Expert Panel on Assessing and Communicating Alluvial Fan Flood Risk

Alluvial Fan Task Force
Plenary Meeting 2
Borrego Springs, CA
January 4, 2008
Introducing the Panel Members

- Steve Cowdin, DWR Division of Planning and Local Assistance
- Tammy Conforti, Army Corps of Engineers & AFTF Member
- Martin Teal, Floodplain Management Association and AFTF Member
- Ray Lenaburg, FEMA & AFTF Member

Susan Lien Longville, Panel Moderator & AFTF Coordinator
What this panel will do...

- Discuss definitions of risk
- Discuss the adequacy of 100 Year Flood or the 1% Chance of Flooding
- Discuss the challenges of risk communication
- Discuss how flood risk is estimated
- Discuss ways to mitigate for flood risk
- Discuss residual risk

...from the USACE, FEMA, DWR and FMA perspective.
Topics you’ll learn

- Definition of Risk
- Risk Communication Challenges
- The 100-year flood
- Residual Risk
- Reducing Flood Risk
- Mitigation Measures
Question #1

Define “risk” and discuss the challenge of communicating risk to the public.
USACE DEFINITION OF RISK

Risk = $P_e \times P_f \times \text{Consequence}$

$P_e = \text{Probability of Event}$

$P_f = \text{Probability of Failure}$

$\$ \text{Damages or Loss-of-Life}$
What is the 100-year flood?

- The size of flood with a return period (or recurrence interval) of 100 years
- The size of flood that’s exceeded once every 100 years on average
- The size of flood that has a 1 in 100 chance or 1% chance of being exceeded each year

We now prefer to call it the 1%-chance flood, to prevent misunderstanding…
A COE Risk Analysis

The analysis of flood damage reduction measures and plans using the principles associated with risk and uncertainty.

Considers the uncertainties associated with imperfect/short record lengths, incomplete knowledge, imperfect analysis methods, and/or nature.
Risk Analysis Results

- **Economic**
  - Expected Annual Damage (EAD)
  - Expected Annual Damage Reduced (EADR)
  - Net Benefits = EADR - Cost

- **Performance**
  - Annual Exceedance Probability
  - Expected Long-term (10, 30, 50 years) Exceedance probability
  - Conditional Non-Exceedance Probability (Assurance)
Risk Communication Challenges
from *Explaining Flood Risk*, EP 1110-2-

- Lack of Interest in Risk Information
- Incorrect Estimation of Risk
- Misunderstanding of Probability
- Lack of Experience
- Desire for Certainty
- Difficult Language
- Disagreement Among Experts
DWR Definition of Risk

The probability that some undesirable event will occur, which is usually linked with a description of the corresponding consequences of that event, or:

\[
\text{Risk} = \text{Probability} \times \text{Consequences}
\]

- **Probability** = frequency of the storm event
- **Consequences** = the effects of the storm water upon the human and natural environment
Risk Example

Example:

- Probability of event = 1% (0.01)
- Consequences = $1,000,000
- Risk = 0.01 X $1,000,000 = $10,000
Challenges of communicating risk

- Risk involves probabilities and consequences
- Probabilities may be most difficult to understand
- Annual percent chance of flooding (for example, “1%”) – it’s a small number; people may underestimate potential for flooding
- Long-term chance of flooding (for example, at least a 26% chance of flooding from a 1% event during a 30-year mortgage) – may be more understandable.
FMA Definition of Risk?

- **Probability of Occurrence**
  - Statistics (including uncertainty)
  - Geomorphic, Engineering Studies

- **Consequences of Occurrence**
  - Damage estimates
  - Features such as levees may induce “step functions”
Public Perception of Risk

“...I’ve lived here 30 years and it’s never flooded...”
- Not long time period for riverine hazards...
- Very short period for arid regions

“...a homeowner behind a 100-year levee has a one-in-four chance of being flooded during the life of a 30-year mortgage, double the risk of a fire.” (SD Union Tribune, 12-4-05)

“Katrina...a once-every-100-years storm...” (SD U-T)

“...requirements to get levees to 200-year protection – tough enough to withstand storm-driven flows so strong they occur only once every two centuries...” (Sacramento Bee 1/1/08)

“A flood that occurs once every 100 years” (NOT)
“Risky Business”
Alluvial Fan Flood Hazards

Objectives

- Define and communicate risk to the public
- Explain FEMA existing regulatory framework
- Identify and manage alluvial fan risk
What is “Risk”? 

- Bulletin 17B defines risk as “…the probability that one or more events will exceed a given flood magnitude within a specified period of years.”
- For the popularly-named “100-year flood”:
  - It is not the flood event that will occur once every 100 years
  - It is not the flood event that equals the 1-percent annual chance computed discharge.
What is “Risk”? 

- It is the flood event that has a 1-percent annual chance of being exceeded each year.
  - Two or more 100-year floods could occur in the same year.
  - The 100-year flood, which is the standard used by most Federal and state agencies, is used by the National Flood Insurance Program (NFIP) for floodplain management and to determine the need for mandatory flood insurance.
Question #2

- Within the existing regulatory framework, describe how your public agency or a private firm assesses risk on alluvial fans.
Before Effort to Limit Risk...
Risk that Remains after FC Measure

1/105-year event
The Corps’ mission does not focus on the 1%-chance flood event. A primary Civil Works mission of USACE is to reduce flood damages by identifying projects that maximize net economic benefits.

- Dollars are invested to reduce flood damage by an equal or greater amount and includes damage-causing events of any size or frequency.
- We use the entire flood-frequency curve, rather than a single event, to compute EXPECTED ANNUAL FLOOD DAMAGE
Flood Risk Reduction

- The USACE has established the National Flood Risk Management Program to develop an integrated national flood risk strategy to improve public safety including Loss-of-Life considerations.
- The USACE Levee Safety Program emphasizes the role of levees to reduce risk and the need to educate the public of the risks associated with levee systems.
Mitigation Measures

- Non-Structural
  - Relocation
  - Elevating Structures
  - Zoning
  - Flood Warning/Evacuation
DWR Assessment of Risk
Includes

- Identify hazard
- Identify assets at risk
- Communicate risk
Assessing Risk

- Identify hazard
  - Frequency
  - Extent
  - Depth
  - Velocity
  - Debris
  - Speed and duration of inundation
  - Uncertainties
  - Etc.
Assessing Risk

- Identify assets at risk
  - People
  - Structures
  - Essential facilities
  - Transportation facilities
  - Agriculture
  - Etc.
Assessing Risk

- Communicate risk
  - Local media
  - Websites
  - Community workshops
  - Direct mailers
  - Etc.
Borrego Springs HAZUS Analysis
Borrego Springs HAZUS Analysis
FEMA Alluvial Fan Regulations

Alluvial Fan Flooding Requires Special Attention

Alluvial fan flood hazard areas are shown on FIRMs as AO Zones with a “depth number” and anticipated velocity. Special attention is required if buildings are proposed in these areas:

- Lowest floors must be elevated at least as high as the depth number above the highest adjacent grade (plus freeboard, if required).
- Buildings may be elevated on a fill pad or a raised foundation – fills and foundations must be designed by a qualified registered professional engineer to resist the anticipated flood depths, erosion, and velocities.
- Drainage and grading must prevent directing water, sediment and debris flows onto adjacent properties.

Some of California's mountains have alluvial fans at their base. Alluvial fans are a landform created where floodwaters rushing off the steep mountains spread out and deposit sand, cobbles, and rocks.
Borrego Springs HAZUS Analysis

HAZUS Enhanced Quick Look Analysis

(PRELIMINARY Analysis)

Table 1: Expected Building Damage by Occupancy

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Count</th>
<th>Count (%)</th>
<th>Count</th>
<th>Count (%)</th>
<th>Count</th>
<th>Count (%)</th>
<th>Count</th>
<th>Count (%)</th>
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<td>0.00</td>
<td>1</td>
<td>16.67</td>
<td>1</td>
<td>16.67</td>
<td>0</td>
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<tr>
<td>Education</td>
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<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>1</td>
<td>16.67</td>
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<tr>
<td>Government</td>
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<td>Industrial</td>
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<td>0.00</td>
<td>1</td>
<td>16.67</td>
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<td>3.48</td>
<td>69</td>
<td>5.00</td>
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<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>0</td>
<td>2</td>
<td>49</td>
<td>69</td>
<td>365</td>
<td>26.40</td>
<td>897</td>
<td>65.05</td>
</tr>
</tbody>
</table>
Risk Management on Alluvial Fans

- regulation or prohibition of development in high hazard areas
- non-structural methods of protecting individual structures
  - elevation and/or floodproofing
  - routing floodwaters around structures, down properly aligned streets
- structural methods such as dikes, channels or dams (large areas?)
  - Force characterization
Identification of Hazard Areas

- Recognizing and characterizing alluvial fan landforms
- Defining the nature of the alluvial fan environment and identifying active and inactive areas of the fan
- Defining and characterizing the 100-year flood within the identified areas

FEMA, 2002
MAP MODERNIZATION

Guidelines and Specifications for Flood Hazard Mapping and Mapping

Appendix D: Guidance for Abutment, Foundation, and Sheet Piling Analyses and Mapping

February 2002

Federal Emergency Management Agency

U.S. Department of Homeland Security
Office of Information

June 2008

 reminded to consult the

An integrated approach to flood hazard assessment on alluvial fans using numerical modeling, field mapping, and remote sensing

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BASE CLASSIFICATION SYSTEM

STEP 1
- Is this an alluvial fan?
  - No
  - Yes

STEP 2
- Is the fan still active?
  - No
  - Yes

STEP 3
- Is the area subject to flooding?
  - No
  - Yes

- Is the area developed?
  - No
  - Yes

CLASS 1
- Inactive Fan
- No Flooding

CLASS 2
- Inactive Fan
- Flooding

CLASS 3
- Active Fan
- Flooding
- Undeveloped Area

CLASS 4
- Active Fan
- Flooding
- Developed Area

USACE, 2000
APPROPRIATE LAND USE

CLASS 1
Inactive Fan
No Flooding
- Allow development
- Adopt proper drainage system requirements
- Do not require flood insurance

CLASS 2
Inactive Fan
Flooding
- Protect existing structures if economical
- Adopt zoning ordinances and regulations
- Require flood insurance
- Allow development outside of floodway
- Set regulatory guidelines for new development
- Educate citizens

CLASS 3
Active Fan
Flooding
Undeveloped Area
- Prohibit or strongly discourage development
- Preserve the natural environment
- Designate special flood hazard zones
- Set strict regulatory guidelines for hazard areas
- Educate citizens

CLASS 4
Active Fan
Flooding
Developed Area
- Protect or relocate existing structures if economical
- Adopt zoning ordinances and regulations
- Require flood insurance
- Do not allow new development in undeveloped areas
- Enforce Federal, State, and local regulations
- Educate citizens

USACE, 2000
The broad spectrum of alluvial fan landforms and types of flooding illustrates, as previously discussed, the futility of developing a “cookbook” method to apply to all fans in all geographic areas. The analysis of the flood hazards on alluvial fans therefore requires a flexible approach that is based on site-specific evaluations. Several methods for quantifying the 100-year flood are presented in the following sections and are summarized in Table G-1. Not all methods are appropriate for all situations. The assumptions and limitations of each should be carefully considered in deciding which methods to apply to particular areas of an alluvial fan.
### Table G-1. Methods for Defining the 1-Percent-Annual Chance (100-Year) Flood Within Floodprone Areas Defined During Stage 2

<table>
<thead>
<tr>
<th>METHOD</th>
<th>ASSUMPTIONS</th>
<th>LIMITATIONS</th>
<th>RECOMMENDED APPLICATIONS</th>
<th>FIGURE NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk-Based Analysis</td>
<td>Refer to Guidelines for Risk and Uncertainty Analysis in Water Resources Planning (USACE, 1992).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAN Computer Program</td>
<td>Flooding in rectangular channel; critical depth, erosion of rectangular channel banks until the change in width divided by the change in depth equals ~200; the probability density function of a discharge occurring at the apex is log-Pearson Type III; the frequency of flood events for various recurrence intervals, i.e., 2-years through 500-year, can be adequately defined; equal probability along contour arcs (random flow paths); (also provides for multiple channels at normal depth, assuming total width is 3.8 times the single-channel width)</td>
<td>Fluvial (as opposed to debris flow) formed fan, unstable flow paths</td>
<td>Highly active, conical fans</td>
<td>G-5</td>
</tr>
<tr>
<td>Sheetflow</td>
<td>Broad, unconfined, shallow flooding</td>
<td>Not for use in areas of undulating terrain</td>
<td>Shallow flooding across uniformly sloping surfaces</td>
<td>G-6</td>
</tr>
<tr>
<td>Hydraulic Analytical Methods</td>
<td>Stable flow path, uncertainty is to a degree that may be disregarded</td>
<td>Not for use with active alluvial fan flooding</td>
<td>Entrained stable channel network, constructed channels, urbanized areas</td>
<td>G-7 and G-13</td>
</tr>
<tr>
<td>Geomorphic Data, Post-Flood Hazard Verification, and Historical Information</td>
<td>Raised primarily on qualitative information, post-flood verification, historical data, and interpretive studies</td>
<td>Approximate method</td>
<td>Alluvial fans with little or no urbanization</td>
<td>G-8 and G-9</td>
</tr>
<tr>
<td>Composite Methods</td>
<td>As identified in the sections referring to the methods being applied</td>
<td>Must integrate multiple methods into one result</td>
<td>Floodprone areas that contain unique physical features in some locations or have areas varying in levels of erosion and migration activity</td>
<td>G-10, G-11, and G-12</td>
</tr>
</tbody>
</table>
Borrego Valley Flood Management Report

- Prepared for San Diego County October, 1989
- Flood and Environmental Management on Fans
  - Characteristics, flood protection, NFIP, groundwater
- Borrego Valley Special Flood Hazards
  - Mapped fans, FTAW
- Non-structural Methods of Flood Protection
- Preliminary Designs for Structural Measures
- Design Criteria for Structural and Non-structural
FEMA ASSESSMENT OF RISK
Mitigating Risk

- Modify susceptibility to flooding
  - Avoid development
  - Elevate or floodproof
  - Flood forecasting/warning systems
  - Emergency plans
  - Public education
  - Etc.
Mitigating Risk

- Modify impact of flooding
  - Public education
  - Flood insurance
  - Disaster assistance programs
  - Emergency plans
  - Post-recovery plans
  - Etc.
Mitigating Risk

- Modify flooding
  - Detention basins
  - Floodwalls
  - Levees
  - Bypasses
  - Etc.
Mitigating Risk

- Preserve and restore natural resources
  - Land acquisition
  - Easements
  - Tax incentives
  - Public education
  - Etc.
FEMA Regulatory Framework

- Floodplain mapping and map revisions must comply with FEMA 44 CFR 65.13
  - Section 65.13 does **not** provide credit for elevating structures by fill or other means.
  - Section 65.13 **does** provide credit for major structural flood control measures that control the base flood plus debris and sediment measured at the apex, such as:
    - Detention/retention basins
    - Diversion systems
    - Channelization
    - Floodwalls and/or levees
FEMA Alluvial Fan Zones

- Know FEMA map flood hazard limitations
- Calculated using FEMA computer program "FAN"
  - Zone AO (D, V)
  - Zone AO (D, V)
  - Zone B (D<1 ft, V<4 fps)
- Need to develop methods for assessing non-FEMA flood hazards (i.e. A/B Zone)
Methods of Assessing Risk

- Regulatory approach: Per Section 65.13 of NFIP (stochastic, or probabilistic)
- Geomorphologic approach: Per "Appendix G: Guidelines for Determining Flood Hazards on Alluvial Fans" (deterministic)
Methods of Assessing Risk

- FEMA map limitation – maps show widths, depths, and velocities for the 1 percent annual chance event.
- But not the 1 percent annual chance discharge.
Methods of Assessing Risk

- For example, calculating discharge passing through sector A-B (Wo) from fan to watershed requires the reverse of calculations in FEMA FAN.
Question #3

What suggestions or advice do you have for reducing risks on alluvial fans developed in the future that the Alluvial Fan Task Force can incorporate in the Model Ordinance and Design Guidelines for Development on Alluvial Fans being developed?
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Alluvial Fan Flooding

Project Site
Boundary Conditions
Computational Grid With Blocked Cells
Scenario 4 – Max Flow Depth
Scenario 8 – Max Flow Depth
Assessment Results

- Minimum Pad Elevations Determined Above 100-year WSE
- Identified Locations of Flow Concentration
- Maximum Flow Velocity for Design of Erosion Protection
- Sedimentation Issues (Deposition/Scour) to be Included Subsequently
Alluvial Fan Risk Mitigation

Consult local flood control agencies for guidelines:
- Regional engineering and construction to protect the whole fan below the apex.
- Subdivision or subregional engineering and construction to protect portions of the fan.
- Single lot or dwelling flood protection.

Typical mitigation measures:
- Regional debris basins, channels, floodwalls or levees
- Local channels designed to convey flows around or through development
- Flood protection techniques
Community Partnership

- Encourage flood control master planning early in the entitlement process for new communities
- Encourage regional master planning for existing flood control facilities to better define, or update, current flood prone areas
- Communities need to be up-to-date on State and Federal flood hazard regulations before approving land development projects
- Etc.
Comments or Questions

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Questions?

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Comments or Questions

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