Case Studies in Dam Breach Analysis

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Teton Dam Failure

- Idaho – 1976
- 251,000 ac-feet of water (80 Billion Gallons)
- Breach Length – Approximately 130 miles (Teton Dam to American Falls Dam)
- Breach Travel Time – Approximately 2 Days
- Average Speed – 4 f.p.s.

Rexburg, Idaho – 13 miles downstream

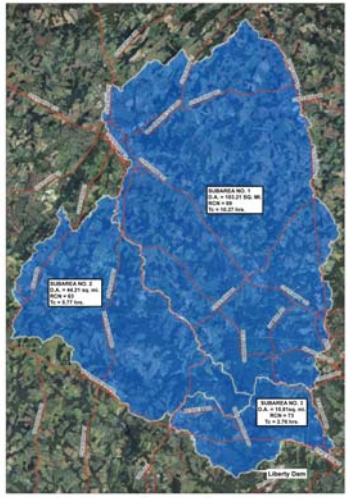
Liberty Reservoir

- Location – Sykesville, Maryland
- Dam Height - 175 feet
- Construction Type – Gravity – multiple monoliths
- Drainage Area – 163 Square Miles
- Impacted Areas – Ellicott City, Patapsco River valley, Baltimore City

Hydraulics and Hydrology Methodology

- Hydrology
  - GISHydro
  - Calibrated using USGS regression equations for area.
- Hydraulics
  - Volume via MGS Bathymetric Survey
  - Discharge via broad crested weir equation with adjustments for construction by abutments. Obtained via field survey
- USACE HEC-1 Modeling program used to develop hydrographs

Liberty Dam Drainage Area Map



Breach Parameter Development

- Multiple monoliths (1, 2, 3, 4)
  - Sensitivity to breach width
- Breach at abutments – RULED OUT
  - Shallow earth fill
- Breach from water surface elevation to bottom of upstream side of dam
- Time to Failure
  - 3 minutes - Very short due to method of failure

Breach Routing and Flood Mapping

- Cross Sections
  - 2' LiDAR from Carroll, Howard, Anne Arundel, and Baltimore Counties and Baltimore City
  - Determined Manning's n values from Chows' *Open Channel Hydraulics*
- Roads
  - No road crossings built into current model but plans are to update model to include crossings where applicable.
- Dams
  - Low head dams (Bloede, Daniels) not included because of height relative to breach wave and lack of available flood storage

Breach Routing and Floodplain Mapping

- ARCGIS 10
  - Developed DEMs from 2' LiDAR data sets
  - Delineated cross section lines
  - Created georeferenced floodplain maps

Breach Routing and Flood Mapping

- USACE HEC-GeoRAS 4.3
  - Unsteady Flow Model – Breach Hydrograph Input
  - Accounting for Flow Attenuation = Reduced Peak Flows
  - More accurate water surface profiles
  - Geo-referenced Floodplain Mapping

Challenges and Solutions

- *CHALLENGE: Large scope of work with limited funding*
  - *SOLUTION: Drew on freely available information and software to minimize survey (examples: MGS Bathymetric Survey, HEC-1 and HEC-RAS software packages, MDE Dam Safety technical resources)*
- *CHALLENGE: Multiple Data Sources*
  - *SOLUTION: Verified datum of each data source and used ARCGIS to "sew" together multiple LiDAR datasets.*
- *CHALLEGE: Inflow Hydrograph Accuracy*
  - *SOLUTION: Calibrated model using sensitivity analysis to drainage area, RCN, and time of concentration. Adjust time of concentration (most sensitive)*

If we had to do it again . . .

- Include Road Crossings (will be done as a revision to this model)
- Calibrate hydrologic model to additional gauged regression equations
- Consider steady flow model at Road Crossings to promote model stability
- Include second inflow hydrograph to simulate rainfall over downstream drainage areas

Kentlands Dams

- Location – Gaithersburg, Maryland
- Dam Heights – 24, 19, 37, 24, and 15 feet
- Construction Type – Earth embankment w/ structural spillways
- Drainage Area – 323 Acres
- Impacted Areas – Kentlands neighborhood, Gaithersburg, Maryland

Hydraulics and Hydrology Methodology

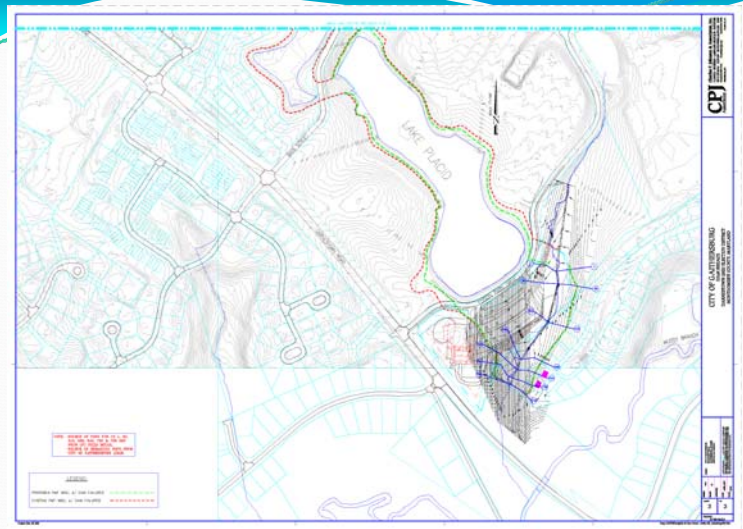
- Hydrology
  - Delineated drainage areas manually
  - Determined time of concentration manually using TR-55 guidance
  - Determine Runoff Curve Number using ARC GIS and GIS land use and soils data sets.
- Hydraulics
  - Normal pool and flood storage volumes determined using as-built plans and GIS data and geo-referenced into survey datum.
  - Stage Discharge determined using as-built plans and geo-referenced field survey data from all five dams to establish a common datum.
- USACE HEC-1 Modeling program used to develop hydrographs

Breach Parameter Development

- Earth Embankment
  - NWS Simple DAMBRK Program
  - Assumed largest flow yielded the most conservative breach parameters (width, time to failure)
  - Minimum time to failure of 10 minutes (0.17 hours)
- Breach from water surface elevation to bottom of upstream side of dam

Breach Routing and Flood Mapping

- Cross Sections
  - 2' LiDAR from City of Gaithersburg and Field Surveyed topography
  - Modeled using HEC-1
- Roads
  - No road crossings encountered in breach area.
- Mapping
  - Plotted water surface elevations for each event on base information in AutoCAD to address impacts to adjacent downstream properties



Challenges and Solutions

- *CHALLENGE: Complex dam system requiring multiple levels of input to develop breach maps*
  - *SOLUTION: Used conservative approach of assuming all dams breach "in-series" with the breach of an upstream dam flooding the next dam downstream and breaching it.*
- *CHALLENGE: Significant Tailwater Effects*
  - *Used HY-8 Culvert Analysis program to develop and balance tailwater rating curves on each principal spillway pipe.*
- *CHALLENGE: Multiple datums*
  - *SOLUTION: Used field survey of "hard points" such as riser weirs, pipe inverts, etc. to rectify all datums into one common datum. Adjusted table top information accordingly.*

If we had to do it again . . .

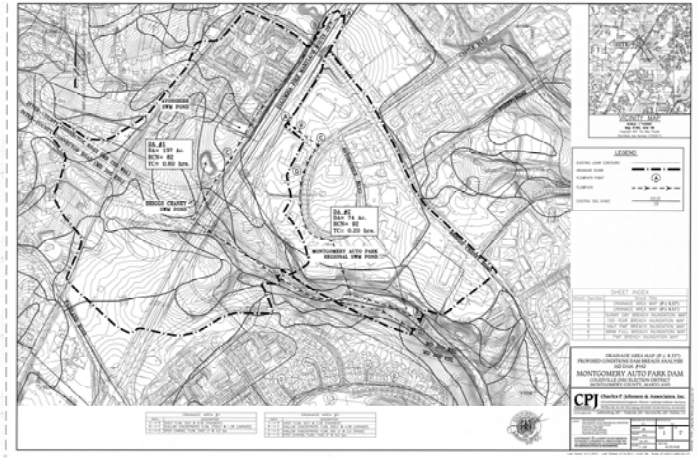
- Model downstream flooding in stream valley using HEC-RAS or other open channel modeling program.
- Examine dam breach parameters using Froelich Equations.
- Extend breach modeling downstream to Muddy Branch Tributary, beyond Darnestown Road

Montgomery Auto Park SWM Pond

- Location – Silver Spring, Maryland
- Dam Height - 29 feet
- Construction Type – Earth Embankment, structural outlets
- Drainage Area – 220 Acres
- Impacted Areas – local residential communities along Paint Branch Tributary, Inter-County Connector

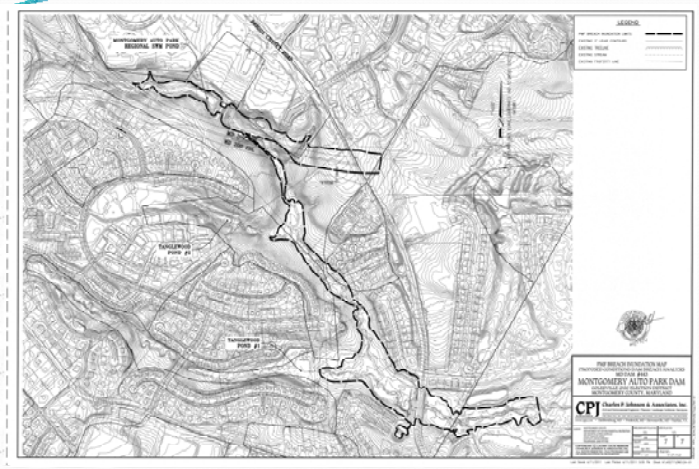
Hydraulics and Hydrology Methodology

- Hydrology
  - Manually determined drainage areas, runoff curve numbers, and times of concentration
  - Verified ICC stormwater management computations
- Hydraulics
  - Volume via field survey
  - Discharge via field survey
- USACE HEC-1 Modeling program used to develop hydrographs – upstream stormwater facilities included in 100 year analysis



Breach Routing and Flood Mapping

- Downstream area - small depression with 60" R.C.P. outlet – MODEL AS A DAM
- Discharges to second downstream area – small depression with 48" R.C.P. – MODEL AS A DAM
- ICC Noise Wall channels overtopping flows down roadway
- Use HEC-1 to model dams (part of larger dam breach model)
- Use HEC-RAS 4.1 to model overtopping flows on ICC and discharge flows from 48" and 60" R.C.P.



Challenges and Solutions

- *CHALLENGE: Extremely complex downstream area*
  - *SOLUTION: Used split flows between those that overtop and flow down ICC and those that pass through 48" and 60" culverts to downstream tributary*
- *CHALLENGE: Timing of analysis with major adjacent construction project.*
  - *SOLUTION: Owner coordinated with ICC project teams very closely to obtain all pertinent information required for analysis.*

If we had to do it again . . .

- Perform bathymetric survey of pond bottom (pond empty but inaccessible) to improve stage-storage rating table accuracy
- Assess downstream flow modeling approach.
  - Consider using 2-D flow routing model to more accurately model complex downstream area.

Take-Away's

- Each dam is unique. No two breach analyses are the same.
- Think about the reality of a breach scenario: How does the breach occur? Where and how does the water flow when it is released? Visit the site if possible
- Data sources must be rectified into common baselines, either by data type or physical datum
- Over-simplification can lead to inaccurate results

Questions and Comments?

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