FEMA’s CNMS Database – More Than Metrics: Hurricane Harvey Disaster Response

Association of State Floodplain Managers Annual Conference
Phoenix AZ
June 21, 2018

AECOM

Tammie Tucker
Erik Danielson
Hurricane Harvey

- Intensified rapidly from a tropical storm to a major hurricane in less than 2 days
- Made landfall with winds of 130 mph on the Texas coast on August 25, 2017
- 1st Category 4 hurricane to make landfall along the Texas coast since 1961
- Stalled over the Texas coast for 4 days
- The area that received at least 20” of rain is greater in size than the State of West Virginia. The area that received >40” of rain is larger than the State of Delaware. The top rainfall total occurred in Nederland, TX where over 60” fell.
- Nearly 800,000 Texans evacuated their homes
- Nearly 80,000 homes had at least 1.5’ of floodwater
- 24 hospitals were evacuated
- 68 people died from the direct effects of Harvey
Hurricane Harvey

Presidentially-declared disaster in 41* TX counties

* Caldwell and Grimes Counties received disaster declaration after the start of the project this presentation covers
Texas Floodplain Mapping Studies

Prior to Hurricane Harvey the 39 counties in Texas that received a declaration of disaster as of mid-September:

- 5,242 riverine miles of effective detailed (Zone AE or AO) study (3,447 miles valid)
- 16,692 riverine miles of effective approximate (Zone A) study (2,101 miles valid)
- 6,195 riverine miles of draft/preliminary study (1,194 miles unmapped)

Is an update to FEMA’s valid effective studies warranted due to Hurricane Harvey?

Are FEMA’s preliminary studies still acceptable to become effective studies post-Harvey?
Coordinated Needs Management Strategy (CNMS)

• Inventory of FEMA’s riverine and coastal mapped special flood hazard areas.
• Comprehensive approach to managing mapping needs.
• Used to organize, store and analyze flood hazard mapping needs as well as document study reaches that meet FEMA’s validity standards.
• A Geospatial Database that tracks:
  • New, Validated or Updated Engineering (NVUE)
  • Unverified study reaches (need of restudy)
  • Flood mapping requests
CNMS Components

CNMS Inventory
• flooding source centerlines (streamlines) and coast lines that contain FEMA’s inventory of flood hazard studies.

CNMS Requests
• polygons or points that identify areas where study or mapping updates are desired.
CNMS Touchpoints

- Discovery
- Scoping
- Preliminary Issuance
- LOMR
- LFD Issuance

5 Year Validation Assessment
CNMS Validation Assessments

• Engineering studies that adequately identify the level of flood risk identified on a community’s flood insurance rate map are classified in CNMS as “VALID – NVUE COMPLIANT”

• Studies found to be deficient are classified as “UNVERIFIED”

• Valid studies require re-assessment by FEMA every five years
  – Validation assessment procedures for Detailed, Approximate and Coastal Studies
  – Changes in topography, hydrology & land development are evaluated
  – Unverified studies can only become Valid through a restudy
Detailed Study Assessment Checks

CRITICAL ELEMENTS

• C1: Major change in gage record since effective analysis
• C2: Updated and effective peak gage discharges differ significantly based on confidence limits criteria
• C3: Model methodology no longer appropriate
• C4: Additional/removal of a major flood control structure
• C5: Current channel reconfiguration is outside the effective Special Flood Hazard Area (SFHA)
• C6: Five or more new/removed hydraulic structures that impact Base Flood Elevations (BFEs)
• C7: Significant channel fill or scour

The failure of any single critical element will result in a study becoming UNVERIFIED.
Detailed Study Assessment Checks

SECONDARY ELEMENTS

- S1: Use of rural regression equations in urbanized areas
- S2: Repetitive property losses outside the effective SFHA
- S3: >50% increase in impervious area in the sub-basin
- S4: 1-4 new/removed hydraulic structures that impact BFEs
- S5: Channel improvements
- S6: Availability of better topography
- S7: Significant changes to vegetation or land use
- S8: Significant storms with High Water Marks (HWMs) since effective analysis
- S9: New regression equations

Failure of at least 4 secondary elements for a study to be flagged UNVERIFIED.
Data Sources

- National Inventory of Dams (NID)
- National Levee Database (NLD)
- National Bridge Inventory (NBI)
- National Land Cover Database (NLCD)
- National Urban Change Indicator (NUCI)
- FEMA Rep Loss Inventory
- Topography Inventory
- Flood Insurance Studies (FIS)
- USGS Gage data
- Letters of Map Change (LOMR)
- Effective DFIRM Database
- Ortho imagery
- High Water Mark (HWM) data
Project Approach

- Assess all VALID detailed riverine miles in the 39 disaster-declared counties
- Assess all BEING STUDIED detailed riverine miles in the 39 counties
  - Assess based on the draft or preliminary data
- **4,661** total detailed miles were assessed

Two-phased approach:

1. Phase I – Assess Critical Elements C1 and C2 using Hurricane Harvey streamflow analyses. This phase gave a very quick snapshot of how significantly Harvey affected gage records and discharges
2. Phase II – Assess the remainder of the critical and all secondary elements using available post-disaster data to classify studies as VALID or UNVERIFIED.
Phase I

C1 and C2 assessments utilized existing USGS gage record data and Hurricane Harvey Precipitation and Streamflow Analysis results.
Should a gage be considered?

• There should be a gage on the stream within a distance of the reach being assessed that a statistical analysis would influence. A good approximate rule of thumb is that a gage analysis would affect 0.5 - 1.5 times the drainage area (DA) of the gage.

• There should be a minimum of 10 years of record at the gage to perform statistical analysis. For CNMS assessment purposes, this means there needs to be at least 10 years of record prior to the effective date of analysis.

• To assess elements C1 and C2, there must be new gage records since the effective date of analysis.
C1 Assessment

Has a record event or event > the published 1%-annual-chance discharge been recorded at gage since the effective date of analysis?

- Approximately 32% (1,500 mi) of the assessed miles had useful stream gage data available
- Approximately 24% (1,100 mi) of the assessed miles failed this check
- Approximately 22% (1,050 mi) of the assessed miles had Hurricane Harvey gage data available
- Approximately 17% (780 mi) of the assessed miles failed this check.

*¾ of the assessed miles that had Harvey gage data available showed the event to be a record event at that gage and/or the Harvey peak discharge to be > the published 1%-annual-chance discharge
C2 Assessment

Do the effective and current peak gage discharges differ significantly based on confidence limits criteria?

From FEMA CNMS Technical Reference:

- Determine if 100-yr discharge obtained by running PeakFQ at effective date is still within 68% confidence interval of the Bulletin 17B 100-yr estimate using updated gage data and PeakFQ. If not, Critical Element is set to “FAIL”.

What does the 68% confidence interval represent?
C2 Assessment

There has been confusion as to what confidence interval or limit to use in the PeakFQ Output Options tab to achieve the desired 68% confidence interval.

All screen shots are from the current PeakFQ User’s Manual
(https://pubs.usgs.gov/tm/2006/tm4b4/)
C2 Assessment

The Output Options tab of the current version of PeakFQ (V 7.1) looks a little different from the examples in the current User’s Manual.
Clarification from USGS:

• The Confidence Intervals/Limits (depending on what version of PeakFQ you are using) entry is meant to represent the **Upper Limit of the Confidence Interval** you want to be produced in the output file.

• So, for CNMS assessment purposes, the 68% Confidence Interval has lower and upper limits of 0.16 and 0.84. In PeakFQ, you would enter 0.84 as the Confidence Intervals/Limits. The output file will say 84% Confidence Interval, but it is in fact the 68% Confidence Interval.

The output file says 84% confidence interval, but it is actually the 68% confidence interval.
C2 Assessment

In Phase I, only the assessed miles that passed the C1 check then had the C2 check assessed.

- Approximately 400 miles with useable gage data passed the C1 check and then had the C2 check assessed
- Approximately 32% of these miles failed this check

* In 2-3 weeks time, AECOM was able to complete Phase I assessments and determine that 1,231 of the 4,661 assessed miles would become UNVERIFIED studies due to changes in gage data. The change in validation status of these studies was due in large part to Hurricane Harvey.
Phase II

Phase II included:

• Back check of Phase I results due to the Hurricane Harvey Streamflow Analysis being finalized simultaneously
• Assessment of element C2 for all applicable studies that failed C1 (since Phase I only assessed it for the applicable reaches that passed C1)
• Assessment of elements C3 – C7 and S1 – S9

Phase II resulted in the full CNMS Validation Assessment of all detailed study reaches being assessed.
Post-Harvey Data Sources

Even though all elements were assessed, the impacts of Harvey on the studies could only be assessed through certain elements.

Post-Harvey data sources provided for this analysis were:

- Harvey Streamflow Analysis (used for C1 & C2)
- HWMs collected for Harvey (used for S8)
- Orthoimagery collected (used for C4 - C7 & S4 – S5)
High Water Mark Data

Over 1,500 quality HWMs were collected between September 2 – October 9, 2017.

* There were an additional 600 HWMs collected classified as Poor or Very Poor quality that were excluded from this analysis.
Orthoimagery

Post-event imagery was collected from various sources:

- U.S. Army Corp of Engineers (USACE)
- USGS Hazard Data Distribution (HDD)
Orthoimagery is used to assess current conditions of stream channels and in-stream structures and is a very valuable tool.

Much of the post-event imagery was collected immediately after the event when floodwaters were still high and channels, floodplains, roadways, and structures were still inundated. So, it was often unclear where in-stream structures had been destroyed or damaged.
4,661 detailed miles assessed

2,060 miles remained VALID

2,601 miles became UNVERIFIED

2,415 miles failed at least 1 element as a result of Harvey

498 miles became UNVERIFIED as a direct result of Harvey

* 52% of the miles assessed had at least one element affected by Harvey
* 56% of the valid miles assessed became UNVERIFIED as a result of this analysis
* 11% of the assessed miles would not have become UNVERIFIED if Harvey had not occurred
Results

Valid, No effects due to Hurricane Harvey
Valid, At least one element failure due to Hurricane Harvey
Unverified, No element failures due to Hurricane Harvey
Unverified, Became Unverified due only to Hurricane Harvey

Validation Status
- Green: Valid, No effects due to Hurricane Harvey
- Green: Valid, At least one element failure due to Hurricane Harvey
- Orange: Unverified, No element failures due to Hurricane Harvey
- Yellow: Unverified, At least one element failure due to Hurricane Harvey
- Red: Unverified, Became Unverified due only to Hurricane Harvey

Sources: ESRI, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org and other contributors.
Results

35% of the assessed miles were BEING STUDIED miles (not yet effective studies)

1,654 detailed BS miles assessed
- 618 miles classified as VALID
- 1,036 miles classified as UNVERIFIED
  - 195 miles became UNVERIFIED as a direct result of Harvey
  - 1,185 miles failed at least 1 element as a result of Harvey

* 72% of these miles had at least one element affected by Harvey

* 63% of these not yet effective study miles became UNVERIFIED as a result of this analysis

* 12% of the assessed miles would not have become UNVERIFIED if Harvey had not occurred
Results
Lessons Learned

Lessons learned to apply to future post-disaster CNMS assessments:

• Post-disaster orthoimagery collected after floodwaters have receded will provide a more complete picture of the effects of a flood event on the channels and in-stream structures (C4 – C7 and S4 – S5).

• Bridge inspection data collected post-disaster would be beneficial in assessing the impacts of the event on bridge scour (C7).

• Local community inventory and input on destroyed and damaged structures would allow for further refinement of elements C6, C7, and S4.

• Updated FEMA Repetitive Claims data that includes claims made as a result of the declared disaster would support refinement of element S2.
Future Considerations

The CNMS DB does not provide insight on the degree to which approximate (Zone A) studies are affected by disasters. The elements assessed for Zone A studies are:

- A1: Availability of better topography
- A2: Availability of newer regression equations
- A3: >50% increase in impervious area in the sub-basin
- A4: Studies are backed by technical data

FEMA Regions do have the option to assess additional elements as they see fit. A suggestion made was to consider this option for future assessments.

A potential added check would be for HWMs collected on Zone A study reaches. While Zone A studies are not typically calibrated, the availability of HWM data could indicate impacts of disasters on these studies. Also, as regulatory-ready Zone A studies are becoming more prevalent it would be useful to assess additional elements for Zone A studies.
References

- FEMA’s CNMS Technical Reference

- PeakFQ User’s Guide

- Bulletin 17B
Questions?

Tammie Tucker
Tammie.tucker@aecom.com

Erik Danielson
Erik.danielson@aecom.com