

# Flooding in the Mid-Atlantic: Forecasting and Preparing for Extreme Events



*NWS Emergency Management and Broadcast Media Conference*

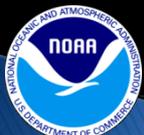
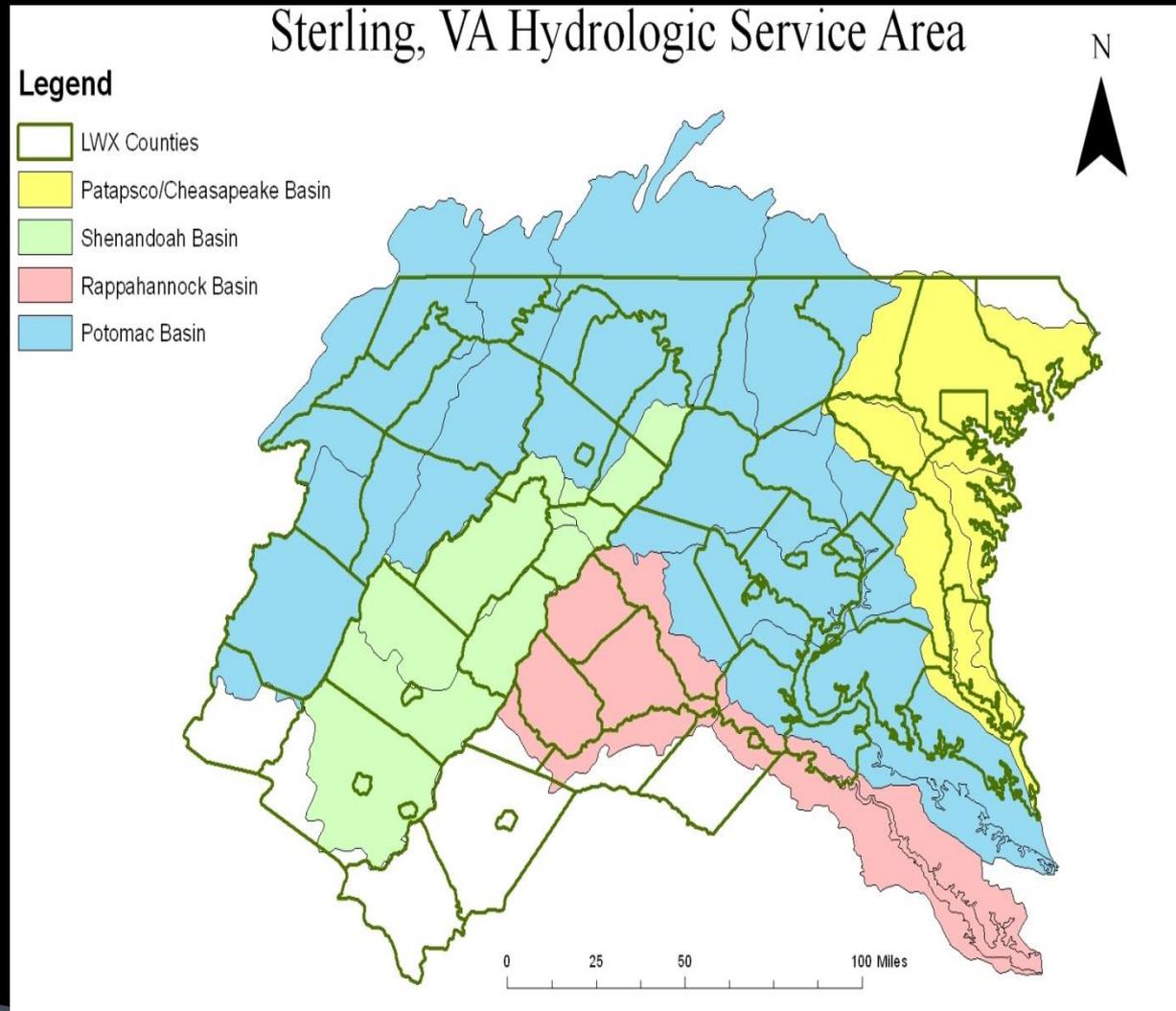
*October 16, 2014*



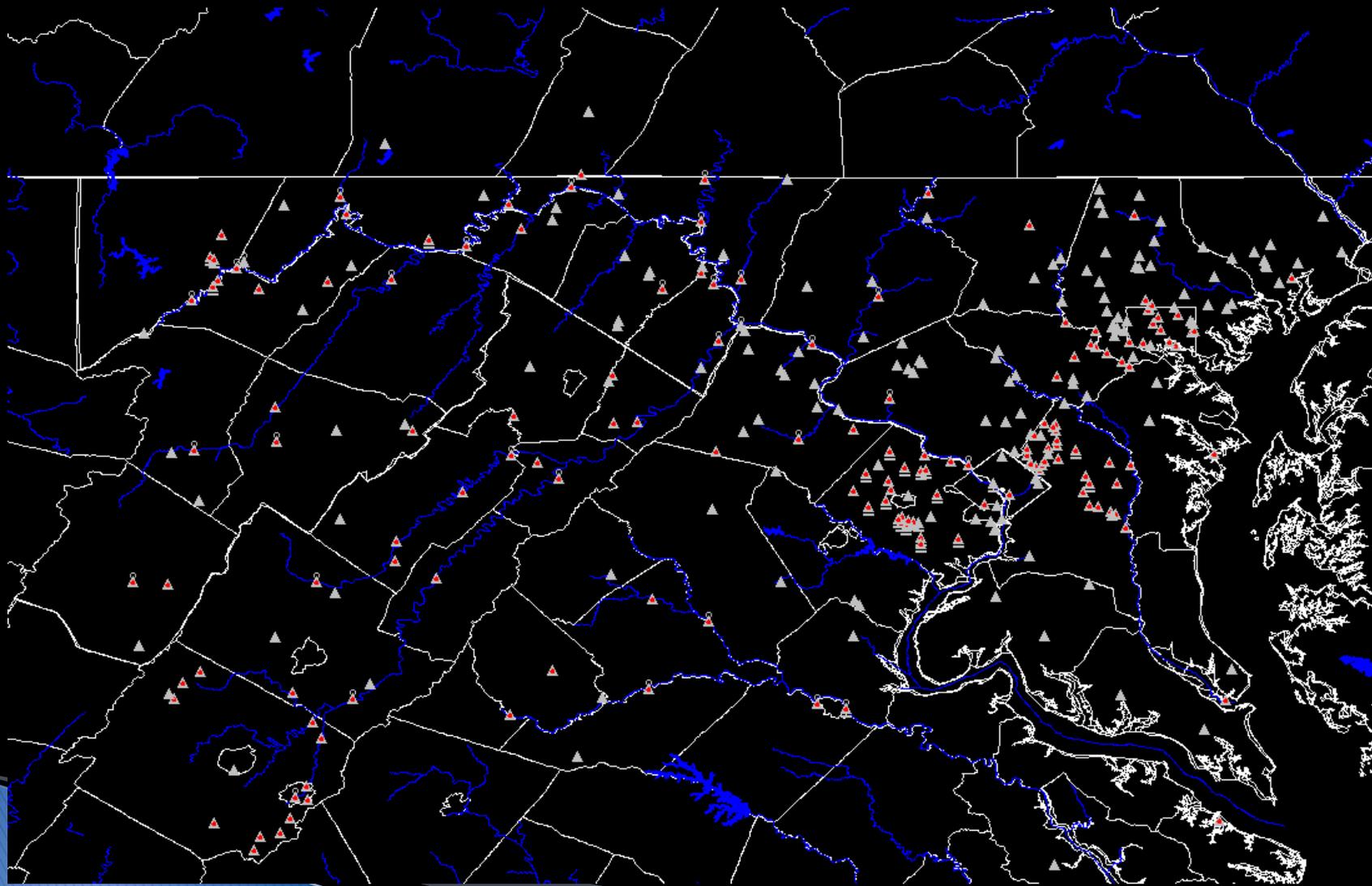
# Area of Responsibility

## ▶ Hydrologic Service Area (HSA)

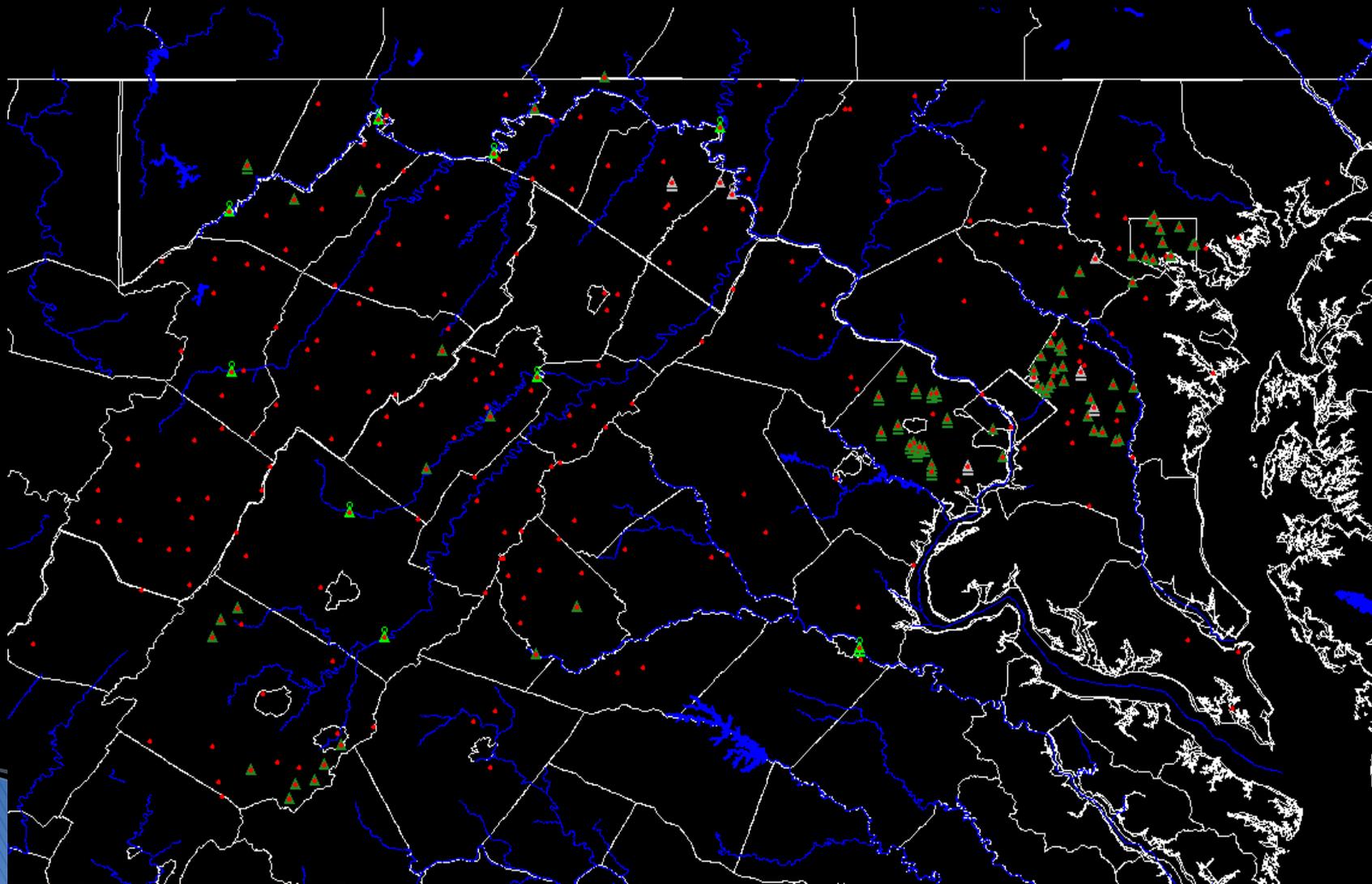
- Potomac Basin
- Shenandoah Basin
- Rappahannock Basin
- Patapsco/Patuxent



# River Gauges

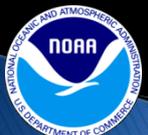


# Precipitation Monitoring

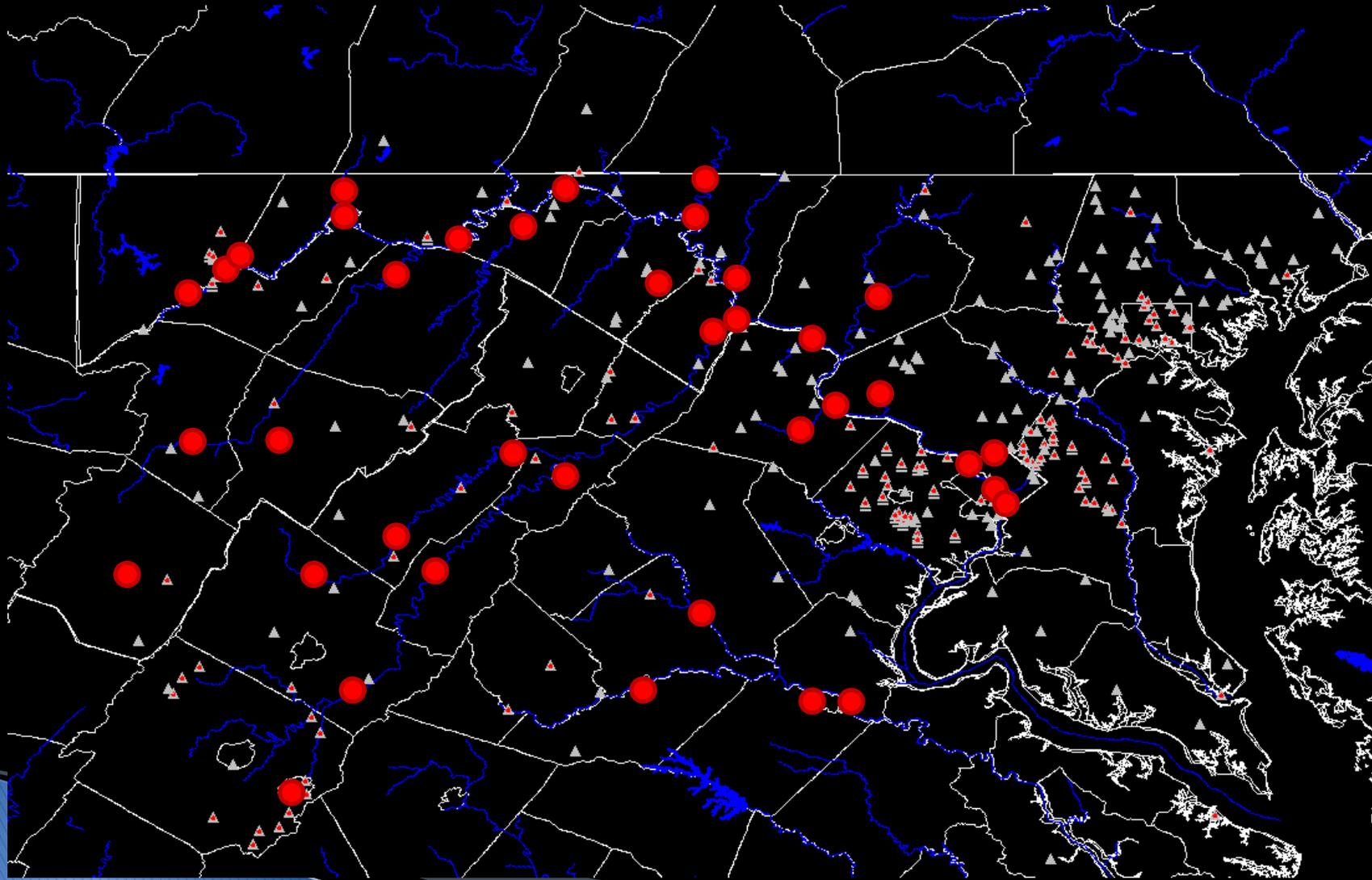


# Types of Flooding

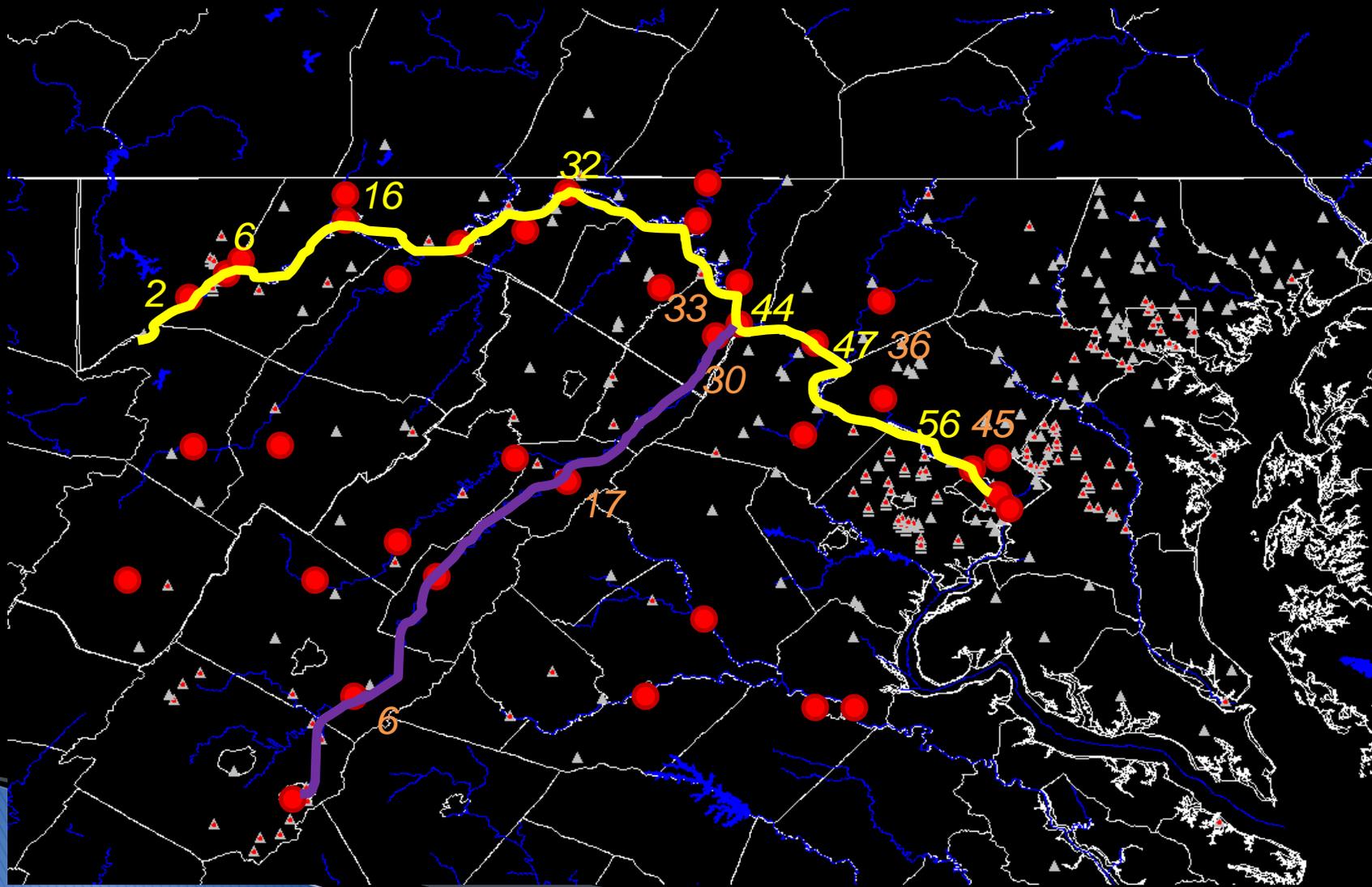
- ▶ **Flash Flood** – A flood which follows within 6 hours of heavy or excessive rainfall, a dam or levee failure, or ice jam break.
- ▶ **(Areal) Flood** – A flood which occurs more than 6 hours after the heavy or excessive rainfall event. Includes small stream flooding.
- ▶ **River Flood** – Floods which occur on a longer timescale and are points/areas directly forecast by a NWS River Forecast Center. (Equivalent to Areal Flood.)



# River Flood Forecast Points

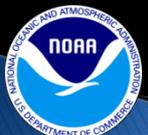


# Travel Times (in hours)

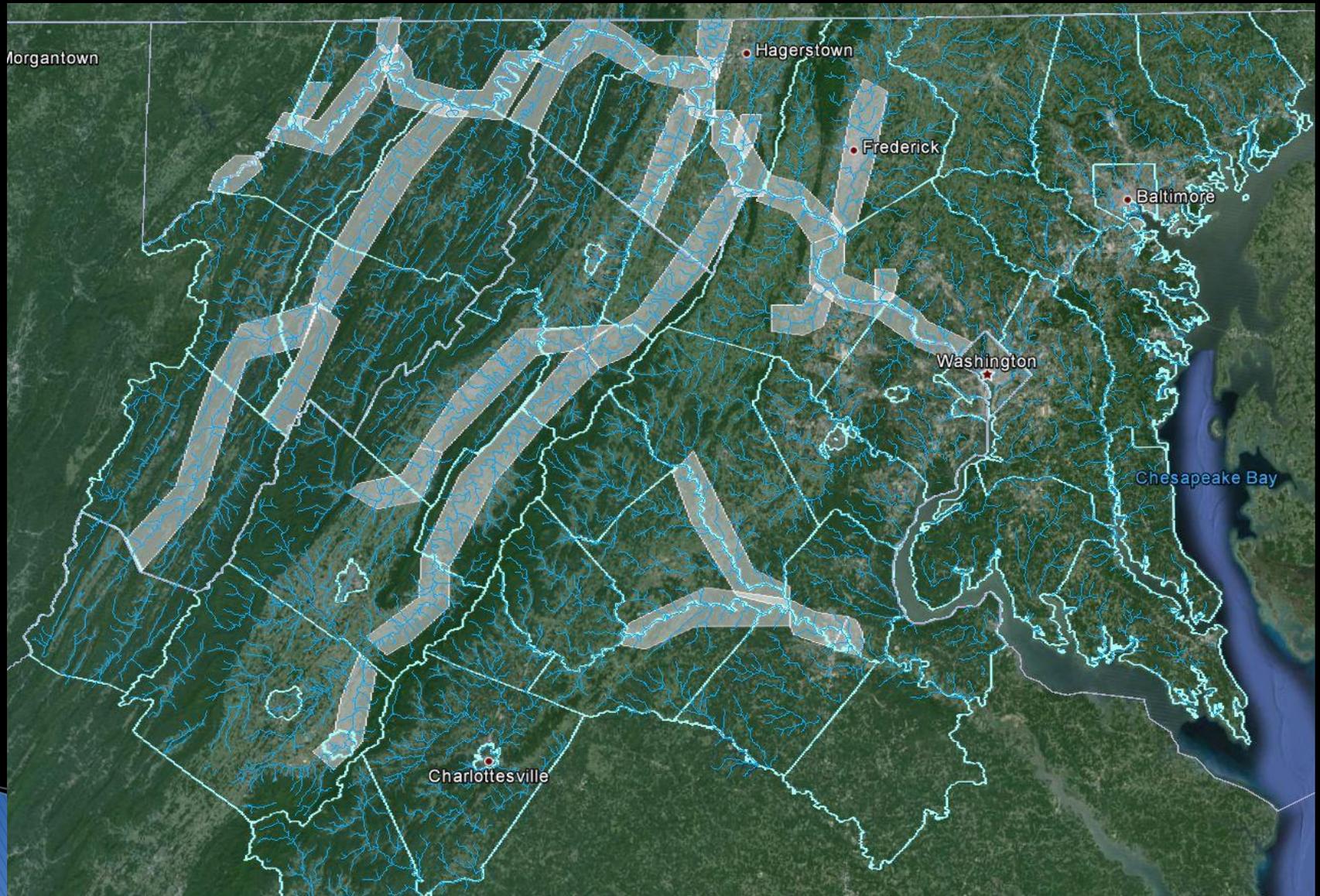


# River Flood Categories/Terminology

- ▶ **Minor Flood** – mainly nuisance flooding  
(for DC = coastal flood advisory)
- ▶ **Moderate Flood** – affects at least one road or building or has significant impact if unmitigated  
(for DC = coastal flood warning)
- ▶ **Major Flood** – affects numerous roads and buildings; is an unusual and remarkable event  
(for DC = coastal flood warning)

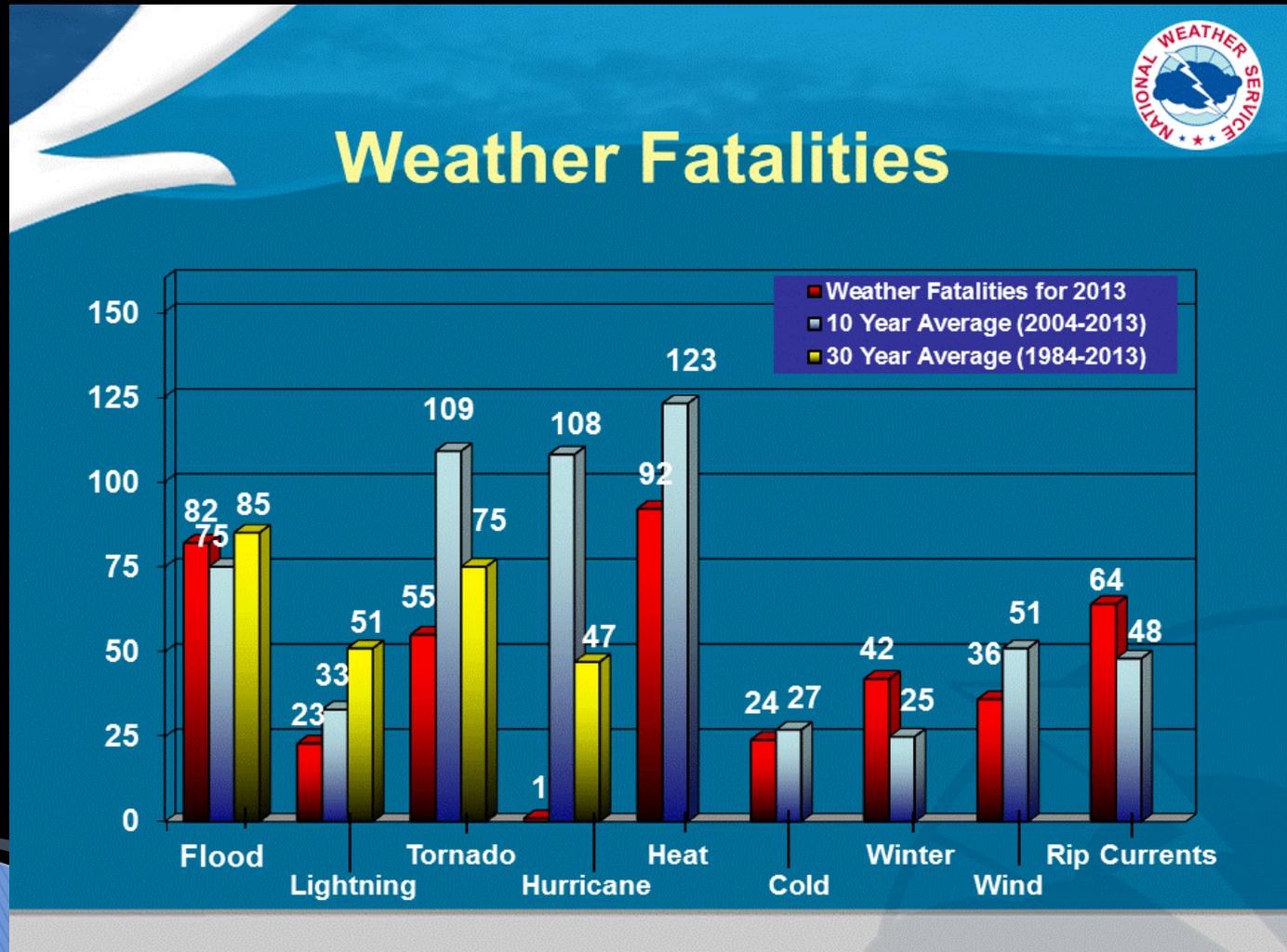


# River Flood Polygons



# Floods – a major weather killer

- ▶ In 2013 & over a long-term period, only heat causes more weather fatalities than floods!

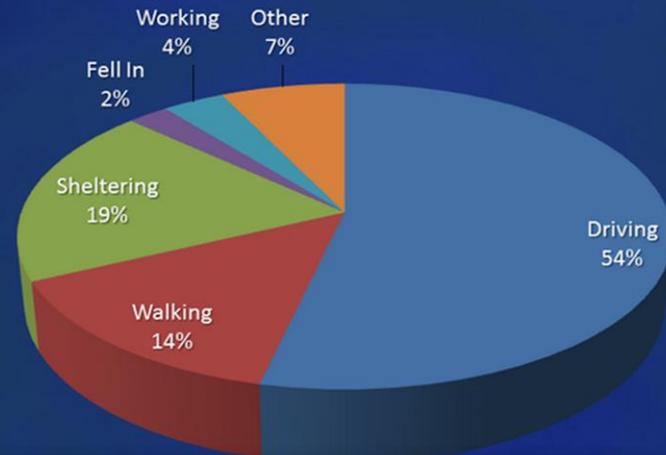


# Flood Fatalities

- ▶ In 2013, there were **82** flood fatalities in the U.S.
  - 30-year average is 89
  - Of these, 44 (54%) were vehicle-related
  - Locally, there was 1 flood fatality in Jan. 2013 (Laurel)
  - Many rescues in 2013.
  - 2 other fatalities in SW VA on July 3<sup>rd</sup> 2013.



## 2013 U.S. Flood Fatalities Activity of Victims



# Top 10 Raindays

Washington DC	
6.39	8/23/1933 (1933 hurricane)
6.14	8/2/1944 (1944 hurricane)
6.11	6/21/1972 (Agnes)
5.97	8/11/1928 (TS remnants)
5.44	8/12/1955 (Connie)
5.19	6/25/2006 (Federal Triangle) **
5.16	9/2/1922 (onshore flow)
4.92	8/12/1898 (strong cold front)
4.83	8/20/1963 (overrunning)
4.76	9/16/1976 (subtropical #3)

Baltimore	
7.62	8/23/1933 (1933 hurricane)
6.30	8/12/2014 (onshore flow)
6.02	9/30/2010 (Nicole)
5.97	9/24/1912 (onshore flow)
5.85	7/8/1952 (onshore flow)
5.51	10/29/2012 (Sandy)
5.02	9/16/1999 (Floyd)
5.00	9/27/1985 (Gloria)
4.91	8/12/1955 (Connie) **
4.76	9/6/1895 (onshore flow)

*The Federal Triangle flood was the highest two-day rainfall at DC (9.41")  
Connie was the highest two-day rainfall at Baltimore (8.50")*

*35 of the 36 wettest days in Baltimore and 39 of the 40 wettest days in DC  
are between June 2<sup>nd</sup> and October 11<sup>th</sup> (exception in both cases: Sandy)*



# Top 10 Raindays

Staunton, VA	
6.67	9/29/1896 (1896 hurricane)
6.20	2/28/2005 (coastal low)
5.50	9/19/2003 (Isabel)
5.40	7/24/1997 (Danny)
5.20	10/6/1972 (rain pre-coastal)
5.15	10/21/1961 (coastal low)
5.00	9/7/1996 (Fran)**
5.00	10/16/1954 (Hazel)
4.35	9/18/1945 (1945 hurricane)
3.86	5/30/1971 (coastal low)

Winchester, VA	
6.51	10/15/1942 (record flood of 42)
4.87	6/22/1972 (Agnes)
4.72	8/31/1975 (stalled front)
4.47	10/22/1929 (intense low)
4.43	4/26/1937 (coastal low)
4.33	8/18/1994 (Beryl)
4.24	4/22/1992 (strong front)
4.15	8/13/1955 (Connie)
4.10	10/30/2012 (Sandy)
3.72	6/28/2006 (cold front post-Fed Triangle)

*Fran was the record two day rainfall at Staunton (7.35")*



# Our Products

## Outlook

- Hazardous Weather Outlook
- Anytime through Day 7
- Some potential

## Watch

- Flood/Flash Flood/River Flood Watch
- Up to 48 hours - up to 72 for rivers
- 50% confidence (preponderance of evidence)

## Warning

- Flood/Flash Flood/River Flood Warning
- Occurring or imminent
- 80% confidence (clear & convincing evidence)

**Note:** A watch does not necessarily precede a warning, especially for river flooding.



# What makes a flash flood?

- ▶ Typical Flash Flood Characteristics
  - Caused by convection (thunderstorms or intense showers)
  - More isolated compared to flooding
  - Response time is short, usually 1-2 hours, but as little as 15 mins. in urban areas (compared to 6-12 hours for flooding)
  - Swift Water Rescues, road closures (especially major roads), creeks and streams flood within an hour or two of the causative event
  - Occurs more frequently in urban areas and in terrain



**Flash Flood debris flow  
near Front Royal, VA – 2011**



# When does flash flooding occur?

- ▶ Can occur anytime – day or night.
- ▶ Approximately two-thirds of all flash flooding, and most fatalities from flash flooding, occur at night.
- ▶ Flash Flooding can happen almost anywhere!

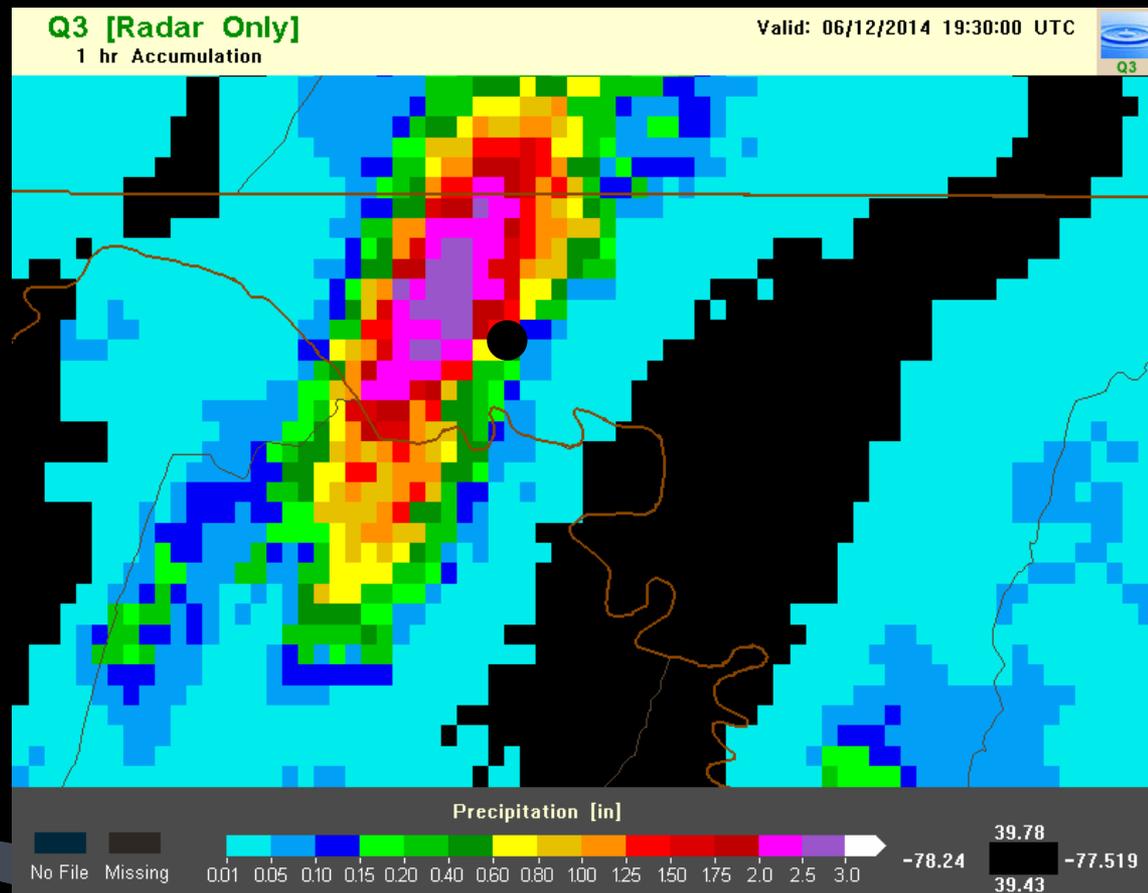


C&O towpath breach at Old Anglers Inn (January 1996)



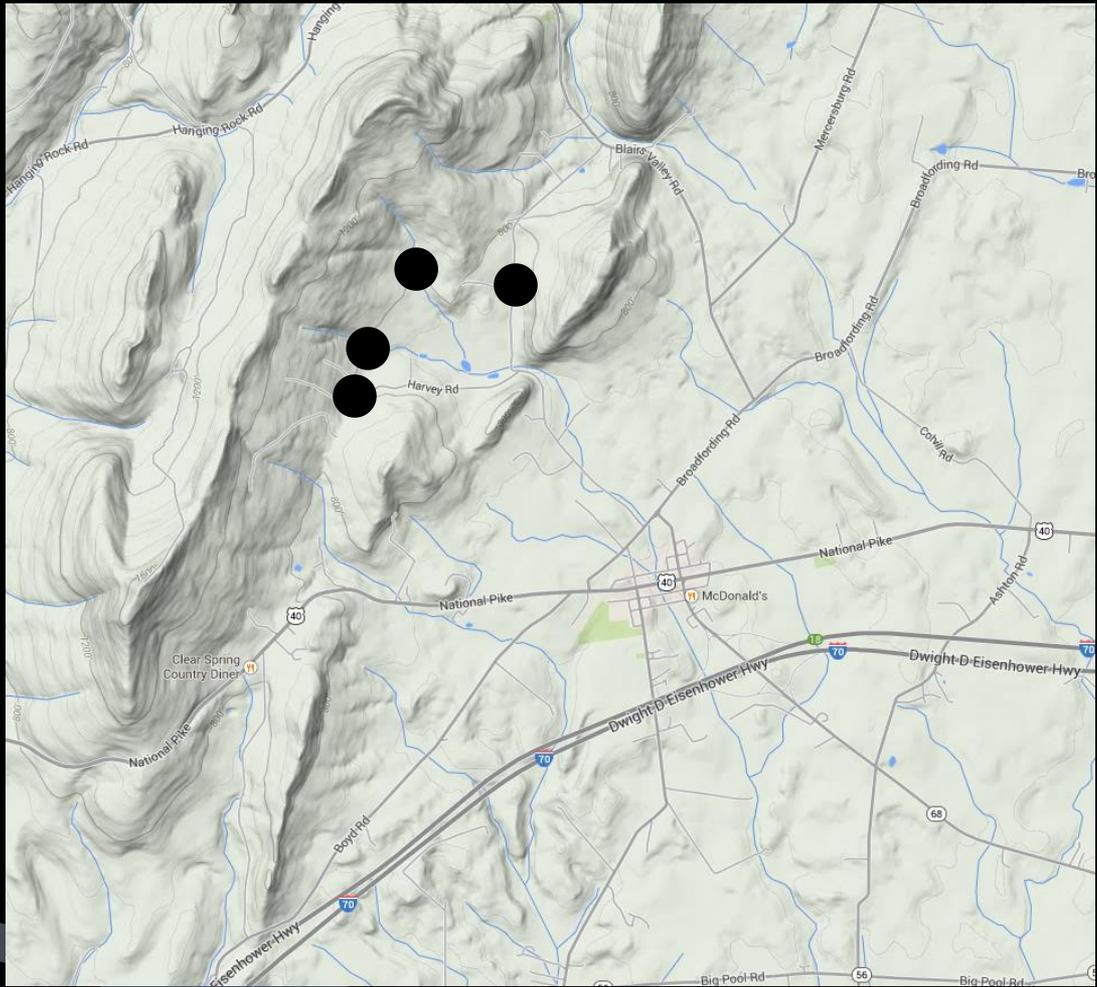
# Basin-Based Warnings

- ▶ Our goal is to warn for:
  - Where the rain is going to go
  - Where the water is going to flow
- ▶ This means we may warn for places where it will not even rain!



# Basin-Based Warnings

- ▶ Warnings include where the rain's going to go and where the water is going to flow!

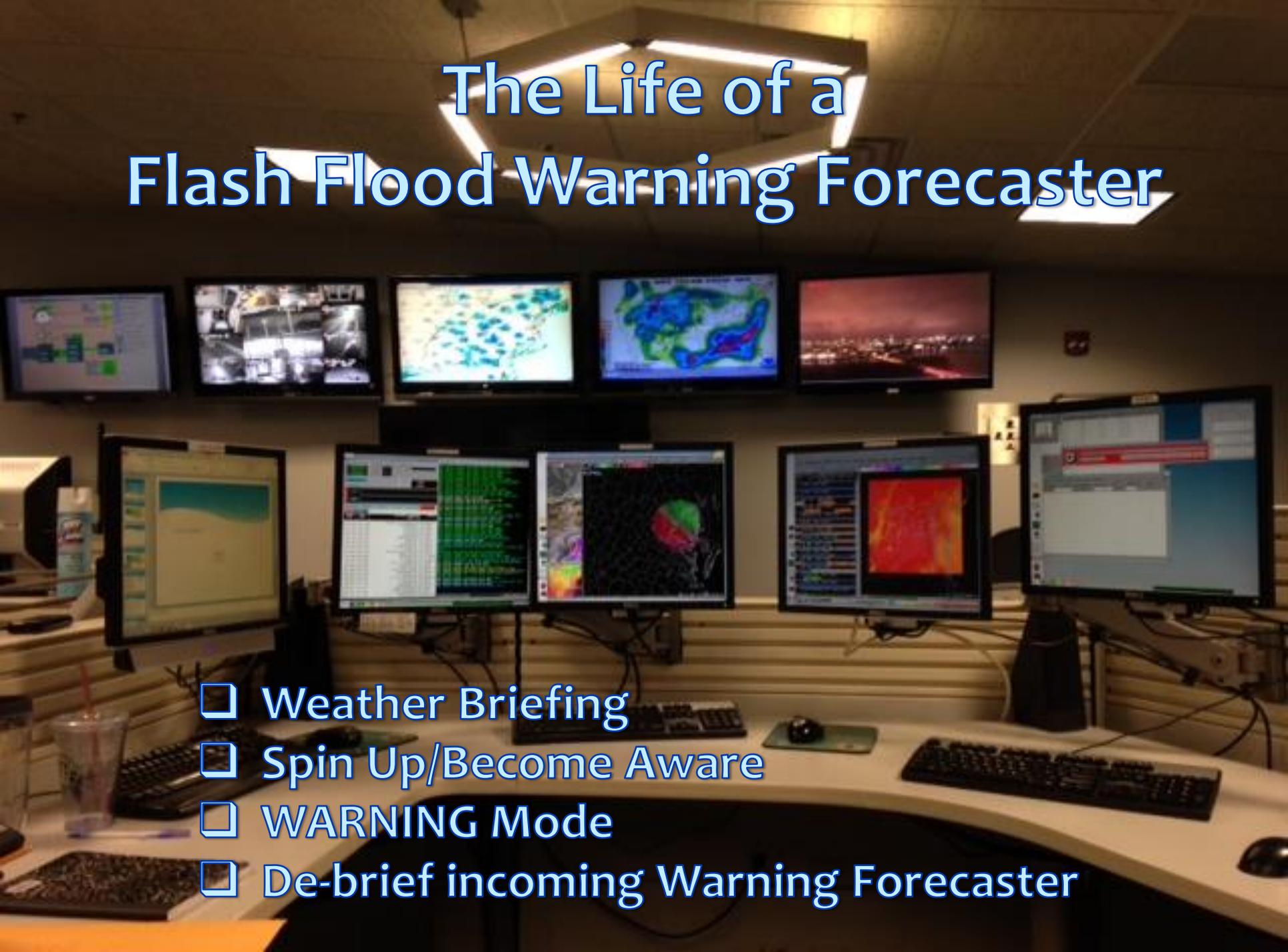


# Scenario

- ▶ Now we will take a look at an overall scenario, with first a flash flood component, then a larger river flood component.
- ▶ As we go through this scenario, think about what a situation like this would mean for you. Although we may focus on a specific area in this scenario – it could truly happen anywhere in our area!



# The Life of a Flash Flood Warning Forecaster

- 
- Weather Briefing
  - Spin Up/Become Aware
  - WARNING Mode
  - De-brief incoming Warning Forecaster

# Weather Set-up

H

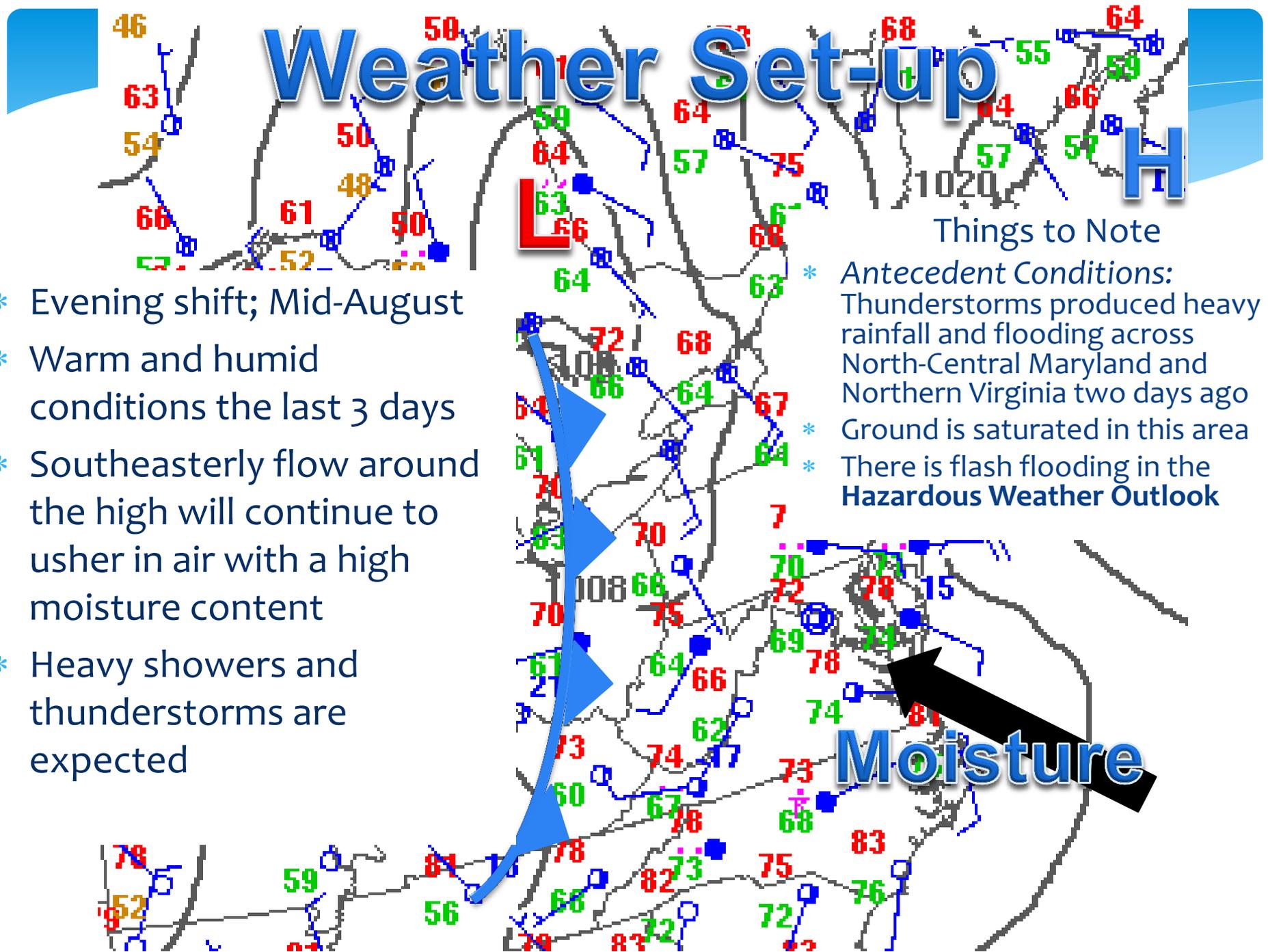
1020

Things to Note

- \* Evening shift; Mid-August
- \* Warm and humid conditions the last 3 days
- \* Southeasterly flow around the high will continue to usher in air with a high moisture content
- \* Heavy showers and thunderstorms are expected

- \* Antecedent Conditions: Thunderstorms produced heavy rainfall and flooding across North-Central Maryland and Northern Virginia two days ago
- \* Ground is saturated in this area
- \* There is flash flooding in the Hazardous Weather Outlook

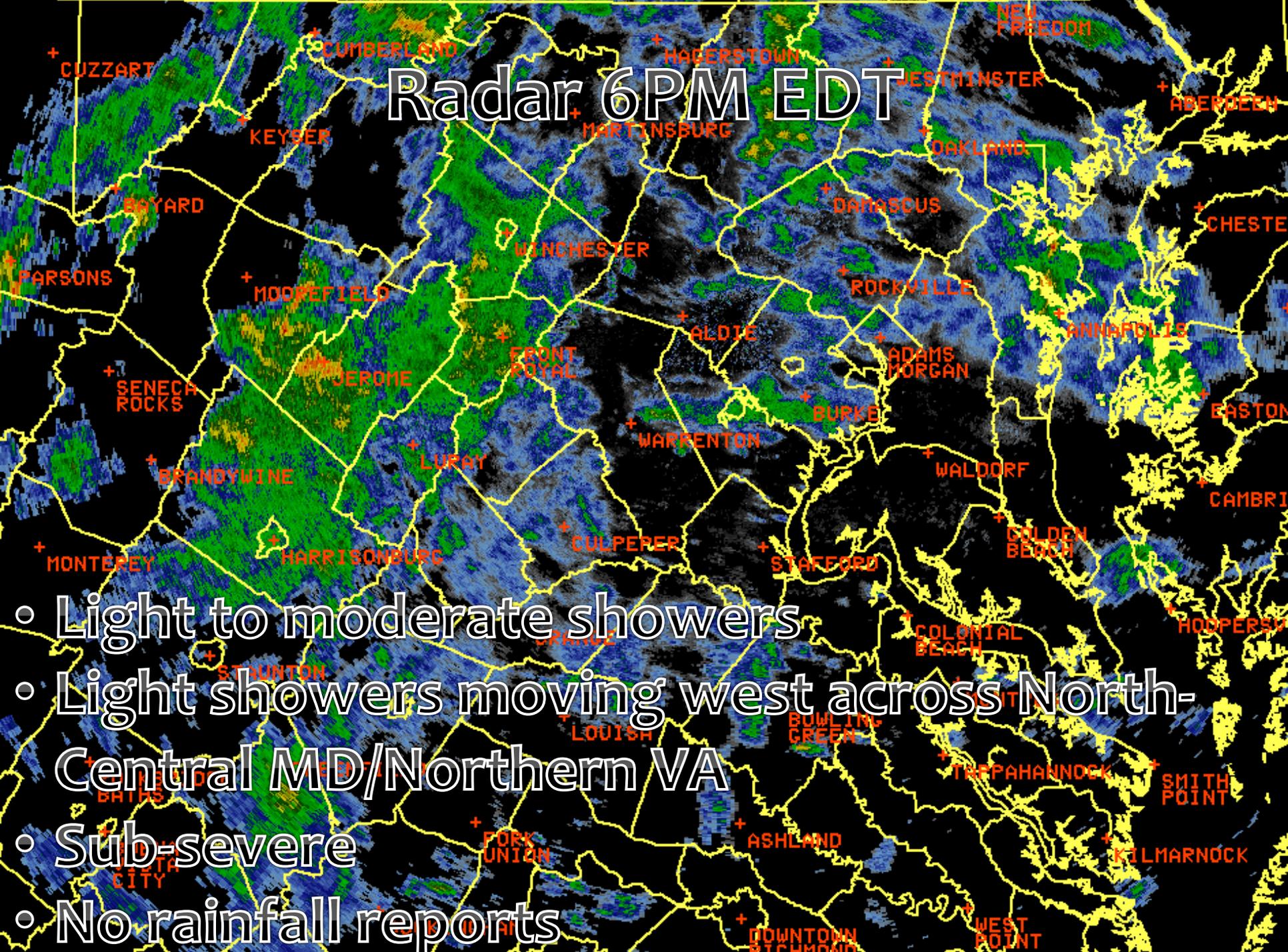
Moisture



# A Day in the Life of a Flash Flood Warning Forecaster...

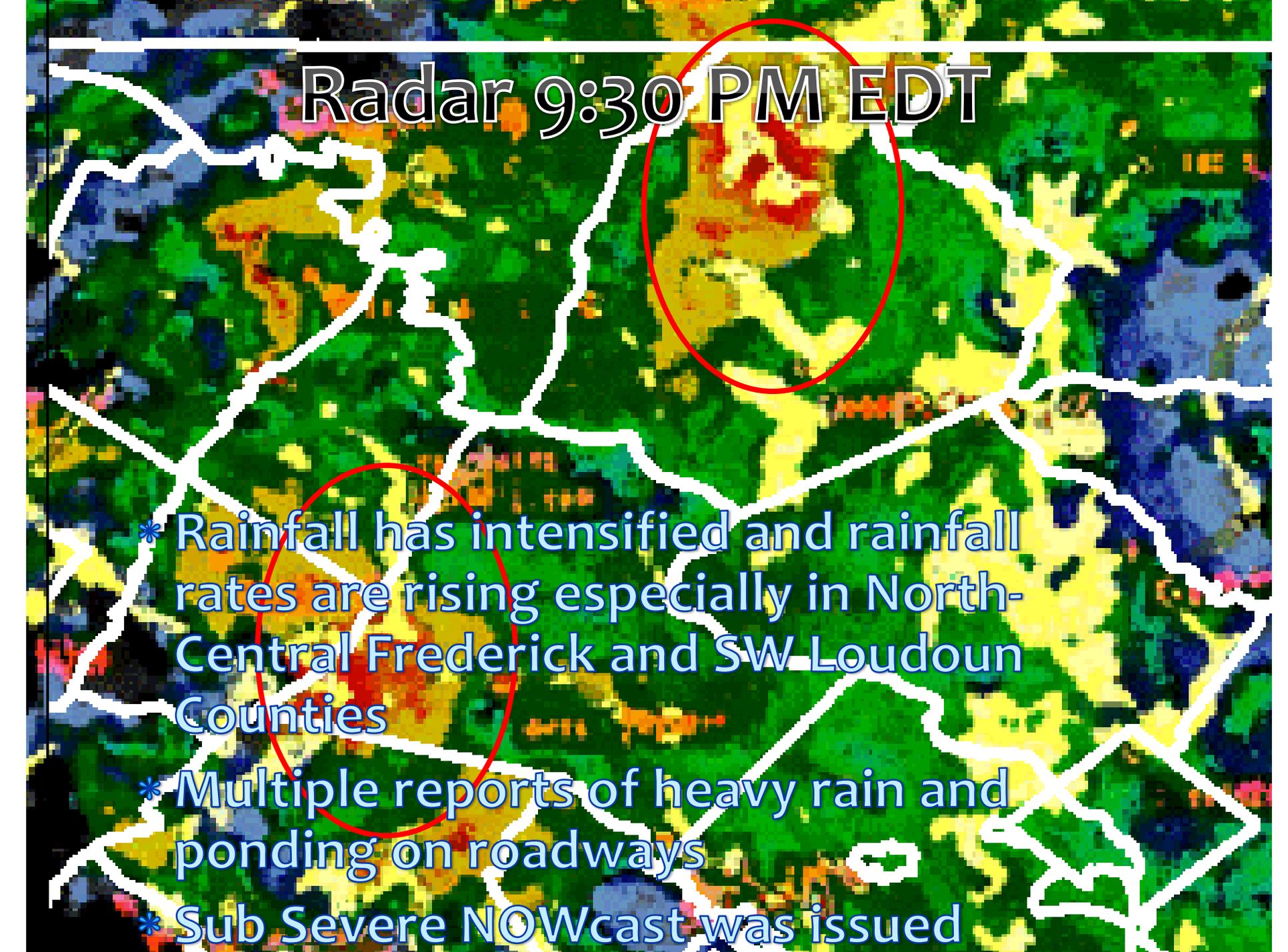


# Radar 6PM EDT



- Light to moderate showers
- Light showers moving west across North-Central MD/Northern VA
- Sub-severe
- No rainfall reports

# Radar 9:30 PM EDT

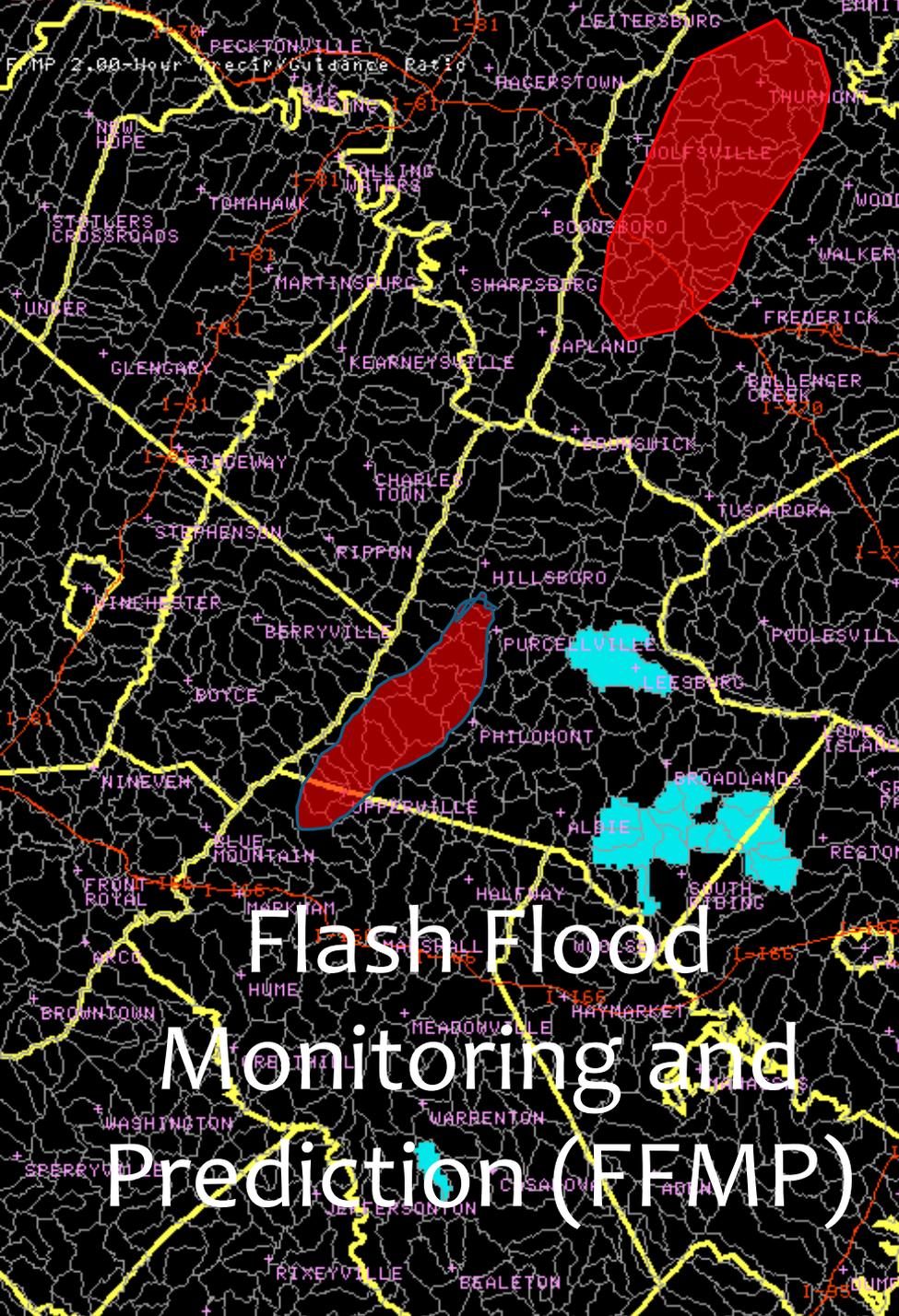


\* Rainfall has intensified and rainfall rates are rising especially in North-Central Frederick and SW Loudoun Counties

\* Multiple reports of heavy rain and ponding on roadways

\* Sub Severe NOWcast was issued





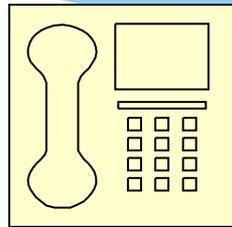
	RFCFFG	RFCFFG	RFCFFG		
NAME	RATE	QPE	GUID	RATIO	DIFF
Rappahannock River	0.00	1.39	1.18	118	0.21
xxx	0.00	1.21	1.06	114	0.15
Indian Run	0.00	1.31	1.17	111	0.13

## FFMP (Flash Flood Monitoring and Prediction)

- Compares Flash Flood Guidance (the forecast of how much rain it would take to send small streams out of their banks) to Rainfall Estimates
- The area is divided into hydrological sub-basins, each of which has its own FFG and Rainfall Estimate
- Each sub-basin has a different value, letting us know which areas are exceeding Flash Flood Guidance, indicating flash flooding is occurring.
- This allows us to reduce the size of warnings further, only warning those residents that lie in particular basin that is expected to flood

# Incoming Reports!!

(Remember it's night time)



- \* Ring... Ring
- \* Spotter LOC123 (Round Hill, VA)... Heavy rain and 1.75 inches in rain gauge in the last few hours
- \* Spotter FDK456 (Thurmont, MD)... 4 inches in rain gauge in 1.5hrs , 1/4 mile visibility, 4 inches of flowing water over nearby road

*INWS Alert!*

*WEA Alert!*

**FLASH FLOOD WARNING**

**ISSUED for Central Frederick County MD**

*NWSChat!*

*[www.weather.gov](http://www.weather.gov)*

*Weather Radio  
Tone Alerts!*

*NAWAS Alerted!*

# FLASH FLOOD WARNING

THE NATIONAL WEATHER SERVICE IN STERLING VIRGINIA HAS ISSUED A

\* FLASH FLOOD WARNING FOR...  
CENTRAL FREDERICK COUNTY IN NORTH CENTRAL MARYLAND...

\* UNTIL 1230 AM EDT

\* AT 925 PM EDT...TRAINED SPOTTERS REPORTED FLASH FLOODING FROM VERY HEAVY RAIN. ADDITIONAL RAINFALL AMOUNTS OF UP TO 2 INCHES CAN BE EXPECTED.

\* SOME LOCATIONS THAT ARE AFFECTED BY THE HEAVY RAIN INCLUDE BRADDOCK HEIGHTS...FREDERICK AND HARRY GROVE STADIUM.

EXCESSIVE RUNOFF FROM HEAVY RAINFALL WILL CAUSE FLASH FLOODING OF SMALL CREEKS AND STREAMS...ROADS AND FARMLAND ALONG THE BANKS OF CREEKS AND STREAMS.

BE ESPECIALLY CAUTIOUS AT NIGHT WHEN IT IS HARDER TO RECOGNIZE THE DANGERS OF FLOODING. ACT QUICKLY IF FLASH FLOODING IS OBSERVED. MOVE TO HIGHER GROUND TO ESCAPE FLOOD WATERS. DO NOT STAY IN AREAS SUBJECT TO FLOODING WHEN WATER BEGINS RISING.

LAT...LON 3962 7747 3962 7732 3939 7740 3941 7755

\$\$

IAS

WARNING MODE





Owens  
Creek

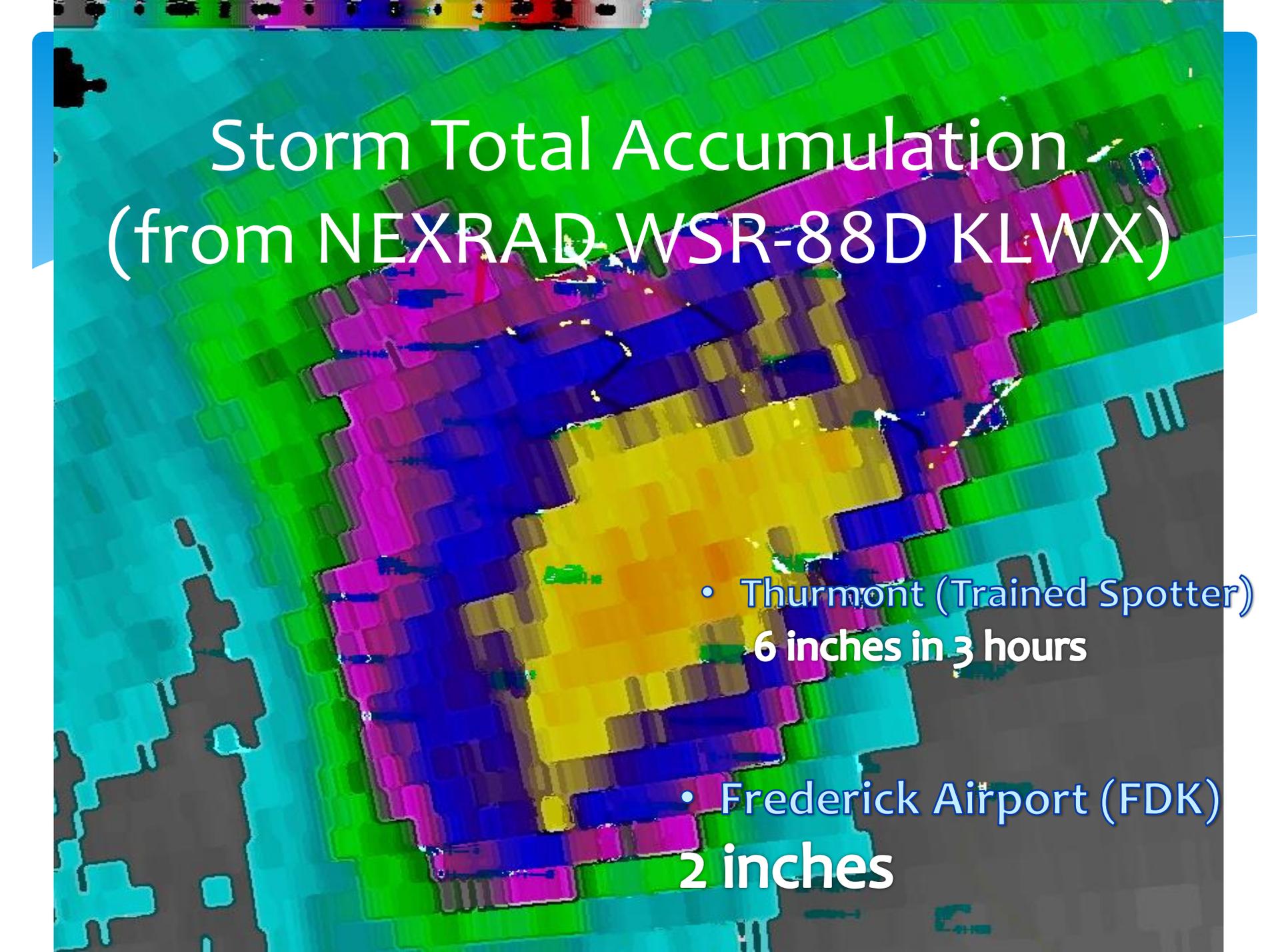
Hunting  
Creek

Monocacy River

NF Goose Creek

Potomac River

Where does the  
water go?



# Storm Total Accumulation (from NEXRAD WSR-88D KLWX)

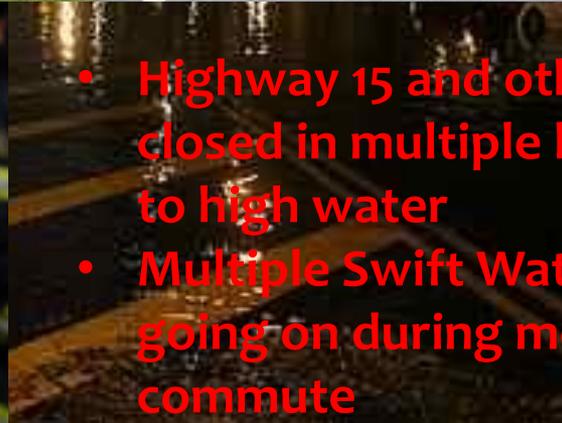
- Thurmont (Trained Spotter)

**6 inches in 3 hours**

- Frederick Airport (FDK)

**2 inches**

# Nighttime Flooding / Warning for the Asleep



- Highway 15 and other roads are closed in multiple locations due to high water
- Multiple Swift Water rescues going on during morning commute
- Road collapsed in Thurmont, MD

# Collaboration & Enhanced W...

...FLASH FLOOD WARNING  
NATIONAL WEATHER SERVICE BALTIMORE MD/WASHINGTON DC  
150 PM EDT TUE AUG 12 2014

...FLASH FLOOD EMERGENCY FOR EXTREME NORTHERN ANNE ARUNDEL COUNTY...

THE NATIONAL WEATHER SERVICE IN STERLING VIRGINIA HAS EXTENDED THE

\* NY

FLASH FLOOD WARNING FOR...

\* Ph

NORTHERN ANNE ARUNDEL COUNTY IN CENTRAL MARYLAND...

\* A

UNTIL 815 PM EDT

\* Exc

can

a se

dam

\* Flas

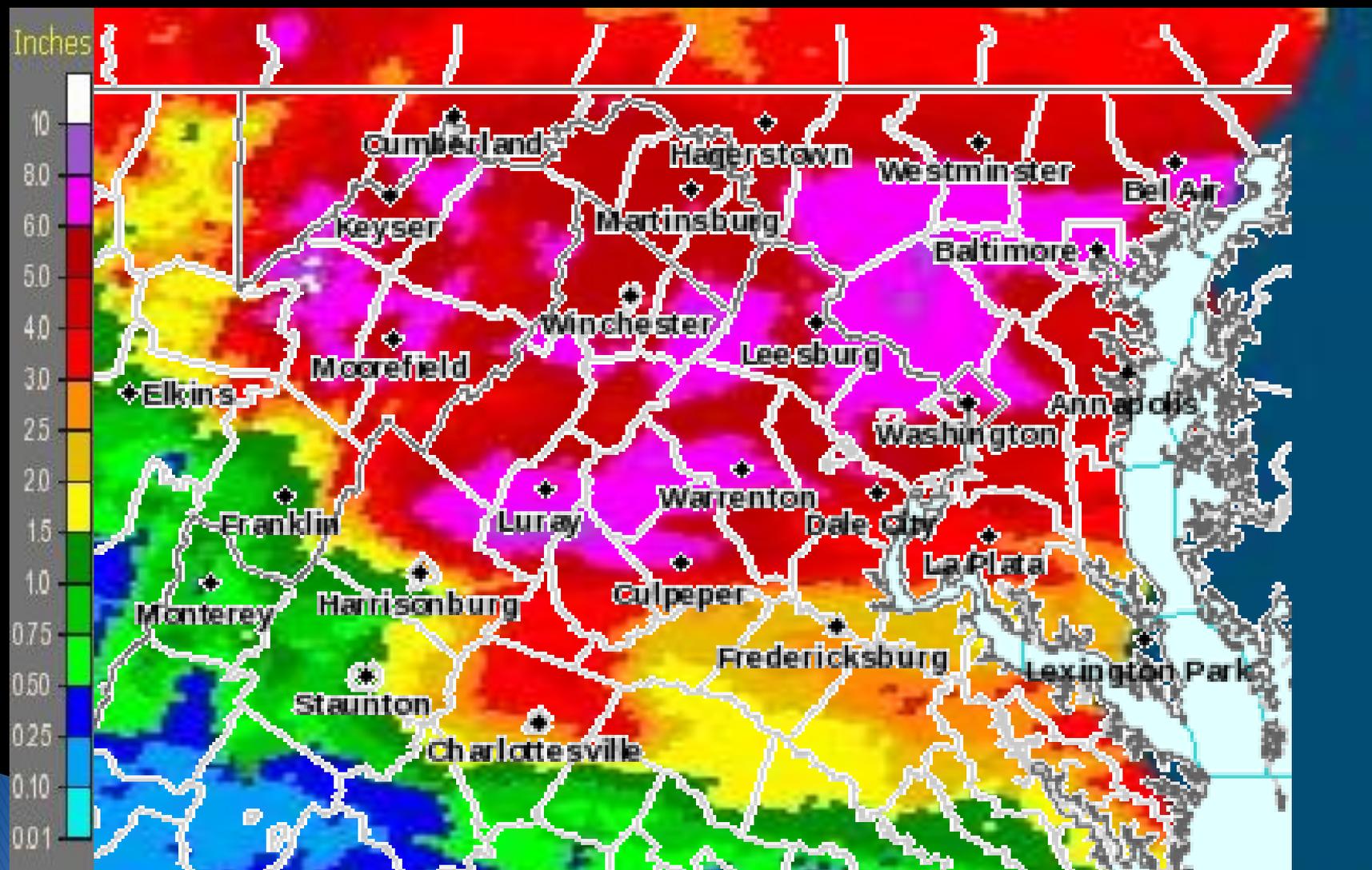
in Ar

AT 445 PM EDT...NATIONAL WEATHER SERVICE DOPPLER RADAR INDICATED VERY HEAVY RAIN CAPABLE OF PRODUCING FLASH FLOODING. RADAR ESTIMATES THAT 4 TO 10 INCHES OF RAIN HAVE ALREADY FALLEN ACROSS NORTHERN ANNE ARUNDEL COUNTY. ALTHOUGH THERE IS A BREAK IN THE RAINFALL CURRENTLY...ANOTHER AREA OF RAIN WILL AFFECT AT LEAST PART OF THE COUNTY BEFORE 6 PM. ADDITIONAL RAINFALL AMOUNTS OF UP TO 1 INCH CAN BE EXPECTED...WITH SIGNIFICANT FLASH FLOODING ALREADY ONGOING.

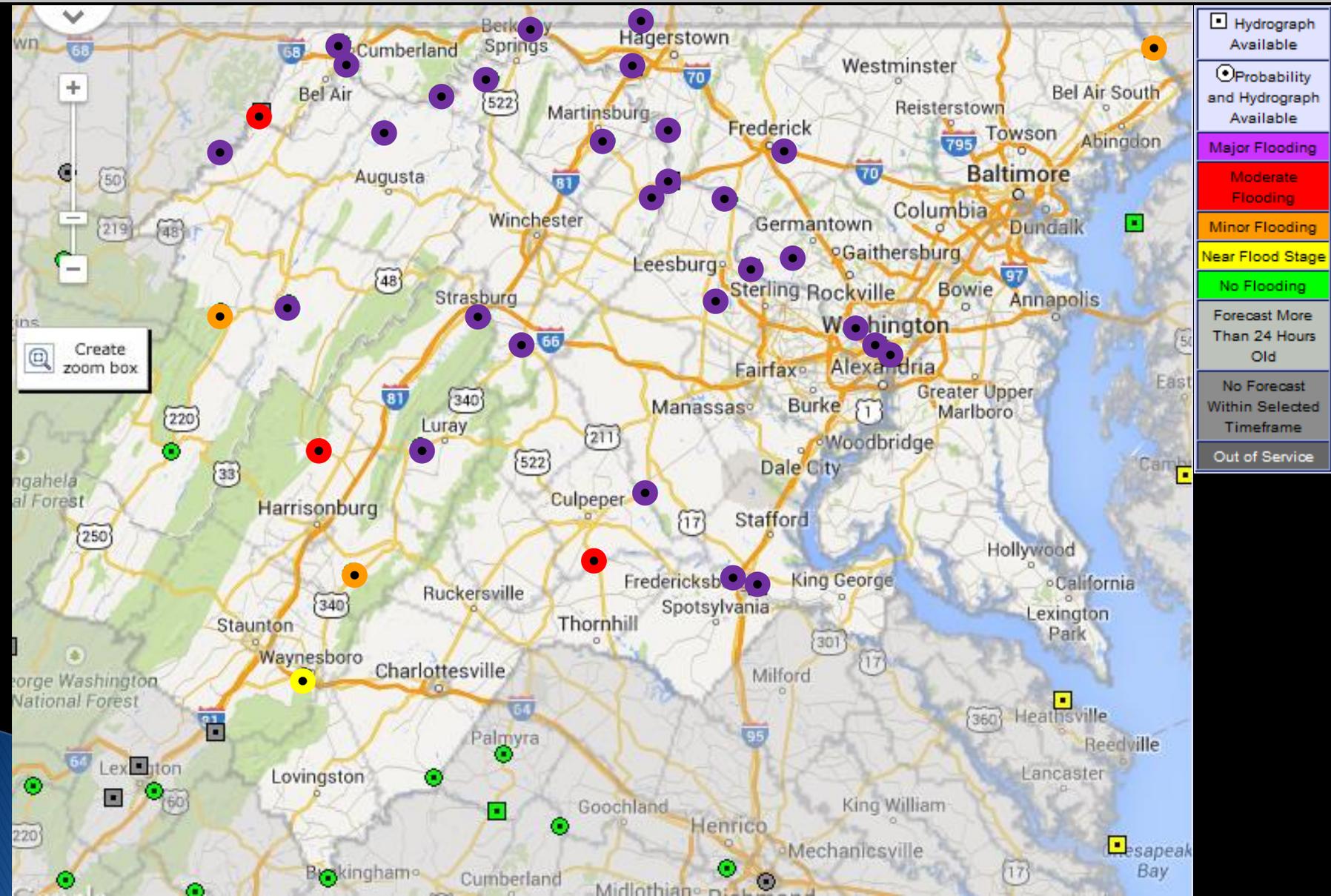
SOME LOCATIONS THAT ARE AFFECTED BY THE HEAVY RAIN INCLUDE ARNOLD...CROFTON...GIBSON ISLAND...GREEN HAVEN...LAKE SHORE... MILLERSVILLE...ODENTON...PAROLE...PASADENA...SEVERNA PARK...SOUTH GATE...BODKIN POINT...FORT SMALLWOOD STATE PARK...PINEHURST... RIVIERA BEACH AND SILLERY BAY.

MOST FLASH FLOOD DEATHS OCCUR IN AUTOMOBILES. NEVER DRIVE YOUR VEHICLE INTO AREAS WHERE WATER COVERS THE ROAD. FLOODWATER USUALLY IS DEEPER THAN IT APPEARS. JUST ONE FOOT OF FLOWING WATER IS POWERFUL ENOUGH TO SWEEP VEHICLES OFF THE ROAD. MAKE THE SMART CHOICE WHEN FLOODED ROADS ARE ENCOUNTERED...TURN AROUND...DONT DROWN.

# Estimated Storm Total Rainfall

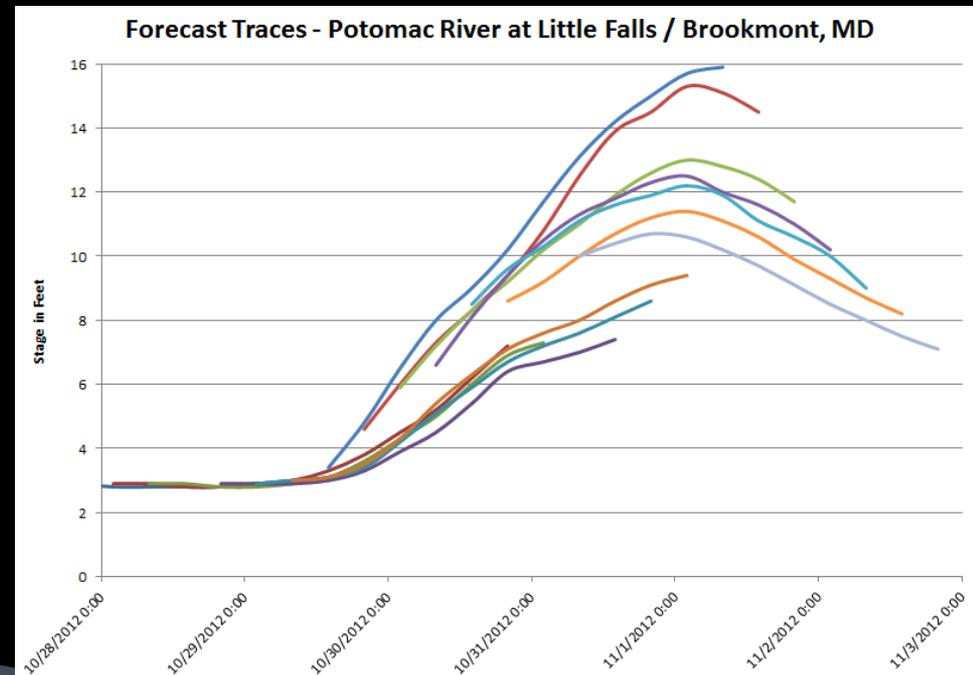


# River Forecasts



# River Forecasts

- ▶ Our official river forecast is available at <http://water.weather.gov> (click on the DC area on the map)
- ▶ What you need to know about these forecasts:
  - We issue forecasts out to 72 hours in the future. So...
  - The earliest predictions of flooding in the upper Potomac will not show much rise downstream closer to DC (it's after the forecast time)
  - When locations are first predicted to flood, the simulated forecast will likely include rain which has not yet fallen
  - As the area of heaviest rain becomes better defined, the forecasts will adjust accordingly.  
(Sometimes this can't happen until after the rain is falling, due to uncertainty.)



# Are we overdue?

## Shenandoah River at Millville, WV

### Last occurrence:

10+ ft – 5/17/2014 (minor)

15+ ft – 4/18/2011 (moderate)

17+ ft – 9/20/2003 (major)

22+ ft – 1/20/1996

Record – 32.40 ft on 10/16/1942



## Potomac River at Little Falls, MD

### Last occurrence:

11+ ft – 5/18/2014

12+ ft – 3/25/2010 (moderate)

14+ ft – 9/8/1996 (major)

18+ ft – 1/21/1996

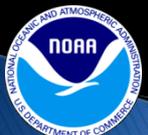
22+ ft – 6/24/1972

Record – 28.10 ft on 3/19/1936



# Are we NOT overdue?

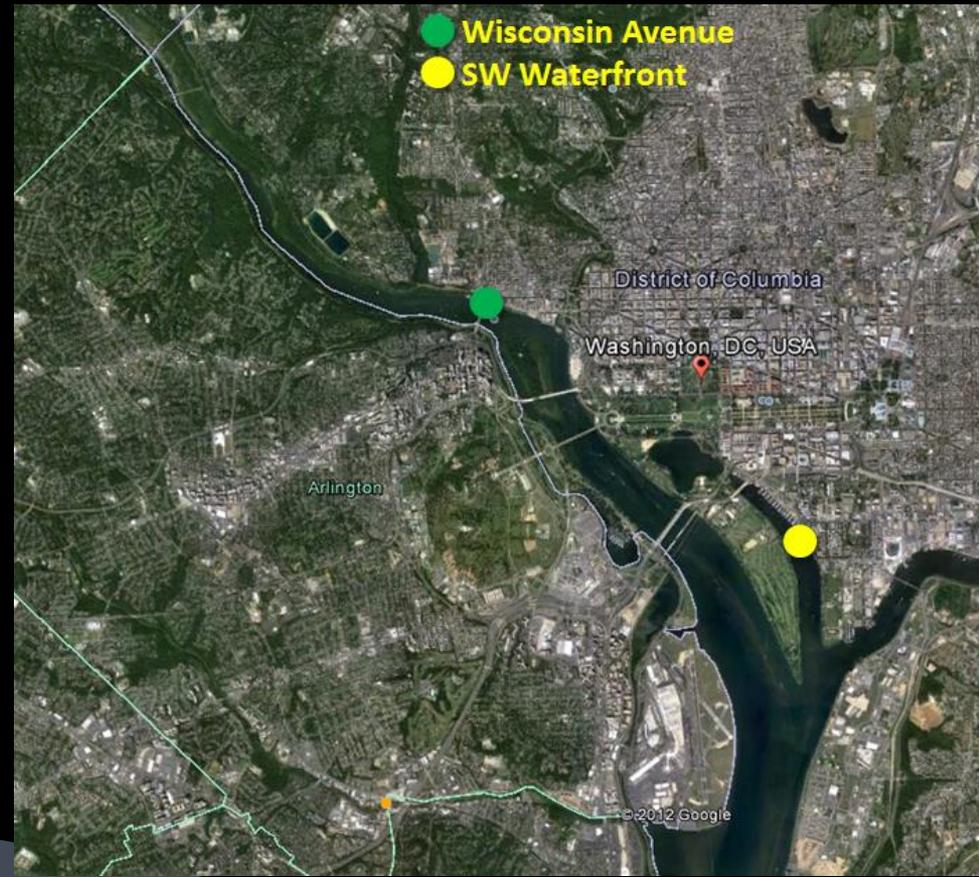
- ▶ Many stream gauges have reached “record levels” since 2010. But almost all of them were put in place after Agnes (many as a result of Agnes) in 1972.
- ▶ So while they have a long period of record (40+ years) the “records” are more indicative of generational floods rather than truly historic ones.
- ▶ However, we have had a lot of sites equal or surpass the 1996 flood this year, including on large streams like the Opequon, Rappahannock, and Conococheague.





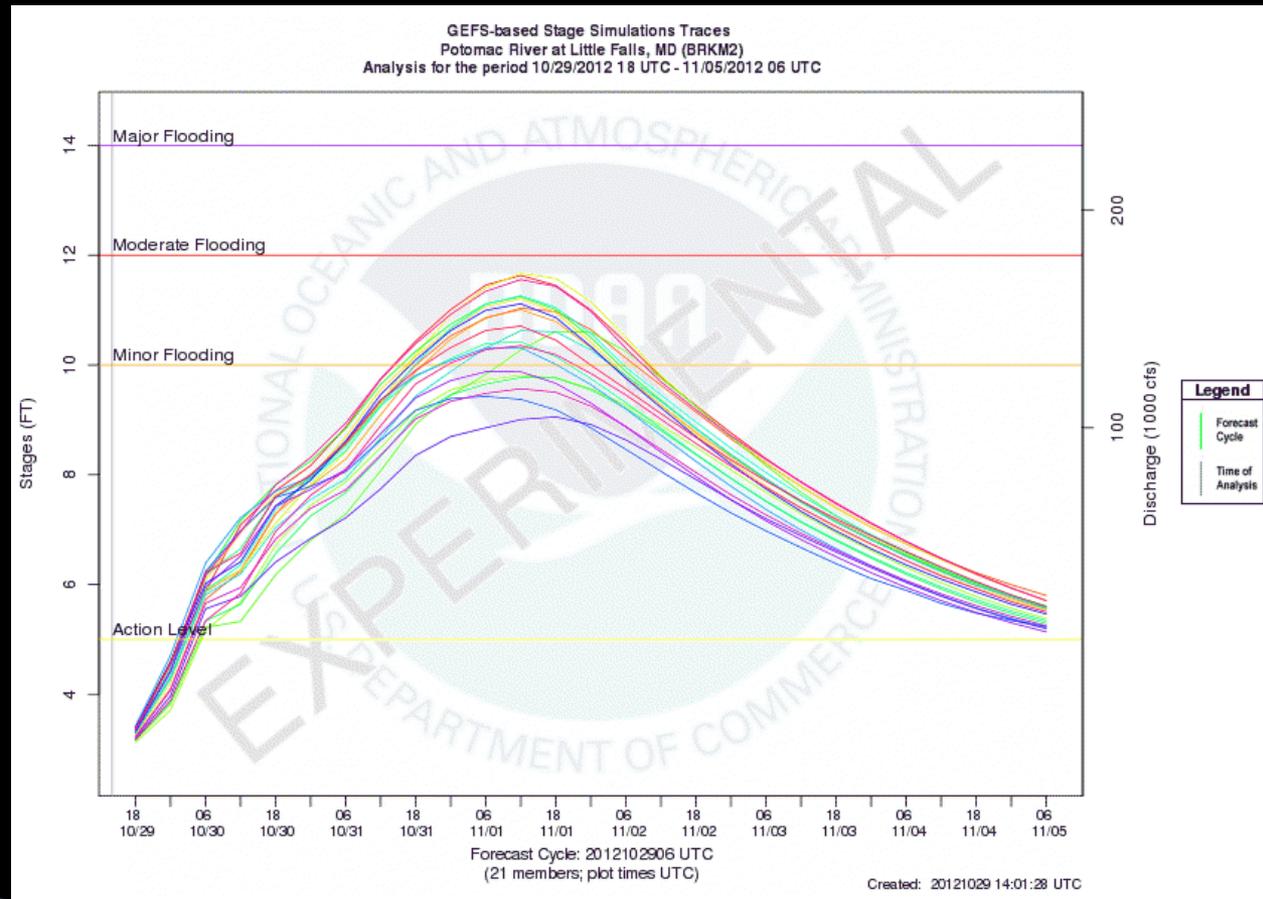
# Important Note

- ▶ In early 2013, we began issuing river forecasts for two tidal locations affecting areas in/near Washington DC.
- ▶ When these locations are expected to flood, we issue **Coastal Flood Advisories & Warnings**, no matter what the cause.
  - You'll hear more about coastal/tidal flooding later today.



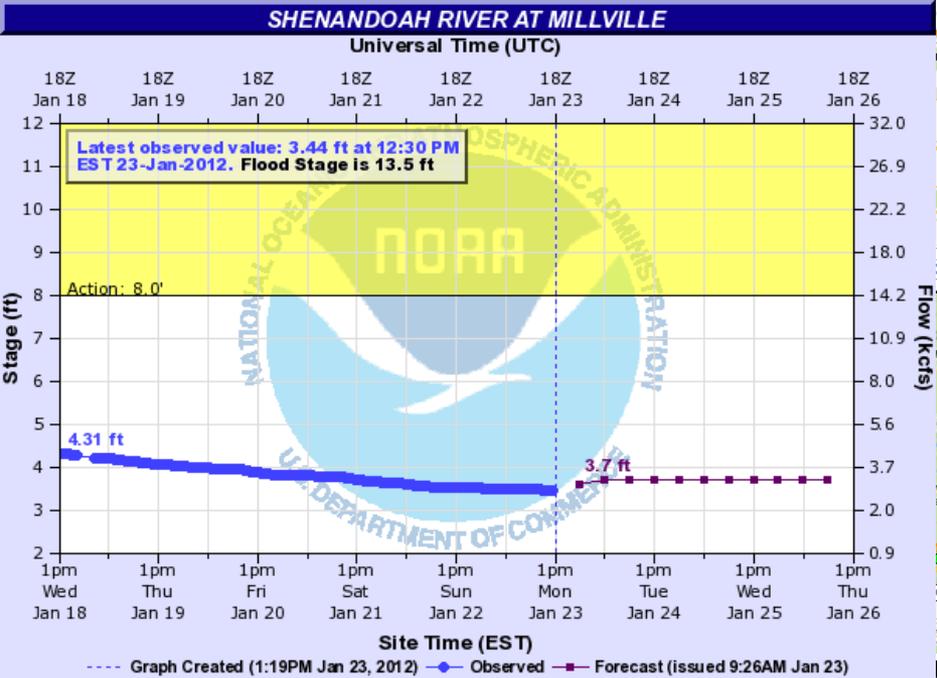
# A Range of Possibilities

- ▶ <http://www.erh.noaa.gov/mmefs>
- ▶ Ensembles offer ranges of possibilities based on different computer model simulations
- ▶ NOTE: the official forecast is not depicted on this graph!



# Advanced Hydrologic Prediction Service (AHPS)

<http://water.weather.gov>



MILW2(plotting HGIRG) "Gage 0" Datum: 293.32' Observations courtesy of US Geological Survey

# Questions?

**Jason Elliott**  
**Senior Service Hydrologist**  
**NWS Baltimore/Washington**  
[jason.elliott@noaa.gov](mailto:jason.elliott@noaa.gov)

**Heather Sheffield**  
**Meteorologist / Flash Flood Program Leader**  
**NWS Baltimore/Washington**  
[heather.sheffield@noaa.gov](mailto:heather.sheffield@noaa.gov)



**Search “US National  
Weather Service  
Baltimore/Washington”**



**@NWS\_BaltWash**

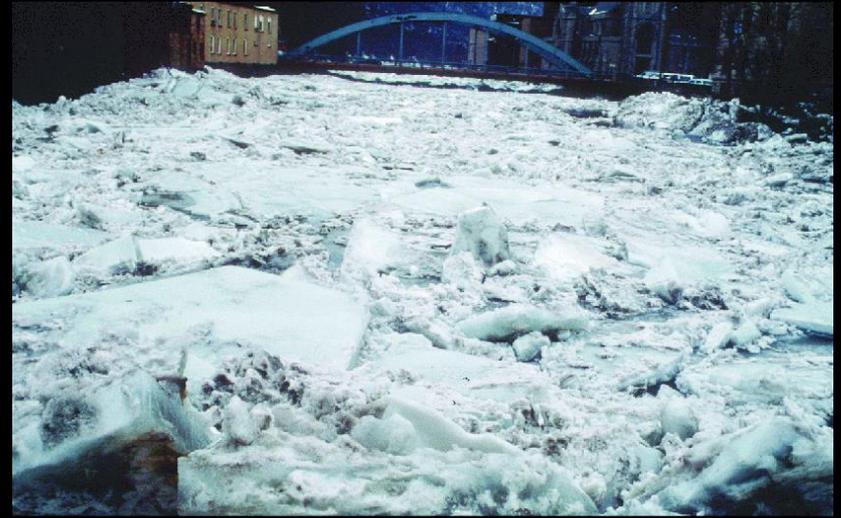
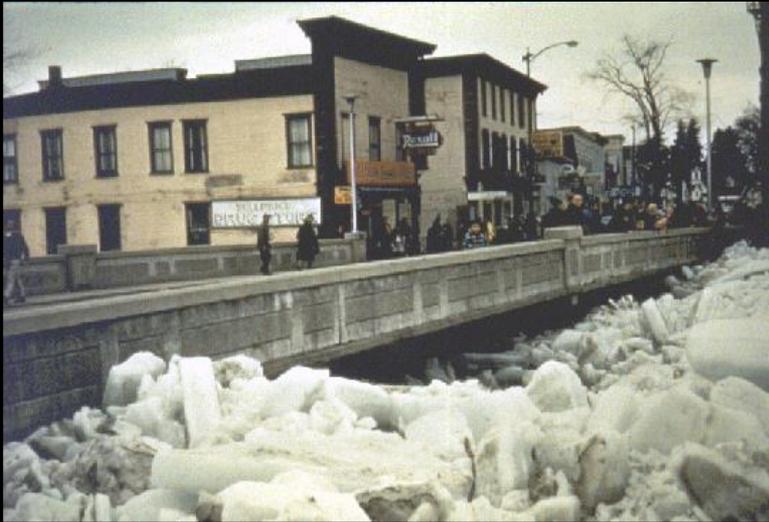


**Visit us online:**

**[weather.gov/washington](http://weather.gov/washington)  
[weather.gov/baltimore](http://weather.gov/baltimore)**



# Special Cases – Ice Jams



*Chunks of ice collect in river channels and may ultimately stop the flow of water.*

*Ice can collect at a bridge and create an ice jam.*

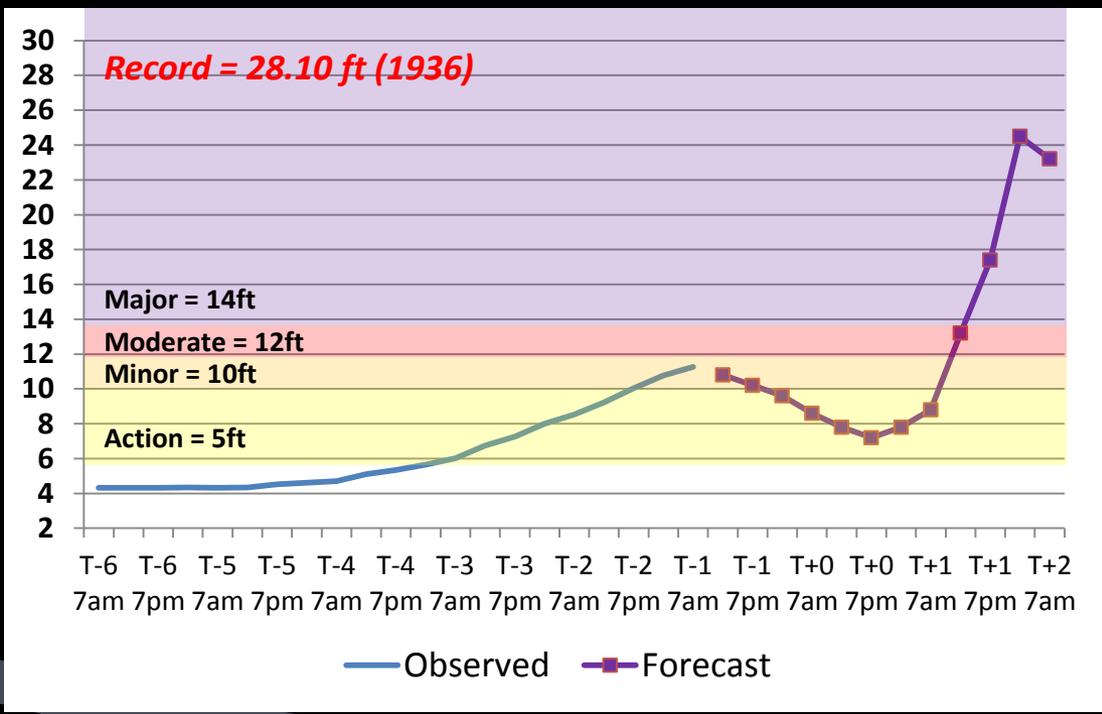
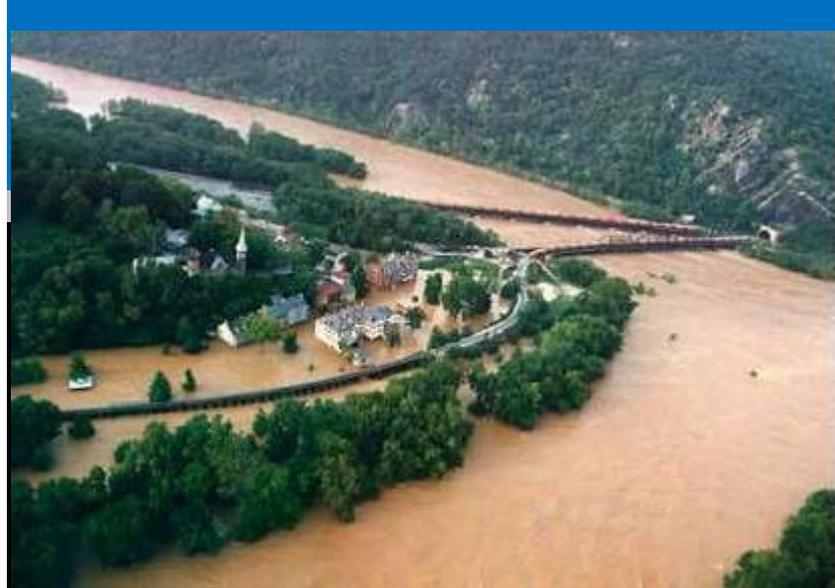
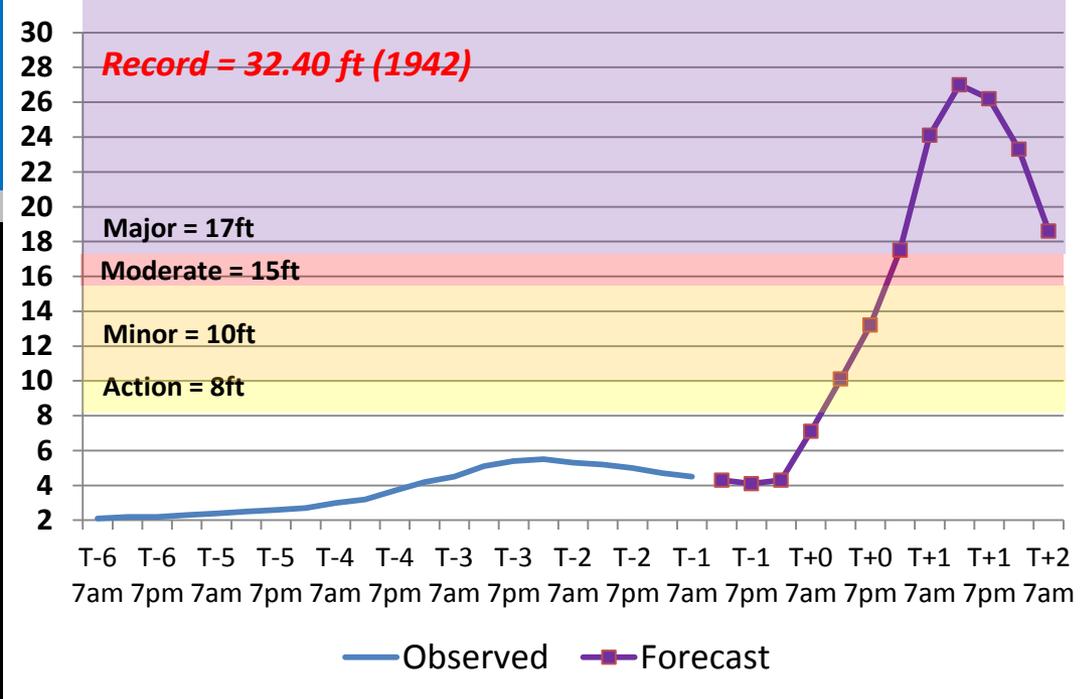
*Water backs up behind the ice jam and subsequent flooding results.*



# Special Cases – Debris Jams

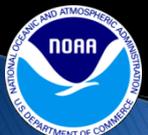
- ▶ Occasionally, floating debris or ice can accumulate at a natural or man-made obstruction and restrict the flow of water.
- ▶ Water held back by the ice jam or debris dam can cause flooding upstream.
- ▶ Subsequent flash flooding can occur downstream if the obstruction should suddenly release.





# Flood Damages

- ▶ Average: \$8.2 billion per year!
- ▶ 2013: \$2.15 billion
- ▶ In 2013, 66% of all Presidentially-declared disasters were at least in part flood-related
  - (plus two leftover 'Sandy' declarations from 2012)



**Great Falls, MD**  
**1996**