only undergone pseudo-static analysis considering a seismic coefficient of 0.05g. Since the projects are located in FERC Seismic Zone 2, a minimum seismic coefficient of 0.1g should have been considered. FEI re-analyzed the seismic stability of the most critical dike (based on the previous analyses) of each of the five developments of the project.
- The dikes were found to be adequately stable under the required design loading.

Dam Safety Inspection, Murphy Dam Project, Connecticut River, New Hampshire Department of Environmental Services - Water Resources Council

- Project Manager, Lead Dam Inspector, and Lead Geotechnical Engineer for a detailed review of the condition of this 100-foot-high zoned earthfill dam in northern New Hampshire. The project consists of a review of project seismicity since two Magnitude 5 earthquakes have occurred within about 10 kilometers of the dam within the past 35 years.
- Work included installation of monitoring piezometers, assessment of liquefaction potential, a review and update of the structural stability of the dam and spillway, review and update of the PMF, a dam break analysis and preparation of inundation mapping for preparation of an Emergency Action Plan, and preparation of a list and cost estimate of capital improvements anticipated to be necessary to maintain the facility into the future.

Buzzard's Roost Project, Dam Safety Inspection, Saluda River, South Carolina, Duke Power Company

- Participated in the FERC Part 12 onsite inspection and prepared the summary report for Duke Power Company's Buzzards Roost Project. The project is located on the Saluda River, near Chappels, South Carolina. The project consists of a 2,400-foot-long, 80-foot-high earth embankment, a 200-foot-long fuse plug, and an 80-foot-high gated spillway/ogee, and integrated intake and 15 MW powerhouse.
- As a follow up to the five-year inspection, provided a peer review of a liquefaction analysis conducted by Duke Power as ordered by the FERC. The analysis is on the 80-foot earth embankment which is founded on alluvial sands.

Lake Blackshear Dam, Dam Breach Repair, Flint River, Georgia, Crisp County Power Commission

- During July 1994, Tropical Storm Alberto released torrential rains which caused overtopping of the 3,400-foot-long north embankment of Lake Blackshear Dam, causing a breach about 650 feet in length. Was retained by the Crisp County Power Commission to provide geotechnical engineering services to investigate subsurface conditions, design a repair of the breached section, and assess the integrity of the intact portion of the northern embankment.
- The subsurface investigation program consisting of 15 borings. Because the dam is founded on alluvial sands which are loose at some locations, liquefaction analysis was conducted using the approach developed by Seed, et al. A 2-dimensional transient finite element seepage model was used to assess the cause of boils observed during the flood at locations of the dam that remained intact.
- As a result of the investigation, a cutoff wall consisting of a cement-bentonite slurry was constructed using slurry trench methods along the axis of the entire northern embankment. The cutoff was determined to be necessary to remediate potential seepage damage to the intact portions of the dam and to mitigate the potential for future piping through the alluvial sands below the breached section.
- Project included close coordination with the Federal Energy Regulatory Commission and the Federal Emergency

Management Agency.

- Presented papers regarding the geotechnical aspects of the project at Waterpower '95 in San Francisco in July 1995, the Association of State Dam Safety Officials Annual Convention in Atlanta in September 1995, and the Maine Section of ASCE in March 1996.

Graham Lake Dam, Graham Lake Dam Remedial Measures Project, Union River, Maine, Bangor Hydro-Electric Company

- Lead geotechnical engineer for the Graham Lake Dam Remedial Measures Project, undertaken to improve dam stability and spillway capacity. Stability analysis and liquefaction analysis indicated the dam had deficient downstream slope stability, and the upstream slope was susceptible to liquefaction. This project consisted of building a new flood control structure just downstream of an existing semi-hydraulic fill dam in Ellsworth, Maine for Bangor Hydro-Electric Company.
- One aspect of involvement included design of a deep well dewatering system to intercept seepage through the existing dam which served as the upstream cofferdam for the work. This design included three-dimensional groundwater flow modeling using the USGS program MODFLOW to assess the effectiveness and number of wells needed to accomplish dewatering.
- After installation of the wells, pumping tests were conducted and the results incorporated into the model to verify expected performance. In addition to the dewatering aspects of the project, the existing dam was founded on soft clay, making excavation for the new flood control structure a potentially risky situation. Developed an innovative excavation stabilization system which consisted of a cellular-constructed granular stabilization berm which was significantly reduced costs over an originally proposed tie-back wall system.
- Project was completed in the spring of 1994, and was the subject of technical papers presented at the 1993 ASCE Specialty Conference on Dam Rehabilitation in Raleigh, N.C., and the 1994 Association of State Dam Safety Officials (ASDSO) Annual Convention in Boston, Mass., and the 1996 ASDSO Annual Convention in Seattle, Wash.

Pontook Hydroelectric Project, New Hydroelectric Development, Androscoggin River, New Hampshire, Combustion Engineering

- Lead geotechnical engineer for development of a new hydroelectric project under contract to Combustion Engineering. The project included geotechnical investigation, design, and construction consultation for a new 11.4 MW hydroelectric facility on the Androscoggin River in mountainous northern New Hampshire. Included was design and construction of a 6,000-foot unlined canal in glacial till to transport water to a new powerhouse.
- The canal construction involved full cut sections up to 70 feet in depth, as well as hill side embankment sections up to 30 feet in height. Excavation for the canal and the powerhouse involved deep well depressurization of artesian layers within the till to mitigate excavation instability. Unlined canal design included assessment of ability of the glacial till to self-armor to limit channel erosion. A 700-foot-long timber crib dam with a shear key to increase sliding stability was constructed across the Androscoggin River, downstream of the canal intake, to raise river levels sufficiently for power production.
- Project was selected by the Consulting Engineers of Maine to receive the “Award for Engineering Excellence” in January of 1988. Authored a technical paper on the subject for the 1988 Second International Conference on Case Histories in Geotechnical Engineering, sponsored by the University of Missouri Rolla, St. Louis, Mo.

Baldwin Hydroelectric Project, New Hydroelectric Development, Connecticut River, N.H., Baldwin Hydro Corporation

- Project manager and lead geotechnical engineer in the development and design of a 4.4 MW hydroelectric facility on the Connecticut River in Pittsburg, N.H.. Includes construction of a 170-foot-wide concrete gravity dam, canal headworks, a 4,600-foot-long unlined canal requiring excavation up to 50 feet deep, a penstock intake, and 450-foot-long penstock, a powerhouse and tailrace.
- Was determined that construction of the powerhouse would require deep dewatering using drilled gravel packed wells to depressurize a confined aquifer to allow excavation up to 50 feet in depth. The project has not yet been constructed.

Hydro-Kennebec Project, Increased Headpond Level, Kennebec River, Maine, Scott Paper Company

- Lead geotechnical engineer for assessment of several miles of shoreline, to be impacted by raising the normal water elevation of the existing dam at Scott Paper Company's (now Kimberly Clark) Winslow, Maine paper making facility. This increase in dam height resulted in a substantial increase in the impoundment elevation, affecting the shoreline at several industrial and residential areas.
- Assessment was made in two phases: a preliminary phase to evaluate the impact at individual locations based on observation, and a follow-up phase which included subsurface investigation and additional assessment at critically impacted areas. The assessment resulted in delineation of areas and recommended methods for slope stabilization.
- Work included development of contract plans and specifications for implementation of the recommendations. Involvement included consultation and monitoring services through construction.

Keowee Hydroelectric Project, Finite Element Seepage Analysis, Keowee River, South Carolina, Duke Power Company

- Developed a finite element model and preliminary input parameters for seepage analysis of an 80-foot-high intake dike for the Keowee Hydroelectric Project/Oconee Nuclear Project in Oconee County, S.C.. The dike is for the intake of the nuclear project, and is also a water retaining structure for Duke's Keowee Hydroelectric Project.
- Work included setting up and debugging the model so that Duke Power could use the model for a parametric study of the effect of varying hydraulic conductivity on seepage. The program SEEP/W (Geoslope International) was used to develop the model.

Drawdown Effects on Bank Stability

- A confidential client was interested in determining how the nominal 2-foot-daily drawdown at one of their reservoirs might safely be interpreted to mitigate reservoir bank stability. For example, if a one-foot rise followed by a three-foot draft in 24 hours could be interpreted as a “net” 2-foot-daily drawdown, some optimization of reservoir operation could be realized, provided such operation did not exacerbate bank erosion. Reservoir fluctuations can impact bank stability if the groundwater does not immediately equilibrate with reservoir level changes. In other words, the greater the lag time of groundwater response, the greater impact on slope stability of the reservoir banks.
- Planned and conducted the study to include field samples and testing, laboratory testing, and groundwater modeling of the response of the water table in the reservoir banks to various reservoir fluctuation scenarios at three selected critical sites.
- Field work included in situ permeability testing. The USGS groundwater flow model MODFLOW was used to assess groundwater response to fluctuations. The resulting groundwater information was then used to analyze impacts on slope stability. Slope stability analysis was completed using the program STABRD (developed at the University of California at Berkeley) to compute the effects of the groundwater lag on slope stability.
- Preliminary results of the study indicate the “net” interpretation will have no significant impact on bank stability up to incremental level changes of 4 feet.

Brassua Hydroelectric Project, Expert Witness for Piping Failure, Rockwood, Maine

- Retained as an expert witness for the contractor during post-construction litigation of a piping failure that developed during construction. The piping developed underneath an existing concrete gravity dam founded on glacial till.
- Thoroughly reviewed the project design and construction documentation and provided a deposition during the discovery period. The litigating parties decided to attempt mediation to settle the case.
- Made a technical presentation for a mediation hearing on the mechanics of piping and a review of the chronology of events leading to the piping failure.

Related Publications

- Findlay, R.C., Knarr, Michael, Hawkins, P.G., Yen, John, (2010), “Fragility Analysis of Mammoth Pool Dam”, a paper accepted to be presented at the 2010 ASDSO Annual Convention, Seattle, WA, September.
- Findlay, R.C., (2009), “Fragility Analysis of Mammoth Pool Dam, Status Report”, Presented at the 2009 Western Regional Dam Safety Forum, Sponsored by the FERC, Pacific Gas & Electric, and Southern California Edison, San Francisco, California.
- Findlay, R.C., Hawkins, P.G., Yen, John, (2008), “Use of a Net Instead of a Line when Fishing for Threshold Values for Deviant Piezometers”, Presented at and Published in the Proceedings of the Association of State Dam Safety Officials Annual Convention, in Indian Wells, California.
- Findlay, R.C., Pelletier, Michael A., (2006), "Rehabilitation to Reduce Piping Potential in the Skelton Dam Artesian Pressure Drainage System", Presented at and Published in the Proceedings of the Association of State Dam Safety Officials Annual Convention, in Boston, Massachusetts.
- Findlay, R.C. and Rabasca, S.J., (2003) "Diversion Dam – Seismic Stability Assessment and Rehabilitation”, Presented at Waterpower XIII, Buffalo, New York
- Rabasca, S.J., and Findlay, R.C. (2003) "Seismic and Seepage Remediation of Diversion Dam", Presented at the USSD Annual Lecture, Charleston, South Carolina.
- Findlay, R.C., and Pelletier, Michael A., (2002), “Foundation Pressure Reduction And Monitoring At Skelton Embankment Dam” Proceedings of the Association of State Dam Safety Officials Annual Convention, in Tampa, Florida.
- Findlay, R. C., and Millikan, D.L., (2000), “Arch Dam Abutment Stability at Big Creek Dam 4”, ASDSO Newsletter, Nov./Dec. 2000, Vol.16, No.6.
- Findlay, R.C., Hsu, F.T., Tracy, L.T., and Viau, J.L., (2000), “Geotechnical Aspects of Schaghticoke Penstock Replacement”, Proceedings of the Association of State Dam Safety Officials Annual Convention, in Providence, Rhode Island.
- ASCE (2000), Guidelines for Instrumentation and Measurement for Monitoring Dam Performance, Dr. Findlay was the lead author and Chapter Leader for Chapter 11, Embankment Dams.
- Findlay, R.C. and Millikan, D.L., (1999), “Arch Dam Abutment Stability at Big Creek Dams 4 and 5”, Proceedings of the Association of State Dam Safety Officials Annual Convention, St. Louis, Missouri.
- Findlay, R.C., Fry, S. A., Swant, T, and Hall, N., (1999) “Clark Fork River Erosion and Sedimentation Issues”, a paper to be present at Waterpower ’99, Los Vegas, Nevada
- Rabasca, S.J., Findlay, R.C. and Hsu, F.T, (1999) “Comparison of Borehole Advancement Techniques on SPT N-Values”, paper presented at USCOLD Annual Lecture, Atlanta, Georgia.
- Findlay, R.C., (1996), "Use of Groundwater Seepage Models for Evaluation of Dam Performance", Proceedings of the Association of State Dam Safety Officials Annual Convention, Seattle, Washington.
- Findlay, R.C., and Jones, A.J., (1996), "Lake Blackshear Dam Breach Repair," Proceedings of Innovation in Civil and Environmental Engineering: An Inventory of Innovative Civil and Environmental Engineering Practices in New England, 1996 Maine Section ASCE Technical Seminar, Portland, Maine.
- Findlay, R.C., Northrop, J., Crisp, R., and Rentfrow, S. (1995), "Repair of Lake Blackshear Dam", Proceedings of the Association of State Dam Safety Officials Annual Convention, Atlanta, Georgia.
- Findlay, R.C., Northrop, J., Crisp, R., and Rentfrow, S. (1995), "Effects of the Georgia Flood of 1994 on Lake Blackshear Dam," Proceedings of Waterpower '95, ASCE Conference, San Francisco, California.
- Findlay, R.C., Tarbell, J., and Carrington, G., (1995), "Beaver River Project Shoreline Erosion Study," published in Sediment Management and Erosion Control, the proceedings of the 1995 USCOLD Annual Meeting and Lecture, San Francisco, California.
- Benoit, J., Atwood, M, Findlay, R.C., and Hillard, B., (1995), "Laboratory and Field Evaluation of Jetting Insertion Parameters for the Self-Boring Pressuremeter in Soft Clays," Canadian Geotechnical Journal,

February.

- Findlay, R.C., (1994), "Geotechnical Aspects of the Graham Lake Dam Remedial Measures Project," Proceedings of the Association of State Dam Safety Officials Annual Convention, September, Boston, Massachusetts.
- Findlay, R.C., (1993), "Piping Security of Glacial Till-Structure Interfaces," Proceedings of Waterpower '93, ASCE Convention, Nashville, Tennessee.
- Jones, A.N., and Findlay, R.C., (1993), "Graham Lake Dam Remedial Measures Project," published in Geotechnical Practice in Dam Rehabilitation, ASCE Geotechnical Special Publication No. 35, Raleigh, North Carolina.
- Findlay, R.C., and Benoit, J., (1993), "Some Factors Affecting In Situ Measurement Using the Cambridge Self-Boring Pressuremeter," ASTM Geotechnical Testing Journal, Vol.16, No.2, June, Philadelphia, Pennsylvania.
- Findlay, R.C., (1991), "Use of the 9-Arm Self-Boring Pressuremeter to Measure In Situ Horizontal Stress, Stress Anisotrophy, and Stress Strain Behavior in Soft Clay," Submitted in partial fulfillment of the degree of Doctor of Philosophy, University of New Hampshire, Durham, New Hampshire.
- Benoit, J.B., Nejame, L.A., Atwood, M.J., and Findlay, R.C., (1990), "Dilatometer Lateral Stress Measurements in Soft Sensitive Clays," Proceedings of the 69th Annual Meeting of the Transportation Research Board, Washington, D.C.
- Findlay, R.C., (1988), "Hydrostatic Pressure at a Soil-Structure Interface," Proceedings of the Second International Conference on Case Histories in Geotechnical Engineering, sponsored by the University of Missouri Rolla, St. Louis, Missouri.
- Wardwell, R.E., Findlay, R.C., and Muzzy, M.W., (1988), "Seepage Effects on Sedimentation of Fly Ash Slurry," published in Hydraulic Fill Structures, ASCE Geotechnical Special Publication No. 21, Colorado State University, Fort Collins, Colorado.

Professional Associations

- American Society of Civil Engineers
- United States Society for Dams (USSD)
- Association of Dams Safety Officials (ASDSO)
- Association of State Dam Safety Officials (ASDSO), Affiliate Member Advisory Committee
- Dam Safety Journal (ASDSO), Editorial Board
- Inter-agency Committee on Dam Safety (ICODS), Subcommittee on Guidelines Past Member
- ASCE Task Committee on Guidelines for Instrumentation and Measurements for Monitoring Dam Performance, Past Member

Charles (Chuck) Hutton, PE

Qualifications Summary

- A civil/structural engineer with over 40 years' experience in design and management of water resource projects involving RCC dams, hydropower, pumping plants, hydraulic structures, intakes, outlets, gates and water conveyance facilities in the United States and overseas.
- MSCE in Structural Engineering from Purdue University.
- Currently, a Principal Engineer employed by GENTERRA Consultants, Inc. (GENTERRA) since 2005, providing engineering design expertise and technical review for dam and hydropower projects worldwide.
- Expertise includes preparing feasibility studies, designs, drawings, and specifications for RCC and gravity dams, intake structures, spillway and regulating gates, hydropower plants, pumping plants, pipelines, canals and hydraulic structures; performing dam safety inspections; conducting condition assessments and evaluation of existing dams, intake structures, spillway and regulating gates, hydropower facilities and water conveyance systems; developing designs for rehabilitation; technical review; project management and construction management.
- Familiar with USACE application of risk and uncertainty analysis in flood damage reduction studies through participation in Independent External Peer Reviews (IEPR) as the Structural Engineer.
- Experience evaluating reinforced concrete structures with emphasis on site specific seismic analysis and design according to USACE Engineering Manuals.
- Structural Engineer for 15 years with the Bureau of Reclamation in Denver, Colorado, followed by 23 years with the international water resource firm ECI Consultants (now AECOM).

Education

- MSCE, Structural Engineering, Purdue University, 1967
- BSCE , Purdue University, 1965
- Potential Failure Modes Analysis, FERC, 2004
- Risk Assessment Methodology for Dams (RAM-DSM), 2002
- Graduate Studies in Water Resource Engineering, University of Colorado, 1984–1987

Certifications and Licenses

- Licensed Professional Engineer, State of Colorado (No. 17795, 1981)
- Licensed Professional Engineer, State of Wyoming (No. 10282, 2004)
- National Council of Examiners for Engineering and Surveying (NCEES) (No. 21677, 2002)

Summary of Professional Experience

Dover Dam Safety Assurance Program, Ohio—*Structural Engineer*

- Corps of Engineers Independent External Peer Review of design modifications to an existing dam and spillway to safely pass the probable maximum flood (PMF). The dam is a 83-foot-high concrete gravity structure constructed in 1937. The dam is categorized as dam safety action class II. The concern is low factors of safety for extreme flood or earthquake events. The peer review involves development of a critical items list and assessment, analysis, interpretation and evaluation of the design/engineering and construction criteria.

Bluestone Dam Safety Assurance Program, West Virginia—*Structural Engineer*

- Corps of Engineers Independent External Peer Review of design modifications to an existing dam and spillway to safely pass the probable maximum flood (PMF). The dam is a 165-foot-high concrete gravity structure constructed in 1942. The dam is categorized as dam safety action class II. The concerns are lack of permanent scour protection in the spillway stilling basin and penstock discharge area, low factor of safety for extreme flood events, potentially lower foundation rock strength than used for design, low loss of life calculation and debris plugging that would increase the frequency of larger floods. The peer review involves development of a critical items list and assessment, analysis, interpretation and evaluation of the design/engineering and construction criteria.
- When completed this will be the largest concrete gravity dam post-tension anchoring project with the largest individual anchors used on any dam modification project in the country.

Isabella Dam Seismic Evaluation, California—*Senior Structural Engineer*

- Seismic structural and stability analysis of the ogee spillway and main dam outlet works, which consists of a tunnel transition conduit, distribution manifold bifurcation conduit and tainter gate structure. The dam is a 185-foot-high rolled earthfill embankment located about 35 miles northeast of Bakersfield, California.
- The dam is a Dam Safety Action Class I Dam – 1 of 6 of the highest risk dams in the Corps of Engineers inventory. The risk is a result of very significant seepage, seismic, and hydrologic deficiencies; along with a very large downstream population. Remediation of the project is urgent.
- The objective of the seismic structural analysis is to identify structural deficiencies under earthquake conditions and to develop conceptual seismic retrofit designs.

Barker Dam and Hydroelectric Project Potential Failure Mode Analysis, Colorado—*Facilitator*

- Federal Energy Regulatory Commission (FERC) Potential Failure Mode Analysis (PFMA) of a 175-foot-high concrete gravity dam; 4.3-mile long, 36-inch diameter concrete gravity pipeline; 18-foot high homogenous earth embankment dam; and a hydro plant that contains two 10 MW pelton turbines designed for 1820-feet of static head..
- Facilitated a team of individuals in the identification, evaluation and categorization of “potential” failure modes for the existing dam and other project works. The results of the PFMA process were used to enhance the Part 12D safety inspection, evaluate monitoring and surveillance programs and formulate risk reduction recommendations.

San Gabriel Dam Potential Failure Mode Analysis and FERC Part 12 Independent Consultant Dam Safety Inspection, Los Angeles County Department of Public Works, Los Angeles County, California—*Structural Engineer, Facilitator*

- Inspection and evaluation of a 320-foot-high earth- and rockfill dam, concrete spillway and outlet works in the San Gabriel Mountains of Los Angeles County. Work included an evaluation of the safety of the dam to meet the requirements of the Federal Energy Regulatory Commission (FERC) for an independent consultant inspection and evaluation of a hydropower project.
- Facilitated the Potential Failure Mode Analysis (PFMA) session with the Independent Consultant, County, FERC and the State Division of Safety of Dams (DSOD). The results of the PFMA process were used to enhance the Part 12D safety inspection, evaluate monitoring and surveillance programs and formulate risk reduction recommendations.

Buford Dam Sluice Gate Replacement Project, Georgia—*Quality Assurance and Quality Control Officer*

- For the design-build contractor and gate manufacturer for replacement of two existing service sluice gates with new gates containing integral jet flow gates. Each jet flow gate will discharge 600 cubic feet per second under a reservoir head of 160 feet. The project is owned and operated by the Corps of Engineers.

Trung Son Hydroelectric Project, Vietnam—*Hydropower Engineer*

- Responsible for assisting the World Bank in preparation, appraisal and supervision of a 260 MW multipurpose

hydroelectric development. The project includes a 290-foot-high RCC dam, gated spillway, four unit powerhouse, access road and transmission line.

- The objective of the consultancy is to assist the Bank in reviewing all technical aspects of the project and provide guidance to ensure the project meets the Bank's policy and international best practice.

Matilija Dam Safety Evaluation, California—*Structural Engineer*

- Review and evaluation of instrument monitoring program for a 164-foot-high concrete gravity arch dam originally constructed in 1949. The dam has experienced severe deterioration and cracking from alkali silica reaction resulting in expansion of the concrete. The structure has also experienced movement from deformation of the weak rock formations in the abutments and foundation.
- Responsibilities included reviewing previous investigations, structural analyses and monitoring data and developing recommendations for future monitoring to evaluate the condition of the concrete and safety of the dam.

Eagle Canyon Dam, Riverside County, California—*Structural Engineer*

- Final design of the spillway and other structures for a 70-foot-high earthfill dam, spillway and outlet facilities for use as flood control by the Riverside County Flood Control and Water Conservation District. Structural designs and analyses were prepared for site specific seismic loadings according to California Division of Safety of Dams criteria and guidelines.

Duckett Dam Modification Project, Maryland – *Structural Engineer*

- Responsible for Independent Technical Review of designs, drawings and specs for modifications to an existing 130-foot-high Ambursen buttress dam to withstand overtopping from the probable maximum flood. Overtopping protection consists of parapet retaining walls on each side of the concrete overflow section, anchored reinforced concrete scour slabs along the downstream toe of the concrete dam and encasement of the penstock.

Rio Valenciano Dam, Puerto Rico—*Dam Specialist*

- Responsible for providing technical guidance and design engineering for preparation of final designs, drawings and specifications for a 100-foot-high RCC dam with a gated spillway and raw water pump station.
- Responsible for developing recommendations for additional hydrologic analyses, seismicity investigations, and dam design studies.
- Prepared dam design criteria for compliance with local and federal dam design guidelines and dam safety requirements.

Nam Theun 1 Dam and Hydropower Project, Peoples Republic of Lao—*Design Manager*

- Stationed in Kuala Lumpur, Malaysia, responsible for coordination between the EPC contractor and design engineers and technical review of preliminary and final designs for a 580-foot-high RCC gravity dam, 550 MW hydroelectric power plant, and 90-mile long 500 KV transmission line.

Al Wehdah Dam, Jordan—*Structural Engineer*

- Responsible for reviewing diversion tunnel plug design and construction; providing advice on concrete temperature control during tunnel plug construction; reviewing structural stability analyses and evaluation criteria; reviewing and evaluating RCC verification coring and strength test results; developing a contraction joint surveying and monitoring program; preparing a contraction joint grouting procedure; providing advice on structural implications of early reservoir impoundment; assessing quality of conventional concrete construction; and reviewing contractor prepared reinforcement placement drawings for the outlet works structure.
- The project consists of a 330-foot-high RCC dam with an uncontrolled overflow stepped spillway, stilling basin and multi-level irrigation and municipal water supply outlet.

Karahnjukar Dam and Hydroelectric Project, Iceland—*Design Engineer*

- Responsible for development of mitigation measures to address an increase in the seismic design criteria for a 635-foot-high concrete-faced rockfill dam. Mitigation measures included revisions to the face slab vertical joint design in the maximum section of the dam, additional grouting of several faults through the foundation, and

modification of the grouting gallery lining to accommodate potential movement across the faults.

- Responsible for performing a design audit of all calculations and reports to ensure compliance with QA/QC procedures.
- Responsible for conducting a review of previous static and dynamic structural analysis of the dam to determine if additional studies are required to evaluate the increase in peak ground acceleration.

Lake Dorothy Hydroelectric Project, Alaska—*Project Manager*

- Responsible for the preparation of final designs, drawings, and specifications for a 45 MW high head hydroelectric facility located near Juneau. The project includes a three unit powerhouse located at tide water, 2-mile long access road through rugged terrain, 1.7-mile long 60-inch diameter welded steel penstock, rockfill dam, tunnel, and lake tap. The project is wholly on U.S. Forest Service land and licensed by the Federal Energy Regulatory Commission.

Anyox Dam Evaluation, British Columbia, Canada—*Project Manager*

- Responsible for coordination and technical oversight for a structural stability and stress analysis of an 80-year old multiple arch buttress concrete dam. The dam was originally constructed to provide water for hydropower generation for the nearby copper mine. The mine and town were vacated in 1935. The dam was abandoned in 1968. The dam is approximately 150-feet high and 700-feet long and includes twenty-six arches, each spanning 24-feet.
- Analysis involved evaluation of the structural integrity and stability of the structure for flood and earthquake loading using simple methods according to the Federal Energy Regulatory Commission Guidelines for the evaluation of hydropower projects. The analysis considered the current state of deterioration of the structure and identified rehabilitation measures needed to restore its integrity.

Hydroelectric Intake Structure and Gate Refurbishment Project, Texas. – Structural Engineer

- Inspection, condition assessment, recommendations for refurbishment, cost estimates, schedules and priorities for modernization and rehabilitation of hydroelectric intake and draft tube structures, gates and hoisting equipment and gantry crane at five dams on the Colorado River near Austin, Texas.

Related Publications

- “Overtopping of Dams: Are We Avoiding the Obvious”, Association of State Dam Safety Officials Annual Conference, September 26 to 30, 2004
- “Logan First Dam and Hydroelectric Facility Rehabilitation”, HydroVision 2004, American Society of Civil Engineers, August 16 to 20, 2004
- “Concrete Dam Overtopping Protection”, National Dam Safety Program Technical Workshop #11, February 18 to 19, 2004
- “Realizing the Dream” (Hydroelectric Power on a Municipal Water System), HydroVision 2002, August 16 to 20, 2002.
- “Tainter Gate Operation and Maintenance,” United States Committee on Large Dams Annual Lecture, Portland, Oregon, May 2000
- “Tainter Gates Analysis and Evaluation,” Waterpower ‘99, Las Vegas, Nevada, 1999
- “Bai Thuong Weir Rehabilitation,” United States Committee on Large Dams Annual Lecture, Atlanta, Georgia, 1999
- “Tainter Gates Studies,” Association of State Dam Safety Officials Annual Conference, Las Vegas, Nevada, 1998
- “Economic Rehabilitation of Earth Dams,” Association of State Dam Safety Officials Regional Conference, Red Lodge, Montana, 1995
- “Design of a Curved Baffle Energy Dissipation Structure,” ASCE National Conference on Hydraulic

Engineering, San Francisco, California, 1993

- "Rehabilitation of Humphreys Concrete Arch Dam, Association of State Dam Safety Officials Annual Conference, Albuquerque, New Mexico, 1989
- Hydraulic Model Studies and Design of Plunge-Flow Drop Structures," ASCE National Conference on Hydraulic Engineering, Colorado Springs, Colorado, 1985

Professional Associations

- American Society of Civil Engineers
- United States Society of Dams
- Association of State Dam Safety Officials

Cheryl P. Ulrich, P.E.

Qualifications Summary

- Currently work for Weston Solutions, Inc., with a M.S. degree in Civil Engineering.
- More than 20 years of experience managing large, complex civil works projects for the USACE.
- Over 8 years of civil works plan formulation experience on watershed studies, flood damage reduction, beach nourishment, deep draft navigation, water supply reallocation, and long-term drought management.
- Over 7 years of civil works project management experience in ecosystem restoration, flood damage reduction, beach nourishment, deep draft navigation, and hydropower rehabilitation.
- Over 5 years senior civil works program experience on South Florida Everglades Ecosystem Restoration Program.
- Currently teaching a Civil Works plan formulation and leadership development course for USACE Jacksonville.
- Has familiarity with economic evaluation of flood risk management alternatives including development of average annual costs and benefits, calculation of net benefits, and identification of the National Economic Development (NED) plan.
  - While working for USACE Jacksonville District, Ms. Ulrich was the project manager for the Modified Water Deliveries to Everglades National Park 8.5 Square Mile Area flood mitigation project, which was the lynchpin to moving Everglades restoration forward. Several alternatives were examined and evaluated. Average annual costs, benefits and identification of the NED plan were prepared.
  - While working for USACE Mobile District, Ms. Ulrich was the planning technical lead for watershed studies for Atlanta GA, Birmingham, AL and Cahaba River, GA. All involved flood risk management alternatives. In addition Ms. Ulrich performed Water Supply Reallocation Reports for Lake Lanier, Carters Lake and Allatoona Lake which involved an analysis of flood control impacts due to the water reallocation within the reservoirs. Also was the planning technical lead for the Panama City Beaches Hurricane and Storm Damage Reduction Project which resulted in an 18.5 mile beach nourishment project (the largest in the US.)
  - While working for USACE Sacramento District, Ms. Ulrich prepared plans and specifications for the San Pablo and Wildcat Creeks, CA Flood Control Project and PL84-99 East Levee (Left Bank) Sacramento River emergency work which protected the Sacramento Regional Airport.
- As a USACE Civil Works planner, incorporated non-structural measures such as flood proofing and land acquisitions for flood damage reduction alternatives. The 8.5 Square Mile Area involved the largest buy-out within the Everglades Restoration program.
- Prepared several USACE planning feasibility studies incorporating HEC-FDA, MCACES and HEC-RAS models.

Education

- MS, Civil Engineering, Emphasis on Coastal and Hydraulics Engineering, University of California, Berkeley, 1987
- BS, Civil Engineering, University of Florida, 1984

Certifications and Licenses

- Licensed Professional Engineer, State of Florida (#40694, 1988)
- Design License for Asbestos Abatement (1988)

Summary of Professional Experience

WESTON Solutions, Jacksonville, Fla.— *Leader for Southern Division's Natural Resource Management Team*

- Independent External Peer Review panel member for Louisiana Coastal Area Ecosystem Restoration Program – Amite River Diversion Canal Modification.
- Primary organizer for National Community for Ecosystem Restoration.

Noblis' Center for Energy and Environmental Sustainability, Falls Church, Va.—*Principal Civil Engineer*

- Identified opportunities for Noblis as an independent third party to provide impartial service and technical advice to state and federal organizations responsible for natural resource management across multi-jurisdictional boundaries.
- Establishment of targets, strategies, execution planning for addressing issues of national significance. i.e., climate change, ecosystem restoration, water resource management, and natural resource optimization decision support.

National Center on Ecosystem Restoration, Washington, D.C., U.S. Army Corps of Engineers (USACE) —*Project Manager*

- Project Manager for creating a National Center on Ecosystem Restoration on behalf of HQ USACE.
- Reported directly to SES for Ecosystem Restoration, Dr. Ed Theriot.

South Florida Ecosystem Restoration Program, Jacksonville, Fla., USACE—*Jacksonville District, Everglades Division, Strategic Execution Branch Chief.*

- Responsible for overseeing the execution of the South Florida Ecosystem Restoration Program, which includes the $10.5 billion Comprehensive Everglades Restoration Program (CERP). CERP is a multi-decade, complex program, which has national and international interest.
- Represented Jacksonville District with Congressional interests, White House Council on Environmental Quality, Office of Management and Budget, ASA(CW), and other high-level federal, state, and local government officials.
- Primary Point of Contact (POC) with non-federal sponsor, the South Florida Water Management District.
- Facilitated resolution of program and project implementation issues.

Civil Works Water Resource Projects, South Florida, USACE, Programs and Project Management Division, South Florida—*Restoration Branch Chief*

- Program Manager for Civil Works Water Resource Projects in South Florida, which included primarily ecosystem restoration and flood control projects.
- Provided leadership and exercised supervisory control over the South Florida region's project managers.

Project Delivery Team Lead, South Dale–Florida Bay–Florida Keys, Fla., USACE, Programs and Project Management Division—*Senior Project Manager*

- Leader of Project Delivery Teams for South Dade–Florida Bay–Florida Keys area, which included technical team, as well as other agency representatives.

Civil Works Program, Mobile, Ala., USACE – Mobile District, Programs and Project Management Division—*Project Manager*

- Project Manager for large complex, multi-disciplinary civil works projects, and O&M projects.
- Types of projects included storm damage reduction/shore protection, deep-draft navigation, major rehabilitation (hydropower rewind and prevention of structural failure), and watershed studies for Atlanta GA; Birmingham, AL; and Cahaba River, GA.
- Value Engineering Officer for Mobile District.

Civil Works Program, Mobile, Ala., USACE – Mobile District, Planning Division—*Planning Technical Lead*

- Planning Technical Lead for large, complex Hurricane and Storm Damage Reduction project and Harbor Deepening project.
- Special assignments included New Madrid Earthquake Response Plan, Water Supply Reallocation Reports, and Southeast Drought Action Report.

Engineering and Industrial Hygiene Projects, Pensacola, Fla., Environmental Protection Systems—*Supervisor Engineering and Industrial Hygiene Manager*

- Responsible for all engineering and industrial hygiene projects.

Remedial Action Planning, Livermore, Calif., Lawrence Livermore National Laboratory—*Civil Engineer*

- Performed remedial action planning demonstration of innovative technology to remove gasoline hydrocarbons from unsaturated and saturated soils by elevating the temperature of the influent of the air stripping tower and soil venting.

Civil Works and Military Programs, Sacramento, Calif., USACE – Sacramento District—*Planning Technical Lead and Design Engineer*

- Planning and Engineering Divisions, military environmental planning, and plans and specifications for flood control project.

Professional Associations

- National Conference on Ecosystem Restoration 2011, Program Chair
- Greater Everglades Ecosystem Restoration Conference 2010, Planning Committee Member
- American Water Resources Association – National Policy Committee and Florida Chapter
- Society of American Military Engineers

Awards

- Commander's Award for Civilian Service – Strategic Communication (2006)
- Achievement Medal for Civilian Service – Improving Project Management Business Process (2003)
- Commander's Award for Civilian Service – South Atlantic Division Project Management Business Process Modernization (2000)
- Florida Shore and Beach Preservation Association – Per Brunn Distinguished Service Award (1999)
- Special Act Award for Efforts on Cape Sable Seaside Sparrow (1998)
- South Atlantic Division's Civil Works Project Manager of the Year (1996)
- Mobile Area Council of Engineers' Young Engineer of the Year (1995)
- Able Toastmasters (1996)

Appendix C – Charge for IEPR Panel

The study level Charge Questions provided by the USACE and guidance to support the DSMS for the Rough River Dam, Kentucky, are listed below.

C.1 Objectives

The objective of this work is to conduct an IEPR of the Rough River Dam, Kentucky, DSMS and related documents. The IEPR will follow the procedures described in the Department of the Army USACE guidance *Peer Review of Decision Documents* (EC No. 1165-2-209), and the OMB's *Final Information Quality Bulletin for Peer Review*.

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, the validity of the research design, the quality of data collection procedures, the robustness of the methods employed, the appropriateness of the methods for the hypotheses being tested, the extent to which the conclusions follow from the analysis, and the strengths and limitations of the overall product.

This IEPR will analyze the adequacy and acceptability of the alternatives in the formulation of the DSMS as well as other potentially viable alternatives. The independent review will be limited to technical review and will not involve policy review. The peer review will be conducted by experts with extensive experience in engineering, economic, and environmental issues associated with flood protection feature design. The experts will be "charged" with responding to specific technical questions as well as providing a broad technical (engineering, economic, and environmental) evaluation of the overall project.

The experts (i.e., peer review panel members) will identify, analyze, and comment upon assumptions that underlie the analyses and evaluate the soundness of proposed models and planning methods. The panel members will evaluate whether the interpretations of analyses and conclusions are technically sound and reasonable, provide effective review in terms of both usefulness of results and of credibility, and have the flexibility to bring important issues to the attention of decision makers. The panel members may offer opinions as to whether there are sufficient technical analyses upon which to base the ability to implement the project. The panel members will address factual inputs, data, and the use of geotechnical analyses, assumptions, and other scientific and engineering tools/methodologies to inform decision-making.

C.2 Documents Provided

The following is a list of documents and reference materials provided for the review. **The documents presented in bold are the only ones for which comments were requested.** All other documents were provided for reference only.

- **Dam Safety Modification Report (DSMR), Vol. 1**
- **DSMR, Vol. 2—Environmental Assessment and Finding of No Significant Impact**
- **DSMR, Vol. 3—Appendix A through G**
- **DSMR, Vol. 4—Appendix G through L**
- Rough River Lake Operation and Maintenance Manual, *1987 Revisions
- Quality Control Certificates (QCC) Out-brief for Rough River Dam
- Willowstick Report – Aquatrack Geophysical Investigation

- As-built Drawings—Rough River Dam and Spillway
- As-built Drawings—Rough River Outlet Works
- Drawings—Additional Foundation Grouting
- Drawings—Cathodic Protection
- Drawings—Channel Improvements
- Drawings—Outlet Bucket and Channel Repairs
- Drawings—Tailwater Area Repairs
- Design Memoranda
- Foundation Completion Reports
- Geologic Maps

C.3 Charge for Peer Review

Members of this peer review panel were asked to determine whether the technical approach and scientific rationale presented in the Rough River DSMS were credible and whether the conclusions were valid. The reviewers were asked to determine whether the technical work was adequate, competently performed, properly documented, satisfied established quality requirements, and yielded scientifically credible conclusions. The panel was asked to provide feedback on the review and selection of alternatives. The reviewers were not asked whether they would have conducted the work in a similar manner.

C.4 General Charge Guidance

Please answer the scientific and technical questions listed below and conduct a broad overview of the Rough River Dam, Kentucky, DSMS. 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 make any relevant and appropriate comments on any of the sections and appendices; you may be asked to focus specifically on certain areas. In addition, please note the following guidance. Note that the panel will be asked to provide an overall statement related to 1 and 2 below per USACE guidance (EC No. 1165-2-209; Appendix D).

1. Assess the adequacy and acceptability of the evaluation and selection of alternatives.
2. If appropriate, offer opinions as to whether there are sufficient analyses upon which to base a recommendation for construction, authorization, or funding.
3. Evaluate whether the interpretations of analysis and conclusions are reasonable.
4. Please focus the review on scientific information, including factual inputs, data, the use and soundness of models, analyses, assumptions, and other scientific and engineering matters that inform decision makers.
5. 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.

6. 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.
7. 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.

C.5 General Charge Questions

1. 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?
2. Are the methods used to evaluate the condition of the structure adequate and appropriate given the circumstances?
3. Have the hazards that affect the structure been adequately described?
4. Have the appropriate alternatives, including removal of the dam, been considered and adequately described for this project?
5. Do the alternatives and their associated costs appear reasonable?
6. Do the benefits and consequences appear reasonable?
7. Are there any additional analyses or information available or obtainable that would affect decisions regarding the structure?
8. Has anything significant been overlooked in the development of the assessment of this structure or the alternatives?
9. Have appropriate considerations been made to support the decisions regarding this structure?
10. 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?