FINAL
Independent External Peer Review Report

Independent External Peer Review of the Greater New Orleans Hurricane and Storm Damage Risk Reduction System
LPV 109.02a - New Orleans East Levee, Southpoint to CSX Railroad

Prepared By
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Prepared for
Department of the Army
U.S. Army Corps of Engineers
Coastal Storm Damage Reduction Planning Center of Expertise
Baltimore District

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SHORT TERM ANALYSIS SERVICE (STAS)

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for the

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ACRONYMS

A/E	Architect/Engineer
ASCE	American Society of Civil Engineers
CECW-CP	Corps of Engineers Civil Works – Coastal Protection
CIL	Critical Items List
COI	Conflict of Interest
CPT	Cone Penetration Test
CSSC	Chicago Sanitary and Ship Canal
DDR	Design Documentation Report
DMM	Deep Mixing Method
DrChecks	Design Review and Checking System
EC	Engineer Circular
ER	Engineer Regulation
ERDC	Engineer Research and Development Center
FEA	Finite Element Analysis
FS	Factor of Safety
HSDRRS	Hurricane and Storm Damage Risk Reduction System
IEPR	Independent External Peer Review
IPET	Interagency Performance Evaluation Task
LPV	Lake Pontchartrain Vicinity
NWR	National Wildlife Refuge
OMB	Office of Management and Budget
O&M	Operations and Maintenance
PCX	Planning Center of Expertise
PDT	Project Delivery Team
PRQCP	Peer Review Quality Control Plan
QA/QC	Quality Assurance/Quality Control
RCC	Roller Compacted Concrete
SEI	Structural Engineering Institute
SFWMD	South Florida Water Management District
SWL	Still Water Level

TLP	Tension-Leg Platform
USACE	United States Army Corps of Engineers
WRDA	Water Resources Development Act

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Independent External Peer Review of the Greater New Orleans Hurricane and Storm Damage Risk Reduction System, LPV 109.02a – New Orleans East Levee, Southpoint to CSX Railroad

Executive Summary

The U.S. Army Corps of Engineers (USACE) is currently designing and constructing the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS). One of the vital components of this system is the Lake Pontchartrain Vicinity (LPV) 109.02a – New Orleans East Levee Southpoint to CSX Railroad (hereinafter LPV 109.02a) project. An integral part of the HSDRRS is the conduct of an Independent External Peer Review (IEPR) to ensure the reliability of scientific information and engineering analysis contained within the project documents and continuing through the construction phase. In consideration of the importance of this project to USACE, an IEPR of the LPV 109.02a was conducted. Independent, objective peer review is regarded as a critical element in ensuring the reliability of scientific analysis and engineering utilized for flood management project execution.

Battelle Memorial Institute (hereinafter Battelle), as a 501(c) (3) non-profit science and technology organization experienced in establishing, administering, and conducting expert peer reviews, was engaged by the USACE Coastal Storm Damage Reduction Planning Center of Expertise (PCX) to conduct the IEPR of the LPV 109.02a project. Subject matter experts with knowledge of specific technical disciplines and project knowledge pertinent to the LPV 109.02a project were engaged to form an IEPR Panel (also known as peer reviewers or panel members) and to specifically address key criteria associated with the design, engineering, and construction of this project.

Battelle developed processes and procedures for the IEPR to be in compliance with the procedures described in the Department of the Army, Corps of Engineers Civil Works – Coastal Protection (CECW-CP) Memorandum dated March 30, 2007; *Engineering and Design, Quality Management* (Engineer Regulation [ER] 1110-1-12) dated July 21, 2006; *Engineering and Design, DrChecks* (ER 1110-1-8159) dated May 10, 2001, and *Civil Works Review Policy* (Engineer Circular [EC] 1165-2-209) dated January 31, 2010.

This final IEPR report describes the IEPR process developed by Battelle and followed by the IEPR Panel, summarizes final comments of the Panel, and describes the panel members' qualifications and the selection process.

Battelle uses both an established internal resource database and external resources to identify candidate peer reviewers. From a list of potential candidates, Battelle initially identified candidate peer reviewers, confirmed their availability, evaluated their technical expertise, and inquired about potential conflicts of interest (COIs). The credentials of the available candidate peer reviewers were evaluated according to the overall scope of the LPV 109.02a project requirements. Participation in previous USACE technical review committees and other related technical review expertise and experience was considered. From a draft list of peer review candidates, Battelle selected the final IEPR panel members based on availability, technical background, and COIs and provided the selected list of peer review candidates to USACE to review for COI. Battelle selected the final IEPR panel members based on their specific experience in the areas of expertise specified in the scope of work. Other candidates that were interested and available were proposed for participation on other HSDRRS IEPR Panels that were being conducted.

The four reviewers selected for the LPV 109.02a IEPR Panel were affiliated with consulting companies or were independent engineering consultants. Corresponding to the technical content of the LPV 109.02a IEPR project, the areas of technical expertise of the selected IEPR panel members were geotechnical engineering (one panel member), civil engineering (one panel member), hydraulic engineering (one panel member), and structural engineering (one panel member).

The IEPR panel members were provided electronic copies of the LPV 109.02a plans and specifications, reports, and supporting documentation listed in Table ES-1, along with the charge for conducting the review.

Table ES-1. LPV 109.02a IEPR Project Review Documents

Documents Provided at Start of the Review
Final - Geotechnical Engineering Evaluation Report Contract 109.02a – 1% Design Elevations New Orleans East Levee, Southpoint to CSX Railroad Reach LPV 109 - October 2009
Design Documentation Report (DDR) 100% Submittal for LPV 109.02a- November 2009
100% Plans and Specs for LPV 109.02a
Documents Provided by USACE in Response to Panel Requests and Comment Review Teleconference
2011/2012 Flood Protection Plan
DDR 95% Submittal; Plans and Specs for LPV 109.02c
CEMVN-HPO Memorandum dated 13 May 2009, Subject: *HSDRRS Design Guidelines, Criteria for Resiliency Design Checks for T-walls in the Lake Borgne Basin*
Impact_Punching_shear.pdf – schematic drawing
Draft Report - Wave Overtopping Simulator Testing of Proposed Levee Armoring Materials, Colorado State University – December 2010

In addition, the following supporting documents were provided to the IEPR panel members:

- HSDRRS Quality Management Plan, 30 October 2009
- HSDRRS Design Guidelines, June 2008

- ER 1110-1-12, Engineering and Design, Quality Management, 21 July 2006
- ER 1110-1-8159, Engineering and Design, DrChecks, 10 May 2001
- EC 1165-2-209, Water Resources Policies and Authorities, Civil Works Review Policy, 31 January 2010

On June 9, 2011, the USACE Project Delivery Team (PDT) conducted an orientation briefing on the LPV 109.02a project for the IEPR panel members at the USACE New Orleans District Office. The PDT also hosted a construction site visit for the IEPR Panel concurrent with the orientation briefing, during which panel members were further briefed by USACE on the project. Subsequent to the site visit, the panel members identified nine issues and concerns which were discussed during the Construction Site Visit Outbrief on June 10, 2011. During the Outbrief, the IEPR panel members provided positive feedback on the orientation briefing and site visit; posed specific questions and concerns related to their observations during the site visit; and identified and requested various technical project documents that would further assist in the IEPR.

At the start of the review, Battelle (with input from the IEPR panel members) developed a Critical Items List (CIL) for the peer review, which identified specific design/construction elements and components that are critical to the successful completion and function of the construction project. In total, the IEPR panel members produced 24 critical items. Using the CIL as the basis for their review, panel members developed 48 individual comments on the LPV 109.02a review documents. Of the 48 comments provided by the IEPR panel members, 23 comments were initially identified as 'critical,' defined as pertaining to any critical component, subcomponent, or system whose malfunction can cause a failure of a structure or cascading failure of the entire system and pose a risk of serious injury, loss of life, or loss of mission objectives.

USACE evaluated and reviewed the IEPR panel comments in the Design Review and Checking System (DrChecks) and provided responses to the IEPR panel comments. The IEPR panel members then conducted an initial round of BackCheck responses, which were entered into DrChecks by Battelle. There was immediate concurrence and closeout for 38 of the 48 comments. The remaining 10 open comments (seven of which were critical) needed further discussion in an IEPR comment review teleconference.

On December 1, 2011, Battelle facilitated a comment review teleconference between the IEPR Panel, USACE PDT, and its contractor to discuss the 10 open DrChecks comments. State agencies and local stakeholders were also invited to attend. The teleconference was successful in clarifying technical issues and establishing actions to resolve the 10 open comments. USACE PDT responses to all of the comments were determined sufficient for closeout during the teleconference subject to subsequent documentation in DrChecks. Once the second round of USACE Evaluator Responses and Panel BackCheck Responses was completed in DrChecks, the IEPR panel members considered all of the comments to be sufficiently addressed, and the comments were closed.

In general, the IEPR panel members agreed that the LPV 109.02a project documents contained sufficient design-engineering information to provide a reasonable level of safety assurance for the engineering aspects of the project within the context of USACE's latest HSDRRS Design

Guidelines. The IEPR panel members also agreed that the design assumptions made during the design phase appear to be carried forward through construction, and that the levees and structures were being built as designed. Observation of ongoing and completed construction areas was very informative during the construction site visit, notably the flowing water drainage from the wick drains through the drainage (sand) blanket. The use of the observational method (trusted but verified through monitoring, instrumentation, and in-situ testing, including cone penetration tests [CPTs]) in the geotechnical design and construction monitoring appears to be reasonable and appropriate. It appears that the construction and finish (e.g., sedimentation and erosion control, earthwork and grading, concrete work) are of high quality and meet the project requirements.

1 INTRODUCTION

1.1 Program Background

The U.S. Army Corps of Engineers (USACE) is currently designing and constructing the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS). One of the vital components of this system is the Lake Pontchartrain Vicinity (LPV) 109.02a – New Orleans East Levee Southpoint to CSX Railroad (hereinafter LPV 109.02a) project. An integral part of the HSDRRS is the conduct of an Independent External Peer Review (IEPR) to ensure the reliability of scientific information and engineering analysis contained within the project documents and continuing through the construction phase. Battelle Memorial Institute (hereinafter Battelle), as a non-profit science and technology organization experienced in conducting expert peer reviews, was engaged by the USACE Coastal Storm Damage Reduction Planning Center of Expertise (PCX) to conduct the IEPR of the LPV 109.02a project. Subject matter experts with knowledge of specific technical disciplines and project knowledge pertinent to the LPV 109.02a project were engaged to form an IEPR Panel (also referred to as peer reviewers or panel members) and to specifically address key criteria associated with the design, engineering, and construction of LPV 109.02a.

Battelle developed processes and procedures for the IEPR to be in compliance with the procedures described in the Department of the Army, Corps of Engineers Civil Works – Coastal Protection (CECW-CP) Memorandum dated March 30, 2007; *Engineering and Design, Quality Management* (Engineer Regulation [ER] 1110-1-12) dated July 21, 2006; *Engineering and Design, DrChecks* (ER 1110-1-8159) dated May 10, 2001 and *Civil Works Review Policy* (Engineer Circular [EC] 1165-2-209) dated January 31, 2010.

This final IEPR report describes the IEPR process developed by Battelle and followed by the IEPR Panel, summarizes final comments of the Panel, and describes the panel members' qualifications and the selection process.

1.2 Project Description

LPV 109.02a extends 7.48 miles from its junction with the New Orleans East Lakefront Levee just south of Southpoint to the CSX Railroad just north of the Gulf Intracoastal Waterway. Interstate Highway 10 (I-10), U.S. Highway 11 (US 11) and U.S. Highway 90 (US 90) cross LPV 109 at various locations. The LPV 109.02a project consists of raising approximately 7.5 miles of levee with a protected-side offset levee enlargement utilizing wick drains and geotextile, and replacing four existing drainage structures. The levee reach will provide a 100-year level of risk reduction (i.e., a 1% storm event) to Orleans Parish.

1.3 Purpose of the IEPR

The purpose of the IEPR is to strengthen USACE's safety assurance as outlined in Water Resources Development Act (WRDA) 2007, Section 2035 (Type II IEPR) for the HSDRRS program in the Greater New Orleans area. Independent, objective external peer review is regarded as a critical element in ensuring the reliability of scientific and engineering analyses. To help ensure that USACE documents are supported by the best scientific, technical, and engineering information, a peer review process has been implemented by USACE that utilizes an IEPR to complement the agency technical review, as described in the Department of the Army, USACE, guidance *Civil Works Review Policy* (EC 1165-2-209), dated January 31, 2010. In this case, the IEPR of the LPV 109.02a project was conducted and managed using contract support from an independent 501(c)(3) organization, Battelle, to ensure independent objectivity, along with a high degree of flexibility and responsiveness, which was essential for USACE to meet deadlines.

2 IEPR PROCESS

This section describes the approach for selecting IEPR panel members and for planning and conducting the IEPR. The IEPR followed the process described in the Peer Review Quality Control Plan (PRQCP) that Battelle developed specifically for this project and was conducted in accordance with procedures described in USACE's guidance (cited in Section 1.1) and the Office of Management and Budget's (OMB's) *Final Information Quality Bulletin for Peer Review*, released December 16, 2004. Supplemental guidance on the evaluation of conflicts of interest (COIs) from the National Academies' *Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports*, dated May 12, 2003, was also followed.

2.1 Planning and Schedule

Table 1 defines the schedule followed by Battelle in executing the LPV 109.02a IEPR. Actions in bold represent deliverables submitted to the USACE.

Table 1. LPV 109.02a IEPR Project Schedule

Task	Action	Due Date
1	LPV 109.02a IEPR Start Date	5/9/2011
	USACE provides the Final - Geotechnical Engineering Evaluation Report Contract 109.02a – 1% Design Elevations New Orleans East Levee, Southpoint to CSX Railroad Reach LPV 109 - October 2009 and the DDR 100% Submittal for LPV 109.02a- November 2009 review documents	5/26/2011
	USACE/Battelle kick-off meeting	6/1/2011
	Battelle submits draft PRQCP	6/1/2011
	USACE provides 100% Plans and Specs for LPV 109.02a	6/10/2011
	USACE provides comments on draft PRQCP	6/17/2011
	Battelle submits final PRQCP	6/28/2011
2	**Battelle submits list of final experts for Panel**	5/20/2011

Table 1. LPV 109.02a IEPR Project Schedule, continued

Task	Action	Due Date
	USACE confirms Panel has no COI	5/25/2011
	Battelle completes subcontracts for Panel	6/3/2011
3	**Battelle submits Final Critical Items List (CIL)**	7/29/2011
4	Battelle/Panel kick-off meeting	6/7/2011
	USACE provides materials for orientation briefing	6/9/2011
	Orientation Briefing and Construction Site Visit (USACE/Battelle/Panel)	6/9/2011
6	**Battelle enters Panel review comments into Design Review and Checking System (DrChecks)**	7/28/2011
	USACE evaluates Panel review comments and enters responses into DrChecks (i.e., Round 1 comment evaluation) *(two comments still pending evaluation)*	9/7/2011
	USACE evaluates remaining two Panel review comments and enters responses into DrChecks	9/26/2011
	Battelle enters Panel's BackCheck Responses into DrChecks	10/5/2011
	Battelle convenes Comment Review Teleconference	12/1/2011
	USACE conducts Round 2 of comment evaluation (based on the teleconference discussion)	12/19/2011
	Battelle enters Panel's Round 2 BackCheck Responses into DrChecks and closes all comments	1/5/2012
7	Construction Site Visit Outbrief Presentation	6/10/2011
	Battelle submits Draft Field Site Visit Report	7/8/2011
	USACE provides comments on the draft Field Site Visit Report	7/21/2011
8	**Battelle submits Draft Final Report to USACE**	2/1/2012
	USACE provides comments on Draft Final Report	2/29/2012
	Battelle submits Final Report to USACE	4/18/2012
	Project closeout	6/30/2012

Notes: Task 5 represents monthly reporting activity and is not shown in the above schedule.
Activities in bold text represent deliverables.

2.2 Identification and Selection of IEPR Panel Members

Battelle initially identified 20 candidates for the LPV 109.02a IEPR Panel. The process required confirming their availability, evaluating their technical expertise, and inquiring about/assessing potential COIs. Of those initially contacted, four external peer review candidates confirmed their interest and availability. The remaining candidates were not proposed because they either were unavailable, disclosed COIs, lacked the precise technical expertise required, or were being proposed for participation on a different HSDRRS IEPR Panel.

The credentials of the available candidates were evaluated according to the requirements of the overall scope of the project. The evaluation focused on the key technical areas of geotechnical engineering, civil engineering, hydraulic engineering, and structural engineering. Participation in previous USACE technical review committees and other technical review panel experience was also considered a benefit.

The peer reviewer candidates were screened for the following *potential* exclusion criteria or COIs.[1] Past participation in USACE peer reviews and other technical reviews did not automatically preclude a candidate from serving on the Panel. The following outlines the screening inquiry for assessing the peer reviewer candidates:

- Financial or litigation association with USACE, "The State" (defined as the State of Louisiana and Local governing entities, including Southeast Louisiana Flood Protection Authority any Levee District under their supervision), the Design Architect/Engineer (A/E), their engineering teams, subcontractors, or construction contractors.
- Current employment by USACE.
- Current employment by any federal or state government organization.
- Current personal or firm[2] involvement as a cost-share partner on USACE projects. If yes, provide description.
- Participation in developing the HSDRRS project.
- Any publicly documented statement (including, for example, advocating for or discouraging against) related to any HSDRRS project.
- Involvement with paid or unpaid expert testimony or litigation related to the work of USACE.
- Past, current, or future interests or involvements (financial or otherwise) by self or immediate family related to any HSDRRS project, notably the LPV 109.02a project or future benefits from the project.
- Current personal or firm[2] involvement with other USACE projects. If yes, provide titles of documents or description of project, dates, and location (USACE district, division,

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

[2] Includes any joint ventures in which a firm is involved and if the firm serves as a prime or as a subcontractor to a prime.

Headquarters, Engineer Research and Development Center [ERDC], etc.), and position/role.

- Any previous employment by the USACE as a direct employee or contractor (either as an individual or through a firm[2]) within the last 10 years. If yes, provide title/description, dates employed, and place of employment (district, division, Headquarters, ERDC, etc.), and position/role.
- Previous direct employment by the USACE, New Orleans District. If yes, provide title/description, dates employed, and position/role.
- A significant portion (i.e., greater than 50%) of personal or firm[2] revenues within the last 3 years came from USACE contracts.
- Pending, current or future financial interests in any projects that are *specifically* with the New Orleans District.
- Repeatedly serving as a peer reviewer for Task Force Hope projects (please list).
- Personal relationships with USACE staff in Mississippi Valley Division Headquarters, Task Force Hope, New Orleans District (Protection Restoration Office), Hurricane Protection Office, or officials from the State of Louisiana and Local governing entities including Southeast Louisiana Flood Protection Authority.
- Participation in the Interagency Performance Evaluation Task (IPET) Force, American Society of Civil Engineers External Review of IPET, the Louisiana Coastal Protection and Restoration Study, and/or National Research Council Committee on New Orleans Regional Hurricane Protection Projects.
- Past, present, or future activity, relationship, or interest (financial or otherwise) that could make it appear that it would be unable to provide unbiased services on this project. If so, please describe.
- Any other perceived COI not listed.

The four available candidates were determined to fit the criteria for the required expertise and did not have any actual or perceived COIs. Based on these considerations, the four peer reviewers were selected for the final Panel (Section 3 provides biographical information on the selected panel members). The four selected panel members were affiliated with consulting companies or were independent engineering consultants. Corresponding to the technical content of the LPV 109.02a project, the areas of technical expertise of the four selected panel members represented geotechnical engineering (one expert), civil engineering (one expert), hydraulic engineering (one expert), and structural engineering (one expert). Battelle established subcontracts with each of the selected panel members after confirming the absence of COIs for each panel member through a signed COI form.

2.3 IEPR Kick-Off Teleconferences and Orientation Briefing

Battelle held a project kick-off teleconference with USACE on June 1, 2011, to review the preliminary schedule, discuss the IEPR process, and address any questions regarding the scope of the LPV 109.02a project. On June 7, 2011, Battelle staff conducted an internal kick-off teleconference with the Panel for the review of the LPV 109.02a project. During this teleconference, Battelle provided an overview of the IEPR process, reviewed project and reference materials, and discussed overall schedule dates, milestone activities, and logistics for the orientation briefing and site visit.

The USACE PDT conducted the orientation briefing on the LPV 109.02a project for Battelle and the IEPR panel members on June 9, 2011, at the USACE New Orleans District offices in New Orleans, Louisiana. During the meeting, the USACE PDT briefed the panel members on the LPV 109.02a project, and the panel members were provided an opportunity to ask questions. The USACE agenda for the orientation briefing is shown in Attachment 1 of Appendix B. Concurrent with the orientation briefing, the PDT also conducted a tour of the construction site for the IEPR Panel, during which panel members were further briefed by USACE on the project. During the construction site visit, the peer reviewers were again able to ask questions.

2.4 Construction Site Visit

The construction site visit for the LPV 109.02a project was conducted on June 9, 2011, following the orientation briefing. USACE, Battelle staff, and IEPR panel members drove the length of the LPV 109.02a levee and stopped at various points along the reach to observe the key structural components, the interface of dissimilar materials, and intersections of levees with roadways. Throughout the construction site visit, members of USACE pointed out specific project features to help the IEPR panel members better comprehend the design and construction intent of the project and answered questions posed by the panel members.

2.4.1 Results of the Construction Site Visit

On the morning of June 10, 2011, the USACE PDT, Battelle, and the peer reviewers convened at the USACE New Orleans District Office for the Construction Site Visit Outbrief. The Outbrief addressed areas of focus and/or critical items observed by the peer reviewers during the site review. In general, the content of the Outbrief included positive feedback based on the peer reviewers' observations and review of available reference documents, questions/concerns from the site visit, and requests from Battelle for additional documentation (Appendix B, Attachment 4 – Exit Briefing Presentation).

A draft Field Visit Report was submitted to USACE on July 8, 2011, and is being finalized in Appendix B as part of the final IEPR report (this deliverable). Questions and concerns (see Section 2.4.1.2) restated in the draft Field Visit Report were either discussed and answered during the Outbrief by USACE or were answered by the panel members during the review of the documents. All of the additional documents/material (see Section 2.4.1.3) requested by the Panel during the Outbrief were provided with the exception of the geotechnical field reports and construction management summary reports, as they were not readily available in summary form. Refer to the Field Visit Report in Appendix B for additional details.

2.4.1.1 Positive Feedback

During the Outbrief, the peer reviewers provided the following observations about the site visit (that was held concurrent to the orientation briefing).

- The orientation briefing was very informative, thorough, concise, professional, and supplemented appropriately with photos, maps, data plots, and test data.

- The geotechnical information and design details provided were very thorough and complete. The presentation of soil data (including the results of cone penetration tests [CPT]) was thorough and useful.
- The use of the observational method (trusted but verified through monitoring, instrumentation, and in-situ testing, including CPT) in the geotechnical design and construction monitoring appears to be reasonable and appropriate.
- The flexibility by the USACE Team during the site visit to allow stops at numerous points along the levee provided for discussions on key points and review of the project.
- The information exchange between USACE and the peer reviewers during the site visit was very informative, professional, and open.
- Observation of ongoing and completed construction areas was very informative, including the observation of flowing water drainage from the wick drains through the drainage (sand) blanket which daylighted at the berm toe. The magnitude and apparent success of the application of wick drains to facilitate drainage, consolidation, settlement, and ground improvement is impressive.
- The availability of material samples, including wick drain and geotextile fabrics, was useful and provided the peer reviewers insight into the use of the wick drains and their effectiveness for drainage.
- It appears that the construction and finish (e.g., sedimentation and erosion control, earthwork and grading, concrete work) are of high quality and meet the project requirements.

2.4.1.2 Questions and Concerns

The IEPR panel members identified the following nine issues and concerns from the construction site visit, which are restated in the Field Visit Report. These issues were discussed among USACE, the State, and the peer reviewers during the Outbrief. The questions and concerns were either resolved through discussion during the Outbrief with USACE or answered by the panel members during the review of the documents and supporting documentation (see Table 2 below).

- **Gate closure redundancy.** The steel closure flood gates are located along portions of the levee construction intersecting major highways understood as major hurricane evacuation routes for local residents. Concerns about the proper operations of the gates during a storm situation include the following questions:
  - Are there redundant gate closure means (e.g., winch backup) for fail-safe operation? A proper gate opening and closing mechanism with a backup system should be installed.
  - Are there sufficient personnel and backup to perform all of the gate closures in time?
  - Is the CSX Railroad closure coordination procedure sufficient (e.g., keys needed from both CSX and the levee board to close the gate)? The logistics addressing the process for opening and closure of the roller gate across the railroad tracks should be adequately addressed with the railroad company.

- Are gate security and operation and maintenance (O&M) measures sufficient to ensure that the gates will be operational when needed? Adequate gate security measures in both the storm and non-storm situations should be installed; the gate security concerns include vandalism of gates, traffic accidents impacting gates, etc.
- Is the gate-closure strategy or procedure (trigger/sequence/timing) sufficient and does it have redundant systems in case of failure of the primary mechanisms? Proper coordination of gate closure/opening operation, timing, etc. should be addressed in advance among governing authorities, gate operators, local officials, etc., in order to avoid confusion and/or lack of response during a storm event.

- **Barge/boat impact**
  - What factors or considerations for barge/boat impact loading were used in the design?
  - What design value for the barge/boat impact load was used in the design of floodwalls?
- **Design Guidelines**
  - Is the design based on the latest revised HSDRRS Design Guidelines?
- **Levee shrinkage**
  - Will the levee experience shrinkage/settlement that will lead to cracking or other degradation over the course of time?
  - What mitigation measures for cracking have been incorporated into the design?
  - How will the levee be protected/maintained to reduce this risk?
- **Levee armoring**
  - What is the plan for wave impact/slope protection on the flood side? Concerns about the proper armoring of the levee on the flood side can significantly dissipate the wave energy of the breaking-waves and provide significant protection to the levee slopes.
  - What is the plan for crest and protected-side armoring due to overtopping? The levee crests should be adequately protected against erosion due to the wave-overtopping.
- **Future raises**
  - Is the levee designed to accommodate future raises?
  - What raises are contemplated and may be accommodated by the existing structures/levees/foundation soils?
  - Does the design account for the future levee rises due to settlement, potential sea level rises, global warming effects, etc.?
- **Pump station**
  - Is the discharge piping above the net levee section? The pump station operation and the routing of the discharge piping with respect to the levee section were not evident during site review.
- **Instrumentation**
  - While construction monitoring instrumentation was briefly discussed and observed, it was not clear what construction monitoring instrumentation was to remain in place and/or what supplemental instrumentation would be installed and how it would be used for long-term performance monitoring.
- **General**

- How will the issues of O&M, all-weather, and emergency access be provided and applied to all portions of the levee, pump station, and closures?

Plans and specifications were provided to the Panel after the site visit, with the awareness that some of the comments and questions could be addressed later based on the information in those documents or in operating manuals, closure plans, or other data sources.

2.4.1.3 Requests for Documentation

During the Outbrief, the peer reviewers indicated that additional documentation was needed to conduct a thorough IEPR. The additional documents requested included the 2011/2012 Flood Prevention Plan, LPV 109.02a O&M Manual, a geotechnical field report documenting the construction phase, a construction management summary report (similar to the field report), monthly summaries of challenges and changes, and contract modifications. At the conclusion of the Construction Site Visit Outbrief on June 10, 2011, USACE provided Battelle with a CD of the project documents, notably the plans and specifications to be reviewed for the project. All of the requests made by the Panel during the Outbrief were fulfilled with the exception of the geotechnical field reports and construction management summary reports, as they were not readily available in summary form. It was also explained to the peer reviewers that the LPV 109.02a O&M Manual was still being developed and was not available for review.

2.5 Preparation of the Charge to Panel Members

The charge (Appendix A) to the IEPR panel members was provided by USACE based on guidance provided in *Civil Works Review Policy* (EC 1165-2-209), dated January 31, 2010, and the OMB's *Final Information Quality Bulletin for Peer Review*, released December 16, 2004. The LPV 109.02a IEPR charge consisted of five questions applicable to all review documents and identified as follows.

1. Do the assumptions made during the decision document phase for hazards remain valid through the completion of design as additional knowledge is gained and the state-of-the-art evolves?
2. Do the project features adequately address redundancy, resiliency, or robustness with an emphasis on interfaces between structures, materials, members, and project phases?
   - **Redundancy**: The use of multiple lines of defense that are linked to potential failure modes. The most vulnerable failure modes need the greatest redundancy.
   - **Resilience:** The use of enhancements to improve the ability of the system to sustain loads greater than the design load to achieve gradual failure modes over some duration rather than sudden failure modes.
   - **Robustness**: The use of more conservative assumptions to increase capacity to compensate for greater degrees of uncertainty and risk.
3. Do the project features and/or components effectively work as a system?
4. Do the assumptions made during design remain valid through construction?

5. For O&M manuals, do the requirements adequately maintain the conditions assumed during design and validated during construction? [3] Will the project monitoring adequately reveal any deviations from assumptions made for performance?

2.6 Conduct of the Design Peer Review

The review of the LPV 109.02a project was conducted according to the schedule shown in Table 1. The IEPR panel members were provided electronic copies of the LPV 109.02a project review documents and supporting documentation listed in Table 2, along with the charge (Appendix A) for conducting the review of the project documents.

Table 2. LPV 109.02a Review Documents

Documents Provided at Start of the Review
Final - Geotechnical Engineering Evaluation Report Contract 109.02a – 1% Design Elevations New Orleans East Levee, Southpoint to CSX Railroad Reach LPV 109 - October 2009
Design Documentation Report (DDR) 100% Submittal for LPV 109.02a- November 2009
100% Plans and Specs for LPV 109.02a
Documents Provided by USACE in Response to Panel Requests and Comment Review Teleconference
2011/2012 Flood Protection Plan
DDR 95% Submittal; Plans and Specs for LPV 109.02c
CEMVN-HPO Memorandum dated 13 May 2009, Subject: *HSDRRS Design Guidelines, Criteria for Resiliency Design Checks for T-walls in the Lake Borgne Basin*
Impact_Punching_shear.pdf – schematic drawing
Draft Report - Wave Overtopping Simulator Testing of Proposed Levee Armoring Materials, Colorado State University – December 2010

To maintain independence and control, the Panel did not have direct or unmonitored discussions, e-mail, or phone contact with USACE. Battelle managed and facilitated interactions between the Panel and USACE during the orientation briefing, the construction site visit, and the subsequent IEPR comment review teleconference to resolve remaining open comments.

2.6.1 Preparation of the Critical Items List (CIL)

Battelle (with input from the IEPR panel members) developed a CIL for the peer review, which listed specific items that are critical to the successful completion and function of the construction project. The intended purpose of the CIL was to assist the panel members and focus their review. The CIL considered:

- Information provided at the USACE orientation briefing for the LPV 109.02a project on June 9, 2011

[3] It was explained to the peer reviewers the LPV 109.02a O&M Manual was still being developed and in process and was not available to review.

- Observations from the construction site visit on June 9, 2011
- Project review documents and supporting documentation (see Table 2)
- HSDRRS Quality Management Plan, 30 October 2009
- HSDRRS Design Guidelines, June 2008

The development of a CIL is important for conducting an analysis and identifying critical components, subcomponents, or systems whose malfunction can cause a failure of a component/subcomponent or a cascading failure of the entire system or structure and pose a risk of serious injury, loss of life, or loss of mission objectives. The CIL is a living document that the IEPR panel members could continue to develop throughout the life of the project to focus the review of the design documents and construction activities towards critical issues. With the aid of the CIL, a more effective and efficient peer review was conducted because the Panel was able to focus on those items that must not fail, rather than reviewing all details of design and construction. Table 3 shows an example of a critical item for the LPV 109.02a project.

Table 3. Example of a Critical Item from the LPV 109.02a IEPR

LPV 109.02a – Critical Item		
1	**Component/System Name**	Levee
2	**Component/System Function**	Hurricane Protection
3	**Potential Failure Mode**	Global slope instability / failure
		Localized slope instability / sloughing / failure
		Seepage, piping, erosion, and ground loss
		Settlement – overtopping, breach
4	**Possible Cause(s) of Potential Failure**	Non-conservative design soil parameters
		Non-conservative design assumptions / analysis methods
		Geotechnical analyses, design methods, assumptions and criteria: As per HSDRRS vs. deviation from HSDRRS
5	**How is the Failure Detected**	Review of derivation of design soil parameters and assumptions
		Review of analysis, design methods and assumptions
		Review of criteria vs. HSDDRS
6	**Consequence(s) of Failure**	Levee slope failure / settlement / displacement - breaching and overtopping
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☐Moderate ☒Severe
8	**Potential Mitigation Measures**	Proper derivation, development and selection of Design Soil Parameters, analyses, criteria, design procedure (per HSDRRS)

In total, the IEPR panel members produced 24 critical items. It should be noted that technical references, design-construction documents, and failure modes pertaining to the roller gates, which are part of a separate project known as the LPV 109.02c project, were not specifically reviewed; however, those design-construction documents were provided to the panel members as reference documents due to the interface of the roller gates with the levee design of the LPV 109.02a project. For example, roller gates – as they relate to potential failure modes or possible cause(s) of potential failure – could interact and interface with the LPV 109.02a project; therefore, consideration of the interface is a factor.

Table 4 shows the number of critical items in the CIL by discipline for the LPV 109.02a project. The full text of the 24 critical items for the LPV 109.02a project was presented in an earlier deliverable submitted on July 29, 2011, and is included in Appendix C of this report.

Table 4. Number of LPV 109.02a Critical Items by Discipline

Summary of CIL	
Discipline	**Number of Critical Items**
Geotechnical	12
Structural	3
Civil	5
Hydraulic	4
Total	**24**

2.6.2 Design Review

Using the CIL as the basis for their review, panel members developed a total of 48 individual comments on the LPV 109.02a review documents. Battelle reviewed the comments to ensure applicability and consistency in response to the charge. Battelle's review also served as means to remove duplicate comments and resolve contradictory comments, ensuring that all comments were of acceptable quality. Battelle entered the Panel's individual comments into the Design Review and Checking System (DrChecks) on July 28, 2011. Items deemed "Critical" in nature by panel members were marked upon entry into DrChecks.

Of the 48 comments provided by the IEPR panel members, 23 comments were initially identified as critical, defined as pertaining to any critical component, subcomponent, or system whose malfunction can cause a cascading failure of the entire structure and pose a risk of serious injury, loss of life, or loss of mission objectives. Table 5 lists the number of comments identified as critical during the initial review by the panel members.

Table 5. Categorized DrChecks Comments

Report	Total Comments	Initial Critical Comment
Final - Geotechnical Engineering Evaluation Report Contract 109.02a – 1% Design Elevations New Orleans East Levee, Southpoint to CSX Railroad Reach LPV 109 - October 2009	4	3
Design Documentation Report (DDR) 100% Submittal - November 2009	31	17
100% Plans and Specs for LPV 109.02a	13	3
Total	**48**	**23**

USACE evaluated and reviewed the IEPR panel comments in DrChecks and provided responses on September 26, 2011. The IEPR panel members then conducted an initial round of BackCheck responses, which were entered into DrChecks by Battelle on October 5, 2011. As part of the first round of responses, there was concurrence and closure for 38 of the 48 comments. The remaining 10 open comments needed further discussion at the IEPR comment review teleconference. Not all of the remaining open comments were identified as being a critical comment.

2.7 IEPR Comment Review Teleconference

On December 1, 2011, Battelle conducted and facilitated an IEPR comment review teleconference between the Panel, USACE, and its contractor who responded to the Panel's DrChecks comments. State agencies and local stakeholders were also invited to attend. The purpose of the comment review teleconference was to provide an interactive, real-time forum for discussion of all comments, with a focus on those comments that were still open after the first round of responses.

This teleconference provided an opportunity for the IEPR panel members to ask clarifying questions regarding some of the USACE Evaluator responses. The teleconference was successful in clarifying responses and establishing actions to resolve the open comments. Of the remaining 10 open comments, USACE PDT responses to all of the comments were determined sufficient for closeout during the teleconference; however, closeout of the comments was contingent upon review and confirmation by the panel members during their second round of BackCheck evaluations.

Once the second round of USACE Evaluator Responses and Panel BackCheck Responses was completed in DrChecks, the IEPR panel members considered all of the comments to be sufficiently addressed, and the comments were closed. Section 4 of this report contains a summary of the results.

Figure 1 shows an example of an IEPR panel member comment that was entered into DrChecks, evaluated by USACE and its contractor, further discussed with IEPR panel members, and then agreed upon and closed. The names of the reviewer and USACE members providing the comment and response have been removed in this example.

Figure 1: Example of Panel Member Review and USACE Evaluator Entries in DrChecks

Id	Discipline	DocType	Spec	Sheet	Detail
4098345	Geotechnical	Plans and Specs	Specs - 31 32 13.00 16 Cement Soil Stabilization, 31 32 13.01 12 Specialty Grouting	n/a	n/a
Potential effect of high salinity and or sodium content soils and groundwater: It is not clear if mix design, test samples / results for the soil cement used in the deep soil mixing or the cement grout used in the jet grouting, or the design of the respective deep soil mixing panels or jet grout columns has accounted for the potential effect of high salinity and or sodium content soils and groundwater. 1. Have the mix design / test samples employed actual soil and groundwater samples? While the salinity / sodium content may have more influence on the bentonite than the cement, and the ground improvement is focused more on strength and ground improvement / reinforcement, rather than permeability, does the high salinity and / or sodium content influence the short and / or long term performance of the completed deep soil mixing panels or jet grout columns? Please confirm / comment on the above including field experience / test results to date.					
1-0	Evaluation **For Information Only** URS Response: The bench scale testing of DMM with on-site soils and verification DMM elements and production DMM elements all went very well. Different mix designs were used in higher organic content zones. All test results met 120 psi unconfined strengths that we saw. Submitted on Aug 9, 2011				
1-1	Backcheck Recommendation **Open Comment** Did the mix design and bench scale testing of DMM with on-site soils use on-site groundwater with its high salinity and or sodium content? Or "tap" water? Will the DMM when constructed in and exposed to the high salinity and or sodium groundwater undergo a reduction in strength or negative impact on other properties over time? Please address these comments.				
2-0	Evaluation **For Information Only** URS response: The mix design and bench-scale testing of DMM used on-site fine-grained soils that would have had the salinity of the on-site actual soils. The mix design used off-site potable water (i.e., not water pumped from the marsh area). The actual DMM elements did not use on-site saline water but off-site non-saline water. The actual soil-cement columns that are embedded in soils are not thought to undergo any appreciable reduction in strength due to any exposure to higher salinity on-site waters. We do not believe any bentonite was utilized in the DMM. Submitted on October 19, 2011 and Rev Dec 9, 2011 Additional comment by USACE: Long-term soil cement column testing in Japan has shown that salinity has little effect on the strength of soil cement. DM is frequently used in salt water environments and in offshore applications. Further, the bench scale tests are really just for the contractor's use in mix design. QA from the designer's perspective came from the verification UCS testing of cored samples.				
2-1	Backcheck Recommendation **Close Comment** Closed without comment.				
	Current Comment Status: **Comment Closed**				

2.8 IEPR Final Report

After concluding the review, Battelle prepared a draft final IEPR report on the overall IEPR process and the IEPR panel members' findings. The draft final IEPR report was reviewed by each IEPR panel member and Battelle technical and editorial experts prior to submission to USACE for review. USACE comments on the draft final IEPR report have been considered in preparing the final IEPR report (this document). Each IEPR panel member will review the final IEPR report along with Battelle technical and editorial experts prior to submission to USACE.

3 IEPR PANEL MEMBER SELECTION

Potential peer review candidates were identified through Battelle's IEPR database of experts, trade organizations, engineering societies, targeted recruitment using key expertise (e.g., terms focusing on technical area and geographic region), recruitment at universities or other compiled expert recruitment mechanisms, and referrals.

The IEPR panel members met the following minimum requirements:

- Experience with design and construction of projects similar in scope to the LPV 109.02a project
- Familiarity with the HSDRRS Design Guidelines
- Master's degree or hands-on relevant engineering experience in the listed disciplines (see following bullet)
- Minimum 20 years of experience and responsible charge of engineering work
- Registered professional engineer

Panel members in each discipline also were required to have specific technical experience in the areas summarized in Table 6.

Table 6. Required Technical Experience for IEPR Panel Members

Discipline (Number of Reviewers)	Required Experience
Geotechnical Engineer (1 expert reviewer)	• Very soft Louisiana-type clay soil foundations • Large-diameter pile design • Axial and lateral load testing for piles • T-wall and L-wall design experience • Subsurface investigations in very soft soil • Seepage design • Wave impact/armoring • Slope stability analyses for very soft soils
Civil Engineer (1 expert reviewer)	• Design utilizing very soft soils • Design of roadways and roadway ramps
Hydraulic Engineer (1 expert reviewer)	• Hurricane surge and wave generation
Structural Engineer (1 expert reviewer)	• T-wall and L-wall floodwall design experience

Battelle identified a draft list of peer review candidates; selected the final IEPR panel members based on availability, technical background, and COIs; and provided the selected list of peer review candidates to USACE to review for COI. Battelle selected the final IEPR panel members (Table 7) based on their specific experience in the areas of expertise specified in the scope of work (Table 8).

Table 7. Final IEPR Panel Members

Discipline/Name	Affiliation	Location	Education	Years of Experience
Geotechnical Engineer				
Steven McCaskie	Hanson Professional Services Inc.	Maryland Heights, MO	MS Civil Engineering (Geotechnical Engineering)	34
Civil Engineer				
C. Alan Hall	Independent Consultant, C. Alan Hall	Melbourne, FL	BS Professional Management, Graduate studies in Engineering Management	38
Hydraulic Engineer				
Mark Houck	Independent Consultant, MHH Engineering, LLC	Ellicott City, MD	BES, Engineering Science, PhD in Environmental Engineering	36
Structural Engineer				
Jay Jani	Engineering Consulting Services, Inc.	Metairie, LA	BECE, MSCE, Ph.D. Ocean Engineering	26

Table 8. Specific Experience of IEPR Panel Members Requested in Scope of Work

Expertise	Total	McCaskie	Hall	Houck	Jani
Geotechnical Engineer					
Extensive experience in very soft Louisiana-type clay soil foundations	1	X			
Extensive experience in large-diameter pile design	1	X			
Extensive experience in axial and lateral load testing for piles	1	X			
Experience in T-wall and L-wall design	1	X			
Experience in subsurface investigations in very soft soil	1	X			
Experience in seepage design	1	X			

Table 8. Specific Experience of IEPR Panel Members Requested in Scope of Work, continued

Expertise	Total	McCaskie	Hall	Houck	Jani
Experience in wave impact/armoring and slope stability analyses for very soft soils	1	X			
Civil Engineer					
Extensive experience in designs utilizing very soft soils	1		X		
Extensive experience in the design of roadways and roadway ramps	1		X		
Hydraulic Engineer					
Extensive experience in hurricane surge and wave generation	1			X	
Structural Engineer					
Extensive experience in T-wall and L-wall floodwall design	1				X

The credentials and qualifications of the four reviewers selected for the Panel are summarized in the following paragraphs. Appendix D includes a resume for each reviewer that provides detailed biographical information and the reviewer's technical areas of expertise.

Mr. Stephen McCaskie, P.E., serves as a senior geotechnical engineer for Hanson Professional Services. He has over 33 years of experience in project management, engineering, and quality assurance/quality control (QA/QC) of flood protection, water resource, transportation, inland navigation, underground, port and harbor projects. He has conducted numerous projects involving soft clay soil foundations for dams and levees, waterfront and marine structures, and transportation structures in Florida (involving peat, marl, phosphatic clays and wastes) and the Mississippi River and its tributaries (riverine deposits), including design and construction monitoring of deep foundations and ground improvement. His experience with high-capacity pile foundations (driven and drilled) includes design, load testing (axial and lateral), and construction monitoring for numerous waterfront/marine and transportation structures. His T-wall and L-wall design experience has been gained from participating in a number of large flood protection projects (floodwalls and closures structures) and retaining walls. Those projects included pile-supported structures as well as numerous geotechnical explorations for dams/levees and waterfront/marine and transportation structures involving soft clay soil foundations that included difficult site access and sampling and testing of very soft soils. He has performed seepage analysis of numerous dam/levee and deep excavation projects for both flood protection (short-term) and water impoundment/below ground structures (long-term) as well as a number of slope protection projects involving dams and waterfront structures having significant wave environments, including fine-grain soil foundations/earth structures. His slope stability experience includes analysis of numerous dam/levee projects having soft clay soil foundations with significant settlement potential and the associated mitigation measures required.

Mr. C. Alan Hall, P.E. has over 38 years of experience in the fields of water resources, environmental, and civil engineering in government service and private practice. Mr. Hall serves as a technical consultant to the South Florida Water Management District (SFWMD) on its $2 billion Acceler8 Program, a 5-year design and construction initiative to fast-track restoration of the South Florida ecosystem, enhance flood protection, and increase water supply. During his 25+ year public career as Director of Ecosystems Restoration for the SFWMD, Mr. Hall oversaw more than $1 billion in ecosystem restoration construction projects. Mr. Hall's specific accomplishments with SFWMD include the $600 million Everglades Construction Project, the Kissimmee River Restoration Program, and the Florida Bay Restoration and Emergency Interim Project. As Deputy Director of Operations and Maintenance at SFWMD, Mr. Hall was responsible for the leadership and control of the water management operations and project maintenance functions for a 2,000-mile water control and treatment system, which provided flood control, water supply, and environmental enhancement for central and south Florida. Mr. Hall has led the design and construction management of levees and structures on top of very soft, muck-based soils within fresh water marshlands of south Florida, as well as erosion control measures and multi-use roadways on multiple water resource projects. In addition to his background in water resources engineering and his professional civil engineering registration, Mr. Hall also has credentials in the fields of professional and engineering management and has served on previous IEPRs.

Dr. Mark Houck, P.E., has over 36 years of experience in the fields of environmental, hydraulic, and civil engineering in teaching and as a consulting engineer. Dr. Houck has conducted research efforts focusing on the use of systems analysis and engineering in support of public sector decision-making, with special emphasis on environmental and water resources problems. His teaching and research focus on water resource planning, design, and management specific to hydrologic and hydraulic analyses for flood risk management projects. He has more than 30 years of experience in the study of hurricane surge and wave generation. He began his teaching career at the University of Washington, and earned tenure as a Full Professor at Purdue University and George Mason University, in addition to consulting in the private sector. In a recent study of the critical infrastructure resilience of the Hampton Roads region of Virginia (16 jurisdictions including Norfolk, Newport News, and the largest military establishment in the nation), an area where a major threat is hurricane surge and waves, he led an assessment of these threats on the water and wastewater infrastructure. He has also been active in teaching outside of the university in a variety of forums. For example, he has lectured on the legal and engineering implications of a new drainage control ordinance before a group of practicing engineers and government officials; on expert systems at a bi-national conference organized by the Chinese Academy of Sciences and the U.S. National Science Foundation in the People's Republic of China; and on systems analysis, modeling, and decision support systems at a North Atlantic Treaty Organization scientific conference in Scotland. Dr. Houck is the author of numerous refereed journal papers and reports on water resources, hydrology, and hydraulics, including hurricane surge, wave generation, their effects, and mitigation strategies.[4] He is a Diplomate, American Academy of Water Resources Engineering; a certified Professional Hydrologist, American Institute of Hydrology; and Board Certified Environmental Engineer, American Academy of Environmental Engineers.

Dr. Jay Jani, P.E., has more than 26 years of experience as a structural engineer working on a variety of projects for offshore and coastal, flood protection, and industrial structures. He earned his Ph.D. in ocean engineering with a major in structural engineering and an emphasis on offshore and coastal structures from Florida Atlantic University in 1990. Dr. Jani founded his firm, Engineering Consulting Services, Inc., in 2000; he currently serves as the president and senior structural engineer. He is also an adjunct faculty member in the Department of Civil Engineering at the University of New Orleans. Dr. Jani served as the Chairman of American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) Structures Committee - New Orleans Chapter for the 2008-2009 term. Dr. Jani has served on previous IEPRs for USACE projects with T-walls, L-walls, levees, and flood protection structures, specifically the LPV 144 project. He also participated in the IEPR for the HSDRRS Design Guidelines. Dr. Jani has extensive experience applying structural design to steel, reinforced concrete structures, pile foundations, construction, and rehabilitation projects in soft Louisiana soils. He also has extensive experience designing and assessing the structural integrity of all phases of offshore platform design for various projects, including in-place analysis, installation engineering (load-out, transportation analysis, lift analysis, lift rigging design etc.), pile foundation design, and earthquake analysis. He also participated in assessing the structural integrity of many residential buildings following Hurricane Katrina in metro New Orleans and vicinity.

4 RESULTS — SUMMARY OF REVIEW

The IEPR panel members followed the processes described in Sections 2.5 through 2.7 to conduct their review, execute the comment review teleconference, and finalize remaining comments in DrChecks. These processes were in accordance with the PRQCP and the USACE guidance documents cited in Section 1.1. This section of the report summarizes the overall review approach by the peer review experts (Section 4.1), the IEPR panel member comments that were entered into DrChecks (Section 4.2), the approach taken by each panel member to perform the review according to discipline (Section 4.3), and any critical or other open issues identified by the four panel members that remain to be resolved (Section 4.4).

4.1 Overall Review Approach

As discussed in Sections 2.3 and 2.4, the IEPR panel members attended an orientation briefing held by USACE, which was held concurrently with a construction site visit to the LPV 109.02a levee reach in order to familiarize themselves with the project and remaining construction activities at the site and gain a better understanding of the project scope. This familiarity with the site also aided in the development of the CIL that was used to guide the review.

[4] Houck, M.H., Baecher, G., Grizzard, T., Williams, W., *et al*., "Hurricane Isabel: Critical Infrastructure Interdependency Assessment," Final Report, Volume 20, Critical Infrastructure Protection in the National Capital Region, University Consortium for Infrastructure Protection, George Mason University, Fairfax, Virginia, 39 pages, September, 2005.

With feedback from the IEPR panel members, Battelle developed the CIL (see Appendix C) and provided it to the IEPR panel members. Along with the review documents, the IEPR panel members were instructed to use the CIL to focus their review, within their area of expertise, on those project components that are critical to the successful completion and safe operation of the project. For each critical item identified, potential failure modes and causes were assessed. This assessment provided the basis for the review of the LPV 109.02a review documents.

If a concern was identified in the review documents, the panel members provided a comment, which was then entered into DrChecks by Battelle. Most disciplines used the HSDRRS Design Guidelines and all used their respective expertise in engineering practice and their experience as a guide for the technical review of the review documents provided.

The IEPR panel members were encouraged to work independently and in groups according to their assigned expertise specified in the scope of work (Table 8), and to contribute to the reviews being conducted by their fellow IEPR panel members, as appropriate. The broad range of experience possessed by the panel members allowed them to offer comments within their assigned discipline as well as in other allied disciplines. In general, each of the panel members chose to work independently in reviewing the project documents; however, the IEPR panel members engaged in project discussions during the site visit as well as throughout the IEPR review process. For instance, IEPR panel members discussed their comments with each other before the IEPR comment review teleconference. The IEPR panel members were also able to discuss their BackCheck responses before Battelle entered the responses into DrChecks.

4.2 Summary of Panel Comments

This section provides a summary by discipline of the types of comments and the USACE Evaluator responses. Of the 48 comments provided by the IEPR panel members, 23 comments were initially identified as 'critical.' Table 9 indicates, by discipline, how many total comments were generated by the IEPR panel members. It also identifies the results of the USACE response (e.g., concurred, non-concurred, for information only).

Table 9. Total Comments and Initial USACE Evaluator Responses

Discipline	Total Comments	Critical Comment by Discipline	USACE Evaluation		
			Concurred	Non-Concurred	For Information Only
Geotechnical	10	1	--	--	10
Structural	15	10	3	4	8
Hydraulic	13	9	1	1	11
Civil	10	3	3	1	6
Total	48	23	7	6	35

Critical comments entered in DrChecks during the initial review by the IEPR panel members focused on topics such as:

- Gate and culvert performance during a storm event
- Accessibility of the controls for gate operations during a storm
- Overtopping criteria and the need for additional armoring
- Structural calculations for barge impact loads and its distribution
- Damage from barge impact on the flood side
- Failures at transitions due to differential settlement or erosion
- Settlement of soft clays that exceed the overbuild height
    - Erosion potential of wave overtopping on the protected side due to lack of armoring
    - Inconsistencies in suggested overtopping rates associated with armoring
- Lack of information on construction and operations details of a gate, possible weak link due to hinges being on the non-flood side
    - Impacts on gates from barges or debris
    - Impacts of cars or trains on gates when closing or closed
    - Inconsistencies in the designs with specifications in the HSDRRS Design Guidelines
- Insufficient pile driving criteria provided (tip elevation only?), means for confirming pile capacity and production pile quality control
- "Resiliency" design load case
- Use of proper "Uplift Load Diagram" based on the HSDRRS Design Guidelines

4.3 Discipline-Specific Review Approaches

In addition to the general approach, each IEPR panel member also employed specific approaches for their review of the LPV 109.02a review documentation. Those specific approaches are summarized in the following paragraphs.

Geotechnical Engineering Panel Member Comments

The IEPR reviewer with geotechnical engineering expertise focused on the geotechnical issues of the overall project, primarily related to slope stability, seepage control, settlement, slope/overtopping protection, and levee construction methods. Examples of some of the comments (critical and non-critical items) that this panel member generated during his review include: levee and floodwall/closure structure analyses for stability, foundation support, settlement, seepage control and scour/overtopping protection. Within these issues, specific attention was given to subsurface characterization, development and selection of design soil parameters, design assumptions/analysis methods employed, and the HSDRRS Design Guidelines.

Civil Engineering Panel Member Comments

The IEPR reviewer with civil engineering expertise focused on the civil issues of the overall project, mainly related to seepage control, armoring requirements, settlement issues as related to levee heights, potential for cracking, operational requirements including integrity of gate operations, slope stability, and construction methods. Examples of some of the comments (critical and non-critical items) that this panel member generated during his review include: construction sequencing, gate designs, access ramps, differential settlement potentials, constructed levee heights in relation to settlement, velocities of overtopping waves in relation to armoring concerns, and O&M access.

Structural Engineering Panel Member Comments

The IEPR reviewer with structural engineering expertise focused on the structural issues of the overall project, ensuring that the overall design approach of the flood protection structures are based on the latest HSDRRS Design Guidelines as well as ensuring that clarity, accuracy, and completeness are maintained over the review documents. The primary objective of the structural engineer was to assess the structural integrity of the proposed floodwalls, levees, and other components when subjected to the realistic loading conditions within the context of the latest HSDRRS Design Guidelines.

Hydraulic Engineering Panel Member Comments

The IEPR reviewer with hydraulic engineering expertise focused on the hydraulics issues of the overall project, mainly related to wave forces on all components of the levee system, erosion potential on the protected and flood sides of the levees, and adequacy and reliability of piping systems through the levee. Examples of some of the comments (critical and non-critical items) that this panel member generated during his review include: potential for wave overtopping to erode the protected side of the levee, possible loss of integrity of the levee system due to the piping and control system to allow one-way flow from Bayou Sauvage National Wildlife Refuge (NWR) into Lake Pontchartrain, and adequacy of the armoring on the protected side to withstand water, wave, and impact loads.

4.4 Discussion of Critical Comments

This section discusses the feature-specific issues that the Panel identified as important or critical to the success of the LPV 109.02a project. The IEPR panel member comments generally fell into the following categories:

- Requesting that additional material be added to the review documents to provide a more complete analysis or paper trail
- Providing further explanation of accessibility, operation, construction methods, and design calculations
- Ensuring consistency throughout all documents

Sections 4.4.1 through 4.4.7 consolidate and summarize the 23 critical comments raised in DrChecks during the review of the LPV 109.02a documents.

4.4.1 Comments on Drainage Structures

- The IEPR Panel questioned the accessibility and operation of sluice gates located on the flood side of the levee crest that control drainage structure flow. These drainage structures are RCP culverts designed to allow excess water to flow from the protected side (Bayou Sauvage NWR) to the flood side when the water levels allow. During a storm event, it may be difficult to access this gate because of high water, wind, and waves. A representative from the State said that structures would probably be closed two days prior to landfall and weather would permit them to access the gates at that time. The Panel was satisfied with this response and the comment was closed.

- The IEPR Panel had several questions about the four drainage culverts that allow movement of water from the protected side (Bayou Sauvage NWR) to the flood side when the water level on the protected side is high and the water level on the flood side is sufficiently low. There is a possible loss of integrity of the levee system due to the piping and control system. The panel members requested clarification that gates and the culverts are performing properly during flood events. The USACE PDT stated that the primary means of protection are the sluice gates and that they are protected from being struck during a storm event, and that access is restricted by locks on the grating. Flap valves installed on the flood side provided secondary protection, but may be damaged during a storm event. USACE also clarified questions on how the flow rate through the culverts would be controlled. As far as O&M for the piping and controls, USACE noted that periodic inspection should detect the need for preventive maintenance and repairs. Based on this response, the Panel closed the comment.

4.4.2 Comments on Impacts

- The IEPR Panel asked if the design considered possible damage from barge impact on the flood side. Possible failure mechanisms from an impact may include: (1) breaking the flap gate, thereby allowing water to enter the culvert and possibly flow to the protected side, and (2) rupturing the culvert, thereby allowing water to flow from the culvert into the surrounding soils of the levee. The USACE PDT stated that flowable fill (light concrete) was added during construction at the haunch areas of the pipes, improving the permeability. In the event of a rupture, likely to happen between the sluice gate structure and the outlet discharge on the flood side, the sluice gate should minimize any water flow into the surrounding levee soils. The IEPR Panel accepted the USACE response and closed the comment.
- The IEPR Panel questioned the magnitude of the barge impact load used for T-Walls (i.e., only 50 kips). The USACE PDT explained that the highway crossings fall within category #2, which is the impact loading from a pleasure craft (i.e., 50-kip). The transition between #2 (50 kip) and #1 (100 kip) occurs at the southeastern-most point in the New Orleans East System, where east-west floodwalls along the Intracoastal Waterway (#1) meet the north-south walls along the east edge of the levee protection (#2). Tie-in to another project (LPV 110) used the 100-kip barge impact load to match the criteria created for that specific project. The IEPR Panel accepted the USACE response and closed the comment.
- The IEPR Panel questioned the magnitude of the barge impact load used for one of the gates or the earthen levee. The Panel felt that the result of the failure of the gate due to a barge impact can be as great as the failure of the T-wall under similar impact loading. The USACE PDT explained that gates are designed for a minimum of 50-kip boat impact load and cited the location of the design and load combination criteria for the design of

boat/barge impacts for the gates in the documentation. The IEPR Panel accepted the USACE response and closed the comment.

- The IEPR Panel asked what the consequences would be of another type of impact such as a car or train crashing into one of the gates (from either the protected or the flood side) during or after closure. The IEPR Panel also suggested the types (e.g., reinforce/replace/repair) of mitigation in place so that flooding is controlled should be discussed. The USACE PDT referenced drawings in the LPV 109.02c project for details of the gate closure signal and barricades placed on the flood side and protected side of the gate. Because the potential failure mode(s) of gates are not part of the LPV 109.02a project, the Panel recognized the issue was not part of their review, and closed the comment.

4.4.3 Comments on Transitions at the Gates

- The Panel was concerned with the lack of information on the gates at the crossings with regard to operational details for maintaining, monitoring, and testing to ensure that the gates and the culverts perform properly during flood events. A representative from the State provided the IEPR Panel with quarterly inspection sheets for the gates (communicated through DrChecks). Furthermore, USACE said they were preparing O&M manuals for all portions of the HSDRRS, including a formalized O&M procedure for floodgates within that manual. The Panel said that assuming that this improved, system-wide O&M process is completed and implemented, the concern is resolved and this comment may be closed.
- The Panel requested confirmation that failures at the proposed transitions from T-Walls to earthen levees will not occur due to differential settlement or erosion. The USACE PDT explained how the design and construction of the transitions from T-Walls to earthen levees is supported. Deep mixing method (DMM) elements as well as high-strength geotextile over the DMM and the earthen levee provide a measure of mitigating differential settlement. The IEPR Panel accepted the USACE response and closed the comment.

4.4.4 Comments on Pile Design

- The IEPR Panel requested that pile-driving criteria be included in order to confirm pile capacity and production pile quality control. The USACE PDT concurred and said they would add a note about timber piles to the plans and specifications; however, there was enough information about the timber piles to complete the construction of the pump stations without any delay.

- The IEPR Panel commented that the Design Documentation Report (DDR) provided design criteria and recommendations for pile capacities/factors of safety for piles with and without load tests; however, the specifications do not provide pile-driving criteria (tip elevation only?), means for confirming pile design capacity /information, or production pile quality control. The USACE PDT responded by stating that piles were driven to the specified tip elevation and that pile capacity for a FS=3 does not require confirmation. QC is upon the contractor and QA is upon the USACE field personnel as required in the specifications. The IEPR Panel accepted the USACE response and closed the comment.

4.4.5 Comments on Settlement

- The IEPR Panel commented on the settlement of soft clays that exceed the overbuild height. If only 2 feet of overbuild is planned, then the levee height will be 7 inches short of the 1% storm event requirement at the crest; therefore, what plan or schedule is in place to correct this deficiency? The USACE PDT explained the measures they have taken to address this issue. Additional fill has been applied to Sub-Reach 2 and USACE will continue to monitor this. Additional fill may be added before the contractor leaves the site. USACE also responded that annual monitoring of the crest of the levees has been recommended to ensure that all elevations do not fall below 2011 design elevations. The Panel accepted the USACE explanation and closed the comment.

4.4.6 Comments on Overtopping

- The IEPR Panel was concerned that without armoring or even consideration of the erosion potential, there is opportunity for a failure mode from the protected side due to overtopping, as some overtopping may occur even with the 1% chance event. The USACE PDT stated that current design entails limiting the overtopping of protections that occur in the 1% event to a quantity that can be carried by typical turf covering. The panel members requested additional clarification to see evidence where erosion protection to protect against overtopping during the 1% event has been incorporated. USACE clarified that erosion studies have been performed and concluded that grass cover will protect the levee against erosion for overtopping during a 1% event. The Panel appreciated the detailed response provided by the USACE and closed the comment.
- The IEPR Panel requested an explanation on the need for additional armoring given inconsistent overtopping rates for the LPV 109.02a levees. The USACE PDT explained that recent wave overtopping testing at Colorado State University withstood much higher wave overtopping flow rates and was successfully compacted to the HSDRRS Design Guidelines. Given this additional information, the Panel closed the comment.

4.4.7 Comments on Design Calculations

- The IEPR Panel requested that the correct Uplift Load Diagrams be used in the design calculations for both the “Impervious” and “Pervious” sheet pile cut-offs, as they do not match the recommended Uplift Load Diagram in the HSDRRS Design Guidelines. The USACE PDT said it was determined that neglecting the protected-side uplift would result in a more conservative analysis and that uplift on the protected side of the monolith was ignored to amplify the effects of overturning due to flood-side hydrostatic force and flood-side uplift force. The Panel asked for additional clarification about the Uplift load on the protected side, as it may or may not be conservative for all the design load cases. The USACE PDT and its contractor clarified that no simplifications were adopted on the “Uplift Load Diagram.” HSDRRS Design Guidelines only shows the case when the water level is above the bottom of the base slab at the protected side (not the case for this project); instead, a linear distribution of the pressure on the bottom of the slab from zero in the protected side up to the uplift value in the flood side is used. Historical hydrologic data for the area show that groundwater on the protected side of the alignment rarely rises above the elevation in question (EL 4.0). If the water level is higher than EL 4.0, the protected side will be flooded. Whether impervious or pervious, all of the load cases presented in the calculations, with the exception of the construction cases, will result in a slightly more conservative analysis when protected-side uplift is not present, especially considering that the protected-side water level is beneath the bottom of the base slab. The Panel requested that this explanation be included in the design file(s) and closed the comments.

- The IEPR Panel requested that the design for all the monoliths include all applicable load cases and combinations described since it appears that:
  - The Unbalanced load was considered for some and ignored for most load cases. The USACE PDT agreed that the description of load cases for the transition to LPV 110 monoliths is confusing, explained why they were written this way, and explained why it was generally not called out in the load case descriptions table. In the design calculations for monoliths T-13, T-14, and T-15, the unbalanced loads for both the Still Water Level (SWL) and Resiliency cases have been included in all relevant analyses. The Panel closed the comment and noted that the clarification should be added to the design file(s) to make it easier for any engineer to follow the design calculations.
  - The "Water to Reverse Head Plus Wind" load cases were not included in the design. The USACE PDT stated that this load case was neglected by inspection, as it does not govern the design. The reverse water level is expected to be below the bottom of all the T-wall base slabs for this project. The Panel closed the comment, but requested that the basis for neglecting this load case be included in the design files.
- The IEPR Panel requested that the correct barge impact load of 100 kips be used for all monoliths. The USACE PDT explained that the highway crossings fall within category #2, which is impact from a pleasure craft (i.e., 50-kip). The transition between #2 (50 kip) and #1 (100 kip) occurs at the southeastern-most point in the New Orleans East System, where east-west floodwalls along the Intracoastal Waterway (#1) meet the north-south walls along the east edge of the levee protection (#2). Tie-in to another project (LPV 110) uses the 100-kip barge impact to match the criteria created for the LPV 110 project. The IEPR Panel closed the comment, but said the use of term "boat impact" instead of "barge impact" in the design calculations would be more appropriate, if the design was based on the "pleasure craft" impact loading.
- The IEPR Panel requested clarification as to why certain overstress factors were not used for specific T-Wall load cases. The USACE PDT said the table the Panel was using was for the monolith foundation calculations. The overstress factors listed in this comment are for wall designs, not foundation designs. The Panel member requested additional information from USACE, as the table does not mention anywhere that the load combinations are for the foundation design. USACE stated that due to an accidental omission, the load combination table in question was named "T-Wall Monolith Load Combinations" and not "T-Wall Monolith Foundation Load Combinations," and assured the Panel that all overstress factors used in the design calculations are properly applied to foundations and T- walls per the HSDRRS Design Guidelines. The IEPR Panel closed the comment, but said the clarification should be included in the design file(s).

- The IEPR Panel noted some inconsistencies in elevations in the DDR. The USACE PDT agreed and verified the correct elevations that should be listed and provided an updated file (through DrChecks) of stem wall calculations. Additionally, USACE explained that the flood walls at this crossing are in a stair-step pattern, and T-12 is at the top of the slope. The SWL (EL. 12.5) is below the top of the slab for monoliths T-7 and T-12 because of the stair-step pattern. The Panel appreciated the responses and closed the comment.
- The IEPR Panel was concerned that incorrect barge/boat impact load magnitudes and load distribution patterns were used throughout the design, notably in the "Impact Load Application and Distribution" in the design documents. The USACE PDT responded that perhaps the wording of the General Notes in the Stem Wall Design Calculations could have been more clearly expressed to say that the load is still applied horizontally, but that the distribution width becomes larger as you analyze sections farther down the wall. USACE PDT also provided a sketch for a visual of how the barge load is applied in the LPV 109 calculations. The Panel still felt that the load distribution of barge impact did not seem realistic even if the barge impact load is applied horizontally. The HSDRRS Design Guidelines clearly states, "Boat/Barge impact loads shall be distributed over 5 feet **width** plus **the width** gained along a 45-degree angle" (in horizontal plane along the length of the wall). USACE responded again by saying they agree that a check of punching shear, which they believe is being expressed by the comments about distribution of the impact load along the horizontal plane, could be derived from the statements on page 5-25 of the HSDRRS Design Guidelines. However, as can be seen by the calculation (through DrChecks, the Impact Punching Shear calculation was provided) for two-way shear due to barge impact, a 2-foot-thick wall (which is the minimum thickness for walls exposed to 50-kip and higher-impact loads) will always be able to sustain these impact forces. This may be why a specific guideline for punching shear checks was not inserted in the HSDRRS Design Guidelines, because as long as the thickness requirements set forth in Section 5.5.5 are followed, two-way shear will not be a problem. The Panel accepted the response and closed the comment, but requested that the clarification be included in the design file(s).
- The IEPR Panel questioned why the "Hydrostatic Force & Moment" for the load cases on all the spreadsheets are computed as "zeroes" and whether it had something to do with the still-water elevation used in the analysis. The USACE PDT explained that the floodwalls at this crossing are in a stair-step pattern, and T-12 is at the top of the slope (stair). The SWL (EL. 12.5) is below the top of the slab for monolith T-12 because of the stair-step pattern. For this reason, any loads related to the SWL hydrostatic force are set to zero in this spreadsheet. The Panel accepted the response and closed the comment.

4.5 Critical Comments and Any Other Open Issues to be Resolved

After the first round of responses, there was concurrence and closure for 38 of the 48 comments. The remaining 10 open comments were the focus of discussion during the IEPR comment review teleconference; however, not all of the remaining open comments were initially identified as being critical and are marked as such in the list below. Seven of the 10 open comments were critical comments. The 10 open comments focused on the following topics:

- In-place density of sand and stone in drainage blanket
- Potential effect of high salinity and/or sodium content soils and groundwater on DMM for ground improvement
- Compacted clay embankment buffer distance between the containment geomembrane wrapped stone layer/drainage blanket and the flood-side slope of the levee
- Analysis of erosion potential/overtopping on the protected side of the levee (critical)
- Impacts or damages to the concrete T-wall (critical)
- Use of proper "Uplift Load Diagram" based on the HSDRRS Design Guidelines for "Impervious" sheet pile cut-offs (critical)
- Use of proper "Uplift Load Diagram" based on the HSDRRS Design Guidelines for "Pervious" sheet pile cut-offs (critical)
- "Resiliency" design load case (critical)
- Confirmation that the design calculations and overstress factors were accurately based on the latest HSDRRS Design Guidelines (critical)
- Confirmation that correct barge/boat impact load magnitudes and load distribution patterns were consistently applied (critical)

The IEPR comment review teleconference provided an effective forum to communicate and discuss peer review comments on the LPV 109.02a project with USACE. This teleconference was an essential component of the IEPR process, especially since there was no unmonitored e-mail or additional telephone contact between USACE and the IEPR panel members. As a result of the IEPR comment review teleconference, all issues included in DrChecks were resolved.

5 CONCLUSIONS

The four IEPR panel members were selected using pre-defined technical qualifications criteria and COI standards, and the IEPR process was conducted in strict compliance with USACE peer review guidance documents (see Section 1.1) and the Battelle PRQCP.

In general, the IEPR panel members agreed that the LPV 109.02a project documents contained sufficient information to provide a reasonable level of safety assurance for the project within the context of USACE's latest HSDRRS Design Guidelines. The IEPR panel members also agreed that the design assumptions made during the design phase appear to be carried forward through construction, and that the levees and structures were being built as designed. Observation of ongoing and completed construction areas was very informative during the construction site visit, notably the flowing water drainage from the wick drains through the drainage (sand) blanket. The use of the observational method (trusted but verified through monitoring, instrumentation, and in-situ testing, including CPTs) in the geotechnical design and construction monitoring appears to be reasonable and appropriate. It appears that the construction and finish (e.g., sedimentation and erosion control, earthwork and grading, concrete work) are of high quality and meet the project requirements.

APPENDIX A

LPV 109.02a IEPR: Charge and Guidance to the Peer Reviewers

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Charge and Guidance to the Panel Members
for the
Independent External Peer Review of LPV 109.02a –
New Orleans East Levee, Southpoint to CSX Railroad

BACKGROUND

The U.S. Army Corps of Engineers is currently designing and constructing the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS). One of the vital components of this system is the Lake Pontchartrain & Vicinity (LPV) 109.02a project (hereinafter: LPV 109.02a), which consists of raising approximately 7.5 miles of levee with a protected side offset levee enlargement utilizing wick drains and geotextile; and replacing four existing drainage structures.

OBJECTIVES

The objective of this work is to conduct an independent external peer review (IEPR) of the design and construction of LPV 109.02a in accordance with the Department of the Army, USACE, Water Resources Policies and Authorities' *Civil Works Review Policy* (EC 1165-2-209) dated January 31, 2010, and the Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

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

The purpose of the review is to determine if the design and construction of the LPV 109.02a project is consistent with the HSDRRS Design Guidelines and standard practice (Safety Assurance Review) (EC 1165-2-209; Appendix E). The IEPR will be limited to technical review and will not involve policy review. The IEPR will be conducted by subject matter experts (i.e., panel members) with extensive experience in geotechnical engineering, civil engineering, hydraulic engineering, and structural engineering issues relevant to the project. They will also have experience with the HSDRRS Design Guidelines and applying their subject matter expertise to flood risk management.

The IEPR Panel (the Panel) will be "charged" with reviewing the documents and the project in relation to items identified as part of a Critical Items List (CIL) as well as providing a broad technical evaluation of the overall project in relation to significant threats to human safety. Per EC 1165-2-209, Appendix E, review panels should identify, explain, and comment upon assumptions that underlie all the analyses, as well as evaluate the soundness of models, surveys, investigations, and methods. Review panels should be able to evaluate whether the interpretations of analysis and the conclusions based on analysis are reasonable. Reviews should focus on the "adequacy, appropriateness, and acceptability of the design and construction activities for the purpose of assuring that good science, sound engineering, and public health, safety, and welfare" (EC 1165-2-209, Appendix E Section 1a, page E-1) have been taken into account. These "are the most important factors that determine a project's fate" (EC 1165-2-209, Appendix E Section 1a, page E-1). The panel members may offer their opinions as to whether there are sufficient analyses upon which to base a recommendation.

GENERAL GUIDANCE

Throughout this project, there will be a variety of formal and informal opportunities to interact with USACE in the presence of project sponsors, including representatives of the State of Louisiana. Battelle is providing each panel member with the following guidance on how various portions of the project will be conducted:

- Orientation Briefing – The orientation briefing (e.g., kick off meeting with USACE/Battelle/Panel) will be combined with the construction site visit. During this briefing, USACE will provide an overview of the document. Panel members will not render any opinions or recommendations at this time, but they are encouraged to ask questions to assist in their understanding of the document.

- Site Visits – Panel members will participate in one construction site visit to review construction activities. Upon completion of each site visit, the panel members will participate in an exit briefing, which will include USACE and project sponsor personnel, to discuss any findings. Following each site visit, panel members are to provide written feedback to the Battelle Deputy Project Manager on what discussion and input they provided at the exit briefing.

- Design Review Teleconference – Panel members will participate in a design review teleconference following review of the 100% Geotechnical Report, design A/E 100% design, and 100% plans and specifications. Following teleconference, panel members are to finalize the panel review comments and provide written feedback to the Battelle Deputy Project Manager on what discussion and input they provided at the design conference.

- Design Reviews and Comment/Response Process – Each panel member assesses the provided documents and then prepares comments for Battelle. panel members can discuss openly their reviews with other panel members; however, they should not discuss their findings with anyone outside of the team (except when requested to do so by the Battelle Project Manager or Battelle Deputy Project Manager). Individual findings from each respective expert reviewer must remain as an individual finding; no consolidation of similar findings will be developed to form a joint finding. However, notation of independent panel members arriving at similar conclusion(s) through independent means will be highlighted.

Clarifying Questions – If a USACE/Contractor responds in DrChecks with a clarification question to the panel member, the panel member will answer the question. In providing comments, the panel member must refer to the specific reference so that the representative can easily access the information in question.

- Handling of Non-Conforming Design and Construction Issues – At times, the panel member and the USACE design engineer may end up having a difference of opinion. It is not the purpose of the IEPR to resolve these non-conforming issues. These unresolved non-conforming issues will be clearly noted in DrChecks, at Design Review Conferences, and in Design Review Reports.

- All comments are to remain within the scope of the project to be reviewed.

- To maintain an IEPR, it is important that at all times the panel members maintain their independence. If they feel that any representative is trying to unduly interfere with this independence in providing an opinion, this is to be brought immediately to the attention of the Battelle Project Manager and Battelle Deputy Project Manager.

DOCUMENTS PROVIDED

The following documents and reference materials will be provided for the review. **The documents and files presented in bold font are to be reviewed**. All other documents are provided as supporting documentation or for reference.

- **100% Geotechnical Report**
- **Design Documentation Report (DDR) 100% Submittal (which includes the A/E 100% designs**
- **100% Plans and Specs**
- HSDRRS – Quality Management Plan 30 October 2009
- HSDRRS Design Guidelines – June 2008
- ER 1110-1-12, Engineering and Design, Quality Management, 21 July 2006
- ER 1110-1-8159, Engineering and Design, DrChecks, 10 May 2001
- EC 1165-2-209, Water Resources Policies and Authorities, Civil Works Review Policy, 31 January 2010
- CECW-CP Memorandum dated March 31, 2007
- Office of Management and Budget's *Final Information Quality Bulletin for Peer Review* released December 16, 2004.

CHARGE FOR IEPR PANEL MEMBERS

Members of this Panel should understand that they are being asked to review "the adequacy, appropriateness, and acceptability of the design and construction activities for the purpose of assuring that good science, sound engineering, and public health, safety, and welfare" have been taken into account.

Per EC 1165-2-209 (page E-1), "The following excerpt from The American Society of Civil Engineers (ASCE), *Civil Engineering* magazine, February 2009, Volume 79, Number 2, Guiding Principles for Critical Infrastructure, page 58, column one, by ASCE's Critical Infrastructure Guidance Task Committee should serve as a back drop for conducting Safety Assurance Reviews. It captures the essence of the challenge and purpose of the review:

> "For example, critical infrastructure must be designed to provide a balanced level of protection based on hazard level and reliability, and designs must be sufficiently conservative to accommodate unforeseen conditions. With the rapid expansion of knowledge and the spread of practices that have proved to be extremely effective ("best practices"), we must review the adequacy of existing infrastructure within the context of that new knowledge and ensure that processes are in place to respond quickly to any performance problems that arise. Resilience to prevent catastrophic failures must be a component of all designs. Performance monitoring should be rigorously employed in the operation and maintenance of protection systems."

The panel members are not being asked whether they would have conducted the work in a similar manner. Specific questions for the Panel are derived from the Critical Items List (CIL) and included in the general charge questions below.

General Charge Guidance

Please answer the questions listed below and conduct a Safety Assurance Review of the LPV 109.02a design documents and construction. Please feel free to make any relevant and appropriate comment on any of the information you were asked to review. In addition, please note the following guidance.

1. Your response to the charge questions and CIL should not be limited to a "yes" or "no." Please provide complete answers to fully explain your response. Note that for each Panel review comment entered into DrChecks, you will be responsible for providing the following information: (1) a clear statement of the comment; (2) the basis for the comment; (3) a statement as to whether the comment is a "critical" level comment; and (4) recommendations to resolve the comment (including additional research or analysis that may influence the conclusions).
2. The project design requires redundancy, resiliency, and robustness.
   a) Redundancy is the duplication of critical components of a system with the intention of increasing reliability of the system, usually in the case of a backup or failsafe.
   b) Resiliency is the ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or manmade, under all circumstances of use.

c) Robustness is the ability of a system to continue to operate correctly across a wide range of operational conditions (the wider the range of conditions, the more robust the system), with minimal damage, alteration or loss of functionality, and to fail gracefully outside of that range.

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

1. If desired, panel members can contact one another. However, panel members **should not** contact anyone who is or was involved in the project, prepared the subject documents, or was part of the USACE Independent Technical Review.
2. Please contact the Battelle Project Manager (Mario Lopez, lopezm@battelle.org) or Deputy Project Manager (Rachel Sell, sellr@battelle.org) for requests or additional information.
3. In case of media contact, notify the Battelle Program Manager, Karen Johnson-Young (johnsonyoungk@battelle.org) immediately.
4. Your name will appear as one of the panel members in the IEPR of LPV 109.02a. Your review comments will be included in the DrChecks entries but will remain anonymous.

Charge Questions

1. Do the assumptions made during the decision document phase for hazards remain valid through the completion of design as additional knowledge is gained and the state-of-the-art evolves?
2. Do the project features adequately address redundancy, resiliency, or robustness with an emphasis on interfaces between structures, materials, members, and project phases?

   - **Redundancy**: The use of multiple lines of defense that are linked to potential failure modes. The most vulnerable failure modes need the greatest redundancy.
   - **Resilience:** The use of enhancements to improve the ability of the system to sustain loads greater than the design load to achieve gradual failure modes over some duration rather than sudden failure modes.
   - **Robustness**: The use of more conservative assumptions to increase capacity to compensate for greater degrees of uncertainty and risk.

3. Do the project features and/or components effectively work as a system?
4. Do the assumptions made during design remain valid through construction?
5. For operation and maintenance (O&M) manuals, do the requirements adequately maintain the conditions assumed during design and validated during construction? Will the project monitoring adequately reveal any deviations from assumptions made for performance?

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APPENDIX B

Final Field Site Visit Report

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US ARMY CORPS
OF ENGINEERS

FINAL
FIELD VISIT REPORT
for
INDEPENDENT EXTERNAL PEER REVIEW OF LPV 109.02a – NEW ORLEANS EAST LEVEE, SOUTHPOINT TO CSX RAILROAD

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Prepared for
U.S. Army Corps of Engineers
Coastal Storm Damage Reduction Planning Center of Expertise
Baltimore District

Contract No. W911NF-07-D-0001
Delivery Order: 1055
Task Control Number: 11-028
Scientific Services Program

July 8, 2011

FINAL
FIELD VISIT REPORT

Independent External Peer Review
of
LPV 109.02a – New Orleans East Levee, Southpoint to CSX Railroad

Submitted to:

Department of the Army
U.S. Army Corps of Engineers
Coastal Storm Damage Reduction Planning Center of Expertise
Baltimore District

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Prepared by:

Battelle
505 King Avenue
Columbus, OH 43201

July 8, 2011

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1. INTRODUCTION

The U.S. Army Corps of Engineers (USACE) is currently designing and constructing the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS). One of the vital components of this system is the Lake Pontchartrain Vicinity (LPV) 109.02a – New Orleans East Levee Southpoint to CSX Railroad (hereinafter LPV 109.02a) project. An integral part of the HSDRRS is the conduct of an Independent External Peer Review (IEPR) to ensure the reliability of scientific information and engineering analysis contained within the project documents and through the construction phase. Battelle Memorial Institute (hereinafter Battelle), as a non-profit science and technology organization experienced in conducting expert peer reviews, was engaged by the USACE Coastal Storm Damage Reduction Planning Center of Expertise (PCX) to conduct the IEPR of the LPV 109.02a. Subject Matter Experts with knowledge and expertise of specific technical disciplines and project knowledge similar to LPV 109.02a are engaged to form a Battelle IEPR Panel (a.k.a. peer reviewers or panel members) and specifically address the assessment and analysis of key criteria associated with the design, engineering, and construction of LPV 109.02a.

2. OBJECTIVE

Specific background on the overall USACE project, objectives of this IEPR, and the key tasks for the IEPR are defined in detail in the USACE Project Statement of Work (SOW), (Appendix A), received in the award notification on May 9, 2011[1]. In general, the purpose of the review is to determine if the design and construction of the LPV 109.02a project is consistent with the HSDRRS Design Guidelines, standard practice (Safety Assurance Review), and associated design-construction documents. Details on the key components of the LPV 109.02a IEPR are described in the following sections. These sections reflect on tasks that are based on the USACE SOW.

The objective of this report is to summarize the observations and key items identified by the peer reviewers for the LPV 109.02a construction site during the field visit (e.g., site review).

3. ACTIVITIES

3.1 Field Visit Briefing

The field visit for the LPV 109.02a project was conducted on June 9, 2011 (see Attachment 1 – Agenda). On the morning of June 9, the peer reviewers, Battelle and USACE (see Attachment 2 – Attendance) convened in the USACE New Orleans District Office, for an initial briefing of the project and construction activities (see Attachment 3 – USACE briefing) given by the USACE Program Manager, Mr. Pete Cali. During the briefing, the peer reviewers were able to ask any questions to help them better comprehend the design and construction intent of the project prior to proceeding to the project construction site.

[1] Received award notification from Battelle's Army Research Office (ARO) office via e-mail on May 9, 2011.

3.2 Site Review

Subsequent to the briefing by the USACE team, Battelle and the peer reviewers were given a safety briefing and caravanned through the construction site, stopping at various points along the length of the levee to observe the key structural components, the interface of dissimilar materials, and intersections of levees with roadways. The following photographs illustrate some of the construction activities observed by the peer reviewers:

- Figure 1 shows water removal from the levee foundation resulting from the placement of wick drains and the drainage blanket system near the southern terminus of the project.
- Figure 2 shows the intersection of Highway US-90 and a concrete levee wall. Provided the highway is allowed to interrupt the wall, the concrete levee wall is designed-constructed to accommodate a steel closure gate. The levee wall and steel closure gate appeared to be of high quality construction.

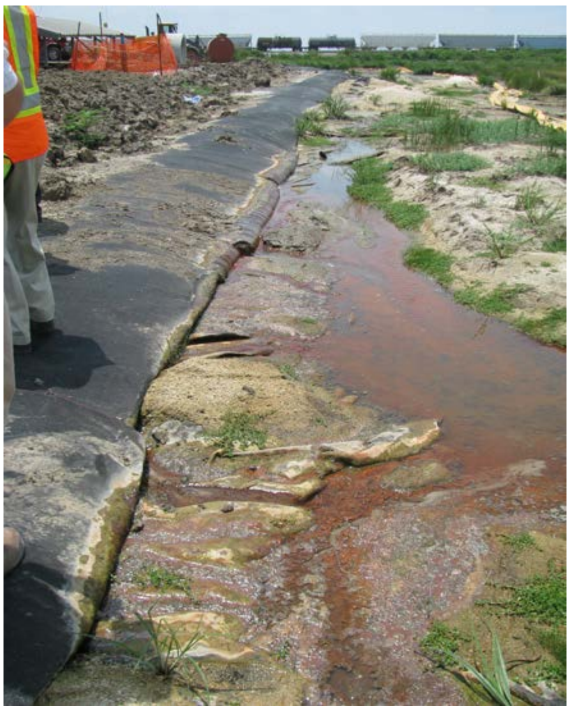

Figure 1. Water removal from levee system

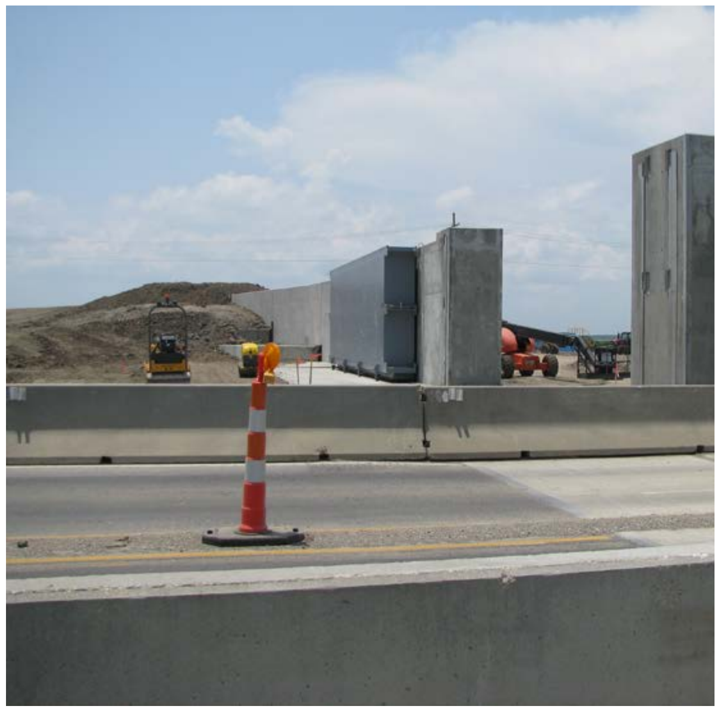

Figure 2. View of Highway closure gate at US-90

- Figure 3 shows the continuity of the earthen levee and the distant construction of the replacement for Pump Station Number 2 near the southern end of the project.
- Figure 4 shows the interface/junction of the LPV 109.02a project with LPV108 at northern end of project at Lake Pontchartrain. LPV108 is further distinguished by the growth of grass for erosion control, LPV 109.02a is intended to contain the same design-construction feature

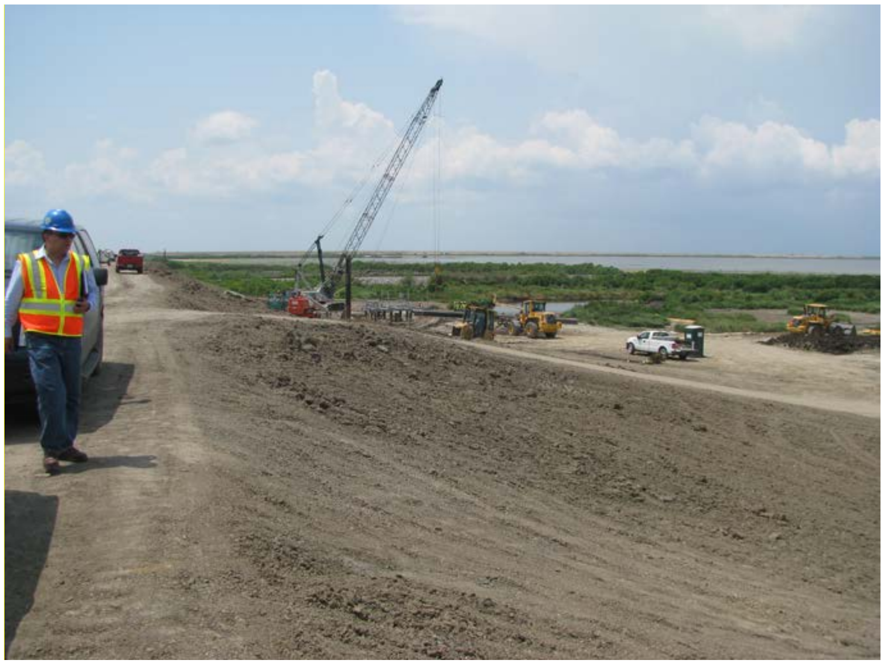

Figure 3. Levee with Pump Station No. 2 construction in the distance

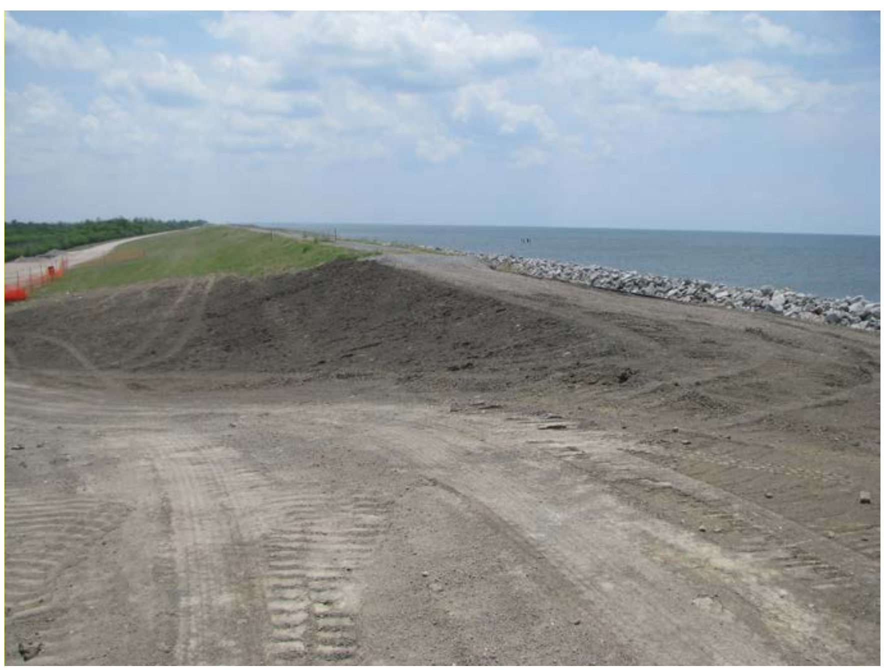

Figure 4. LPV 109.02a with LPV108 project interface/junction

3.3 Peer Reviewer Exit Briefing

On the morning of June 10, 2011, the USACE Team, Battelle and the peer reviewers convened at USACE New Orleans District Office for the Peer Reviewer exit briefing. The exit briefing addressed areas of focus and/or critical items observed by the peer reviewers during the site review. The Peer Reviewers asked specific questions related to their observations and sought clarity on the goals of the project which resulted in a discussion among the USACE, the state and the Peer Reviewers. This discussion is documented in section 4. In general, the content of the exit briefing includes positive feedback, questions/concerns, and requests from Battelle for additional documentation (see Attachment 4 – Exit Briefing Presentation).

4. CONCLUSIONS

The following sections summarize the feedback and outcome of the construction site review, based on the peer reviewers' observations and review of available reference documents.

4.1 Positive Feedback

The peer reviewers provided the following observations about the orientation briefing and site visit.

- The orientation briefing was very informative, thorough, concise, professional, and supplemented appropriately with photos, maps, data plots, and test data.
- The geotechnical information and design details provided were very thorough and complete. The presentation of soil data (including the results of CPT) was thorough and useful.
- The use of the observational method (trusted but verified through in-situ testing including CPT) in the geotechnical design and construction monitoring appears to be reasonable and appropriate.
- The flexibility by the USACE Team during the site visit to allow stops at numerous points along the levee provided for key review points of the project.
- The information exchange between USACE and the peer reviewers during the site visit was very informative, professional and open.
- Observation of on-going/completed construction areas was very informative including the observation of flowing water drainage from the wick drains through the sandbed which daylighted at the berm toe. The magnitude and apparent success of the application of wick drains to facilitate drainage, consolidation, settlement, and ground improvement is impressive.
- The availability of material samples including wick drain and geotextile fabrics was useful and provided the peer reviewers insight into the use of the wick drains and their effectiveness for drainage.
- It appears that the construction and finish (e.g., sedimentation and erosion control, earthwork and grading, concrete work) are of high quality.

4.2 Questions/Concerns

The peer reviewers provided the following questions and comments. Plans and specifications were provided after the site visit; therefore it is possible that some of the comments and questions may be addressed in those documents, plus operating manuals, closure plans, or other data sources.

- **Gate closure redundancy.** The steel closure gates are located on concrete walls along portions of the levee construction intersecting major highways understood as major hurricane evacuation routes for local residents. Concerns about the proper operations of the gates during a storm situation include the following questions.
  - Are there redundant gate closure means (e.g. winch backup) for fail safe operation? A proper gate opening and closing mechanism with a backup system should be installed.
  - Are there sufficient personnel and backup to perform all of the gate closures in time?
  - Is the CSX Railroad closure coordination procedure sufficient (e.g. keys needed from both CSX and the levee board to close the gate)? The logistics addressing the process for the opening and closure of the roller gate across the railroad tracks should be adequately addressed with the railroad company.
  - Are gate security, and operation and maintenance measures sufficient to ensure the gates will be operational when needed? Adequate gate security measures in both the storm and non-storm situations should be installed, the gate security concerns include: vandalism of gates, traffic accidents impacting gates, etc.
  - Is the gate closure strategy or procedure (trigger/sequence/timing) sufficient and does it have redundant systems in case of failure of the primary mechanisms? Proper coordination of gate closure/opening operation, timing, etc. should be addressed in advance amongst governing authorities, gate operators, local officials, etc. in order to avoid confusion and/or lack of response during a storm event.
- **Barge/Boat impact**
  - What factors or considerations for barge/boat impact loading were used in the design?
  - What design value for the barge/boat impact load was used in the design of floodwalls?
- **Design Guidelines**
  - Is the design based on the latest revised HSDRRS Design Guidelines?
- **Levee shrinkage**
  - Will the levee experience shrinkage/settlement that will lead to cracking or other degradation over the course of time?
  - What mitigation measures for shrinkage have been incorporated into the design?
  - How will the levee be protected/maintained to reduce this risk?
- **Levee armoring**
  - What is the plan for wave impact/slope protection on the flood side? Concerns about the proper armoring of the levee on the flood side can significantly dissipate the wave energy of the breaking-waves and provide significant protection to the levee slopes.

- What is the plan for crest and protected side armoring due to overtopping? The levee crests should be adequately protected against erosion due to the wave-overtopping.

- **Future raises**
  - Is the levee designed to accommodate future raises?
  - What raises are contemplated and may be accommodated by the existing structures/levees?
  - Does the design account for the future levee rises due to settlement, potential sea level rises, global warming effects, etc.?
- **Pump station**
  - Is the discharge piping above the net levee section? The pump station operation and the routing of the discharge piping with respect to the levee section were not evident during site review.
- **Instrumentation**
  - While construction monitoring instrumentation was briefly discussed and observed, it was not clear what construction monitoring instrumentation was to remain in place and or what supplemental instrumentation would be installed and how it would be used for long term performance monitoring?
- **General**
  - How will the issues of O&M, all weather, and emergency access be provided and applied to all portions of the levee, pump station, and closures?

4.3 Requests for Documents

During the Outbrief, the peer reviewers indicated that additional documentation was needed to conduct a thorough IEPR. The additional documents requested included the 2011/2012 Flood Prevention Plan, LPV 109.02a O&M Manual, a geotechnical field report documenting the construction phase, a construction management summary report (similar to the field report), monthly summaries of challenges and changes, and contract modifications. At the conclusion of the Construction Site Visit Outbrief on June 10, 2011, USACE provided Battelle with a CD of the project documents, notably the plans and specifications to be reviewed for the project. All of the requests made by the Panel during the Outbrief were fulfilled with the exception of the geotechnical field reports and construction management summary reports, as they were not readily available in summary form. It was also explained to the peer reviewers that the LPV 109.02a O&M Manual was still being developed and was not available for review.

Attachment 1 – Agenda

US ARMY CORPS
OF ENGINEERS

LPV 109.02a – New Orleans East Levee, Southpoint to CSX Railroad Orientation Briefing

Thursday, 9 JUN 11
0900 – 1500

Location: USACE New Orleans District Office, Room 386
Site Tour Location, Contractors Trailer, 15380 Chef Menteur Highway, New Orleans, LA 70129

Purpose: To hold an orientation briefing with independent external peer reviewers on LPV 109.02a for providing 100-year level of risk reduction to Orleans Parish

AGENDA

0900	Welcome and Introductions	
0910	Hurricane and Storm Damage Risk Reduction System Orleans Parish Video	
0930	Overview of LPV 109.02a (30 mins)	Pete Cali
1000	Questions & Answer	
1015	Leave MVN going to Construction Site	
10:50	Safety Brief and PPE (15 mins)	Safety Officer
1105	Site Visit (1.5 hrs)	Peter Cali
1245	***Lunch*** (1.5 hrs)	
1415	Post Tour Discussions with Key Design and Construction Personnel	Cali/PDT
1500	Adjourn	

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Attachment 2 – Attendance

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Name	Company	Thursday June 9	Friday June 10
Rhonda Braud	OCPR	X	
Rickey Brouillette	OCPR	X	On phone
Pete Cali	USACE – HPO	X	X
Lauren Dimattia	OCPR	X	
Julie Fritz	USACE – PCX	On phone	On phone
Jerry Gianelli	USACE – HPO	X	X
Ryan Gnedry	OCPR	X	
Michael Grzegorzewski	USACE – HPO	X	X
Alan Hall	IEPR Member	X	X
Mark Houck	IEPR Member	X	X
Carly Hyer	USACE – TFH		X
Jay Jani	IEPR Member	X	X
Kevin Johnson	USACE – HPO	X	
Mario Lopez	Battelle	X	X
Steve McCaskie	IEPR Member	X	X
Sheila Rice – McDonnell	USACE – PCX Rep	X	X
Rachel Sell	Battelle	X	X
Stevan G. Spencer	SLFPAE	X	On phone
Tawanda Wilson-Prater	USACE – TFH	X	X

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Attachment 3 – USACE Briefing

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Attachment 4 –Exit Briefing Presentation

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APPENDIX C

Final Critical Items List (CIL)

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US ARMY CORPS
OF ENGINEERS

Final
CRITICAL ITEMS LIST
for
INDEPENDENT EXTERNAL PEER REVIEW OF LPV 109.02a – NEW ORLEANS EAST LEVEE, SOUTHPOINT TO CSX RAILROAD

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Prepared for
U.S. Army Corps of Engineers
Coastal Storm Damage Reduction Planning Center of Expertise
Baltimore District

Contract No. W911NF-07-D-0001
Delivery Order: 1055
Task Control No: 11-028
Scientific Services Program

July 29, 2011

CRITICAL ITEMS LIST (CIL)

Independent External Peer Review
of
LPV 109.02a – New Orleans East Levee, Southpoint to CSX Railroad

Submitted to:

Department of the Army
U.S. Army Corps of Engineers
Coastal Storm Damage Reduction Planning Center of Expertise
Baltimore District

Contract No. W911NF-07-D-0001
Delivery Order: 1055
Task Control No: 11-028
Scientific Services Program

Prepared by:

Battelle
505 King Avenue
Columbus, OH 43201

July 29, 2011

Battelle
The Business of Innovation

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Appendices

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1. Background

The U.S. Army Corps of Engineers (USACE) is currently designing and constructing the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (GNOHSDRRS). One of the vital components of this system is the LPV 109.02a project which consists of raising approximately 7.5 miles of levee with a protected side offset levee enlargement utilizing wick drains and geotextile; replacing four existing drainage structures and the existing Hwy 11 and Hwy 90 floodgates. An integral part of the HSDRRS process is the conduct of an Independent External Peer Review (IEPR) to ensure the reliability of scientific information and engineering analysis contained within the project documents and continuing through the construction phase. Battelle Memorial Institute (hereinafter Battelle), as a non-profit science and technology organization experienced in conducting expert peer reviews, was engaged by the USACE Coastal Storm Damage Reduction Planning Center of Expertise (PCX) to conduct the IEPR of the LPV 109.02a project. Subject Matter Experts with knowledge of specific technical disciplines and project knowledge and expertise similar to LPV 109.02a are engaged to form a Battelle IEPR Panel (a.k.a. peer reviewers or panel members) and specifically address key criteria associated with the design, engineering, and construction of LPV 109.02a.

2. Objective

The identification of the critical items list (CIL) is one of the resulting documents from the conduct of the IEPR analysis and assessment of design and construction components, subcomponents or systems of the flood management project, whose malfunction can cause a single significant failure or a cascading failure of the entire structure and can pose a risk of serious injury, loss of life, or negative critical impact on one or more mission objectives. The IEPR Panel will prepare the CIL, and respective updates throughout the life of the project, intended to focus their review of design documents and construction activities on critical issues for mission success. Of significance for the IEPR is consideration of resilience, redundancy, and robustness of components, subcomponents or systems; subsequently the experts focus on reviewing critical items of the design and construction versus reviewing all the details of design and construction. The experts focus on those critical items which must not fail. DrChecks will be used to provide specific comments on an issue or question that relates to the CIL. Appendix A contains instructions on completing the CIL assessment. The approach and example developed for the NASA O-ring CIL was used as a basis for developing this CIL assessment.

3. References

The following project technical references and design-construction documents were used by the expert reviewers to develop the CIL:

- 100% Geotechnical Report
- Design Documentation Report (DDR) 100% Submittal (which includes the A/E 100% designs
- 100 % Plans and Specs
- HSDRRS Design Guidelines, June 2008
- HSDRRS Quality Management Plan, 30 October 2009.

4. CIL and Failures

A critical item (as defined in 2.0) and the resulting CIL (as represented by the examples in Table 1) exemplify those component, subcomponents or system components that demand greater attention during the design-engineering development as well as the construction execution to ensure mission success. The failure of any of these represented items can result in endangering mission success. A failure is also defined as non-conformance with defined performance criteria and inability to perform as intended. As noted, the following is a list of a representative CIL that each of the disciplines would further develop to identify associated concerns and effects.

Table 1. Examples of Critical Items List

Examples of Critical Items List	
Design soil parameters	Pile static load test
Scour protection	Interface seals
T-wall stem	Gate monolith columns
T-wall on levee design	Operations & Maintenance access
Sheet pile wall	Embankment underneath the T-wall

Based upon each professional discipline's focus and view point, and analysis of failure effects, two or more disciplines can develop a different set of CIL tables as a supplement to the original CIL. Table 2 describes some of the possible causes of failures. Table 3 provides a summary of the quantity of critical items in the CIL by disciplines for the LPV 109.02a Project. The actual CIL is contained in the referenced Appendix (see Appendices B through E). It should be noted that technical references, design-construction documents, and failure modes pertaining to the roller gates, which are part of a separate project known as the LPV 109.02c Project, were not specifically reviewed; however, those design-construction documents were provided to the panel members as reference documents due to the interface of the roller gates with the levee design of the LPV 109.02a Project. For example, roller gates – as they relate to potential failure modes or possible cause(s) of potential failure – could interact and interface with the LPV 109.02a Project; therefore consideration of the interface is a factor.

Table 2. Examples of Possible Causes of Failure

Examples of Possible Causes of Failure
Floodwall settlement – displacement and overtopping
Foundation support system failure
Excessive seepage and ground loss
Displacement & differential settlement
Human negligence

Defective materials or construction
Piling failure
Inadequate armoring protection

Table 3. Summary of CIL by Disciplines

Summary of CIL		
Discipline	**Number of CIL**	**Appendix**
Geotechnical	12	B
Structural	3	C
Civil	5	D
Hydraulic	4	E

5. Conclusion

The CIL is a dynamic document developed and updated as needed by each of the panel members throughout the course of the project. The CIL analysis will assist in the focus of the expert panel reviewer's attention to the critical components, subcomponents and/or systems that can fail through one or more modes. The panel member can evaluate how these possible failures are mitigated. Shortcomings in the design and construction of the critical items will prompt the panel member to enter review comments into DrChecks. If the comments cannot be resolved through the USACE/contractor evaluator's comments, then these unresolved comments may be addressed at the design review teleconferences. Changes to the CIL may also be discussed at the teleconferences. Subsequent to the teleconferences, DrChecks input will be adjusted to reflect all discussions held between the peer reviewers and the USACE/contractor evaluators.

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APPENDIX A

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Appendix A – Instruction for Completing a CIL

A critical item is defined as a component, subcomponent or system component whose failure can result in endangering mission success. A failure is also defined as non-conformance with defined performance criteria and inability to do what was intended.

The following areas will be assessed per component/system, as outlined on the form below:

- Component/System Name
- Component/System Function
- Potential Failure Mode
- Possible Cause(s) of Potential Failure
- How is the Failure Detected
- Consequence(s) of Failure
- Severity of Failure (Mild, Moderate, Severe)
- Potential Mitigation Measure
- Actions Taken.

To fill out the form use the following section descriptions as a guide:

1. Critical Item (Component/System) Name: The component/system name indicates the component/system that the form is assessing

2. Component/System Function: Indicates the primary function of the component/system.

3. Potential Failure Mode: A failure mode is defined as the manner in which the component/system could potentially fail to meet the design intent (i.e., corrosion, cracking, electrical short, etc.).

4. Possible Cause(s) of Potential Failure: A failure cause is defined as a design weakness that may result in failure. The potential causes for each failure mode should be identified and documented. The cause should be listed in technical terms and not in terms of symptoms (i.e., improper torque applied, contamination, erroneous algorithms, etc.).

5. How is the Failure Detected:

6. Consequence(s) of Failure: For each critical item, the form should indicate what the ultimate effect will be. A failure effect is defined as the result of a failure mode on the function of the design/system. This should be described in terms of what will happen if the failure mode occurs (i.e., personal injury, degraded performance, etc.).

7. Severity of the Failure: The severity of the failure is assessed based on the probability of occurring, the likelihood of detection and ultimately the impact (minor, major, or severe). This block should indicate the overall impact as defined below:

- Minor = Insignificant loss or no loss of component function or system functionality;
- Moderate = Important loss of component function or system functionality;
- Severe = Catastrophic loss of component function or system functionality that could result in serious injury, loss of life, or severe damage to protected property or equipment

8. Potential Mitigation Measures: These actions are those to be performed to mitigate the failure from occurring (i.e., inspections, perform preventative maintenance, redesign, etc.).

LPV 109.02a. Hurricane Protection System			
1	**Critical Item (Component/System Name)**		
2	**Component/System Function**		
3	**Potential Failure Mode**		
4	**Possible Cause(s) of Potential Failure**		
5	**How is the Failure Detected**		
6	**Consequence(s) of Failure**		
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☐Moderate ☐Severe	
8	**Potential Mitigation Measures**		

Appendix B - Geotechnical Engineer

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Table of Contents

1. LPV 109.02a – Critical Item		
1	**Component/System Name**	Levee
2	**Component/System Function**	Hurricane Protection
3	**Potential Failure Mode**	Global slope instability / failure
		Localized slope instability / sloughing / failure
		Seepage, piping, erosion, and ground loss
		Settlement – overtopping, breach
4	**Possible Cause(s) of Potential Failure**	Non-conservative design soil parameters
		Non-conservative design assumptions / analysis methods
		Geotechnical analyses, design methods, assumptions and criteria: As per HSDRRS vs. deviation from HSDRRS
5	**How is the Failure Detected**	Review of derivation of design soil parameters and assumptions
		Review of analysis, design methods and assumptions
		Review of criteria vs. HSDDRS
6	**Consequence(s) of Failure**	Levee slope failure / settlement / displacement - breaching and overtopping
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☐Moderate ☒Severe
8	**Potential Mitigation Measures**	Proper derivation, development and selection of Design Soil Parameters, analyses, criteria, design procedure (per HSDRRS)

2. LPV 109.02a – Critical Item		
1	**Component/System Name**	Floodwall / Closure Structure(s)
2	**Component/System Function**	Hurricane Protection / Closure
3	**Potential Failure Mode**	Global instability / failure
		Pile displacement, loss of foundation support / pile capacity, floodwall / closure settlement – displacement and overtopping
4	**Possible Cause(s) of Potential Failure**	Non-conservative soil parameters
		Non-conservative design assumptions / analysis methods
		Geotechnical analyses, design methods, assumptions and criteria: As per HSDRRS vs. deviation from HSDRRS
5	**How is the Failure Detected**	Review of derivation of design soil parameters and assumptions
		Review of analysis, design methods and assumptions
		Review of criteria vs. HSDDRS
6	**Consequence(s) of Failure**	Floodwall / closure settlement – displacement and overtopping
		Foundation support system failure
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☐Moderate ☒Severe
8	**Potential Mitigation Measures**	Proper derivation, development and selection of Design Soil Parameters, analyses, criteria, design procedure (per HSDRRS)

	3. LPV 109.02a – Critical Item	
1	**Component/System Name**	Floodwall / closure pile foundations
2	**Component/System Function**	Pile foundation support - various load cases
3	**Potential Failure Mode**	Bearing / displacement in compression / tension
		Lateral capacity / displacement
		Global instability / failure
		Loss of foundation support / pile capacity, floodwall / closure settlement – displacement and overtopping
4	**Possible Cause(s) of Potential Failure**	Insufficient capacities
		Excessive settlement & displacement
		Overtopping, erosion
		Gapping, seepage & piping
5	**How is the Failure Detected**	Review of analyses, design methods and assumptions, drawings and specifications
		Monitoring during preproduction pile load test, production pile testing (PDA)
6	**Consequence(s) of Failure**	Floodwall / closure settlement – displacement and overtopping
		Foundation support system failure
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☐Moderate ☒Severe
8	**Potential Mitigation Measures**	Review / confirm design assumptions and pile load test results

4. LPV 109.02a – Critical Item		
1	**Component/System Name**	Scour Protection – Protected Side (levee, floodwall / closure)
2	**Component/System Function**	Overtopping scour and erosion protection
3	**Potential Failure Mode**	Scour, erosion, ground loss
		Overtopping, breach
4	**Possible Cause(s) of Potential Failure**	Loss of soil, hence soil resistance
5	**How is the Failure Detected**	Review of analyses, design methods and assumptions, drawings and specifications
6	**Consequence(s) of Failure**	Levee slope failure / settlement / displacement - breaching and overtopping
		Floodwall / Closure settlement / displacement – breaching and overtopping
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☐Moderate ☒Severe
8	**Potential Mitigation Measures**	Concrete slab apron, grouted riprap, rock-filled mattresses, articulated concrete mats, crest road / protection

5. LPV 109.02a – Critical Item		
1	**Component/System Name**	Scour Protection – Flood Side (levee, floodwall / closure)
2	**Component/System Function**	Wave action scour and erosion protection
3	**Potential Failure Mode**	Scour, erosion, ground loss
		Overtopping, breach
4	**Possible Cause(s) of Potential Failure**	Loss of soil, hence soil resistance
5	**How is the Failure Detected**	Review of analyses, design methods and assumptions, drawings and specifications
6	**Consequence(s) of Failure**	Levee slope failure / settlement / displacement - breaching and overtopping
		Floodwall / Closure settlement / displacement – breaching and overtopping
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☐Moderate ☒Severe
8	**Potential Mitigation Measures**	Concrete slab apron, grouted riprap, rock-filled mattresses, articulated concrete mats

6. LPV 109.02a – Critical Item		
1	**Component/System Name**	Floodwall / closure - monolith/wall sheet pile cutoff
2	**Component/System Function**	Seepage cutoff, piping protection, scour and erosion protection
3	**Potential Failure Mode**	Seepage & piping
		Opening of sheet pile interlocks
		Splicing failure during driving
4	**Possible Cause(s) of Potential Failure**	Poor utility connections
		Displacement & differential settlement
		Quality of splicing
5	**How is the Failure Detected**	Review of analyses, design methods and assumptions, drawings and specifications
		Quality control during construction
6	**Consequence(s) of Failure**	Excessive seepage and ground loss
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	account for differential settlement during design, utility penetration design details, construction monitoring and inspection

7. LPV 109.02a – Critical Item		
1	**Component/System Name**	Monolith Transitions: Waterstops
2	**Component/System Function**	Water tightness, leakage & seepage control
3	**Potential Failure Mode**	Waterstop failure
		leakage
4	**Possible Cause(s) of Potential Failure**	Mis-alignment
		Lack of maintenance
		Differential settlement
5	**How is the Failure Detected**	Quality assurance during construction
6	**Consequence(s) of Failure**	Uncontrolled leakage, erosion and ground loss
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	Design details, construction monitoring and inspection

8. LPV 109.02a – Critical Item[1]		
1	**Component/System Name**	Roller Gates: Seals
2	**Component/System Function**	Water tightness, leakage control
3	**Potential Failure Mode**	Seal failure
		leakage
4	**Possible Cause(s) of Potential Failure**	Mis-alignment
		Lack of maintenance
5	**How is the Failure Detected**	Quality assurance during installation
		Routine inspection during operation and maintenance
6	**Consequence(s) of Failure**	Uncontrolled leakage.
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	Maintenance, alignment / adjustment, protection

[1] Documents pertaining to the roller gates, which are part of a separate project known as the LPV 109.02c Project, were not specifically reviewed; however, technical references and documents for the roller gates were provided to panel members as reference due to the interaction and interface with the LPV 109.02a Project.

9. LPV 109.02a – Critical Item		
1	**Component/System Name**	Roller Gates: Rollers[2]
2	**Component/System Function**	Rollers on rails for closing gate
3	**Potential Failure Mode**	overloading / misalignment
		difficulty in closing
		rollers lock up
4	**Possible Cause(s) of Potential Failure**	lack of maintenance
		design details
		construction and installation
5	**How is the Failure Detected**	Quality assurance during installation
		Routine inspection during operation and maintenance
6	**Consequence(s) of Failure**	Gate not closing during flood emergency.
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	Ease of access, maintenance, alignment / adjustment, protection

[2] Documents pertaining to the roller gates, which are part of a separate project known as the LPV 109.02c Project, were not specifically reviewed; however, technical references and documents for the roller gates were provided to panel members as reference due to the interaction and interface with the LPV 109.02a Project.

10. LPV 109.02a – Critical Item		
1	**Component/System Name**	Roller Gates: Operations & Maintenance[3]
2	**Component/System Function**	Closure of line of flood protection
3	**Potential Failure Mode**	Difficulty / lack of timely closure
		leakage
		failure of gate closure mechanism (cables & winch)
4	**Possible Cause(s) of Potential Failure**	Rollers jamming or getting stuck
		Damaged rollers
5	**How is the Failure Detected**	Quality control during installation
		Routine inspection during operation and maintenance
6	**Consequence(s) of Failure**	Gate not closing during flood emergency.
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☐Moderate ☒Severe
8	**Potential Mitigation Measures**	Scheduled frequent drills or practice closures, inspection and documentation, have redundant tools for closure operation on site.

[3] Documents pertaining to the roller gates, which are part of a separate project known as the LPV 109.02c Project, were not specifically reviewed; however, technical references and documents for the roller gates were provided to panel members as reference due to the interaction and interface with the LPV 109.02a Project.

11. LPV 109.02a – Critical Item		
1	**Component/System Name**	Operations & Maintenance: Emergency & Safety[4]
2	**Component/System Function**	Supervision Audits during Flood Emergency
3	**Potential Failure Mode**	Roller gates not closed
		Roller gates not accessible
4	**Possible Cause(s) of Potential Failure**	Human negligence
		Low visibility due to hurricane & storm
5	**How is the Failure Detected**	Audit supervisors during Emergency
6	**Consequence(s) of Failure**	Gates not closed during flood emergency.
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☐Moderate ☒Severe
8	**Potential Mitigation Measures**	Painting protected side of the gate with bright colors, gates accessible from two sides via service road at all times

[4] Documents pertaining to the roller gates, which are part of a separate project known as the LPV 109.02c Project, were not specifically reviewed; however, technical references and documents for the roller gates were provided to panel members as reference due to the interaction and interface with the LPV 109.02a Project.

12. LPV 109.02a – Critical Item		
1	**Component/System Name**	Operations & Maintenance: As-Built Drawings
2	**Component/System Function**	Emergency Response Plan, Operations & Maintenance
3	**Potential Failure Mode**	Performing proper maintenance
		Not able to develop good emergency response plan
4	**Possible Cause(s) of Potential Failure**	
5	**How is the Failure Detected**	
6	**Consequence(s) of Failure**	
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	Develop As-Built drawings

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Appendix C - Structural Engineer

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1. LPV 109.02a – Critical Item			
1	**Component/System Name**	7.5 Miles Levee	
2	**Component/System Function**	1 Provide Flood Protection against 100-year Storms 2 Control Flood Waters from entering the Protected Side	
3	**Potential Failure Mode**	Overtopping	Differential Settlement
		Soil Piping Erosion	Seepage
		Scouring	
		Slope Failure	
4	**Possible Cause(s) of Potential Failure**	Breaking Waves	High Velocity Currents
		Wave Run-up	Settlement of Underlying Soil
		Wave Overtopping	Underestimating the Realistic Values of Design Loads
		Wave Slamming	
5	**How is the Failure Detected**	Flood Water Entering the Protected Side	
		Seepage on the Protected Side	
		Degradation or Loss of Levee Section(s)	
6	**Consequence(s) of Failure**	Loss of Structural Stability or Complete Collapse	Loss of Means of Transportation for Hwy US 90 & Hwy 11 Traffic
		Loss of Flood Protection	High Negative Economical Impact in the Flooded Area
		Potential Large Scale Flooding of nearby communities	
		Possible Loss of Lives	
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☒Severe	
8	**Potential Mitigation Measures**	Conservative Design which considered all the Possible & Realistic Loading Conditions. Using proper Soil-Structure Interaction Models and Methodology to ensure adequate Foundation Design	

2. LPV 109.02a – Critical Item			
1	**Component/System Name**	Reinforced Concrete Floodwalls	
2	**Component/System Function**	1 Provide Flood Protection against 100-year Storms 2 Control Flood Waters from entering the Protected Side	
3	**Potential Failure Mode**	Overturning	Differential Settlement
		Concrete Fracture/Brittle Failure	
		Concrete Cracking	
		Loss of Stability	
4	**Possible Cause(s) of Potential Failure**	Breaking Waves	Barge/Boat Impact Load
		Seepage	Differential Soil Settlement
		Scouring at the Base or Sides	Underestimating the Realistic Values of Design Loads
5	**How is the Failure Detected**	Flood Water Entering the Protected Side	Settlement of Floodwall
		Seepage on the Protected Side	Overturning of the Floodwall
		Cracking of the Concrete	Damaged or Deteriorated Floodwall Sections
6	**Consequence(s) of Failure**	Loss of Structural Stability or Complete Collapse	Loss of Means of Transportation for Hwy US 90 & Hwy 11 Traffic
		Loss of Flood Protection	High Negative Economical Impact in the Flooded Area
		Potential Large Scale Flooding of nearby communities	
		Possible Loss of Lives	
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☒Severe	
8	**Potential Mitigation Measures**	Conservative Design which considered all the Possible & Realistic Loading Conditions. Using proper Soil-Structure Interaction Models and Methodology to ensure adequate Foundation Design	

3. LPV 109.02a – Critical Item			
1	**Component/System Name**	Roller Gates[5]	
2	**Component/System Function**	1 Provide Flood Protection against 100-year Storms 2 Control Flood Waters from entering the Protected Side	
3	**Potential Failure Mode**	Failure of Gate Operating Machinery or Components	
		Corrosion	
4	**Possible Cause(s) of Potential Failure**	Improper Maintenance	
		Lack of Proper Periodic Inspection	
5	**How is the Failure Detected**	Problems with Flood gate Closure & Opening Operations	
6	**Consequence(s) of Failure**	Loss of Flood Protection	Loss of Means of Transportation for Hwy US 90 & Hwy 11 Traffic
		Potential Large Scale Flooding of nearby communities	High Negative Economical Impact in the Flooded Area
		Possible Loss of Lives	
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☒Severe	
8	**Potential Mitigation Measures**	Proper Maintenance & Periodic Inspection of Gate Operating Machinery & Components	

[5] Documents pertaining to the roller gates, which are part of a separate project known as the LPV 109.02c Project, were not specifically reviewed; however, technical references and documents for the roller gates were provided to panel members as reference due to the interaction and interface with the LPV 109.02a Project.

Appendix D - Civil Engineer

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1. LPV 109.02a – Critical Item		
1	**Component/System Name**	Replacement of Drainage Structures
2	**Component/System Function**	Provides flood protection when water levels are not in hurricane mode.
3	**Potential Failure Mode**	Potential Seepage Route
		Differential settlement at transitions
4	**Possible Cause(s) of Potential Failure**	Underestimation of settlement parameters
		Underestimation of seepage effects
		Inadequate armoring protection
5	**How is the Failure Detected**	Gaps develop around transition areas.
		Unusual settlement of levee crown above the structure.
		Observed erosion at base of structure/levee connection
6	**Consequence(s) of Failure**	Partial or full collapse of levee crown
		Protection system fails due to levee breach
		Expensive repair required/property damage
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	Frequent inspections, settlement measurements, etc.

2. LPV 109.02a – Critical Item		
1	**Component/System Name**	Removal of old pump station and pipes
2	**Component/System Function**	Replacement at a different location provides water control for the USFWS Refuge..
3	**Potential Failure Mode**	Potential Seepage Route
		Differential settlement at transitions
4	**Possible Cause(s) of Potential Failure**	Underestimation of settlement parameters
		Underestimation of seepage effects
		Insufficient compaction/care taken during removal and backfilling
5	**How is the Failure Detected**	Gaps develop around transition areas.
		Unusual settlement of levee crown above the former structure location.
		Observed unusual erosion at base of levee at site of former pipes.
6	**Consequence(s) of Failure**	Partial or full collapse of levee crown
		Protection system fails due to levee breach
		Expensive repair required/property damage
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	Frequent inspections, settlement measurements, etc.

3. LPV 109.02a/c – Critical Item		
1	**Component/System Name**	Roller highway gates through T-Wall[6]
2	**Component/System Function**	Provides access for evacuation and normal traffic
3	**Potential Failure Mode**	Gates are damaged and cannot be closed
		Flood protection system fails due to open gate
4	**Possible Cause(s) of Potential Failure**	Barge Impact
		Vandalism
		Other Transportation-related accident
		Operating tolerances limit mobility
5	**How is the Failure Detected**	Gate is stuck in the open position during storm
		O&M staff cannot move the roller gate
		Observed damage on flood side of gate
6	**Consequence(s) of Failure**	Partial or full failure of flood protection system
		Poor performance of team blamed on dysfunctional element
		Expensive repair required/property damage
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	Frequent inspections, repairs, alternative closure plans, etc.

[6] Documents pertaining to the roller gates, which are part of a separate project known as the LPV 109.02c Project, were not specifically reviewed; however, technical references and documents for the roller gates were provided to panel members as reference due to the interaction and interface with the LPV 109.02a Project.

4. LPV 109.02a – Critical Item		
1	**Component/System Name**	T-Wall on Levee at Highway Crossings.
2	**Component/System Function**	Provides flood protection in areas of transition such as highway gates.
3	**Potential Failure Mode**	Differential Settlement of the wall and levee. T shape sits adjacent to and partially within the levee and settlement of levee may be bridged by the T-Wall structure
		Loss of levee supporting wall base due to erosion on flood or protection side of wall.
4	**Possible Cause(s) of Potential Failure**	Levee settlement due to poor subsurface conditions
		Soil design assumptions in T-wall foundation is typical of reaches. Soil in specific areas may differ allowing more settling at one point in wall
		Armor system on flood side of levee inadequate
5	**How is the Failure Detected**	Observed leaning or cracks in T-wall.
		Observed settlement between wall and embankment causing separation cracks.
		Erosion on either side of wall.
6	**Consequence(s) of Failure**	Partial or full collapse of wall section.
		Poor performance of team blamed on dysfunctional element
		Expensive repair required/property damage
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐ Severe
8	**Potential Mitigation Measures**	Frequent inspections, repairs, alternative access plans, etc.

	5. LPV 109.02a – Critical Item	
1	**Component/System Name**	Earthen Levee
2	**Component/System Function**	Provides primary flood protection .
3	**Potential Failure Mode**	Differential Settlement of the levee, especially near transitions.
		Loss of levee integrity due to erosion, wetting and drying cracks, etc.
4	**Possible Cause(s) of Potential Failure**	Levee settlement due to poor subsurface conditions
		Soil design assumptions in foundation is typical of reaches. Soil in specific areas may differ allowing more settling at junctions with Deep Soil Mixing zones.
		Armor system on flood and/or protected side of levee inadequate
		Armor on top of levee inadequate for overwash effects.
5	**How is the Failure Detected**	Observed cracks in levee crest.
		Observed differential settlement of crest causing separation cracks.
		Erosion on either side of levee or crest.
6	**Consequence(s) of Failure**	Partial or full collapse of levee section.
		Poor performance of team blamed on dysfunctional element
		Expensive repair required/property damage
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐ Severe
8	**Potential Mitigation Measures**	Frequent inspections, repairs, alternative access plans, etc.

Appendix E – Hydraulic Engineer

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1. LPV 109.02a – Critical Item		
1	**Component/System Name**	Drainage Structures
2	**Component/System Function**	There are four new RCP culverts with sluice gates and flap valves to allow one way flow from Bayou Sauvage NWR into Lake Pontchartrain when water levels are high on the protected side (NWR) and sufficiently low on the flood side
3	**Potential Failure Mode**	Potential flow route through the culverts from flood side to protected side during high water events on the flood side
		Differential settlement at transitions
		Potential erosion/failure of the levee if leakage through the RCP into the surrounding soils occurs
4	**Possible Cause(s) of Potential Failure**	Underestimation of settlement parameters
		Underestimation of seepage effects
		Inadequate armoring protection
		Failure of sluice gates and flap valves
5	**How is the Failure Detected**	Gaps develop around transition areas.
		Unusual settlement of levee crown above the structure.
		Observed erosion at base of structure/levee connection
		Water flow through or around RCP culverts
6	**Consequence(s) of Failure**	Partial or full collapse of levee crown
		Protection system fails due to levee breach
		Expensive repair required/property damage
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	Frequent inspections, settlement measurements, etc.

2. LPV 109.02a/c – Critical Item		
1	**Component/System Name**	Roller highway and CSX railroad gates through T-Wall[7]
2	**Component/System Function**	Provides access for evacuation and normal traffic
3	**Potential Failure Mode**	Gates are damaged and cannot be closed
		Flood protection system fails due to open gate
		Gates are damaged/breached after closure
4	**Possible Cause(s) of Potential Failure**	Barge impact
		Vandalism
		Other transportation-related accident
		Operating tolerances limit mobility
5	**How is the Failure Detected**	Gate is stuck in the open position during storm
		O&M staff cannot move the roller gate
		Observed damage on protected or flood side of gate
		Water is flowing through gate opening after gate is closed
6	**Consequence(s) of Failure**	Partial or full failure of flood protection system
		Poor performance of team blamed on dysfunctional element
		Expensive repair required/property damage
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐Severe
8	**Potential Mitigation Measures**	Frequent inspections, repairs, alternative closure plans, etc.

[7] Documents pertaining to the roller gates, which are part of a separate project known as the LPV 109.02c Project, were not specifically reviewed; however, technical references and documents for the roller gates were provided to panel members as reference due to the interaction and interface with the LPV 109.02a Project.

	3. LPV 109.02a – Critical Item	
1	**Component/System Name**	T-Wall on Levee at Highway Crossings
2	**Component/System Function**	Provides flood protection in areas of transition such as highway or CSX railroad gates.
3	**Potential Failure Mode**	Differential Settlement of the wall and levee. T shape sits adjacent to and partially within the levee and settlement of levee may be bridged by the T-Wall structure
		Loss of levee supporting wall base due to erosion on flood or protected side of wall.
4	**Possible Cause(s) of Potential Failure**	Levee settlement due to poor subsurface conditions
		Soil design assumptions in T-wall foundation is typical of reaches. Soil in specific areas may differ allowing more settling at one point in wall
		Armor system on flood side of levee inadequate
		Armor system on protected side of levee inadequate
5	**How is the Failure Detected**	Observed leaning or cracks in T-wall.
		Observed settlement between wall and embankment causing separation cracks.
		Erosion on either side of wall.
6	**Consequence(s) of Failure**	Partial or full collapse of wall section.
		Poor performance of team blamed on dysfunctional element
		Expensive repair required/property damage
7	**Severity of Failure (Mild, Moderate, Severe)**	☐Mild ☒Moderate ☐ Severe
8	**Potential Mitigation Measures**	Frequent inspections, repairs, alternative access plans, etc.

4. LPV 109.02a – Critical Item		
1	**Component/System Name**	Earthen Levee
2	**Component/System Function**	Provides primary flood protection
3	**Potential Failure Mode**	Differential Settlement of the levee, especially near transitions.
		Loss of levee integrity due to erosion, wetting and drying cracks, etc.
4	**Possible Cause(s) of Potential Failure**	Levee settlement due to poor subsurface conditions
		Soil design assumptions in foundation is typical of reaches. Soil in specific areas may differ allowing more settling at junctions with Deep Soil Mixing zones.
		Armor system on flood and/or protected side of levee inadequate to withstand wave/water/impact forces
		Armor on top of levee inadequate for overwash effects.
5	**How is the Failure Detected**	Observed cracks in levee crest.
		Observed differential settlement of crest causing separation cracks.
		Erosion on either side of levee or crest.
6	**Consequence(s) of Failure**	Partial or full collapse of levee section.
		Poor performance of team blamed on dysfunctional element
		Expensive repair required/property damage
7	**Severity of Failure (Mild, Moderate, Severe)**	☐ Mild ☒ Moderate ☐ Severe
8	**Potential Mitigation Measures**	Frequent inspections, repairs, alternative access plans, etc.

APPENDIX D

IEPR Panel Member Resumes

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Education

B.S., Professional Engineering Management, Nova University
Graduate Studies, Master of Science Program, Engineering Management, University of South Florida
Undergraduate Studies, Industrial Engineering and Operations Research, Virginia Polytechnic Institute and State University

Registrations

Professional Civil Engineer, Florida

Affiliations

American Academy of Water Resources Engineering, Diplomate
American Society of Civil Engineers, Member
Institute of Industrial Engineers, Senior Member
National Society of Professional Engineers, Member
Florida Engineering Society, Member
Governor's Conference on Library and information Systems, Delegate
Governor's Technical Advisory Committee on Lake Okeechobee, Member
South Florida Ecosystems Restoration Task Force, Member
Society of Collegiate Scholars, Member
Vice-President, Alpha Pi Mu, Industrial Engineering Honor Society, Virginia Tech
Member, Alpha Pi Mu, Industrial Engineering Honor Society, USF
President, American Institute of Industrial Engineers, Virginia Tech Chapter
Contract Expert for SFWMD Expert Assistance Program, 2001-2004

Summary of Experience

Mr. Charles Alan Hall, P.E., D.WRE, offers over 38 years of experience in the fields of water resources, environmental, and civil engineering in government service and private practice. Mr. Hall is currently responsible for marketing and management of watershed-scale water resources consulting services to the public and private client groups. He has managed over $2 billion in water resources programs and has led organizations made up of 700+ persons. Prior to his career in private practice, Mr. Hall had a 25-year record of accomplishments in public service. He served as the Director of Ecosystems Restoration for the South Florida Water Management District (SFWMD) from 1994 to 1999, where he oversaw more than a billion dollars in ecosystems restoration construction projects.
Mr. Hall's specific accomplishments with SFWMD include the design and implementation of the Everglades Construction Project, The Kissimmee River Restoration Program, Florida Bay Restoration and the Emergency Interim Flood Control Project. Before serving as Director of Ecosystems Restoration for SFWMD, Mr. Hall was Deputy Director of Operations and Maintenance. His responsibilities included the leadership and control of the water management operations and project maintenance functions for a 1,800-mile water control and treatment system which provided flood control, water supply, and environmental enhancement for central and south Florida. Mr. Hall led the emergency operations for hurricane response and recovery for severe storms such as Hurricane Andrew in 1992.

Relevant Projects

- **Gulf Intracoastal Waterway Closure Complex** - As an expert in Civil Engineering, Water Resources Engineering and Operations and Maintenance, Mr. Hall served in multiple professional capacities to oversee the design and construction of the Gulf Intracoastal Waterway Closure Complex project. Included within the GIWCC were a 19,000-cubic-foot-per-second (cfs) flood control pumping station, a 225-foot waterway closure gate, extensive levees and hurricane protection walls, and an environmentally sensitive water control structure.
- **C-51 Flood Control Project, Palm Beach County, Florida** - Project manager for a $200 million stormwater management project serving a 174 square mile urban watershed. Project elements included a 6,600-acre above-ground stormwater detention area, two stormwater pumping stations of 3,700 cubic feet per second each, and 6.5 miles of conveyance canal enlargements.
- **Kissimee River Restoration Demonstration Project, Okeechobee County, Florida** - Project hydrologist for a $15 million pilot project designed to demonstrate the feasibility of large-scale river restoration by strategically installing three steel sheet-pile notched wiers in a canal which was 30 feet deep and 250 feet wide. This project was so successful that a $430 million joint federal-state river restoration program was subsequently approved founded upon the Demonstration Project's performance and principles.

- **Hurricane Andrew Restoration Project, Miami-Dade County, Florida** - Project manager for restoration and recovery program to restore the water control systems to operation readiness in the quickest possible time that resulted from the devastation in south Florida in 1992 from Hurricane Andrew.
- **Royal Palm Beach Flood Emergency, Palm Beach County, Florida** - Project manager responsible for leading a disaster and emergency response team and directing the use of physical and fiscal resources on a real-time basis to reduce and eliminate severe flooding of residences in western Palm Beach County community served by the West Palm Beach Canal.
- **Everglades Forever Act Implementation, South Florida** - Project manager responsible for the identification and organization of the necessary agency resources to implement the requirements of this landmark Florida legislation. Project elements included: a $700 million water quality improvement construction program, a regulatory program for monitoring agricultural clean-up efforts, a research program to identify best management practices (BMPs) and new clean-up technologies, and a fiscal management program to generate revenues and monitor expenses.
- **Lake Apopka Restoration Demonstration Project, Central Florida** – Deputy project manager for the development, design, construction and operation of a pilot project to investigate the feasibility of using lake bottom sediments as capping material on adjacent farm lands to prevent migration of pesticides. Project results will be used to quantify costs of full-scale lake restoration options.
- **CERP – ASR Pilot Projects Source Water Characterization, South Florida** – Project manager for two south Florida Aquifer Storage and Recovery Source Water Characterization studies in support of the Comprehensive Everglades Restoration Plan. The surface and groundwater are characterized in relation to all major public drinking water standards for two pilot projects around Lake Okeechobee and the Hillsboro Canal in Palm Beach County. Project work involves sampling and analysis for both surface waters and ground water from the Upper Floridan Aquifer system.
- **Multi-year Professional Services for Dredging Design and Technology, Central Florida** – Deputy project manager for this five-year professional services contract to provide expert assistance to the St. Johns River Water Management District. Work involves identification of problems and development of design solutions for sediment contamination problems in the many lakes and waterways of the District.
- **Loxahatchee Wetland Mitigation Bank, Palm Beach County, Florida** – Construction director for the restoration of a 1,250-acre wetland system in south Florida. Developed and designed the hydrologic restoration and hydraulic performance criteria for the removal of exotic vegetation and recovery and planting of natural wetland species. Project is used for selling of mitigation credits for developments. Example of a highly successful private-public partnership between Foster Wheeler and the South Florida Water Management District.

Publications

Basis of Review for Surface Water Management System Design. C.A. Hall and R.A. Rogers. South Florida Water Management District (SFWMD), West Palm Beach, Florida, 1976.

Permit Information Manual Volume IV. C.A. Hall. South Florida Water Management District (SFWMD), West Palm Beach, Florida, 1979.

Staff Manual for Program/Project Management. C.A. Hall, et al. South Florida Water Management District (SFWMD), West Palm Beach, Florida, 1985.

Lake Okeechobee Supply-Side Management Plan. C.A. Hall. South Florida Water Management District (SFWMD), West Palm Beach, Florida, 1991.

Guide for the Management of High Stages of Lake Okeechobee. C.A. Hall. South Florida Water Management District (SFWMD), West Palm Beach, Florida, 1992.

Design of Ex-filtration Trenches. C.A. Hall. South Florida Water Management District (SFWMD), West Palm Beach, Florida, 1981.

Finally! An Easy Hydrograph Method. C.A. Hall. South Florida Water Management District (SFWMD), West Palm Beach, Florida, 1978.

Technical Memorandum: Water Storage Under Impervious Services. C.A. Hall. South Florida Water Management District (SFWMD), West Palm Beach, Florida, 1978.

De-watering Plan for the S-362 Everglades Pump Station. C.A. Hall. Contract Product for REP Associates, 2000.

Reevaluation of the C-51 Basin Rule. C.A. Hall. Contracted flood management study of a 164-square-mile watershed for South Florida Water Management District (SFWMD). Included the construction of hydrologic and hydraulic simulation models of the watershed, 2002.

Experience
36 years

Education
Ph.D., Environmental Systems Engineering, The Johns Hopkins University, 1976
B.E.S., Engineering Science (concentrations in Environmental Engineering and Operations Research), The Johns Hopkins University, 1972

Registrations
Professional Engineer
Indiana (#PE60018343)
Maryland (#16694)
Professional Hydrologist
American Institute of Hydrology
Board Certified
Environmental Engineer, American Academy of Environmental Engineers

Affiliations
American Academy of Water Resources Engineers, Diplomate
American Geophysical Union, Member
American Society of Civil Engineers (F.ASCE), Fellow
American Society for Engineering Education, Member
American Water Resources Association, Member
Chi Epsilon (Civil Engineering Honorary), Member
INFORMS (Operations Research and Management Science), Member
Omega Rho (Operations Research Honorary), Member
Sigma Xi: The Scientific Research Society, Member

Summary of Experience

Dr. Mark Houck, P.E., has more than 36 years of experience in the fields of environmental, hydraulic, and civil engineering in teaching and as a consulting engineer. As President of MHH Engineering, LLC, Ellicott City, Maryland, he provides engineering consulting in water resources and environmental engineering, including risk assessment and mitigation, hydraulics, hydrology, infrastructure security, and planning, design, operations and management of water resource systems. Dr. Houck's research efforts have focused on the use of systems analysis and engineering in support of public sector decision-making, with special emphasis on environmental and water resources problems. His most recent work has been in flood risk assessment in critical areas such as the National Capital Region surrounding Washington, DC, as well as New Orleans. For example, universities from Maryland, DC, and Virginia (University of Maryland, University of the District of Columbia, and George Mason University) have recently established the National Capital Region Flood Risk Assessment Program to assess the flood risk in the region and to develop strategies for addressing the risk; Dr. Houck is the senior member of the team from George Mason University. Dr. Houck also has more than 30 years of experience in the study of hurricane surge and wave generation, as demonstrated through his consulting in the private sector and his tenure as Professor of Civil Engineering at such institutions as Purdue University and George Mason University. In a recent study of the critical infrastructure resilience of the Hampton Roads region of Virginia (16 jurisdictions, including Norfolk, Newport News, and the largest military establishment in the nation), an area where a major threat is hurricane surge and waves, he led the assessment of these threats on the water and wastewater infrastructure. His current teaching and research focus on water resource planning and design and management specific to hydrologic and hydraulic analyses for flood risk management projects. Currently, as a Professor in the Department of Civil, Environmental & Infrastructure Engineering at George Mason University, he teaches and conducts research in water resources engineering, management, and planning; and environmental engineering

Relevant Projects

- **IHNC-02 Lake Borgne Protection Project for the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS)** - Hydraulics engineering panel member for the Independent Peer Review, with a focus on hurricane surge and wave generation expertise.
- **Assessment, Analysis and Evaluation of Site 1 Impoundment/Fran Reich Preserve (Site 1) Palm Beach County, Florida** – Hydrology and hydraulics engineering panel member for the Independent Peer Review.
- **Development of Expert Systems / Management Systems**
  - Conducted research for USACE Waterways Experiment Station for development of expert systems to manage potentially hazardous dredged materials.
  - Assisted U.S. Department of the Interior with drought management, expert systems for infrastructure

rehabilitation, and design of optimal drainage control networks.
  - Conducted research for National Science Foundation for development of optimal reservoir system operating rules.
  - Assisted U.S. Departments of Homeland Security and Justice with assessment of risk management in the water sector of the National Capital Region, and development of methods to enhance water security.

- **Publications** – Author of numerous refereed journal papers and reports on the topic of hurricane surge, wave generation, their effects, and mitigation strategies, including:
  - Flooding — a growing national and regional threat. Presented with Drs. G.E. Galloway, Jr., G.B. Baecher of the University of Maryland, and P. Behera of the University of the District of Columbia, at the Cannon House of Representatives Office Building, American Water Resources Association National Capital Section Seminar Series, March 2011.
  - Flood Risk in the National Capital Region: Recognizing and Addressing Present and Future Severe Flood Threats in DC, Northern Virginia, and Suburban Maryland. G.E. Galloway, Jr., M.H. Houck, K. Brubaker, G.B. Baecher. Invited Speakers, DC Area Water Issues Program Seminar, University of the District of Columbia, Washington, DC, August 26, 2010.
  - Water and Wastewater Sector. M.H. Houck, G. Baecher, T. Grizzard, and W. Williams. Final Report, Volume 3, Critical Infrastructure Protection in the National Capital Region, University Consortium for Infrastructure Protection, George Mason University, Fairfax, Virginia, 37 pages, September, 2005.
  - Hurricane Isabel: Critical Infrastructure Interdependency Assessment. M.H. Houck, G. Baecher, T. Grizzard, W. Williams, et al. Final Report, Volume 20, Critical Infrastructure Protection in the National Capital Region, University Consortium for Infrastructure Protection, George Mason University, Fairfax, Virginia, 39 pages, September, 2005.
  - Water Resources Systems: Optimal Management of Complex River Systems. Presented as a two-week short-course jointly with Dr. Uri Shamir, Vice Provost, The Technion, Israel, at the Headquarters of the Yellow River Conservancy Commission, Zhengzhou, People's Republic of China, October 1991.

Experience
25+ years

Expertise
Structural design
Structural integrity assessment

Education
Ph. D., Ocean Engineering (Major: Structural Engineering) Florida Atlantic University, Boca Raton, 1990
M.S., Civil Engineering (Major: Structural Engineering) Carnegie-Mellon University, Pittsburgh, 1984
B.E., Civil Engineering (Major: Structural Engineering) University of Bombay, Bombay, India,1982

Registration
Professional Engineer, Louisiana, 1997
Engineer-In-Training, Pennsylvania, 1983

Special Skills
Extensive software experience:
(i) *ALGOR, COSMOS, MARC, ADINA* - Finite element analysis (FEA)
(ii) *RISA-3D* - Interactive 3-D structural analysis
(iii) *MicroSAS* - Structural design & analysis of offshore structures
(iv) *PIPELAY* - Analysis related to marine pipe-laying
(v) *MOSES* – Naval architectural/ ocean engineering analysis
(vi) *AutoPipe* – Pipeline stress analysis
(vii) *AGA I & II* - Submarine pipeline on-bottom stability analysis
(viii) *Caesar II* - Pipeline stress analysis
(ix) *MathCad*

Professional Affiliations
American Society of Civil Engineers (ASCE), member
American Concrete Institute, Louisiana Chapter
ASCE-Structural Engineering Institute (SEI), New Orleans Chapter, Chairman, 2008-2009; Vice Chairman, 2007-2008

Dept. of Civil Engineering at

Summary of Experience

Dr. Jay Jani is president and senior structural engineer, Engineering Consulting Services, Inc., in Metairie, Louisiana. He has extensive experience in structural design for the civil and marine/offshore engineering industries. His experience includes applying structural design to steel, reinforced concrete structures, pile foundations, construction, and rehabilitation projects in soft Louisiana soils. He also has extensive experience designing and assessing the structural integrity of all phases of offshore platform design, including: (1) analyses of offshore oil/gas pipelines; (2) earthquake analysis of offshore platforms; and (3) installation engineering, including jacket/deck tow-safety analysis, jacket and deck lift analyses, hook evaluations, jacket/deck/pile tie-down design, jacket on-bottom stability analysis, barge structural integrity assessment, etc. He has worked on all phases of naval architecture and structural design engineering in the field of offshore marine construction.

Relevant Projects

USACE's Hurricane Protection Project

- Independent Technical Review: Structural Design of T-Walls, 56 feet Sector Gate, Pile Foundation, etc. (9% Submittal*)*, "WBV 16.2 Segnette Pumping Station to New Westwego Pumping Station Flood Wall," N-Y Associates, New Orleans
- Independent Technical Review: Structural Design of T-Walls, Pile Foundation, etc. (100% Submittal), "Fronting Protection at Cousins, Whitney Barataria and Estelle 1 & 2 Pumping Stations," N-Y Associates, New Orleans
- Independent Technical Design Review: Reconnaissance Level Study for three (3) Hurricane Protection Alignments Western Tie-in, Jefferson and St. Charles Parishes, Lake Cataouatche Hurricane Protection Levee, N-Y Associates, New Orleans

Inner Harbor Navigational Canal Replacement Lock, Riverside Gatebay Module

- Independent Technical Design Review: Structural Design, Brown Cunningham and Gannuch, Inc., New Orleans

Harvey Canal Flood Walls

- Independent Technical Design Review: Structural Design, URS Corporation, New Orleans

International Matex, Six-Oil Project

- Structural Design of Pipe Bridge (112 feet long), Pipe Racks, Electrical Platform, Reinforced Concrete Pump-Pit Foundation Slab and Containment Wall, Walkway, Pipe Supports, etc., W. S. Nelson and Co., New Orleans.

Shell's "Auger" Tension-Leg-Platform (TLP), Gulf of Mexico

- Mating of the deck-hull of the "Auger" TLP
- Analyses off lateral mooring system for TLP-hull
- Deck transportation analyses

University of New Orleans, Adjunct faculty

- Miscellaneous installation procedures for "Auger" TLP installed in a water depth of 2,860 feet in the.

Structural Design

- Structural design of reinforced concrete pile-foundation of about 56,000 sq. ft. for a proposed new church to be located at Marrero, Louisiana.
- Structural design for reinforced concrete slab with or without pile foundation for: various carwash structures, vacuum canopy structure, etc., New Orleans.
- Structural design of a reinforced concrete foundation for an 8,000-gallon insulated double-wall fuel storage tank, New Orleans.
- Structural design of weather station equipment support structure at various canals in New Orleans, Sutron Corporation, Sterling, Virginia.
- Structural design of a proposed new casino building, and a food court building to be constructed in Baton Rouge, Louisiana, using PolySteel Form, Insulated Concrete Building System. Also designed roof system for both the structures using Vulcraft Steel Joists.

Structural Rehabilitation / Structural Assessment

- Structural rehabilitation of a floor slab and the foundation for a commercial building by: (1) designing new reinforced concrete foundation slab and grade beams and, (2) foundation under-pinning using concrete segmented piles, New Orleans.
- Residential structural assessment of more than 225 houses, to determine the extent of structural damage caused by hurricane-Katrina to the houses in New Orleans, a Federal Emergency Management Agency/Shaw Project, New Orleans.
- Structural integrity assessment of various shutters, doors, framings, etc., for various wharf structures in Port of New Orleans, to determine the extent of structural damage caused by hurricane-Katrina, Port of New Orleans, Hurricane Reconstruction Program, PB Americas, New Orleans.
- Structural integrity assessment of all phases of offshore platform design for various projects including in-place analysis, transportation analysis, installation engineering (lift analysis, lift rigging design, etc.), pile foundation design, earthquake analysis of offshore platforms, etc., J.Ray, McDermott, Inc., New Orleans.
- Analysis and structural integrity assessment of Shell's Na Kika hull pipe support design based on PDMS model. Consultant to Deepwater Consultant Alliance, New Orleans.
- Reassessment of PEMEX's Bay of Campeche platforms and subsea pipelines. Responsibilities involved evaluation of structural integrity of potentially unstable marine pipelines subjected to a 100-year storm condition. The analysis included (1) assessment of on-bottom stability of the pipelines subjected to a 100-year storm condition; (2) determination of hydrodynamic loads; (3) determination of the soil friction and passive resistance; and (4) estimation of maximum lateral movement and bending stress in the pipelines caused by a 100-year storm condition. Also performed a 1,000-year return period earthquake analysis for the ductility assessment of Pemex's CA-AC-1 platform.

Design / Analysis

- Design and analysis of A&R and SCR hooks for several deepwater pipeline installation projects, using J. Ray McDermott's J-Lay System. The pipeline hook design included a 775-Kips capacity A&R hook for one of Shell's subsea pipeline projects. Also performed a finite element analysis for 775 Kips hook, using 'COSMOS' FEA software to study the stress distribution in the hook in a more comprehensive manner.

Experience
34 years

Education
M.S., Civil Engineering (Geotechnical Engineering), Carnegie-Mellon University, 1980
B.S., Civil Engineering (Geotechnical/Structural Engineering), University of Miami, 1977
Graduate Certificate, Earthquake Engineering, Washington University, 2004

Registrations
Professional Engineer
Missouri (#024338)
Illinois (#062-056969)
Kansas (#17644)
Florida (#37673)
North Dakota (#PE-7167)
Louisiana (#36406)
Texas (#109003)

Civil Engineer
California (C-35092)

Geotechnical Engineer
California (GE-2800)

Professional Affiliations
American Society of Civil Engineers
Earthquake Engineering Research Institute
Society of American Military Engineers
American Council of Engineering Companies - Missouri
United States Society on Dams
Association of State Dam Safety Officials
International Society for Soil Mechanics and Foundation Engineering

Tau Beta Pi (National Engineering Honor Society)

Summary of Experience
Mr. Steven McCaskie is a Project Manager / Senior Geotechnical Engineer with Hanson Professional Services Inc., St. Louis, Missouri. Mr. McCaskie primarily serves the Department of Defense market. He has experience in project management, engineering and quality assurance/quality control (QA/QC) of flood protection, water resource, transportation, inland navigation, underground, port and harbor projects; planning, conducting, and supervising subsurface explorations, condition surveys/evaluations/ assessments, safety inspections, foundation analysis and design, construction monitoring and inspection; operations and maintenance; specialized foundation analyses, earth dam/levee and embankment design, instrumentation, data collection and analyses, soil-structure interaction, and earthquake engineering.

Relevant Projects
- **USACE, St. Louis and New Orleans Districts / Battelle, Independent External Peer Review (IEPR), Louisiana, Missouri** - Geotechnical engineer. Projects have included: IEPR of Navigation and Ecosystem Sustainability Program, Lock and Dam 22 Fish Passage Improvement; IEPR Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS) of LPV 111.01 - CSX to Michoud Canal, LPV 18.2 - Floodwall and Gate at Williams Blvd. Boat Launch Phase 2, and LPV 109.2a - South Point to CSX Railway.
- **USACE, St. Paul District, Devils Lake Flood Risk Management, Roads Acting As Dams, City Embankments Phases 1, 2A, and 2B, Creel Bay and East Ditch Pump Stations, Devils Lake, North Dakota** - Project manager / geotechnical engineer. Design documentation report (DDR), plans and specifications and Engineering During Construction (EDC) for 12 miles of roads acting as dams and 5 miles of dam raise adjacent to Devils Lake, currently impounding water due to the flooding of Devils Lake. Complete analysis and design of road alignments, dam raises and features including pump stations, drainage structures and ancillary components.
- **USACE, Rock Island District, Lockport Pool Stage IB Approach Dike, Chicago Sanitary and Ship Canal (CSSC), Will County, Illinois** - Project Manager, responsible for test section evaluation, instrumentation plan, and construction monitoring; planning, development, design and implementation of test plan and instrumentation program including: observation wells, seepage weirs, reference points, survey monuments, inclinometers, and data loggers to monitor and evaluate seepage cutoff barrier (cement/bentonite) construction for the 4,300 ft long west approach dike on the CSSC.
- **USACE, Rock Island District, Lockport Concrete Canal Wall, CSSC, Will County, Illinois** - Project Manager, exploration and evaluation of existing canal wall. Geotechnical engineer. Roller compacted concrete (RCC) replacement canal wall and replacement guidewall, slope stability analyses, RCC wall stability, construction methods and sequences, existing wall demolition, thermal study, preliminary designs, and DDR for the 2.2 mile long east canal wall on the CSSC.
- **USACE St. Louis District, Monarch-Chesterfield Levee, Walnut Grove Flood Wall, Walnut Grove Railroad Closure, Centaur Road Railroad Closure, Chesterfield, Missouri** - Geotechnical engineer, providing engineering services for the design and construction of a flood wall and two railroad closure structures protecting Chesterfield Valley from the Missouri River and tributaries. Prepared plans and specifications, material

quantities and a construction cost estimate for a pile-supported reinforced-concrete T-type floodwall and two pile supported closure structures.

- **South Florida Water Management District (SFWMD), East Coast Protective Levee Independent External Peer Review (IEPR) of existing levees L-33, L-35, L-35A, L -36 and L-37, Broward County, Florida** - Geotechnical engineer, IEPR review of technical evaluations, findings and recommendations for levee certification.
- **USACE, Louisville District Olmsted Dam, Olmsted, Illinois** - Geotechnical engineer, provided geotechnical evaluations, seismic analyses including soil-structure interaction, foundation analyses, ground stability/liquefaction analyses, foundation analyses and designs, under seepage control, and instrumentation for the Feature Design Memorandum and construction plans and specifications for the planned 2,400-foot-long Olmsted Dam on the Ohio River near Olmsted, Illinois.
- **USACE, St. Paul District, Lock and Dam #4, Alma, Wisconsin** - Geotechnical engineer for geotechnical evaluations, foundations analysis and designs, and construction consultation for rehabilitation of lock chamber monoliths, guidewalls, and support buildings, for the 50-year-old Lock and Dam #4 on the Mississippi River.
- **Monarch-Chesterfield Levee District - Monarch-Chesterfield Levee, St. Louis County, Missouri** - District engineer/project manager/geotechnical engineer, provided all engineering services for an urban flood protection system, involving 12 miles of levee, closure structures, floodwalls, relief wells and pump stations; protecting 4,700 acres of commercial/industrial development, including I-64 and the Spirit of St. Louis Airport, from the Missouri River and tributaries. Included: operations/maintenance (O&M), flood monitoring/inspection, analyses, design, permitting and construction of post 1993 flood repair and improvements, 100-year certification, and 500-year levee improvements, wetlands mitigation and recreational use, and coordination with all federal, state and local jurisdictions. Project included accommodations for two I-64 Missouri River / tributary bridges and pipelines across the levee system, floodplain, and associated floodway / wetlands impacts
- **Riverport Levee District, St. Louis County, Missouri** - District engineer (2004-2007), providing engineering services for an urban flood protection system involving an earth levee, relief wells and pump station to protect 410 acres of commercial development from the 500-year Missouri River flood. Services include engineering evaluations, flood protection and interior drainage system operation, maintenance, inspection, and monitoring.
- **Lakeside 370 Levee District, St. Charles County, Missouri** - District engineer (2005-2007), providing engineering services for an urban flood protection system, involving an earth levee, relief wells and pump station to protect 1,400 acres of commercial development from the 500-year Mississippi River flood. Services include engineering evaluations, analyses, flood protection and interior drainage system, operation, maintenance, inspection, and monitoring.
- **Missouri Bottoms Levee District, St. Louis County, Missouri** - Project manager. Provided preliminary planning, geotechnical explorations, analyses, design, and permitting for upgrade/improvements to the existing levee protecting over 3,000 acres from a 500-year Missouri River flood. Protection will include 10 miles of earth levee, closure structures, and floodwalls.