Volume 3
Part 6.3

Model Certification Review Report for Arkansas HGM Guidebook

U.S. Army Corps of Engineers
Memphis District

Battelle
The Business *of* Innovation

Final Model Certification Review Report for the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook

Prepared by
Battelle Memorial Institute

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Rock Island District

Contract No. W911NF-07-D-0001
Task Control Number: 09210
Delivery Order: 0799

April 14, 2010

SHORT-TERM ANALYSIS SERVICE (STAS)

Final Model Certification Review Report
for the
Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook

by

Battelle
505 King Avenue
Columbus, OH 43201

for:

Department of the Army
U.S. Army Corps of Engineers
Ecosystem Restoration Planning Center of Expertise
Rock Island District

Contract Number: W911NF-07-D-0001
Task Control Number: 09210
Delivery Order Number: 0799

April 14, 2010

Scientific Services Program

This page intentionally left blank

Final
MODEL CERTIFICATION REVIEW REPORT
for the
Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook

EXECUTIVE SUMMARY

An independent external peer review of the Delta Region of Arkansas Hydrogeomorphic Methodology Guidebook (HGM Guidebook) was conducted for the U.S. Army Corps of Engineers (USACE) Ecosystem Restoration Planning Center of Expertise (ECO-PCX) under Contract Number W911NF-07-D-0001, Task Control Number 09-210. The Guidebook supports efforts for assessing the most common types of wetlands that occur in the Delta Region of Arkansas in the Lower Mississippi River Alluvial Valley in the United States. The HGM Guidebook provides a method for developing functional indices and the protocols used to apply these indices to the assessment of wetland conditions at a site-specific scale. The HGM approach initially was designed to be used in the context of the Clean Water Act, Section 404 Regulatory Program, to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. However, a variety of other potential uses have been identified, including the determination of minimal effects under the Food Security Act, design of wetland restoration projects, and management of wetlands.

Normally, a HGM Guidebook focuses on a single regional wetland subclass. This HGM Guidebook, however, considers multiple regional wetland subclasses. Its objectives are to:

- Characterize selected regional wetland subclasses in the Delta Region of Arkansas within the Lower Mississippi River Alluvial Valley.
- Present the rationale used to select functions to be assessed in these regional subclasses.
- Present the rationale used to select assessment variables and metrics.
- Present the rationale used to develop assessment models.
- Describe the protocols for applying the functional indices to the assessment of wetland functions.

Use of certified models for all USACE planning activities is mandatory; therefore the HGM Guidebook models were subjected to a model certification review. The USACE Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of USACE planning models and to assure that high quality methods and tools are available so that informed decisions on investments in the Nation's water resources infrastructure and natural environment can be made. The main objective of the PMIP is to carry out "a process to review, improve and validate analytical tools and models for USACE Civil Works business programs" (USACE EC 1105-2-407, May 2005). In accordance with the *Planning Models Improvement Program: Model Certification* (EC 1105-2-407, May 2005), certification is required for all planning models developed and/or used by USACE. The objective of model certification is to ensure that models used by USACE are technically and theoretically sound, computationally accurate, and in compliance with USACE planning policy.

As a 501(c)(3) nonprofit science and technology organization with experience in establishing and administering peer review panels for USACE, Battelle was engaged to conduct the model certification review for the HGM models. Independent, objective peer review is regarded as a critical element in ensuring technical quality, system quality, and usability of the models.

Four subject matter experts (i.e., model reviewers) were selected to serve on the model review panel from 32 identified candidates. As appropriate for the technical nature of the HGM Guidebook models, the technical expertise of the four selected model reviewers included Civil Works planning/HGM modeling, wetland ecology, forestry, and programming/spreadsheet auditing.

The model reviewers were provided with electronic versions of the HGM Guidebook and associated spreadsheets along with a charge (included with Attachment A) that solicited their comments on specific aspects of the document and model spreadsheets. The charge questions solicited comments regarding key technical quality, system quality, and usability criteria that are critical for model certification as described in the USACE *Protocols for Certification of Planning Models* (July 2007). There was no communication between the model reviewers and the model developers during the review of the documents and models.

Approximately 100 individual comments were received from the model reviewers in response to 34 charge questions. Following the individual reviews of the model documentation and spreadsheets by the model reviewers, a model review teleconference was conducted to review comments on the key model review criteria, discuss charge questions for which there were conflicting responses, and reach agreement on the Final Panel Comments (FPC) to be provided to USACE. The findings of the models' independent external peer review regarding their technical quality, system quality and usability are documented in specific sections of this report, and FPCs are provided in Appendix B.

This Draft Report for the Model Certification Review of the Delta Region of Arkansas HGM Guidebook describes the model review process, describes the model review panel members and their selection, and summarizes the findings and FPCs of the model reviewers. This report is subject to USACE review. USACE comments on the draft report (expected by February 10, 2010) will be the subject of discussion with USACE and the model reviewers during a teleconference (scheduled for 9:00 am EDT February 16, 2010). Once the report has been finalized, the results of the model review as presented in the final report will be taken into consideration for certifying or revising the HGM Guidebook and models.

Overall, the model reviewers agreed that the models are suitable for limited application to meet some of their intended purposes; however, they were concerned that the models have some conceptual flaws that limit their ability to achieve all of the intended purposes. One model reviewer believes these flaws are serious. Models are simple representations of complex systems and, as such, must balance complexity and reality with simplicity and usability. The ability of the HGM Guidebook models to assess wetland functions is undetermined; the models are more appropriate for limited assessment of wetland condition. Although the guidebook has deficiencies, they are not insurmountable and can be resolved.

There were some issues identified with the models' documentation, application, and variables, and some potentially serious errors were noted in the spreadsheet calculations and formulas. The model reviewers provided the following recommendations for improving the models based on the most significant concerns they identified during their review.

1. Describe the relationships between wetland condition and function from the point of scientific validity and program requirements under the Clean Water Act.
2. Provide in an appendix a description of the process for selecting and measuring data from reference wetlands. Also, show reference data points on the graphs of Functional Capacity Index curves relating independent variables to the dependent subindex, and explain how recovery trajectory curves were developed.
3. Provide a better method for capturing frequency and duration of flooding as controlling factors, or provide a clear statement explaining why these indicators could not be reasonably measured.
4. Include an explanation for each of the FCI functions that describes why the specific mathematical form was chosen.
5. Provide information on the relationship between actual measurements of wetland functions and FCI curves.
6. Provide additional information on 1) the sensitivity of the FCIs to their inputs and on the least significant differences for policy analysis, 2) empirical validation of the FCIs against field data, and 3) precision, accuracy, and uncertainty for the FCI calculations.
7. Redesign the forms and spreadsheets as an integrated system to prevent errors.
8. Provide better justification in the guidebook for classifying anthropogenically disconnected floodplain depressions (depressions behind mainstem levees), as unconnected alluvial depressions rather than treating them as altered floodplain depressions.
9. Include non-wetland sites that were former wetlands as part of the reference data set in order to represent the most altered end of the gradient and provide a basis for identifying potential restoration sites.
10. Consider using indicators of channelization and flooding duration in the FCIs.
11. Consider changing how V_{POND}, V_{LITTER} V_{SSD}, V_{GVC}, V_{OUT}, and V_{TBA} are measured and used in the FCIs.
12. Provide additional documentation to: (1) provide links or citations for easily obtainable case studies that apply this method, (2) provide a series of tables, sorted by wetland subclass, showing variable-by-function matrices, and (3) explain that the models have not been designed to address climate change.
13. Improve field measurements to remove subjectivity and to improve precision.
14. Summarize the assumptions implicit in the HGM approach and FCI models.
15. Ensure consistency in terminology and names of variables throughout the HGM Guidebook.

This list of actions summarizes the recommendations for resolution in the FPCs; more detailed recommendations are provided in the FPCs in Appendix B. Failure to address the issues identified may lead to incorrect interpretation or use of the HGM models and outputs.

The reviewers strongly suggest incorporating the recommended resolutions into the FCI models and modifying the documentation before allowing widespread use of the models for planning purposes. Making the recommended revisions will result in better precision of model inputs, accuracy of model outputs, comprehension of the scientific basis and logic behind the models, and understanding of the models results, as well as promote model transparency and allow uncertainty and sensitivity analysis to be performed. The model will also be better able to achieve its intended purpose.

During a teleconference on April 5, 2010 to discuss the review findings with USACE, the model reviewers were asked whether the guidebook was usable prior to making the suggested revisions (as described above). The model reviewers' response was that there could be continued conditional use. The guidebook has been in use for approximately five years and could potentially be used with the same level of accuracy under the condition that existing users will be the ones who continue to use the method. Upon further consideration of this question, the model reviewers agreed that, at the very least, the errors noted in the spreadsheets and the potential for errors in transferring data among field sheets and spreadsheets must be corrected to improve the ability of the models to yield accurate results. Failure to correct the errors and data transfer issues may lead to unreliable model outputs (see FPC #7 and Appendix C). Once these issues are addressed, the models could continue to be used prior to addressing all other comments under the following conditions:

1) The same team of experts who developed the regional HGM guidebook will perform the assessments for all wetland sites to ensure the models are used as intended and that there is consistency in the results. Otherwise, scores among sites are not likely to be comparable (see FPC #15).
2) All other comments will be addressed as soon as possible to certify the regional HGM guidebook for widespread application by users external to the development team. The reviewers understand the immediate need to use the guidebook; however, the guidebook should not continue to be used beyond the immediate needs without the technical issues identified being addressed.
3) Users understand that the regional HGM guidebook's process for assessing wetland functions did not include any actual measurement of wetland functions and is based on measurements of wetland characteristics hypothesized to be indicators of wetland functions. The relationships between these indicators and wetland functions have yet to be independently tested and verified with field data. Therefore, the ability of the guidebook to assess wetland functions will remain unknown until appropriate testing and validation are carried out.

Although the panel concurs that the guidebook is usable once the spreadsheet errors and data transfer issues are corrected, there are still risks associated with its continued use. Those risks include (1) potential for inaccurate measurement of changes in wetland function among project alternatives, (2) potential misapplication of the HGM approach from reclassifying floodplain wetlands to non-floodplain types following an alteration by levee construction (and thus overlooking loss of functions related to the loss of overbank flooding), and (3) the possible selection of an incorrect alternative for minimizing wetland impacts. The question on usability of the guidebook asked by USACE was primarily in reference to the St. John's/New Madrid project. Although addressing the issues identified by this independent external peer review (IEPR) would improve the usability and accuracy of the models for application to projects in the region, the question of application of the guidebook for the St. John's/New Madrid project was not specifically addressed because it was out of the scope for this review and the model reviewers were not provided with review materials specific to the selection of alternatives for the St. John/New Madrid project.

This page intentionally left blank

TABLE OF CONTENTS

straight lines, and why the minimum subindex score for some altered conditions equaled zero while others were greater than zero.

3. The treatment of flood frequency and flood duration within the models implies greater ecological measurement of flood frequency and duration than is actually occurring.
4. The justification for the mathematical form of the six Functional Capacity Indices (FCIs) should be expanded.
5. The Functional Capacity Indices (FCIs) have not been validated against independent empirical estimates of the actual function in the relevant terrains.
6. The Hydrogeomorphic (HGM) Guidebook needs to explain more fully the overall reliability of the outputs of the model.
7. The procedures used to transform raw field data into tables of Functional Capacity Indices (FCIs) and Functional Capacity Units (FCUs) are overly complex and prone to errors.
8. The Unconnected Alluvial Depression subclass should not include wetlands that have been cut off from the channel of major river floodplains by man-made levees.
9. The reference data set does not seem to have included former wetlands (now non-wetlands) as part of the model calibration, which means that the most altered end of the gradient is not well represented in the calibration, and former wetlands will likely be overlooked as potential restoration sites.
10. The Functional Capacity Index (FCI) for Detain Floodwater could be improved by use of channelization and flooding duration indicators and by careful consideration of the calibration of V_{FREQ}.
11. The Functional Capacity Index (FCI) for Detains Precipitation could be improved by changing how V_{POND} and V_{LITTER} are measured.
12. The Functional Capacity Indices (FCIs) for Cycles Nutrients and Export Organic Carbon could be improved by changing the use or measurement of V_{SSD}, V_{GVC}, V_{OUT}, and V_{TBA} in the FCI calculation.
13. The Functional Capacity Index (FCI) for Provide Habitat for Fish and Wildlife could be made more robust by using fewer subindices in its calculation.
14. The Hydrogeomorphic (HGM) Guidebook should include references to easily-obtainable case studies that apply this method.
15. Some field measurement approaches should be improved to improve the precision (repeatability of measurements) of variables in the models.
16. At the beginning of the document, a clear statement needs to be provided about how the guidebook is intended to support decisions made by regulators and managers and how the guidebook supports that purpose.
17. The Hydrogeomorphic (HGM) Guidebook should explain why some functions commonly included in HGM assessments were not chosen for this HGM assessment method.

LIST OF TABLES

LIST OF ACRONYMS

CECW	Corps of Engineers Directorate of Civil Works
CE/ICA	Cost-Effective Incremental Cost Analysis
COI	Conflict of Interest
dbh	diameter at breast height
ECO-PCX	Ecosystem Restoration Planning Center of Expertise
FCI	Functional Capacity Index
FCU	Functional Capacity Unit
FPC	Final Panel Comment
HGM	Hydrogeomorphic
IEPR	Independent External Peer Review
LSD	Least Significant Difference
PCX	Planning Center of Expertise
PMIP	Planning Models Improvement Program
SOW	Statement of Work
USACE	U.S. Army Corps of Engineers
WAA	Wetland Assessment Area

1 INTRODUCTION

Planning models are defined as any models and analytical tools that planners use to define water resources management problems and opportunities, formulate potential alternatives to address the problems and take advantage of the opportunities, and evaluate potential effects of alternatives and to support decision-making. The U.S. Army Corps of Engineers (USACE) Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of planning models used by USACE and to make recommendations to assure that high quality methods and tools are available to enable informed decisions on investments in the Nation's water resources infrastructure and natural environment. The main objective of the PMIP is to carry out a process to review, improve, and validate analytical tools and models for USACE Civil Works business programs. The PMIP Task Force collected the views of USACE leaders and recognized technical experts, and conducted investigations and numerous discussions and debates on issues related to planning models. This task force identified an array of model-related problems, conducted a survey of planning models, prepared papers on model-related issues, analyzed numerous options for addressing these issues, and formulated recommendations.

Use of certified models for all USACE planning activities is mandatory. This policy is applicable to all planning models currently in use by USACE, as well as models under development and new models that may be developed in the future. District Commanders are responsible for providing high quality, objective, defensible, and consistent planning products. Development of these products requires the use of tested and defensible models. National certification of planning models will result in significant efficiencies in the conduct of planning studies and enhance the capability to produce high quality products. The appropriate USACE Planning Center of Expertise (PCX) is responsible for model certification. The goal of certification is to establish that USACE planning products are theoretically sound, compliant with USACE policy, computationally accurate, based on reasonable assumptions, and in compliance with the requirements of the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* (Federal Register Vol. 70, No. 10, January 14 2005, pp 2664-2677). The use of a certified model does not constitute technical review of the planning product. Independent technical review of the selection and application of the model and the input data is still the responsibility of the users. Once a model is certified, the PCXs will work with model developers and managers to ensure that documentation and training in model use are available and that model updates comply with certification requirements.

The primary criterion for model certification is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of theory, the certified model should:

- be based on validated and accepted "state of the art" theory
- incorporate USACE policies and requirements
- properly incorporate the conceptual theory into the software code
- clearly define the assumptions inherent in the model.

In terms of computational correctness, the certified model should:

- employ proper functions and mathematics to estimate functions and processes represented
- properly estimate and forecast the actual parameters it is intended to estimate and forecast.

Other criteria for certification are efficiency, effectiveness, usability, and clarity in presentation of results. A certified model will stand the tests of technical soundness based on theory and computational correctness, efficiency, effectiveness, usability and clarity in presentation of results.

An independent external peer review of the Delta Region of Arkansas Hydrogeomorphic Methodology Guidebook (HGM Guidebook) was conducted for the USACE Ecosystem Restoration Planning Center of Expertise (ECO-PCX) under Contract Number W911NF-07-D-0001, Task Control Number 09-210. The objective of the review was to evaluate the technical quality, system quality, and usability of the HGM Guidebook models in accordance with *Planning Models Improvement Program: Model Certification* (EC 1105-2-407, dated May 31, 2005) and the *Protocols for Certification of Planning Models* (July 2007). USACE's ultimate goal is to certify the HGM models developed for use within the geographic area specified in the HGM Guidebook. The review did not include a technical evaluation of the application of the model on a specific project.

1.1 Model Purpose

The HGM approach is a method for developing functional capacity indices (FCIs) and the protocols used to apply these indices to the assessment of wetland condition at a site-specific scale. The HGM classification was developed specifically to identify groups of wetlands that function similarly using three criteria that fundamentally influence how wetlands function:

- Geomorphic setting--the position of the wetland in the landscape.
- Water source--the primary origin of the water that sustains wetland characteristics, such as precipitation, floodwater, or groundwater.
- Hydrodynamics--the level of energy with which water moves through the wetland, and the direction of water movement.

Based on these three criteria, any number of functional wetland groups can be identified at different spatial or temporal scales. Although the HGM approach is applicable to any wetland, the models included in this HGM Guidebook are specifically applicable to the Delta Region of Arkansas in the Lower Mississippi River Alluvial Valley in the United States.

1.2 Model Assessment

In accordance with the *Planning Models Improvement Program: Model Certification* (USACE, 2005; EC 1105-2-407), certification is required for all planning models developed for and/or used by USACE. The objective of model certification is to ensure that models used by USACE are technically and theoretically sound, computationally accurate, and in compliance with

USACE planning policy. Model assessments are conducted in accordance with the USACE *Protocols for Certification of Planning Models* (USACE, 2007).

Model development is a multi-step, iterative process, with the number of steps and iterations being dependent upon the complexity of the model. In general, the basic steps of the USACE model certification process, designed to guide the model review, occur in four stages.

- Stage 1 (Requirements Stage), identify the need for a specific analytical capability and the options for tools to meet the need.
- Stage 2 (Development Stage), develop software programming code or a spreadsheet and have it tested by the model developer.
- Stage 3 (Model Testing Stage), conduct a beta test of the model by selected users whose objective is to validate the model and ensure that it is usable in real-world applications.
- Stage 4 (Implementation Stage), provide training, user support, maintenance, and continuous evaluation of the model.

The certification procedure depends on the stage of model development. The process may include the following steps.

1. Model reviewers determine whether project needs/objectives are clearly identified and whether the model described is meeting those needs/objectives.
2. Model reviewers evaluate the technical quality of the models (review of model documentation), including whether:
    a. The model is based on well-established contemporary theory.
    b. The model is a realistic representation of the actual system.
    c. Analytical requirements of the model are properly identified and the model addresses and properly incorporates the analytical requirements.
    d. Assumptions are clearly identified, valid, and support the analytical requirements.
    e. USACE policies and procedures related to the model are clearly identified, and the model properly incorporates USACE policies and accepted procedures.
    f. Formulas used in the model are correct and model computations are appropriate and done correctly.
3. Model reviewers evaluate system quality (review by running test data sets or analyzing the results of beta tests) to determine whether:
    a. The rationale for selection of supporting software tool/programming language and hardware platform is adequately described, and supporting software tool/programming language is appropriate for the model.
    b. The supporting software and hardware are readily available.
    c. The programming was done correctly.
    d. The model has been tested and validated, and all critical errors have been corrected.
    e. Data can be readily imported from/into other software analysis tools, if applicable.

4. Model reviewers evaluate the usability of the model to:
    a. Examine the data required by the model and determine the availability of the required data.
    b. Examine how easily model results are understood.
    c. Evaluate how useful the information in the results is for supporting project objectives.
    d. Evaluate the ability to export results into project reports.
    e. Determine whether training is readily available.
    f. Determine whether user documentation is available, user friendly, and complete.
    g. Determine whether adequate technical support is available for the model.
    h. Determine whether the software/hardware platform is available to all or most users.
    i. Determine whether the model is easily accessible.
    j. Determine whether the model is transparent and allows for easy verification of calculations and outputs.

The HGM models are at Stage 3 in the development process. They have already been applied to projects from other areas, and are being assessed for quality and applicability to this area. This review of the HGM Guidebook and spreadsheets focused on the technical quality, system quality, and usability of the FCI models and the approach to their application.

The level of effort for a model review depends on the complexity of the models developed, the risks associated with planning decisions made using the models, and the stage of model development. The HGM models have undergone an Intermediate Level Review, based on the models' intermediate level of complexity relative to other planning models. The Intermediate Level Review included an Independent External Peer Review (IEPR) of the models. Although the technical review of the models has been conducted external to USACE, it is ultimately USACE's decision whether to certify planning models for use on other projects or in other geographic areas.

1.3 Contribution to Planning Effort

The USACE planning regulations require that ecosystem restoration benefits be estimated. Benefit results are included in a Cost-Effective Incremental Cost Analysis (CE/ICA) to determine the best project for implementation. As stated in the HGM Guidebook "The HGM Approach initially was designed to be used in the context of the Clean Water Act, Section 404 Regulatory Program, to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. However, a variety of other potential uses have been identified, including the determination of minimal effects under the Food Security Act, design of wetland restoration projects, and management of wetlands" (page 1).

1.4 Report Organization

The remainder of this report is organized into the following sections:

Section 2.0 Model Description — Describes the applicability of the models for planning projects and summarizes the models' inputs and components.

Section 3.0 Model Evaluation — Describes the criteria used to assess technical quality, system quality, and usability; summarizes the approach to the model review; and describes the results of the model assessment.

Section 4.0 Conclusions — Summarizes the overall recommendations of the model review.

Section 5.0 References — Lists the references used for this model assessment.

Appendix A Biographic Information for Model Review Panel Experts — Contains biographic information on the expert model review panel members selected to perform the review of the model certification assessment criteria.

Appendix B Final Panel Comments — Contains the Final Panel Comments (FPCs) from the model review as well as each comment's basis, significance, and recommendations for resolution.

Appendix C Specific Comments on Spreadsheets — Contains specific comments on the spreadsheets provided as part of the review

Appendix D Additional Suggested Edits — Contains additional suggested edits to the HGM Guidebook provided by the model reviewers

Attachment A Revised Final Work Plan — Contains the Revised Final Work Plan for the Certification of Four Ecological Models: Envirofish, Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, Waterfowl Assessment Methodology, and the Delta Region of Arkansas Hydrogeomorphic Methodology Guidebook, which contains the final charge guidance and questions to the model reviewers to guide the review of the models and model documentation.

2 MODEL DESCRIPTION

2.1 Model Applicability

The HGM Guidebook is a Regional Guidebook developed for assessing the most common types of wetlands that occur in the Delta Region of Arkansas, which is that portion of the alluvial valley of the Mississippi River that lies within Arkansas, bounded on the west by the Ozark and Ouachita Mountains, the Arkansas River Valley, and the West Gulf Coastal Plain, and bounded on the east by the Mississippi River levee. The HGM models in this HGM Guidebook were developed for the Delta Region of Arkansas and are intended for use only on forested wetlands (or sites that could support forested wetlands). The subclasses modeled are Non-Alkali Flat (Flat), Low Gradient Riverine Backwater, Low-Gradiant Overbank, headwater depression, unconnected depression, and connected depression. Models were not included within this HGM

Guidebook for Alkali Flat, Mid-Gradient Riverine, Fringe Class, or Riverine Impounded subclasses.

2.2 Model Summary

Normally, a Regional Guidebook focuses on a single regional wetland subclass (the term for wetland types in HGM terminology). This Regional Guidebook, however, considers multiple regional wetland subclasses. The rationale for this approach is that the Lower Mississippi River and its tributaries have created a complex landscape that supports a variety of interspersed wetland types in the Delta Region of Arkansas specifically and the Lower Mississippi River Alluvial Valley generally. Subtle differences in terrain and water movement result in distinctly different functions being performed by wetlands that are in close proximity to, or contiguous with, one another. Further, massive flood control and drainage works instituted in the twentieth century have dramatically affected nearly all of the wetlands in the Lower Mississippi River Alluvial Valley. Because these wetland systems have closely related origins and have been universally influenced by flood protection and drainage efforts, it is most sensible to deal with their classification and assessment in a single integrated Regional Guidebook. This does not mean that wetlands of different hydrogeomorphic classes and regional wetland subclasses are lumped for assessment purposes, but rather that the factors influencing their functions and the indicators employed in their evaluation are best developed and presented in a unified manner. Therefore, this Regional Guidebook was developed for multiple regional wetland subclasses that commonly occur together in a subbasin. It is expected that the classification of regional wetland subclasses, assessment variables, and the assessment models developed for the Delta Region of Arkansas will have general applicability in other subbasins of the Lower Mississippi River Alluvial Valley. The objectives of the HGM Guidebook are:

- Characterize selected regional wetland subclasses in the Delta Region of Arkansas within the Lower Mississippi River Alluvial Valley,
- Present the rationale used to select functions to be assessed in these regional subclasses,
- Present the rationale used to select assessment variables and metrics,
- Present the rationale used to develop assessment models, and
- Describe the protocols for applying the functional indices to the assessment of wetland functions.

2.3 Model Components

The HGM approach consists of four components:

- HGM classification
- Reference wetlands
- Assessment variables and assessment models from which functional indices are derived
- Assessment protocols.

The HGM classification and reference wetlands components are determined during the development phase in which an interdisciplinary Assessment Team (A-Team) of experts develop and integrate the classification, reference wetland information, assessment variables, models, and protocols of the HGM approach into a Regional Guidebook. During a second phase, the

Application Phase, the assessment variables, models, and protocols are used to assess wetland functions. The Application Phase involves two steps. The first is to apply the assessment protocols outlined in the Regional HGM Guidebook to complete the following tasks:

- Define assessment objectives
- Characterize the project site
- Screen for red flags[1]
- Define the Wetland Assessment Area
- Collect field data
- Analyze field data.

The second step involves applying the results of the assessment at various decision-making points in the planning or permit review sequence, such as alternatives analysis, impact minimization, assessment of unavoidable impacts, determination of compensatory mitigation, design and monitoring of mitigation, comparison of wetland management alternatives or results, determination of restoration potential, or identification of acquisition or mitigation sites.

In the HGM approach, an assessment model is a simple representation of a function performed by a wetland ecosystem. The assessment model defines the relationship between the characteristics and processes of the wetland ecosystem and the surrounding landscape that influence the functional capacity of a wetland ecosystem. Characteristics and processes are represented in the model by assessment variables. Functional capacity is the ability of a wetland to perform a specific function relative to the ability of reference standard wetlands to perform the same function based on the wetland's condition. Application of assessment models results in a Functional Capacity Index (FCI) ranging from 0.0 to 1.0. Wetlands with an FCI of 1.0 perform the assessed function at a level that is characteristic of reference standard wetlands. A lower FCI indicates that the wetland is performing a function at a level below the level that is characteristic of reference standard wetlands.

The wetland functions that can be assessed using this HGM approach were identified by participants in a workshop held in Arkansas in 1997. That group selected hydrologic, biogeochemical, and habitat functions that are important and measurable in Arkansas wetlands from a suite of potential functions identified in *A Guidebook for Application of Hydrogeomorphic Assessments to Riverine Wetlands* (Brinson et al., 1995). This regional HGM Guidebook, based on the workshop recommendations, provides models and reference data required to determine the extent to which forested wetlands of the Arkansas Delta perform the following functions:

- Detain Floodwater
- Detain Precipitation
- Cycle Nutrients
- Export Organic Carbon

[1] "Red flags are features in the vicinity of the project area to which special recognition or protection has been assigned on the basis of objective criteria" (HGM Guidebook, page 108). For example, areas supporting endangered species.

- Maintain Plant Communities
- Provide Habitat for Fish and Wildlife.

3 MODEL EVALUATION

USACE requires that planning models be reviewed and certified. The purpose of the review is to evaluate the technical quality, system quality, and usability of the planning models. The results of the model review will be used by USACE to determine whether to certify the model for inclusion in the toolbox of USACE planning models. The ECO-PCX conducted an Intermediate Level review of these regional models based on their anticipated wide use for wetland projects in the Lower Mississippi River Alluvial Valley. As a 501(c)(3) nonprofit science and technology organization with experience in establishing and administering external peer review panels for USACE, Battelle was engaged to conduct the model certification review for the HGM Guidebook models.

3.1 Model Review Approach

Independent, objective peer review is regarded as a critical element in ensuring technical quality, system quality, and usability of the models. Details of the review process and charge guidance are provided in the Final Charge for the Model Certification Review for the HGM Guidebook Models (see as part of Attachment A). The review consisted of eight tasks:

Task 1 – Kick-off Meeting
Task 2 – Work Plan
Task 3 – Prepare and Finalize Charge to Reviewers
Task 4 – Identify Candidate Reviewers
Task 5 – Conduct Assessment of Model
Task 6 – Prepare Draft Certification Report
Task 7 – Meeting to Discuss Findings
Task 8 – Prepare Final Certification Report.

Battelle participated in a kick-off teleconference meeting with representatives from the USACE ECO-PCX and the Model Proponents (Task 1). The purpose of the meeting was for USACE to brief Battelle on USACE's specific goals and objectives for the model review and for Battelle to present to USACE its approach to conducting the model review. Battelle prepared a work plan, which included charge questions and guidance to the model review panel, based on the goals and objectives discussed and the USACE Statement of Work (SOW) (Tasks 2 and 3).

Battelle initially identified 32 candidates for model review panel positions, evaluated their technical expertise, and inquired about potential conflicts of interest (COI). Of those contacted initially, Battelle chose seven of the most qualified candidates based on background, years of experience, and lack of actual or perceived COI (Task 4) and confirmed their interest and availability. Of those seven candidates, four were proposed for the final model review panel and three as backup model reviewers. These experts were approved by the USACE ECO-PCX (Task 4). The four proposed primary model reviewers constituted the final panel. The remaining candidates were not proposed as model review panel members for a variety of reasons including lack of availability, disclosed COI, or because they did not possess the precise technical expertise required.

The model review panel included:

- A Civil Works Planner/HGM expert with experience in floodplain management including ecosystem restoration, impact analysis, compensatory mitigation, knowledge of Lower Mississippi River Valley ecosystems, and the use of the HGM approach.
- A wetland ecology expert with experience in the wetland ecology of large floodplain rivers, including experience in southern bottomland wetlands and familiarity with ecosystem output evaluation, particularly the HGM approach.
- A forestry expert with experience in riverine forest ecology and bottomland hardwood community structure and dynamics within the Lower Mississippi River Valley, and familiarity with ecosystem output evaluation, particularly the HGM approach.
- A programmer/spreadsheet audit expert with experience testing, debugging, and auditing computer programs/spreadsheets to check for accuracy of formulas, cell references, and computer code.

Information on the experts selected for the model review panel is summarized in Table 1, and a short biography for each panel member is provided in Appendix A.

Table 1. Experts Selected for the HGM Guidebook Model Review Panel

Name	Affiliation	Location	Education	Exp (yr)
Civil Works Planner/HGM Specialist				
Richard Rheinhardt	Independent consultant	Pocasset, MA	Ph.D. in marine science/ biological oceanography	15
Wetland Ecologist				
Paul Keddy	Independent consultant	Carleton Place, Ontario, Canada	Ph.D. plant ecology	35
Forester				
James Shepard	Mississippi State University	Mississippi State University, MS	Ph.D. in forest soils	34
Programmer/Spreadsheet Auditor				
Stephen Powell	Tuck School of Business, Dartmouth College	Hanover, NH	Ph.D. in engineering-economic systems	15

After the model reviewers were under subcontract, Battelle conducted a kick-off teleconference to brief the model review panel on the purpose and approach for the review process. Another kick-off teleconference was convened with Battelle, the model reviewers, ECO-PCX, and the model developers to provide the model reviewers an opportunity to be briefed specifically on the models and to ask questions directly of USACE. The model reviewers received electronic versions of the review documents, along with guidance and a charge that solicited their comments on specific aspects of the documents that were to be reviewed.

The following documents and reference materials (*file names are provided in italics*) were provided to the model reviewers for the review (most of the documents contained HGM Guidebook and Methodology information):

- A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley (*Draft Revision_AR_Delta_HGM_6-8-09.pdf)*
- *Delta_FCI_Calculators_6-17-09.xls* (containing six worksheets)
- *Appendix D_trel04-16-spreadsheet.zip* (containing three files *ArkansasBasalAreaCondensed12_2001.xls; ArkansasWoodyDebrisFinal12_2001.xls; DeltaFCICalculators12_2003.xls*)
- *AppendixE_trel04-16-spatial.zip* (containing six shape files [.dbf, .prj, .sbn, .sbx, .shp, .shx]for the following items – AR_Roads_27; CitiesandTowns_27_delta; DeltaCounties_27; DeltaHydrology_27; DeltaRoads_27; DeltaStatsgosoils; Final_WPA&WPR; Saucier_Nad_27_AR_only).

Model reviewers were asked to review the documentation for the HGM models and supporting worksheets. They also received the following additional documents, for reference only and not for review:

- Protocols for Certification of Planning Models (http://www.usace.army.mil/CECW/PlanningCOP/Pages/models.aspx)
- EC 1105-2-407, Planning Models Improvement Program: Model Certification (http://www.usace.army.mil/CECW/PlanningCOP/Pages/models.aspx).

The model reviewers were asked to review the models and their documentation using guidance and charge questions provided to them. There was no communication between the model review panel and the model developers during the peer review process. The guidance and charge questions are based on the model certification criteria discussed in USACE *Protocols for Certification of Planning Models* (July 2007). The intent of these questions was to focus the review on the assessment criteria that are critical for the certification of planning models. The process and evaluation criteria for the review are outlined in the *Protocols for Certification of Planning Models* (USACE, 2007) and described in Section 1.2, Model Assessment, of this report.

Thirty-four charge questions developed by Battelle and approved by USACE were provided to the model review panel in Individual Charge Response Forms to be used by the model reviewers. Following the panel members' individual reviews of the HGM Guidebook and spreadsheets, the Individual Charge Response Forms were compiled into a Merged Charge Response Form that contained all of the model review comments. Approximately 100 individual comments were received.

A teleconference between Battelle and the model reviewers was conducted to discuss key technical comments and conflicting opinions identified from the Merged Charge Response Form and to reach agreement on the key findings of the review to be provided to USACE in the Model Certification Review Report. By the end of the teleconference, the participants had formulated 22 Final Panel Comments (FPCs) that identify and discuss the key concerns with the models and model documents found during the review and present recommendations for their resolution. The model reviewers were also assigned the responsibility of drafting specific sections of the Draft Model Certification Review Report. The results and conclusions of the model review are discussed in Sections 3.4 through 4.0 of this draft report. All the FPCs are presented in Appendix B.

Battelle and the model reviewers will meet via teleconference with representatives of the Corps of Engineers Directorate of Civil Works (CECW), representatives of the ECO-PCX, and Model Proponents to discuss the Draft Report for Model Certification Review on February 16, 2010 9:00 am EDT. Suggested revisions will be incorporated into the report within five days of the teleconference, after which Battelle will provide USACE with the Final Report on February 23, 2010.

3.2 Assessment Criteria

In accordance with the *Planning Models Improvement Program: Model Certification* (EC 1105-2-407, May 2005), the Delta Region of Arkansas HGM Guidebook and models were subjected to an independent external peer review. Based on guidance in the USACE *Protocols for Certification of Planning Models* (July 2007). The models were reviewed and assessed for technical quality, system quality, and usability. These three criteria are described in the following sections.

3.2.1 Technical Quality

Analytical tools used for planning purposes, including models, need to be technically sound and based on widely accepted contemporary scientific theory. The study area, and how it responds to the influences that act upon it, must be realistically represented by the components of the models. The architecture of the model calculations must reflect how the system is expected to respond to changes in measured variables based on the application of scientific theory. Formulas and calculation routines that form the mechanics of the models must be accurate and correctly applied, with sound relationships among variables. The models should be able to reflect natural changes as well as the influence of anthropogenic laws, policies, and practices. All model assumptions must be valid and should be well-documented. The analytical requirements of the models must be identified, and the model must address these requirements. The models should also produce robust, reproducible results that stand up to rigorous scrutiny in later stages of the plan formulation process.

3.2.2 System Quality

System quality refers to the quality of the entire system used to develop, use, and support the models, including the software and hardware platform. System quality is assessed by testing the hardware and software components, design verification planning for customer acceptance, third party interoperability, compatibility with various hardware and operating systems such as USB, Windows, and MacIntosh, and the development of problem-tracking database. Most of this is done through USACE internal review and tracking. However, some criteria can be evaluated by external model reviewers. In general, peer review evaluation of system quality can include assessing whether supporting software tools/programming language are appropriate for the models, programming is done correctly, software and hardware are available, the models have been tested and validated, and data can be readily imported into other software analysis tools (if applicable).

In this case, the model reviewers were not asked to assess software for the models because the models are spreadsheet based. Therefore, the model reviewers were provided with spreadsheets containing each of the HGM FCI models. The review of the spreadsheets included model testing and validation.

3.2.3 Usability

Usability refers to how easily model users can access and run the models, interpret the model output, and use the model output to support planning decisions. An assessment of model usability includes evaluating the availability of data required to run the models and the ability of the user to learn how to use the model properly and effectively. Model outputs must also be easy to interpret, useful for supporting the purpose of the models, easy to export to project reports, and sufficiently transparent to allow for easy verification of calculations and outputs.

3.3 Approach to Model Testing

USACE did not provide the model reviewers with example data for which to test the HGM models for accuracy; therefore, testing was not conducted as part of this model review. The model reviewers' assessment included only a review of the information available in the model documentation and associated spreadsheets.

3.4 Technical Quality Assessment

The reviewers assessed the technical quality of the models against the criteria described in Section 1.2, and based on a review of the HGM Guidebook (September 2004) and spreadsheets provided by USACE. Without knowing all of the relevant USACE policies and procedures, the model reviewers were unable to determine whether the models properly incorporate USACE policies and procedures. The results of the model reviewers' assessment of the other criteria are summarized in the following sections.

3.4.1 Review of Theory

The HGM Guidebook incorporates standard scientific knowledge about patterns and processes in alluvial wetlands. The 21 input variables for the FCI models measure a wide array of physical, biological, and structural attributes that are generally accepted as indicators of wetland condition.

The six FCI equations transform these indicators of condition into estimates of function. There is a clear rationale provided for the selection and weighting of variables, but the structure of the equations themselves needs more theoretical justification. The relationship between condition and function is still an area of research with emerging theory, but the variables and equations in the guidebook appear to represent current expert opinion. Other theoretical approaches to measuring ecosystem services exist. The HGM Guidebook should explain why these other approaches are less desirable and how the HGM approach compares to them.

Each measured variable is indexed by wetland subclass relative to the value attained by the least-altered wetlands of the subclass. The individual indices are then aggregated into a mathematical form (FCI equations) that represent the capacity of a wetland to provide ecological functions at a level relative to the least altered wetlands of the subclass. The theoretical justification for selecting and aggregating variables into models is based on expert opinion, founded on current scientific understanding of functional processes. The FCI equations represent coarse, logic-based models of relationships that have not yet been empirically validated (i.e., the theory has not been tested for accuracy).

3.4.2 Review of Representation of the System

The general purpose of any ecological model or theory is to represent one or more selected aspects of an ecological system, and to make predictions about future states of the system. All modeling requires simplification, and the challenge of simplifying while retaining important properties is one of the real challenges of modeling (Starfield and Bleloch, 1991).

For the HGM Guidebook, it was difficult for the reviewers to assess whether the model represents actual Arkansas Delta wetland ecosystems because data were not presented for the reference wetlands. The guidebook states, "Each subclass was the focus of detailed sampling during development of this HGM Guidebook, and the reference data collected for each subclass have been independently summarized for application" (Chapter 5, page 74). However, the documentation does not provide sufficient information to enable the end user to understand how field data were calibrated to produce the subindex graphs that are in turn used to calculate subindex scores when applying the protocol. Without seeing the agreement between the actual data and the subindex curves, the model reviewers could not determine whether the model represents the wetland ecosystems being modeled

The purported strength of the HGM approach is that the use of reference data provides a transparent framework for assessing functions. Lack of user access to the raw data, or a raw data summary, and the procedures used to calibrate the subindex curves inhibits transparency and reduces the user's confidence in assessment results. For a more thorough review of representation of the system being modeled, the model reviewers would need to see the data from reference wetlands relating measurements of wetland functions to the measurements of the variables that comprise the FCI curves. Therefore, an appendix with information about reference sites, the field data collected in the reference sites and an explanation of how field data were used to calibrate subindex graphs would provide the transparency necessary for users to have confidence in the assessment method (see FPC #2).

In the *Guidebook for Developing Regional Guidebooks,* Smith and Wakeley (2001) said, "The final step in functional definition is to identify an independent measure of each function, along with appropriate quantitative units. ...[I]dentification of an independent, quantitative measure of function is mandatory if assessment models are to be amenable to testing and validation and accepted by the scientific and regulatory communities. Assessment models are validated by comparing their output (i.e., the FCI) against the independent measure of function (e.g., a direct count of breeding bird species, or a direct measure of sediment accretion)." However, this process was not reported in the HGM Guidebook (see FPC #2 for additional information). Therefore, the documentation does not provide sufficient information to enable the end user to understand how field data were calibrated to produce the subindex graphs that are in turn used to calculate subindex scores when applying the protocol. The purported strength of the HGM approach is that the use of reference data provides a transparent framework for assessing functions. Lack of user access to the raw data, or a raw data summary, and the procedures used to calibrate the subindex curves inhibits transparency and reduces the user's confidence in assessment results. An appendix with information about reference sites, the field data collected in the reference sites and an explanation of how field data were used to calibrate subindex graphs would provide the transparency necessary for users to have confidence in the assessment method (see FPC #2).

There is still uncertainty about the relationship between condition and function that requires further testing (see FPC #1). Cole (2006) noted that models which rely on structural variables may not relate to actual wetland function. Likewise, Stein et al. (2009) observed that the "determination of function requires repeated measurements that quantify rates of processes over time," and so rapid assessment approaches like HGM are designed only to "measure a combination of physical and biological structural attributes at a moment in time, providing a snapshot of the status of a wetland that is used to infer the degree, or functional capacity, to which functions are being performed." Fennessy et al. (2007) stated, "The relationship between the rapid method and comprehensive data must be established so that the rapid method, with careful sampling design, can be used to extrapolate the more detailed results to the resource base as a whole (i.e., through probability based sample design). It will also allow confidence limits on the use of a rapid assessment to be determined, increasing the reliability and defensibility of the method." Hill et al. (2006) observed that "…most regional HGM Guidebooks include functional assessment models that have not been subjected to even the crudest levels of testing and validation." According to Hoeltje and Cole (2009), "The most important limitation is that HGM does not actually measure function."

Since the HGM models may be used to implement federal policy on water resources and wetland protection, the model reviewers need to see how FCI curves were developed and how well the models fit the data used in model construction. This could be included in an appendix to the HGM Guidebook. A particular issue that concerned model reviewers is the treatment of flood frequency (V_{FREQ}) and flood duration (V_{DUR}) (see FPC#3). These are two key drivers that control wetlands, of which neither is directly measured. If measures of flooding are not incorporated, then the most important driver in the system is missing. Failure to capture the nature of changes in flooding frequency and duration may result in an inability to effectively capture changes in wetland condition, which is the focus of the approach. Extreme events on a fifty-year cycle (typical life of USACE projects) are important for many wetlands. It is the wettest and driest extremes which determine many of the conditions. Therefore, deviation from reference standard conditions (which should represent natural variations in extremes) should be the basis for calibrating a flooding variable.

Furthermore, flood frequency subindices are based on mid-20th century condition (after "major river engineering projects") and is assumed to be unaltered (V_{FREQ}= 1.0) unless flood frequency has been *recently* modified or a change to flood frequency is proposed. The implication of using mid-20th century conditions as baseline is that the approach will not be applicable for restoring hydrologic regime to conditions in existence before wide scale river engineering projects, should that be proposed. Furthermore, the composition of bottomland forests established before mid-20th century cannot be used as a reference standard condition because they developed under a flood regime that was explicitly eliminated from consideration as reference standard. The decision for choosing reference standard for flood frequency as mid-20th century condition is practical, but the effects on other reference standards (e.g., tree composition) and the implications for restoration should be clearly articulated in the guidebook.

3.4.3 Review of Analytical Requirements

For a model to provide reliable information to its user, four attributes of the model must be fully communicated: precision, accuracy, sensitivity, and degree of uncertainty. Precision (degree of repeatability) can only be determined by having more than one field team measure the same field variables in the same location and compare the similarity of their results. It is unclear whether this comparison was conducted, as it is not reported in the documentation (see FPC #6 for additional information).

Potential lack of precision in the HGM approach is likely associated with measuring or estimating litter cover (V_{LITTER}), tree composition based on cover estimates (V_{TCOMP}), percent of floodplain ponded (V_{POND}), composition of the tallest stratum (V_{COMP}), composition of the canopy tree stratum (V_{COMP}), woody debris volume (V_{WD}), snag density (V_{SNAG}), and down log volume (V_{LOG}). These variables either vary spatially or are difficult to measure using the methods provided. The model reviewers suggested the following recommendations:

- Consider using indicators of channelization (e.g., intensity of channelization: depth of channel, height of levees) in the Detain Floodwater FCI.
- Incorporate a flooding duration variable (e.g., based on regional curves, unless affected by backwater flooding) as a potential model subindex for the Detain Floodwater function.
- Estimate alterations to depressional storage using cover categories.
- Consider eliminating the variable V_{LITTER}, and using V_{TBA} in its place.
- Consider using V_{TBA} of trees greater than some threshold size that represents canopy individuals (e.g., >15 cm dbh) as a variable in the Provide Habitat for Fish and Wildlife FCI.
- If the first recommendation is adopted, consider eliminating the use of V_{STRATA}, V_{SNAG}, V_{LOG}, and V_{OHOR} in the Provide Habitat for Fish and Wildlife FCI equation.
- Consider using more objective methods to measure V_{TCOMP}, V_{COMP}, and V_{TBA}.

- Reduce the relative weights of or eliminate the variables V_{LITTER}, V_{SNAG}, V_{LOG}, and V_{WD} (which tend to vary widely in space and/or time), thereby reducing their relative effect on the models that incorporate them.

More precise methods for measuring some of these variables (e.g., V_{TCOMP}) and the elimination of others were recommended in FPCs #11, 13, and 15. Also, a few additional variables were suggested that would increase robustness of the FCI models and understanding by end-users (see FPC #10).

Accuracy reflects how closely the model's output matches what it is purported to measure. These models do not appear to reflect true functional capacity, a fact that should be clearly articulated in the documentation along with providing reasons why the models are not meant to be predictive (see FPC#5 for additional information).

Sensitivity measures the degree to which a change in inputs (subindices) or assessment measures affect a change in output (FCI). For example, the FCI for the Detain Floodwater function changes as one of the input variables (e.g., V_{SSD}) changes from zero to 1.0. In functions that have many variables, one variable has little influence on the FCI score, so although it would not tend to be very sensitive, it could dilute the effect of more explanatory variables by reducing their sensitivity depending on how they are weighted. This problem could be particularly problematic in complex functions with many variables (e.g., the Provide Habitat for Fish and Wildlife function with 10 variables).

Although many of the input variables likely co-vary, a sensitivity analysis would determine how any given variable affects the FCI score and whether the variable is weighted correctly. Based on the current documentation, the user has no idea how sensitive the various variables are and therefore cannot assess the reliability of the models. A sensitivity analysis should be conducted, if it has not been already, and the results provided in an appendix (see FPC #6 for additional information).

Uncertainty in a model partly reflects the uncertainty of its inputs. If the level of uncertainty is known for a variable, then its effect on an FCI can be quantified. Uncertainty could arise from degree of precision in measuring the variable or degree to which the variation in a variable is related to a change in condition (how predictive it is). In either case, the user should know that a certain FCI can only be interpreted to within $\pm$ 10%, for example, due to uncertainty in its inputs. An estimate of uncertainty for each variable and model should be provided. Information regarding the uncertainty associated with model inputs is critical for understanding the accuracy of model outputs and how much of a change in the FCIs is meaningful.

3.4.4 Review of Model Assumptions

The review of assumptions is complicated by the scale of the Regional Guidebook – it is a package of models with five components, and each with its own set of assumptions:

- Wetland classification
- Assessment models
- Assessment variables/Subindices

- Subindex graphs
- Reference data.

1. Wetland Classification.

Wetland classification by hydrogeomorphic criteria is the underpinning of the hydrogeomorphic (HGM) approach to wetland assessment, in that wetlands in similar landscape position with similar sources and fates of water are similar to one another from a functional perspective (Brinson, 1993). Although variation is likely continuous, the assumption that the landscape can be divided into wetland types based on hydrogeomorphic similarities is reasonable and has been accepted by the scientific community. Further, the assumption that classification by hydrogeomorphic similarities can reduce the amount of variation that has to be accounted for in assessment models has been generally accepted by the scientific community as well.

The principal factors for predicting wetland composition and function would normally be independent variables such as flooding and fertility. The HGM approach assumes that many of these are incorporated into the model without direct measurement by using the habitat classification (Smith et al., 1995). This assumption is generally justified, since each habitat type in the HGM Guidebook has its own characteristic flood regime and water chemistry.

The wetland classification scheme provided in this guidebook reasonably represents the variation that is required, and the illustrations of wetland subclasses are helpful and clearly describe this region of Arkansas. However, for the Unconnected Alluvial Depression subclass, the classification is inconsistent with the stated definition (page 9) that reference standard wetlands represent "the least altered wetland sites in the least altered landscapes." The inconsistency is due to the fact that some unconnected alluvial depressions are really disconnected (altered) Floodplain Depressions (page 52). To be consistent with the definition of reference standard wetlands, the former floodplain depressions that were now reclassified as unconnected alluvial depressions should be treated as hydrologically altered (disconnected) floodplain depressions because they were artificially disconnected from the overbank flooding that once controlled them. Making an exception to the definition of reference standard for former floodplain depressions is likely to lead to unanticipated repercussions, discussed in detail in FPC #8, Appendix B.

2. Assessment Models

Normally the assumptions of a model are tested by exploring its sensitivity to changes in input, and by applying it to a number of situations and looking for instances of failure (i.e., where the model predicts an outcome that is known to be wrong). The model reviewers noted that the FCI equations do not appear to have been tested or validated in such a way. The guidebook assumes there is a good relationship between FCIs predicted from wetland condition data and actual wetland functions. This assumption was not tested by analyzing the relationship between actual measurements of wetland functions and FCIs (see FPC #5 for more information).

Six assessment models (FCI models) are the foundation of the document. Although the model equations seem complex, in most cases the equations use arithmetic or geometric means of assessment sub-indices to obtain FCI scores. In general, the rationale for each equation is clearly stated, but the rationale for the specific mathematical form chosen for the functions is not. The assumptions applied for the development of mathematical relationships between model variables needs to be provided.

3. Assessment Variables/Subindices

There are 21 variables used as input data for the FCI models. The key assumption is that these measurements adequately capture the condition of a site and that such measurements of condition are appropriate for being transformed into measures of function. The model reviewers agreed that the measurements in the guidebook are typical of those used in wetland ecology but had suggestions for better measurement of several variables that might better capture the condition of the site in relation to function (e.g., FPC's #11 and #12).

Two of the most important variables, V_{FREQ} and V_{DUR}, stood out because of the overwhelming importance of flooding in determining wetland structure and function. The guidebook assumes that these two key ecological drivers can be assessed indirectly from conditions in reference wetlands rather than by using actual measurements of flood regimes. It is also assumed that the complexity of flood regimes can be captured on a scale of zero to one. This assumption may limit the predictive capacity of the model for projects where natural flood regimes are being restored because, as previously mentioned in 3.4.2, reference conditions represent conditions for wetlands that have been altered by flood risk management projects, and restoration may not be assessed as an improvement.

4. Subindex Graphs and 5. Reference Data

The HGM Guidebook provides a large number of subindex graphs that describe the relationships between the measured field variables (horizontal axis) and the variable subindices. There are a large number of these relationships and they differ among wetland types. The HGM Guidebook did not document the reference site conditions nor explain how raw field data were used to calibrate the derived subindices (FPC #2). The model reviewers had to assume that the field data were appropriately collected, the analyses were appropriately made, and therefore that the subindex curves are valid.

One important assumption in the HGM Guidebook is that current forest composition reflects present and ongoing flood regimes. Dams and levees have already heavily modified flow patterns of the Mississippi River and its major tributaries, in particular, and the world's wetlands in general (Dynesius and Nilsson, 1994; Middleton, 2002). Ecosystems, particularly those with long-lived organisms such as trees, may be derived from past events such as extreme historic floods or fires (Botkin, 1990; Brown and Kennett, 1999). The HGM Guidebook assumes that the water level regime of the mid-20th century is the baseline condition, and that any deviations away from this will reduce function. Projects that attempt to restore, at least partially, the original water level fluctuations to pre-levee construction conditions, which might eventually increase certain functions like "Provide Habitat for Fish and Wildlife," would automatically be assumed negative when the HGM is applied. This could also lead to underestimation of the current negative effects of levees and dams overall, and the potential functional benefits from removing dams and levees.

3.4.5 Review Ability to Evaluate Risk and Uncertainty

Risk and uncertainty cannot be directly evaluated by the models in their current form. The purpose of the model is to provide one index of the condition and function of wetlands. There are no confidence intervals on the resulting values (e.g., FPC #6). Small differences in indices between projects may not be biologically meaningful, but may yield large differences when multiplied by large acreages. Therefore, there is a risk that two projects might appear to have different impacts on function, when in fact the differences are not statistically significant.

In principle, if the FCI values are calculated for a before-and-after condition, it should allow assessment of the risk of negative consequences from projects. Similarly, if the FCI values are calculated for a series of competing projects, they should also identify which has the lowest risk of damaging wetland function. Such decisions, however, are dependent on how sensitive the FCI equations are to different kinds of ecological perturbations.

To further explore the issue of risk and uncertainty, it would be necessary to document the performance of the FCI output under different kinds of perturbations or with different sets of field data. For example, a plot of FCI scores against proportion of watershed that was forested or the proportion of spring flood pulse removed would allow users to judge the sensitivity of the indices to potential perturbations.

From one perspective, the calculation of an index between zero and one gives the impression of being cardinal numbers (quantity). However, the model's coarse nature suggests that a small number of ordinal labels should be used, such as low, medium, or high functional capacity (i.e., condition). Having the model output a number from 0 to 1 gives a false impression of the model's resolution. Although the FCI equations give the appearance of producing quantitative estimates of functional capacity, they may only being giving information that is qualitative.

One way the HGM approach does incorporate risk is the use of red flags, as described on page 108. This is a procedure for identifying potential impacts that might not be detected by the FCIs. In some cases FCI values may not be appropriate since, as the report notes, "… if a proposed project has the potential to adversely affect threatened or endangered species, an assessment may be unnecessary since the project may be denied or modified based on the impacts to the protected species alone."

3.4.6 Review Ability to Calculate Benefits for Total Project Life

Functional assessments were designed to be conducted on a wide variety of "projects" to determine pre- and post-construction condition or changes in functional capacity through time in restoration projects. A project life could be short, as when a wetland is converted to a use that has no wetland functions (wetland to a highway), or long, as when changes in functional capacity are to be determined over a 75-year life of a mitigation bank. In the first example, pre-project FCIs are compared with post-project FCIs (either actually measured or predicted prior to construction), and loss of wetland functions (determined as FCIs) could be assumed to last forever. In the second example (a restoration scenario), FCIs are measured at periodic intervals over time or predicted using the projected recovery trajectories provided in Figure 32 of the HGM Guidebook (page 133), providing the user with a measure of change (presumably an increase) in FCIs over time.

Theoretically, an HGM functional assessment approach should be able to evaluate or predict both losses of functional capacity (project-induced degradation) and increases in functional capacity (following restoration). The protocol therefore measures current condition, a change in condition, or a predicted change in condition. However, the utility of this assessment depends on its ability to provide repeatable results for subindex scores and the ability of the models to accurately approximate condition relative to the identified functions. If project benefits are defined as the change in the functional capacity of a wetland over time due to a project, then the approach has the ability to provide output that can be used to calculate benefits for total project life.

However, the accuracy of calculated benefits depends on the precision of the methods used to measure variables, the accuracy of models used to calculate FCI, the sensitivity of variables and models as an integrated whole, and the level of uncertainly is related to precision and accuracy. Given the concern that the HGM Guidebook lacks this information for present conditions, estimates of project lifetime benefits are even more problematic. Suggestions for improving the utility of the models and usefulness of results to end users include discussing that the FCIs are measures of wetland condition rather than function (FPC #1); improving how several subindex variables, including those for flood duration and flood frequency, are used or measured for the models (FPCs # 3, 10, 11, 12, 13); improving how field measurements are performed (FPC #15); validating FCIs against actual wetland function for relevant subclasses (FPC #5); not including wetlands that have been anthropogenically cut off in the calculations for the Unconnected Alluvial Depression FCI; and including former wetlands in the reference data set for model calibrations (FPC #9). These issues and recommendations are discussed in more detail in the FPCs in Appendix B.

3.4.7 Review of Model Calculations/Formulas

Field measurements or remote data are converted to subindices in order to normalize extremely different types of data and make them comparable. The derived subindices are then used in the function models (FCI equations) provided for each wetland subclass. All conversions from variable to subindex to FCIs could be done by hand, with a calculator, or with a spreadsheet program. Unfortunately, the spreadsheets and data sheets may confuse the end user because they are unnecessarily complex and filled with internal errors. The current mixed paper-spreadsheet procedure has a number of shortcomings, including:

- Inconsistencies in variable names, field names, units of measure, and spreadsheet layouts
- Inconsistencies between paper forms and spreadsheets
- Limitations in model and user documentation in the spreadsheets
- Unnecessarily complex linkages between spreadsheets, and more spreadsheets than necessary
- The inclusion of hand calculations
- Incorrect references to data forms

- Missing formulas
- Duplicate output cells
- Parameters used inside formulas
- Unexplained conversions from metric to English units
- Unnecessarily complex IF statements
- Lack of data validation and error controls (see FPC #7 and Appendix C).

Another problem related to transparency of the model calculations and formulas is the lack of sufficient explanations concerning why variables were weighted as they were in the functional capacity models and why the particular mathematical forms of the models were chosen (averaging, multiplication, square roots). Explanations were provided concerning why identified variables were mathematically grouped in the models. However, the model reviewers thought it would be useful to provide the end user with an explanation for how the mathematical relationships were defined, as this is directly related to the sensitivity and level of uncertainty associated with the model outputs.

3.5 System Quality

3.5.1 Review of Supporting Software

The procedure that is currently used to transform field data into outputs (FCIs and Functional Capacity Units [FCUs]) is largely based on paper forms with limited spreadsheet support. No reason is given in the report for this approach, or why a more integrated spreadsheet approach has not been developed. The current system may be adequate, but it is far from ideal. As noted in 3.4.7, the current mixed paper-spreadsheet procedure has a number of shortcomings. For instance instead of using Excel to conduct some of the calculations, the user is expected to do them by hand then enter them into the spreadsheet. Complex, error-prone procedures, such as this one, could lead to erroneous outputs and thereby decrease confidence in planning decisions made based on the outputs. In addition, it requires far more time than is needed and allows no facility for sensitivity analysis of the results. The model reviewers recommend that an integrated spreadsheet template be developed for this application (see FPC#7 and Appendix C for more information).

3.5.2 Review of Programming Accuracy

During the review of the three spreadsheets provided, the model reviewers identified places where errors could arise due to inconsistencies in naming conventions between the forms and the spreadsheets, places where the user performs calculations or transfer of numbers by hand which can be prone to errors, conversions between metric and English units, etc. However, the more significant problem with the approach taken is not the accuracy of the programming, but rather that most of the procedure is not programmed at all. As noted in 3.5.1, the model reviewers suggest that this process be automated to increase accuracy. See Appendix C for more details on specific problems with the paper forms and current spreadsheets.

3.5.3 Review of Model Testing and Validation

The discussion of each FCI includes a justification of why the relevant function is appropriate to an overall assessment, but does not include evidence that the FCIs accurately measure the *actual* function in the field. The user of the HGM Guidebook may assume that the FCI measures of function have been validated in the field and thus can be taken as accurate estimates of actual function. However, there was no evidence in the HGM Guidebook that the procedure for transforming field data into tables of FCIs and FCUs was either verified or validated (see FPC#5). Verification of the logic of the procedure would require providing a test dataset that produced correct outputs. Validation would require showing that the outputs of the model correspond to actual values in the field with sufficient accuracy.

3.6 Usability

3.6.1 Review of Data Availability

Data are required for different phases of an assessment, including the pre-project assessment, field data collection from the project wetlands, and assessment of post-project conditions. The pre-project assessment and field data are well-described.

The methods for measuring the model variables and for converting field measurements or remote data to subindices using subindex graphs (Figure 21 in the HGM Guidebook) are explained in detail in the HGM Guidebook. Anyone familiar with making basic ecological field measurements should be able to conduct the field assessments with a little field training, and technical requirements are not beyond those currently possessed by field personnel conducting wetland delineations.

The HGM Guidebook provides a good description of data needed to characterize a project area on page 106. A useful addition may be to identify the data sources and perhaps URLs to their locations, although the latter could change after the HGM Guidebook has been published. A table such as the example provided below (Table 2) could be included. Data for the models are already readily available; however, providing this information would improve their availability.

Table 2. Example of Data Sources and URLs That Could Be Included in the HGM Guidebook

Data Required	Data Source	URL
Aerial Photography	ArcGIS Explorer (ESRI) Google Earth TerraServer USDA Farm Services Agency USGS National Aerial Photography Program	http://www.esri.com/software/arcgis/explorer/index.html http://earth.google.com/ http://terraserver-usa.com/ http://www.fsa.usda.gov/FSA/apfoapp?area=apfohome&subject=landing&topic=landing http://www.usgs.gov/pubprod/aerial.html
Topographic Maps	USGS	http://topomaps.usgs.gov/
Geomorphic Maps	Saucier 1994	In Appendix E the HGM Guidebook gives this URL: http://el.erdc.usace.army.mil/publications.cfm?Topic=techreport&Code=emrrp for Saucier (1994) and other data, but neither Saucier nor the other data were there. The URL needs revision.
Soil Survey	Natural Resources Conservation Service	http://soils.usda.gov/survey/
National Wetlands Inventory	U. S. Fish and Wildlife Service	http://www.fws.gov/wetlands/

3.6.2 Review of Results

The result of applying the HGM Guidebook approach to a unit of landscape will be a matrix of FCI values between zero and one. This matrix provides one tool for describing functional capacity occurring in a landscape, watershed, or set of wetlands. It is difficult to judge the significance of any single matrix without knowledge of the typical matrices found in natural systems, as well as those found in heavily altered landscapes. It would be helpful if the guidebook included some representative matrices to illustrate typical patterns. A matrix typical of a highly industrialized or highly agricultural watershed might be contrasted with a matrix from a more natural watershed within a large protected area such as Big Woods in Arkansas.

In the same way, the sensitivity of individual elements in the matrices, the FCI values, is not shown. A site with a function of 0.45 may not be significantly different from a site with 0.52. Users of the HGM Guidebook might benefit from a better understanding of the sensitivity of FCI values, perhaps again with a series of examples from reference sites, to prevent over-interpretation or misinterpretation of results.

3.6.3 Review of Model Documentation

The quality of the model's documentation varies. Chapter 6 on the Assessment protocol and the appendices provide good, detailed explanations of how the model are to be used to produce the FCIs. However, in general, the report is written in an overly abstract style, devoid of simple examples that could make the task of the reader far easier. The model reviewers provided the following examples of ways in which the HGM Guidebook could be made more user-friendly.

1. On page 1, the HGM Guidebook states:

   > "The HGM Approach initially was designed to be used in the context of the Clean Water Act, Section 404 Regulatory Program, to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. However, a variety of other potential uses have been identified, including the determination of minimal effects under the Food Security Act, design of wetland restoration projects, and management of wetlands."

   This provides information on how the HGM approach could be used. However, no references were provided to specific examples of how HGM has been used. Given that HGM has been in use for over a decade, it is expected that there are examples that could be provided in an appendix to describe how the HGM method and its FCIs were used to assess project alternatives, minimize impacts, determine mitigation requirements, and monitor success of mitigation (see FPCs #14 for more information).

2. The HGM Guidebook does not provide documentation on the accuracy and precision of the FCI predictions. Users need to know the "least significant difference" (LSD) for each FCI for each subclass. Specification of LSD would help users interpret FCIs in the context of such applications as project alternatives and impact minimization.

3. The model lacks clear documentation on the computational form of the FCI equations and why some variables were combined with equal weighting.

4. There is no section summarizing and discussing the model's assumptions and limitations.

Technical terms are not defined in one place, such as a "Definitions Section," and are used inconsistently throughout the report. One example: metrics are called *indicators* on Data Form 2.
A table of all variables and their definitions should be included in the HGM Guidebook, similar to Table 3 below.

Additional specific comments regarding typographical errors, suggestions for clarity, and inconsistencies are provided in Appendix D.

Table 3. The 21 Predictor or Independent Variables Used in Calculating FCIs in the HGM Guidebook for the Delta Region of Arkansas*

Variable	Condition Measured	Definition of Measure
V_{AHOR}	A Horizon Organic Accumulation	Total mass of organic matter in the A horizon below O horizon
V_{COMP}	Composition of Tallest Woody Vegetation Stratum	Species composition of the tallest woody stratum (tree, shrub-sapling, or seedling) as percent concurrence
$V_{CONNECT}$	Habitat Connectivity	Proportion of the perimeter of forested wetland tract connected to suitable wildlife habitat
V_{CORE}	Core Area	Portion of a wetland tract that lies to the inside a 100-meters (m) (330-feet [ft]) perimeter buffer
V_{DUR}	Change in Growing Season Flood Duration	Maximum number of continuous days in the growing season that overbank or backwater flooding from a stream inundates the wetland assessment area (WAA)
V_{FREQ}	Change in Frequency of Flooding	The frequency (return interval in years, 1-5) with which overbank or backwater flooding from a stream inundates the WAA
V_{GVC}	Ground Vegetation Cover	Percent cover of herbaceous and woody ground vegetation (less than or equal to 1.4 m (4.5 ft) in height.
V_{LITTER}	Litter Cover	Average percent of the ground surface covered by recognizable dead plant materials (primarily decomposing leaves and twigs) excluding undecomposed woody material larger than 0.6 centimeters (cm) (0.25 inches [in.]) in diameter
V_{LOG}	Log Biomass	Log biomass per hectare
V_{OHOR}	O Horizon Organic Accumulation	Thickness of the O soil horizon (soil layer dominated by organic material that consists of partially decomposed organic matter such as leaves, needles, sticks or twigs < 0.6 cm in diameter, flowers, fruits, insect frass, dead moss, or detached lichens on or near the surface of the ground
V_{OUT}	Change in Surface Water Flow	Change in frequency at which water is discharged as surface flow from a headwater depression wetland to a downslope stream
V_{POND}	Total Ponded Area	Percent of the WAA ground surface likely to collect and hold precipitation for periods of days or weeks at a time
V_{SNAG}	Snag Density	Density of snag stems (standing dead woody stems at least 1.4 m (4.5 ft) tall with a diameter at breast height (dbh) greater than or equal to 10 cm (4 in.) per hectare
V_{SOIL}	Soil Integrity	Assume that soil integrity exists where evidence of alteration is lacking
V_{SSD}	Shrub-Sapling Density	Density of shrub-sapling (woody stems less than 10 cm (4 in.) dbh and greater than 1.4 m (4.5 ft) in height) stems per hectare
V_{STRATA}	Number of Vegetation Strata	Canopy, subcanopy, understory, ground (0-4)
V_{TBA}	Tree Basal Area	Basal area of living woody stems greater than or equal to 10 cm (4 in.) dbh
V_{TCOMP}	Tree Composition	Percent concurrence of the dominant tree species in the assessment area with the species composition of reference wetlands in various conditions; calculated if the total canopy cover of trees (living woody stems ≥ 10 cm or 4 in. at breast height) within the plot is 20 percent or more
V_{TDEN}	Tree Density	Number of trees (living woody stems greater than or equal to 10 cm or 4 in.dbh) per hectare
V_{TRACT}	Wetland Tract	Area of contiguous forested wetland that includes the WAA
V_{WD}	Woody Debris Biomass	Volume of woody debris per hectare

* Not all of the listed variables are applicable to all wetland subclasses or functions.

3.7 Model Assessment Summary

A review of the technical quality, system quality, and usability of the Delta Region of Arkansas HGM models determined that the models and approaches are generally appropriate for the intended purpose of evaluating coarse level impacts for planning projects. Some improvements, however, are needed, particularly corrections to the model spreadsheets and augmented documentation to guide the user in model development and application. In addressing and answering charge questions designed to focus the review of the HGM Guidebook based on the model assessment criteria in the USACE *Protocols for Certification of Planning Models*, (USACE, 2007) the following underlying issues were identified:

1. Documentation on the HGM Guidebook model's intended use, scientific basis, approach, limitations and assumptions, reliability, and outputs is limited (FPCs #4-6, 10-13, 16 - 21)
2. The FCI models described in the HGM Guidebook are measuring ecological condition or functional capacity, not function (FPC #1). The relationship between function and FCI models may be a reasonable assumption, but it has yet to be validated independently.
3. Without the raw data, or raw data summary, and information on the process used to calibrate the derived subindices and projected recovery trajectories, the validity of the subindex graphs, which are the basis for the entire HGM Guidebook approach, is not supported (FPC #2).
4. Flood frequency and flood duration subindices within the models do not account for extreme events (FPC #3), and the use of 20th century data (before large-scale levee construction) as the reference conditions could result in the appearance of negative impacts if the area is restored to conditions occurring prior to those of the mid-20th century (FPC #10).
5. The current mixed version of paper forms and spreadsheets to perform the subindex and model calculations is cumbersome to use and prone to errors and could be made more user friendly by redesigning it as an integrated spreadsheet-based system that takes field data as inputs and produces the FCI and FCU outputs (FPC #7).
6. The HGM Guidebook should include references to easily obtainable case studies that apply this method (FPC #14).
7. Some of the field measurement approaches should be improved or explained in more detail to ensure that subjectivity invoked by each user does not affect precision (repeatability of measurements) (FPC#15).
8. The Unconnected Alluvial Depression subclass should not include wetlands that have been cut off from the channel of major river floodplains by man-made levees (FPC#8).
9. Stream channelization, channel incision, and drainage by ditches should be included as model variables in a number of FCIs for a number of subclasses (FPC#10)
10. Several FCI models are unnecessarily complex, leading to potentially less robust model results (FPC #13).
11. A table showing a function by sub-index matrix should be provided for each subclass, matching the sub-indices with the functions in which they occur (FPC#21).

These issues affect the ability of users to apply the model and the ability of users, reviewers, and readers to fully understand the scientific basis and logic of the model; how model outputs are linked to on-the-ground changes in wetland ecosystems; the ability of the model to evaluate changes in wetland ecosystems for project life; and the ability to perform uncertainty and sensitivity analysis associated with each of the models evaluated. Many of the issues identified by the model reviewers are the direct result of limited documentation to support the method and the model and can be addressed relatively easily.

4 CONCLUSIONS

Models are simple representations of complex systems and, as such, must balance complexity and reality with simplicity and usability. Overall, the model reviewers agreed that the models are suitable for limited application to meet some of their intended purposes; however, they were concerned that the models have some conceptual flaws that limit their ability to achieve all of the intended purposes. One model reviewer believes these flaws are serioU.S. The HGM models have an unknown ability to assess wetland functions and are more appropriate for limited assessment of wetland condition. Although the HGM models have deficiencies, they are not insurmountable and can be resolved.

There were some issues identified with the models' documentation, application, and variables, and some potentially serious errors were noted in the spreadsheet calculations and formulas. The model reviewers provided the following recommendations for improving the models based on the most significant concerns they identified during their review.

1. Describe the relationships between wetland condition and function from the point of scientific validity and program requirements under the Clean Water Act.
2. Provide a description of the process for selecting and measuring data from reference wetlands in an appendix. Also, show reference data points on the graphs of FCI curves relating independent variables to the dependent subindex, and explain how recovery trajectory curves were developed.
3. Provide a better method for capturing frequency and duration of flooding as controlling factors, or provide a clear statement explaining why these indicators could not be reasonably measured.
4. Include an explanation for each of the FCI functions that describes why the specific mathematical form was chosen.
5. Provide information on the relationship between actual measurements of wetland functions and FCI curves.
6. Provide additional information on 1) the sensitivity of the FCIs to their inputs and on the least significant differences for policy analysis, 2) empirical validation of the FCIs against field data, and 3) precision, accuracy, and uncertainty for the FCI calculations.
7. Redesign the forms and spreadsheets as an integrated system to prevent errors.
8. Provide better justification in the guidebook for classifying anthropogenically disconnected floodplain depressions (depressions behind mainstem levees), as

unconnected alluvial depressions rather than treating them as altered floodplain depressions.

9. Include non-wetland sites that were former wetlands as part of the reference data set in order to represent the most altered end of the gradient and provide a basis for identifying potential restoration sites.
10. Consider using indicators of channelization and flooding duration in the FCIs.
11. Consider changing how V_{POND}, V_{LITTER} V_{SSD}, V_{GVC}, V_{OUT}, and V_{TBA} are measured and used in the FCIs.
12. Provide additional documentation to: (1) provide links or citations for easily obtainable case studies that apply this method, (2) provide a series of tables, sorted by wetland subclass, showing variable-by-function matrices, and (3) explain that the models have not been designed to address climate change.
13. Improve field measurements to remove subjectivity and to improve precision.
14. Summarize the assumptions implicit in the HGM approach and FCI models.
15. Ensure consistency in terminology and names of variables throughout the HGM Guidebook.

This list of actions summarizes the recommendations for resolution in the FPCs; more detailed recommendations are provided in the FPCs in Appendix B. Failure to address the issues identified may lead to incorrect interpretation or use of the HGM models and outputs.

The reviewers strongly suggest incorporating the recommended resolutions into the FCI models and modifying the documentation before allowing widespread use of the models for planning purposes. Making the recommended revisions will result in better precision of model inputs, accuracy of model outputs, comprehension of the scientific basis and logic behind the models, and understanding of the models results, as well as promote model transparency and allow uncertainty and sensitivity analysis to be performed. The model will also be better able to achieve its intended purpose.

During a teleconference on April 5, 2010 to discuss the review findings with USACE, the model reviewers were asked whether the guidebook was usable prior to making the suggested revisions (as described above). The model reviewers' response was that there could be continued conditional use. The guidebook has been in use for approximately five years and could potentially be used with the same level of accuracy under the condition that existing users will be the ones who continue to use the method. Upon further consideration of this question, the model reviewers agreed that, at the very least, the errors noted in the spreadsheets and the potential for errors in transferring data among field sheets and spreadsheets must be corrected to improve the ability of the models to yield accurate results. Failure to correct the errors and data transfer issues may lead to unreliable model outputs (see FPC #7 and Appendix C). Once these issues are addressed, the models could continue to be used prior to addressing all other comments under the following conditions:

1) The same team of experts who developed the regional HGM guidebook will perform the assessments for all wetland sites to ensure the models are used as intended and that there

is consistency in the results. Otherwise, scores among sites are not likely to be comparable (see FPC #15).

2) All other comments will be addressed as soon as possible to certify the regional HGM guidebook for widespread application by users external to the development team. The reviewers understand the immediate need to use the guidebook; however, the guidebook should not continue to be used beyond the immediate needs without the technical issues identified being addressed.
3) Users understand that the regional HGM guidebook's process for assessing wetland functions did not include any actual measurement of wetland functions and is based on measurements of wetland characteristics hypothesized to be indicators of wetland functions. The relationships between these indicators and wetland functions have yet to be independently tested and verified with field data. Therefore, the ability of the guidebook to assess wetland functions will remain unknown until appropriate testing and validation are carried out.

Although the panel concurs that the guidebook is usable once the spreadsheet errors and data transfer issues are corrected, there are still risks associated with its continued use. Those risks include (1) potential for inaccurate measurement of changes in wetland function among project alternatives, (2) potential misapplication of the HGM approach from reclassifying floodplain wetlands to non-floodplain types following an alteration by levee construction (and thus overlooking loss of functions related to the loss of overbank flooding), and (3) the possible selection of an incorrect alternative for minimizing wetland impacts. The question on usability of the guidebook asked by USACE was primarily in reference to the St. John's/New Madrid project. Although addressing the issues identified by this independent external peer review (IEPR) would improve the usability and accuracy of the models for application to projects in the region, the question of application of the guidebook for the St. John's/New Madrid project was not specifically addressed because it was out of the scope for this review and the model reviewers were not provided with review materials specific to the selection of alternatives for the St. John/New Madrid project.

5 REFERENCES

Botkin, D. B. 1990. *Discordant Harmonies. A New Ecology for the Twenty-first Century*. New York, NY: Oxford University Press.

Brinson, M. M. 1993. A Hydrogeomorphic Classification for Wetlands. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, USA. Technical Report WRP-DE-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brinson, M. M., K. H. Miller, R. Rheinhardt, R. Christian, G. Meyer, J. O'Neal. 2006. Developing reference data to identify and calibrate indicators of riparian ecosystem condition in rural coastal plain landscapes in North Carolina. Report to the Ecosystem Enhancement Program, North Carolina Department of Environment and Natural Resources. Raleigh, NC, USA. *http://www.nceep.net/pages/resources.htm*

Brown, P. and J.P. Kennett 1999. Marine evidence for episodic Holocene megafloods in North America and northern Gulf of Mexico. Paleoceanography 14: 498-510.

Cole, C. A. 2006. HGM and wetland functional assessment: Six degrees of separation from the data? *Ecological Indicators* 6:485-493.

Dynesius, M. and C. Nilsson. 1994. Fragmentation and flow regulation of river systems in the northern third of the world. *Science*, **266**, 753–62.

Fennessy, M. A. Siobhan, D. Jacobs, and M. E. Kentula. 2007. An evaluation of rapid methods for assessing the ecological condition of wetlands. *Wetlands* 27(3):543-560.

Hill, A., V. Jason, S. Neary, and L. K. Morgan. 2006. Hydrologic modeling as a development tool for HGM functional assessment models. *Wetlands* 26(1):161-180.

Hoeltje, S.M. and C. A. Cole. 2009. Comparison of Function of Created Wetlands of Two Age Classes in Central Pennsylvania. *Environmental Management* 43:597-608.

Middleton, B.A. (ed.) 2002. *Flood Pulsing in Wetlands: Restoring the Natural Hydrological Balance.* New York, NY: John Wiley.

Smith, R. D., A. A. Ammann, C. Bartoldus, and M. M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Technical Report WRPDE-9. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Smith, R. D. and J. S. Wakeley. 2001. Hydrogeomorphic approach to assessing wetland functions: Guidelines for developing regional guidebooks. Chapter 4 Developing assessment models. Report ERDC/EL TR-01-30, U.S. Army Corps of Engineers.

Starfield, A. M. and A.L. Bleloch. 1991. *Building Models for Conservation and Wildlife Management*. 2nd edn. Edina, MN: Burgers International Group.

Stein, E. D., M. M. Brinson, M. C. Rains, W. Kleindl, F. R. Hauer. 2009. Wetland assessment alphabet soup: How to choose (or not choose) the right assessment method. *Wetland Science and Practice* 26(4): 20-24.

USACE. 2007. Protocols for Certification of Planning Models Under the Planning Models Improvement Program (PMIP). July 2007.

USACE. 2005. Planning Models Improvement Program (PMIP): Model Certification. Engineering Circular No. 1105-2-407, May 2005.

Appendix A

Biographic Information for Model Review Panel Experts

This page intentionally left blank

Richard Rheinhardt (Civil Works Planner/HGM Specialist). Dr. Rheinhardt earned his Ph.D. in marine science and biological oceanography from the College of William and Mary's Virginia Institute of Marine Science in 1991. As a Marine Scientist with the Virginia Institute if Marine Science (VIMS), he conducted research on the impacts of nutrient enrichment in tidal salt and freshwater marshes. He is currently an independent consultant and a research associate professor in the biology department at East Carolina University. Dr. Rheinhardt is a member of the original team that developed the HGM approach to wetland assessment. He co-authored the first National HGM Guidebook (for riverine wetlands) and was a primary author of a Regional HGM Guidebook for assessing wet pine flats on mineral soils. He has conducted training for and provided technical advice on reference-based wetland assessment approaches, including HGM, to federal, state, and private sector resource managers throughout the United States. He is currently a member of a team developing a Regional HGM Guidebook for riverine wetlands for the Gulf and Atlantic coastal plans, which involves collecting reference field data for the Virginia, North Carolina, Alabama, and Mississippi portion of the reference domain. He has extensive experience developing assessment procedures for assessing and monitoring stream and riparian restoration projects for the North Carolina Ecosystem Enhancement Program. Dr. Rheinhardt's compensatory mitigation expertise includes research evaluating the effectiveness of existing North Carolina Department of Transportation (NCDOT) wetland mitigation sites. Also for the NCDOT, he designed methods and conducted an HGM wetland assessment for the mitigation of a fen wetland in the Piedmont of North Carolina. Dr. Rheinhardt has researched the role of reference wetlands in functional assessment, mitigation, and restoration. While a senior biologist with USFWS, he contributed to and reviewed numerous environmental impact statements.

Dr. Rheinhardt has a also conducted numerous published studies on the relationships between plant composition and environmental factors (including hydrologic factors) in a wide variety of ecosystems, including subalpine forests, tidal freshwater swamps, bottomland hardwood forests, headwater riparian forests, forested fens, vernal pools, and interdunal swale wetlands.

Paul Keddy (Wetland Ecologist). Dr. Keddy holds a Ph.D in plant ecology and, in addition to acting as an independent consultant, is currently a professor at Southeastern Louisiana University. He has 35 years of experience working with freshwater and coastal wetland ecosystems, particularly in Louisiana, the Great Lakes, and central and eastern North America. His research focuses on biotic (plant and animal) and abiotic (hydrology, nutrients, salinity, sedimentation, disturbance) factors controlling the composition, productivity, distribution, and extent of wetland plant communities and on predicting the effects and assessing the results of environmental manipulation in the context of wetland restoration and ecological benefit. Dr. Keddy worked for eight years on restoration of the Lake Pontchartrain estuary (the second largest estuarine system in the U.S.) to maximize ecological benefits. He was the co-author of the *Comprehensive Habitat Management Plan (CHMP) for the Lake Pontchartrain Basin*, which included a comprehensive analysis of the historic form and function of diverse bottomland habitats of both the Mississippi River and the Pearl River valleys. Development of the CHMP involved evaluating the relative ecological benefits of different coastal wetland and estuarine management strategies as well as the establishment of quantitative restoration targets for these ecosystems. Dr. Keddy has evaluated the ecological benefits of different Mississippi River management scenarios on a variety of habitats, including swamp, fresh marsh, intermediate marsh, brackish marsh, saline wetlands, open water, and uplands. As the principal author of a comprehensive review, The Wetlands of Lakes Pontchartrain and Maurepas: Past, Present and Future, Dr. Keddy prepared a synthesis of plant communities and their ecological drivers for bottomland wetlands found in the Pontchartrain-Maurepas region at the southeastern end of the Mississippi River alluvial plain. This scientific paper included an environmental history of the wetlands and a review of existing vegetation patterns and their causes as a basis for identifying restoration targets and priorities for wetland conservation. Additionally, Dr. Keddy's research has focused on vegetation classification and quantification of the relative importance of biotic and abiotic controls on plant species assemblages in bottomland wetlands in Louisiana analogous to the shrub- and tree-dominated marshes and wet savannas of the Delta Region of Arkansas. Dr. Keddy served on the Coastal Restoration and Enhancement Through Science and Technology (CREST) Technical Advisory Committee until 2007, designing terms of reference and evaluating restoration project proposals with emphasis on maximizing cost effectiveness in terms of ecological benefit. He served on the review panel of the Everglades Restoration Acceleration Project and acted as an expert witness at a Special Master Hearing on Everglades water quality. Dr. Keddy recently completed a review book chapter on the measurement of ecological services and benefits from wetlands and he is familiar with the latest conceptual and technical advances in measuring benefits. Dr. Keddy has authored five books including *Wetland Ecology: Principles and Conservation*, the second edition of which is in currently in press.

James Shepard (Forester). Dr. Shepard earned his Ph.D. in forest soils from Mississippi State University in 1985 and has 34 years of experience in forestry. He is currently a professor of forestry at Mississippi State University in addition to being the Associate Director of the Forest and Wildlife Research Center and the Mississippi Water Resources Research Institute. Dr. Shepard is the former Forest Wetlands Program Manager for the National Council for Air and Stream Improvement (NCASI), a non-profit organization that conducts environmental research for its large forest products company members. NCASI invests in university studies investigating the compatibility of timber management operations and wetland functions, especially examining indicators such as timber harvesting, effects on hydrology, water quality, soil organic matter, nutrients, chemical and physical properties, wildlife habitat, and wildlife populations. Most of these studies were conducted in bottomland hardwood wetland forests adjacent to rivers and streams. Dr. Shepard's work with NCASI involved reviewing the potential for the hydrogeomorphic method (HGM) to assess wetland functions in NCASI projects and participating in an HGM training course. His experience with evaluating ecosystem restoration output includes the Sharkey Restoration Project, a large-scale, long-term reforestation study in a Sharkey County, Mississippi bottomland hardwood forest area. For the Sharkey Restoration Project, Dr. Shepard and other investigators have spent almost 15 years evaluating a variety of parameters related to reforestation such as survival and growth of planted trees, colonization of the site by other plant species, soil organic matter and soil carbon, and small mammal and bird populations. He has received numerous forestry-related grants, including for *Forest restoration in the Lower Mississippi Alluvial Valley: Science at the crossroads of economics and ecology* from the USDA Forest Service (2007-2008) and *Implementation of new technologies for hardwood reforestation demonstration project* from the USDA Farm Service Agency (2008-2009). His experience with large civil works projects includes providing wetland-related technical support for a public road project and supporting landowners, foresters, loggers, and mills to better utilize wood damaged in large-scale wind events in the eastern United States.

Stephen Powell (Programmer/Spreadsheet Auditor). Dr. Powell holds a Ph.D. in engineering-economic systems and is currently a professor of business administration at Dartmouth College's Tuck School of Business. His research interests include modeling production lines and service sector business processes, as well as how novices formulate models and use models in decision making. Additionally, Dr. Powell was the co-director of the Tuck Spreadsheet Engineering Research Project (SERP) which sought to improve the design and use of spreadsheets by individuals and organizations. SERP's research focused on identifying best practices in spreadsheet development (design, testing, documenting); procedures for implementing, modifying, sharing, and archiving spreadsheets; and organizational policies relating to standards, training and quality control. One of the first SERP tasks involved collecting numerous spreadsheet models from a variety of companies and performing audits on them to assess the quality of design, technical correctness, and suitability of use. SERP ultimately designed a training program for spreadsheet engineering. Dr. Powell has authored numerous papers and books, including the spreadsheet textbook *Management Science: The Art of Modeling with Spreadsheets* (2007; J. Wiley & Sons) and *Modeling for Insight: A Master Class* (2009; J. Wiley & Sons), an advanced spreadsheet modeling book. With his co-investigators from SERP, he also developed an auditing protocol for spreadsheets, which was published in *Information and Management* in 2008 and co-authored two papers on errors in operational spreadsheets. He is also the associate editor for the *International Journal of Simulation and Process Modeling* and offers spreadsheet consulting services for spreadsheet design, debugging, optimization, and sensitivity analysis.

This page intentionally left blank

APPENDIX B

Final Panel Comments

Final Panel Comments

The following forms include the Final Panel Comments from the review of the HGM Guidebook. These comments reflect the key issues identified during the assessment according to the model certification criteria described in the USACE *Protocols for the Certification of Planning Models*. Each form contains a concise statement of the issue (the comment), the basis of the comment, the significance of the comment, and recommendations for resolution. Significance levels are defined as follows:

> **High:** Describes a fundamental problem with the model(s) that could affect the models' ability to serve their intended purpose
>
> **Medium:** Affects the completeness or understanding of the model(s), model usability, or the level of performance of the model(s)
>
> **Low:** Affects the technical quality of the model documentation but will not affect the performance of the model(s).

Final Panel Comments are arranged from High to Low significance, but in no other particular order. The Final Panel Comments are:

1. It appears that the models in the Hydrogeomorphic (HGM) Guidebook assess ecological condition rather than wetland functions. .
2. The Hydrogeomorphic (HGM) Guidebook did not explain how raw field data were used to calibrate the derived subindices, why subindex graphs were straight lines, and why the minimum subindex score for some altered conditions equaled zero while others were greater than zero.
3. The treatment of flood frequency and flood duration within the models implies greater ecological measurement of flood frequency and duration than is actually occurring.
4. The justification for the mathematical form of the six Functional Capacity Indices (FCIs) should be expanded.
5. The Functional Capacity Indices (FCIs) have not been validated against independent empirical estimates of the actual function in the relevant terrains.
6. The Hydrogeomorphic (HGM) Guidebook needs to explain more fully the overall reliability of the outputs of the model.
7. The procedures used to transform raw field data into tables of Functional Capacity Indices (FCIs) and Functional Capacity Units (FCUs) are overly complex and prone to errors.
8. The Unconnected Alluvial Depression subclass should not include wetlands that have been cut off from the channel of major river floodplains by man-made levees.
9. The Functional Capacity Index (FCI) for Detain Floodwater could be improved by use of channelization and flooding duration indicators and by careful consideration of the calibration of V_{FREQ}.
10. The Functional Capacity Index (FCI) for Detains Precipitation could be improved by changing how V_{POND} and V_{LITTER} are measured.

11. The Functional Capacity Indices (FCIs) for Cycles Nutrients and Export Organic Carbon could be improved by changing the use or measurement of V_{SSD}, V_{GVC}, V_{OUT}, and V_{TBA} in the FCI calculation.
12. The Functional Capacity Index (FCI) for Provide Habitat for Fish and Wildlife could be made more robust by using fewer subindices in its calculation.
13. The Hydrogeomorphic (HGM) Guidebook should include references to easily-obtainable case studies that apply this method.
14. Some field measurement approaches should be improved to improve the precision (repeatability of measurements) of variables in the models.
15. At the beginning of the document, a clear statement needs to be provided about how the guidebook is intended to support decisions made by regulators and managers and how the guidebook supports that purpose.
16. The Hydrogeomorphic (HGM) Guidebook should explain why some functions commonly included in HGM assessments were not chosen for this HGM assessment method.
17. The Hydrogeomorphic (HGM) Guidebook should summarize the assumptions implicit in its approach, including those pertaining to the Functional Capacity Index (FCI) models.
18. The descriptions of some model variables needs to be more clear, consistent, and complete.
19. The model, as designed, does not address global climate change issues as required by EC 1165-2-211 Water Resource Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs (01 July 2009).
20. The Hydrogeomorphic (HGM) Guidebook should include a table for each wetland subclass that provides a matrix of subindices and the FCI models in which they occur.

Final Panel Comment 1:
It appears that the models in the Hydrogeomorphic (HGM) Guidebook assess ecological condition rather than wetland functions.
Basis for Comment:
The HGM's success in assessing wetland functions hinges on its ability to relate wetland condition to wetland function in a statistically rigorous manner. However, this information is not provided in the HGM Guidebook, and this adds to the uncertainty associated with the models' ability to assess wetland functional capacity. Many of the variables used in the HGM—organic matter, tree species composition, amount of coarse woody debris—describe condition. Most of these variables have good ecological justification as meaningful measures of site conditions. Moreover, some of the key variables that will affect function, like flood frequency and flood duration, are not incorporated in the FCI equations as actual measurements. Only changes in these variables are considered relevant to the FCI calculation (and for the latter variable this is assumed to be zero, page 119). Some model reviewers thought that this weakens the value of the FCI as a real functional index. The variables are put into equations which attempt to extract function levels relative to reference standard wetlands. This requires an added degree of complexity. From the documentation provided, there does not appear to have been any independent testing of how the model results are related to wetland functions. The model reviewers suggest, however, that it would be simpler and more realistic to acknowledge that the HGM approach provides a rapid assessment of wetland condition, but that the indicators of condition are organized in a way that provides information about functional capacity (Stein et al., 2010). The explanation/rationale for the transformation of measures of condition into measures of function is generally clear, and expert opinion is that functions will arise from conditions. However, the FCIs are actually a reflection of condition.
Significance – High:
Implying that the HGM models are measuring function, rather than condition, could lead users to incorrectly interpret projected changes that could result from project alternatives. Since changes in condition do not necessarily reflect similar changes in function, this could lead to the selection of an alternative that may result in decreased wetland function over one that may result in no change or improved wetland function.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional HGM Guidebook would need to: Describe the relationships between condition and function, both from the point of view of scientific validity and program requirements under the Clean Water Act. Acknowledge early in the HGM Guidebook that the FCIs measure wetland condition, rather than function, and that a change in condition does not necessarily reflect a similar change in function.

Final Panel Comment 2:
The Hydrogeomorphic (HGM) Guidebook did not explain how raw field data were used to calibrate the derived subindices, why subindex graphs were straight lines, and why the minimum subindex score for some altered conditions equaled zero while others were greater than zero.
Basis for Comment:
Without access to raw data or raw data summaries, the model reviewers could not critique the validity of the subindex curves, (i.e., the relationship between variable metrics and subindices) and projected recovery trajectories presented in Chapter 6, or the models overall. Only by examining the subindex graphs in Chapter 5 can readers infer how metrics might have been distributed among reference sites. Values for the most-altered wetlands and the range of values for reference standard wetlands (the wetlands representing the least altered condition represented by a subindex score of 1.0) can be inferred most easily from the graphs, but inferring the variation of values between the least and most altered sites is not possible without the raw data. The reviewers had to assume that the calibrations were conducted in a statistically valid manner. The form of all the subindex graphs shows a straight-line relationship between the reference standard values and conditions less than standard, but the assumption for this relationship was not justified. Further, there was no explanation of why, in some cases, the lowest possible subindex score was defined to be zero, while in other cases the lowest score was defined to be a value greater than zero.
Significance – High:
If subindex scores are not directly related to wetland condition, the user will not be able to fully understand the meaning of the subindex values and, consequently, the meaning of the model results on which planning decisions are based.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional HGM Guidebook would need to be expanded to include: 1. An appendix providing raw field data (e.g., size, location) and a description of how those data were used to calibrate the derived indices (e.g., raw data plotted on the graphs, measure of scatter, and rationale for the chosen shape). At a minimum, several examples should be included in an appendix (or in Chapter 2) explaining how the calibrations were achieved. 2. An assumption or justification for each case where the lowest score for a subindex value is not zero. 3. Supporting data for the projected recovery trajectories graphed in Chapter 6.

Final Panel Comment 3:
The treatment of flood frequency and flood duration within the models implies greater ecological measurement of flood frequency and duration than is actually occurring.
Basis for Comment:
Wetlands are produced by a set of flooding factors including (1) the number of flood events in a year, (2) the duration of each flood event, (3) the timing of each flood event and (4) the variation in these events among years. None of these is directly included in the calculation of subindices and Functional Capacity Indices (FCIs). <u>1. Input variables describing flooding are weak to non-existent</u> The HGM Guidebook uses flood frequency, transformed as the index $V_{FREQ,}$ and flood duration, transformed as V_{DUR}, to measure flooding effects. There is no real flood record data for input into the FCI. For V_{DUR}, "Estimates of growing-season flood durations are not typically readily available for any particular site, and in most cases the change in duration will be assumed to be zero unless specific information to the contrary is available from project planning or permit application documents" (page 119). <u>2. Key input variables describing flooding are changes, not current conditions</u> Neither of these is input as an actual value, but only as a potential change from existing conditions. Thus they only measure potential impacts of changes from the current situation, not an existing situation. <u>3. Flood duration is used only in a subset of situations</u> Flood duration (V_{DUR}) appears only in equations e and f : Maintain Plant Communities and Provide Wildlife Habitat, respectively, and only for a subset of habitats. Flood duration would be expected to affect many wetland functions, but it is used in only two of the six FCIs. <u>4. All change is regarded as negative.</u> The variation in water level among years is an important factor in many wetlands. Occasional flood peaks likely determine the distribution of wetlands, their species, and their functions. The model reviewers appreciate that measuring the extreme conditions that affect ecological phenomena is a difficult problem. However, the document should acknowledge that it is the pattern of extreme high and low water years that likely sets the limits of wetlands, and the use of typical frequency and duration of the longest annual flood, captures some, but not all, of the effects of flooding. Extreme events on a fifty-year cycle are important for many wetlands. It is the wettest and driest extremes which determine many of the conditions. Therefore, deviation from reference standard conditions (which should represent natural variations in extremes) should be the basis for calibrating a flooding variable.

Significance – High:
Wetlands are controlled by flooding. If measures of flooding are not incorporated, then the most important driver in the system is missing. Failure to capture the nature of changes in flooding frequency and duration may result in an inability to effectively capture changes in wetland condition, which is the focus of the approach.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional Hydrogeomorphic Guidebook would need to be expanded to include: 1. A better method for capturing frequency and duration of flooding as controlling factors such as using the long term water level data available for the Mississippi River. 2. A clear statement explaining why these variables could not reasonably be measured and incorporated in the models if a better method for capturing frequency and duration of flooding is no adopted.. 3. A clear statement of the importance of infrequent flood maxima (i.e., naturally occurring extreme conditions) in determining wetland boundaries and functions. 4. A rationale for the use of V_{DUR} in only two of the six FCI equations.

Final Panel Comment 4:
The justification for the mathematical form of the six Functional Capacity Indices (FCIs) should be expanded.
Basis for Comment:
All of the FCI functions (pages 58-73) involve averages of two or more assessment variables. In these cases, a justification should be offered for the relative weights of each of the assessment variables in the function. FCI functions 1, 4, 5, and 6 involve multiplication of terms or the taking of roots. These mathematical forms carry certain implications for the output that should be explained and justified. FCI functions 1 and 4, which involve products of two terms, should perhaps include a square root (geometric mean), as does FCI 5. If not, the difference in form between FCI functions 1, 4, and 5 should be explained.
Significance – High:
Lack of justification for the mathematical form of each of the individual FCIs could lead to improper use if the user is not aware of the importance of and rationale for the functions. Improper use could lead to model results that will not be able to support planning decisions.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional Hydrogeomorphic Guidebook would need to add an explanation to each of the sections on the FCI functions for why the specific mathematical form was chosen.

Final Panel Comment 5:
The Functional Capacity Indices (FCIs) have not been validated against independent empirical estimates of the actual function in the relevant terrains.
Basis for Comment:
The discussion of each FCI includes a justification of why the relevant function is appropriate to an overall assessment, but does not include evidence that the FCIs accurately measure the *actual* function in the field. The report cites an "independent quantitative measure that can be used to validate the functional index," but provides no evidence that these measures actually validate the FCI functions. This is an important gap in the justification for these functions of which the reader should be fully aware.
Significance – High:
The user of this report might naturally assume that the FCI measures of function have been validated in the field and thus can be taken as accurate estimates of actual function. Since this final step has not yet been carried out, a naïve user might place unwarranted confidence in FCI estimates and thereby make erroneous planning decisions.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional Hydrogeomorphic Guidebook would need to be expanded to include a description of how FCI values have been validated against independent empirical estimates of wetland function. If validation has not been performed, then FCI model outputs need to be validated against actual field conditions.

Final Panel Comment 6:
The Hydrogeomorphic (HGM) Guidebook needs to explain more fully the overall reliability of the outputs of the model.
Basis for Comment:
For a model to provide reliable information to its user, four attributes of the model must be fully communicated: 1. precision 2. accuracy 3. sensitivity 4. uncertainty The *precision* of a model reflects how stable its outputs are when its inputs are measured repeatedly. In this context, the question would be how similar would estimates based on measurements from two or more independent field teams be if they were compared. The *accuracy* of a model reflects how closely its output matches actual conditions in the field. In this situation, this would require information on how well a Functional Capacity Index (FCI) such as Export Organic Carbon measured the actual ability of a terrain to export organic carbon. The *sensitivity* of a model measures the degree of change in model outputs that result from a change in inputs. For example, how much the FCI for Detain Floodwater changes when our assessment of V_{SSD} changes by 1%. If these FCIs are to be successfully used in planning decisions, it is essential for the user to understand how sensitive the results are to the inputs (subindices) and to the mathematical form of the model. For example, if an FCI is an arithmetic average of two subindices (measured as 0.5), then a 0.1 error in either input translates into a 0.05 error in the FCI. On the other hand, if an FCI is a geometric mean of two subindices, then a 0.1 error in either input translates into a 0.0477 error in the output. In addition, the user needs to know the potential error or uncertainty in the input values to know how reliable the output might be. If a subindex can only be measured to $\pm$ 10%, the resulting FCI is less accurate than if the subindex can be measured to $\pm$ 1% Finally, *uncertainty* in a model reflects the uncertainty in the outputs that follows from uncertainty in the inputs. If, for example, there is an element of uncertainty in one or more assessment variables, then there will be uncertainty in the output. For example, the user should know that a certain FCI can only be measured to within $\pm$ 10% due to uncertainty in its inputs. The uncertainty in the results of a model is important because it relates directly to how a user interprets differences in those results. For example, if the current FCI is 0.5 and we estimate that this will improve to 0.6 under a proposed alternative, the user would need to

know if this difference of 0.1 *meaningful*, or if it could be due to a) errors in the estimation of subindices, or b) the mathematical form of the function. Specifying a *least significant difference* (LSD) for each FCI would assist the user in making good policy. For example, if the LSD for a particular FCI were 0.3, and two alternatives measured 0.5 and 0.7, the user would know that this difference as not meaningful.
Significance – High:
Users of this model are likely to put unwarranted confidence in the numerical estimates of FCIs and Functional Capacity Units unless these issues are addressed fully in the report. This could negatively affect the ability of the model to achieve its stated purposes.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional Hydrogeomorphic Guidebook would need to be expanded to include a discussion of the precision, accuracy, sensitivity, and uncertainty associated with each of the FCIs.

Final Panel Comment 7:
The procedures used to transform raw field data into tables of Functional Capacity Indices (FCIs) and Functional Capacity Units (FCUs) are overly complex and prone to errors.
Basis for Comment:
The procedure described here, which transforms field data into FCIs/FCUs, is a complex combination of paper forms and spreadsheets. Data must be transferred manually back and forth between forms, and between forms and spreadsheets. This is both time-consuming and error-prone. Some of the paper forms require manual calculations that could be performed more easily and safely in a spreadsheet. The three spreadsheets provided with this review apply to only a portion of the overall procedure, and two spreadsheets exist alongside alternative paper forms in a different format. The current mixed paper-spreadsheet procedure has a number of shortcomings, including: a. Inconsistencies in variable names, field names, units of measure, and spreadsheet layouts b. Inconsistencies between paper forms and spreadsheets c. Limitations in model and user documentation in the spreadsheets d. Unnecessarily complex linkages between spreadsheets, and more spreadsheets than necessary e. The inclusion of hand calculations f. Incorrect references to data forms g. Missing formulas h. Duplicate output cells i. Parameters used inside formulas j. Unexplained conversions from metric to English units k. Unnecessarily complex IF statements l. Lack of data validation and error controls
Significance – High:
Complex, error-prone procedures could lead to erroneous outputs and thereby decrease confidence in planning decisions made based on the outputs.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas HGM forms and spreadsheets would need to be redesign as an integrated spreadsheet-based system that takes field data as inputs and produces two seven-by-six tables for FCIs and FCUs as outputs. This can be accomplished in a single spreadsheet, although that spreadsheet may have to be tailored to a specific application from a generic template.

Final Panel Comment 8:
The Unconnected Alluvial Depression subclass should not include wetlands that have been cut off from the channel of major river floodplains by man-made levees.
Basis for Comment:
Page 52 of the guidebook states that, "Unconnected alluvial depressions occur in major river floodplains that have been cut off from the channel by levees," which means that they were disconnected due to levee construction (a major alteration). Reclassifying altered wetlands rather than treating them as altered wetlands is a departure from the usual procedure in HGM to classify wetlands as the type they were prior to alteration. Wetlands that are hydrologically separated from their floodplains by man-made levees or berms represent a major altered hydrologic condition. They may resemble other unaltered wetland types in some respects, but are anthropogenic. Such anthropogenically disconnected floodplain depressions should be treated as hydrologically altered floodplain depressional wetlands because they are disconnected from the overbank flooding that once controlled them. These disconnected floodplain depressions may still possess some functional capacity, but none of these wetlands should be capable of attaining reference standard condition for HGM, which could occur by reclassifying them. This is a particular problem for hydrologic functions dealing with flood detention and wildlife functions dealing with potential fish habitat. Restoration could be conducted in disconnected depressions, but they can never be restored to reference standard condition unless they are hydrologically reconnected to the channel with which they were once associated.
Significance – High:
The significance of this problem is high for two reasons. First, reclassifying wetlands in an altered condition creates the erroneous impression that some wetlands appear to be in better condition than they are. Second, it sets a precedent for reclassifying other wetland types following large-scale anthropogenic alteration. For example, former floodplains behind levees might be reclassified as wet flats. Were the HGM assessments used to evaluate wetland functional capacity over a large region (rather than for just an individual project), depressional wetlands behind levees would be shown to be in much better condition than they are by ignoring the deleterious regional effects of mainstem levees on floodplain wetlands. This would tend to both erase the historical reference point (that these were once fully connected and fully functional wetlands) and it would mask the future degradation of wetlands through time as more levees are constructed.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional Hydrogeomorphic Guidebook should treat depressions on former floodplains as floodplain depressional wetlands and not reclassify them as unconnected depressions. In the analyses of projects, the best attainable score for floodplain depressions behind levees should be determined and treated as HGM would normally treat unaltered wetlands in determining compensation. For example, if 0.6 is the best FCI attainable score for the fauna maintenance function, then a score of 0.6 would be treated as one would normally treat a score of 1.0. This would be a policy choice, but it would be better to invoke policy in the

dealing with compensation rules rather than override science by reclassifying. Treating former floodplain wetlands as altered floodplain wetlands would maintain the integrity of HGM in defining standards relative to unaltered wetlands. In contrast, ignoring the hydrogeomorphic origin of former (now altered) floodplain wetlands would lead to ignoring large areas of wetland that are potentially restorable and the loss of ecological services associated with levee construction.

Final Panel Comment 9:
The reference data set does not seem to have included former wetlands (now non-wetlands) as part of the model calibration, which means that the most altered end of the gradient is not well represented in the calibration, and former wetlands will likely be overlooked as potential restoration sites.
Basis for Comment:
The hydrogeomorphic (HGM) Guidebook states that in developing the HGM Guidebook, "reference wetlands are identified to represent the range of variability exhibited by the regional subclass, and field data are collected and used to calibrate assessment variables and indices resulting from assessment models." However, the most altered part of the reference population is the former wetlands that are no longer functioning as wetlands. These former wetlands are in the correct geomorphic landscape position, but are no longer wetlands because they lack one or more of the three parameters that are used to define them jurisdictionally as wetlands (vegetation, soils, and wetland hydrology). By restricting the reference data set to jurisdictional wetlands, the low end of the continuum of alteration is not represented in the calibration of sub-index scores. Another ramification of excluding the former wetlands (now non-wetlands) is that a large population of useful sites could be excluded from being considered as potential restoration sites. Furthermore, including non- (but former) wetland sites in the reference set could provide information to managers that could be used to develop site-specific restoration plans and develop sampling protocol to assess the condition of wetland resources at a regional scale.
Significance – High:
Excluding the most altered wetlands from the reference data set could compromise the validity of the calibrations of the models, and hence, their performance.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional HGM approach would need to be expanded to: 1. Include non-wetland sites that were formerly wetlands in the reference data set so that their values can be used to help calibrate subindices. 2. Explain, in Chapters 2 and 6, the importance of non- (but former) wetlands for calibrating models and providing an important potential basis for identifying restoration sites. 3. If these recommendations are not adopted, the HGM Guidebook should state why non-wetlands were excluded from the reference data set and the potential ramifications of doing so. If non-wetlands were a part of the data set, then that fact should be clearly stated along with the importance for including them.

Final Panel Comment 10:
The Functional Capacity Index (FCI) for Detain Floodwater could be improved by use of channelization and flooding duration indicators and by careful consideration of the calibration of V_{FREQ}.
Basis for Comment:
The Detain Floodwater FCI model (pages 58-60) is a reasonable representation of this function, particularly in estimating potential changes to the function due to alteration. However, indicators of the extent of channelization and flooding duration might make on-site evaluations possible and improve the end user's understanding of the relationship between these indicators and floodwater detention. Channelization affects frequency and duration of overbank flow, and a variable related to channelization could be a very useful indicator (model variable) for representing flooding frequency. In fact, channelization disconnects a floodplain wetland from its main source of water (the channel); thus, channelized streams rarely or never overtop their banks, and frequency of flooding becomes zero. The variables V_{FREQ} and V_{DUR} (used in other functions) are designed to measure the effects of alterations such as channelization, but they are not straightforward, site-level indicators like degree of channelization because models and/or external data are required to calculate their values. Flooding duration is an important indicator of a floodplain's capacity to store and reduce the velocity of floodwater as it moves through the floodplain, two important characteristics identified for the Detain Floodwater function. Impediments to flow on the floodplain surface (logs, ground cover, woody vegetation density) are modeled as factors that increase the capacity of the floodplain to slow flow (detain floodwater), presumably because flooding duration is difficult to quantify in a rapid assessment procedure. However, a change (deflection from normal) in flooding duration (V_{DUR}) is used as a model variable in some functions (e.g., plant and wildlife models) and for some wetland subclasses (Table 9, page 112). V_{DUR} "is intended to reflect changes in function that result where changes in growing season hydrology have occurred or are expected to occur as a result of levees, drainage, impoundments, or other engineering projects" (page 118). Where flooding duration cannot be calculated or is not available, the end user is instructed to assume no change (thus giving V_{DUR} a value of 1.0). Thus, the protocol provides a placeholder for V_{DUR}, with the realization that determining deflection from normal flooding duration is difficult to determine using a rapid assessment procedure. It seems that changes in flooding duration should also be used in the Detain Floodwater function when appropriate data are available, particularly since V_{DUR} was "structured specifically to accommodate the type of hydrologic information generated in the Corps project planning process" (page 118). Because the reference standard (baseline) condition is the mid-20th Century condition (i.e., after Mississippi River flood control projects), the way V_{FREQ} is scored in the Detain Floodwater function could potentially cause a problem with the resulting FCI scores if hydrologic restorations are designed to mimic pre-20thCentury conditions. For example, if restoration causes a large change in the "return interval group" for V_{FREQ} because the

hydrologic mimics flooding regimes prior to mid-20th century flood control projects, the resulting FCI might show a negative environmental impact rather than the planned beneficial one. Therefore, the calibration of V_{FREQ} should be examined regarding how it might affect post-project projections associated with the New Madrid/St. Johns project. It is possible that the HGM approach would not be appropriate for predicting post-project conditions for such projects.

Significance – Medium:

Without on-site indicators of flooding frequency and duration, the ability of the Detain Floodwater model to link on-site condition with the ability of a floodplain to detain water is limited and the accuracy of the outputs is lower; including these indicators in the model would improve the utility of model outputs for planning projects.

Recommendations for Resolution:

To resolve these concerns:

1. Consider using indicators of channelization (e.g., intensity of channelization: depth of channel, height of levees) in the Detain Floodwater FCI.
2. Incorporate a flooding duration variable (e.g., based on regional curves, unless affected by backwater flooding) as a potential model subindex for the Detain Floodwater function. The variable could replace the field indicators of flooding duration used in the model if data are available to show that flood duration was being deflected from normal conditions.
3. Determine how the current calculation of V_{FREQ} might affect post-project projections for large-scale hydrologic restoration projects that return flooding regime to conditions prior to the mid-20th Century baseline condition and consider how the V_{FREQ} subindex calibration would be appropriate for such situations.

Final Panel Comment 11:

The Functional Capacity Index (FCI) for Detains Precipitation could be improved by changing how V_{POND} and V_{LITTER} are measured.

Basis for Comment:

The Detains Precipitation FCI model (pages 61-62) is a reasonable representation of a site's ability to detain precipitation. However, the methods for measuring the variables may pose a problem with repeatability and may miss removal of ponding that is evident. For the model variable V_{POND} (page 124), estimating percentage of a wetland assessment area (WAA) that is ponded is imprecise (unlikely to be repeatable), particularly since WAAs and depressions vary so widely in size.

The fact that the V_{POND} variable (page 69) is calibrated to underlying geology is helpful, and the fact that the variable constitutes 50% of the FCI score is reasonable. However, although V_{POND} was described as focusing on the *removal* of microtopography, the variable is measured as *coverage* of ponded area. (Removal of storage is assumed if ponding coverage is less than reference standard coverage.) An estimate of depressional storage would not measure a removal of storage (e.g., due to fill) that might be evident. An alternative to estimating coverage would be to more directly measure the amount of ponding removed (usually by fill), since measuring coverage alone might not be sensitive enough to depict alteration, except in the most severe cases (e.g., burial by fill or land leveling).

The model variable V_{LITTER} (page 62) would likely vary spatially and temporally (as indicated on page 62). Guidance in the guidebook suggests excluding the variable if measurement is problematic. However, considering that the variable is so spatially and temporally variable, it is probably not a very good predictive indicator of condition. In contrast, tree basal areas (V_{TBA}) could be used as a surrogate for litter in forested wetlands because there is a positive relationship between tree biomass and the litter it produces.

Significance – Medium:

Lack of precision in the way V_{POND} and V_{LITTER} input variables are currently measured limits the accuracy and performance of the Detains Precipitation FCI model.

Recommendations for Resolution:

To resolve these concerns, the Delta Region of Arkansas Regional HGM approach would need to:

1. Directly measure alterations to depressional storage. If percent area ponded is required, then precision (repeatability) would be increased by using the midpoint of cover categories, for example (midpoints in parentheses): 0-5% (2.5%), 5-25% (15%), 25-50% (37.5%), 50% (50%), 50-75% (62.5%), 75-95% (85%), 95-100% (97.5%), 100% (100%).
2. Consider eliminating the variable V_{LITTER}, and using V_{TBA} in its place.

Final Panel Comment 12:
The Functional Capacity Indices (FCIs) for Cycles Nutrients and Export Organic Carbon could be improved by changing the use or measurement of V_{SSD}, V_{GVC}, V_{OUT}, and V_{TBA} in the FCI calculation.
Basis for Comment:
Both models essentially use the same variables, except that a hydrologic component is a part of the export model and V_{AHOR} is replaced by V_{LITTER} in the Export Organic Carbon model. The Cycles Nutrients FCI model (pages 62-65) and Export Organic Carbon FCI model (pages 65-67) reasonably represents nutrient cycling and carbon export, respectively, by incorporating indicators of living and detrital biomass, a precedent established by other HGM approaches. However, selectively using only the most predictive model variables, and realistically weighting them in the FCI equations, would improve the performance of the models and make them sensitive to alterations. Although many components of living and detrital biomass are useful indicators, aboveground tree biomass (V_{TBA}) constitutes 99.6% of total aboveground biomass in mature riparian forests in North Carolina based on published regression equations for tree species, derived regression equations for shrubs and saplings, and organic carbon content of groundcover (Brinson et al. 2006). Therefore, shrub/sapling density (V_{SSD}) and ground vegetation cover (V_{GVC}) are likely of limited value as model variables for indicating living biomass. Percent contributions of detrital biomass in the Brinson et al (2006) study were 37% for litter, 49% for soil organic matter, 4% for woody debris adjusted for the density of five decay data classes, and 10% for snag. These percentages will vary somewhat among forested wetlands, and belowground root biomass (probably correlated best with tree biomass) was not included; but these percentages can provide some guidance for more realistically weighting model variables, rather than weighting every variable the same, as is the currently done for the models. By not emphasizing the overwhelming importance of tree biomass (V_{TBA}) to total forest biomass, the Cycles Nutrients model might show a more rapid rate of recovery during restoration than is warranted. For example, a site in early stages of restoration might not have any canopy-sized trees, but will have a well-developed understory. Such sites might then have higher FCI scores than is warranted. Also, although variables mathematically associated with V_{TBA} in the models might simply be redundant (i.e., they should be highly correlated with V_{TBA}), under some situations the importance of V_{TBA} could be diluted by those variables. For example, if a mature swamp were very wet, shrub/sapling density and ground vegetation cover might be naturally low (e.g., in a cypress-tupelo swamp). This could lead to a wetland assessment area (WAA) having lower FCI scores than would be warranted. Alternatively, a successional swamp might have dense understory and few canopy trees, thus leading to a higher FCI score than is warranted. For V_{OUT} (page 123), the field procedure identifies impediments to flow and additional inputs of water as alterations in headwater depressions. Another potential (and perhaps common) alteration would be ditching or other drainage activities that remove water

more quickly and lower the water table. Indicators of drainage should be considered as an additional type of alteration to V_{OUT}.
Significance – Medium:
Using models variables that are of poor predictive power make the models that use them less predictive and sensitive to alteration, and dilute the effect of more predictive variables.
Recommendations for Resolution:
To resolve these concerns for the Export Organic Carbon and the Cycles Nutrients models: 1. Eliminate the model variables V_{SSD} , V_{GVC} , and V_{WD}. 2. Adjust the FCI models to reflect the overwhelming importance of canopy tree biomass. 3. Adjust the relative weights of detrital components to more realistically reflect their contribution to organic carbon. 4. Add indicators of drainage activities as an additional alteration to V_{OUT}

Final Panel Comment 13:
The Functional Capacity Index (FCI) for Provide Habitat for Fish and Wildlife could be made more robust by using fewer subindices in its calculation.
Basis for Comment:
The Provide Habitat for Fish and Wildlife FCI model (pages 69-73) incorporates all the potentially useful indicators for the function, but doing so makes the model unnecessarily complex. The hydrologic and landscape portions of the model are suitable for indicating habitat condition, but the number of variables in the forest structure and detrital components reduces the potential robustness of the model. As forests mature, they produce snags and large down wood, build soil organic matter, and increase the number of strata (to a maximum value). Thus, forest structure measured by tree basal area (V_{TBA}) greater than some diameter threshold (e.g., >15 cm diameter at breast height [dbh]) could be used as a mega-indicator of forest structure, since canopy tree basal area incorporates information available in V_{STRATA}, V_{SNAG}, V_{LOG}, and V_{OHOR}. The importance of canopy tree basal area, an indicator of living and detrital forest structure, is diluted by the weaker and covarying indicators for number of strata, number of snags, volume of down wood, and soil organic matter. Including a greater number of variables reduces the robustness of the model. This is particularly true of V_{SNAG} and V_{LOG}, which are patchily distributed in most forests and so would likely be imprecisely measured.
Significance – Medium:
A proliferation of model variables, incorporating weak and strong variables, dilutes the effect of the stronger variables in the function models when the variables are weighted equally, making the model less robust.
Recommendations for Resolution:
To resolve these concerns: 1. Consider using V_{TBA} of trees greater than some threshold size that represents canopy individuals (e.g., >15 cm dbh) as a variable in the Provide Habitat for Fish and Wildlife FCI. 2. If the first recommendation is adopted, consider eliminating the use of V_{STRATA}, V_{SNAG}, V_{LOG}, and V_{OHOR} in the FCI equation.

Final Panel Comment 14:
The Hydrogeomorphic (HGM) Guidebook should include references to easily-obtainable case studies that apply this method.
Basis for Comment:
The model reviewers suggest that the guidebook should include examples of the proper use of the model, how the model has been applied elsewhere, what sort of output values have been obtained, and how these have been used to make management decisions. It should be possible for potential users better understand how the model has been applied elsewhere in several well-documented case studies. These studies should be cited early on in the HGM Guidebook and should be easily accessible to potential users. References to articles in journals or book chapters are a first step, but providing URLs for links to on-line studies would provide more rapidly accessible information.
Significance – Medium:
Lack of example case studies for the application of the Regional HGM approach limits the user's ability to fully comprehend how the approach can be applied.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional HGM Guidebook would need to be expanded to include: 1. Citations to a set of case studies that have applied these methods. 2. Assurance of the on-line availability of these documents on an appropriate public web site.

Final Panel Comment 15:
Some field measurement approaches should be improved to improve the precision (repeatability of measurements) of variables in the models.

Basis for Comment:

Field methods for various field measurements should be either improved or explained more clearly. Some field measurements should be considered for removal because they are likely to be imprecise (not repeatable among users due to the subjectivity of the measurements). Potentially problematic variables and methods are discussed below.

1. The data form for calculating V_{TCOMP} and V_{COMP} (page B5) shows that *Quercus falcata* and *Ulmus americana* are listed in Column B as disturbance indicator species. Model reviewers note that these two species should represent reference standard conditions.
2. The method for determining percent tree cover is unnecessarily subjective. When measuring basal area with an angle gauge (Bitterlich stick, prism, Relaskop), each tree "counted" (eligible stems) needs to be identified by species to get an indicator of relative dominance (i.e., relative basal area is a good estimate of relative cover or dominance). The angle gauge biases the outcome slightly by including some understory trees too, but understory stems would rarely be counted and so they would not affect the outcome using the 50/20 rule. Counting understory stems could be avoided by only recording trees (by species) if they were larger than some critical diameter. For example, if only trees greater than 15 cm diameter at breast height [dbh] were counted, all trees would be canopy size and measuring them would provide an objective, consistent, and unbiased determination of relative dominance. Restricting V_{TBA} to basal area of canopy-sized trees would likely not affect the calibration already provided for V_{TBA} and it would have the added advantage of providing an unbiased estimate of relative dominance, by species, for canopy trees. The variable V_{COMP} could still be estimated for sites with <20% cover, but estimating dominance for such sites would be easier than it would be in fully stocked stands (where subjectively estimating cover might bias results). The guidebook states that a 10-factor English angle gauge is the most appropriate tool for measuring basal area (page 113, 127). However, a 2-factor SI angle gauge is comparable to a 10-factor English gauge and would provide a direct measure of basal area in m^2/ha(when multiplying counts by 2). Using the SI prism would reduce the likelihood of error when converting English units (ft^2/acre) to the SI units (m^2/ha) needed for obtaining the index for V_{TBA}.

The following variables have the highest potential to be imprecise: V_{COMP}, V_{TCOMP}, V_{POND}, V_{WD}, V_{LOG}, V_{LITTER}, and V_{SNAG}. These seven variables are either subjectively measured, can be difficult to measure, or vary widely in space and/or time

Significance – Medium:

Field measurements that do not generate repeatable results could cause FCI scores to vary among users, thus reducing the model's usability and the level of performance.

Recommendations for Resolution:
To resolve these concerns,: 1. Consider using more objective methods to measure V_{TCOMP}, V_{COMP}, and V_{TBS}, such as those suggested in the Basis for Comment. 2. Reduce the relative weights of or eliminate the variables V_{LITTER}, V_{SNAG}, V_{LOG}, and V_{WD} (which tend to vary widely in space and/or time), thereby reducing their relative effect on the models that incorporate them.

Final Panel Comment 16:
At the beginning of the document, a clear statement needs to be provided about how the guidebook is intended to support decisions made by regulators and managers and how the guidebook supports that purpose.
Basis for Comment:
It is not clear whether the Hydrogeomorphic (HGM) Guidebook is meant exclusively for state and federal agency personnel or for a wider audience. A manager or engineer needs to be provided succinct information about how the HGM approach works and how they can use it for their projects. Since the HGM approach has been in use for over a decade, the model review panel notes that there must be many examples that can be cited in the document or provided in an appendix.
Significance – Low:
Not providing a clear statement regarding how the HGM approach is intended to support decision-making can lead limits understanding about the target audience and the potential application of the models by the potential user community.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional HGM Guidebook would need to be expanded to include: 1. Statements early in the Introduction that the process entails the following steps: - Documentation of the project's assessment purpose and characteristics - Collection of field data from assessment areas - Summarizing assessment results by transforming field data to subindices and combining these into Functional Capacity Indices (FCIs). - Multiplying FCIs by area to obtain FCUs. - Application of assessment results 2. Statements that the process will take data measured in the field (independent variables) and predict a FCI number from 0-1 (dependent variables) for each of six wetland functions for each wetland assessed. 3. A description of how these FCIs can be used to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. Specific examples of how the HGM approach and the FCIs have been applied in actual projects should be provided in an appendix. 4. The reference set in an appendix, including locations of reference sites, particularly any well-known regional examples of reference standard sites. By including this information, users could better understand the natural and anthropogenically-mediated variation of the subclass and visit reference field sites if needed.

Final Panel Comment 17:
The Hydrogeomorphic (HGM) Guidebook should explain why some functions commonly included in HGM assessments were not chosen for this HGM assessment method.
Basis for Comment:
The HGM Guidebook notes the six functions included in the HGM Guidebook were developed during a workshop in Arkansas in 1997. It provides adequate discussion regarding why these particular six functions were chosen. Other HGM documents and Guidebooks identify anywhere from 8 to 15 functions. Why other functions commonly included in HGM assessments were not chosen for this one is not explained.
Significance – Low:
Not providing an explanation of why functions typically used for other HGM approaches are not used for this approach does not affect the technical quality or comprehension of the approach, but it does reduce the quality of the documentation of the approach.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional HGM Guidebook would need to be expanded to include an explanation of why wetland functions commonly used in other HGM approaches were not included.

Final Panel Comment 18:
The Hydrogeomorphic (HGM) Guidebook should summarize the assumptions implicit in its approach, including those pertaining to the Functional Capacity Index (FCI) models.
Basis for Comment:
Assumptions are stated throughout the HGM Guidebook, but they are never summarized in one place. In addition, very few of the HGM Guidebook's assumptions are supported by literature citations or data.
Significance – Low:
Lack of a summary of assumptions affects the technical quality of the model documentation but will not affect the performance of the model.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional HGM Guidebook would need to be expanded to include a complete list of assumptions and scientific justification to support the assumptions.

Final Panel Comment 19:
The descriptions of some model variables needs to be more clear, consistent, and complete.
Basis for Comment:
Inconsistencies in naming variables are confusing, i.e., giving different names to the same variables in different functions. 1. Terminology for V_{LITTER} should be reconciled throughout the hydrogeomorphic (HGM) Guidebook, i.e., V_{LITTER} is referred to as both litter thickness (page 62) and litter cover (page 122). (Litter cover is preferred because that is what was measured.) 2. The terminology defining the model variable V_{OHOR} is inconsistent. It is called “O horizon thickness” on page 62, 64, 66 (etc.) and “O horizon organic accumulation” on page 123. Also, on page 61, on line 7 under Rationale, “overbank” should be inserted before the word, “flooding” (end of third sentence of paragraph). 3. The terminology for V_{POND} should be made consistent; it varies throughout the HGM Guidebook (see pages 62, 68, 124 for variations). 4. The model variable V_{AHOR} is inconsistently named throughout the HGM Guidebook, A-horizon thickness (e.g., page 75), A-horizon biomass (e.g., page 62), and A-horizon organic matter accumulation (e.g., page vi, 115). 5. The variable V_{LOG} is not consistently named in the HGM Guidebook. Sometimes it is called log density, sometimes log volume, and sometimes log biomass. Log volume is the most descriptive term to use since log density was not measured and log biomass could vary widely depending on the log’s state of decay (volume was not partitioned by decay state).
Significance – Low:
Although clarifying terminology will not affect the performance of the function models, clarification would improve an understanding of the protocol by end users and minimize mistakes in application of the protocol.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional Hydrogeomorphic Guidebook would need to be revised to make sure that terminology and names of variables are consistent throughout the HGM Guidebook, particularly $V_{LITTER,}$, V_{OHOR}, V_{POND}, V_{AHOR}, and $V_{LOG.}$

Final Panel Comment 20:
The model, as designed, does not address global climate change issues as required by EC 1165-2-211 Water Resource Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs (01 July 2009).
Basis for Comment:
Current USACE guidance for planning, engineering, and design (EC 1165-2-211, July 2009) and USACE policy for plan formulation (ER 1105-2-100) indicate that the effects of sea level rise are to be incorporated into analytical methods used to support planning decisions. The model was designed to address potential changes in wetland condition that may be related to climate change, however, climate change is not incorporated into the models. As one example, the model uses changes in frequency of flooding as its main flooding variable. Changing climate will likely affect timing of floods, which is not included in the model. Another example is the shape of the subindex graphs in the Hydrogeomorphic (HGM) Guidebook is fixed. Changing climates might affect the shape of the subindex graphs. However, sea level rise and other climate change responses can be addressed external to the model.
Significance – Low:
Since the model was not designed to accomplish this purpose, it is necessary only to be aware of this limitation on its application.
Recommendations for Resolution:
1. To resolve these concerns, the Delta Region of Arkansas Regional HGM Guidebook would need to be expanded to include: 2. A discussion that the models are not designed to address effects of changing climate, particularly where these affect flood duration, flood timing, or the subindex graphs. 3. A discussion of how climate change issues could be addressed external to the model. 4. If climate change issues need to be addressed in the Delta HGM Guidebook, it would need to be expanded to examine climate change sensitivity. This could include: - Possible effects from changes in timing of flooding - Potential effects on subindex graphs - Possible changes in equation structure - Possible changes in species composition and function in reference wetlands.

Final Panel Comment 21:
The Hydrogeomorphic (HGM) Guidebook should include a table for each wetland subclass that provides a matrix of subindices and the FCI models in which they occur.
Basis for Comment:
It is often difficult to keep track of all the many functions and variables (with different standards), all used in various combinations in six wetland subclasses. It would benefit the end user if there were a matrix table for each subclass matching the subindices and the functions in which they occur (a function by sub-index matrix). These matrices would also allow users to get a general idea about how frequently each variable is used within the context of a given wetland subclass, i.e., it would provide an idea of each variable's relative importance. An estimate of a variable's relative importance, combined with an indication of its sensitivity and precision, could help users decide if the models are likely to realistically differentiate functional condition among wetlands within a subclass.
Significance – Low:
Without a matrix table showing the subindices within each FCI model, it is difficult to keep track of the variables that are included in each function.
Recommendations for Resolution:
To resolve these concerns, the Delta Region of Arkansas Regional HGM Guidebook would need to be expanded to include a matrix table of the subindices in each FCI model for each wetland subclass.

This page intentionally left blank

APPENDIX C

Specific Comments on Spreadsheets

The following issues were noted while performing the review of the following spreadsheets.

Appendix B Page #B3 - Data Form 1

HGM Variable Addressed: There is a conceptual error here – these variable names (e.g., V_{TRACT}) are used throughout to refer to subindices, not to metrics.

Indicator Value: This is the raw field data. It has been referred to before as "variable metric," or "metric," or (in the FCI/FCU spreadsheet) as "metric value." However, it is now referred to it as "Indicator Value."

Geomorphic surface (Check One): Notice that in the FCI/FCU spreadsheet these checkboxes and the single value below for V_{Pond} will be entered in one of the cells B20:B22. Here is just one instance where the paper form and the spreadsheet are inconsistent.

Appendix B Pages #B4-6 - Data Form 2

As in Data Form 1, the language used ("HGM Variable Addressed" and "Indicator Value") is confusing.

Under "Observations from the Center Point," a calculation is required that involves a conversion factor. The first paragraph says "using the appropriate conversion factor," leaving that decision up to the user. The bottom paragraph suggests using the worksheet (model reviewer assumed Alternate Data Form C1) in Appendix C. It fails to mention that the spreadsheet Basal Area Calculator can be used as well. Why there is an Alternate Data Form and a spreadsheet (which differ in formats) is unknown and confusing.

Note that the user of this form is expected to perform various calculations (presumably using a hand calculator), entering the results on the form. The form provides inconsistent assistance in this effort. In some places formatting is used to help the user enter the necessary data and the result; in others no such assistance is given. For example, under "Observations within a 0.04-HA Plot" the user is expected to calculate a complex weighted average without recording the partial results. This is a potential location where errors can occur.

Under "Observations along Transects" the user enters data that will eventually be used to calculate V_{LOG} and V_{WD}. There are three size classes; for the first two we record #stems for two transects. For size-class 3 we can record up to five entries for each of two transects. This is confusing and should be further explained.

Appendix B Page #B7 - Data Form 3

As in Data Forms 1 and 2, the language used ("HGM Variable Addressed" and "Indicator Value") is confusing.

"Transfer the data below from Data Form 1" Transferring data from sheet to sheet is prone to errors. If it has to be done this way, the model reviewer suggests that the location of the source number should be made unambiguous, perhaps with a line number (as it is done on federal tax forms: e.g., "Enter line 42 here."

"Transfer the plot data below from Data Form 2 and average all values" This requires the user to scan multiple versions of Data Form 2, one for each plot, and manually enter the values for 10 metrics, and then average them. This is another place where errors could easily occur.

"Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) …." This procedure requires the user to find Data Form 2 for Plot 1, find the data for Size Class 1 for one transect, transfer it to the appropriate cell in the Woody Debris Calculator spreadsheet, and repeat for Transect 2. Then go on to Plot 2 and repeat. Then do the same for Size Class 2, and Size Class 3. OR, accomplish the same thing by using Alternate Data Form C2, which uses a very different layout for recording the data, and requires extensive manual calculations. This form applies to just one plot, whereas the spreadsheet calculates the results for all plots. The model reviewer feels this is very confusing and believes that a simpler way can be developed.

Spreadsheet: Basal Area Calculator

Cell A3: Currently reads "Data Form 4" but should read "Data Form 3."

Alternate Data Form C1 is all in metric units but the spreadsheet is in both centimeters and inches. This should be consistent.

This spreadsheet seems to be built as a calculator, rather than for documentation. For example, there is no way to document the instance being evaluated. By contrast, Alternate Form C1 allows for Subclass, WAA#, and Plot# to be recorded. The model reviewer suggests adding fields for user, date, plot location, description, etc.

Documentation in C4:D4 is inconsistent: The model reviewer suggests using names like "tree diameter" or row/column labels like "Column C," but not both.

Cells C12:C18: These cells contain the number 0 instead of the formula required in that column.

Cells D12:D18: These cells contain the number 0 instead of the formula required in that column.

Cells D56:D59: These cells contain the number 0 instead of the formula required in that column.

Cells D56:D59: These cells contain the number 0 instead of the formula required in that column.

Cells D36 and D70: The model reviewer believes that having duplicate output cells (only one of which is to be manually copied to Data Form 3) is dangeroU.S.

Alternative spreadsheet model.
To illustrate some alternative ways of building this model, the model reviewer has provided an Excel spreadsheet entitled *Basal Area Alternative.xls* that suggests some useful features that could be incorporated. Some of its features are:

a. Cell A3: One set of instructions.
b. Cells B4:B7: User documentation.
c. Cell B8: Pull-down menu for user to specify centimeters or inches; created using Data Validation.
d. B9: Result pulled up from end of calculations to where user can easily see it.
e. Cells C13:C42: Formula uses IF function to calculate correctly for inputs in centimeter or inches.
f. Errors in formulas in existing spreadsheet corrected.

This example spreadsheet will be provided in addition to the final report as an Excel file.

Spreadsheet: Arkansas Woody Debris
Cell A2: The model reviewer noted that the instructions tell the user what to do, but not where this information comes from (Data Form 2) or where it is going (Data Form 3). It is suggested that this additional information be provided.

Output data for V_{LOG} and V_{WD} is in columns by plot in the spreadsheet but must be transposed to rows for Data Form 3. It then must be averaged. The model reviewer suggests that this be done electronically in the spreadsheet.

Spreadsheet layout:
This sheet is laid out as if it were a paper form. Color coding is used to try to separate modules where white space and blank rows and columns would work better. Separate Size Classes 1, 2, and 3 physically and give instructions for each. Note that Size Class 3 uses a completely different format from the previous two Size Classes. The model reviewer suggests that this be laid out across one row rather than two.

Isolate parameters:
One of the basic principles of good spreadsheet design is to isolate parameters outside of formulas. Thus, formulas themselves should contain no numbers (except, perhaps, 1 and 3.14159). The model reviewer suggests that the following numbers should be removed from the formulas, placed in a *single* cell location, and referred to using cell references: 0.1866, 0.892, 0.3937, 0.0687, 32.5, 0.58, and 0.07. Also, each of these parameters should be documented. This would make the spreadsheet easier to audit and would reduce the chances for errors.

Cells C15:D24: It is unclear to the model reviewer why these cells convert diameters in centimeters into diameter^2 in inches. The result is in metric units so it is unclear why the users would not want to keep the data in metric units throughout. Tons/acre in Size Classes 1 and 2 are in English units. The model reviewer suggests using one set of units throughout to simplify the calculations.

Suggested redesign:
The model reviewer suggests redesigning this spreadsheet so that the user can enter the inputs and read off the outputs. Everything else should be moved out of the way. The user (as far as the model reviewer can tell) has no interest in the intermediate calculations that clutter up the current design. The model reviewer suggests the following:

a. Take all the input cells and collect them in one module.
b. Copy the outputs (yellow cells) so they are alongside the inputs for easy reference.
c. Move the intermediate calculations to a separate module.
d. Stay in metric units throughout.
e. Isolate parameters and document.

Alternative spreadsheet model.
To illustrate some alternative ways of building this model, the model reviewer has provided an Excel spreadsheet entitled *Arkansas Woody Debris Alternative.xls*.

Spreadsheet: Delta FCI Calculators
Use of multiple sheets:
The overall output of this workbook should be two seven by six cell tables: one for the FCI values by subclass and function; the other for FCU values, also by subclass and function. This workbook uses nine sheets, one each for the six subclasses in the Delta, plus three duplicates for alternative methods. The various FCI and FCU values are distributed across these sheets and should be pulled together into the two tables described above. This could be accomplished by combining all nine sheets into one, or by retaining the nine sheets but creating a single OUTPUT worksheet with the two tables. This would also reduce a great deal of duplication across the sheets. The model reviewer has provided an Excel spreadsheet entitled *Delta FCI Calculator Alternative.xls* to demonstrate how these ideas could be implemented.

Cell A7: Data Form 4 should be Data Form 3.

Cells C10:C31: Listing the units in which the inputs in Column B should be given is a good idea. However, using “%” is ambiguous and could result in incorrect values being entered (e.g., “five percent” could be entered as 5 or 0.05, or 5%). The model review suggests changing “%” to “%: i.e., 5% or 0.05.”

Cells D10:D31: These cells use very complex IF statements, such as the following:

=IF(ISBLANK(B10),"invalid entry",IF(CELL("type",B10)="l","invalid entry",IF(B10<0,"invalid entry",IF(B10>=6,0.5,IF(B10>=4,2+(-0.25*B10),IF(B10>=2,1,IF(B10>=0,0.5+(0.25*B10))))))))

This formula does two different things: 1) it checks for invalid data entry in cells B10:B31; and 2) it transforms the metric values into subindex values using the piece-wise linear functions described in the report. The model reviewer has three suggestions for improving these IF functions:

1. Use Data Validation to enforce valid inputs and warn the user when data requirements are violated.
2. Remove the numbers in the formulas to a separate location where they can be documented.
3. Write the IF statement in a repeating form to reduce errors and ease auditing.

1. Data Validation is a tool in Excel (on the Data ribbon in Excel 2007) that allows the user to require certain values in a cell or range. Here the model reviewer believes the designer would want to require that the inputs in B10:B31 be Whole Numbers between a Minimum (usually 0) and a Maximum (the maxima would be specific to the subindex function, for example, 6 in the case of the V_{AHOR}). The designer could also insert a warning message that would appear on the screen whenever a user entered an invalid input.

Removing the data validation task from the IF statements accomplishes two things: it removes the first several tests for invalid entries, and it allows the range numbers to be removed from the formula.

2 and 3. Another problem with the existing IF statements is that the subindex function values are embedded in them. This is always a poor practice, as it makes errors highly likely and makes the formula very difficult to audit. A better approach would be to enter the subindex functions as data in a separate part of the spreadsheet and then use cell references in these formulas to that data. This is difficult to describe in words. The model reviewer has provided an Excel spreadsheet entitled *FCI-FCU Demonstration.xls* as a sample of this implementation. The subindex function for V_{AHOR} is shown in table form in cells C4:D7 and plotted to the right. In cells C23:D37 the model review has plotted this function for a range of inputs. See the IF statement in cell D23. This looks complex at first blush, but it has two advantages over the one in the current spreadsheet: all the input numbers are taken via cell references from the table above, and the functional form of each IF is identical: if the input is in the following range, interpolate the subindex value between the low and high values in that range.

Alternate Data Form C1:

As stated above, this form is not consistent in layout with the spreadsheet alternative, which could cause confusion. For example, it uses “dbh” while the spreadsheet uses "diameter." Also, the form is entirely in metric units, while the spreadsheet allows for both metric and English units.

The form is laid out so that Column 4 appears twice, and the user is expected to sum the values in *both* Column 4s to get the total basal area. It would be an easy mistake to leave out the first Column 4. And having users do the calculations of squaring a column of diameters, multiplying by a constant (0.00196), and then summing seems pretty archaic in the age of spreadsheets.

A value like 0.00196 should be documented. The model reviewer eventually figured out that it is 3.14159*0.0001*25/4, but that's a lot to ask of a user.

Alternate Data Form C2:
This is a manual alternative to the Woody Debris spreadsheet. As with Alternate Data Form C1, the manual form and the spreadsheet are designed on completely different patterns. While the spreadsheet performs all calculations for Class Sizes 1, 2, and 3 for two transects and multiple plots, here a separate sheet is devoted to each plot.

To use this sheet requires finding transect data on Data Form 2, transferring it to this form, carrying out some algebra, and then transferring the results to Data Form 3. The model reviewer believes this will be prone to errors.

APPENDIX D

Additional Suggested Edits

The model review panel provides these additional specific comments regarding typographic errors, suggestions for clarity, and inconsistencies:

(pages 40, 44) Loblolly pine flats are probably successional communities of hardwood and oak flats and not a separate subclass.

(pages 56, 57, 59) Three changes to the introduction to Chapter 4 are needed: (1) page 56, behind “a. Flat,” add “(non-alkali),” (2) page 57, 2nd ¶, change “seven functions” to “six functions”, and (3) page 59, end of 1st ¶, change “are consistent” with “vary little.”

(page 61, line 7 under Rationale) The word “overbank” should be inserted before the word, “flooding” (end of third sentence of paragraph).

(page 63) Beginning sentence under “Rationale” should read, “In fully functioning wetlands,” and last sentence before “General form of the model,” “for a rapid assessment approach” should be replaced with, “and is a relatively minor component of biomass.”

(page 67) The top sentence on page 67 should be broken into two sentences, i.e., “…relative immobility. In addition, flooding...”

(page 116) The second sentence (¶ 1) starting with “Note that” should be deleted because it repeats the last sentence at the end of page 115. For V_{CORE}, Figure 29 needs a scale (e.g., 100m) and the 100m buffer line should be shown for the region to the right of the purple wetland boundary. A dashed line denoting the buffer boundary on the right side would be helpful. The core area and the wetland area outside the core area should be labeled (e.g., A1 and A2, respectively).

(page 116, end of first paragraph and page 129, end of section 3) The words, “get help” should be changed to “get assistance from someone who can.”

(page 117, Figure 28) Although the landscape variables are useful indicators for the wildlife model, the methods and illustrations for calculating them are confusing in places. Fig. 28 needs a scale (e.g., 500m) to show that the purple line running between the thick green line is indeed >500m from the forest edge. The caption could be expanded to identify the length (in meters) of total forested wetland tract boundary (purple line), the connected forested wetland tract boundary (thick green line), and the % of connected wetland tract boundary. These changes would clarify how the variable is calculated.

(page 117) The $V_{CONNECT}$ explanation in the narrative needs clarification to be consistent with part (3). Under part (1), sentence 1, “total” should be inserted before “forested” and “(purple line, Figures 25 and 28)” should be appended to the end of the sentence. Under part (2), sentence 1, “connected” should be inserted before forested and “(thick green line, Figure 28)” should be appended to the end of the sentence.

(page 117, 118) The narrative accompanying Fig.29 needs improvement for clarification. Under V_{CORE}, ¶ 1, line 6, “contiguous forested wetlands” should be changed to “contiguous forests (upland and wetland).” Under part (1), append “(dashed line in Figure 29)” to the end of the last sentence: Under part (2), append “(A1, Figure 29)” (or some other appropriate label for metric A1) to the last line. Under part (3), second line, insert “total” before “wetland tract.”

(page 118) Figure 29, the caption should include, “V_{CORE}= (A1/(A1+A2)*100 (if A1 and A2 are used to designate portions of core area).

This page intentionally left blank

ATTACHMENT A

Revised Final Work Plan

This page intentionally left blank

Battelle
The Business of Innovation

US Army Corps of Engineers

REVISED FINAL WORK PLAN
INDEPENDENT EXTERNAL PEER REVIEW
for
Certification of Four Ecological Models: EnviroFish, Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, Waterfowl Assessment Methodology (WAM), and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Prepared for
U.S. Army Corps of Engineers
Ecosystem Planning Center of Expertise

Contract No. W911NF-07-D-0001
Task Control Number: 09-210
Delivery Order Number: 0799

October 8, 2009

This page intentionally left blank.

REVISED FINAL WORK PLAN

Independent External Peer Review
for
Certification of Four Ecological Models:
EnviroFish, Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, Waterfowl Assessment Methodology (WAM), and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook

Submitted to:

Department of the Army
U.S. Army Corps of Engineers
Ecosystem Planning Center of Expertise

Contract No. W911NF-07-D-0001
Task Control Number: 09-210
Delivery Order Number: 0799

Prepared by:

Battelle
505 King Avenue
Columbus, OH 43201

October 8, 2009

Battelle
The Business of Innovation

This page intentionally left blank.

Table of Contents

List of Tables

This page intentionally left blank.

REVISED FINAL WORK PLAN
Independent External Peer Review
for
Certification of Four Ecological Models:
EnviroFish, Waterfowl Assessment Methodology (WAM), Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook

General Project Information

- Project Title: Independent External Peer Review (IEPR) for Model Certification for Four Ecological Models: EnviroFish, Waterfowl Assessment Methodology (WAM), Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley, and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook (Four Ecological Models Review).
- Project Number: TG/G898592
- Client: U.S. Army Corps of Engineers, Ecosystem Planning Center of Expertise
- Effective Date of Work Plan: September 8, 2009
- Version Number: 1
- Project Manager: Karen Johnson-Young
- Deputy Project Manager: Amanda Maxemchuk
- Deliverable Due Dates: Draft Work Plan: October 1, 2009; Final Work Plan: October 8, 2009; Draft Charge: October 1, 2009; Final Charge: October 8, 2009; List of Peer Reviewers: October 16, 2009; Draft Model Review Reports: (A) January 5, 2009, (B) March 1, 2010; (C) February 3, 2010; (D) February 3, 2010; Final Model Review Reports: (A) January 22, 2010; (B) March 17, 2010; (C) February 22, 2010; (D) February 22, 2010
- Period of Performance: September 8, 2009 – April 30, 2010

1.0 Background, Objectives, and Scope of Work

1.1 Background

Planning models are defined as any models and analytical tools that planners use to define water resources management problems and opportunities, formulate potential alternatives to address the problems and take advantage of the opportunities, and evaluate potential effects of alternatives and to support decision-making. The United States Army Corps of Engineers (USACE) Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of planning models in the USACE and to make recommendations to assure that high quality methods and tools are available to enable informed decisions on investments in the Nation's water resources infrastructure and natural environment. The main objective of the PMIP is to carry out a process to review, improve and validate analytical tools and models for USACE Civil Works business programs. The PMIP Task Force collected the views of USACE leaders and recognized technical experts, and conducted investigations and numerous discussions and debates on issues related to planning models. This task force identified an array of model-related problems, conducted a survey of planning models, prepared papers on model-related issues, analyzed numerous options for addressing these issues, and formulated recommendations.

Use of certified models for all USACE planning activities is mandatory. This policy is applicable to all planning models currently in use by USACE, as well as models under development and new models. District Commanders are responsible for providing high quality, objective, defensible, and consistent planning products. Development of these products requires the use of tested and defensible models. National certification of planning models will result in significant efficiencies in the conduct of planning studies and enhance the capability to produce high quality products. The appropriate USACE Planning Center of Expertise (PCX) will be responsible for model certification. The goal of certification is to establish that USACE planning products are theoretically sound, compliant with USACE policy, computationally accurate, based on reasonable assumptions, and are in compliance with the requirements of the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* (Federal Register Vol. 70, No. 10, January 14 2005, pp 2664-2677). The use of a certified model does not constitute technical review of the planning product. Independent technical review of the selection and application of the model and the input data is still the responsibility of the users. Once a model is certified, the PCXs will work with model developers and managers to ensure that documentation and training in model use are available and that model updates comply with certification requirements.

The primary criterion identified for model certification is technical soundness. Technical soundness reflects the ability of the model to represent or simulate the processes and/or functions it is intended to represent. The performance metrics for this criterion are related to theory and computational correctness. In terms of the theory, the certified model should: 1) be based on validated and accepted "state of the art" theory; 2) incorporate USACE policies and requirements; 3) properly incorporate the conceptual theory into the software code; and, 4) clearly define the assumptions inherent in the model. In terms of computational correctness, the certified model should: 1) employ proper functions and mathematics to estimate functions and processes represented; and, 2) properly estimate and forecast the actual parameters it is intended to estimate and forecast. Other criteria for certification are efficiency, effectiveness, usability, and clarity in presentation of results. A certified model will stand the tests of technical soundness based on theory and computational correctness, efficiency, effectiveness, usability and clarity in presentation of results.

1.2 Objectives

The objectives of this work are to conduct a review for the USACE Ecosystem Planning Center of Expertise (ECO-PCX) to evaluate the technical quality, system quality, and usability of the following models in accordance with *Planning Models Improvement Program: Model Certification* (EC 1105-2-407, dated May 31, 2005) and the *Protocols for Certification of Planning Models* (July 2007), with the goal of certifying each model for use within the geographic area specified in the model documentation.

Model A EnviroFish Functional Reproductive Habitat Model

Model B Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley
Model C Waterfowl Assessment Methodology (WAM)
Model D Delta Region of Arkansas Regional HGM Guidebook

The review will not include a technical evaluation of the application of these models on a specific project. However, sample documentation of model application may be provided for informational purposes.

The general objectives of this work are to: a) prepare a work plan that will describe the process for conducting the model certification reviews of the four ecological models, b) identify potential panel members for the external peer review panel, and c) execute the work plan to conduct the model certification review.

1.3 Scope of Work

As a 501(c)(3) nonprofit science and technology organization with experience in establishing and administering peer review panels for USACE, Battelle was engaged to conduct the Model Review of the Four Ecological Models. Independent review ensures the quality and credibility of USACE planning tools. The Model Certification Review will follow the procedures described in the Department of the Army, USACE guidance entitled *Planning Models Improvement Program: Model Certification* (EC 1105-2-407), dated May 31, 2005, and the PMIP document entitled *Protocols for the Certification of Planning Models*, dated July 2007.

To accomplish the model certification review, subject matter experts will be recruited to participate on the peer review panel. Potential candidates for the peer review panel will be screened for availability, interest, and technical experience in defined areas of expertise and any actual or perceived conflicts of interest (COIs) will be determined. Ultimately, no more than 12 total panel members will be selected for the model certification review panels using predetermined criteria related to technical expertise and credentials in the subject matters related to the documents and materials to be reviewed. The following is a list of documents and reference materials that will be provided to the panel members for the review.

1. EnviroFish User Manual
2. EnviroFish Software
3. EnviroFish model code
4. Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley documentation
5. Habitat Model for Migrating Shorebirds communications
6. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley, including HGM spreadsheets (Appendix D) and spatial data (Appendix E)
7. Waterfowl Assessment Methodology (WAM), also called the Duck-use-day Model

2.0 Methods and Technical Approach

One of the initial steps in the review process is to prepare a detailed work plan (this document) under Task 2. Additional tasks are detailed below in Section 2.0 (this section). The tasks described are based on the key tasks defined and described in detail in the USACE Model Certification For Four Ecological Models: Envirofish, Waterfowl Assessment Methodology (WAM), Migrating Shorebird Habitat Suitability Index Model, and the Delta Region of Arkansas Hydrogeomorphic Methodology (HGM) Guidebook Statement of Work (SOW). All tasks for the reviews shall be performed independent of government supervision, direction, or control.

Task 1: Kick-off Meeting.
Battelle will hold a kick-off teleconference with the PMIP team and representatives from the ECO-PCX. The purpose of the kick-off is to review the schedule, discuss the model review process, and address any questions regarding the scope, review documents, or required panel member expertise. Battelle will review the model documentation provided with the SOW and, based on a comparison with Table 2 of the USACE *Protocols for the Certification of Planning Models*, determine if additional information will be required to conduct the model reviews. A plan for the ECO-PCX providing the additional information required will be developed at this kick-off meeting.

Task 2: Work Plan.
Battelle will prepare a draft and final work plan (this document) that describes the process for conducting four separate and consecutive model reviews, including the screening criteria and process for selecting model review panel members, the schedule, charges to model review panel members (including charge questions), the process for conducting the reviews and drafting and finalizing four reports that summarize the results of each model review, communication and meetings with the USACE project team, and quality control. Battelle will also conduct a cursory review of each model to determine the level of effort required for panel members to conduct their reviews.

USACE has provided comments on the draft work plan and draft charge questions. Battelle has consolidated and address all comments in this final work plan, which was submitted within three (3) working days of the receipt of comments.

Task 3: Prepare and Finalize Charge to Reviewers.
Battelle will prepare and finalize the charge to each model review panel based on technical direction received from USACE and guidance provided in Department of the Army, U.S. Army Corps of Engineers EC No. 1105-2-407, *Planning Models Improvement Program: Model Certification*, dated 31 May 2005, and *Protocols for the Certification of Planning Models*, dated July 2007.

The process and evaluation criteria for the review, as outlined in the *Protocols for Certification of Planning Models* (July 2007), may include any or all of the following steps:

1. Panel members determine whether project needs/objectives are clearly identified and whether the model described is meeting those needs/objectives.

2. Panel members evaluate the technical quality of the models (review of model documentation).
    a. Model is based on well-established contemporary theory.
    b. Model is a realistic representation of the actual system.
    c. Analytical requirements of the model are properly identified and the model addresses and properly incorporates the analytical requirements.
    d. Assumptions are clearly identified, valid, and support the analytical requirements.
    e. USACE policies and procedures related to the model are clearly identified, and the model properly incorporates USACE policies and accepted procedures.
    f. Formulas used in the model are correct and model computations are appropriate and done correctly.
3. Panel members evaluate system quality (review by running test data sets or reviewing the results of beta tests).
    a. Rationale for selection of supporting software tool/programming language and hardware platform is adequately described, and supporting software tool/programming language is appropriate for the model.
    b. Supporting software and hardware is readily available.
    c. Programming was done correctly.
    d. Model has been tested and validated, and all critical errors have been corrected.
    e. Data can be readily imported from/into other software analysis tools, if applicable.
4. Panel members evaluate the usability of the model.
    a. Examine the data required by the model and the availability of the required data.
    b. Examine how easily model results are understood.
    c. Evaluate how useful the information in the results is for supporting project objectives.
    d. Evaluate the ability to export results into project reports.
    e. Training is readily available.
    f. User documentation is available, user friendly and complete.
    g. Adequate technical support is available for the model.
    h. Software/hardware platform is available to all or most users.
    i. Model is easily accessible.
    j. Model is transparent and allows for easy verification of calculations and outputs.

Each model review panel member will be provided with a charge that will guide their review of any model documentation, software, and code provided. The charge will include an assessment of the criteria listed above which are relevant to each review and ask panel members to respond to specific charge questions or directives regarding individual sections of the model document, as appropriate.

Battelle prepared a generic draft charge to the model review panels. The draft charge has been finalized based on technical direction received from USACE. The final charge is being submitted to USACE (Appendix A of this document) for final approval and distribution to the model review panel members.

Task 4: Identify Candidate Reviewers.

Screen Candidate Reviewers
Battelle will develop criteria for selecting the candidate reviewers; contact potential reviewers to evaluate technical skills, potential COIs, availability, and hourly rates; and identify up to 24 (12 primary and 12 backup) available potential experts to serve on the model review panels. The selection criteria used to identify candidate reviewers are provided in Appendix B to this work plan. Battelle will also develop a detailed COI screening questionnaire to be included in recruiting communications (Appendix C of this document). USACE will review the questionnaire, suggest changes (if needed), and approve this COI list prior to any potential reviewer receiving it.

To identify potential reviewers, Battelle will review candidates in Battelle's database of peer reviewers, seek recommendations from colleagues, contact former panel members, and conduct targeted internet searches. Preliminary information about the up to 24 potential reviewers, including brief biographical information and their responses to the COI questionnaire, will be provided to USACE as early as possible.

Specifically, the final model review panels will include members with the expertise described in Table 1 below.

Table 1. Number of Required Panel Members

Panel Member Expertise	A. EnviroFish Model	B. Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley	C. Waterfowl Assessment Model	D. HGM Guidebook
Civil Works Planner/Habitat Evaluation Procedures (HEP) Specialist	1	1	1	
Civil Works Planner/HGM Specialist				1
Programming/Spreadsheet Auditor	1			1
Fisheries Biologist	2			
Hydraulic Engineer	1			
Avian Biologist		2		
Waterfowl Biologist			2	
Wetland Ecologist				1
Forester				1
Total Number of Reviewers	**5**	**3**	**3**	**4**

Greater detail on the desired expertise for each of the panel members is presented in Appendix B of this work plan, along with the selection criteria. Each panel member will review one model, with the exception of the civil works planner/HEP specialist (who will review three models) and the programmer/spreadsheet auditor (who will review two models).

Finalize Contracts with Peer Reviewers
Battelle will identify up to 24 potential panel members and select no more than 12 final panel members according to the selection criteria. For each reviewer, Battelle will prepare a tailored scope of work that describes required panel member activities for this project. This scope of work description, along with a request for quotation and a COI inquiry form (Appendix C) will be sent to each selected peer reviewer. Upon receipt of the reviewers' written quotations indicating willingness to participate and the absence of a COI, Battelle will establish contracts with the panel members at agreed-upon rates and hours to ensure/secure participation. Each contract established also includes a non-disclosure statement.

The scope of work for each peer reviewer will consist of:

- Participation in a Battelle kick-off meeting (via teleconference)
- Participation in a USACE kick-off meeting (via teleconference) with the PDT and Battelle
- Participation in a Habitat Evaluation Procedures (HEP) training teleconference (8 panel members)
- Review and assessment of the technical quality, system quality, and usability of the Four Ecological Models and preparation of individual written comments
- Participation in a panel review teleconference to discuss findings and agree on a list of key topics/issues that will be presented in the Draft Model Certification Review Report and form the basis for the model certification review Final Panel Comments
- Preparation of the model certification review Final Panel Comments
- Review of the Draft Model Certification Review Report before it is submitted to USACE
- Review of USACE comments on the Draft Model Certification Review Report and Final Panel Comments
- Participation in a teleconference with USACE to discuss USACE's comments on the Draft Model Certification Review Report and Final Panel Comments
- Revision of the Draft Model Certification Review Report and Final Panel Comments in response to USACE comments
- Review of the Final Model Certification Review Report before it is submitted to USACE
- Provide additional technical support as directed.

Battelle has estimated the level-of-effort required for each panel member for the reviews in Table 2.

Table 2. Estimated Levels-of-Effort (hours) for Panel Members

	Kickoff Meeting	HEP short-course	A. EnviroFish Model	B. Shorebird Model	C. Waterfowl Model	D. HGM Guidebook	Total Hours
CWP/HEP Specialist	3	15	74	29	74		195

	Kickoff Meeting	HEP short-course	A. EnviroFish Model	B. Shorebird Model	C. Waterfowl Model	D. HGM Guidebook	Total Hours
Fisheries Biologists	3	3	74				80
Hydraulic Engineer	3	3	74				80
Spreadsheet Auditor	3		74			74	151
Avian Biologists	3	3		29			35
Waterfowl Biologists	3	3			74		80
CWP/HGM Specialist	3					74	77
Wetland Ecologist	3					74	77
Forester	3					74	77

Note: CWP = Civil Works Planner; HEP = Habitat Evaluation Procedures

The estimated hours listed above include time for the model review and charge question response, teleconferences, preparation of final comments and Draft Model Certification Review Report, report review, responding to USACE comments on the draft report, Final Model Certification Review Report review, and support-related activities.

Task 5 A-D: Conduct Assessment of Model.
A kick-off meeting with Battelle, the model review panel members, representatives from the USACE ECO-PCX, and Model Proponents will be held via teleconference to discuss the model certification requirements and expectations and to facilitate information exchange for each of the model reviews. One kick-off meeting will be conducted and it will cover all four model certification reviews for models A through D.

The description of the model review process in the following paragraphs applies to each of the four models being reviewed. Battelle will provide the panel members with electronic copies of the documentation for the model, software, and model code; *Protocols for Certification of Planning Models;* EC 1105-2-407, *Planning Models Improvement Program: Model Certification*; and other supporting documentation. USACE will provide these documents to Battelle via its FTP site. Battelle will prepare and deliver a memorandum instructing the panel members to undertake the review and outlining the steps and deadlines. Working with USACE, Battelle will respond to any panel member questions or information requests during the review process.

The panel members will complete their review and provide comments to Battelle. After receipt of all individual panel member comments, Battelle will merge all comments into one document and share the document with the panel members. In addition, Battelle will carefully review the comments and identify key issues/topics related to the technical quality, system quality, and usability of the model, as well as the model description and model testing. These key issues/topics identified in the merged individual comments will be distributed to the panel members.

A panel review teleconference will be convened to ensure the exchange of technical information among the panel members, many of whom will be from diverse scientific backgrounds, and to identify key issues/topics specifically associated with the technical quality, system quality, and usability of the model. The result of the teleconference will be a list of key issues/topics (i.e., findings) that the panel members agree should be presented to USACE in the Draft Model Certification Review Report (Task 7) and as final panel comments. During the teleconference, the specific wording for the final panel comment statement will be agreed upon by all panel members, and final panel comments will be assigned "high," medium," or "low" significance based on the following definitions:

- High: Describes a fundamental problem with the model that could affect the model's ability to serve the intended purpose.
- Medium: Affects the completeness or understanding of the model, model usability, or the level of performance of the model.
- Low: Affects the technical quality of the model documentation but will not affect the performance of the model.

At the end of the teleconference, Battelle will prepare a memorandum to the panel members directing them to prepare specific sections of the Draft Model Certification Review Report (Task 6) based on the findings discussion and the technical quality, system quality, and usability criteria outlined in the *Protocols for Certification of Planning Models*, July 2007. The panel members will also be directed to prepare final panel comments, each of which will include the following four parts: (1) a clear statement of the comment; (2) the basis for the comment; (3) the significance of the comment (high, medium, or low); and (4) recommendations to resolve the comment (including additional research or analysis that may influence the conclusions). The individual comments in response to the charge and the panel review teleconference notes will be used as background information to prepare the final panel comments and the Model Certification Review Report.

Task 6 A-D: Prepare Draft Certification Report.
Four separate Draft Model Certification Review Reports for models A through D will be prepared and submitted. Battelle will prepare each Draft Model Certification Review Report and submit it to USACE for review. The report will assess the degree to which the model meets the technical quality, system quality, and usability criteria outlined in the *Protocols for Certification of Planning Models*, July 2007.

The report will follow the general outline below:

1.0 Introduction

1.1. Model Purpose

1.2. Model Assessment

1.3. Contribution to Planning Effort

1.4. Report Organization

2.0 Model Description

- 2.1. Model Applicability
- 2.2. Model Summary
- 2.3. Model Components

3.0 Model Evaluation

- 3.1. Assessment Criteria
  - 3.1.1. Technical Quality
  - 3.1.2. System Quality
  - 3.1.3. Usability
- 3.2. Approach to Model Testing
- 3.3. Technical Quality Assessment
  - 3.3.1. Review of Theory and External Model Components
  - 3.3.2. Review of Representation of the System
  - 3.3.3. Review of Analytical Requirement
  - 3.3.4. Review of Model Assumptions
  - 3.3.5. Review Ability to Evaluate Risk and Uncertainty
  - 3.3.6. Review Ability to Calculate Benefits for Total Project Life
  - 3.3.7. Review of Model Calculations/Formulas
- 3.4. System Quality
  - 3.4.1. Review of Supporting Software
  - 3.4.2. Review of Programming Accuracy
  - 3.4.3. Review of Model Testing and Validation
- 3.5. Usability
  - 3.5.1. Review of Data Availability
  - 3.5.2. Review of Results
  - 3.5.3. Review of Model Documentation
- 3.6. Model Assessment Summary

4.0 Conclusions

5.0 References

The final panel comments will be included as an appendix to the Draft Model Certification Review Reports. Individual comments will not be included in the Draft Model Certification Review Reports.

The Draft Model Certification Review Reports will be submitted electronically to USACE for review. The ECO-PCX and PMIP will review the Reports and provide comments back to Battelle.

Task 7 A-D: Meeting to Discuss Findings.
As necessary, for each model review (A – D), Battelle and the panel members will meet via teleconference with USACE's Technical Point of Contact, representatives from the ECO-PCX

and CECW-P, and Model Proponents to discuss their initial findings and ask clarifying questions that will aid in determining the information to be included in each of the Model Certification Review Reports.

Task 8 A-D: Prepare Final Certification Report.
For each model review (A – D), Battelle will prepare a Final Model Certification Review Report including a description of the process used to assess the model, assessment of the model based on the criteria outlined in Section 3.a. of *Protocols for Certification of Planning Models* (July 2007) and issues related to model recommendation.

3.0 Quality Control and Quality Assurance

During the review of the Four Ecological Models, there are numerous instances when quality assurance and/or quality control (QA/QC) practices will be implemented to ensure products of the highest quality are being provided to USACE. These QA/QC practices are described below.

Deliverable Review
It is Battelle policy that every deliverable be independently reviewed to ensure that it is accurate, technically sound, has objective interpretation, solid conclusions, satisfying presentation, and meets or exceeds client expectations. The deliverables for this project are listed in Section 4.0 of this work plan. The review may include a technical, editorial, and/or quality assurance component, depending on the document and project requirements. The Project Manager (PM) will determine the type(s) of review appropriate for each deliverable. In addition, per Battelle policy, all deliverables must have a one-over-one review and approval by the appropriate Battelle Manager prior to external distribution.

In addition to general technical, editorial, and/or QA reviews, Battelle will assign at least two people familiar with the project to review the panel members' responses to the charge questions. Because the charge question responses are used to develop the key themes of the panel members' findings, it is important that the responses be reviewed by a second person to ensure that the key themes have been appropriately captured. In addition to the charge question responses, each final panel comment is carefully reviewed by both the PM and the Deputy Project Manager (DPM) to ensure accuracy and thoroughness.

Peer Review Panel Recruitment
As an unbiased panel is critical to the successful completion of the Model Certification Review process, Battelle conducts a thorough peer review panel recruitment process. The first step in this process is the preparation of a COI questionnaire. Each potential panel member must fully complete the COI (see Appendix C for the COI issues identified for the Four Ecological Models reviews). In addition, USACE will provide information on more general COI issues that have been identified by USACE. USACE must approve the final list of potential COI issues before the questionnaire is distributed to potential panel members.

A detailed review is conducted for each candidate panel member. The Battelle recruitment team will present each candidate panel member's technical qualifications and COI screening responses to the Battelle PM and DPM. The candidate's qualifications are compared to the scope of work and to the pool of potential candidates. If there are any outstanding questions regarding the candidates' responses to the COI screening, the candidate is contacted and the questions resolved prior to submitting the candidate's name to USACE.

Teleconferences

Teleconferences are an important component of conducting a Model Certification Review. They are critical to developing the final panel comments and discussing the final panel comments with USACE. Thus, accurate recording of action items, resolutions, and other information discussed during these teleconferences is critical to the process. To ensure that important information is not missed, Battelle provides at least two note-takers for all teleconferences and kick-off meetings with USACE and/or the panel members. All sets of notes taken by Battelle staff are compared and consolidated after each teleconference to provide one set of official notes. These notes are retained in the project files.

Development of Talking Points for Panel Review Teleconference

After reviewing all the panel members' comments in response to charge questions on the review documents, a talking points memorandum is developed by the DPM prior to the panel review teleconference. This document guides the teleconference and includes the key themes identified from the panel's comments, in addition to specific issues where the reviewers may have disagreed with one another. After drafting the talking points memo, the DPM sends it to at least one member of the Battelle project team to ensure that no important issues were omitted. The talking points are also provided to the panel members prior to the teleconference for review.

4.0 Reporting

Deliverables for the Certification of Four Ecological Models project include the following:

- Draft and final version of the work plan and Model Certification Review Charges
- Final list of up to 24 (primary and backup) selected model review panel members
- Draft and final Model Certification Review Report – EnviroFish Model
- Draft and final Model Certification Review Report – Shorebird Model
- Draft and final Model Certification Review Report – Waterfowl Model
- Draft and final Model Certification Review Report – HGM Guidebook

All draft and final deliverables will be provided to USACE electronically only and in PDF format, with the exception of each Final Model Certification Review Report, which will be sent to the USACE Technical Representative in hard copy (in addition to electronically). The draft work plan and charges were also provided to the USACE in Microsoft Word 2003 format to facilitate their review and allow comments and suggested revisions to be made in track changes.

There are no monthly report requirements for this project.

5.0 Schedule

The due dates for milestones and deliverables in Table 3 below are based on the date Battelle was supplied the final decision regarding the process to follow for conducting these four reviews (September 22, 2009). The asterisks indicate deliverables. All changes to the schedule will be documented and a revised schedule will be submitted to the USACE for approval.

Table 3. Four Ecological Models Certification Review Milestones and Deliverables

TASK	ACTION	DUE DATE
	Receipt of final decision on review process	**9/22/09**
	Review documents available	various
1	USACE/Battelle Kick-off Meeting	09/17/09
	USACE/Battelle/Panel Kick-off Meeting with all panel members	10/28/09
2	*Battelle submits Draft Work Plan to USACE	10/1/09
	USACE provides comments on Draft Work Plan	10/5/09
	Conference Call (if necessary)	TBD
	*Battelle submits Final Work Plan to USACE	10/8/09
3	*Battelle submits Draft Charge (combined with Draft Work Plan – Task 1) to USACE	10/1/09
	USACE provides comments on draft charge	10/5/09
	*Battelle submits Final Charge (combined with Final Work Plan – Task 1) to USACE	10/8/09
	USACE approves Final Charge	10/13/09
4	Battelle provides USACE with conflict of interest (COI) statements for review	9/14/09
	Battelle recruits and screens up to **24** candidate panel members	10/16/09
	*Battelle submits list and summary information of candidate panel members	10/16/09
	USACE provides comments on candidate panel members	10/21/09
	Battelle completes subcontracts for panel members	10/30/09
5A	Battelle provides review documents to panel members	11/2/09
	Panel **A** completes its review	11/20/09
	Battelle collates comments from panel **A**	11/24/09
	Battelle convenes panel review teleconference for panel **A**	12/01/09
	Panel **A** provides final panel comments and report section writing assignments to Battelle	12/11/09
6A	Battelle convenes teleconference with USACE to ask clarifying questions	As needed
7A	*Battelle submits Draft Model Certification Review Report **A** to USACE for review	1/5/10
	USACE provides comments on Draft Model Certification Review Report **A**	1/11/10
	Battelle convenes teleconference to discuss USACE comments on Draft Model Certification Review Report **A**	1/14/10
8A	*Battelle submits Final Model Certification Review Report **A** to USACE	1/22/10
5B	Battelle provides review documents to panel members	11/2/09
	Panel **B** completes its review	1/29/10
	Battelle collates comments from panel **B**	2/2/10

TASK	ACTION	DUE DATE
	Battelle convenes panel review teleconference for panel **B**	2/3/10
	Panel **B** provides final panel comments and report section writing assignments to Battelle	2/15/10
6B	Battelle convenes teleconference with USACE to ask clarifying questions	As needed
7B	*Battelle submits Draft Model Certification Review Report **B** to USACE for review	3/1/10
	USACE provides comments on Draft Model Certification Review Report **B**	3/8/10
	Battelle convenes teleconference to discuss USACE comments on Draft Model Certification Review Report **B**	3/10/10
8B	*Battelle submits Final Model Certification Review Report **B** to USACE	03/17/10
5C	Battelle provides review documents to panel members	11/2/09
	Panel **C** completes its review	1/7/09
	Battelle collates comments from panel **C**	1/11/09
	Battelle convenes panel review teleconference for panel **C**	1/12/09
	Panel **C** provides final panel comments and report section writing assignments to Battelle	1/20/10
6C	Battelle convenes teleconference with USACE to ask clarifying questions	As needed
7C	*Battelle submits Draft Model Certification Review Report **C** to USACE for review	2/3/10
	USACE provides comments on Draft Model Certification Review Report **C**	2/10/10
	Battelle convenes teleconference to discuss USACE comments on Draft Model Certification Review Report **C**	2/15/10
8C	*Battelle submits Final Model Certification Review Report **C** to USACE	2/22/10
5D	Battelle provides review documents to panel members	11/2/09
	Panel **D** completes its review	1/7/09
	Battelle collates comments from panel **D**	1/11/09
	Battelle convenes panel review teleconference for panel **D**	1/12/09
	Panel **D** provides final panel comments and report section writing assignments to Battelle	1/20/10
6D	Battelle convenes teleconference with USACE to ask clarifying questions	As needed
7D	*Battelle submits Draft Model Certification Review Report **D** to USACE for review	2/3/10
	USACE provides comments on Draft Model Certification Review Report **D**	2/10/10
	Battelle convenes teleconference to discuss USACE comments on Draft Model Certification Review Report **D**	2/15/10
8D	*Battelle submits Final Model Certification Review Report **D** to USACE	2/22/10
	Project Closeout	4/30/2010

Note: A indicates tasks for the review of the EnviroFish model, B indicates tasks for the review of the Habitat Model for Migrating Shorebirds in the Upper Mississippi Aluvial Valley, C indicates tasks for the review of the Waterfowl Assessment Methodology, and D indicates tasks for the review of the Delta Region of Arkansas Hydrogeomorphic Methodology Guidebook.
* = deliverable

6.0 Project Organization and Communication

Role and contact information for the key persons who will be working on the Four Ecological Models Review are presented in Table 4 (Battelle staff members), and Table 5 (USACE Project Delivery Team).

Table 4. Battelle Staff for the Four Ecological Models Project IEPR

Name	Project Role	Phone	E-mail
Karen Johnson-Young	Project Manager	(561) 656-6304	johnson-youngk@battelle.org
Amanda Maxemchuk	Deputy Project Manager	(781) 952-5384	maxemchuka@battelle.org
Rachel Sell; Corey Wisneski	Recruiting	(614) 424-3579; (781) 952-5296	sellr@battelle.org; wisneskic@battelle.org
Anne Gregg	Subcontracting Lead	(614) 424-7419	gregga@battelle.org

Table 5. USACE Staff for the Four Ecological Models Project

Name	Project Role	Phone	E-mail
Charles Theiling	Technical Representative/Point of Contact (Rock Island District)	(309) 794-5636	charles.h.theiling@usace.army.mil
Jodi K. Staebell	Alternate Technical Representative/Alternate Point of Contact (Mississippi Valley Division)	(309) 794-5448	jodi.k.staebell@usace.army.mil
Daniel Ward	Alternate Technical Representative/Alternate Point of Contact PDT (Memphis District)	(901) 544-0709	daniel.d.ward@usace.army.mil
Kelly Baerwaldt	Contracting Officer's Representative (Rock Island District)	(309) 794-5285	kelly.l.baerwaldt@usace.army.mil

Communication with USACE

Battelle's Point of Contact (POC) is the Technical Representative for the ECO-PCX. The alternate POC will be copied on all emails to the POC. If the POC is not available (e.g., on vacation), Battelle will contact the alternate POC directly. Communications may include status reports, questions, and/or requests for additional information from the panel.

Communication with the Model Review Panel

Battelle will be the main POC between USACE and model review panel members. Direct contact between the USACE and model review panel members will only occur during teleconferences with a Battelle representative present. All other communications will be directed through Battelle's Project Manager and Deputy Project Manager. The panel will be briefed that they are to have no direct communication with USACE and if they are contacted by USACE, they are to immediately inform Battelle.

7.0 Budget

The approved budget for this project is $392,531.

This page intentionally left blank.

APPENDIX A

Final Charge Guidance and Questions to the Peer Reviewers for the Model Certification Review of *Model Name*[1]

BACKGROUND
Model-specific background will be added.

OBJECTIVE

The objective of this effort is to conduct a review to evaluate the technical approach, system quality, and usability of the ***Model Name***. The ***Model Name*** will be evaluated in accordance with EC 1105-2-407, *Planning Models Improvement Program: Model Certification* (May 2005) and the *Protocols for Certification of Planning Models* (July 2007).

The U.S. Army Corps of Engineers Planning Models Improvement Program (PMIP) was established in 2003 to assess the state of planning tools and models in the U.S. Army Corps of Engineers (USACE) and to make recommendations to assure that high quality methods and tools are available to enable informed decisions on investments in the Nation's water resources infrastructure and natural environment. The main objective of the PMIP is to carry out "a process to review, improve and validate analytical tools and models for USACE Civil Works business programs." The model review for the ***Model Name*** will follow the guidance described in the Department of the Army, U.S. Army Corps of Engineers document entitled *Planning Models Improvement Program: Model Certification* (EC 1105-2-407), dated May 31, 2005, and the Planning Models Improvement Programs document entitled *Protocols for the Certification of Planning Models*, dated July 2007.

MODEL REVIEW

The following outlines the basic steps for the USACE model certification process. These steps are designed to guide the review of models being certified for widespread use and are also used to assess the technical quality and applicability of project-specific models. Model development is a multi-step, iterative process, with the number of steps and iterations being dependent upon the complexity of the model. In general, these steps occur in four fundamental stages.

- Stage 1 (Requirements Stage) involves identifying the need for a specific analytical capability and the options for tools to meet the need.
- Stage 2 (Development Stage) involves the development of software programming code or a spreadsheet and testing by the model developer.
- Stage 3 (Model Testing Stage) involves a beta test of the model by selected users whose objective is to validate the model and ensure that it is usable in real world applications.
- Stage 4 (Implementation Stage) involves providing training, user support, maintenance and continuous evaluation of the model.

[1] Note that all highlighted items in this draft charge will be changed to be specific for the model under review

The certification procedure depends on the stage of model development. The process may include the following steps.

1. Panel members determine whether project needs/objectives are clearly identified and whether the model described is meeting those needs/objectives.
2. Panel members evaluate the technical quality of the models (review of model documentation).
    a. Model is based on well-established contemporary theory.
    b. Model is a realistic representation of the actual system.
    c. Analytical requirement of the model are properly identified and the model addresses and properly incorporates the analytical requirements.
    d. Assumptions are clearly identified, valid, and support the analytical requirements.
    e. USACE policies and procedures related to the model are clearly identified, and the model properly incorporates USACE policies and accepted procedures.
    f. Formulas used in the model are correct and model computations are appropriate and done correctly.
3. Panel members evaluate system quality (review by running test data sets or reviewing the results of beta tests).
    g. Rationale for selection of supporting software tool/programming language and hardware platform is adequately described, and supporting software tool/programming language is appropriate for the model.
    h. Supporting software and hardware is readily available.
    i. Programming was done correctly.
    j. Model has been tested and validated, and all critical errors have been corrected.
    k. Data can be readily imported from/into other software analysis tools, if applicable.
4. Panel members evaluate the usability of the model.
    l. Examine the data required by the model and the availability of the required data.
    m. Examine how easily model results are understood.
    n. Evaluate how useful the information in the results is for supporting project objectives.
    o. Evaluate the ability to export results into project reports.
    p. Training is readily available.
    q. User documentation is available, user friendly and complete.
    r. Adequate technical support is available for the model.
    s. Software/hardware platform is available to all or most users.
    t. Model is easily accessible.
    u. Model is transparent and allows for easy verification of calculations and outputs.

The final deliverable for this effort will be a Model Certification Review Report that Battelle will deliver to USACE. The model review panel members will contribute to the preparation of the draft and final reports, as well as participate in two teleconferences with USACE and the Model Proponents to discuss review panel comments on the method (first teleconference) and USACE comments on the Draft Model Certification Review Report (second teleconference). The general outline for the report will be:

1.0 Introduction

1.1. Model Purpose

1.2. Model Assessment

1.3. Contribution to Planning Effort

1.4. Report Organization

2.0 Model Description

2.1. Model Applicability

2.2. Model Summary

2.3. Model Components

3.0 Model Evaluation

3.1. Assessment Criteria

3.1.1. Technical Quality

3.1.2. System Quality

3.1.3. Usability

3.2. Approach to Model Testing

3.3. Technical Quality Assessment

3.3.1. Review of Theory and External Model Components

3.3.2. Review of Representation of the System

3.3.3. Review of Analytical Requirement

3.3.4. Review of Model Assumptions

3.3.5. Review Ability to Evaluate Risk and Uncertainty

3.3.6. Review Ability to Calculate Benefits for Total Project Life

3.3.7. Review of Model Calculations/Formulas

3.4. System Quality

3.4.1. Review of Supporting Software

3.4.2. Review of Programming Accuracy

3.4.3. Review of Model Testing and Validation

3.5. Usability

3.5.1. Review of Data Availability

3.5.2. Review of Results

3.5.3. Review of Model Documentation

3.6. Model Assessment Summary

4.0 Conclusions

5.0 References

DOCUMENTS PROVIDED

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

- **Model Documentation**
- **Software**
- **Model Code**
- Department of the Army, U.S. Army Corps of Engineers *Planning Models Improvement Program: Model Certification* (EC 1105-2-407), dated May 31, 2005
- USACE Planning Models Improvement Programs document entitled: *Protocols for the Certification of Planning Models*, dated July 2007

SCHEDULE

Task	Activity	Due Date	Projected Date
5	*Conduct kick-off conference call with panel members and Model Proponents	Within 3 days of completing contracts	October 28, 2009
	Model review panel members submit comments to Battelle	Within 12 days of kick-off conference call with panel members	*Date*
	Contractor convenes meeting with panel members to discuss initial findings	Within 3 days of receipt of model team comments	*Date*
6	*Convene teleconference with USACE to ask clarifying questions on initial findings	Within 5 days of receipt of model team comments	As needed
	*Submit Draft Model Review Report to USACE for review	Within 14 days of receiving final panel comments and writing assignment from panel members	*Date*
	USACE provide comments on Draft Model Review Report	Within 5 days of receipt of draft report	*Date*
7	Convene a teleconference with USACE to discuss the Draft Review Report	Within 2 days of receipt of USACE comments	*Date*
8	*Submit the Final Model Review Report to the USACE	Within 5 days of review conference call on USACE draft report comments	*Date*

* denotes a deliverable

CHARGE FOR PEER REVIEW

The charge questions and guidelines are based on the model certification criteria discussed in the guidance document *Protocols for Certification of Planning Models* (July 2007) from the USACE

Planning Models Improvement Program. The intent of these questions is to focus your thinking, not to suggest or dictate your answers. We want you to consider several aspects of models during your review, from the inputs to the outputs to the underlying structure of the method.

General Charge Guidance

1. Please answer the scientific and technical questions listed below and conduct a broad overview of the model. Please focus on your areas of expertise and technical knowledge.
2. Evaluate the soundness of model as applicable and relevant to your area of expertise. Comment on whether model explains past events and how model will be validated.
3. Please focus the review on scientific information, including factual inputs, data, the use and soundness of model calculations, assumptions, and results that inform decision makers.
4. Offer opinions as to whether the model parameters and formulas are sufficient to quantify ecosystem function.
5. Panel members may contact each other. However, panel members **should not** contact anyone who is or was involved in the project, prepared the subject documents, developed the model, or was part of the USACE Independent Technical Review.
6. Please contact the Battelle Deputy Project Manager, Amanda Maxemchuk (maxemchuka@battelle.org) and cc: Karen Johnson-Young (johnson-youngk@battelle.org) if you have questions for Battelle or the USACE or need additional information.
7. In case of media contact, notify the Battelle project manager immediately.

Your name will appear as one of the panelists in the peer review. Your comments will be included in the Final Model Certification Review Report, but will remain unattributed. The Final Model Certification Review Report is expected to be released to the public by the USACE at some time in the future.

Please submit your comments in electronic form to Amanda Maxemchuk (maxemchuka@battelle.org) **no later than *Date*.**

MODEL ASSESSMENT CRITERIA

General Questions

1. Are the project needs/objectives clearly identified?

2. Does the model described meet those needs/objectives?

Technical Quality

3. Comment on the overall technical quality of the model.

4. Comment on the temporal and spatial resolution of the model.

5. Is it clear where the model's geographic boundaries fall?

6. Are the limitations of the model clearly defined?
   a. How do the limitations impact the ability of the model to evaluate ecological benefits?
   b. What are the potential impacts to the project?
   c. How can those limitations be overcome?

7. Is the model based on well-established contemporary theory?

8. Is the model a realistic representation of the actual ecosystem?

9. Does the model effectively capture the variables that are most important for the intended use of the model?

10. Comment on the precision and accuracy of the model for evaluating potential outcomes of project alternatives. What factors/variables provide the greatest impact on precision and accuracy?

11. Comment on the sensitivity of the model.

12. Are the analytical requirements of the model properly identified?

13. Does the model address and properly incorporate the analytical requirements?

14. Are the assumptions clearly identified, valid, and do they support the analytical requirements?

15. Comment on the ability of the model to evaluate risk and uncertainty.

16. Comment on the ability of the model to evaluate impacts and benefits for total project life.

17. Comment on the ability of the model to determine adequate compensatory mitigation.

18. Are the formulas used in the models correct and are the model macros and computations appropriate and done correctly?

19. Are USACE policies and procedures related to the model clearly identified, and does the model properly incorporate USACE policies and accepted procedures?

20. Do the models allow the user(s) to make assumptions regarding future global events such as, but not limited to, global climate change and changes to sea level.

System Quality

21. Is the rationale for the selection of the supporting software tool/programming language and hardware platform adequately described?

22. Is the supporting software tool/programming language is appropriate for the model?

23. Was the programming done correctly?

24. Can data be readily imported from/into other software analysis tools?

25. Has the model been sufficiently tested and validated, and have all critical errors been corrected?

26. Are error checks built into the models?

27. Do the models work using both sensible and non-sensible data?

Usability

28. Comment on the model usability.

29. Comment on the availability of the data required by the model.

30. How easily are model results understood?

31. Comment on how useful the information in the results is for supporting project objectives.

32. Comment on the usability of the model for selecting the best project alternative.

33. Is user documentation user friendly, and complete?

34. Are the models transparent and do they allow for easy verification of calculations and outputs?

APPENDIX B

Four Ecological Models Model Certification Review Panels
Considerations and Proposed Selection/Exclusion Criteria

According to the documents for the Certification of Four Ecological Models, the overall model review scope includes:

- Two avian biologists (Migrating Shorebird Habitat Suitability Index Model)
- One civil works planner/HEP specialist (EnviroFish, Migrating Shorebird Habitat Suitability Index Model, Waterfowl Assessment Method)
- One civil works planner/HGM specialist (Delta Region of Arkansas HGM Guidebook)
- Two fisheries biologists (EnviroFish)
- One forester (Delta Region of Arkansas HGM Guidebook)
- One hydraulic engineer (EnviroFish)
- One programmer/spreadsheet auditor (EnviroFish, Delta Region of Arkansas HGM Guidebook)
- Two waterfowl biologists (Waterfowl Assessment Method)
- One wetland ecologist (Delta Region of Arkansas HGM Guidebook)

Technical Criteria /Areas of Expertise for Potential Independent External Peer Reviewers

All panel members should have at least 5-10 years of experience and have familiarity with large, complex civil works projects with high public and interagency interests. The panel members should at least have M.S. degrees, although Ph.Ds are preferred.

Technical areas related to **avian biology** (2 experts; Migrating Shorebird Habitat Suitability Index Model):

- Familiarity with methods for evaluating bird habitat suitability and have knowledge of the Lower Mississippi River Valley bird populations, specifically shorebirds.

Technical areas related to **civil works planning and Habitat Evaluation Procedures** (1 expert; EnviroFish, Migrating Shorebird Habitat Suitability Index Model, and Waterfowl Assessment Method reviews):

- Experience in the area of floodplain management including ecosystem restoration, impact analysis, compensatory mitigation and knowledge of Lower Mississippi River Valley ecosystems.
- Experience in the use of HEP.

Technical areas related to **civil works planning and Hydrogeomorphic Models** (1 expert; Delta Region of Arkansas HGM Guidebook):

- Experience in the area of floodplain management including ecosystem restoration, impact analysis, compensatory mitigation and knowledge of Lower Mississippi River Valley ecosystems.
- Experience in the use of Hydrogeomorphic approach for assessing wetland functions.

Technical areas related to **fisheries biology** (2 experts, EnviroFish):

- Familiarity with the methods for evaluating fish habitat suitability and have knowledge of the Lower Mississippi River Valley fisheries.
- Experience working with hydrologic and hydraulic modelers to evaluate floodplain hydraulics is desirable.

Technical areas related to **forestry** (1 expert, Delta Region of Arkansas HGM Guidebook):

- Experience in riverine forest ecology, experience in bottomland hardwood community structure and dynamics within the Lower Mississippi River Valley.
- Familiarity with ecosystem output evaluation, particularly the hydrogeomorphic approach to assessing wetland function, is essential.

Technical areas related to **hydraulic engineering** (1 expert, EnviroFish):

- Experience in estimating the effects of flood protection on floodplain hydrology using the HEC-RAS 1-D Flow and associated DSS (direct storage system) files and conducting ecosystem restoration output evaluations.

Technical areas related to **programmer/spreadsheet auditing** (1 expert, EnviroFish and Delta Region of Arkansas HGM Guidebook):

- Experience testing, debugging and auditing computer programs/spreadsheets to check for accuracy of formulas, cell references, and computer code.
- Must have experience with Java programming language.

Technical areas related to **waterfowl biology** (2 experts, Waterfowl Assessment Method):

- Familiarity with methods for evaluating waterfowl habitat suitability and have knowledge of the Mississippi River Valley migratory waterfowl.

Technical areas related to **wetland ecology** (1 expert, Delta Region of Arkansas HGM Guidebook):

- Experience in wetland ecology of large floodplain rivers, preferably experience in southern bottomland wetlands.
- Familiarity with ecosystem output evaluation, particularly the Hydrogeomorphic approach to assessing wetland function, is essential.

Other considerations:

- Participation in previous USACE technical review panels
- Other technical review panel experience

Reviewer Categories [candidate may fit into more than one category]

- Academic
- Consultant (company-affiliated, *e.g*., architect-engineer or consulting firm)
- Consultant (independent)
- Non-governmental organization (*e.g.*, public agency)

Potential Exclusion Criteria/Conflicts of Interest

- Involvement by you or your firm[1] in any part of the development, assessment, or review of the following models:
  - EnviroFish Functional Reproductive Habitat Model
  - Habitat Model for Migrating Shorebirds in the Upper Mississippi Alluvial Valley/Migrating Shorebird Model
  - Waterfowl Assessment Methodology/ Duck Use Days Model
  - A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley
- Involvement by your firm[1] in any part of the St. Johns Bayou and New Madrid Floodway Environmental Impact Statement process, including:
  - Final Environmental Impact Statement entitled Mississippi River and Tributaries, Mississippi River Levees (MRL) and Channel Improvement (1976);
  - Final EIS entitled St. Johns Bayou/New Madrid Floodway Project Final EIS (1982);
  - 1998 Mississippi River Mainline Levees Enlargement and Seepage Control EIS
  - Draft Supplemental EIS (1999)
  - Final Supplemental EIS (2000)
  - Revised Supplemental EIS (2002); or,
  - Second Revised Supplemental EIS (2006).
- Any involvement by you or your firm[1] in the conceptual or actual design, construction, or O&M of the St. Johns Bayou and New Madrid Floodway, MO project or the Mississippi River and Tributaries Project.
- Involvement as an expert or provided testimony for the civil action (04-1575) Environmental Defense, et al. v. U.S. Army Corps of Engineers (USACE) et al.
- Involvement as an expert or provided testimony for Water Quality Certification for the St. Johns Bayou and New Madrid Floodway Project (06-0421) Missouri Coalition for the Environment, et al. v. Missouri Department of Natural Resources *et al*.
- Any involvement by you or your firm[1] in any litigation involving the United States of America and the U.S. Army Corps of Engineers in particular
- Any application by you or your firm[1] for a USACE permit of any nature or representation for a client that applied for a USACE permit of any nature within the boundaries of the Memphis or Vicksburg Districts.
- Current employment by the USACE.
- Current or previous employee or affiliation with the interagency mitigation team or the local sponsor, the U.S. Fish and Wildlife Service, Environmental Protection Agency, Missouri Department of Conservation, Missouri Department of Natural Resources, and the St. Johns Levee and Drainage District.
- Any employment as an individual or contractually by a State agency, levee or drainage district, or a city or municipality that had committed to serve as a local sponsor for a USACE project within the boundaries of the Memphis, or Vicksburg Districts.
- Current or previous employment or affiliation with Environmental Defense, National Wildlife Federation, or Missouri Coalition for the Environment (for pay or pro bono).

- Any voluntary service by you or your firm[1] to provide expert opinions or testimony in connection for any party in connection with a federal project.
- Current or future interests in the St. Johns Bayou and New Madrid Floodway Project.
- Involvement with paid or unpaid expert testimony related to the models or document listed above in numbers 1 and 2.
- Current personal involvement with other USACE projects, including whether involvement was to author any manuals or guidance documents for USACE. If yes, provide titles of documents or description of project, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role. Please highlight and discuss in greater detail any projects that are specifically with the Vicksburg District or the Memphis District.
- Current firm[1] involvement with other USACE projects, specifically those projects/contracts that are with the Vicksburg District or the Memphis District. If yes, provide title/description, dates, and location (USACE district, division, Headquarters, ERDC, etc.), and position/role.
- Previous employment by USACE as a direct employee or contractor (either as an individual or through your firm[1]) within the last 10 years, notably if those projects/contracts are with the Vicksburg District or the Memphis District. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
- Other USACE affiliation [e.g., scientist employed by USACE (except as described in NAS criteria, see EC 1105-2-410 section 8d)].
- Previous experience conducting technical peer reviews. If yes, please highlight and discuss any technical reviews concerning flood risk management projects, and include the client/agency and duration of review (approximate dates).
- A significant portion (i.e., greater than 50%) of personal or firm[1] revenues within the last 3 years came from USACE contracts.
- A significant portion (i.e., greater than 50%) of personal or firm[1] revenues within the last 3 years came from U.S. Fish and Wildlife Service contracts.
- Any publicly documented statement (including, for example, advocating for or discouraging against) related to the models or document listed above in numbers 1 and 2.
- Any publically documented statement advocating for or against the Mississippi River and Tributaries Project, including the St. Johns Bayou and New Madrid Floodway Project.
- Is there any past, present or future activity, relationship or interest (financial or otherwise) that could make it appear that you would be unable to provide unbiased services on this project? If so, please describe:
- Any other perceived COI not listed, such as:
  - Repeatedly served as USACE technical reviewer
  - Paid or unpaid participation in litigation related to the work of the USACE.
  - Prior repeated service as technical advisor to, or expert witness for, Environmental Defense, National Wildlife Federation, the Missouri Coalition for the Environment, or any other interest group that opposed a USACE Project.
  - Any other perceived COI not listed.

[1] Note: Includes any joint ventures in which your firm is involved.

APPENDIX C

Peer Review Conflict of Interest Inquiry

Dear (Peer Reviewer -- insert name):

You have been requested by the U.S. Army Corps of Engineers (USACE) to serve as an external peer reviewer for the Independent External Peer Review of the Model Certification for Four Ecological Models: EnviroFish, Waterfowl Assessment Methodology (WAM), Migrating Shorebird Habitat Suitability Index Model, and the Delta Region of Arkansas Hydrogeomorphic Methodology. Your participation in this review will be greatly appreciated. However, it is possible that your personal affiliations and involvement in particular activities could pose a conflict of interest or create the appearance that you lack impartiality in your involvement for this peer review. Although your involvement in these activities is not necessarily grounds for exclusion from the peer review, you should consult the contact named below or other appropriate official to discuss these matters. Affiliations or activities that could potentially lead to conflicts of interest might include:

a) current work or arrangements concerning future work in support of industries or other parties that could potentially be affected by developments or other actions based on material presented in the document (or review materials) that you have been asked to review;
b) your personal benefit (or benefit of your employer, spouse or dependent child) from the developments or other actions based on the document (or review materials) you have been asked to review;
c) any previous involvement you have had with the development of the document (or review materials) you have been asked to review;
d) any financial interest held by you (or your employer, spouse or dependent child) that could be affected by your participation in this matter;
e) any financial relationship you have or have had with USACE such as employment, research grants, or cooperative agreements;
f) significant portion (i.e., greater than 50%) of your personal or firm's revenues within the last 3 years came from USACE contracts;
g) you or your firm made a publicly documented statement advocating for or against the subject project;
h) litigation associated with USACE; and
i) past, present or future activity, relationship or interest (financial or otherwise) that could potentially be perceived by a third party, or give the appearance that you would be unable to provide independent unbiased subject matter knowledge, expertise, and/or services on this project.

[1] Note: Includes any joint ventures in which your firm is involved

If you have any concerns over a potential conflict of interest, please contact Mr. Mike Genovese, Battelle (GenoveseM@Battelle.org, (614) 424-4007) to discuss any potential conflict of interest issues at your earliest convenience, but no later than two (2) days after receiving this request.

If you agree to be on this peer review panel, please check one of the following boxes, sign this form, and fax to Mr. Mike Genovese, Battelle, at (614) 458-4007 no later than two (2) days after receiving this request.

This form does not constitute an authorization to participate in this review; authorization for performance will come from Battelle's Government Subcontracts office.

[ ] I have no known existing or potential conflicts of interest associated with this task.

[ ] I have identified and disclosed in writing all known existing or potential conflicts of interest associated with this task.

________________________________ ________________________________

Signature *Date* *Printed Name*