



US Army Corps of Engineers

Institute for Water Resources - Hydrologic Engineering Center



# Minimum Standards For USACE Evaluation of Levee Systems For the National Flood Insurance Program

Christopher N. Dunn, P.E., Director  
Hydrologic Engineering Center

SAME 2009 Water Conference  
26-28 October, 2009  
Sacramento, CA



Corps of Engineers

BUILDING STRONG™



US Army Corps of Engineers

Institute for Water Resources - Hydrologic Engineering Center



## Levee Evaluation Topics

- Definitions
- Roles and Responsibilities
- Flood Damage Assessment Policies
- Evaluation Guidance
- EC Schedule
- Evaluation Process
- Systems Approach
- Partial Compliance
- Validity Period
- Technical Criteria
- Authorities



Corps of Engineers

BUILDING STRONG™





## Definitions\*

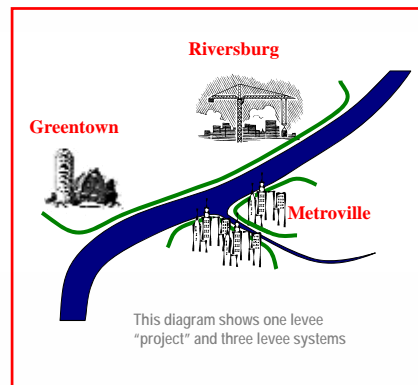
- Levee System
- Accreditation
- Evaluation for Compliance
- Deterministic Analysis
- Probabilistic Analysis
- Assurance or CNP

\* Slide title with red first letter is a definition slide



## Levee System

- A levee system is inclusive of all components that are interconnected and necessary to insure protection of the associated floodplain – levee/floodwall sections, closure structures, pumping stations, culverts, interior drainage works, and system operation and maintenance



This diagram shows one levee "project" and three levee systems





US Army Corps of Engineers

Institute for Water Resources - Hydrologic Engineering Center



## CFR Certified Levee System

A levee system that meets and continues to meet minimum design, operation, and maintenance standards as specified in 44 CFR 65.10. The design criteria and structural requirements outlined in paragraphs (b)(1) through (7) must be *certified* by a registered professional engineer or a federal agency responsible for levee design.



Corps of Engineers

BUILDING STRONG



US Army Corps of Engineers

Institute for Water Resources - Hydrologic Engineering Center



## Accredited Levee System

A levee that the Federal Emergency Management Agency has shown on the Flood Insurance Rate Map as providing protection from the 1-percent-annual-chance or greater flood. This determination is based on the submittal of data and documentation as required by Section 65.10 of the National Flood Insurance Program regulations.



Corps of Engineers

BUILDING STRONG





## Roles and Responsibilities

- **Certification** - registered professional engineer or a federal agency responsible for levee design
- **USACE Evaluation of CFR Criteria**
- **Accreditation – FEMA**



### Deterministic Analysis

- A technical analysis approach that is accomplished using single values for key variables.
- e.g. expected flow only in computation

### Probabilistic Analysis

- A technical analysis approach that uses a probability distribution rather than a single value for key variables, producing a result that captures and describes uncertainty.
- e.g. expected flow including a range of possible flows in computation





## Flood Damage Assessment Policies

### Risk-Based Analysis

- **Objective:** Improve decision making and confidence by quantifying, using, and disclosing risk and uncertainty in key data and parameters.
- **Policy:** All flood damage reduction studies will adopt risk analysis.....
  - ER 1105-2-100 "Guidance for Conducting Civil Works Planning Studies"
  - ER 1105-2-101 "Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies", dated 1 March 1996
  - EM 1110-2-1619 "Risk-Based Analysis for Flood Damage Reduction Studies", dated 1 August 1996



## Risk Analysis Outputs

- Economics
  - Expected Annual Damages (EAD)
- Performance
  - Annual Exceedance Probability (AEP)
  - Conditional Non-Exceedance Probability (CNP)





## Conditional Non-exceedance Probability (CNP)

- CNP is the probability that a specified event will be contained by a project. For levees, includes both the chance of capacity exceedance as well as the chance of failure at lesser stages.
- CNP is computed by determining the expected exceedances/ failures for event for target elevation, top of levee, or conversely, required elevation for base event and specified CNP.



## USACE Levee Certification Guidance

- In 1997, USACE issued an internal levee certification policy
  - Discussed and agreed upon with FEMA
  - Supplements 44 CFR 65.10
  - Requires the application of its risk analysis policy to levee certification
- In 2006, USACE issued updated guidance
  - Risk analysis will be applied to H&H
  - No grandfathering, no exemptions.
  - Will extend to include structural/geotechnical and operational aspects
  - Full and complete engineering analysis with field inspection.
  - Document findings, certification to be signed by PE, Chief of Engineering Division.





## Levee System Evaluation Engineer Circular (EC)

Draft ETL 1110-2-570, June 2007

EC 1110-2-6067, December 2009

**Purpose** ...to provide a consolidated document that will guide USACE procedures for levee/floodwall systems certification determinations in support of National Flood Insurance Program (NFIP) as administered by the Federal Emergency Management Agency (FEMA).



Corps of Engineers

BUILDING STRONG™



## Systems Approach

- Focus is upon the levee system that is associated with a given separable floodplain.
- Levee and floodwall sections, closure structures, pumping stations, culverts, interior drainage works, and system operation and maintenance
- No **PARTIAL** evaluations



Corps of Engineers

BUILDING STRONG™





## Validity Period

- 10 years shall be the agency maximum period of validity
- Consistent with the cycle of inspection and assessment provisions
- Evaluation Findings may be reviewed any time before the maximum period of validity



## USACE Levee System Evaluation

- Data Collection
- Combined Technical Analysis
- H&H Probabilistic
- All others Deterministic
- Other Disciplines as Methods Mature





## Review Available Information

- Design memorandums, computations, as-built drawings
- Subsurface information; foundation material characteristics,
- **Annual and periodic inspection reports,**
- Recent surveys, geospatial information, levee geometry,
- Levee zoning, levee materials, construction methods, construction records,
- Performance history, any flood performance records,
- **Operation and Maintenance Manual**
- Repairs or upgrades made to the levee system.
- Current river velocities, wave properties, or overtopping potential considered.



## Evaluation Site Visit

- Seepage controls are functioning properly,
- Woody growth, erosion, scour, rodent activity, are controlled.
- No abandoned or deteriorated conduits exist in the levee,
- No cracks, roots, or other defects exist.
- Existence of adequate levee cover vegetation,
- Existence of adequate riprap,
- Adjacent construction activities do not affect the structural integrity of levee.



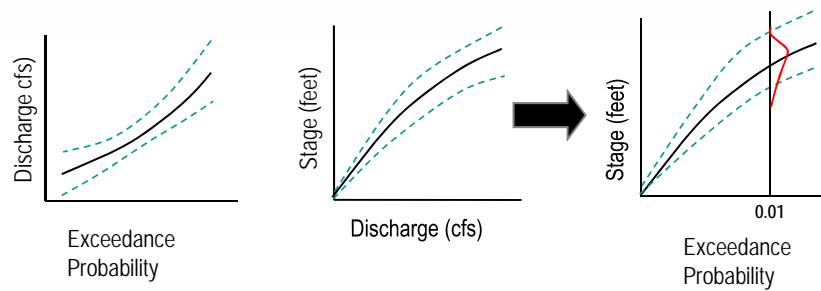


## Probabilistic H&H Analysis

- Discharge vs. Frequency with Uncertainty
- Stage vs. Discharge with Uncertainty
- Surge, Wind Wave and Wave Period with Uncertainty



## Stage - Probability Derivation



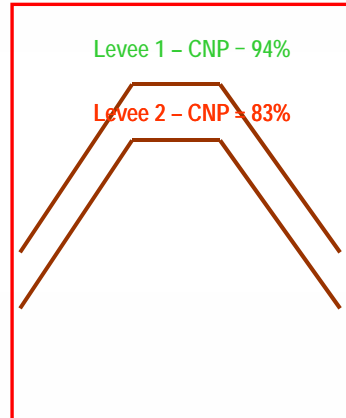
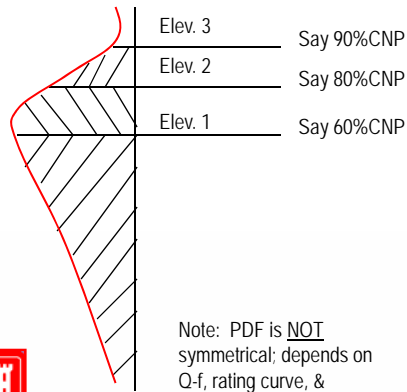
Initial Criteria –  $CNP > 90\%$  for 0.01 event





Elevation PDF for base flood event; e.g. 0.01 exceedance event.

### CNP Concepts



Note: PDF is NOT symmetrical; depends on Q-f, rating curve, & failure prob. Curve.



### CNP Criteria

- CNP = 90% if  $FB \geq 3$  feet
- CNP = 95% if  $FB < 3$  feet
- $FB \not\leq 2$  feet
- Where  $FB = \text{Top of Levee} - 50\% \text{ WSE}$





### CNP Criteria Quiz

Plan	Conditional Non-Exceedance Probability by Events				
	4%	2%	1%	0.4%	0.2%
Levee Raise to El. 510'	0.74	0.56	0.28	0.11	0.02
Levee Raise to El. 512'	0.83	0.69	0.37	0.23	0.14
Levee Raise to El. 515'	0.97	0.83	0.49	0.39	0.22
Levee Raise to El. 518'	1.00	0.99	0.97	0.86	0.52

0.01 Expected WS (50% Stage) = 516.3'



### Geotechnical Analysis

- Levee evaluation based on deterministic analyses and geotechnical judgment.

- 
- Overtopping
  - Slope stability
  - Underseepage
  - Through-seepage
  - Surface erosion
  - Wave attack
  - Flood duration
  - Seismic Stability

Identify Potential Modes of Failure Using EM 1110-2-1913, Design and Construction of Levees"





## Other Deterministic Analyses

- Structural
- Mechanical Electrical
- Interior Drainage
  - Local Sources
  - Wave Overtopping



## Authorities and Programs

- Committing to certify USACE owned/operated/maintained levees currently shown on a FIRM using project O&M funds. Schedule to be determined.
- At request of non-Federal sponsor -
- Non-Federal operated/maintained levees in ICW Program
  - Funding - ICW Program, if available
  - Funding – Reimbursed through Economy Act or Support for Others agreement
- Non-Federal in RIP
  - No RIP funding available for levee certification determinations.
  - Funding – Reimbursed through Economy Act or Support for Others agreement



CECW-P/CECW-E Memorandum, "Authority and Funding Guidance for USACE Levee Certification Activities", 15 August, 2006





## Authorities and Programs

- Other Federal Levees - at the request of the Federal agency  
Funding received from requesting Federal agency through Economy Act
- Cannot do determinations for non-Federal levees not in a USACE program (private, state, local built, owned, operated), unless part of a larger cost-shared project  
Funding – project appropriated funds
- USACE projects in study, design/or construction – Requested by non-Federal sponsor and agreed to be part of the overall project costs
- Cannot initiate a cost-shared study or project exclusively for levee certification



CECW-P/CECW-E Memorandum, "Authority and Funding Guidance for USACE Levee Certification Activities", 15 August, 2006



## Authorities and Programs

For any project, using Flood Plain Management Services (FPMS)

- Can provide support for levee evaluation determinations for others to certify under
- Support activities can include – data collection, mapping, H&H analysis, geotechnical investigations, etc.
- 100% Federally funded, if available
- Can accept voluntary contributions from state or local government to expand scope
- Cannot declare an evaluation finding of a levee system under this program.





**US Army Corps of Engineers**

Institute for Water Resources - Hydrologic Engineering Center



## ETL vs EC

- Certification to Evaluation
- Earthen Closures
- Ice Discussion
- Seismic Criteria Modification
- Flood Fight Clarification



*Corps of Engineers*

BUILDING STRONG™



**US Army Corps of Engineers**

Institute for Water Resources - Hydrologic Engineering Center



## QUESTIONS ?



*Corps of Engineers*

BUILDING STRONG™

