Dam Failure Analysis

Current Methods for Analysis and the Implications for Emergency Action Planning

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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?
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

Photo isCourtesy of Maryland Division of Dam Safety, http://www.mde.state.md.us/Programs/WaterPrograms/Dam_Safety/home/index.asp
Modeling Approach

- Hydrology
- Dam Break
- Routing of Dam Break Wave
- Creation of Danger Reach Map
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)
Modeling Approach: Hydrology

- Application to hydrologic model, HEC-1 or HEC-HMS, TR-20, etc.
- Calibration

→ Input hydrograph
Modeling Approach: Dam Break

- Size and shape of expected breach
- Height of breach
- Time of breach formation
Modeling Approach: Routing of Floodwave

- **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
Modeling Approach: Routing of Floodwave

- **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
  - Disadvantages
    - Computationally difficult, debugging can be cumbersome
    - Difficult to review since model “tricks” may be necessary for a run
Modeling Approach: Routing of Floodwave

Watershed Concepts - A total water resource

Movie isCourtesy of US Army Corps of Engineers,
Modeling Approach: Routing of Floodwave

Comparison of Routing Methods on Bald Eagle Creek

- HEC-HMS (HYDROLOGIC)
- HEC-RAS (HYDRAULIC)
Modeling Approach: Danger Reach Mapping
Modeling Approach: Danger Reach Mapping
Which method or approach is the best?
Final product of dam failure analysis
Which method or approach is the best?

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

Dam Break – Which parameters are critical?

Routing of Floodwave – Hydrologic or Hydraulic?

Creation of Danger Reach Map…
Modeling Approach: Routing of Floodwave

- Hydrologic routing:
  - Examples: HEC-1 or HEC-Hydrologic Modeling System (HEC-HMS)
  - Balance inflow, outflow, and storage through use of continuity equation
  - Use relationship between outflow rate and system storage
Modeling Approach: Routing of Floodwave

- **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....