Mapping and Predicting Flood Inundation in TN

Geohazards Impacting Transportation in the Appalachian Region – 11th Annual Technical Forum

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David Ladd
Scott Gain
Shannon Williams
Rodney Knight
USGS Tennessee WSC
Problem

- Two major flood events in Tennessee since May 2010
  
- Emergency responders and the general public need accurate information quickly
Background
May 2010

- Lower Cumberland
  - 15 to 20 inches
  - Limited flood storage
  - Historic flows at most tribs.

Weekend Rainfall Totals - May 1st & 2nd, 2010
Tennessee

Precipitation Contours

This map is an interpolation of actual reported values, but should be considered an estimation only.

Created by the National Weather Service Forecast Offices Nashville, Tennessee & Louisville, Kentucky

Source: CoCoRaHS
### Background

#### Nashville

- **Cumberland River**
  - Old Hickory Dam (mile 215)
  - Downtown Nash. (mile 190)
  - Cheatham Dam (mile 151)

- **Tribs.**
  - 6 small urban tribs
    - Mansker Creek
    - Dry Creek
    - Mill Creek
    - Browns Creek
    - Richland Creek
    - Whites Creek

- **Stones R. (Regulated)**
- **Harpeth River (870 sq mi.)**
$#!**@&^!!!!!!!!!!!!!!

MY HOUSE!!!
New Collaborative Effort
Multiple Agencies

- Modeling, HWMs, Flood Report
- Forecasting
- GIS & Mapping
- Real-time data
- Others
USGS/USACE/NWS/Metro Nashville

- USGS Install new gages along the Cumberland River
- USACE model hydraulics of main stem and tributaries
- NWS improve prediction models and communications
- USGS deliver real-time inundation maps
- Metro Nashville, OEM develop applications
Gaging on the Cumberland River (Nashville)

1. Old Hickory TW (mile 215) USACE*
2. At Dry Creek (mile 213)
3. At Stones River (mile 205)
4. At Old Lock #2 (mile 200)
5. US of Downtown Nash. (mile 193)
6. Downtown (mile 190) USACE/USGS*
7. DS of Downtown Nash. (mile 184)
8. At Whites Creek (mile 182)

*existing gages
Inundation Between Paired Gages

- Linear slope sections
- Evenly spaced stage gages
- Cascading gage pairs
Building Map Libraries

- Create inundation maps between gage pairs at 1-foot intervals

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Creating Inundation Maps

- Linear profiles in sections along center line
- Cross-sectional controls
- Surface interpolation with boundaries
- Intersection with LiDAR (or best elevation data)
- Validation against modeled surfaces
NHD center line with Profile

Gage pair 5-6
Gage pair 5-6

Interpolation region

Cross-sectional controls
Gage pair 5-6

Elevation surface interpolation
Inundation surface (extent and depth)
Validation against modeled surfaces
May flood peak (52 ft)
May flood peak (52 ft)
Tools

Metro Nashville Flood Mapping Tool
Tools
USGS Flood Mapping Tool (Beta)
Tracking Hydrographs

Pair 5-6
Simulation

Date: 4/30/2010 6:00:00 AM
Background
April-May 2011

- **Mississippi River**
  - Extensive rains in April flooded W TN tribgs
  - Additional rain in early May and upstream snowmelt flooded the Mississippi River in TN
Background

West Tennessee

- **Mississippi River**
  - Levees protect much of the adjacent land

- **Tribs.**
  - Obion River
  - Forked Deer – North, Middle, and South Forks
  - Hatchie River
  - Big Creek
  - Loosahatchie River
  - Wolf River
  - Nonconnah Creek
The USGS worked with FEMA, USACE, NWS, and local agencies to provide emergency real-time stage data in Shelby County.

- Stage data assisted NWS with forecasts.
The USGS…

- Collected high-water marks in emergency areas
- Used high-water mark and gage data to map inundation
  - Separate data for the April / May events (where necessary)
  - Process inundation surfaces for both separately
  - Merge the results
- FEMA used data for emergency assistance and to assess damage
  - Timing is important
• Linearly interpolate along center lines using high water marks and gage peaks for Miss. R. flooding and trib backwater

• Constrain surface interpolation using boundary polygon
- Mississippi River flood extent and depth (from early May 2011)
• Same process for tributary flooding
• Tributary flooding (late April 2011)
• Combination of both

Field verification – water stayed within levee
Conclusions

Using GIS techniques...

- flooding analysis can be conducted in advance to predict inundation under certain stream/river stage conditions
- map libraries can be built and served to depict real-time/predicted inundation
- in combination with sufficient gage/HWM control, inundation extent and depth can be mapped quickly without the use of complex models
Questions

The Grand Ole Opry House, flooded in 1975: