Dam Failure Analysis, Current Methods and Implication for Emergency Action Planning October 24-25, 2007

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# **Dam Failure Analysis**

Current Methods for Analysis and the Implications for Emergency Action Planning

#### **Presented by Brad Newlin, PE**



Photos are courtesy of Dr. J David Rogers, http://web.umr.edu/~rogersda/st\_francis\_dam/

#### Overview

- Maryland Dams
- Overview of methodology and recent developments for dam failure analysis
- What's important from a public safety and emergency action planning perspective?



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# Maryland Dams

- Over 400 Dams
  - Approx. 60% low hazard dams
    - Usually designed to pass 100-year storm



Approx. 22% significant hazard dams

- Usually designed to pass 50% of probable maximum flood (PMF)
- Approx. 18% high hazard dams
  - Usually designed to pass PMF



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# Modeling Approach

- Hydrology
- Dam Break
- Routing of Dam Break Wave
- Creation of Danger Reach Map



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# Modeling Approach: Hydrology

- Determination of Probable Maximum Precipitation (PMP)
  - The greatest depth of precipitation for a given duration that is physically possible over a given storm size area at a particular geographical location at a certain time of year.
  - Process:
    - Determination of incremental PMP
    - Placement of isohyetal pattern
    - Determination of maximum precipitation volume
    - Distribution of storm-area-averaged PMP
    - Determination of temporal distribution of sub-watersheds

# Modeling Approach: Hydrology

- Determination of parameters
  - Drainage area
  - Soils
  - Land use
  - Time of concentration
  - Other parameters (for Snyder's Method and Clark's Method)

Et = X 20 Z	Time of Concentration Criteria	x I	
P BALD_EAGLE_BASINS	Open Channel Curve Numbers	General TC Options	
E BEA_SOLS (HSG)	Source Data Select TC Metho	d Landuse	
â	- Automatic TC Optimization		
E LIVD	C. Find Longest TC using maximum flowlength		
C/0	C Find Eorgest TC dsing maximum howengur		
BALDEAGLE_STREAM	<ul> <li>Find Longest TC using maximum time</li> </ul>		
PMF_WITH_SA_AND_VC	Select Automated TC Methodology SCS TR	-55 💌	Rea
	SCS TEES Requirements		Y
- HMSJIS	Maximum Bural Overland Flow Length 100	feet	
BALD_EAGLE_APPROVS			
RAFR	Maximum Urban Uverland Flow Length 50	Teet	
×	2-year 24-hour precipitation 6.5	inches	
HE_CUT_XS			
BALDEAGLE_>S	Izzard Requirements		
N CHANNEL	Rainfall Intensity	in/hr	
N_OVERBANK (rivisium)	346		
0.04		OK Cancel	

# Modeling Approach: Hydrology

- Application to hydrologic model, HEC-1 or HEC-HMS, TR-20, etc.
   Letter vetered This HEC-1 file has a utomatically been populated by WISE. " this HEC and the populated by WISE. \* This HEC and the populated by WISE. " this HEC and the populated by
- Calibration
- → Input hydrograph



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# Modeling Approach: Dam Break

- Size and shape of expected breach
- Height of breach
- Time of breach formation



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 Many approaches: Prediction of Dam Breach Parameters, USBR (1998)

- Hydrologic routing: HEC-1 or HEC-HMS
  - Advantages
    - Standard used in practice
    - Within same hydrologic program
    - Ease of application and review
  - Disadvantages
    - Not as technically accurate
    - Can vary substantially from hydraulic routing
    - Difficult to transpose on complex topography

- Hydraulic routing: HEC-RAS or FLDWAV
  - Advantages
    - Accounts for complex topography
    - Necessary where floodplain storage is predominant
    - Mapping of floodwave can closely reflect ground conditions

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#### Disadvantages

- Computationally difficult, debugging can be cumbersome
- Difficult to review since model "tricks" may be necessary for a run



Movie is Courtesy of US Army Corps of Engineers, http://www.hec.usace.army.mil/software/hec-ras/hecras-demo.html

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**Comparison of Routing Methods on Bald Eagle Creek** 

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#### Modeling Approach: Danger Reach Mapping

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#### Modeling Approach: Danger Reach Mapping

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Watershed Concepts - A total water resource

## Which method or approach is the best?





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Watershed Concepts - A total water resource

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## Final product of dam failure analysis



Watershed Concepts - A total water resource

#### Which method or approach is the best?

Hydrology – 100 year event, PMP, or % of PMP?

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#### Dam Break – Which parameters are critical?

Routing of Floodwave – Hydrologic or Hydraulic?

Creation of Danger Reach Map...

- Hydrologic routing:
  - Examples: HEC-1 or HEC-Hydrologic Modeling System (HEC-HMS)
  - Balance inflow, outflow, and storage through use of continuity equation

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 Use relationship between outflow rate and system storage

- Hydraulic routing:
  - Examples: NWS FLDWAV, HEC-River Analysis
     System (HEC-RAS)
  - Based on continuity equation and momentum equation
  - Many algorithms account for non-uniform, unsteady flows that occur with upstream movement of tides, backwater effects from reservoirs and tributaries, floodwaves with very flat slopes, and abrupt waves caused by sudden release of water....