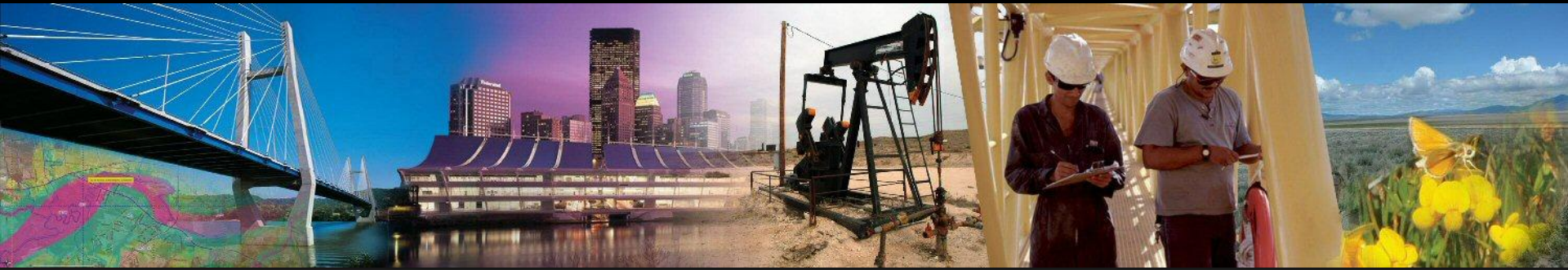


# MICHAEL BAKER CORPORATION



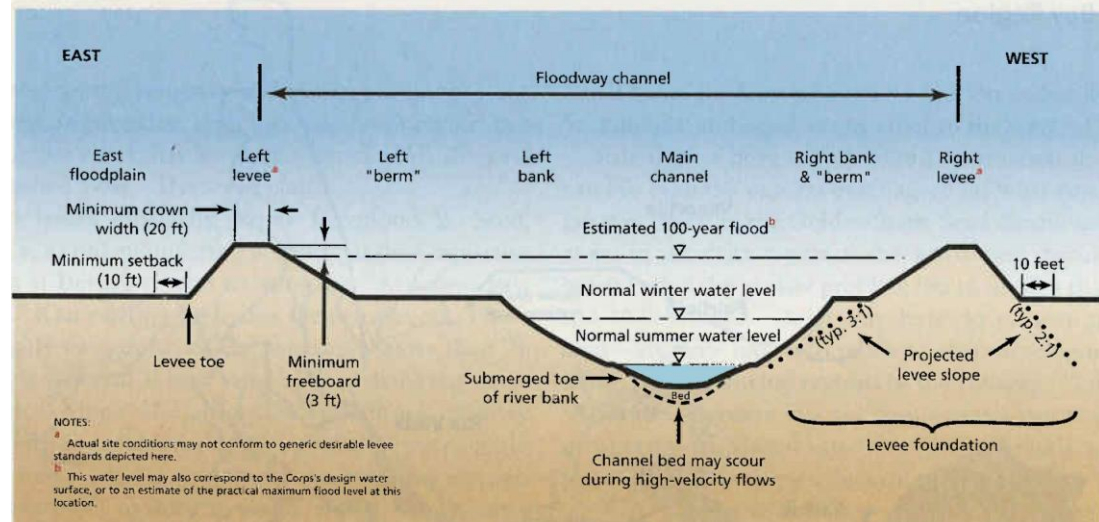
## Levees in the National Flood Insurance Program

**David Preusch, P.E., CFM, D.WRE**  
**Michael Baker Jr., Inc.**

# What is a Levee or Levee System?

- **44 CFR 59.1 Definitions- Levee** means a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding.

Typical Channel Cross Section on the Sacramento River Corridor



## What is a Levee or Levee System?

- **44 CFR 59.1 Definitions- *Levee System*** means a flood protection system which consists of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices.

**Problem- didn't explicitly mention floodwalls, sea walls, bulk heads, revetments, retaining walls.**

**OR FLOODWALLS ON TOP OF LEVEES**

# Floodwalls



**17<sup>th</sup> Street Canal Floodwall on top of levee in New Orleans**



**Floodwall Breach- New Orleans**



# Consequences of a Levee/Floodwall Breach



**City of New Orleans Flooded from Hurricane Katrina**

# Consequences of a Levee Breach



## Sacramento-San Joaquin Delta, California

## §65.10 Mapping of areas protected by levee systems.

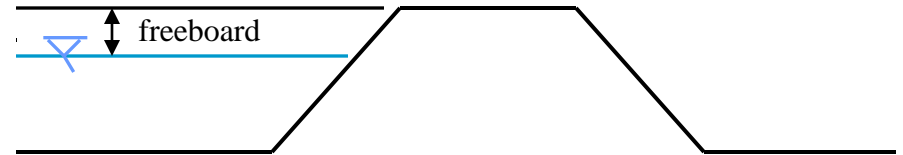
- (1) Freeboard \***
- (2) Closures \***
- (3) Embankment protection \***
- (4) Embankment and foundation stability \***
- (5) Settlement \***
- (6) Interior drainage \***
- (7) Operations plans**
- (8) Maintenance plans**
- (9) As-builts drawing of levee system \***

**\* must be certified by a professional engineer**



## §65.10 (b) Design Criteria (1) Freeboard.

### (1) Freeboard- Riverine

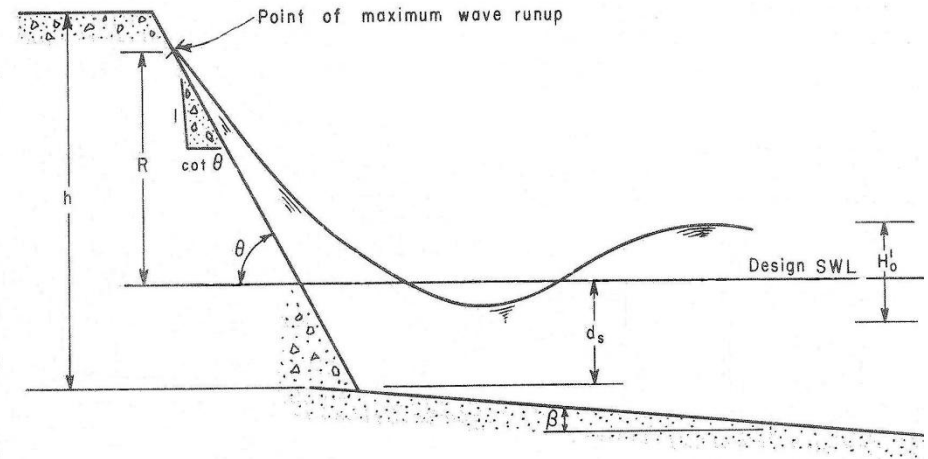


- 3 feet minimum above 100-year water level
- 4 feet within 100-feet of structures (bridges) with pier(s) or embankment(s) inside the levee
- 3.5 feet at the upstream end of levee
- Minimum of 2 feet if uncertainty associated with discharge, stage, debris, sediment, and ice is assessed



## §65.10 (b) Design Criteria (1) Freeboard.

### (1) Freeboard-Coastal



- 2 feet above the 100-year wave crest or wave runup, whichever is higher
- 2 feet minimum above the 100-year stillwater elevation if the effects of wave attack and overtopping on stability are assessed

**(2) §65.10 (b) Design Criteria (2) Closures.**

**All openings must be provided with closures that are part of the levee system**

**(3) §65.10 (b) Design Criteria (3) Embankment protection.**

**Levee embankment protected from erosion from currents, waves, ice, and debris at various stages of flooding, and bends**

**(4) §65.10 (b) Design Criteria (4) Embankment and foundation stability.**

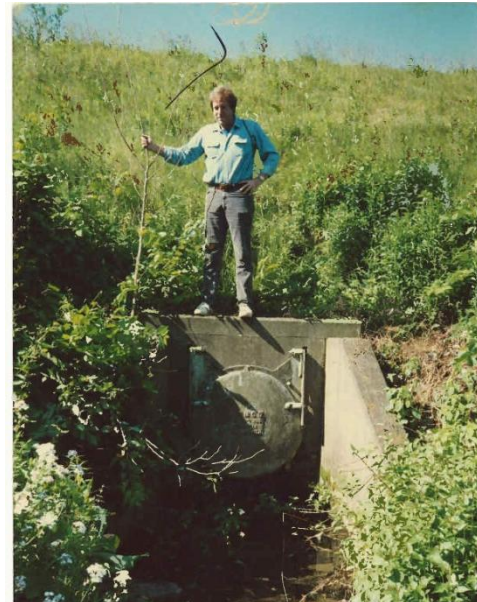
**Seepage will not jeopardize embankment or foundation stability. Corps EM 1110-2-1913 Design and Construction of Levees.**

**(5) §65.10 (b) Design Criteria (5) Settlement.**

**Settlement from consolidation of fill and embankment loads must not result in inadequate freeboard. Corps EM 1110-2-1904 Soil Mechanics Design- Settlement Analysis**

**(6) §65.10 (b) Design Criteria (6) Interior drainage.**

**Based on joint probability of river side and interior flooding, any residual flooding > 1-foot deep must be shown. This includes assessing the capacity of channels, pipes, and pumps**



Flap-gated culvert through levee

## (7) §65.10 (c) Operation plans.

**Closure structures and mechanical systems (e.g.- pumps, gates), either manual or automatic, must have an operation manual that includes:**

- 1. Flood warning system with sufficient warning time to implement operations**
- 2. Assignment of responsibilities**
- 3. Manual backup**
- 4. Periodic inspections and operations (< 1-yr intervals)**
- 5. Backup power source (other criteria)**





## **(9) §65.10 (d) Maintenance plans.**

**Levee system must be maintained to ensure its stability, height and overall integrity.**

**Maintenance plan must specify:**

- 1. Maintenance activities (implies inspections)**
- 2. Frequency of maintenance (no min. interval specified)**
- 3. Responsible party for each activity**

# FEMA Levee Policy Review Committee, Sept. 2006

**FEMA**

**Corps of Engineers**

**USGS**

**NRCS**

**NOAA**

**BuRec**

**ASFPM**

**NAFSMA**

**Baker (NSP)**

**Dewberry**

**Post Buckley**



## **The National Levee Challenge** Levees and the FEMA Flood Map Modernization Initiative

Report of the  
Interagency Levee Policy Review Committee  
Washington, DC

September 2006

**Chaired by:**  
**Gerry Galloway and**  
**Kelly Bronowicz**

This report was prepared for the Federal Emergency Management Agency by an Interagency Levee Policy Review Committee with support from Michael Baker Corporation under contract HSFHQ-04-D0025, Task Order No. HSFHQ-05-J-0008. The recommendations of this report are those of the committee and do not necessarily reflect the views of the participating agencies.

## Recommendations:

- 1. Better public awareness of residual risk behind levee and floodwall systems**
  - new XL Zone behind all levees
  - notification letters once a year
- 2. Require annual inspections**
- 3. Require reporting to FEMA on inspections, operations, maintenance, and performance every 2 years**
- 4. Recertification every 10 years**

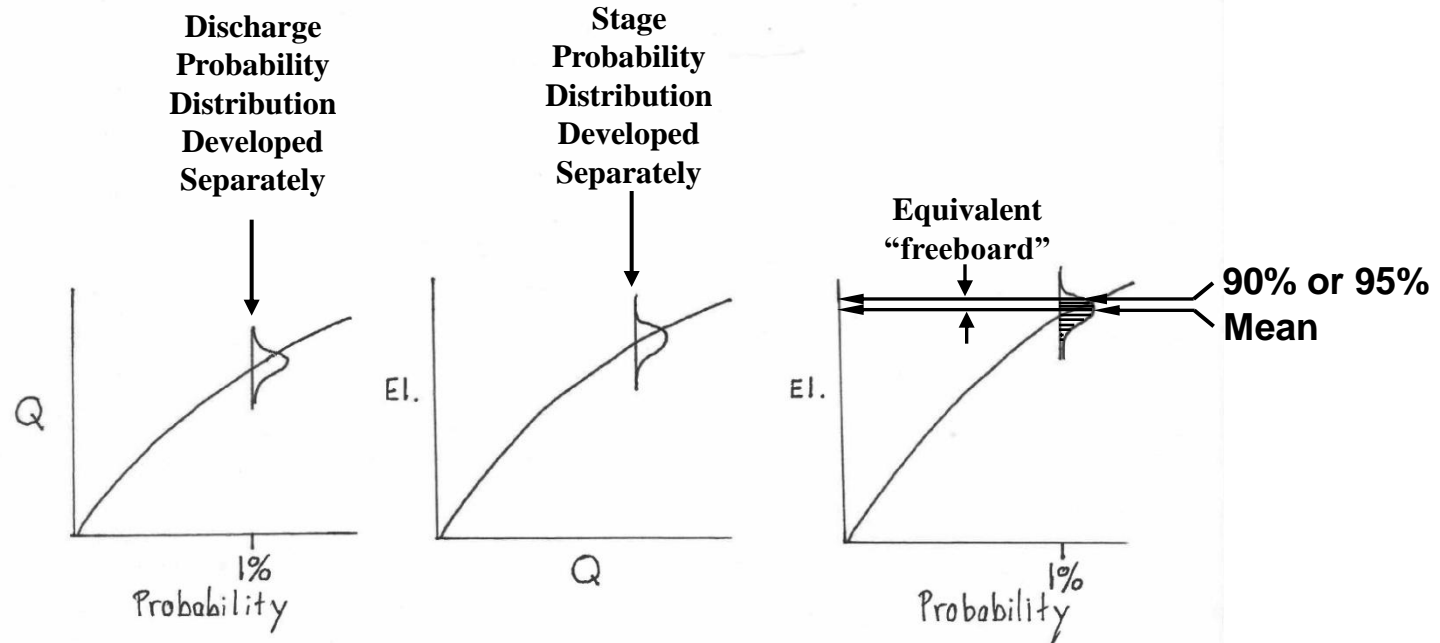
## Recommendations:

- 6. Specifically exclude embankments not designed as levees(e.g.- roadway, railroad, spoil banks)**
- 7. Require emergency actions plans for design exceedance required for certification**
- 8. Require higher level of protection for highly urbanized areas (500- or 1,000-year)**
- 9. Phase-in risk and uncertainty analysis instead of freeboard approach, phased in over 10 years**



# Risk and Uncertainty in Riverine Conditions

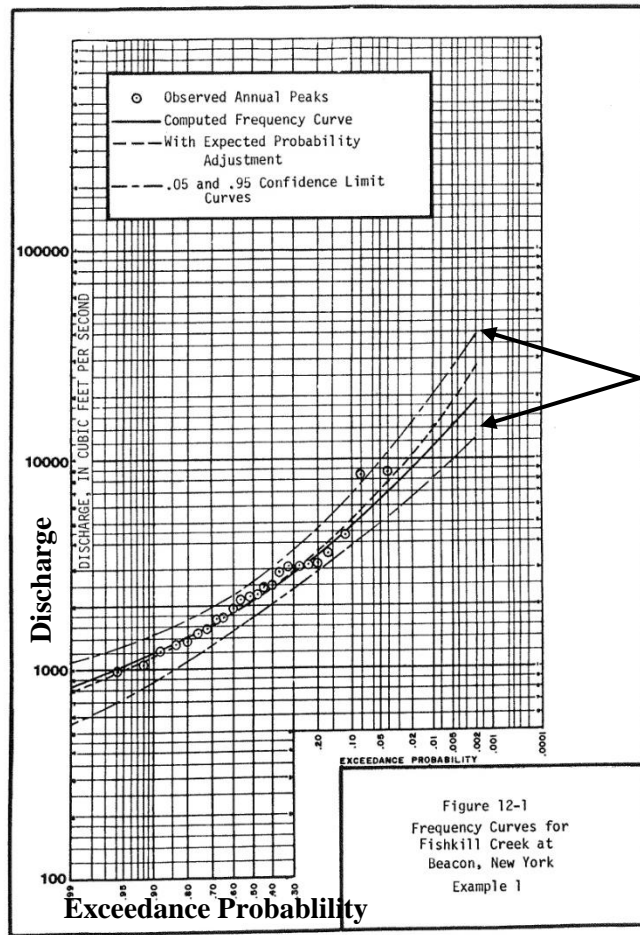
## Monte Carlo Simulation



**Account for H&H Uncertainty in Discharge and Water Surface Elevation**

# Risk and Uncertainty in Riverine Conditions

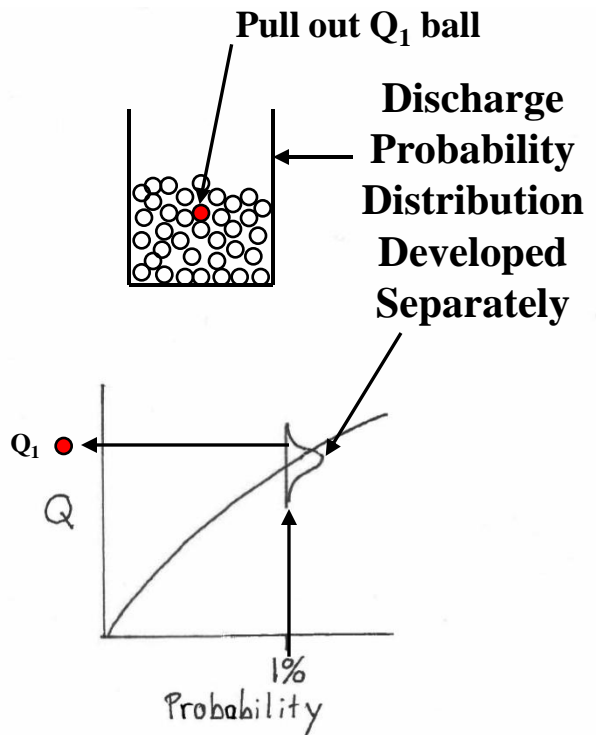
## Discharge Frequency



Confidence limits

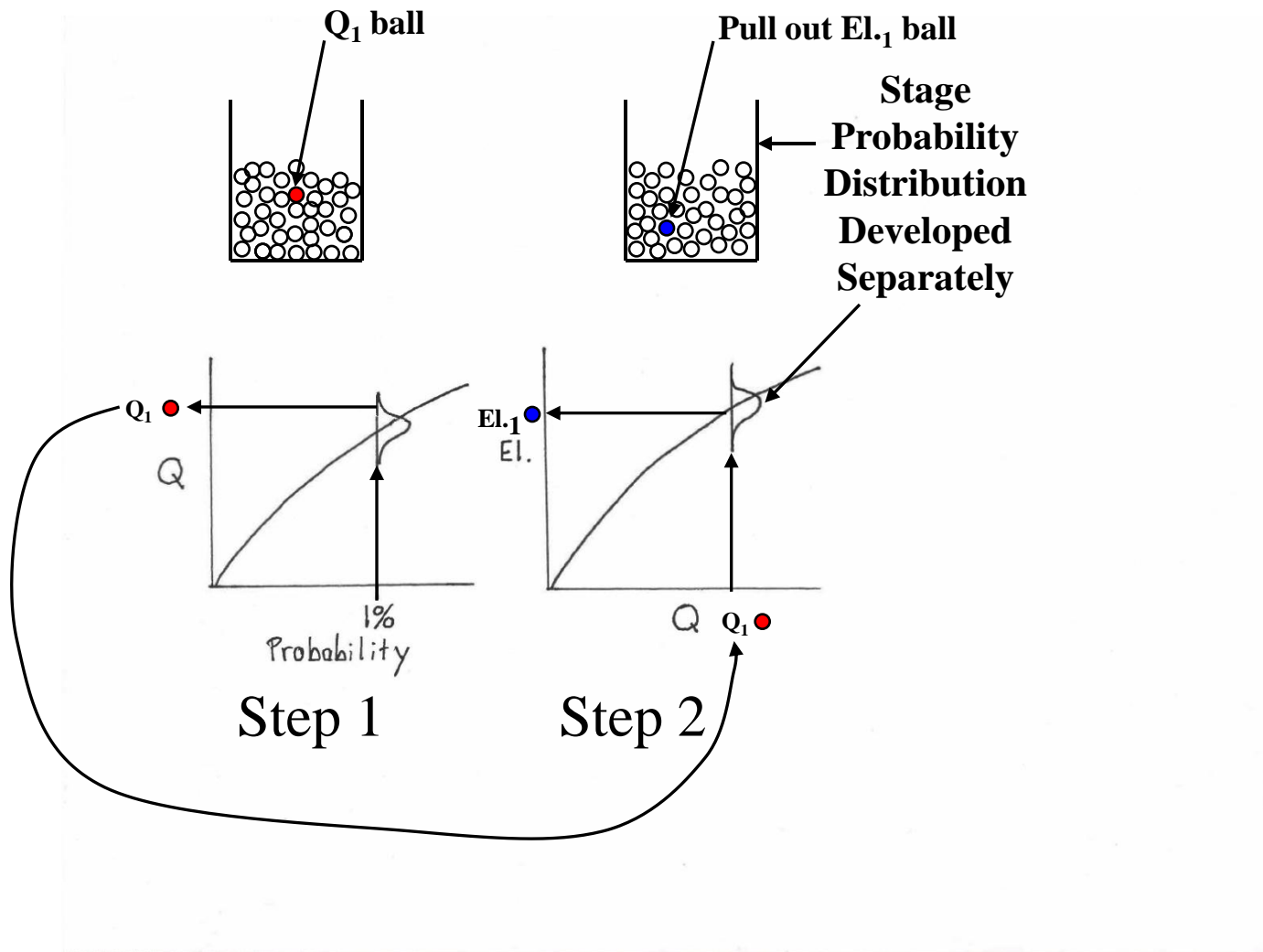
From Bulletin 17B, Guidelines for Determining Flood Flow Frequency, March 1982

# Risk and Uncertainty in Riverine Conditions



Step 1

# Risk and Uncertainty in Riverine Conditions

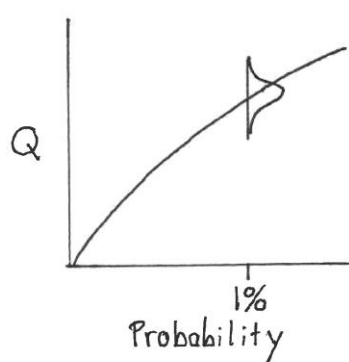
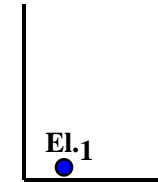




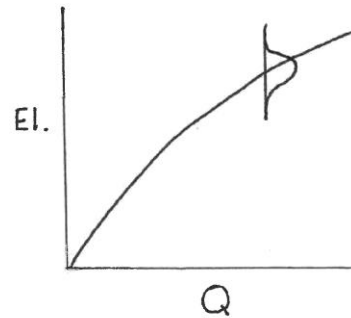
# Risk and Uncertainty in Riverine Conditions

## Monte Carlo Simulation

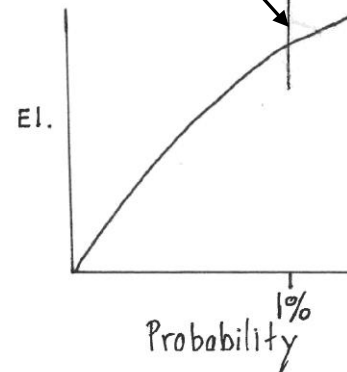
Put  $EL_{.1}$  ball in 3<sup>rd</sup> bin. Do Steps 1 and 2 10,000 times or more



Step 1



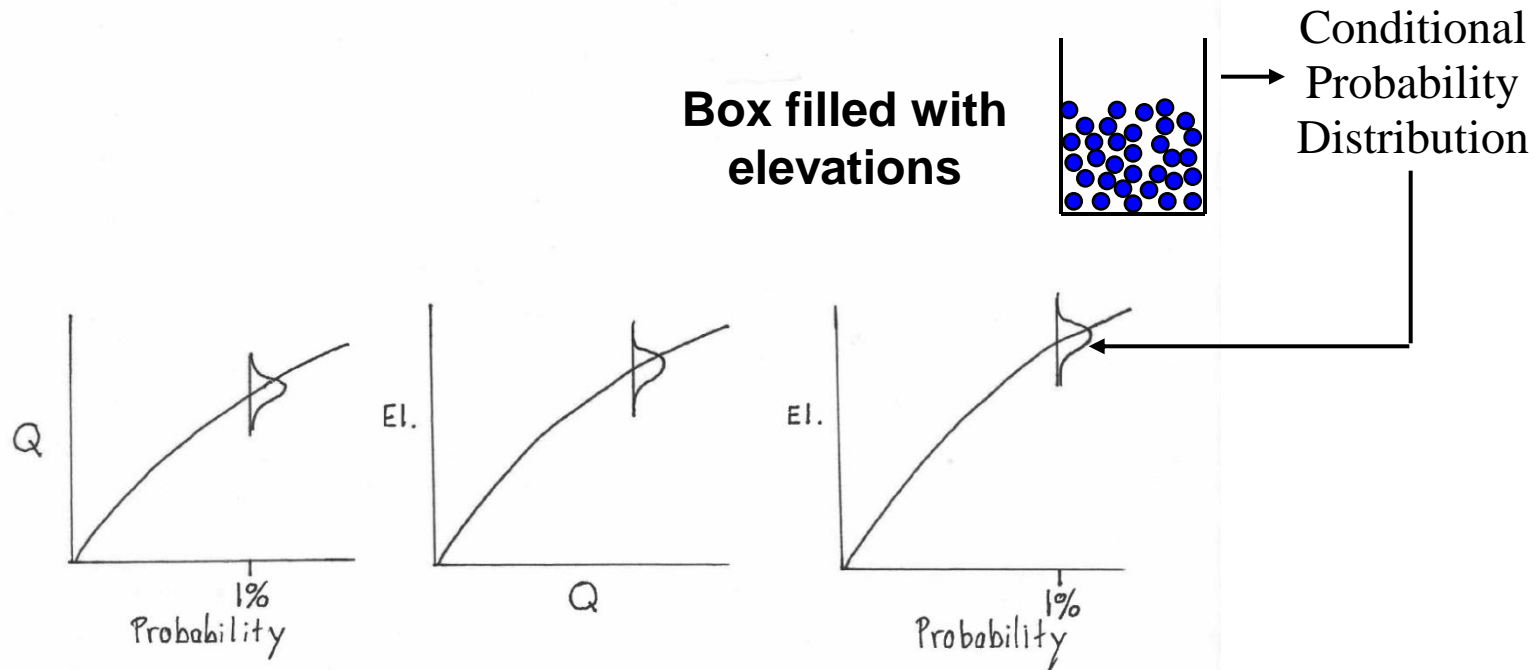
Step 2



Step 3

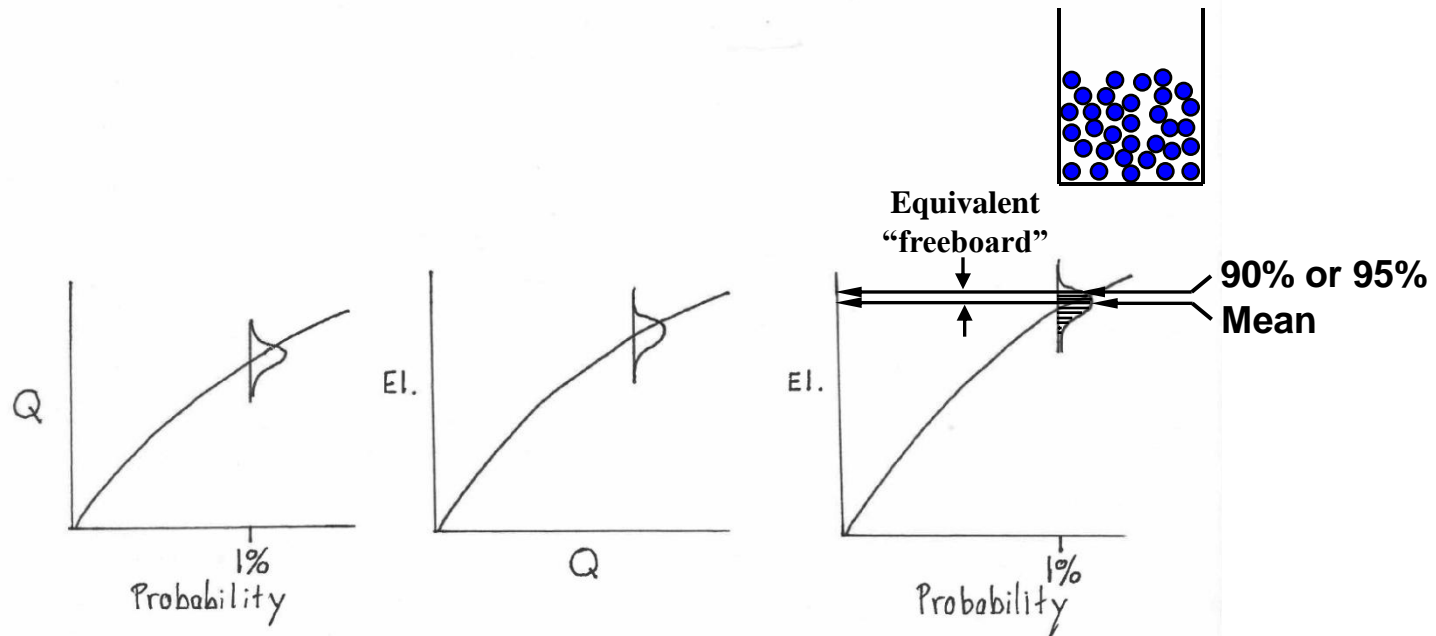
# Risk and Uncertainty in Riverine Conditions

## Monte Carlo Simulation



# Risk and Uncertainty in Riverine Conditions

## Monte Carlo Simulation



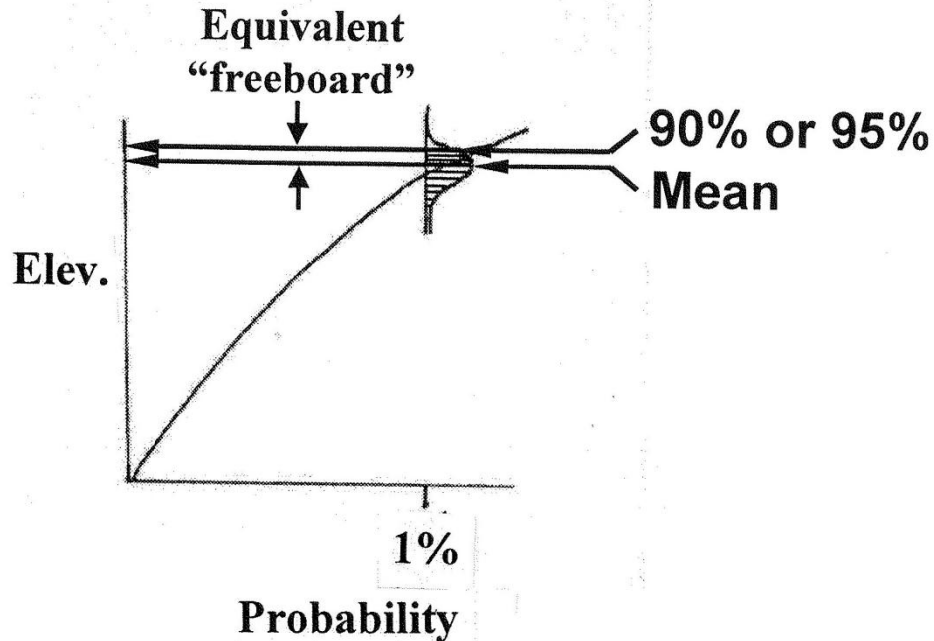
**90% or 95% Assurance**

or

**Conditional Non-Exceedance Probability (CNP)**

# Risk and Uncertainty in Riverine Conditions

## Monte Carlo Simulation



90% or 95% Assurance

or

Conditional Non-Exceedance Probability (CNP)



# Risk and Uncertainty in Riverine Conditions

## Corps ETL 1110-2-570

**Uncertainties to be incorporated in the future  
once the technologies are more mature**

- 1. Geotechnical**
- 2. Structural**
- 3. Mechanical/Electrical (Pumps)**
- 4. Operation and Maintenance**

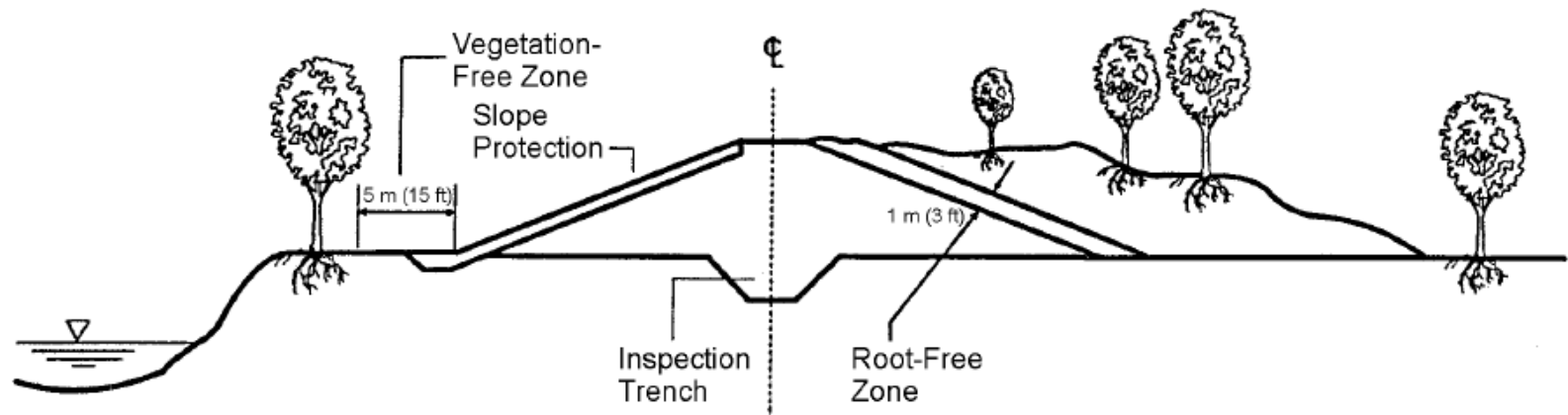
## Additional References to be added to §65.10

- COE ETL1110-2-570 on “Certification of Levee Systems for the National Flood Insurance Program (NFIP)”
- COE EM 1110-2-1619 “Risk-based Analysis for Flood Damage Reduction Studies
- COE ER 1110-2-101 “Risk Analysis for Flood Damage Reduction Studies”
- COE EM 1110-2-1901 “Seepage Analysis and Control for Dams
- COE EM 1100–1–1904 “Settlement Analysis”
- COE EM 1110-2-2502 “Retaining and Flood Walls”
- COE EM 1110-1-1905 “Bearing Capacity”
- COE EM 1110-2-1413 “Hydrologic Analysis of Interior Areas”
- COE EM 1110-2-2902 “Conduits, Pipes and Culvert”
- COE EM 1110-2-2705 “Structural Design of Closure Structures for Local Flood Protection Projects”
- COE EM 1110-2-3102 “General Principles of Pumping Station Design and Layout”
- COE EM 1110-2-3105, “Mechanical and Electrical Design of Pumping Stations”
- COE EM 1110-2-301 “Landscape Planting and Vegetation Management for Floodwalls, Levees and Dams.”
- COE EM1110-2-1100 “Coastal Engineering Manual”
- COE Technical Report CERC-89-15, “Criteria for Evaluating Coastal Flood Protection Projects”.
- COE “Levee Owners Manual for Non-Federal Flood Control Works”

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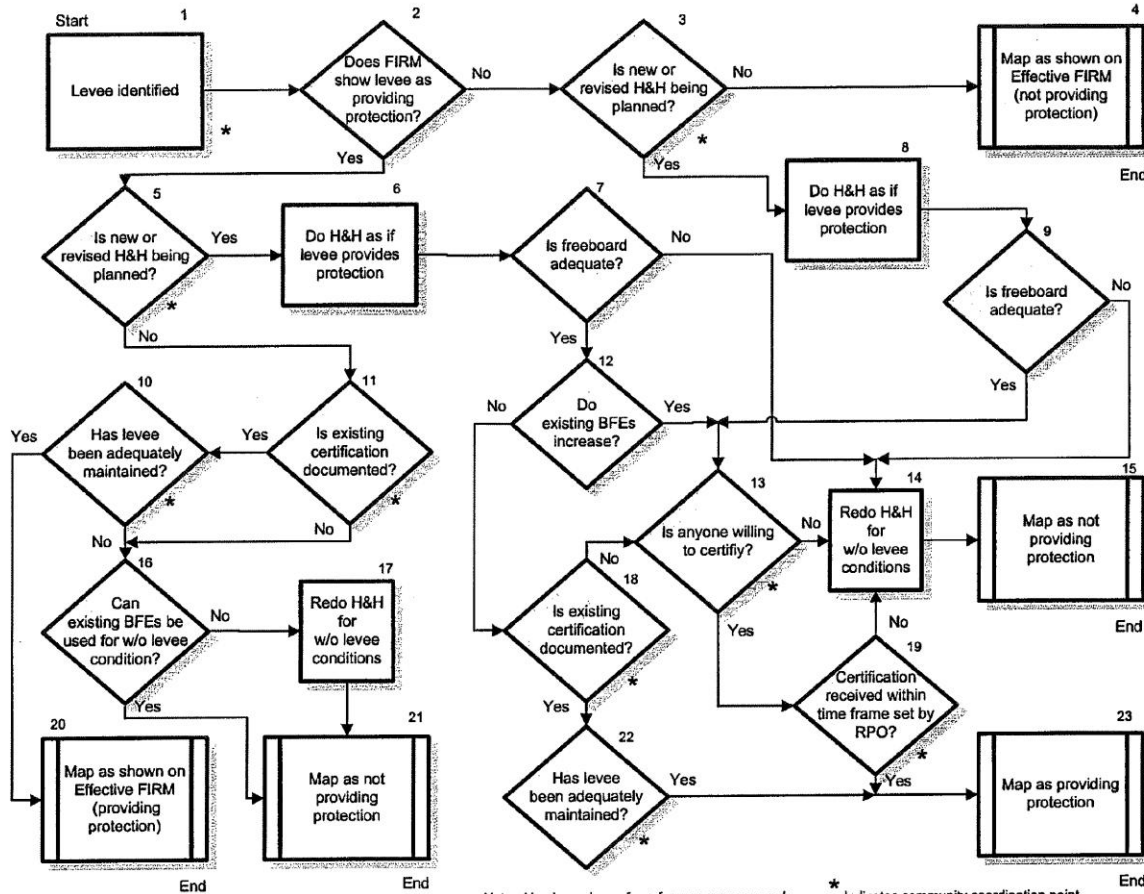
## COE EM 1110-2-301

Landscape Planting and Vegetation Management for  
Floodwalls, Levees, and Dams, January 2000

Not to Scale

a. Vegetation- and root-free zones

# Procedural Memorandum 34- Interim Guidance on Studies Including Levees (Aug 22, 2005)



Note: Numbers shown for reference purposes only \* Indicates community coordination point



Interim Guidance for Studies Including Levees

08/22/2005



## **Procedural Memorandum 43- Guidance for identifying Provisionally Accredited Levees (PAL) Sept 2006**

- For levees previously accredited, allows 24 months for community/levee owner to submit Section 65.10 data and documentation before FEMA de-accredits levee
- FEMA issues preliminary and effective DFIRMs with Zone X designation and PAL note
- Allows an additional “maintenance deficiency correction period” for PL 84-99 levees

## Zone A99

### §61.12 (b) Flood Protection Involving Federal Funds

**For levee system under construction with Federal funding and adequate progress towards completion**

#### **1. Adequate completion is:**

- **100% authorized**
- **60% appropriated**
- **50% expended**
- **50% complete of all critical features (cost based)**

#### **2. Mandatory flood insurance applies**

#### **3. Insurance rates are Zone X**

#### **4. No structural elevation required**

## Zone AR

### §60.3 (f)(3-7)

**For levee systems under restoration that were previously accredited but de-accredited by a new study**

- **Must involve Federal funding and strict time tables**
- **Must protect against the 3% chance flood (33-year)**
- **Mandatory flood insurance applies**
- **Insurance rates are Approximate Zone A (max)**
- **Allows for some relief in structure elevation for new construction (3-foot minimum typically)**
- **Zone AR can be converted to Zone A99 when A99 requirements are met for additional relief**

## Great Books on Levees:

1. **[“The Rising Tide”](#)** By John Barry, 1998, about controlling the Mississippi River and the flood of 1927
2. **[“Battling the Inland Sea”](#)** by Robert Kelley, 1998, about the history of flooding and levee building in the Sacramento Valley (Sacramento, Feather, Yuba, and American Rivers) since 1850 and the flood of 1986

# Questions ?????

**David Preusch, PE, CFM, D.WRE**

**Michael Baker Jr., Inc.**

**Alexandria, Virginia**

**(703) 317-6252**

**[dpreusch@mbakercorp.com](mailto:dpreusch@mbakercorp.com)**