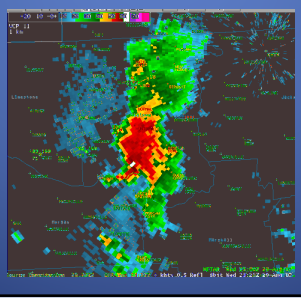
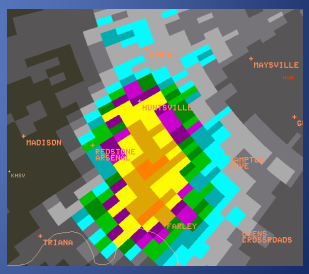
# Event Review

South Huntsville Flooding

August 29th, 2007






# Overview

- A cluster of slow moving and eventually back building thunderstorms dumped very heavy rainfall across south Huntsville late on the afternoon of August 29th.
- The majority of the rainfall fell between 600 PM and 700 PM local time.
- Many rain gauges in south Huntsville and the southern portions of Madison County reported 3+ inches of rainfall.
- These amounts, along with the intensity of the rain (i.e. the “rain rate”) led to significant flash flooding.

# Overview

- During this overview, we will look at a brief synopsis of the following:
  - The National Weather Service forecasts, outlooks, and statements that were in effect at the time of the "event".
  - The meteorological and hydrologic processes that led up to the flash flood event across south Huntsville.
  - The actual observed information from the event
    - i.e. what actually happened.
  - We will conclude with a brief review of some urban flooding/hydrologic considerations

# Forecasts and Outlooks

- Area Forecast Discussions (which includes a more technical analysis of the expected) from earlier in the day included the following:
  - *CONVECTIVE ACTIVITY SHOULD BE ONGOING INTO THE EVENING HOURS*
  - *FCST SNDGS CONTINUE TO INDICATE PWATS ~2.0 INCHES THROUGH TOMORROW…SO…EFFICIENT WARM RAIN PRODUCTION LOOKS SET AGAIN…*
  - *LOCALLY HEAVY RAINFALL IS NOT OUT OF THE QUESTION FROM THESE STORMS...GIVEN THE HIGH AMOUNTS OF MOISTURE AND `RELATIVE` SLOW CELL MOVEMENT.*

## Forecast and Outlooks

- The Hazardous Weather Outlook is our primary tool to assist/alert the Emergency Managers and other decision makers to expected weather in the next 24 hours. This product (issued at 100 PM on Wednesday) included the following:
  - *SHOWERS AND THUNDERSTORMS ARE EXPECTED ACROSS THE TENNESSEE VALLEY THIS AFTERNOON AND EVENING. SOME OF THESE STORMS MAY PRODUCE LOCALLY HEAVY RAINFALL...*

## Short Term Statements and Updates

- The National Weather Service also issues more frequent updates to alert its customers of impending weather as needed. The products include:
  - Warnings
  - Watches
  - Statements
  - Short Term Forecasts

## Short Term Products in Effect

- The Huntsville National Weather Service issued a Significant Weather Alert for Madison County at 555 PM CDT.
- This product was valid until 700 PM CDT and mentioned the following:
  - NATIONAL WEATHER SERVICE DOPPLER RADAR WAS TRACKING STRONG THUNDERSTORMS ALONG A LINE EXTENDING FROM HAZEL GREEN TO OWENS CROSSROADS
  - WINDS UP TO 35 MPH…OCCASIONAL LIGHTNING AND HEAVY DOWNPOURS ARE EXPECTED WITH THESE STORMS.

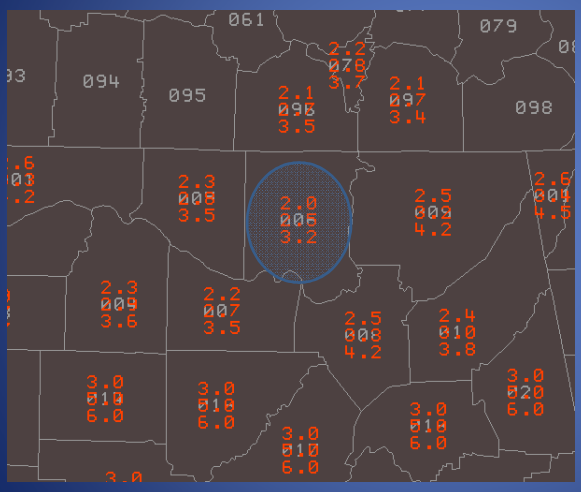
## So What Actually Happened?

- The line/cluster of strong thunderstorms referenced in the previous “Significant Weather Alert” actually intensified/built back toward the west.
- This resulted in intense and prolonged rainfall across the southern sections of Huntsville.
- Why did this occur? We’ll discuss that next.

# A Meteorological Analysis of the Event

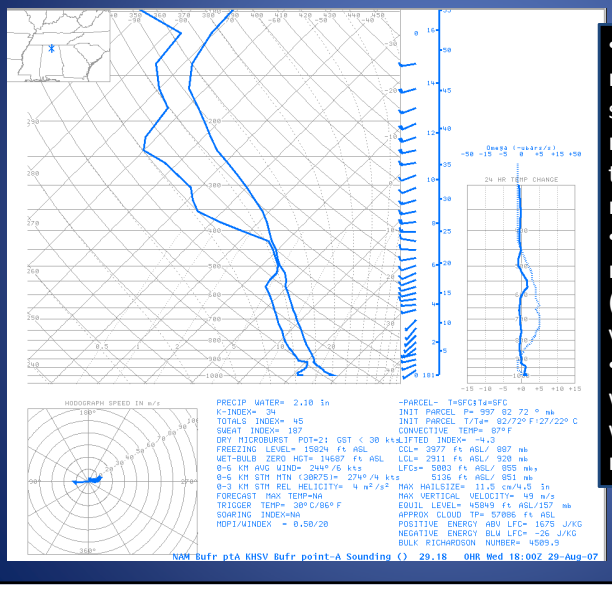
- We will look briefly at the following tools to determine (or attempt to determine) why the storm become quasi-stationary across south Huntsville:
  - Surface observations
  - Satellite
  - Radar data (reflectivity, precip estimates, volume products)
  - Lightning data

# Flash Flood Guidance



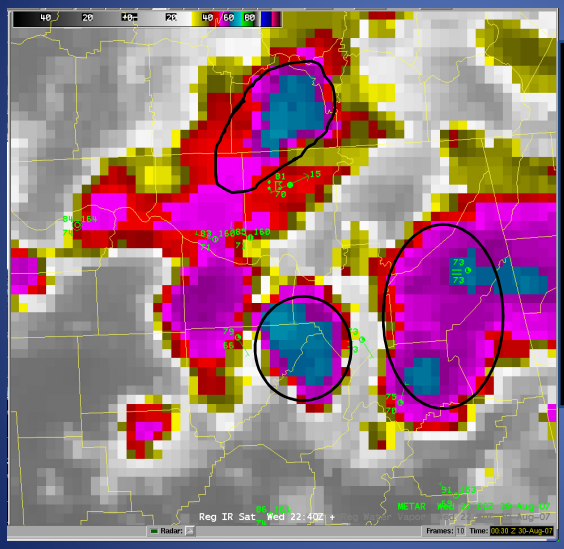

- The River Forecast Centers provides daily Flash Flood Guidance values (1, 3, and 6 hour values as shown on the left)
- These values are used for NWS forecasters only as a "guide" and can typically be too high in urban locations
  - i.e. urban areas can flood with lower rain rates
- Note, we also have access to gridded FFG – not shown

# Moisture Profile




- Forecasters use moisture profiles (or soundings) from radiosondes and models to assess instability and rainfall potential.
- In this case, the moisture was very deep (Precipitable Water values >2")
- Upper level winds were also light which was favorable for slow moving thunderstorms.

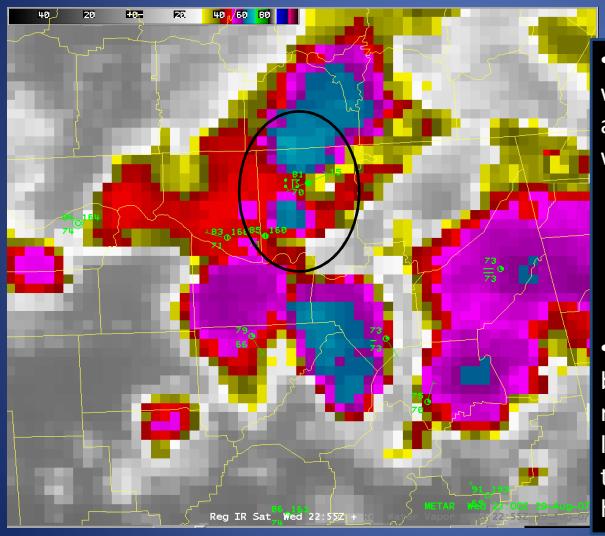
# Infrared Satellite Imagery




2240 UTC (540 PM CDT)

- At 540 PM CDT, the strongest (and most expansive thunderstorms) were located from northeast Limestone County into Lincoln County.
- Additional clusters were indicated across northeast Cullman and DeKalb).

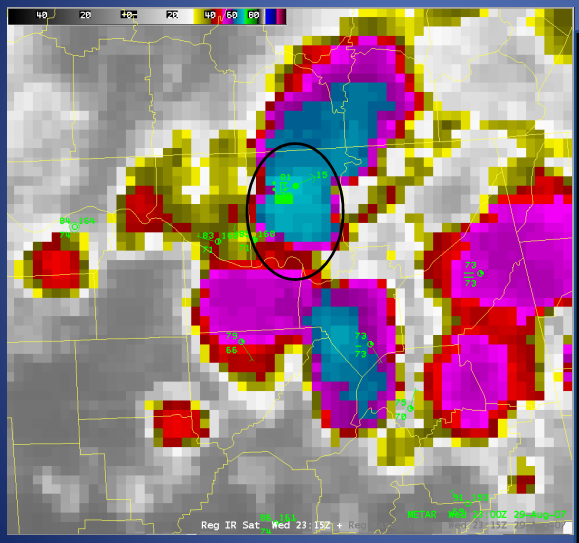
# Satellite Imagery




2255 UTC (555 PM CDT)

- By 555 PM CDT, a cluster was beginning to develop across northern and western Madison County.
  - Note the colder (bright blue) cloud tops from near Hazel Green to just east of Madison)
- Also, a convergence boundary (evident on the radar data to be shown later) was coincident with this developing line and helped anchor it in place.

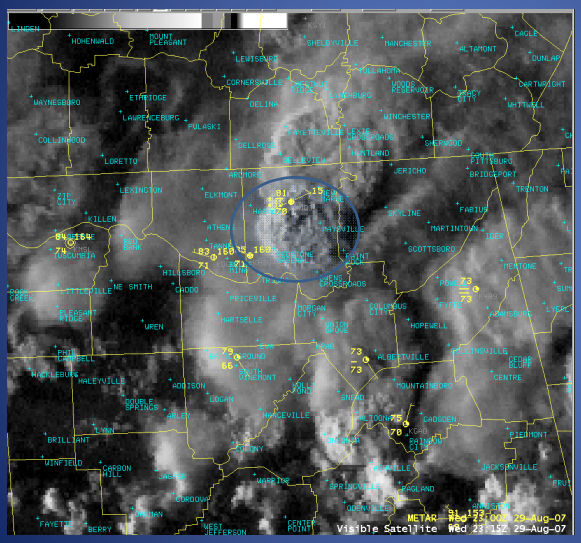
# Satellite Imagery




2315 UTC (615 PM CDT)

- At 615 PM CDT, the coldest cloud tops (indicative of the strongest updrafts and heaviest rainfall potential) were anchored across central sections of Madison County.
- In fact, the green pixels indicate cloud tops approaching -80C!
- This was near the time of the maximum rainfall rates in south Huntsville underneath the updraft cores.

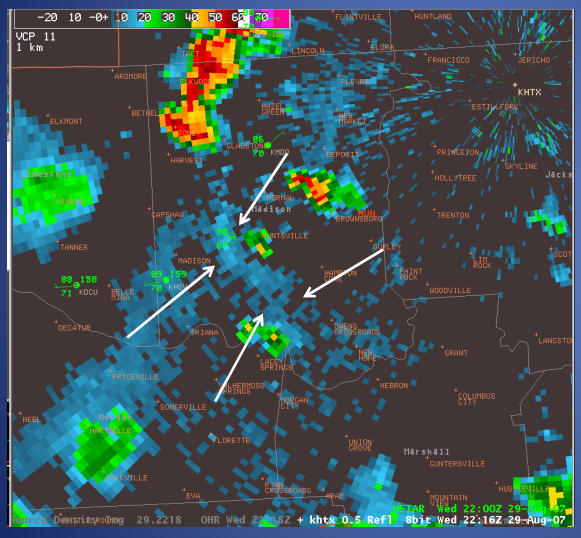
# Visible Imagery




2315 UTC (615 PM CDT)

- The visible satellite imagery from the same time as the previous Infrared Image (615 PM CDT) shows a well defined and intense thunderstorm across Madison County.
- Of specific interest is the overshooting top just south of Meridianville and the backsheared anvil extending well west toward Limestone County.

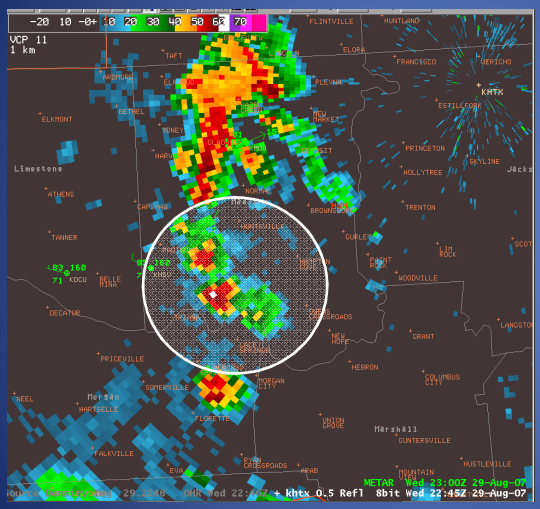
# Radar Imagery and Output




2215 UTC (515 PM CDT)

- Nearly an hour before the heavy rainfall began in South Huntsville, the stage was being set for development in the area.
- In this radar reflectivity image (515 PM CDT), we see a moderate cell across NW Madison County.
- More interesting however is a outflow boundary (annotated in white) extending from near Research Park to South Huntsville.

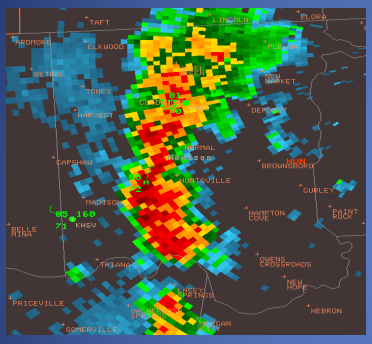
# Radar Imagery and Output



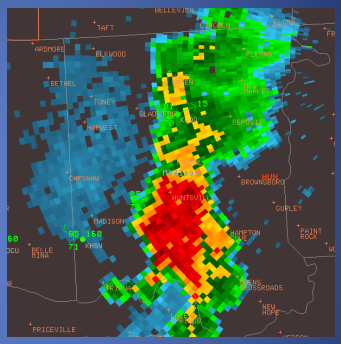

2245 UTC (545 PM CDT)

- Only 30 minutes later, cells have developed and intensified in the location where the outflow boundary originated.
- This would be the genesis region for the cluster of storms that eventually produced the flooding in south Huntsville.

# Radar Imagery and Output



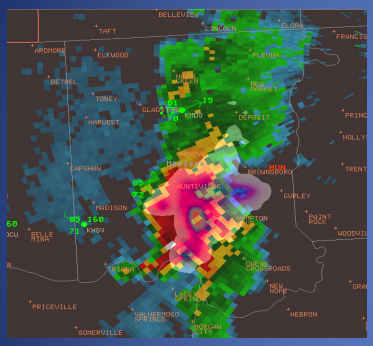
2304 UTC (604 PM CDT)



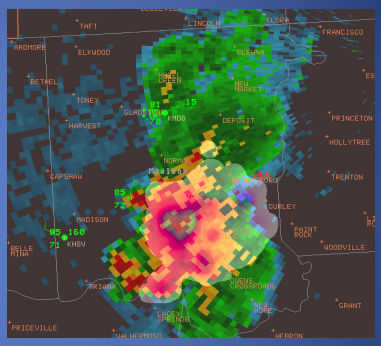
2319 UTC (619 PM CDT)

- As can be seen by these two images, once the southern sector of the line become the dominant portion (partly due to the aforemented convergence boundary) it made very little eastward progress.
- In fact, the stronger/more intense updraft core actually built westward with time.

# Radar Imagery and Output



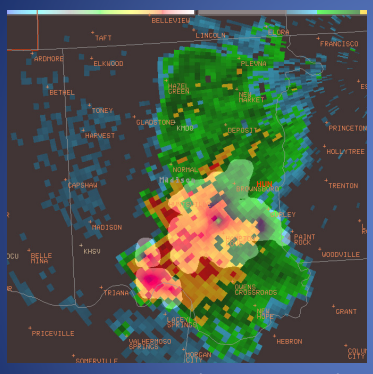
2323 UTC (623 PM CDT)



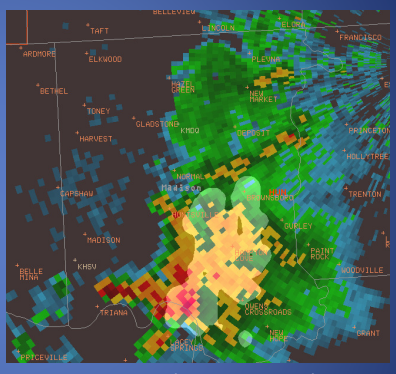
2333 UTC (633 PM CDT)

•In these two images, the lightning flash rates are overlaid on the radar imagery.
•The flash rates help approximate the updraft strength and location of the heaviest rain rates.
•In this case, you can see the updraft core was also quasi-stationary, if not back-building during this period.

# Radar Imagery and Output



2343 UTC (643 PM CDT)



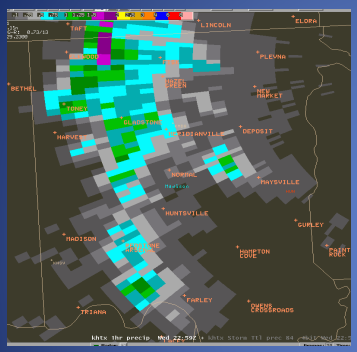
2357 UTC (657 PM CDT)

• Heavy rainfall continued to fall across south Huntsville through about 700 PM.
• The radar reflectivity values and flash rates began to weaken around 700 PM, and the storm continued to dissipate after that time.
• On the next few slides, we'll look at the radar rainfall estimates.

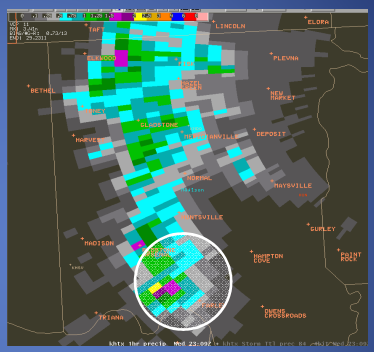
# Radar Rainfall Estimates

- The WSR-88D Doppler provides real-time estimates of hourly rainfall
  - Essentially an integrated rainfall "rate" analysis
- We also receive storm total and 3-hourly precipitation estimates.
- For this review (and for brevity), we will look at a subset of these products.

# Hourly Estimates



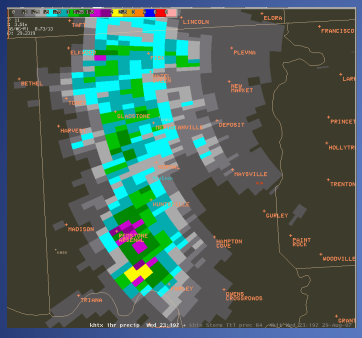

2259 UTC (559 PM CDT)



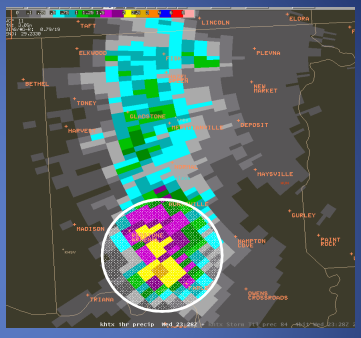

2309 UTC (609 PM CDT)

• The One Hour Precip (OHP) product began to indicate precipitation amounts approaching 2"/hour just northwest of Farley by 609 PM CDT.

# Hourly Estimates



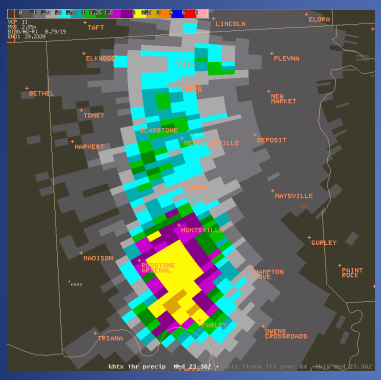
2319 UTC (619 PM CDT)



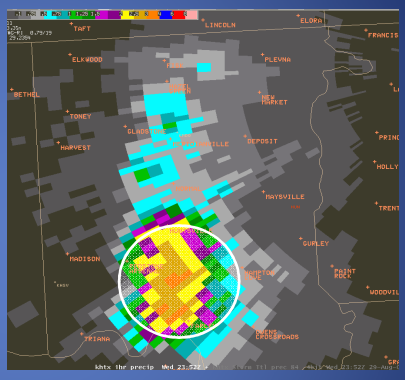
2328 UTC (628 PM CDT)

• OHP estimates showed a large area of 2”+/hour by 628 PM with some areas approaching 3 inches.

# Hourly Estimates



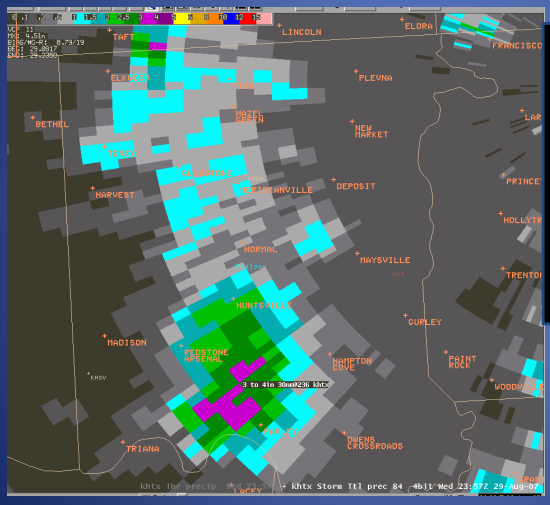
2338 UTC (638 PM CDT)



2352 UTC (652 PM CDT)

• By 652 PM, OHP estimates showed that over 3”+ had fallen in the past hour across south Huntsville.

# Storm Total Estimates

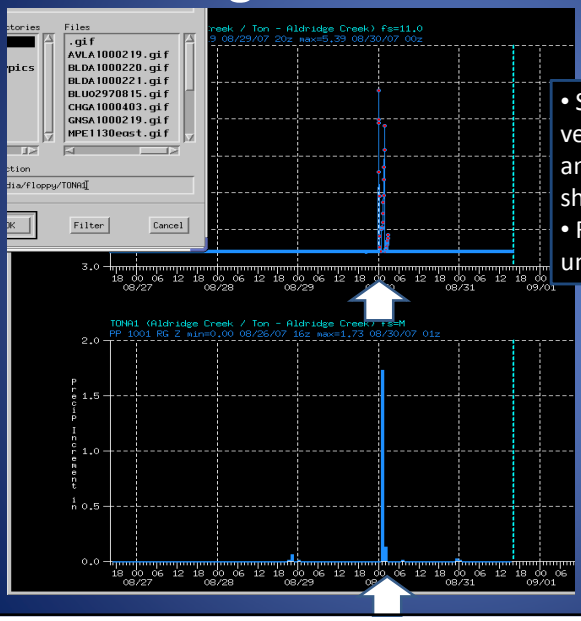



- Radar estimates showed storm total amounts of 3 to 4 inches across South Huntsville.
- This correlated fairly well with gauge reports and spotter reports.
- I will cover these briefly in the following slides.

# Hydrologic Summary

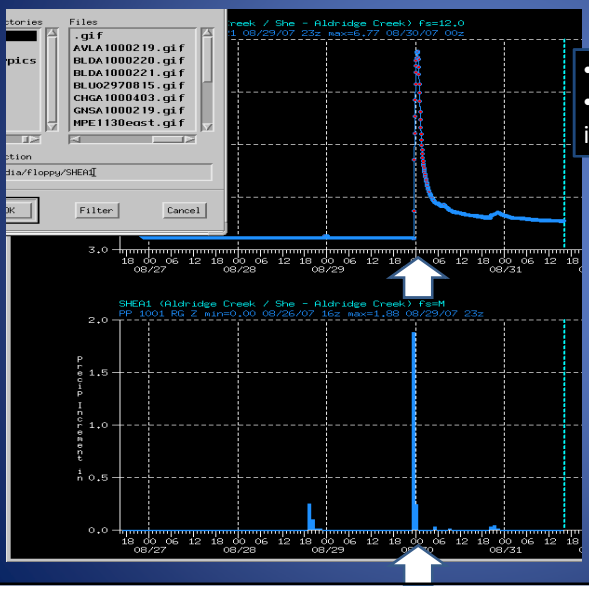

- Let's look briefly at the response on Aldridge Creek to the heavy rainfall.
- Note: this data (stages and rainfall) is preliminary. For official data, please see the USGS.
- We will look at three gauged sites on Aldridge Creek.
  - Jones Valley
  - Sherwood Drive
  - Farley

# Aldridge Creek at Jones Valley



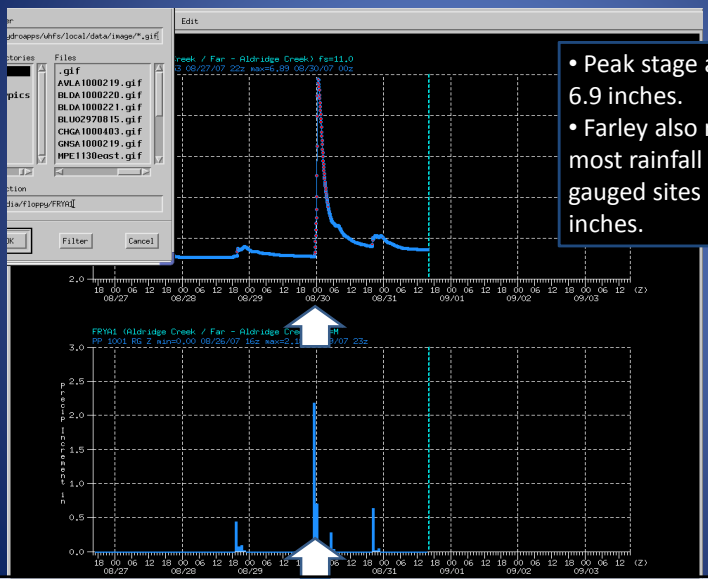

- Stream level responded very quickly to the rainfall and peaked at 5.39 shortly at 700 PM.
- Rainfall total was just under 2 inches.

# Aldridge Creek at Sherwood




- Peak stage was 6.77 feet
- Rainfall total was slightly in excess of 2 inches.

# Aldridge Creek at Farley

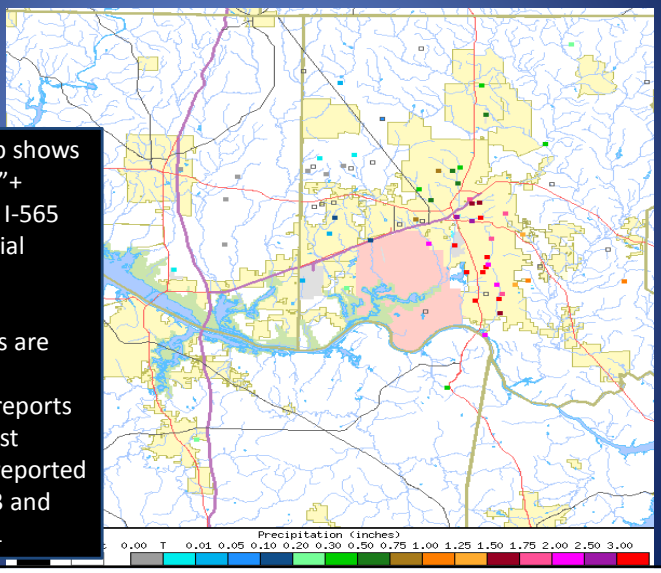



- Peak stage at Farley was 6.9 inches.
- Farley also received the most rainfall of the gauged sites at nearly 3 inches.

# Spotter and Network Precipitation Reports

- Precipitation reports were gathered from our network of cooperative observers and from the Huntsville area CHARM network.
  - wwwghcc.msfc.nasa.gov/charm
- Some of the higher amounts will be highlighted in the following slides.

# CHARM Network Reports




- The CHARM map shows a large swath of 3"+ amounts south of I-565 and along Memorial Parkway in South Huntsville.
- The >3" amounts are depicted in red.
- A review of the reports showed the highest amount of **3.90"** reported at Latitude 34.653 and Longitude -85.581

# Cooperative and Spotter Reports

- Here are some additional reports received at the National Weather Service:
  - Farley (cooperative observer) 3.22"
  - Whitesburg (cooperative observer) 2.13"
  - South Huntsville (CHARM) 3.27"
  - Farley (CHARM) 3.79"

# Event Summary

- A very moist atmosphere, coupled with weak winds aloft and a quasi-stationary surface boundary led to the development of slow moving thunderstorms across south Huntsville on the evening of August 29th.
- These storms were efficient rain producers and dumped 3 to 4 inches of rainfall across the heavily urbanized sections of the city.
- This rainfall, coupled with issues related to the urban watershed, led to flash flooding across portions of south Huntsville.

# Urban Basin Hydrology

# Flash Flood Definition and Metrics

From OCWWS/HSD...NWSI 10-950 on hydro definitions and terminology

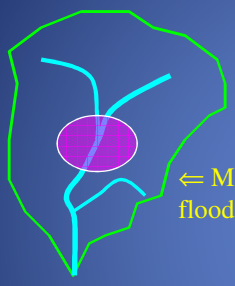
"Flash Flood - a rapid, life threatening flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g., intense rainfall, dam failure, ice jam). However, the actual time threshold may vary in different parts of the country. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters."

Big Thompson Canyon, CO
July 1976

**Objective Criteria?**

# Flash Flood Hydrology

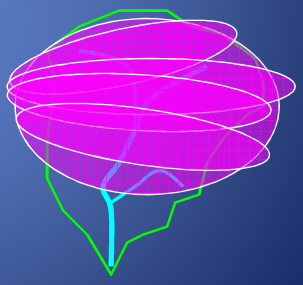
## Wet Footprint vs Basin Size



⇐ Minimal flash flood threat

**Larger intense precip footprint can lead to greater flash flood threat in relatively larger basins (>15 mi²)**

⇓



**Increased flash flood risk for small basins completely covered by intense precip area ⇒**

# Flash Flood Hydrology

Soil Moisture

Soil Type

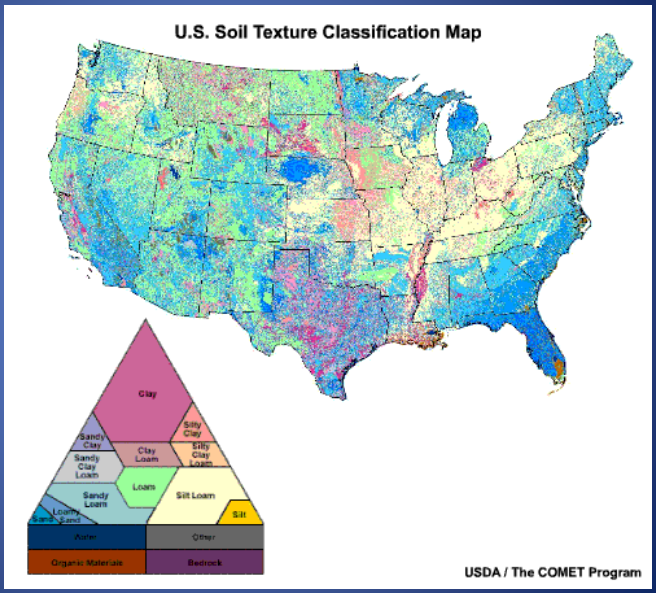
- Clay
- Slit
- Sand

Soil Depth

Surface Cover

- Vegetation
- Urbanization

Surface runoff maximized by compacted clay soils!




# Flash Flood Hydrology Urbanization

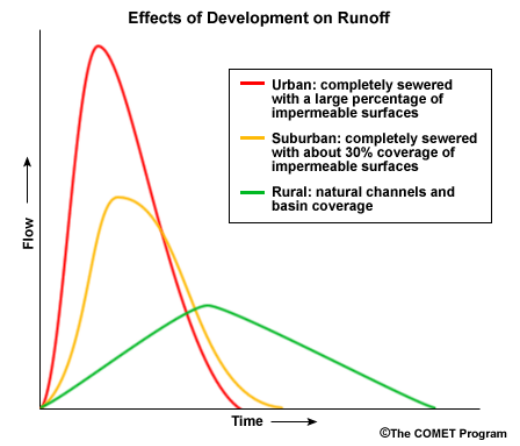
**Contributing factors…**

- **Less infiltration**
- **Reduced surface roughness**
- **Greater drainage density**
- **Increased slope**
- **More constrictions**


# Flash Flood Hydrology Urbanization

The two biggies…

- Increased coverage of impermeable surfaces: more runoff
- Rapid runoff helped by "urban plumbing" (storm drain systems, the road grid, and stream channelization)




# Flash Floods/Urbanization

Urban/Suburban streams need to carry 2-3X more volume

- Flash floods at lower precip threshold
- 30% increase in the amount of impervious surfaces
  - 5X frequency increase of the 2-yr peak flow

# Flash Flood Hydrology
# Urban Runoff

**Runoff ratio (RR)** =
basin discharge/
basin rainfall

Highly urbanized areas: RR ~ 50 90%

Dense Residential:

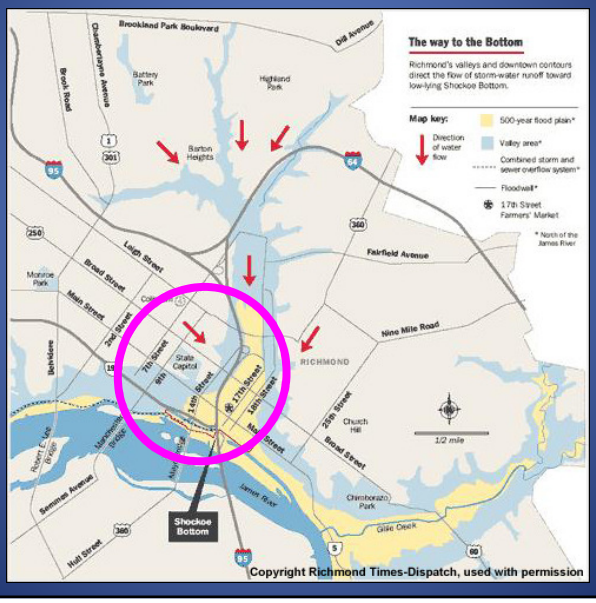
RR ~ 30-40%

Subsaturated rural:

RR ~ 5%

Richmond, VA, 30 August 2004

# Flash Floods/Urbanization
## 30 Aug 2004, Richmond, VA



# Flash Floods/Urbanization

## 30 Aug 2004, Richmond, VA