Levee Accreditation Life Cycle: Design with Community in Mind

2016 ASFPM Conference
What’s in store

1. Who Are We?
2. So, You Own a Levee…
3. Navigating the USACE and FEMA Programs
4. Enhanced Hydrologic & Hydraulic Modeling
5. Resiliency Behind Your Levee
22,000 employees

over 400 locations across 6 continents

62 years of uninterrupted profitability
What’s in store

1. Who Are We?

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5. Resiliency Behind Your Levee
An earthen embankment, floodwall, or structure along a water course whose purpose is flood risk reduction or water conveyance.

- US Army Corps

..a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert flow of water as to reduce risk from temporary flooding.

- 44 CFR 59.1
Levee History

In the beginning:

- ~2600 BC – Indus Valley Civilization (India/Pakistan)
- ~1000 BC – Egypt along Nile

Meanwhile, in the US:

- 1717 – First Mississippi River levee (New Orleans)
- 1882 – levees extend from Cairo, IL to New Orleans
Quick Facts

- Approx 31,200 levee miles
- Located in all 50 States
- 14,500 miles in USACE inventory
- 85% locally owned & maintained
- 17.4% are accredited
I operate and maintain my levee for the USACE, and then FEMA asks for certification of data to 44CFR65.10. So why can’t FEMA and the USACE work together?
What’s in store

1. Who Are We?

2. So, You Own a Levee...

3. Navigating the USACE and FEMA Programs

4. Enhanced Hydrologic & Hydraulic Modeling

5. Resiliency Behind Your Levee
USACE and FEMA Programs

- Levee Accreditation
- Levee Inspection
- Flood Fighting
- Risk Assessments
- Operation and Maintenance
- Levee System Evaluations (Certifications)

Mitigation Programs
- Insurance
- Floodplain Management

Emergency Preparedness

Shared Responsibilities
- FEMA & Local Community
- USACE & Local Community
- Local Community
US Army Corps Role - Levees

- Maintain national inventory of levee systems through National Levee Database (NLD)
- Inspect and Assess approximately 2,500 levees nationwide
- Communicate risk related issues and concerns.
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 16, 1775</td>
<td>George Washington appoints first Engineer</td>
<td>USACE to start regulating dam construction</td>
</tr>
<tr>
<td>1880’s</td>
<td></td>
<td>Flood Control Act of 1936 – declared flood control is a proper activity of federal government</td>
</tr>
<tr>
<td>1936</td>
<td></td>
<td>Flood Control Act of 1941 – established Public Law 84-99</td>
</tr>
</tbody>
</table>
USACE (PL 84-99)

Insurance for your levee
• Rehabilitation assistance if damaged in flood event

Three primary components
• Preparedness
• Response
• Rehabilitation
USACE (PL 84-99)

Requirements (cooperation agreement with USACE)

- Furnish lands, easements, ROW, etc.
- Indemnify government
- Operate, maintain, repair, rehabilitate
USACE (PL 84-99)

Operate & Maintain
- O&M Manual
- Typical Maintenance
  - Vegetation
  - Gates
  - Pumps
  - Closures
  - Pipe Penetrations
  - Encroachments
  - Relief Wells
  - Other (animal control, etc)
USACE (PL 84-99)

Inspections

- Initial Eligibility
- Routine (annual)
  - visual inspection to verify and rate levee system operation and maintenance
- Periodic (~5 year interval)
  - comprehensive inspection
    - Data Collection
    - Field Inspection
    - Final Report Development
USACE (PL 84-99)

Inspections

- Owner Receives Results following inspection
- Ratings
  - Acceptable (A)
  - Minimally Acceptable (MA)
  - Unacceptable (U)
- Must maintain “A” or “MA” to maintain eligibility

<table>
<thead>
<tr>
<th>Rated Item</th>
<th>Rating</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pump Stations Operating, Maintenance, Training, &amp; Inspection Records</td>
<td>A</td>
<td>Operation, maintenance and inspection is used and updated, and personnel have training date shown in the record book.</td>
</tr>
<tr>
<td>2. Pump Station Operations and Maintenance Equipment Manuals</td>
<td>A</td>
<td>Operation and Maintenance Equipment is present and updated as required, and O&amp;M manuals include points of concern used in the facility.</td>
</tr>
<tr>
<td>4. Communications (A or M only)</td>
<td>A</td>
<td>A telephone, cellular phone, two-way radio, operator and maintenance personnel</td>
</tr>
<tr>
<td>5. Plant Building</td>
<td>N/A</td>
<td>The building is in good structural condition. Roof is not leaking, intake &amp; exhaust stacks are clear of debris.</td>
</tr>
<tr>
<td>6. Fencing and Gates</td>
<td>A</td>
<td>Fencing is in good condition and properly secured. Gates: open and close freely, locks are working.</td>
</tr>
</tbody>
</table>

USACE (PL 84-99)
Role of FEMA

- FEMA’s role is mapping levee-related flood risk and “accredits” levees for mapping purposes only.
- FEMA only accredits levees based on the certification documentation provided by the community or other interested party.
- FEMA does not own, operate, maintain, inspect, or certify levees or flood control systems.
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>National Flood Insurance Act</td>
</tr>
<tr>
<td>1973</td>
<td>Flood Disaster Act</td>
</tr>
<tr>
<td>1986</td>
<td>Established detailed requirements for evaluation of levees (44 CFR 65.10)</td>
</tr>
<tr>
<td>2005</td>
<td>Established Provisionally Accredited Levee (PAL) Designation</td>
</tr>
<tr>
<td>2013</td>
<td>Levee Analysis and Mapping Procedures (LAMP)</td>
</tr>
<tr>
<td>2014</td>
<td>Memo of Understanding between USACE and FEMA for Alignment of Levee Activities, Information, and Messaging</td>
</tr>
</tbody>
</table>
Accreditation Requirements

Listed in CFR 65.10

65.10(a) – General Requirements
65.10(b) – Design Requirements
65.10(c) – Operations Plans
65.10(d) – Maintenance Plans
65.10(e) – Certification Requirements
65.10(b) Design Requirements

65.10(b)(1) – Freeboard
65.10(b)(2) – Closures
65.10(b)(3) – Embankment Protection
65.10(b)(4) – Embankment and Foundation Stability
65.10(b)(5) – Settlement Analysis
65.10(b)(6) – Interior Drainage
65.10(b)(7) – Other Design Criteria
Phased Approach

Phase I – Gap Analysis

Phase II – Engineering Analysis

Phase III – Design and Construction (if necessary)

Phase IV – Preparation of Supporting Documentation to FEMA
Possible Submittal Items:
  Site plan showing levee layout

  Surveyed Levee Centerline
  (Recent, within 10 years)

  1% annual base flood elevations along all points of levee

*1% annual base flood elevations that differ from published FIS values must have the model accepted or reviewed by FEMA (LOMR) before it can be used for accreditation.
65.10(b)(2) Closures

Possible Submittal Items:
Site plan showing location of all closures

Details or plans of closures

Operations procedures for implementing and storage of closure devices. Including flood warning times, sill inverts, erection time, and notification procedures.
  • Can reference O&M manual, if applicable
Possible Submittal Items:

- Engineering analysis demonstrating anticipated velocities, wave action, ice loading for 1% annual chance flood event along levee.

- Detailed drawings, product specifications and photos of current embankment protection

- Justification that current embankment protection can withstand maximum velocities, wave action, etc that is expected during 1% annual chance flood event.
65.10(b)(4)
Embarkment & Foundation Stability

Possible Submittal Items:
Analysis as per U.S. Army Corps of Engineers (COE) manual, "Design and Construction of Levees" (EM 1110-2-1913)
  • Recent test boring log including location of borings
  • Laboratory test of borings

If stability analysis was done with initial levee design, must submit recent test borings showing levee composition has not changed.

Levee should meet Factor of Safety design criteria for Existing levees in Table 6-1b (EM 1110-2-1913)
Downtown Levee Systems Analysis and Master Plan
Des Moines, Iowa
DM-I Section B, Station 28+50

Slope Stability - Landslide
Load Case II: Steady-State Seepage, High Des Moines River

<table>
<thead>
<tr>
<th>Material</th>
<th>Sat. Unit Weight (pcf)</th>
<th>Moist Unit Weight (pcf)</th>
<th>Phi' (deg.)</th>
<th>c' (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levee Fill - Lean Clay</td>
<td>129</td>
<td>125</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Alluvial Lean Clay</td>
<td>119</td>
<td>115</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Alluvial Sand</td>
<td>128</td>
<td>120</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>Bedrock</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note:
The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

F.S = 2.0
65.10(b)(5)
Settlement Analysis

Possible Submittal Items:
Initial settlement analysis of levee – validated by certifying engineer that still applicable.


Boring logs, lab tests, calculations used to determine settlement.

Comparative analysis (as-built elevations versus survey elevations) can be submitted in addition to settlement analysis.
Evaluate settlement of LEAN CLAY (CL) layer only. Assume soil is normally consolidated.

**SETTLEMENT ANALYSIS - EMBANKMENT**

**Embankment Information:**
- Groundwater Table: \( D_m = 10.0 \) ft
- Embankment Height: \( H = 16 \) ft
- Fill Unit Weight: \( \gamma_{fill} = 120 \) psf
- \( q = 1920 \) psf
- Width of Slope: \( a = 40 \) ft
- Top half-width of Emb: \( b = 5 \) ft
- Distance from CL: \( x = 0 \) ft
- Output Range: \( x = 0 \) to \( 35 \) ft

\[ \sigma_{eq}(x) = \left( \frac{q}{a(x)} \right) \left( x a(x) + b(x) + a(x) \right) + b(x) \left( x a(x) + a(x) \right) + x \left( a(x) - a(2x) \right) \]

\[ \delta(x) = \delta_{o} + \delta_{u} \]

\[ \delta_{o} = \frac{(b - a)}{x} \left[ \tan^{-1} \left( \frac{b + x}{a} \right) - \tan^{-1} \left( \frac{b + x}{a} \right) \right] \]

\[ \delta_{u} = \frac{(a - b}{x} \left[ \tan^{-1} \left( \frac{a + b + x}{a} \right) - \tan^{-1} \left( \frac{a + b + x}{a} \right) \right] \]

**Soil Properties:** Settlement is calculated at mid-point of layer

<table>
<thead>
<tr>
<th>No.</th>
<th>Bot. of Layer</th>
<th>Soil Type</th>
<th>( \gamma_{mld} ) (pcf)</th>
<th>( \delta_{o} ) (psf)</th>
<th>( \delta_{u} ) (psf)</th>
<th>( \delta ) (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.0 ft</td>
<td>Dense GP</td>
<td>125</td>
<td>625</td>
<td>625</td>
<td>1,889</td>
</tr>
<tr>
<td>2</td>
<td>17.5 ft</td>
<td>Dense GW</td>
<td>125</td>
<td>1,485</td>
<td>1,485</td>
<td>1,701</td>
</tr>
<tr>
<td>3</td>
<td>26.0 ft</td>
<td>CL</td>
<td>125</td>
<td>1,986</td>
<td>1,986</td>
<td>1,508</td>
</tr>
<tr>
<td>4</td>
<td>35.0 ft</td>
<td>CL</td>
<td>125</td>
<td>2,533</td>
<td>2,533</td>
<td>1,317</td>
</tr>
<tr>
<td>5</td>
<td>0.00 ft</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0.00 ft</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0.00 ft</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0.00 ft</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0.00 ft</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0.00 ft</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Cohesive Soils**

- \( C' \)  
- \( C'' \)
- \( C_0 \)
- \( e_0 \)

Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis" Table C-2

Reference: Geotechnical Engineering Principles and Practice: Colantuoni, 1999

**Overconsolidated Soils - Case I** \((\sigma''_o > \sigma''_u)\)  Eqn:11.24

\[
(\delta_{o})_{o} = \sum \frac{C''}{1 + e_0} H \log \left( \frac{\sigma''_o}{\sigma''_u} \right)
\]

**Overconsolidated Soils - Case II** \((\sigma''_o < \sigma''_u < \sigma''_u)\)  Eqn:11.25

\[
(\delta_{o})_{o} = \sum \frac{C''}{1 + e_0} H \log \left( \frac{\sigma''_o}{\sigma''_u} \right) + \frac{C''}{1 + e_0} H \log \left( \frac{\sigma''_u}{\sigma''_o} \right)
\]

**Normally Consolidated Soils** \((\sigma''_u = \sigma''_o)\)  Eqn: 11.23

\[
(\delta_{o})_{o} = \sum \frac{C''}{1 + e_0} H \log \left( \frac{\sigma''_o}{\sigma''_o} \right)
\]

**Cohesive Soils** \((\sigma''_o > \sigma''_u)\)  Eqn:11.25

\[
(\delta_{o})_{o} = \frac{1}{C''} H \log \left( \frac{\sigma''_o}{\sigma''_u} \right)
\]

Reference: FHWA NHI 00-045

Total Settlement of CL layer since construction ending 1923:

- 0.438 ft
- 5.3 in
65.10(b)(6)

Interior Flooding

Possible Submittal Items:
Identified areas of interior flooding (overland flow, under designed pumps, backflow from gravity pipes, etc)

Must conduct interior flooding analysis per COE EM 1110-2-1413 including coincidental peaks analysis.

If interior flooding analysis done with initial levee design, need a independent analysis that initial analysis still valid.

FEMA Accepted models (http://www.fema.gov/plan/prevent/fhm/en_hydra.shtm)

Site map with areas of interior flooding. BFE must be shown on areas with greater than 1 foot depth
65.10 (e) Certification

- Data submitted to support that a given levee system complies with the structural requirements set forth in 65.10(b)(1-7) must be certified by a Registered Professional Engineer.
- Certified as-built plans must be submitted.
<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>Design Criteria Subcategory</th>
<th>USACE Inspection</th>
<th>USACE Screening</th>
<th>USACE Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freeboard (levee height)</td>
<td>NO</td>
<td>RARELY</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Closure devices for all openings</td>
<td>NO</td>
<td>RARELY</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Embankment protection</td>
<td>NO</td>
<td>RARELY</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Embankment and foundation stability</td>
<td>NO</td>
<td>RARELY</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Settlement</td>
<td>NO</td>
<td>RARELY</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Interior drainage</td>
<td>NO</td>
<td>NO</td>
<td>AS APPROPRIATE*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operation Plans</th>
<th>Operation Plans Subcategory</th>
<th>USACE Inspection</th>
<th>USACE Screening</th>
<th>USACE Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Closures</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Interior drainage systems</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

*Interior Drainage. Though the accreditation requirement for interior drainage may not be covered during a USACE risk assessment, USACE and FEMA will ensure the data needed to address interior drainage will be collected.
Ongoing vigilance is required for levee infrastructure to perform during a flood event. Conditions change:

- Banks erode
- Closures rust
- Animals burrow
- Pumps wear out
- Flow frequency studies are updated

Can you sit down and relax?
Managing Your Levee System

Ongoing vigilance is required for levee infrastructure to perform during a flood event.

Conditions change:
- Banks erode
- Closures rust
- Animals burrow
- Pumps wear out
- Flow frequency studies are updated
Managing Your Levee System

What can you as an owner do?
Managing Your Levee System

Priority No. 1 – Levee needs to perform during a flood event

- Diligent maintenance is key
- Know and follow your O&M Plan
- Maintain and exercise your Emergency Action Plan
Maintaining PL 84-99 Eligibility

- Inspections
- Ratings
  - Acceptable (A)
  - Minimally Acceptable (MA)
  - Unacceptable (U)
- Must maintain “A” or “MA” to maintain eligibility
Managing Your Levee System

Address issues identified in the inspections
• “MA” items can progress to “U” if ignored

What if you receive a “U”? 
• System Wide Improvement Framework (SWIF)
  • Opportunity to make required modifications
Managing Your Levee System

Maintaining FEMA Accreditation
• Triggers?
  • FEMA Map Update
  • Certifying engineer conditions
• Maintain data management system
  • Document modifications to levee system
  • All modifications sealed by PE
Managing Your Levee System

What if you need to alter your levee system?
- Raise levee due to higher 100-year flows
- Seepage mitigation measures
- Realignment
- etc

May trigger Section 408 Review
Section 408

- Applies to federally authorized civil works projects
- Confirm project is not injurious to public interest or affect authorized project purpose
- Guidance: EC 1165-2-216
Section 408

Primary components
• Technical Analysis and Design
• H&H System Performance Analysis
• Environmental Compliance
• Real Estate Requirements
• EO 11988 Considerations
• Review Plan
• Operation and Maintenance

Coordination is key
Not all levees were designed to protect to the 1% annual chance flood event, yet may offer some protection. What options are available to me?

A. LAMP
Levee Analysis and Mapping Procedure (LAMP)

- New Approach (July 2013)
- More options to levee owner for partial credit if can’t fully certify
- Levee owner and communities engaged with decisions
<table>
<thead>
<tr>
<th><strong>Inform</strong></th>
<th><strong>Consult</strong></th>
<th><strong>Involve</strong></th>
<th><strong>Collaborate</strong></th>
<th><strong>Empower</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public participation goals</strong></td>
<td><strong>To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions</strong></td>
<td><strong>To obtain public feedback on analysis, alternatives and/or decisions.</strong></td>
<td><strong>To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered</strong></td>
<td><strong>To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.</strong></td>
</tr>
<tr>
<td><strong>Promise to the public</strong></td>
<td><strong>We will keep you informed.</strong></td>
<td><strong>We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.</strong></td>
<td><strong>We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.</strong></td>
<td><strong>We will look to you for advice and innovation in formatting solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.</strong></td>
</tr>
</tbody>
</table>
| **Possible techniques** | • Fact Sheets  
• Website  
• Social Media  
• Open Houses  
• Information Repositories | • Public comment  
• Focus groups  
• Surveys  
• Public meetings  
• Social Media Forums | • Workshops  
• Deliberative polling | • Citizen advisory committees  
• Consensus-building  
• Participatory decision-making | • Citizen juries  
• Ballots  
• Delegated decisions |

**LAMP Public Participation Levels**
Plan Used:
By FEMA
• Analyses to be performed
• Technical procedures to be applied

By State
• NFIP support and outreach

By Community
• Continue with certification
• Inform constituents

Plan Distributed:
To LLPT participants

Forwarded to all other organizations/individuals
Initiation

10 Project Includes Potential Levees

20 Should structure be analyzed as a levee?

Yes

110 Follow Procedures for Accredited Levee System

Meets 44CFR65.10

100 Initial Accreditation Evaluation

Provisionally Meets 44 CFR65.10

No

30 Do Not Process as Levee

Planning

200 Levee Data Collection and Stakeholder engagement

300 Local Levee Partnership Team

400 Levee Analysis and Mapping Program

Data Development

500 AR/A99

600 Flood Hazard Analysis and Mapping

610 System-Wide Procedures
- Interior Drainage
- Natural Valley Zone D

620 Levee Reach Procedures
- Sound Reach
- Freeboard Deficient Reach
- Structural-Based Inundation Procedure
- Natural Valley Procedure

630 Flooding Source Procedure

Regulatory Mapping Process

700 Integrate into the Mapping Process

800 Best Practices and Implementation Review Process
LAMP Approaches

- Natural Valley (always applied initially and for the entire system)
- Sound Reach
- Freeboard Deficient
- Overtopping
- Structural-Based Inundation
What’s in store

1. Who Are We?
2. So, You Own a Levee...
3. Navigating the USACE and FEMA Programs
4. Enhanced Hydrologic & Hydraulic Modeling
5. Resiliency Behind Your Levee
Enhanced Hydrologic & Hydraulic Modeling

- 2D Modeling for Levees
- HEC-RAS 5.0 Computer Model
- Flood mapping and flood animations
- Benefits of 2D Modeling
<table>
<thead>
<tr>
<th>Property or Factor</th>
<th>One-Dimensional Modeling</th>
<th>Two-Dimensional Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>flow direction</td>
<td>prescribed (streamwise)</td>
<td>computed</td>
</tr>
<tr>
<td>transverse velocity and momentum</td>
<td>neglected</td>
<td>computed</td>
</tr>
<tr>
<td>vertical velocity and momentum</td>
<td>neglected</td>
<td>neglected</td>
</tr>
<tr>
<td>velocity averaged over...</td>
<td>cross sectional area</td>
<td>depth at a point</td>
</tr>
<tr>
<td>transverse velocity distribution</td>
<td>assumed proportional to conveyance</td>
<td>computed</td>
</tr>
<tr>
<td>transverse variations in water surface</td>
<td>neglected</td>
<td>computed</td>
</tr>
<tr>
<td>vertical variations</td>
<td>neglected</td>
<td>neglected</td>
</tr>
<tr>
<td>unsteady flow routing</td>
<td>can be included</td>
<td>can be included</td>
</tr>
</tbody>
</table>

Source: Colorado floodplain and Stormwater criteria manual chapter 12
2D Modeling

- 1D, 2D, and combined 1D/2D modeling

- 2D flow equations
  - Fully Dynamic Saint Venant equations
  - Diffusion Wave equations

- 1D and 2D coupled solution algorithm

- Computational mesh
Sub-Grid Bathymetry

Hydraulic Property Tables:

Cell Face
- Elevation vs Wetted Perimeter
- Elevation vs Area
- Roughness
- Profile

Cell
- Elevation vs Volume
Detailed Terrain Data

Spatially Varied Manning’s Roughness

Structure Data – within 2D area
Levee Modeling

1D HEC-RAS set-up
- Model levee as a lateral weir
- End XS at levee

2D Area Incorporation
- Connect weir to 2D mesh
Levee Breach Parameters

- Location
- Size
- Shape
- Weir Coefficient
- Failure Mode
- Time
- Progression

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Center Station</td>
<td>830</td>
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<tr>
<td>Final Bottom Width</td>
<td>95</td>
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<tr>
<td>Final Bottom Elevation</td>
<td>265.7</td>
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<tr>
<td>Left Side Slope</td>
<td>0</td>
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<tr>
<td>Right Side Slope</td>
<td>0</td>
</tr>
<tr>
<td>Breach Weir Coef</td>
<td>2.6</td>
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<tr>
<td>Breach Formation Time (hrs)</td>
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<tr>
<td>Failure Mode</td>
<td>Piping</td>
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<tr>
<td>Piping Coefficient</td>
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<td>Initial Piping Elev</td>
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<td>Trigger Failure at</td>
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<td>Start Date</td>
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<td>Start Time</td>
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Benefits of 2D Modeling

Inundation in leveed floodplain = Complex Hydraulic Process

2D Levee modeling
• Improved accuracy
• Value-added results

Valuable resource for floodplain management
Break!

Price is Right Showcase:

A. Trip Alone to Complain to Yourself

B. All Inclusive Partnership in Rock’n Grand Rapids MI
What’s in store

1. Who Are We?
2. So, You Own a Levee...
3. Navigating the USACE and FEMA Programs
4. Enhanced Hydrologic & Hydraulic Modeling
5. Resiliency Behind Your Levee
Risk Awareness

Know your History

FEMA’s Flood Risk Products for Levees

Visualize the Hazard
3D Mapping
The Cost Of Flooding

4 foot flood

- Stereo - etc.
  $2,000
- Washer/Dryer
  $980
- Accent Furniture & Accessories
  $1,630
- Loss of Personal Items
  $5,500

Total Losses
$74,580

2,000 Square Foot Home

Estimates are for illustrative purposes only and should not be used to estimate any actual flood loss. A flood certified insurance adjuster making a room-by-room item-by-item, detailed estimate of covered flood damage is the only estimating method approved by and acceptable to the National Flood Insurance Program. These estimated costs are based on an average U.S. home of 1,000 and 2,000 square feet, built on a slab and with typical household items. Costs vary from State to State and home to home.
Risk Assessment by Parcel

- 200 homes
- 4 feet of flooding
- $15,000,000 of damage

Substantially Damaged
Risk Reduction

Emergency Action Plan

National Levee Safety Program

Federal Flood Risk Management Standard (FFRMS)
National Levee Safety Program

Levee Safety Initiative
• Hazard Potential Classification System

• Technical Assistance and Materials
  • Promote levee safety
  • Assist States, Communities, and levee owners

• Public Education and Awareness
  • Educate individuals living in leveed areas
  • Consistent information among Federal agencies

“Ensure that human lives and property that are protected by new and existing levees are safe.”

Congress, WRRDA 2014
National Levee Safety Program

Levee Safety Initiative
- State and Tribal Levee Safety Programs
  - Carry out levee inspections, public education, share levee database
  - Funding for levee inventory
  - Actions to address hazard mitigation activities

- Levee Rehabilitation Assistance Program
  - Address flood mitigation activities to reduce flood risk
  - Have a hazard mitigation plan in place
  - O&M for 50 years

- Floodplain Management Plans

“Ensure that human lives and property that are protected by new and existing levees are safe.”

Congress, WRRDA 2014
Federal Flood Risk Management Standard (FFRMS)

- EO 13690
- 3 different methods
  - Climatic-informed science
  - Freeboard Value
  - 500-year Elevation
- Not for Insurance
- Not impact PL84-99 or emergency actions
Levees are an aging infrastructure needing maintenance and upgrades.

Certification of data to 65.10 is only a portion of the overall resiliency to community.

Data Analytics to support Awareness.

Adapt to change.
Questions?

Will Zung, PMP, CFM, ENV SP
Will.Zung@stantec.com

Roger Denick, PE, CFM
Roger.Denick@stantec.com

Matt Hoy, PE
Matt.Hoy@stantec.com

Anish Pradhananga, PE, CFM
Anish.Pradhananga@stantec.com