Dam Breach Analysis using HEC-RAS

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Geography 593

A Brief History of Dams

- First dam was built in Mesopotamia circa 3,000 BCE
- 50,000 dams worldwide; 5,500 exist in the United States
- Design range from earthen gravity dams to modern concrete archgravity
- Largest advances in dam engineering and safety in the last 100 years
- 900 dams removed in the U.S. since 1990!









What would happen if...





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US Army Corps of Engineers Hydrologic Engineering Center

HOME > SOFTWARE > HEC-RAS

Welcome to the Hydrologic Engineering Center's (CEIWR-HEC) River Analysis System (HEC-RAS) website. This software allows the **HEC-RAS** user to perform one-dimensional steady flow, one and two-dimensional unsteady flow calculations, sediment transport/mobile bed computations, and water temperature/water quality modeling. **HEC-RAS** HEC-RAS 5.0.0 File Edit Run View Options GIS Tools Help Debug Stage and Flow Hydrographs Features 이미 지단고한 🖉 🖛 키키키지 🕿 🕿 ~ チットレギト File Type Options Help Bald Eagle Creek Example Dam Break Study d/L ...120 Unsteady Flow Hydraulics/8 Conni Dam What's New Geometric Data - SA to 2D Flow Area - Detailed Plat Stage P Rat Flow P Obs Stage T Obs Flow T Use Ref Stage File Edit Options View Tables Tools GIS Tools Help Stage Plaw | Table | Rating Curve | Gate Openings | Area Com Billion Christophere Description : Parage and Reach Pump 秘 Plan: SA-20 Det Broh SA Connection: Dam Downloads Manu 100 Junct . Documentation Section Bodg/Calo FAQs biline Skrietare Lideral Skrietare **RAS Mapper** Known Issues File Tools Hek L 6 . Q H 10 ← → 📅 🗶 🔣 🖒 Max Min elected Layer: Velocity Barap ana E-E-Single 20 04JAN1393 03:05 00 **Bug Report** (B-V Geometry anna Ana Depth (03JAN 1999 03:10: [Velocity (03.JAN1999 10-1 WSE (03JAN1999 01-10-0 20 Levee Struc Suggestions Did Geometry Depth (00JAN1999-09-35) Pump States WSE (03.JAN1969 20:05:0 Velocity (03J/M1999 04 2 Demo SA-2D Det Broh HTab Pariets B Geometry Cepth (03J3N1999 12:00 View Picture Velocity (5 - WSE (03.04V1999 08:40:0 Sponsors SA-20 Det FEG Geometry Depth (03JAN 1999 09:55 Velocity (03.JAN1999 08-Collaborators [V] WSE (03.14N1999 08-40.0 MapLayers MainChannelBanks Lock Haven CenterLine Support Policy Google Hybrid LandUse Terrains Meanages Views Profile Lines

Hoover Dam

- Type: Concrete arch-gravity dam
- Location: Black Canyon of the Colorado River (NV-AZ Border)
- Built: 1931-1936
- Impounds: Lake Mead (640 km²)
- Height: 221 meters
- Crest Width: 14 meters Base Width: 200 meters
- Weight: 6.6 million tons
- Capacity: 3.5 trillion m^3
- Annual Power Generation: 4.2 TWh



Dam Breach Model Considerations:

- Reservoir Drawdown and Flow Area
 - 1D Steady Flow Reservoir Drawdown to 2D Unsteady Flow Downstream Routing
 - Flow Ara Computational Mesh: 1.8 million 100m^2 computational mesh
 - Major Assumption: No other hydraulic features exist downstream of the Hoover Dam (False)
- Dam Breach Parameters
 - Type of Dam: Concrete Gravity-Arch
 - Breach Mode: Overtopping
 - Speed of Breach formation: Instantaneous
 - Shape/Size of Breach: ~80% Breach
 - Flow from breach: Ideally, full flow is achieved nearly instantaneously
 - Linear buildup was used to avoid model instabilities
- Topography and Manning's Roughness Coefficients (Friction Surfaces)
 - DEM: 30-meter NED DEM was reconditioned using AGREE method in ArcHydro
 - Manning's N: Roughness coefficients were assigned to 2016 NLCD dataset based on USGS Guidelines
- Desired Complexity and Computational Time
 - Simulation time: 72 Hours
 - Computational Interval: 30 seconds
 - Ideally, 1 second or less for dam breach analysis
 - 1 second computational interval would have required 36 hours of computational time on my machine!

Storage Area Editor · Connection Data Editor - breach SA Connection dam ▼ ↓ ↑ Delete this Breach ... Delete all Breaches ... File View Help ↓ ↑ → 2DFlow Storage Area: Storage Area 1

 Image: A contract of the state of the s Breach This Structure X Geometric Data - breact Connection: dam ▼ ↓ ↑ Apply Data Breach Plot Breach Progression Simplified Physical Parameter Calculator Breach Repair (optional) Breach Method: -Connections and References to this Storage Area hec_ras_simulation Plan: Plan 01 Breach (plan data) ... Plot WS extents for Profile User Entered Data Description : Description Legend Spilway Conn: dam 265 Connections Center Station: Storage area: Storage Area 1 Set SA/2D ... Weir Length: 585.51 100 From: Final Bottom Width: Centerline Terrain Set SA/2D ... | Centerline Length: 585.51 Final Bottom Elevation: 275 2D flow area: flood_storage To: Final Breach Left Side Slope: 0.8 450 Centerline GIS Coords... Right Side Slope: 0.8 -Breach Weir Coef: 1.44 Terrain Profile ... Structure Type: Weir, Gates, Culverts, Outlet RC and Outlet TS -Area times depth method Area (1000 m2): 640000. Breach Formation Time (hrs): 1 No Flap Gates -Clip Weir Profile to 2D Cells... Flap Gates: Failure Mode: Overtopping 💌 Min Elev: 320. Weir / dam 0.5 Piping Coefficient: Embaskmen C Elevation versus Volume Curve Compute E-V table from Terrain Initial Piping Elev: Gate I W Culvert Trigger Failure at: Set Time • Elevation Volumne Curve 06SEP2008 350 Start Date 500-Legend First elevation must have zero volume Filter... Start Time 00:00 Spillway Volume (1000 m3) 450 Elevation Centerline Terrain Outlet RC Outlet TS 1 363.819 0 400 2 364.157 2.001 3 364.305 3.864 350-4 364.409 7.171 5 364.543 13.6 300-250 100 200 300 400 500 600 6 364.677 23.992 Station (m) 250 7 364.821 40.448 505755 17 3703340 03 100 200 300 400 500 600 OK Cancel 8 364.992 64.636 Station (m) 9 365.123 87.668 10 365.231 113.327 11 365.328 141.768 -GIS Outline ... | Plot Vol-Elev ... OK Cancel

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L Unsteady Flow Analysis

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1 Storage Area Connection with breach data. 1 set to breach.								

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Conclusions and Future Work

- A breach of the Hoover Dam would be devastating
 - Luckily, it was built to last
- HEC-RAS is a powerful hydraulic modeling software for analyzing and visualizing hydraulic events to varying degrees of complexity
- Outputs from this model could be used for:
 - Flood Inundation mapping (outputs seem to favor CAD systems)
 - Contingency Planning (e.g., evacuation times downriver from a dam breach)
 - Dam Repair/Removal Planning
 - Much more!