REAL-TIME FLOOD FORECASTING IN NASHVILLE, TN USING HEC-RTS

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May 2010 Flood Impacts

- New regulated flood of record for middle and lower Cumberland River
- In Franklin, TN, 17.87 inches of rain fell over May 1st and 2nd exceeding the NOAA Atlas 14 1000-yr storm event by more than 5 inches
- May 1st : 3rd wettest day; May 2nd : wettest day
- Event more than doubled the 2-day rainfall record
- Widespread flooding on the Cumberland and Duck Rivers and especially on tributaries within Metro-Nashville
- May 2010 event resulted in significant impacts
  - Economic Damages - over $2B in damages
  - Fatalities - 26 fatalities overall; 11 in Nashville alone (all in tributaries to the Cumberland River)

Post May 2010 Flood Efforts

- Immediately started working with Nashville and other federal agencies
  - Building models and developed mapping products to better understand flood risk
  - USGS added stream gauges further up in watersheds
  - Created the Nashville SAFE program to better understand NWS forecasts
  - Performed hundreds of miles of updates to flood insurance rate maps in coordination with FEMA
- **Work culminated in the development of HEC-RTS modeling**

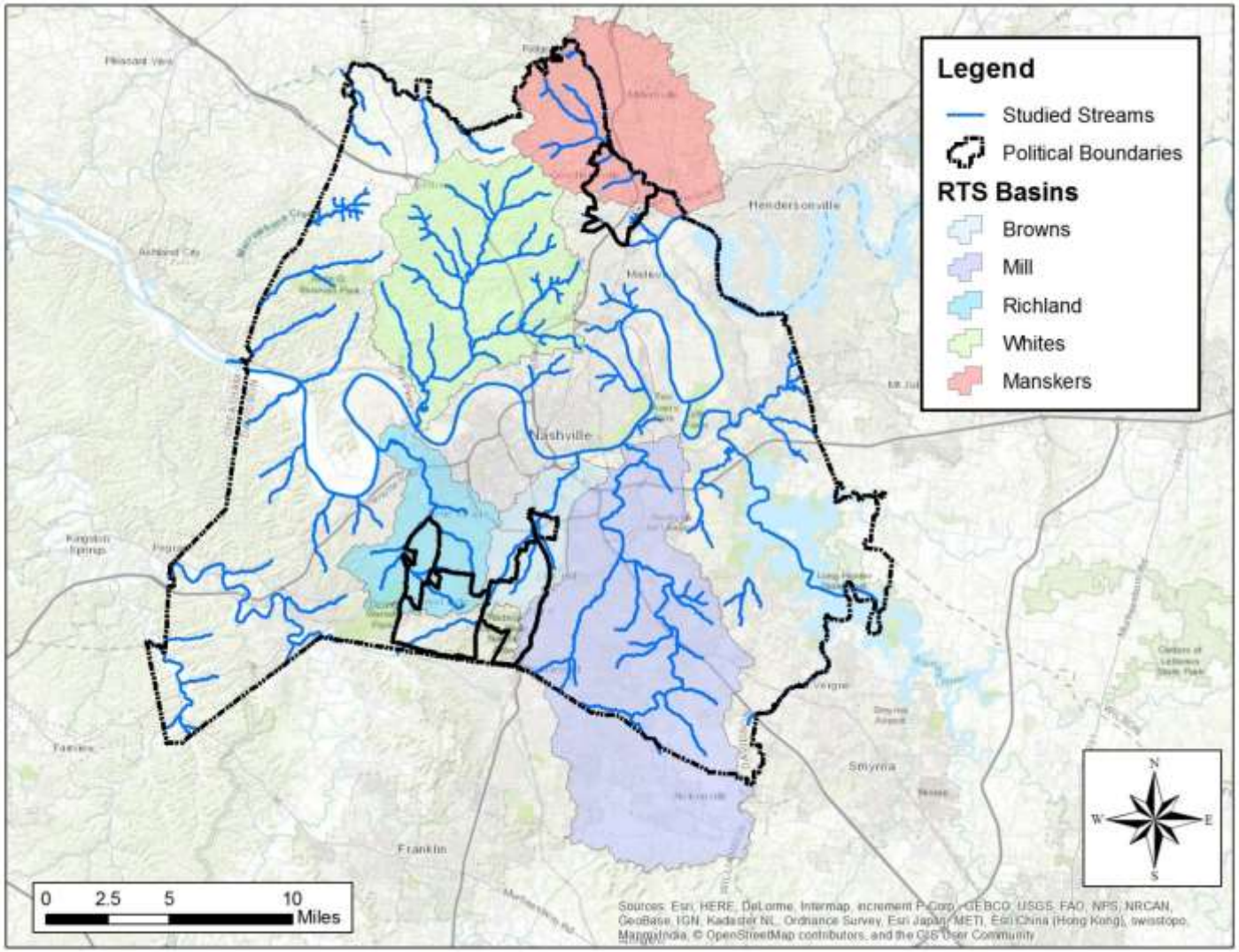
Real Time Simulation (HEC-RTS)

- What is HEC-RTS?
  - Real-time decision support system developed by the USACE - Hydrologic Engineering Center in Davis, CA
  - Desktop version of USACE's Corps Water Management System (CWMS) software
  - Relies on suite of HEC software (HEC-HMS, HEC-RAS, etc.)
  - Provides a real-time flood forecasting environment integrating HEC software
  - Utilizes python scripts to import real-time data from the internet and to publish results

Real Time Simulation (HEC-RTS)

- Why is it important?
  - LIFE SAFETY
  - Time matters – Most basins in Nashville have a very short reaction time
- Who is the suite of Nashville HEC-RTS models intended for?
  - Modelers
    - National Weather Service (NWS)
    - Metro-Nashville Staff
    - USACE
  - Beneficiaries
    - Metro emergency services
    - NWS forecasters
    - Public

Nashville HEC-RTS Watersheds

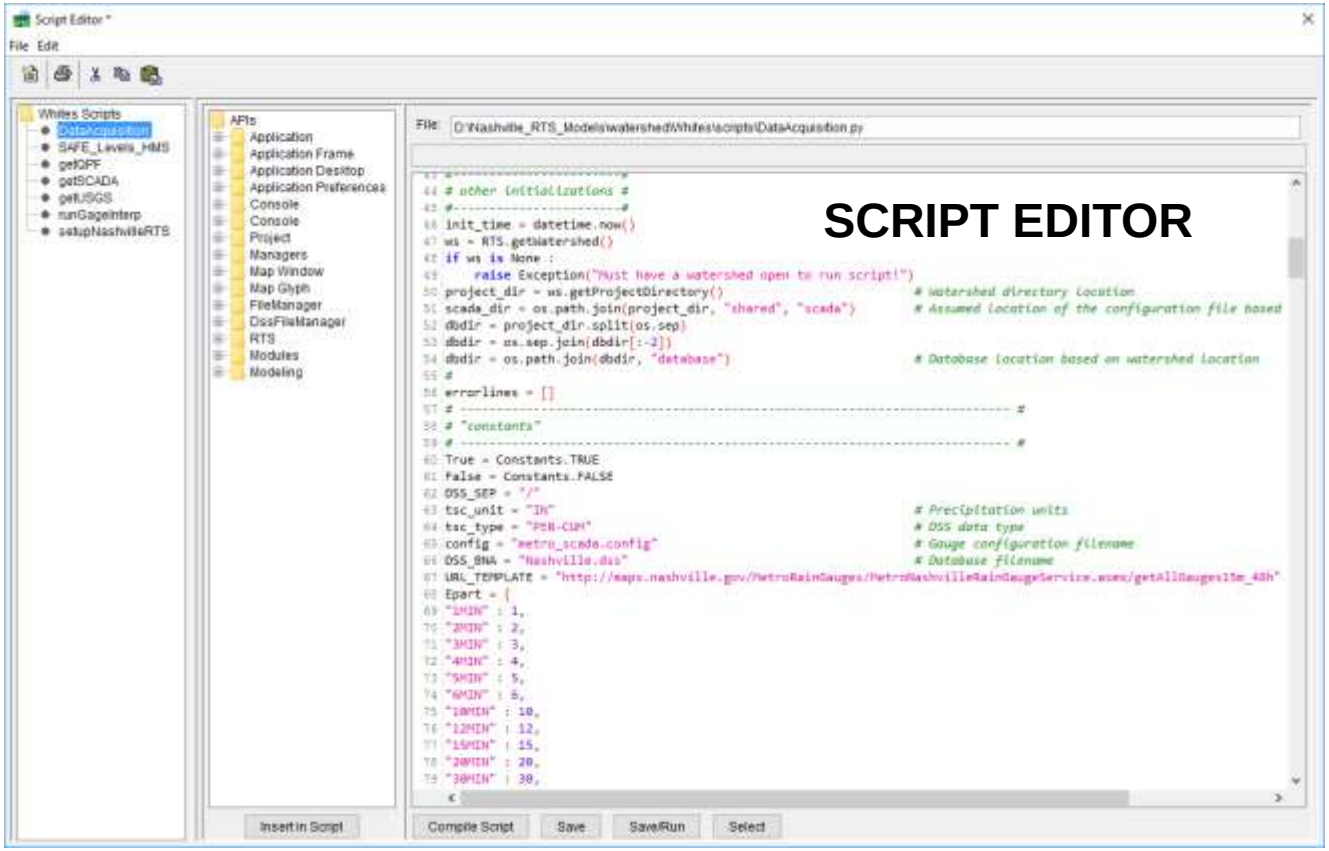


Input Data to the Model

- Data is very important to the model performance
- All data derived from publicly available web sources
- HEC-RTS model relies on several sources of data
  - Stage/Flow Time Series Data – USGS
  - Gridded Precipitation
    - Observed – GageInterp-derived (15-min); NWS QPE (1-hr)
    - Forecasted – NWS/NOAA QPF (6-hr); NWS/NOAA HRRR (1-hr)

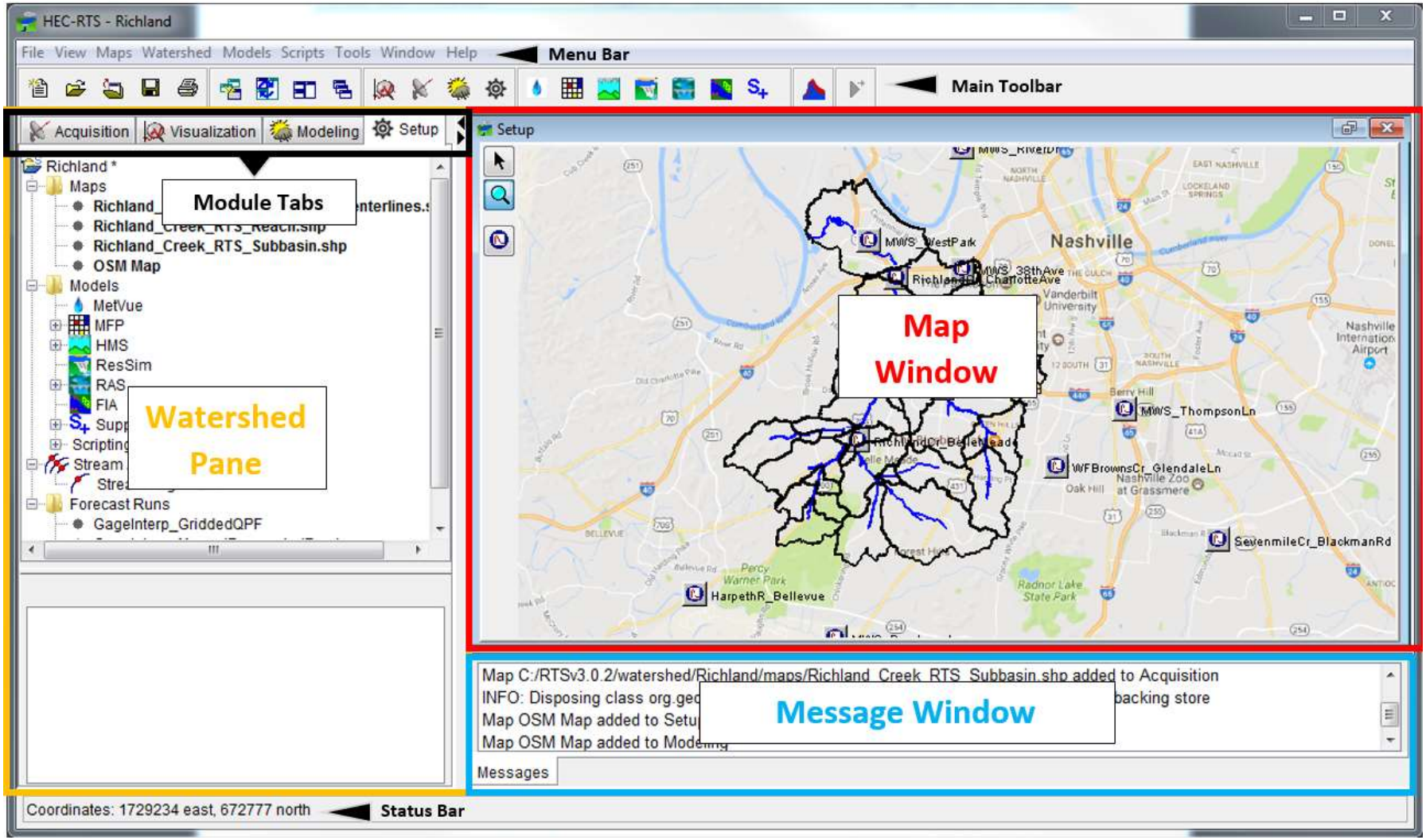
Input Data to the Model

- Python scripting is used to download from public web sources and format input data for integration into the RTS model



- Scripts
  - USGS Data
  - Nashville SCADA Precip Gauges
  - GageInterp
  - NOAA QPE
  - NOAA QPF
  - NOAA HRRR
  - Action Level Tool
- Scripts can be run on a schedule

HEC-RTS Tour


HEC-RTS - Richland
File View Maps Watershed Models Scripts Tools Window Help
Menu Bar
Main Toolbar
Acquisition
Visualization
Modeling
Setup
Module Tabs
Richland *
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Richland_Creek_RTS_Subbasin.shp
OSM Map
Models
MetVue
MFP
HMS
ResSim
RAS
FIA
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Setup
Map Window
Nashville
MWS_WestPark
MWS_38thAve
CharlotteAve
MWS_ThompsonLn
WFBrownsCr_GlendaleLn
SevenmileCr_BlackmanRd
HarpethR_Bellevue
Map C:/RTSv3.0.2/watershed/Richland/maps/Richland_Creek_RTS_Subbasin.shp added to Acquisition
INFO: Disposing class org.ged
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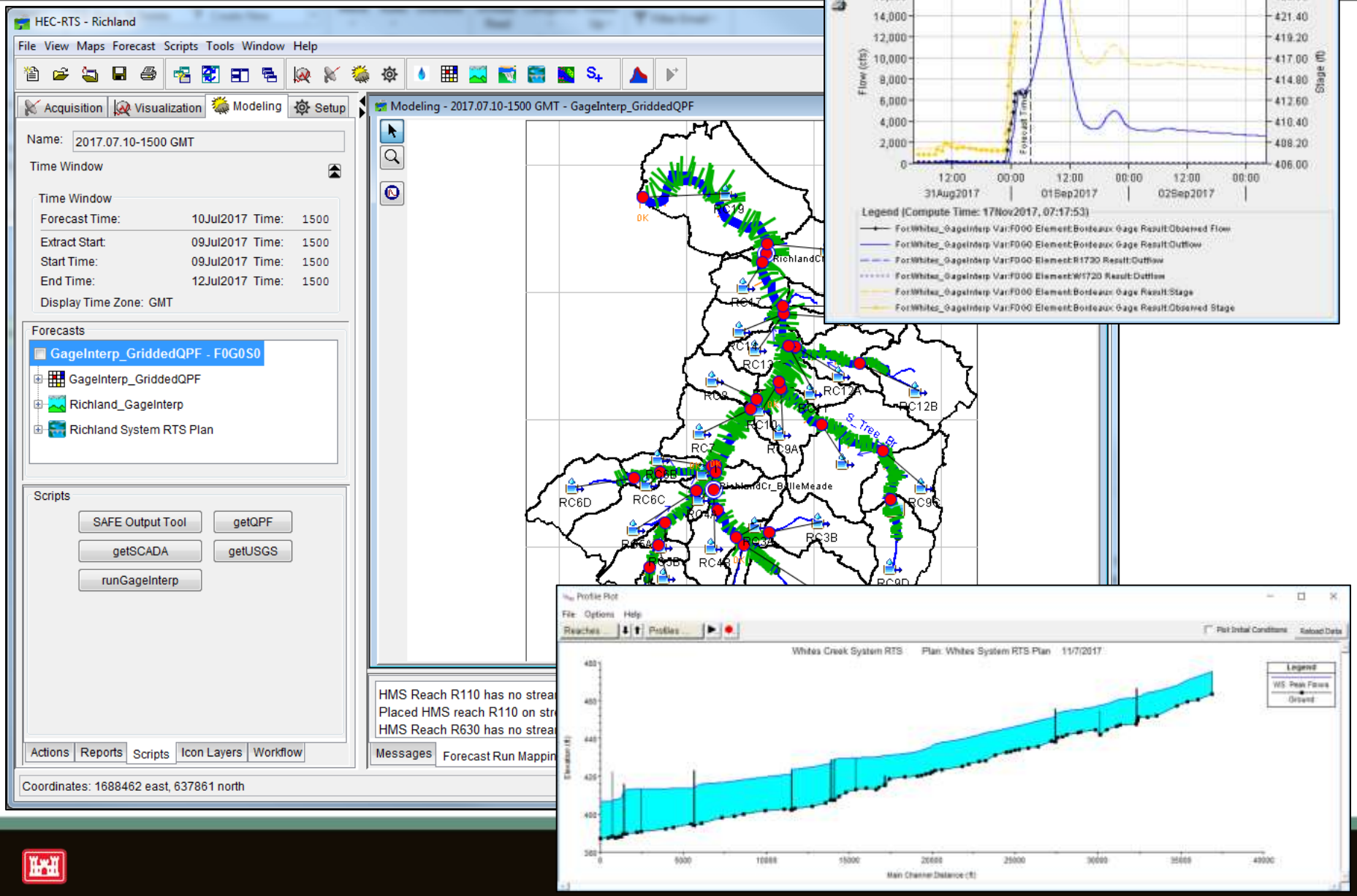
Map OSM Map added to Mode
Message Window
Messages
Coordinates: 1729234 east, 672777 north
Status Bar

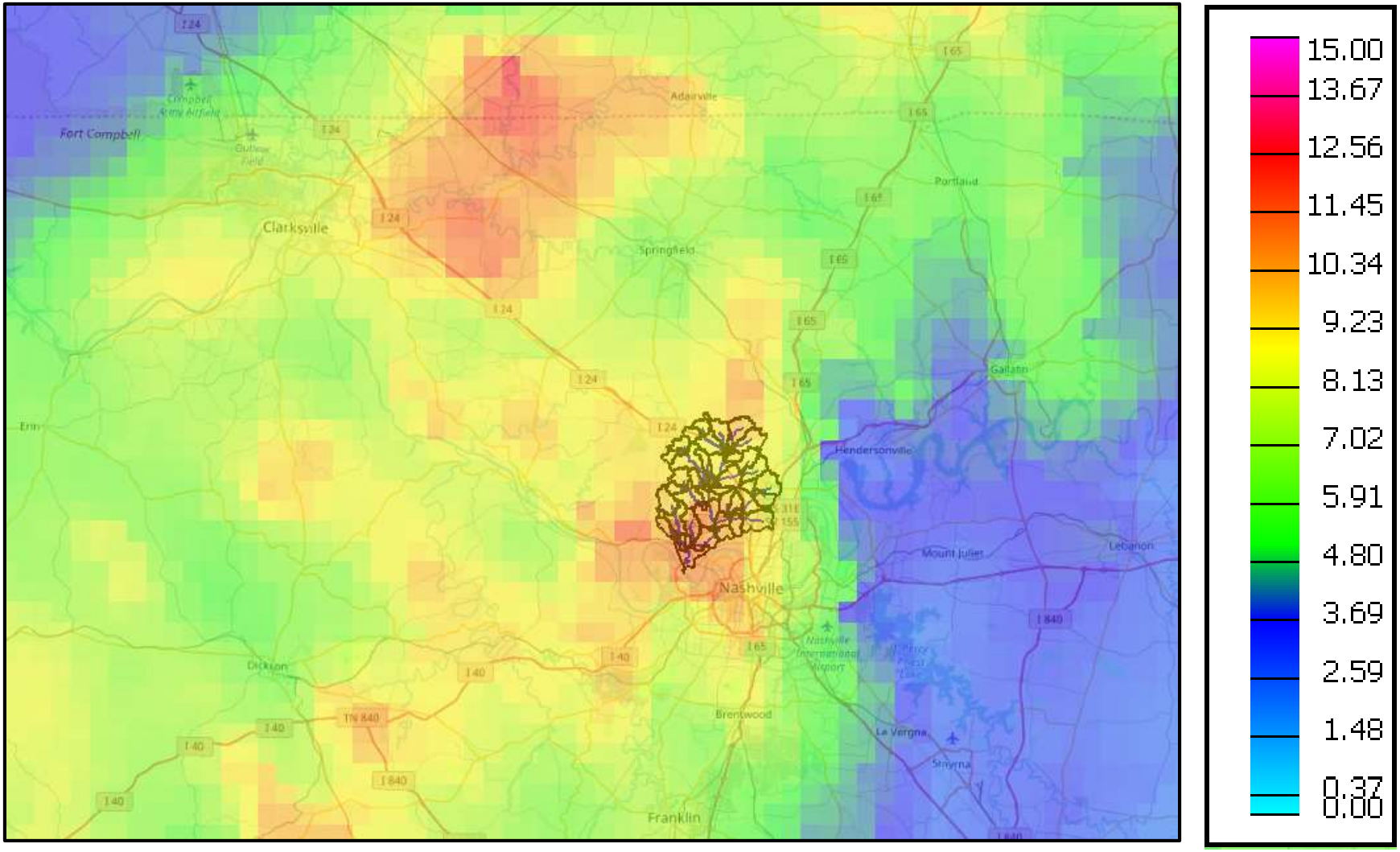
Modeling Module



Real World Application - Remnants of Harvey Event

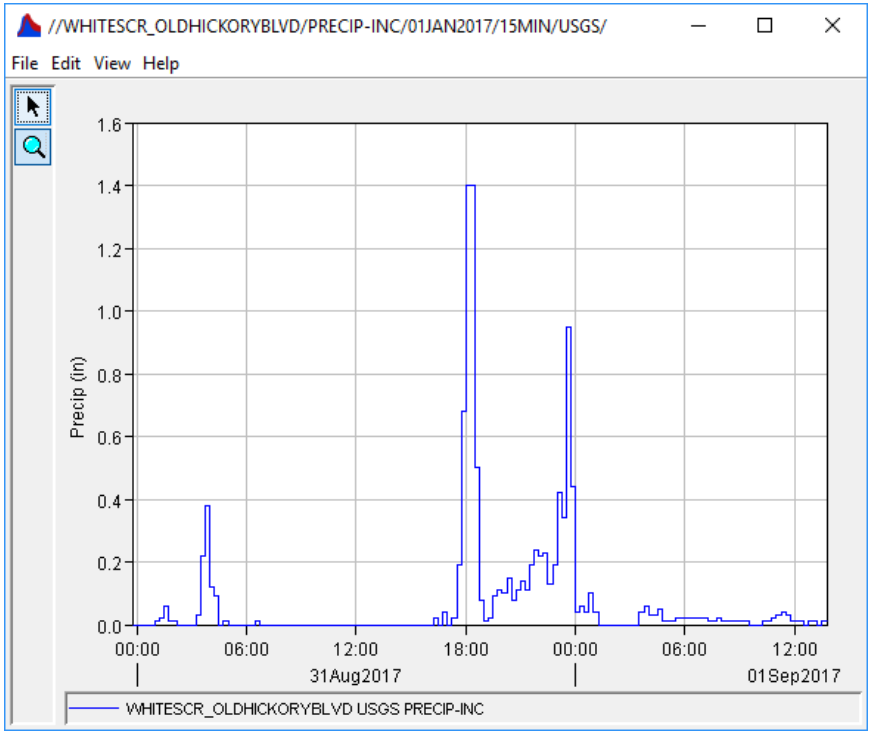
- Hurricane Harvey devastated the Texas coast from 25-29 August 2017
- Harvey system eventually worked its way to middle Tennessee a couple days later
- The system stalled over Nashville on the evening 31 August
- The event resulted in flooding throughout Nashville
- About 30 water rescues were performed mostly in the Whites Creek Basin (a trib to the Cumberland River
- Event also produced several tornadoes in the Middle Tennessee area including Davidson Co.

Harvey Event Cumulative Rainfall

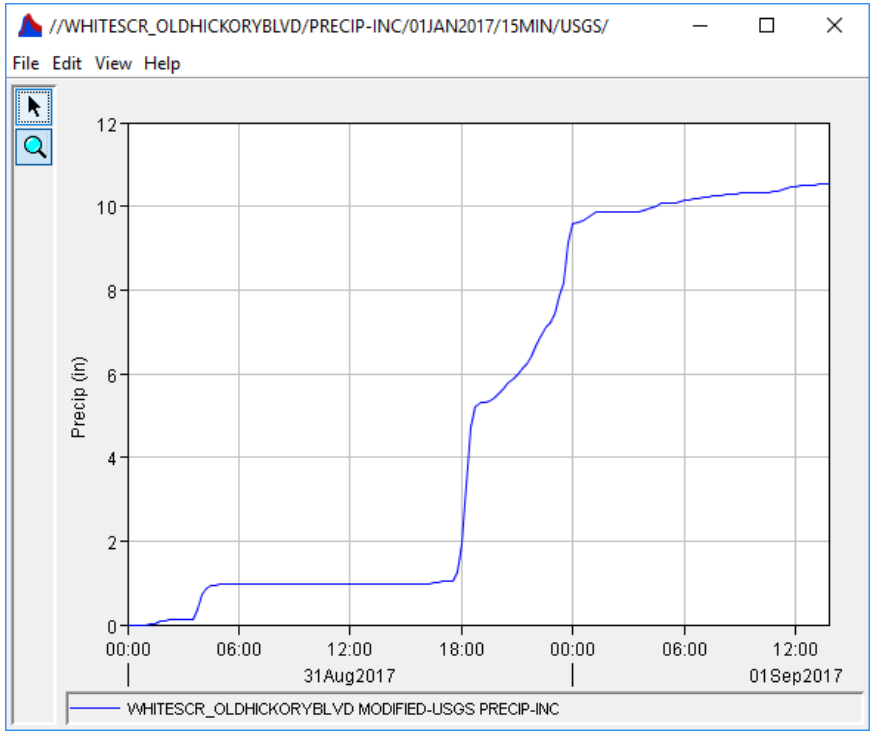


Harvey Event Precipitation Totals

- About an inch of rain occurred early in the morning of 31 August
- Around 4 pm on 31 Aug, an intense rain event began
- From 4 – 7 pm, the initial event dropped about 5.5 inches of rain
- From 7 – 11 pm, it continued to rain steadily totaling ~3” of rain
- From 11 pm to midnight, another relatively intense 2” event occurred



Incremental Rainfall

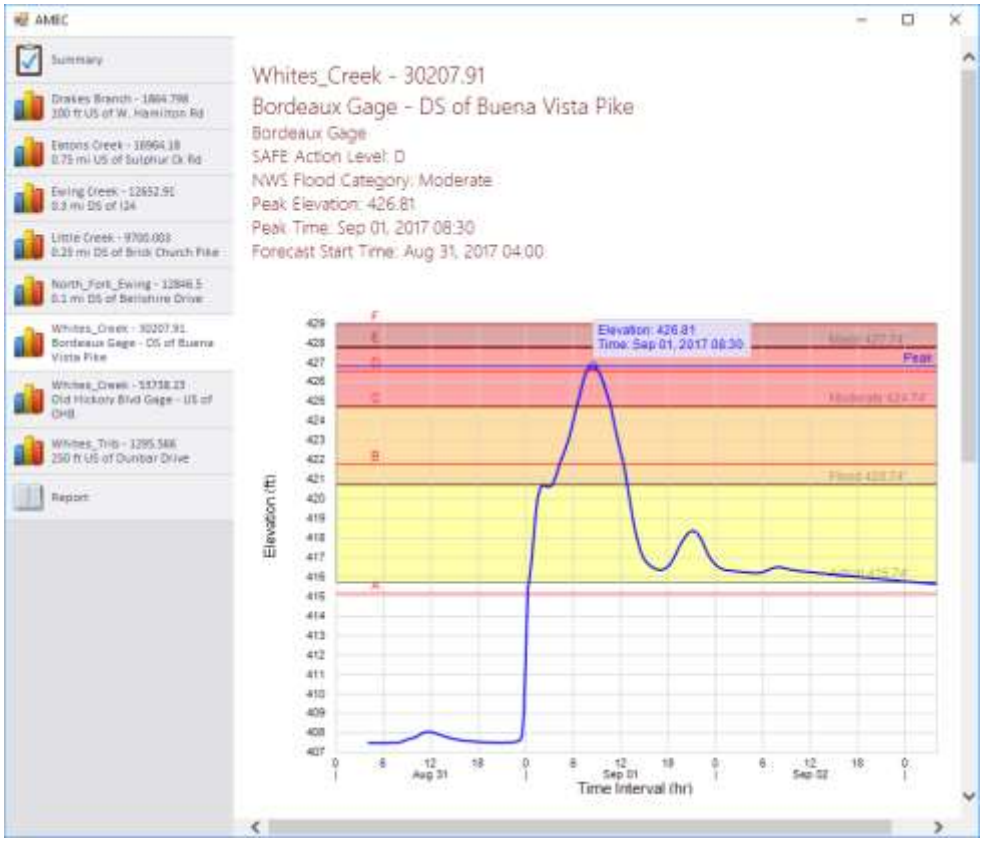


Cumulative Rainfall

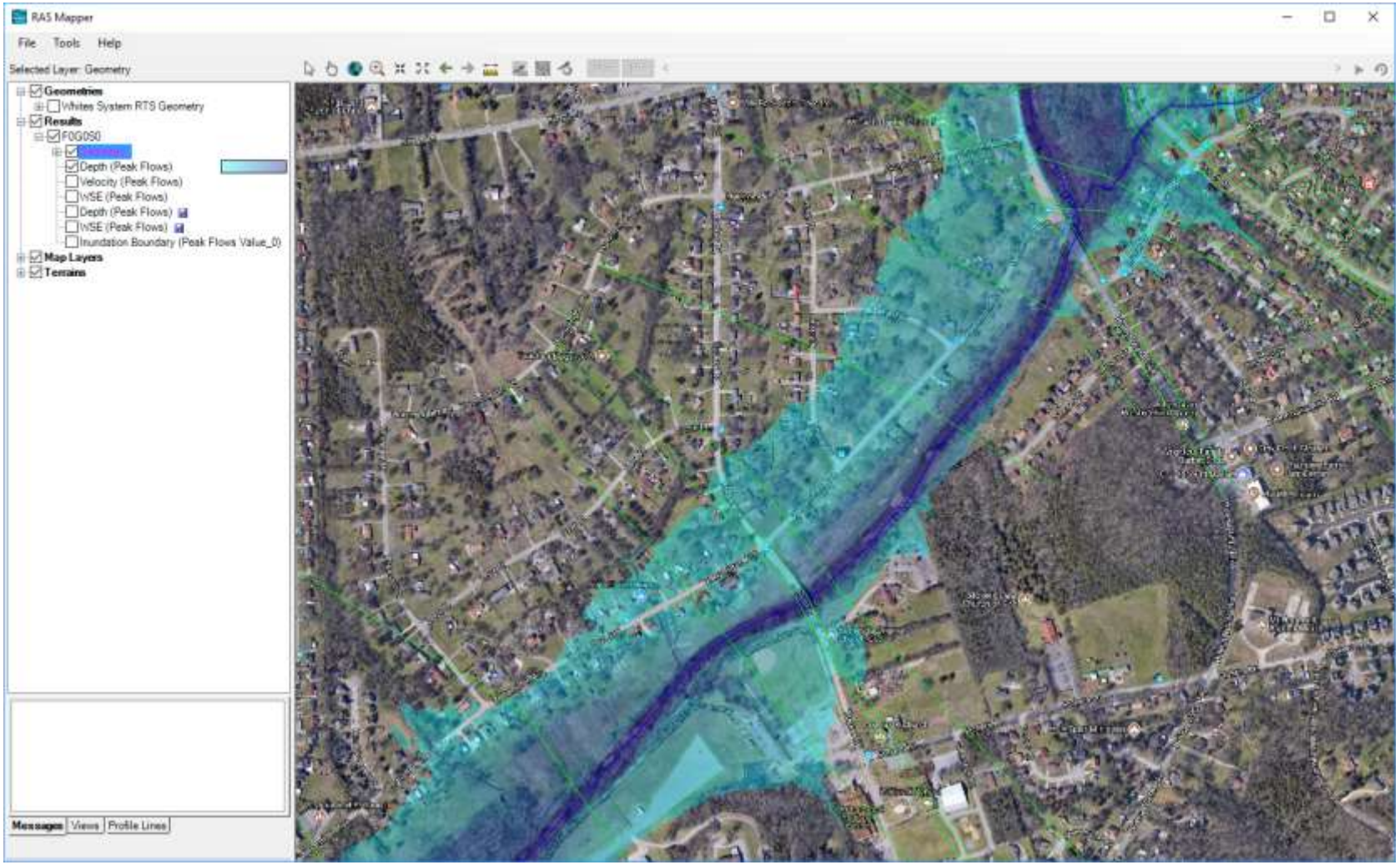
Action Level Tool

- Provides action level information for forecast points throughout the watershed
- Nashville SAFE and NWS Action Levels

- Summary Table (above)
  - Summarizes action levels throughout the basin
- Forecast Point Information (right)
  - Accessed through left portion of the tool
  - Peak elevation and timing
  - Action Level
  - Stage Hydrograph

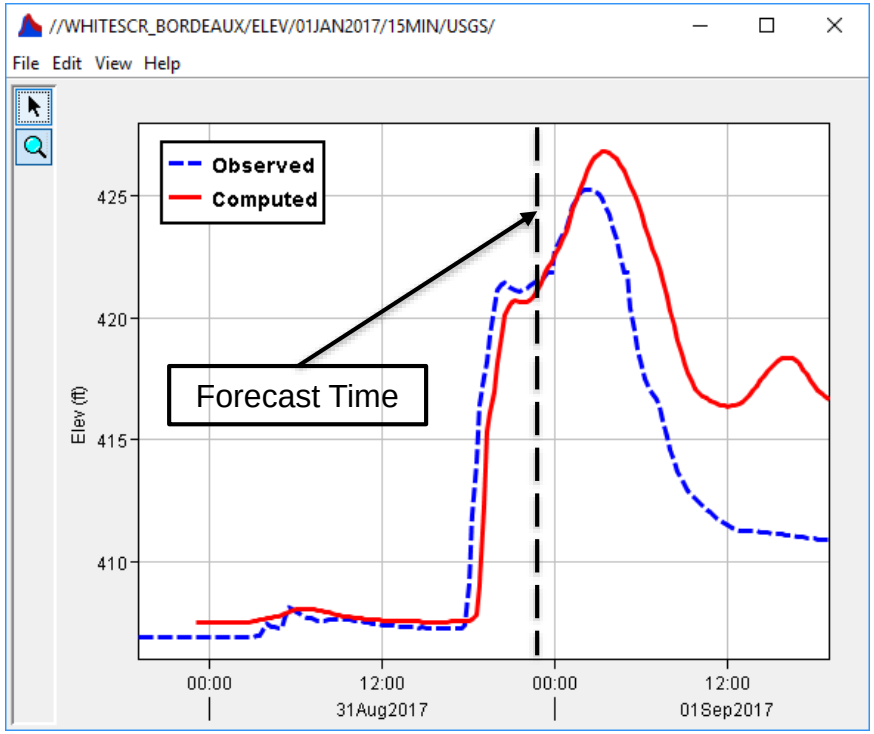


Inundation Mapping



Post-Flood Evaluation

- Information aided Metro staff with warnings and evacuations
- Forecasted flood stages and timing aligned relatively well
- Forecasted inundation represented the observed flooding
- Based on temporally distributed 6-hr QPF



Next Steps

- Expand HEC-RTS model development to the remaining major watersheds in Metro
- Build a comprehensive HEC-RTS model for the entire Metro region as opposed to individual basin models
- Develop processes and outputs that will provide the most useful information to the necessary decision makers and emergency personnel in the Nashville Government
- A flood exercise will be held in August to better understand the needs of emergency managers
- Incorporate HEC-FIA to provide real-time structure by structure damages and population at risk

Summary Conclusions

- HEC-RTS provides an integrated environment to conduct flood forecasting using detailed H&H modeling software developed by HEC
- Interface is relatively user-friendly and provides direct access to commonly used H&H software packages
- Ability to create output products useful to emergency personnel is only limited by our imagination
- The speed at which information and warnings can be distributed can save lives and property
- Supports collaborative relationships between local, state, and federal agencies
- Once completed and implemented, the Nashville HEC-RTS system will be one of the most advanced local flood forecasting systems nationally

QUESTIONS???

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