The University of Texas at Austin
Environmental Science Institute

Hot Science - Cool Talk # 114

Hurricane Harvey
Flood Emergency Response

Dr. David Maidment
September 14, 2018

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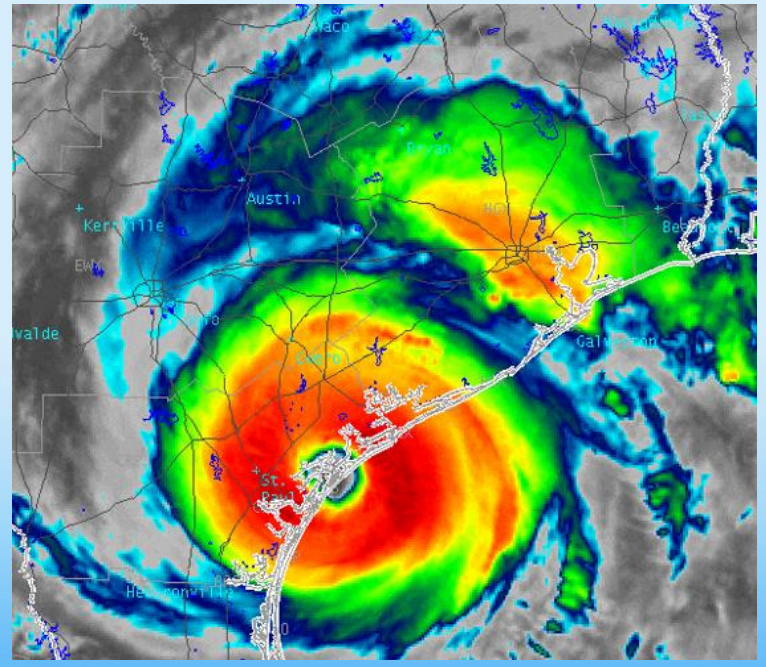
Hurricane Harvey: Flood Emergency Response

David R. Maidment
Center for Water and Environment
University of Texas at Austin

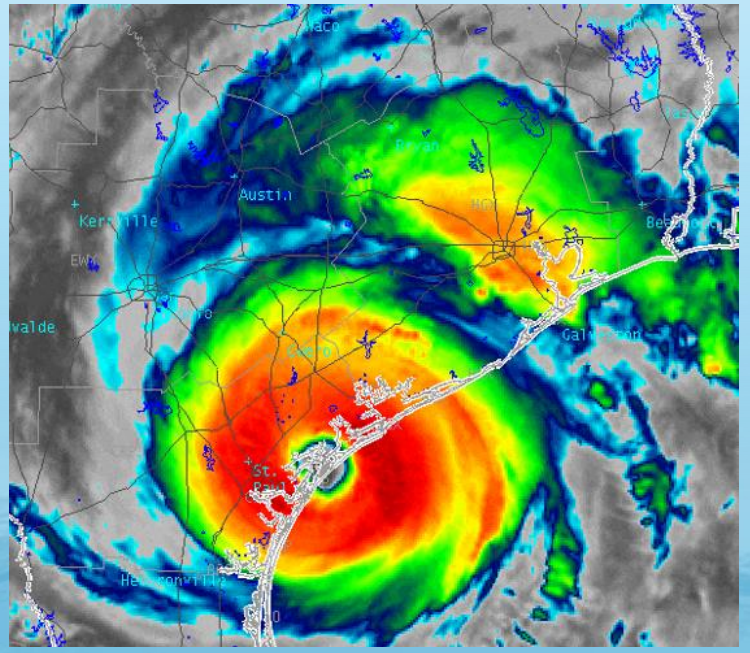


Presentation for Hot Science, Cool Talks, September 14, 2018, University of Texas at Austin

Acknowledgements: National Weather Service, Texas Division of Emergency Management, Michael Ouimet, Xing Zheng, David Arctur, Harry Evans, Erika Boghici, Kisters, ESRI, USGS

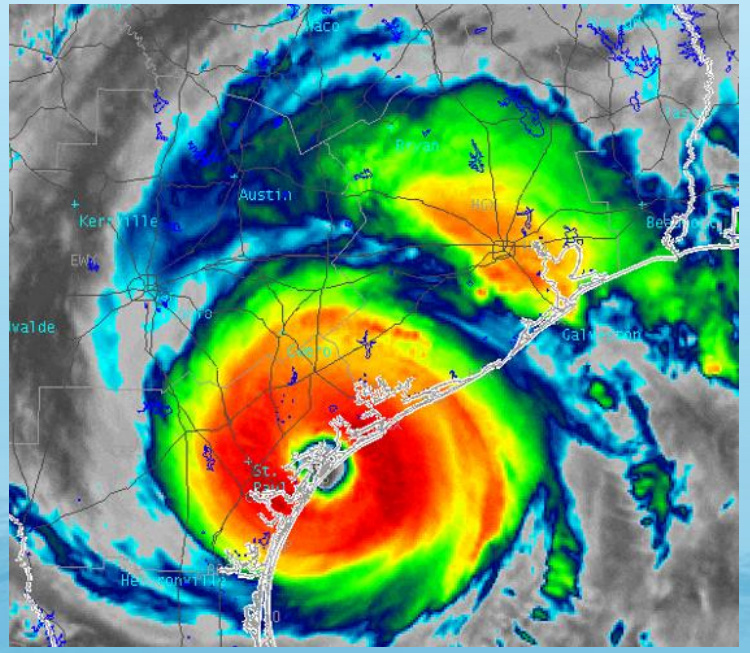
Hurricane Harvey

- Hurricane Harvey … and Florence
- Flood forecasting
- Texas Flood Response System
- How can we do better?

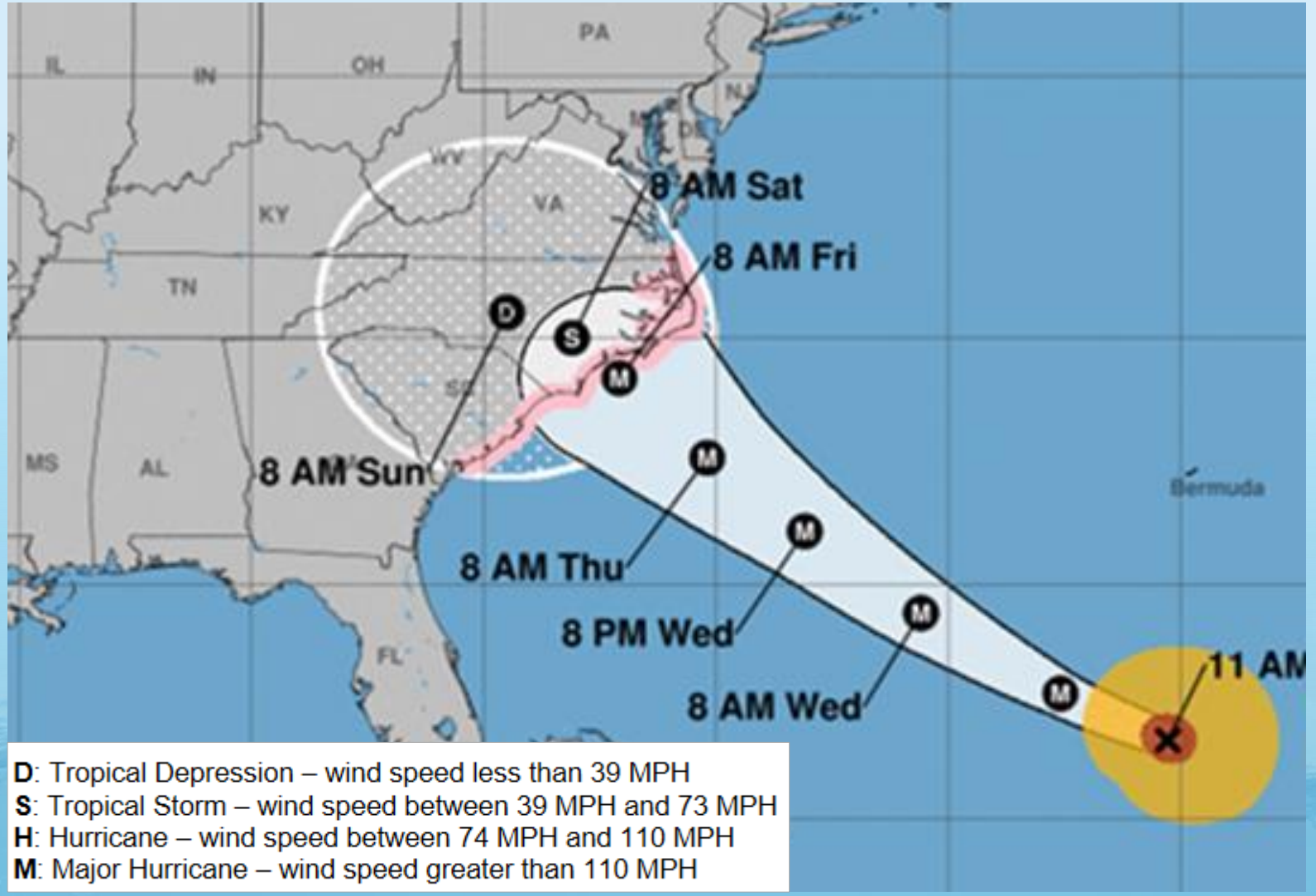


Hurricane Harvey

- ***Hurricane Harvey … and Florence***
- **Flood forecasting**
- **Texas Flood Response System**
- **How can we do better?**

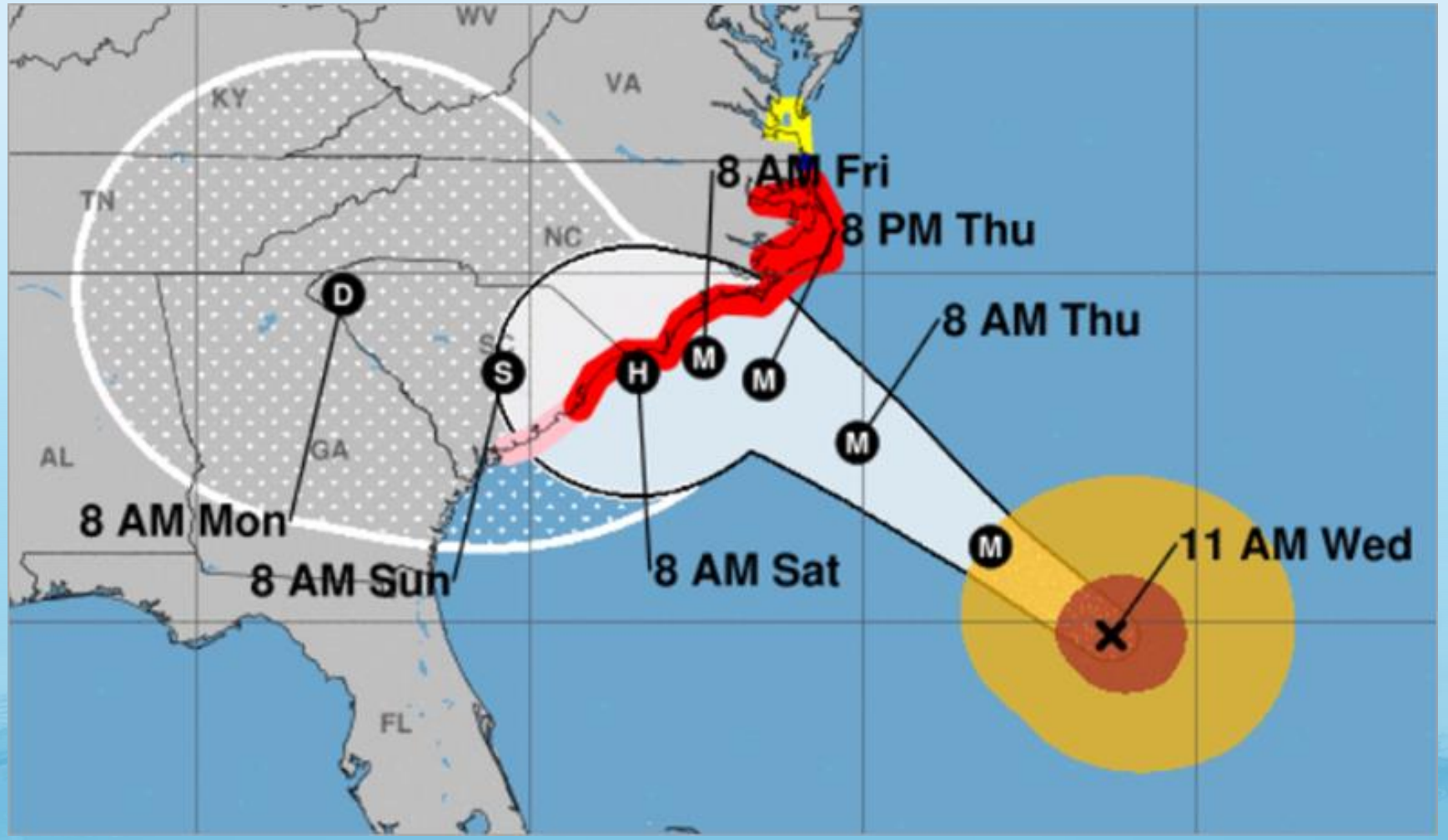


Hurricane Florence Forecast (Tuesday)



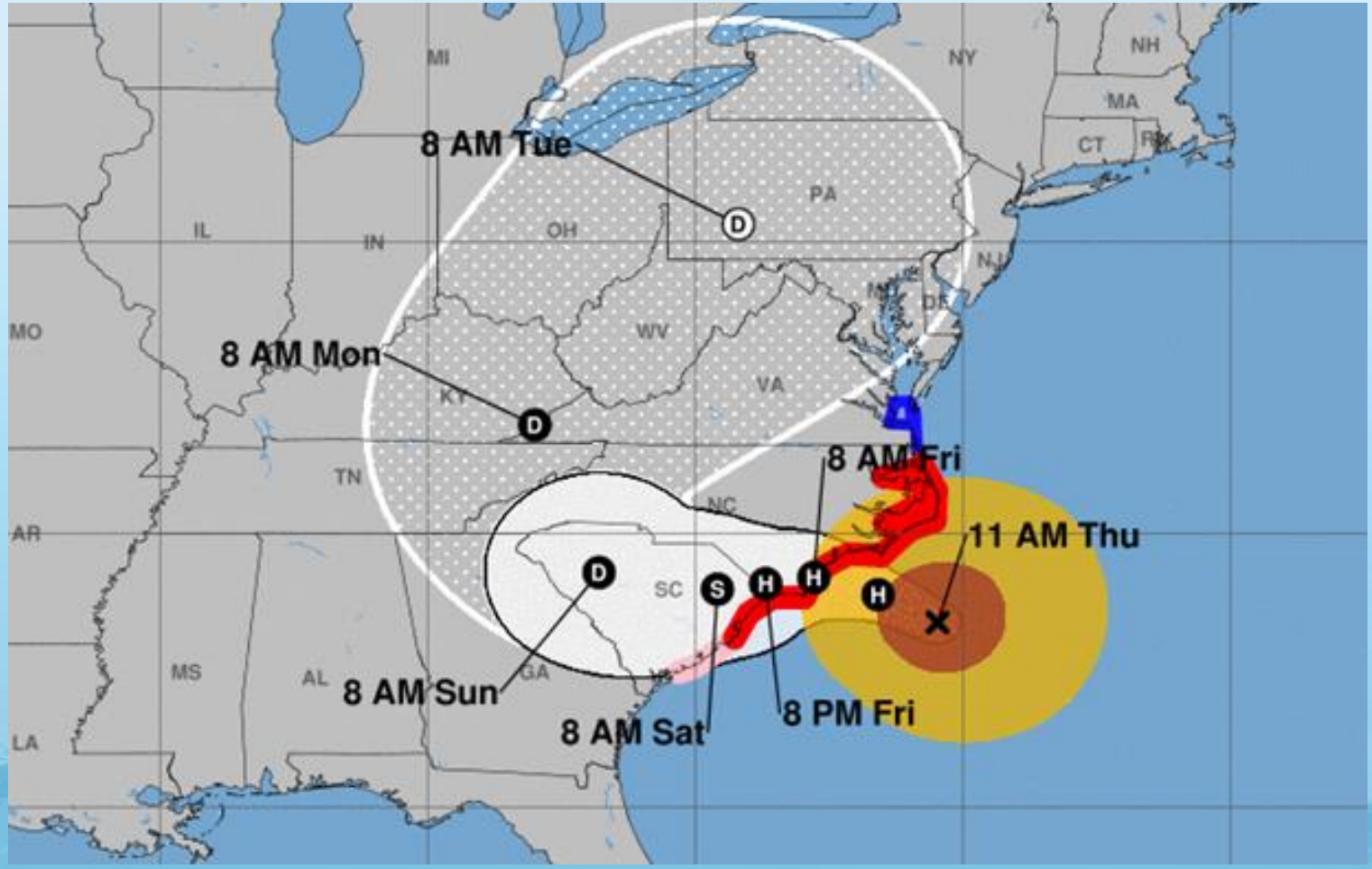
Source: National Hurricane Center

Hurricane Florence Forecast (Wednesday)



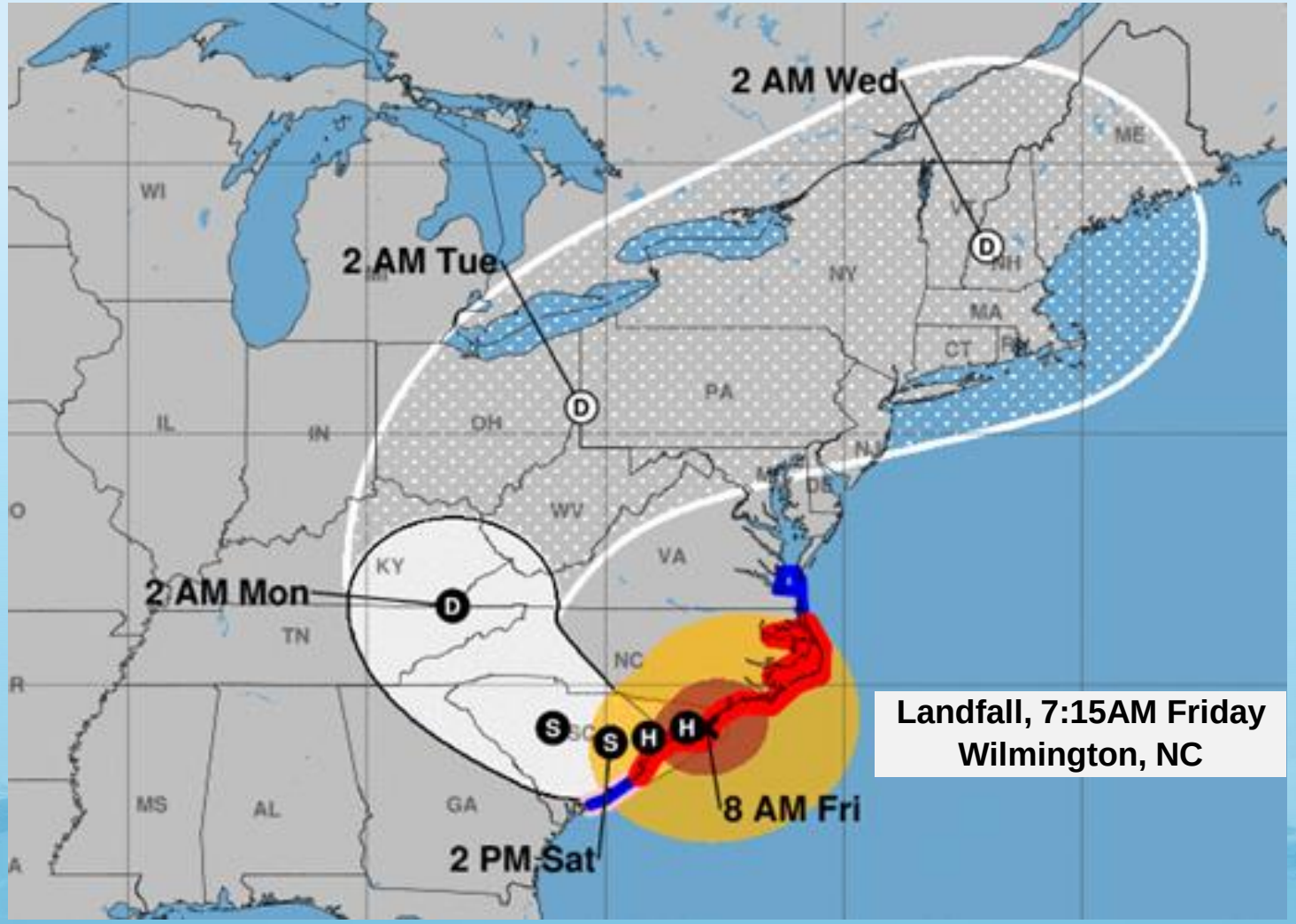
Source: National Hurricane Center

Hurricane Florence Forecast (Thursday)



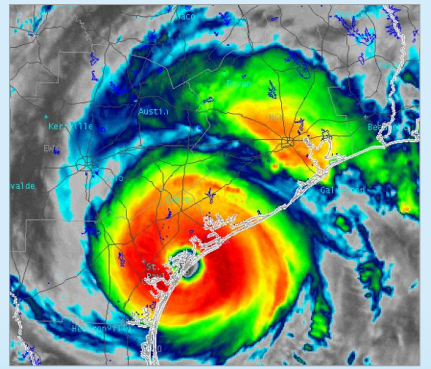
Source: National Hurricane Center

Hurricane Florence Forecast (Friday)



Source: National Hurricane Center

Storm Track for Hurricane Harvey

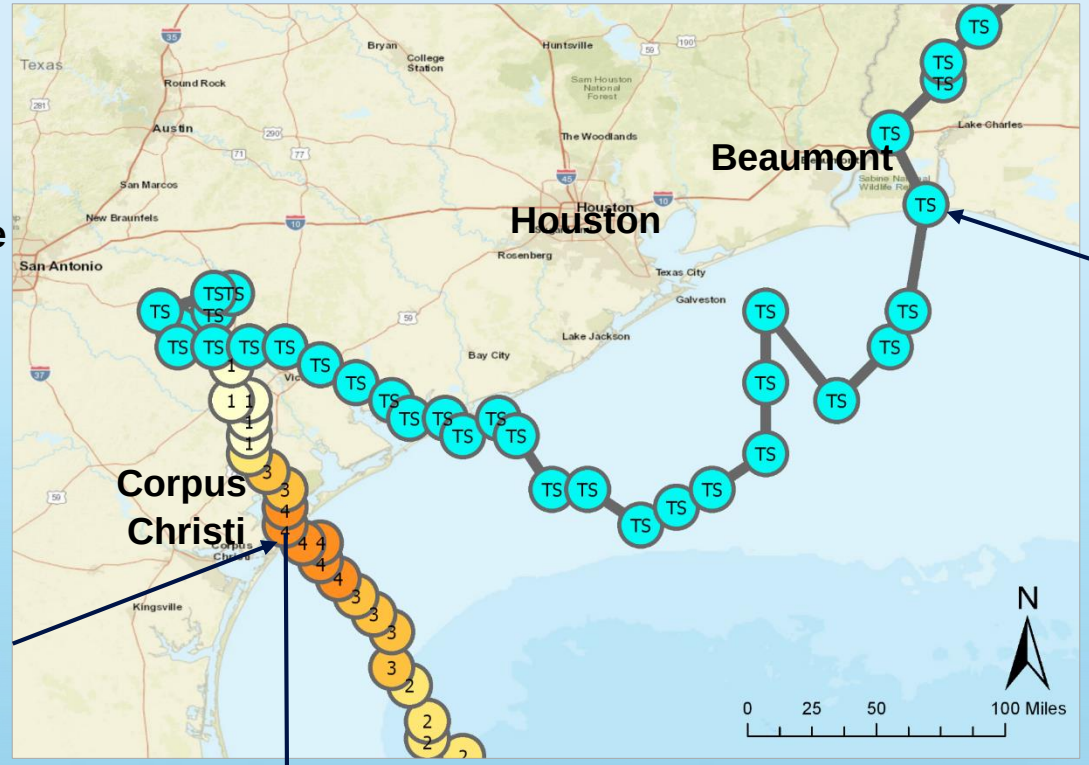


Strength

4
3
2
1

Hurricane Category

Tropical Storm

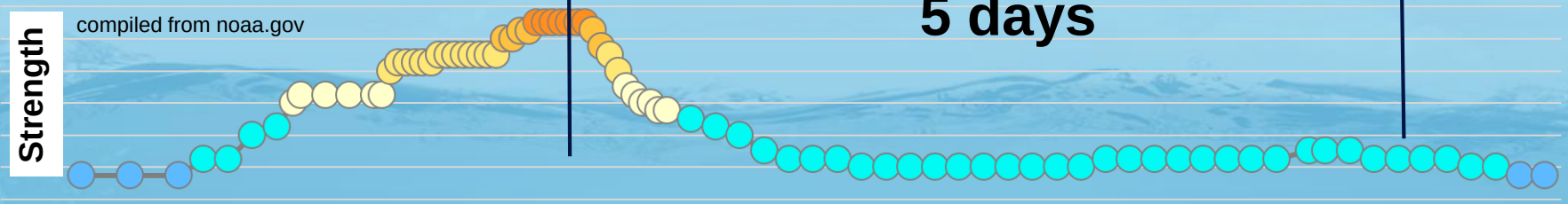


First Landfall as Category 4 Hurricane at 10PM on Friday 25 August

Second Landfall as Tropical Storm at 4 AM on Weds 30 August

5 days

compiled from noaa.gov



Wednesday Thursday Friday Saturday Sunday Monday Tuesday Wednesday

Floods Are Caused by …..

Rainfall from sky

Hurricane Harvey

Inundation from rivers

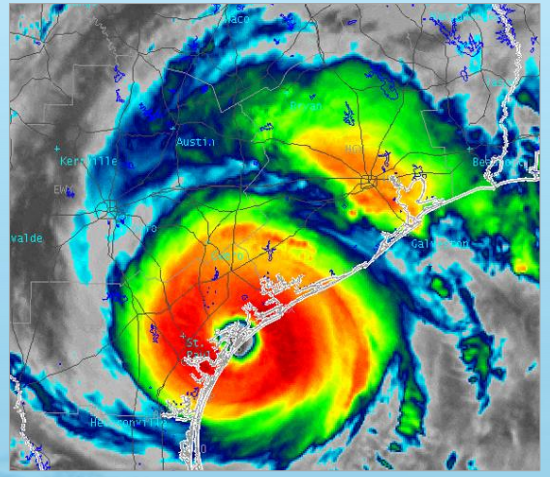
Coastal storm surge

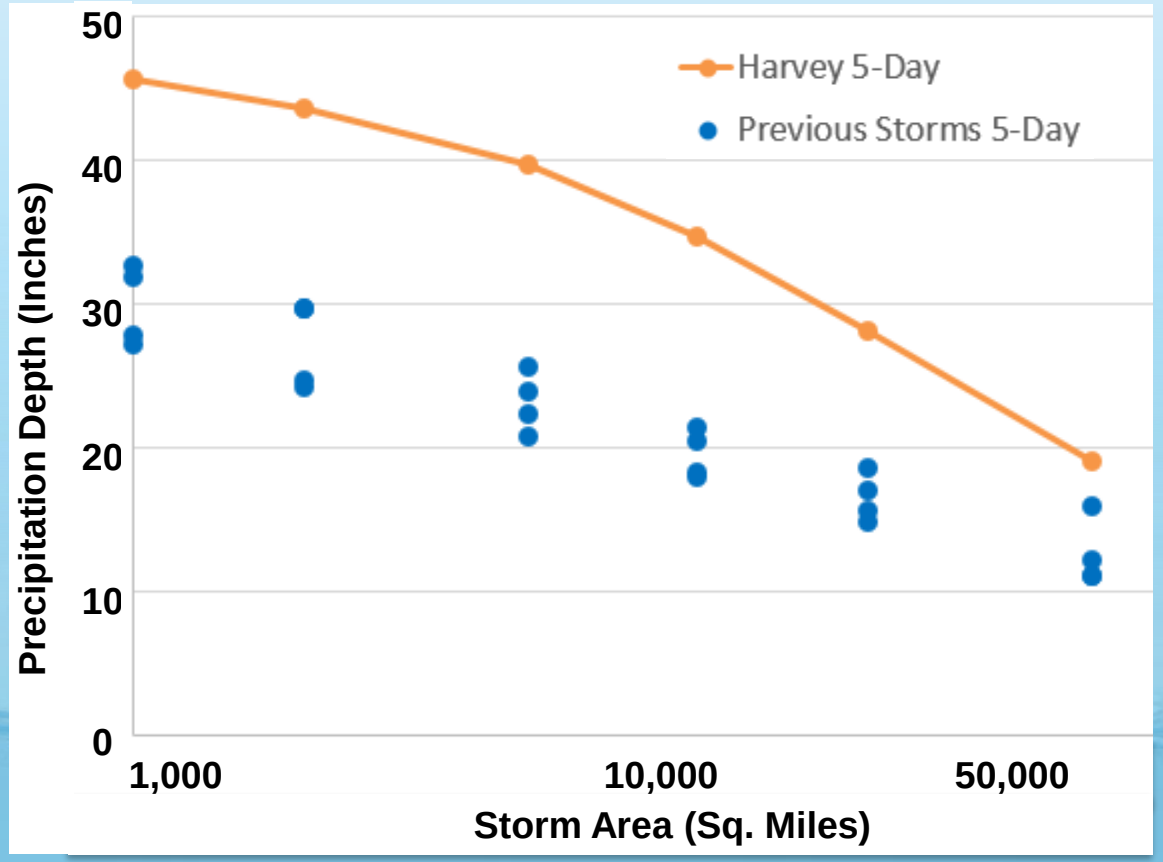
Hurricane Harvey – Record Precipitation

Harvey **2-day** precipitation was the **worst recorded storm** in US history

Harvey **3-day** Precipitation averaged **5 inches more** than previous worst storms

Harvey **5-day** Precipitation averaged ***11 inches more*** than previous worst storms





Data Sources: NWS River Forecast Centers; Applied Weather Associates, Inc., NASA.
Analysis: John Nielsen-Gammon and Brent McRoberts, Texas A&M University

Texas Division of Emergency Management, Austin

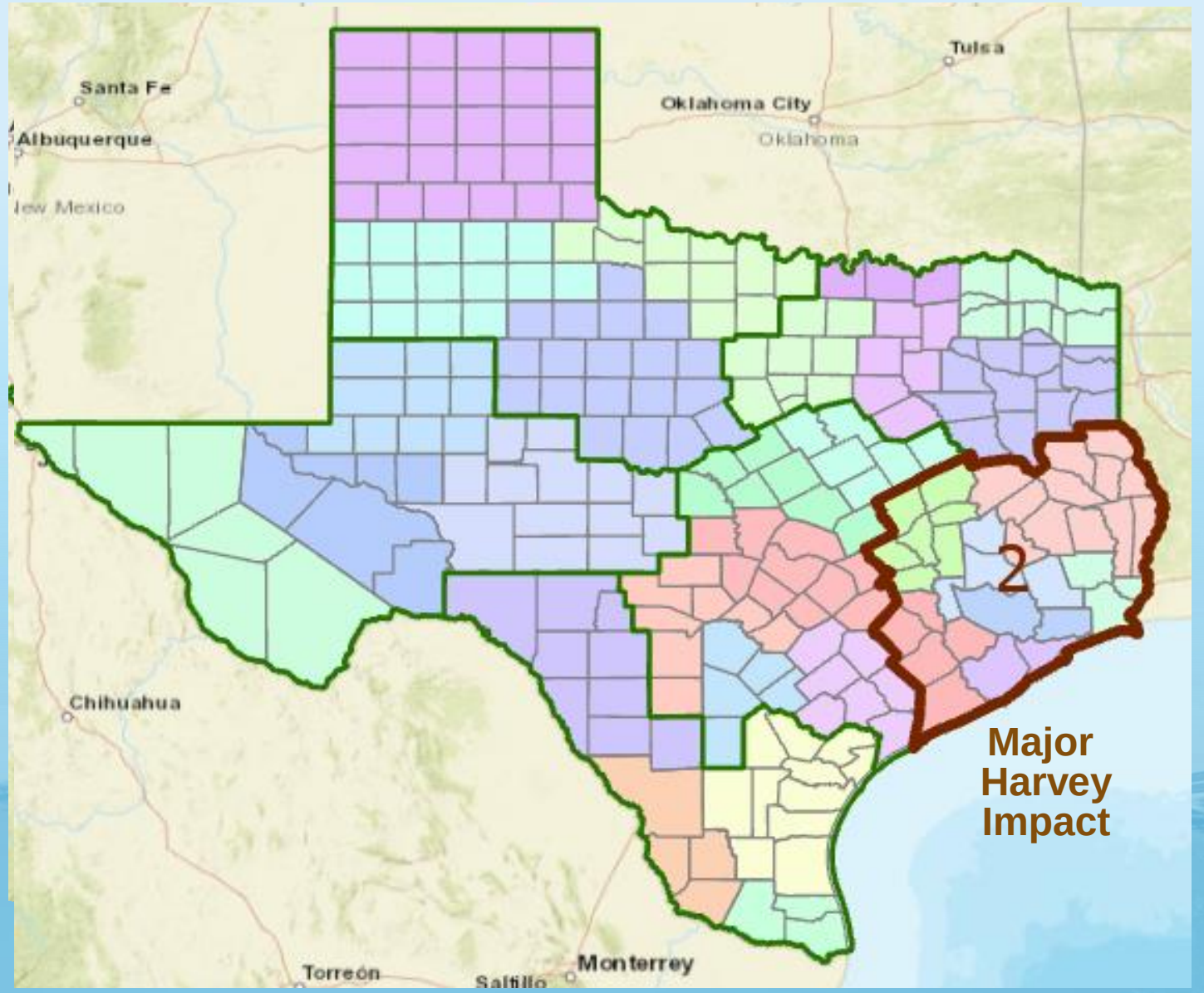
State Operations

Regions

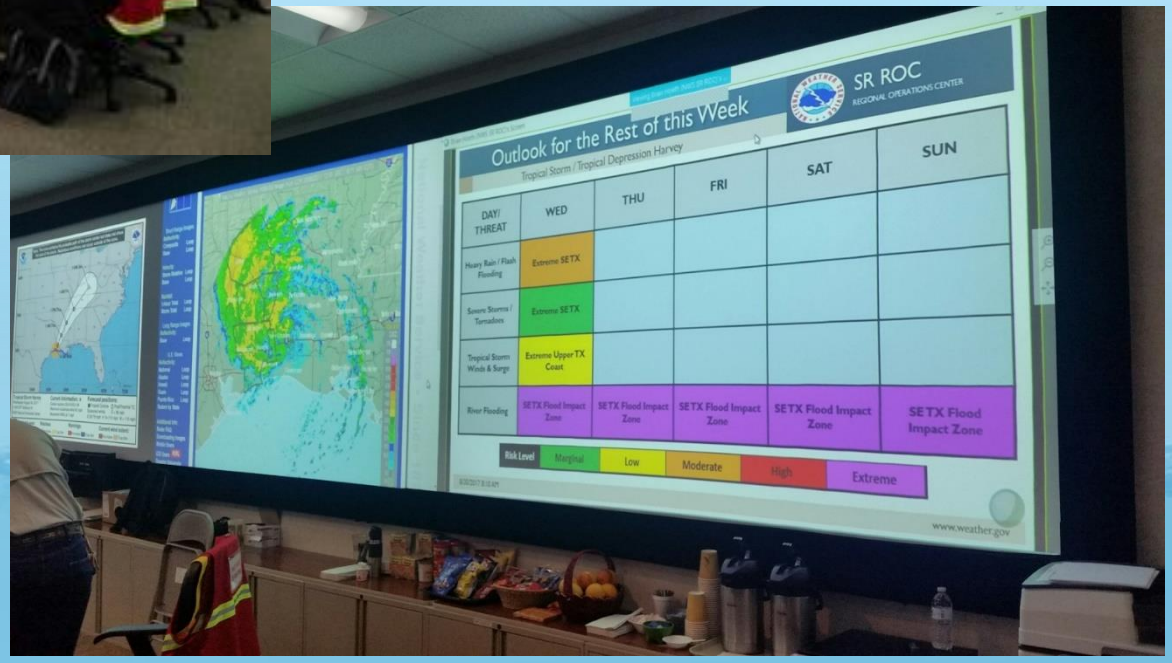
Districts

Counties

Chief Nim Kidd
Director, TDEM



State Emergency Operations Center in Austin



Death Toll:

Harvey: 80

Katrina: 1800

Helicopter Rescues in Beaumont

Day 5: Tuesday 29 August

26 inches (660 mm) of rain fell on Beaumont overnight

Beaumont became like Venice

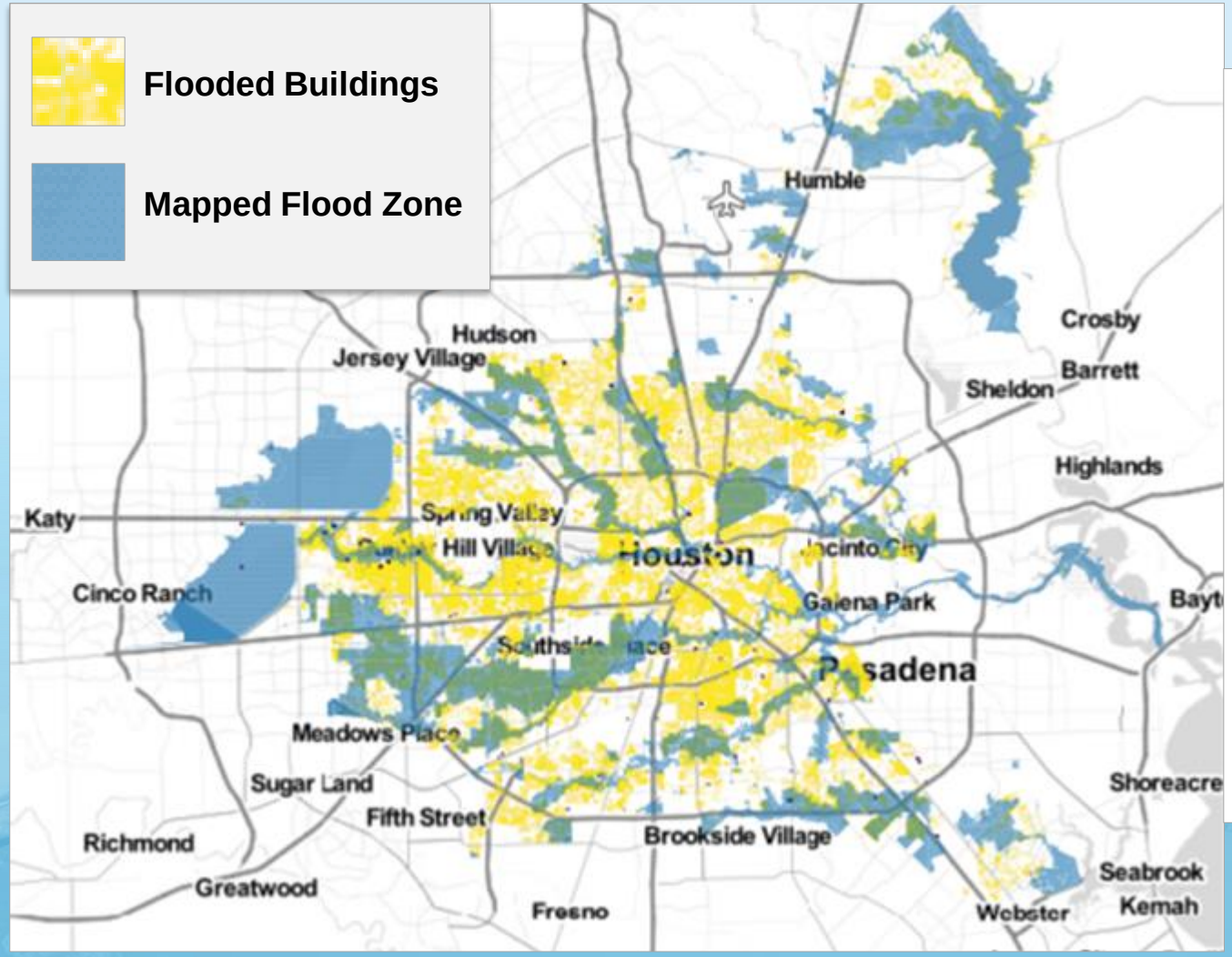
All 26 Urban Search and Rescue teams mobilized across nation

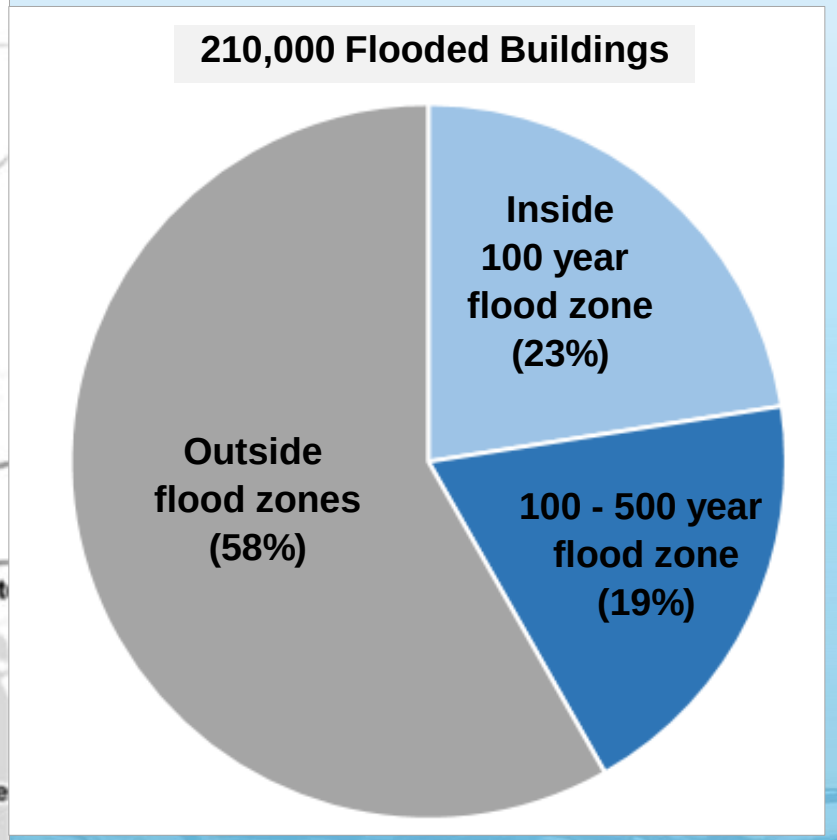
Air space above city completely filled with helicopters

https://www.nbcnews.com/storyline/hurricane-harvey/flash-floods-hit-beaumont-port-arthur-texas-harvey-makes-landfall-n797336

Flooded Residential Buildings in Houston

Flood covered 64% of area of City of Houston

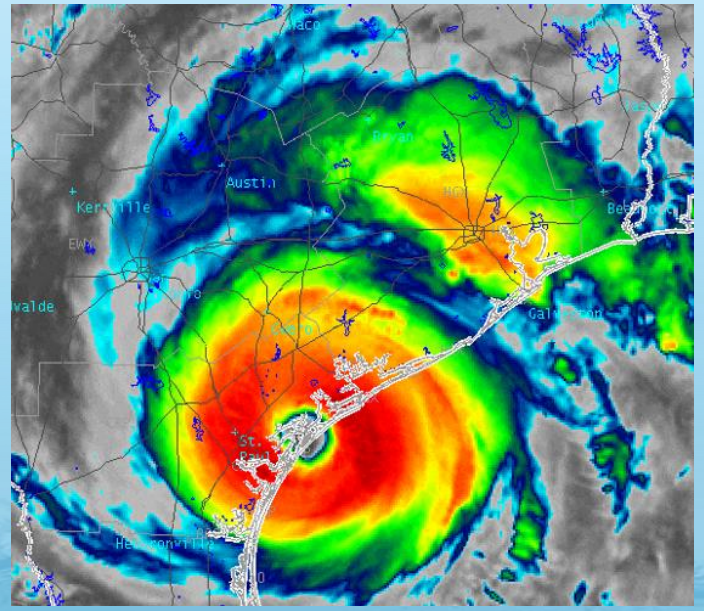




Source: City of Houston, Civis, Dewberry

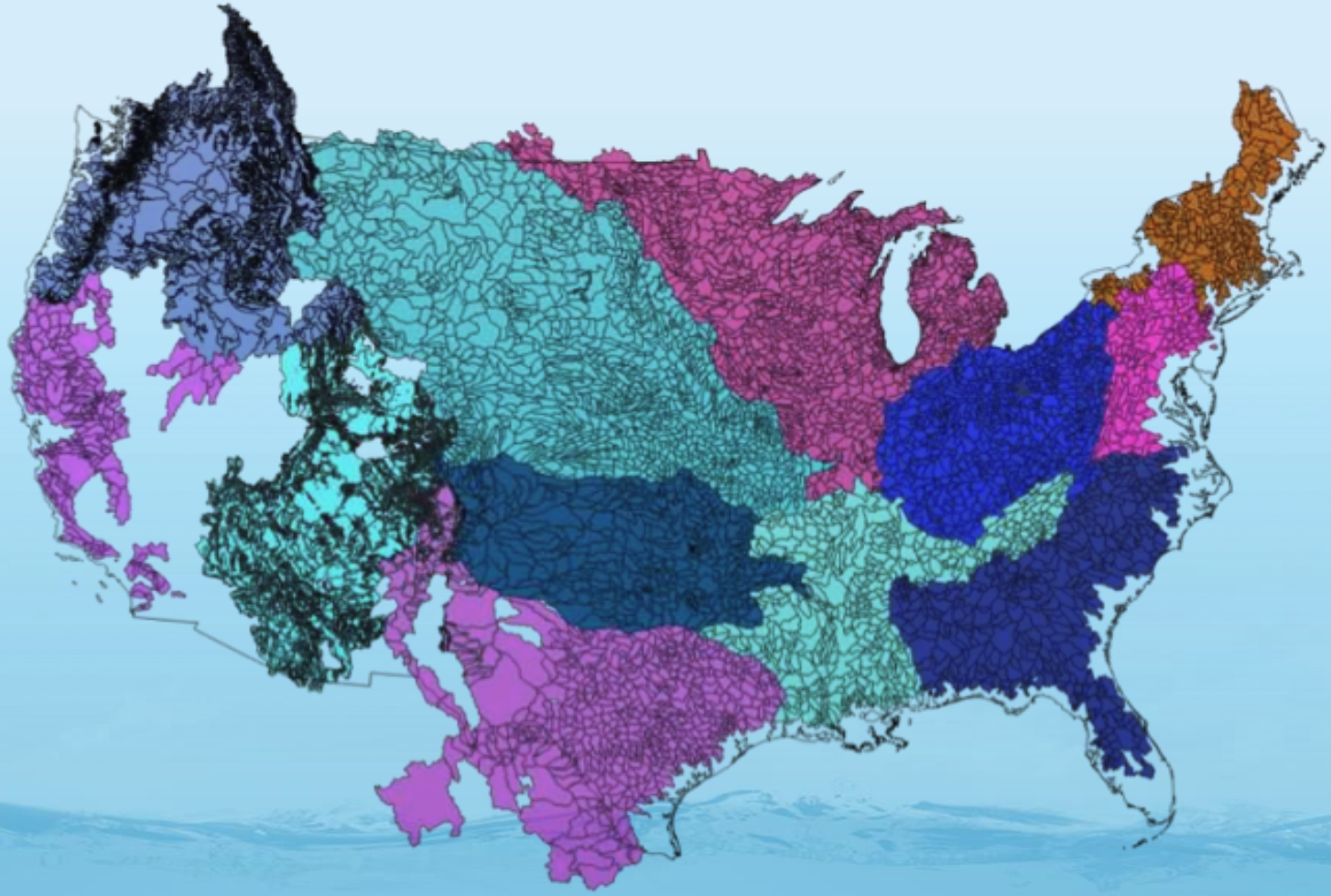
Hurricane Harvey

- Hurricane Harvey … and Florence
- *Flood forecasting*
- Texas Flood Response System
- How can we do better?



How Flood Forecasting is Done Now

- Regional River Forecast Centers
- Do flood forecasts for points on larger rivers and streams
- 48 to 72 hours ahead



West Gulf River Forecast Center in Fort Worth, Tx

An Opportunity

New National Water Center established on the Tuscaloosa campus of University of Alabama by the National Weather Service and federal agency partners

Has a mission to assess hydrology in a new way at the continental scale for the United States

Goal: Centralized Flood Forecasting

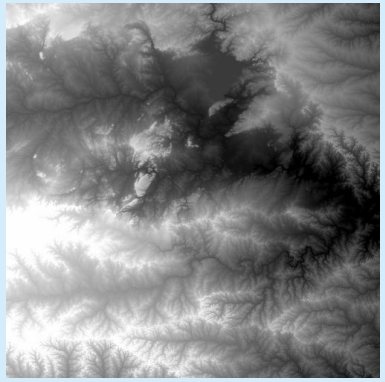
I proposed: Bring in the academic community and rapidly prototype a new national flood forecasting system in one year … this has led to annual Summer Institutes for graduate student research

CUAHSI
UNIVERSITIES ALLIED FOR WATER RESEARCH

Inaugural Meeting – May, 2014

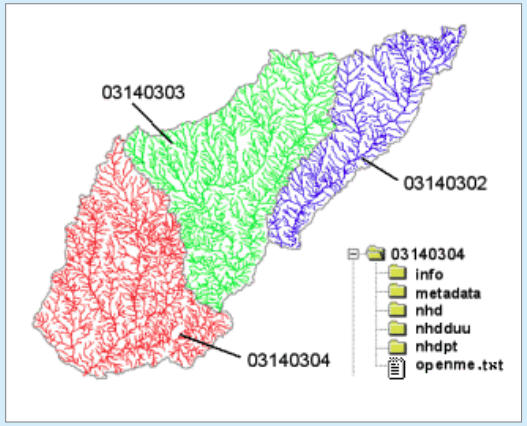
Geographic Information Systems

Foundation for a National Flood Forecasting for the United States



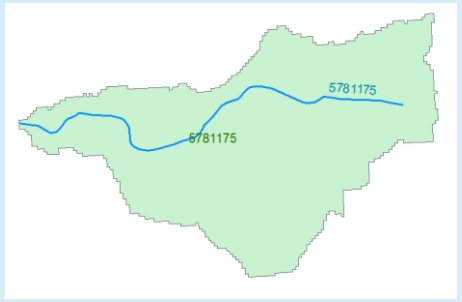
National Elevation Dataset

National Hydrography Dataset

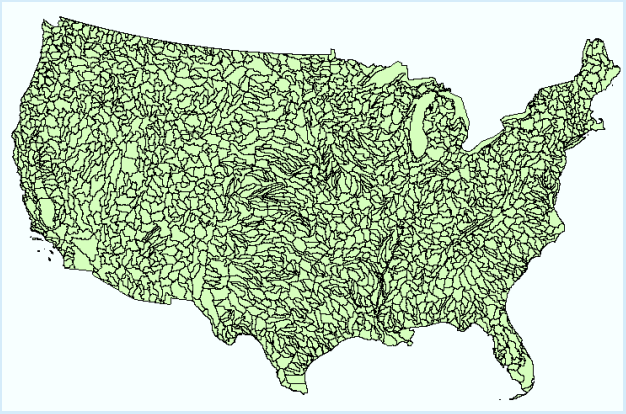


NHDPlus Dataset

2.7 million reach catchments in US
average area 3 km^2
reach length 2 km
Uniquely labelled

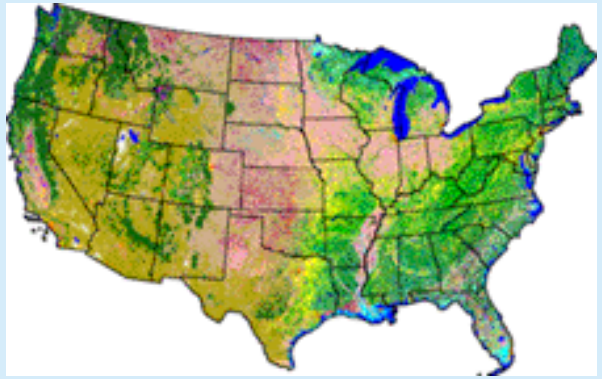


20 years to complete and integrate national data sets

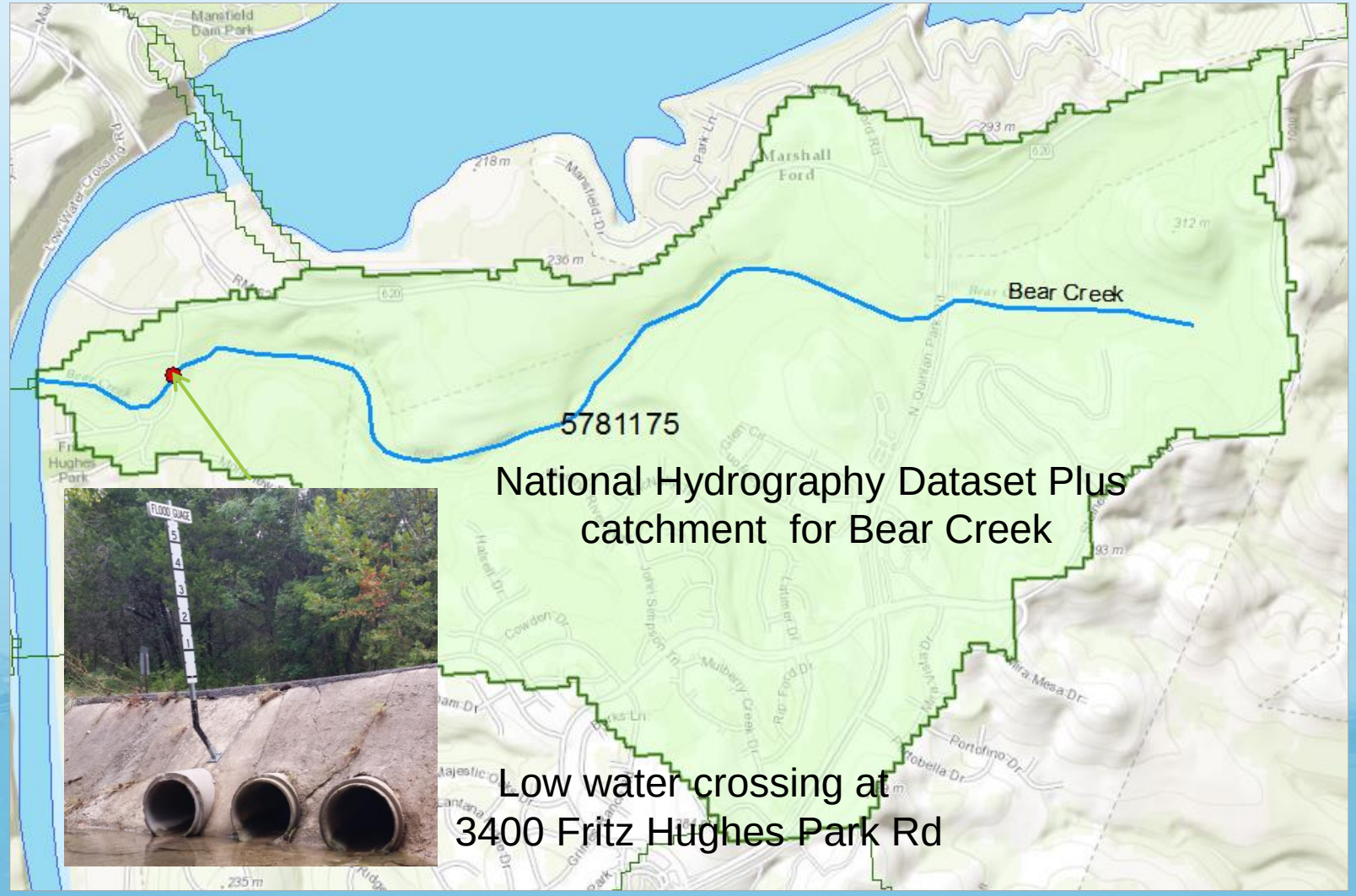


Watershed Boundary Dataset

National Land Cover Dataset



Flood Information for Fritz Hughes Park Rd near Lake Travis



Texas Advanced Computing Center at UT Austin

used to build prototype of National Water Model

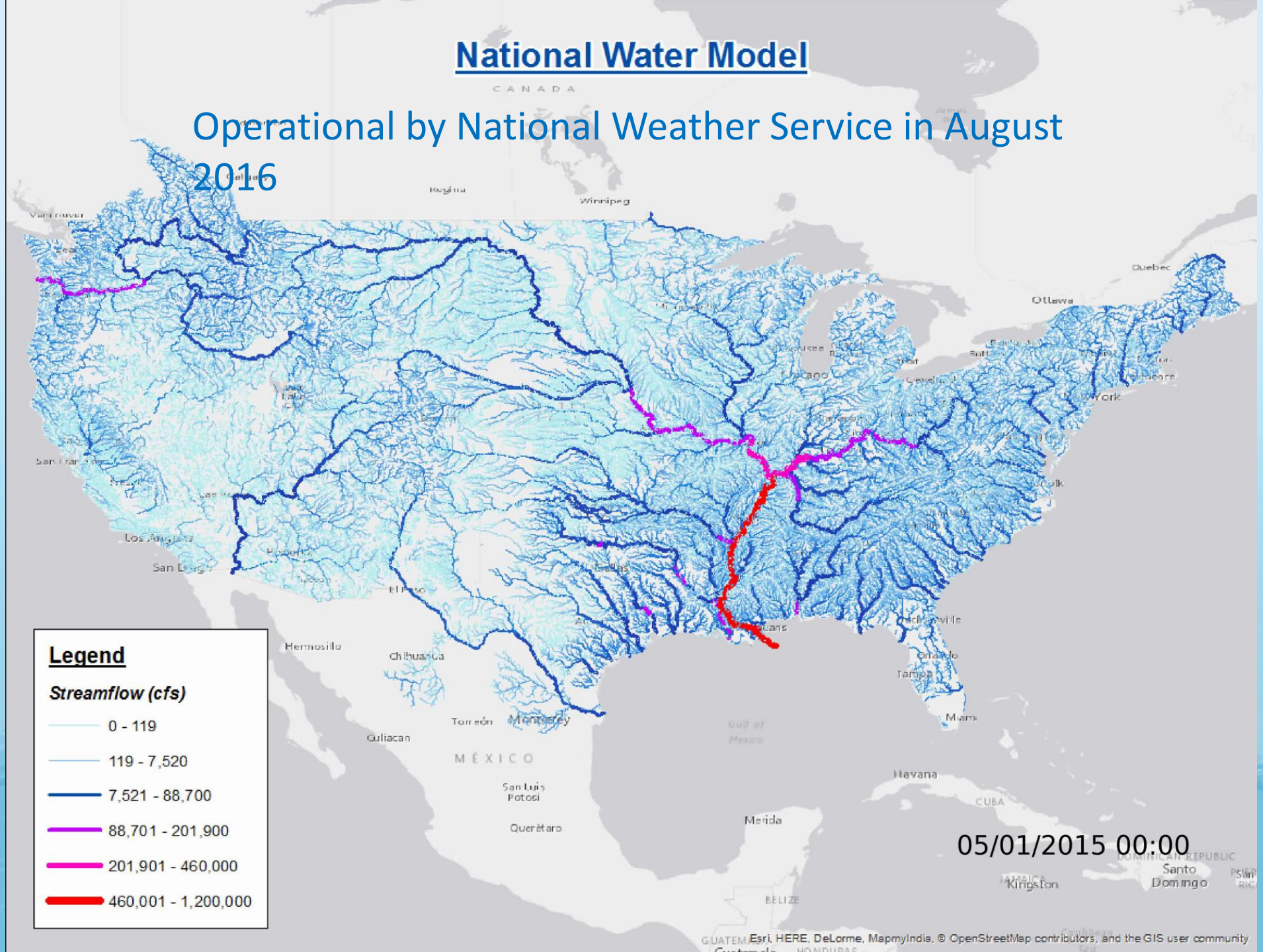
THE UNIVERSITY OF TEXAS AT AUSTIN

NSF

Largest academic supercomputer in the United States

National Water Model

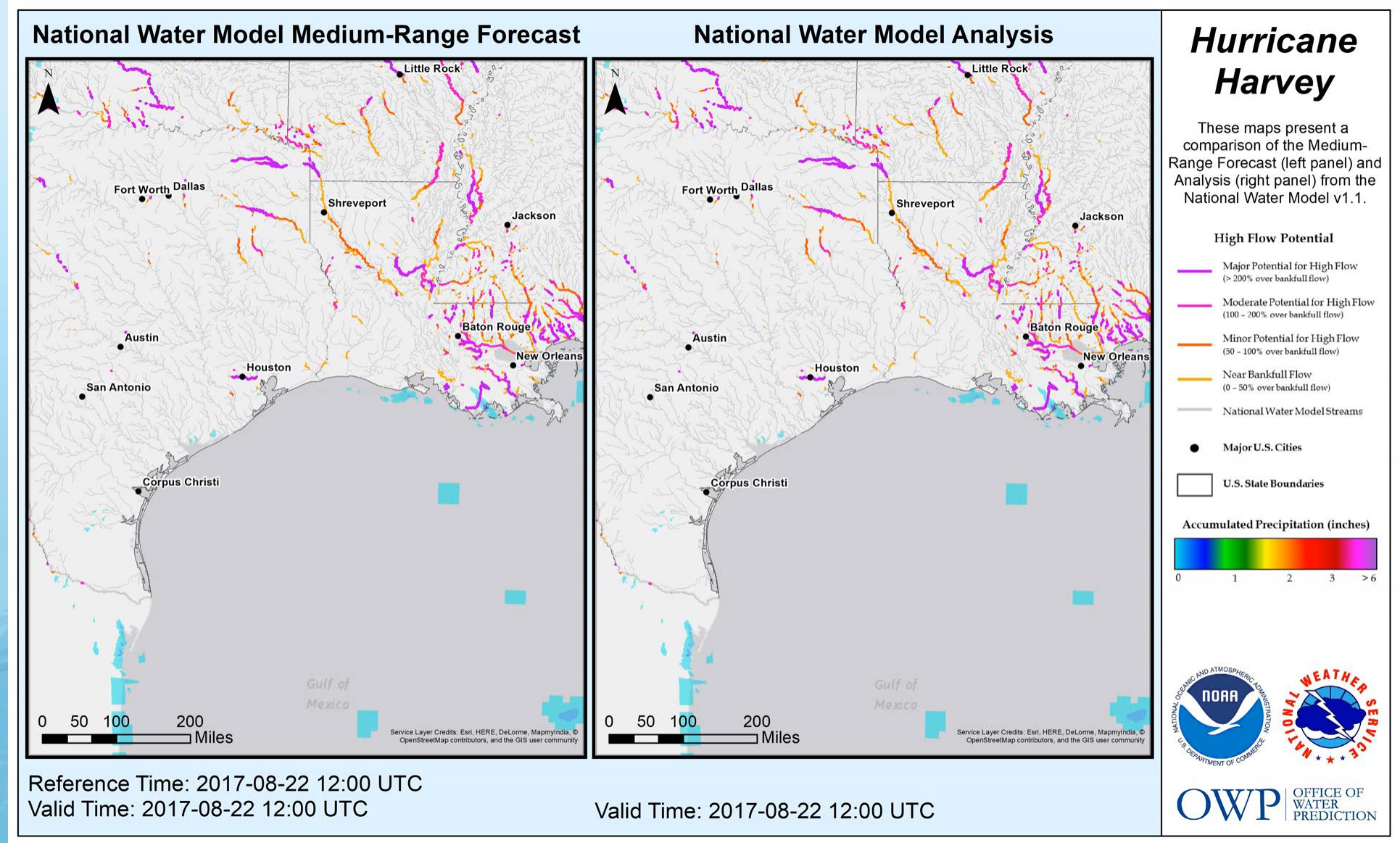
Operational by National Weather Service in August 2016



Hurricane Harvey and National Water Model

10-day Ahead Forecast

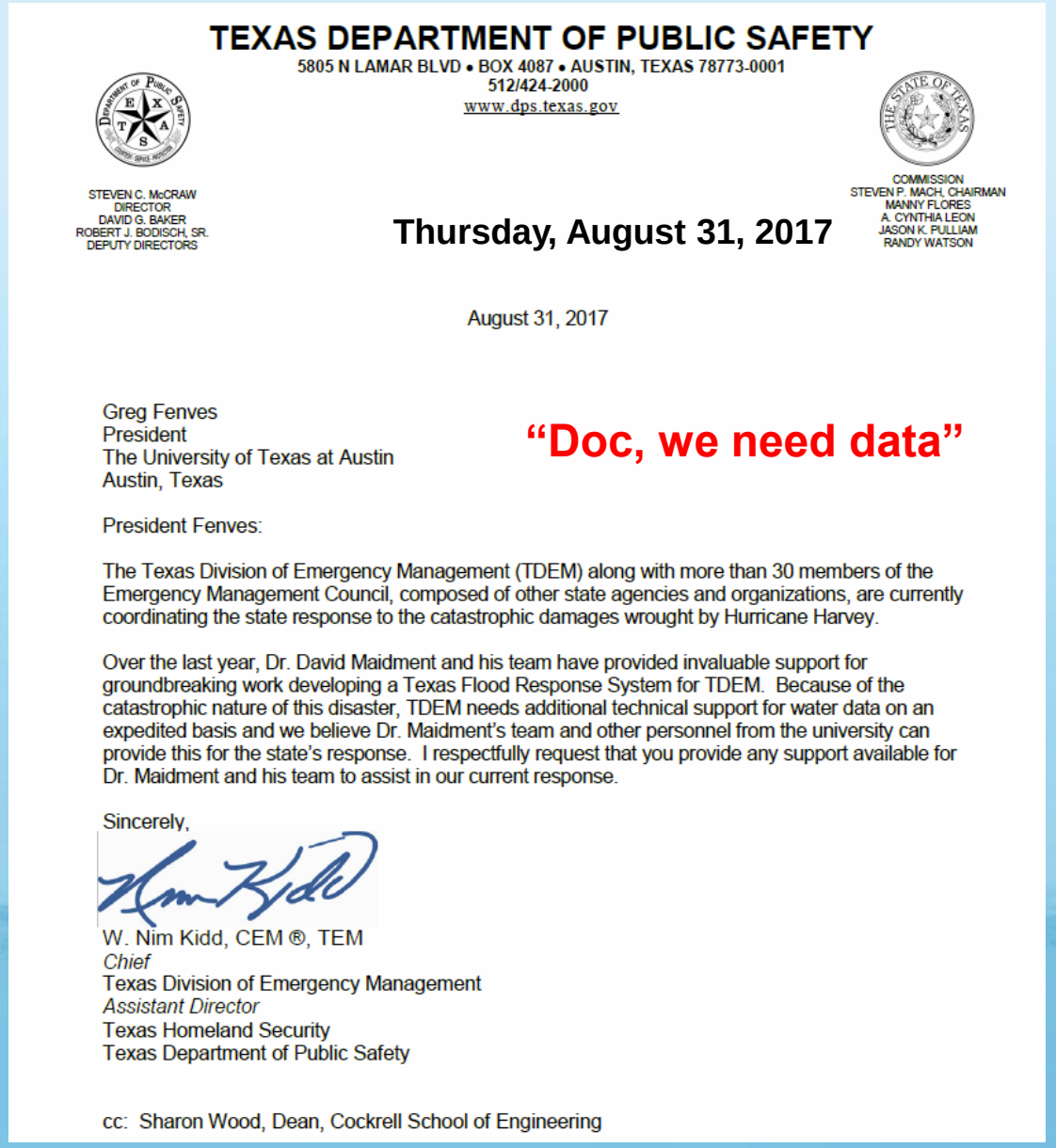
Actual



Letter from Chief Kidd to President Fenves, UT Austin

Over the last year, Dr. David Maidment and his team have provided invaluable support for groundbreaking work developing a ***Texas Flood Response System*** for TDEM.

Because of the catastrophic nature of this disaster, TDEM needs additional technical support for water data on an expedited basis and we believe Dr. Maidment's team and other personnel from the university can provide this for the state's response.



TEXAS DEPARTMENT OF PUBLIC SAFETY

5805 N LAMAR BLVD • BOX 4087 • AUSTIN, TEXAS 78773-0001
512/424-2000
www.dps.texas.gov

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JASON K. PULLIAM
RANDY WATSON

Thursday, August 31, 2017

August 31, 2017

Greg Fenves
President
The University of Texas at Austin
Austin, Texas

"Doc, we need data"

President Fenves:

The Texas Division of Emergency Management (TDEM) along with more than 30 members of the Emergency Management Council, composed of other state agencies and organizations, are currently coordinating the state response to the catastrophic damages wrought by Hurricane Harvey.

Over the last year, Dr. David Maidment and his team have provided invaluable support for groundbreaking work developing a Texas Flood Response System for TDEM. Because of the catastrophic nature of this disaster, TDEM needs additional technical support for water data on an expedited basis and we believe Dr. Maidment's team and other personnel from the university can provide this for the state's response. I respectfully request that you provide any support available for Dr. Maidment and his team to assist in our current response.

Sincerely,

W. Nim Kidd, CEM ®, TEM
Chief
Texas Division of Emergency Management
Assistant Director
Texas Homeland Security
Texas Department of Public Safety

cc: Sharon Wood, Dean, Cockrell School of Engineering

Hurricane Harvey

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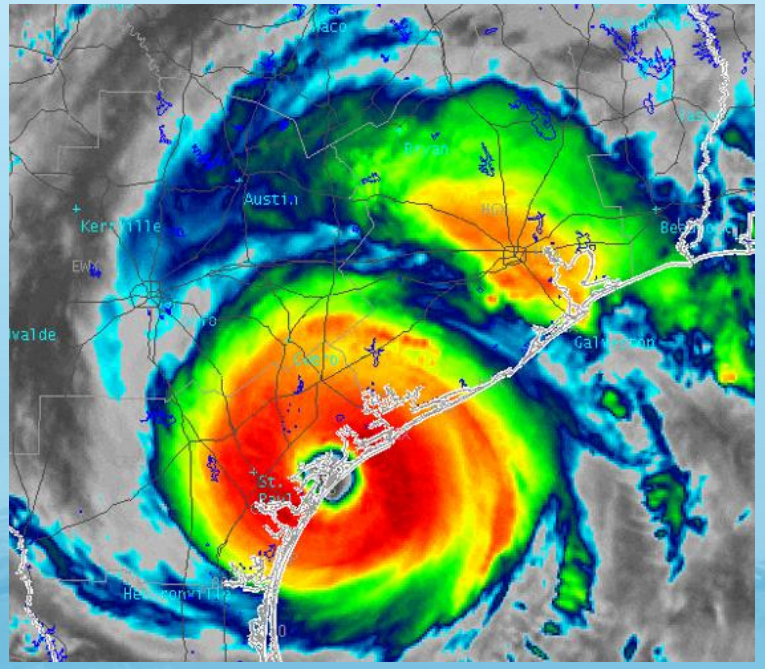
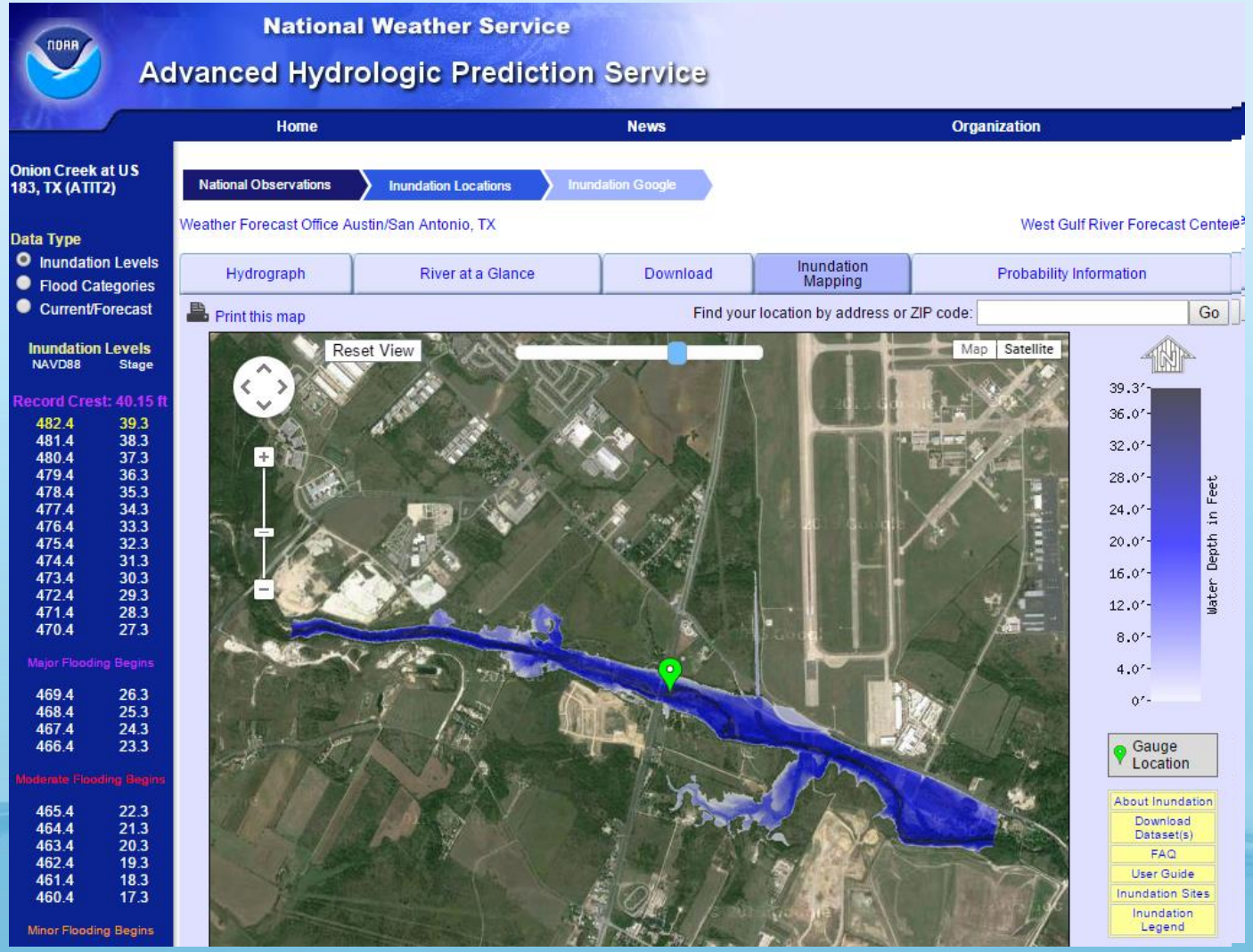


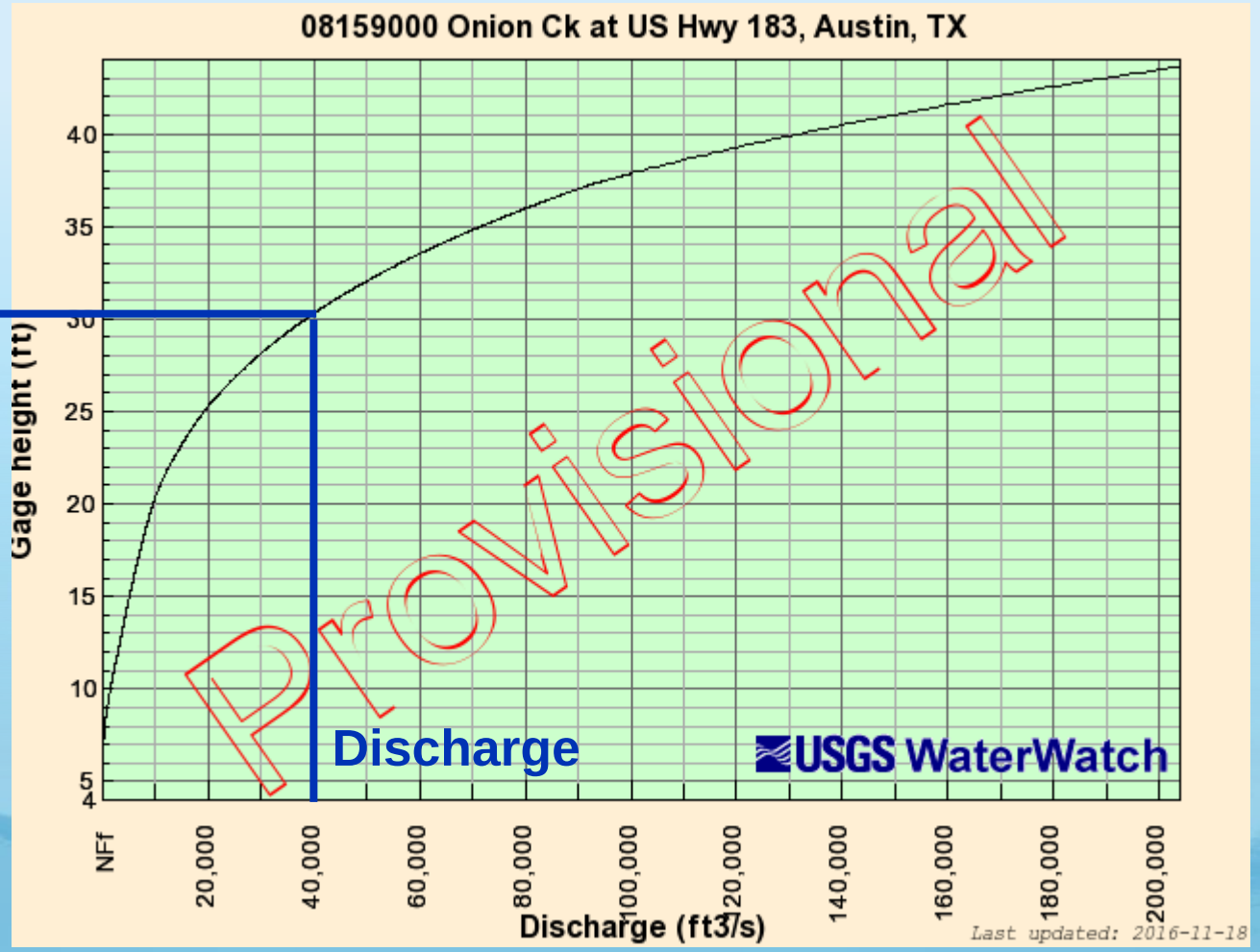
Real-Time Flood Inundation Mapping
Onion Creek at Highway 183



http://water.weather.gov/ahps2/inundation/inundation_google.php?gage=atit2

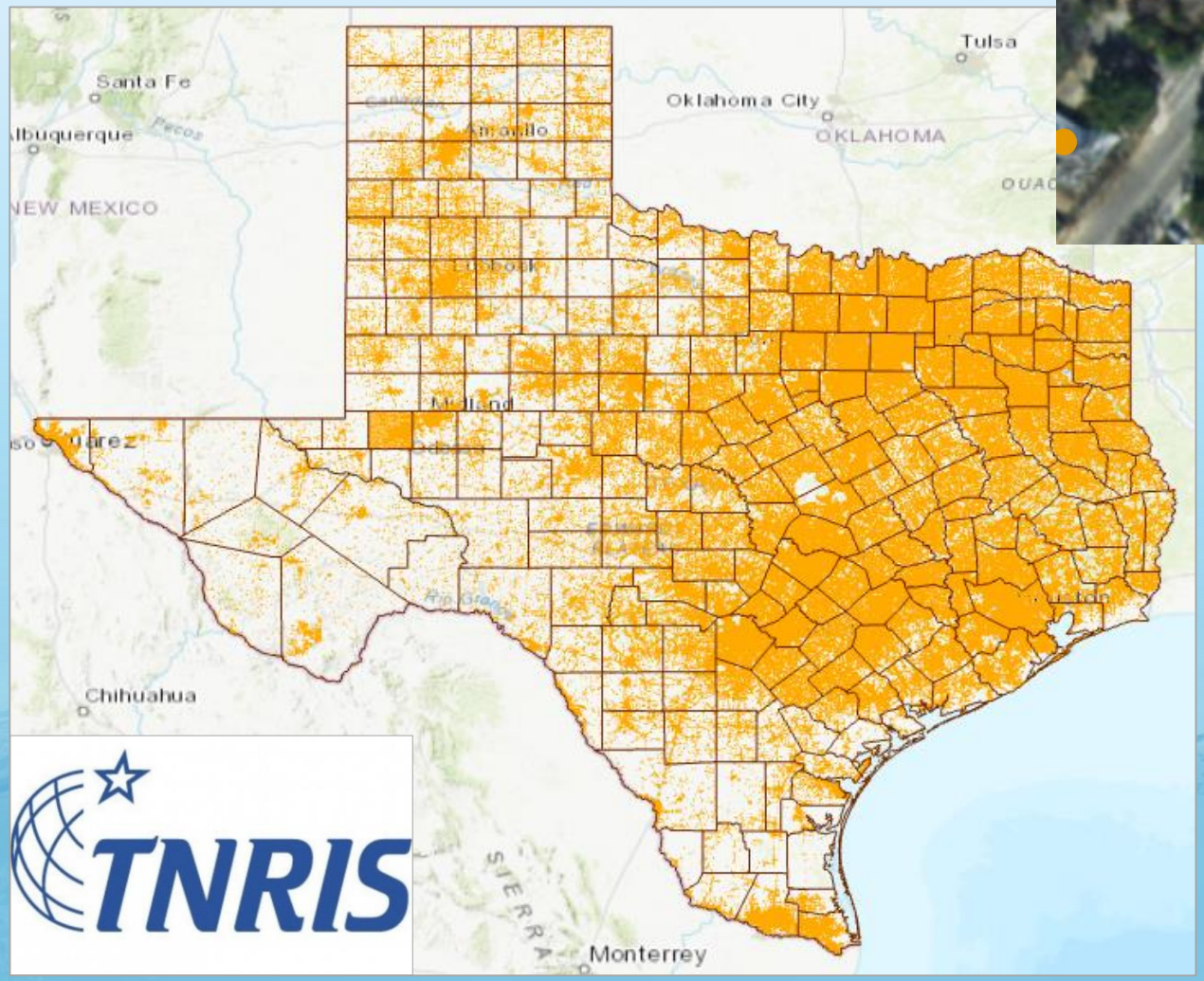
Rating Curve at a Stream Gage

Water Level



Texas Address Points

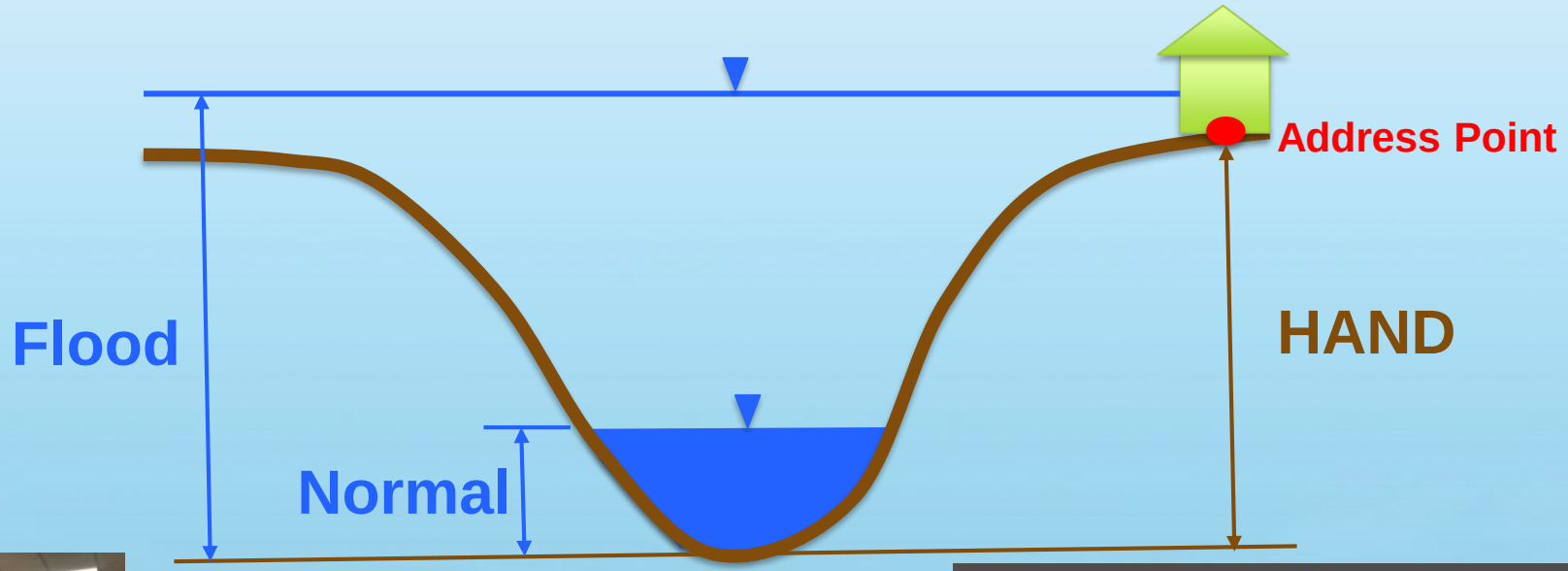
9.28 million points



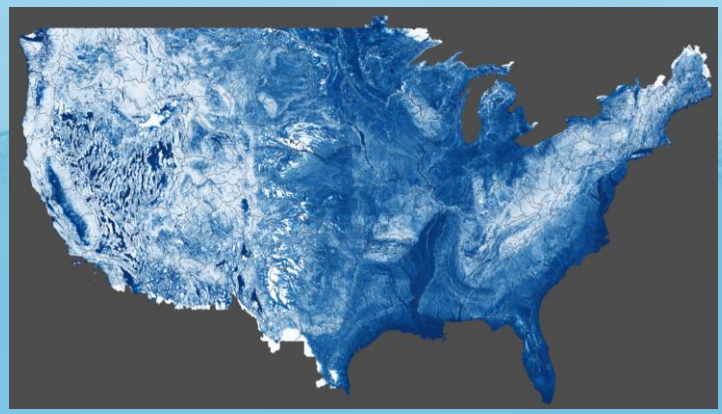
Point on every building used for dispatching emergency response vehicles by 911 systems

Method for Determining Flood Risk:
Height Above Nearest Drainage (HAND)

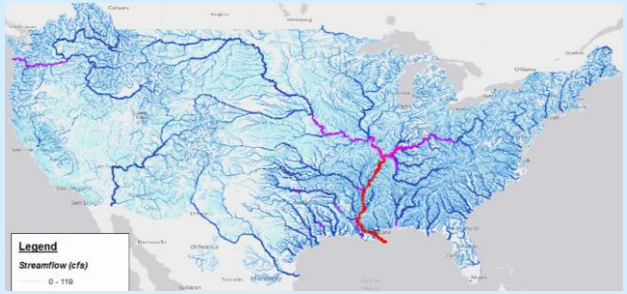
Flooding occurs when Water Depth is greater than HAND

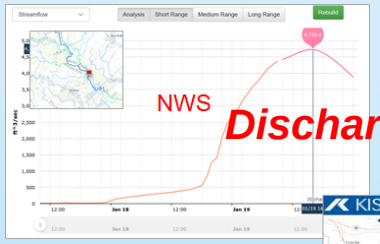


Computed for continental US



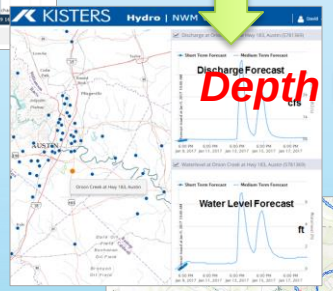
Texas Flood Response System





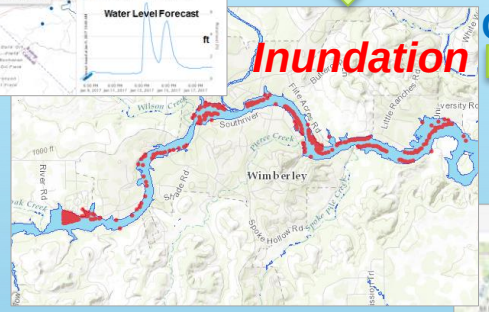
Discharge

Take discharge forecast from the National Water Model



Depth

Transform discharge to depth by rating curve or hydraulic model

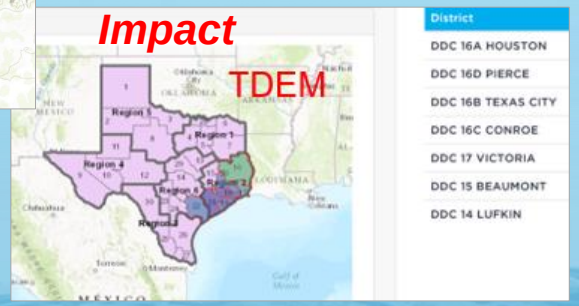


Inundation

Create flood inundation map from water depth

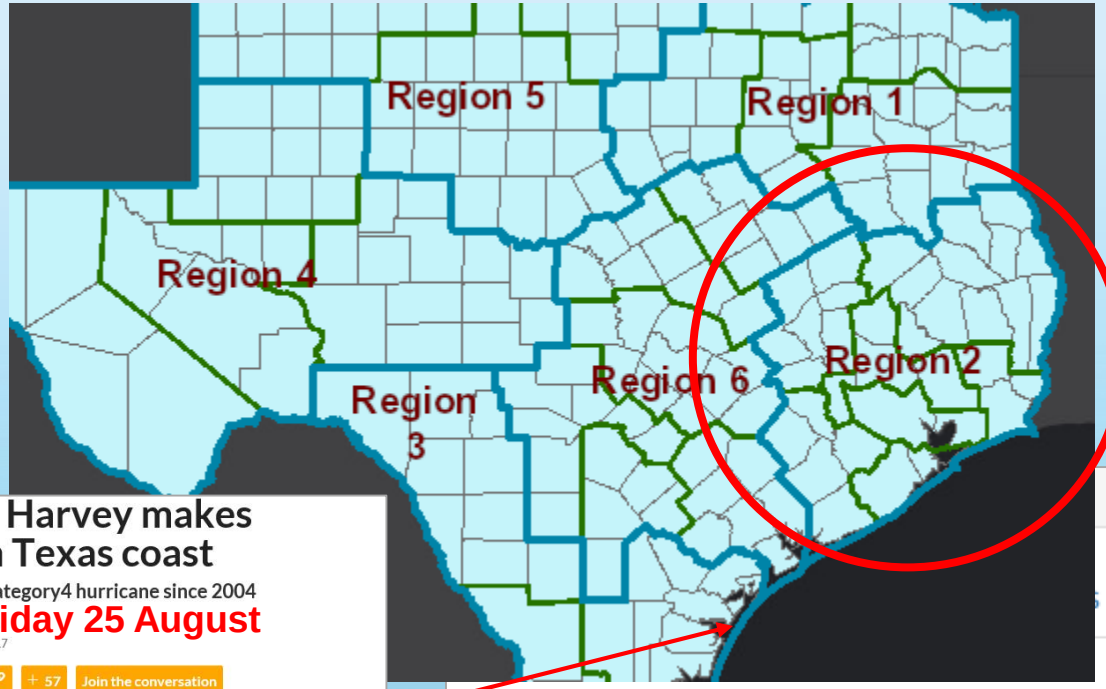
Impact

Assess impact on people and property



Flood emergency response depends on assessment of impact

Flood Impact from National Water Model forecast at 3PM Friday 25 August



Using National Water Model Medium Range forecast

Houston is going to get inundated

10 PM, Friday 25 August

DETAILS

Region	Address Count	Time At Max
Region 2	238465	8/29/2017 6:00:00 AM
Region 6	22120	8/27/2017
Region 1	3209	9/2/2017
Region 4	1761	8/27/2017 3:00:00 AM
Region 3	1425	9/4/2017 12:00:00 PM
Region 5	103	9/4/2017 6:00:00 AM

Buildings Damaged

Data: Texas Division of Emergency Management

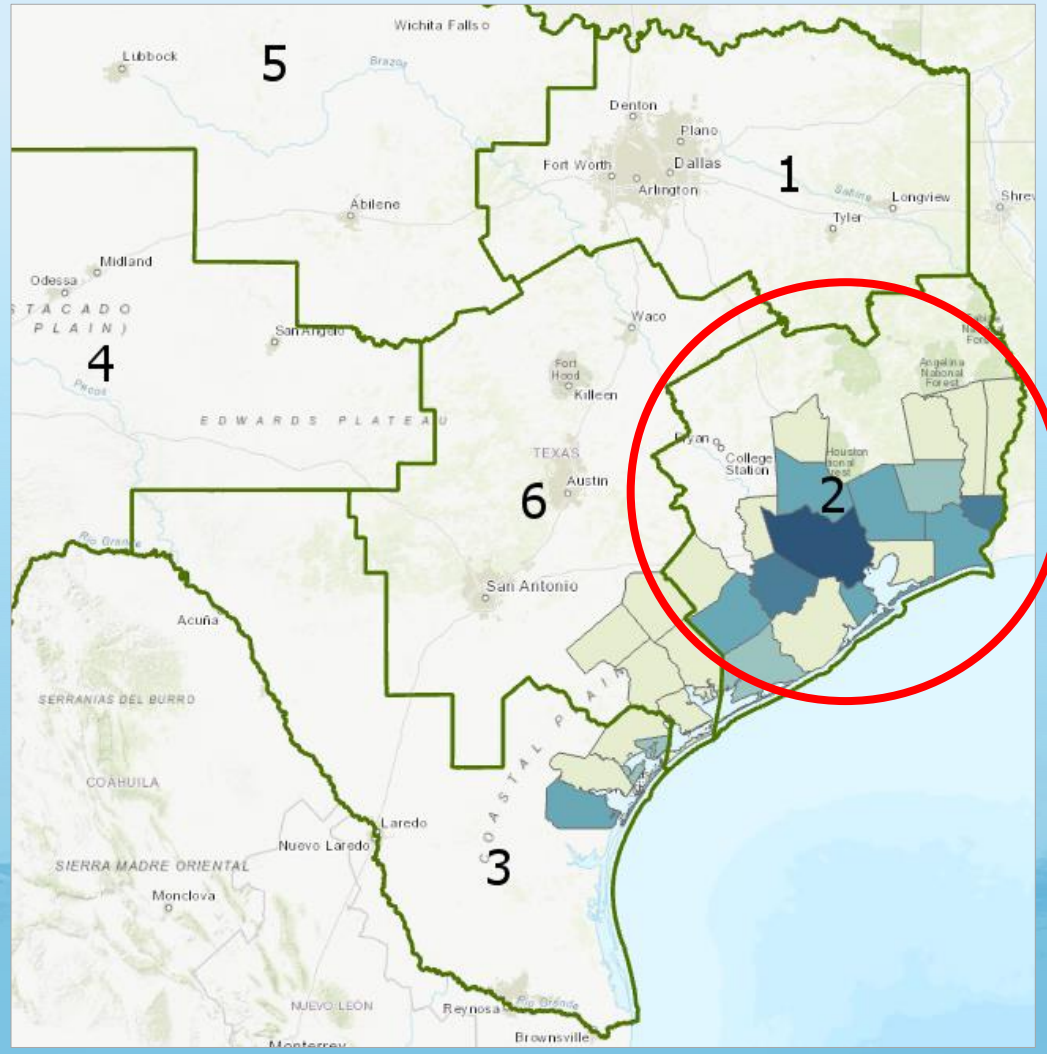
Total = 152,800

NWM Predicted Top 5 Counties

Harris
Fort Bend
Brazoria
Galveston
Montgomery

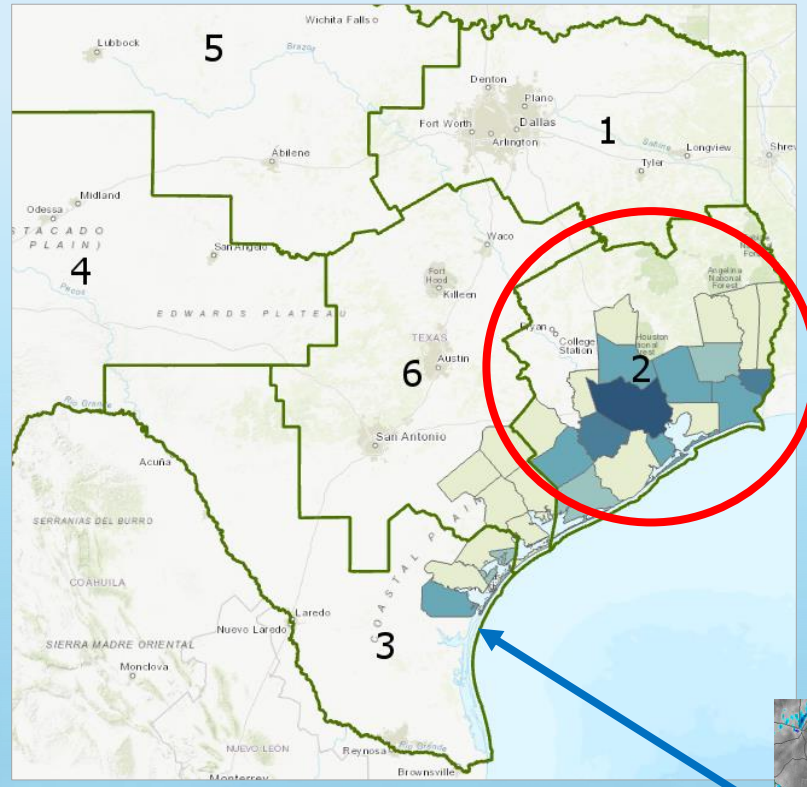
Actual Top 5 counties

Harris
Orange
Fort Bend
Montgomery
Jefferson

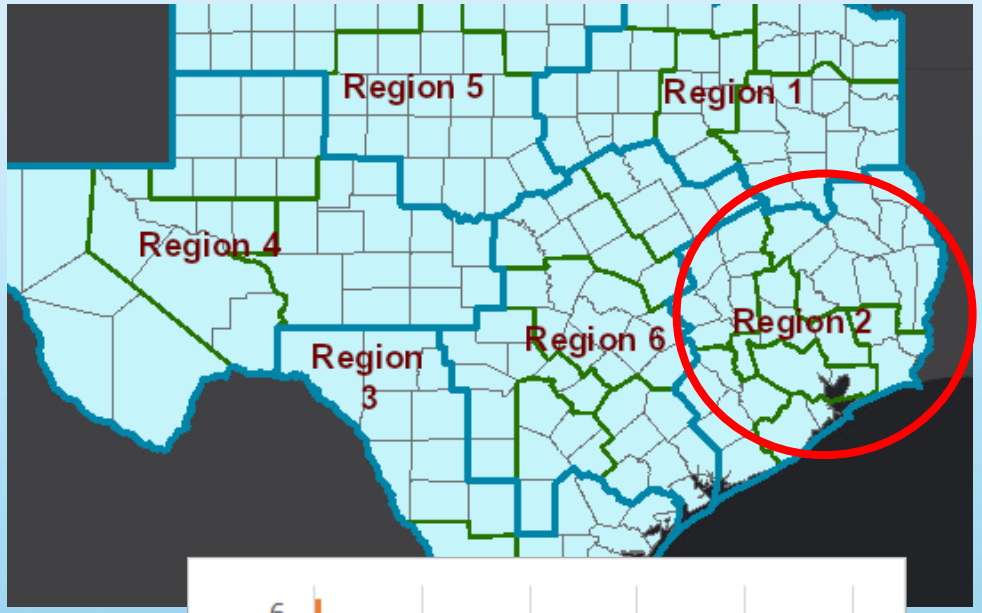


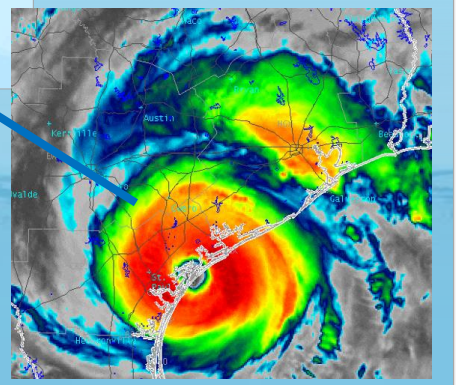
Texas Flood Response System correctly located the major damage zone before the hurricane reached the coast

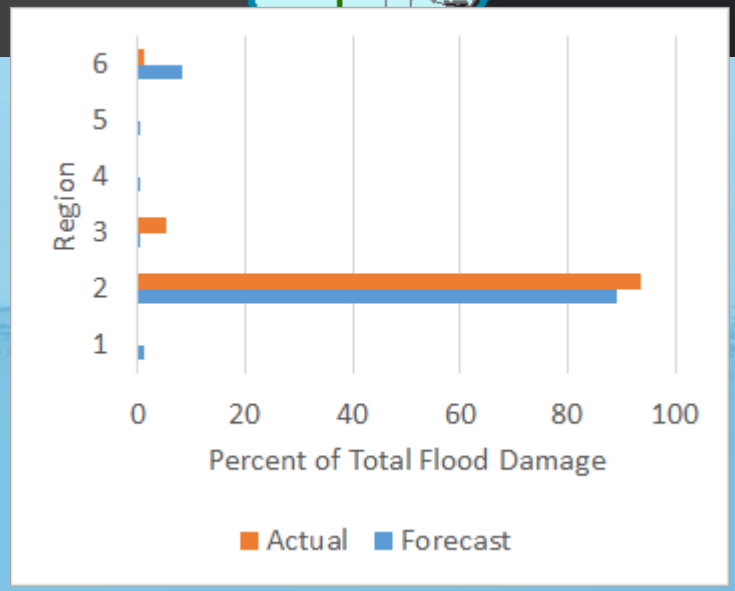
Actual Damage



Forecast Damage

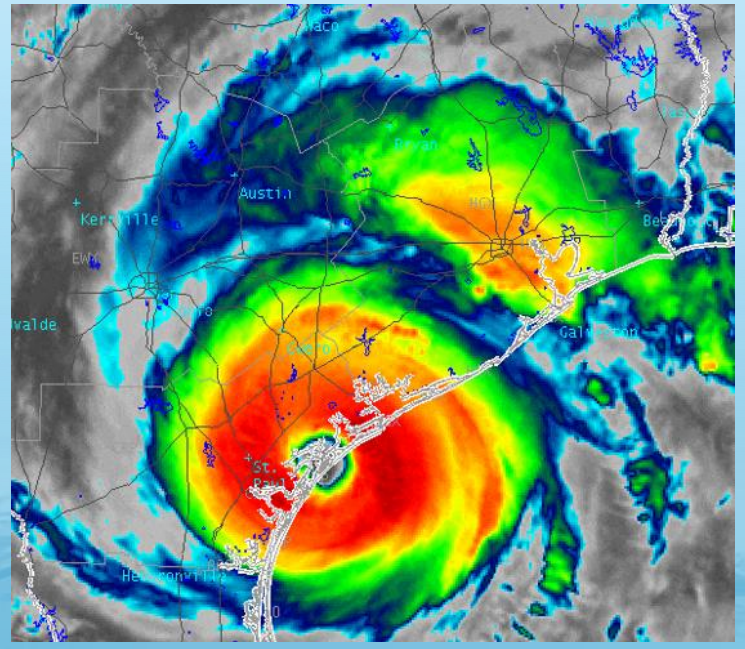






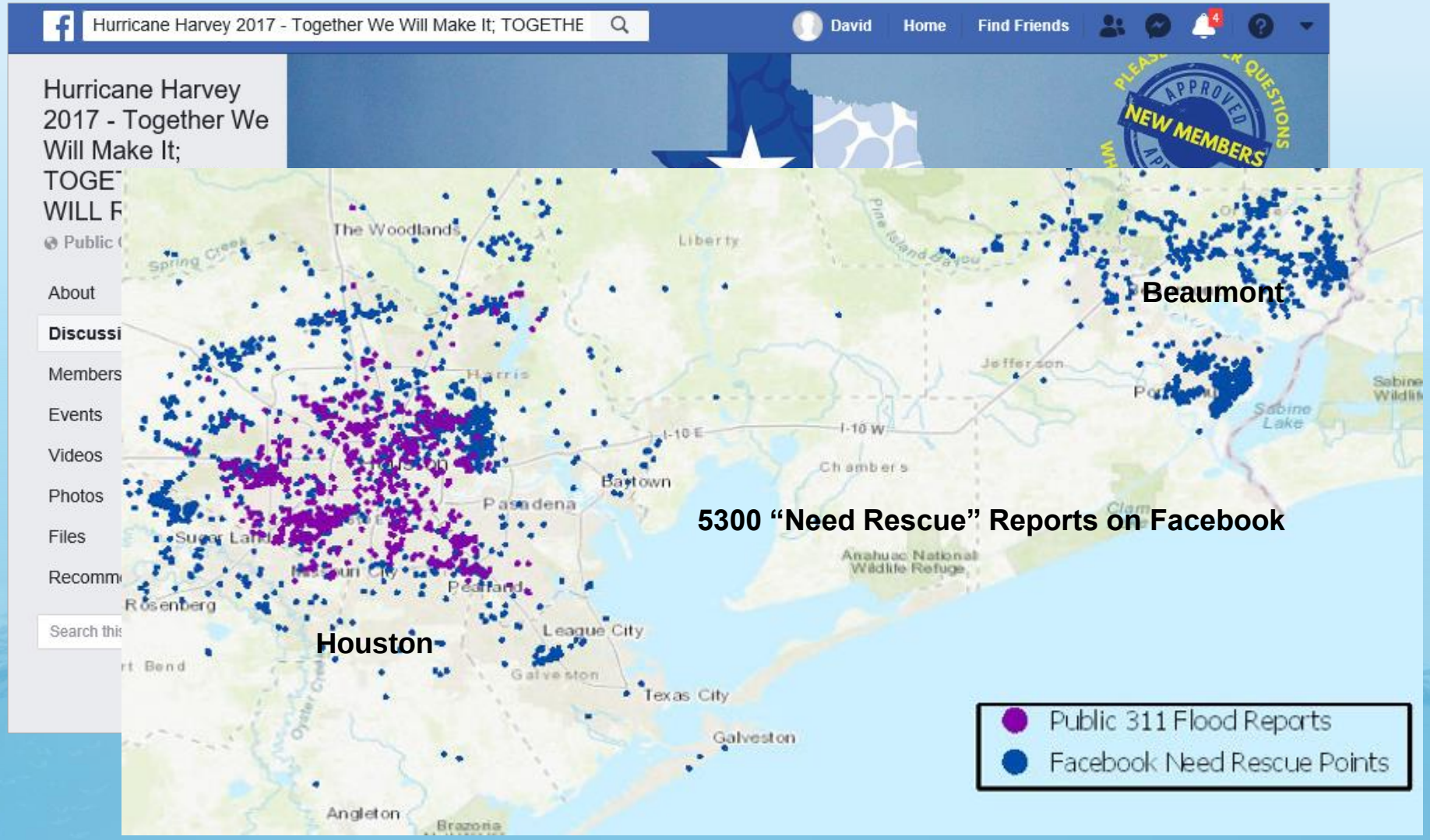
Hurricane Harvey

- Hurricane Harvey … and Florence
- Flood forecasting
- Texas Flood Response System
- ***How can we do better?***



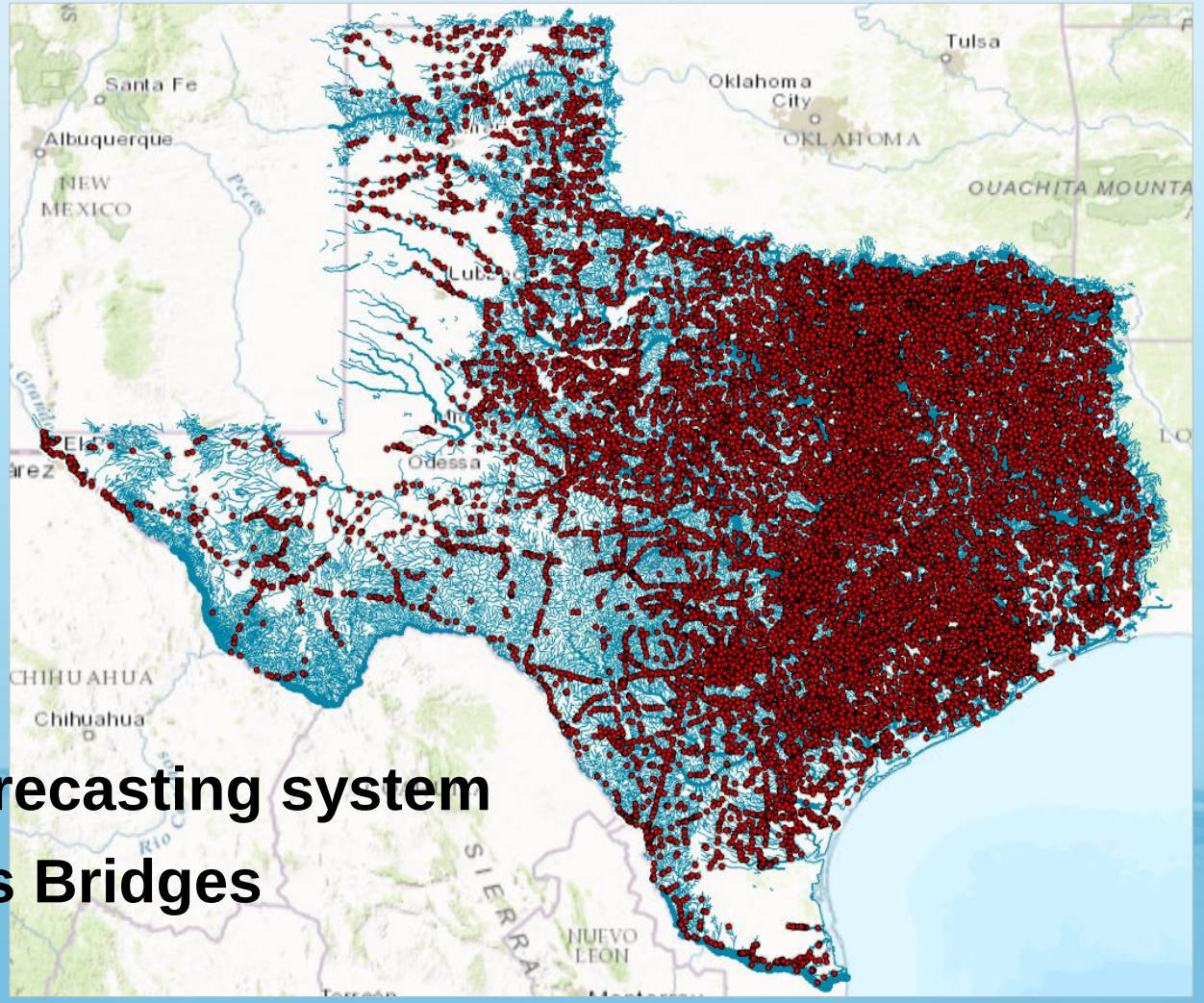
Facebook Page for Hurricane Harvey

121,000 members



Source: Isha Deo

27,000 Texas bridges on 15,700 stream reaches forecast by the National Water Model



Flood forecasting system for Texas Bridges

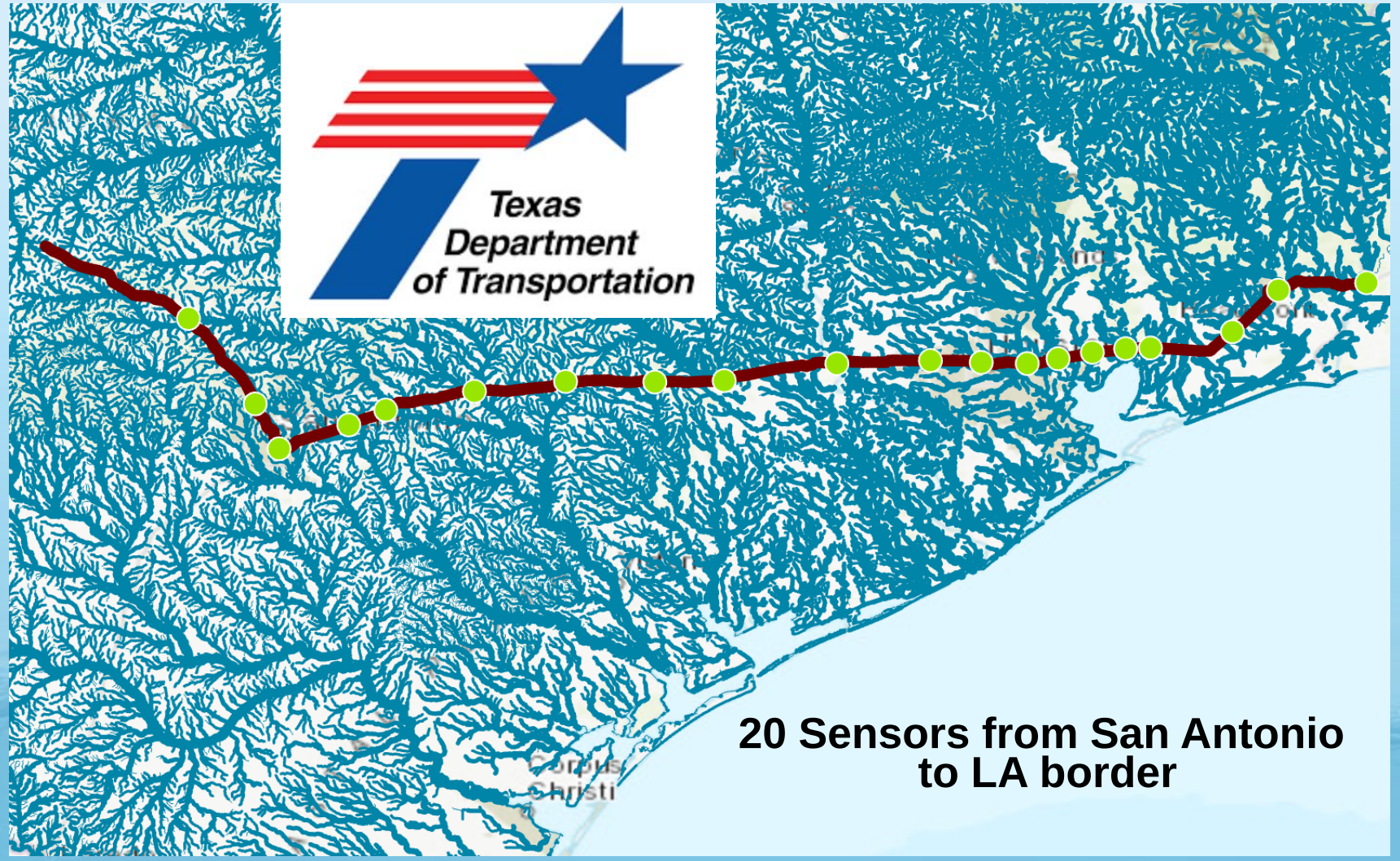
Radar Measurement Technologies

Measures water level

Measures surface velocity

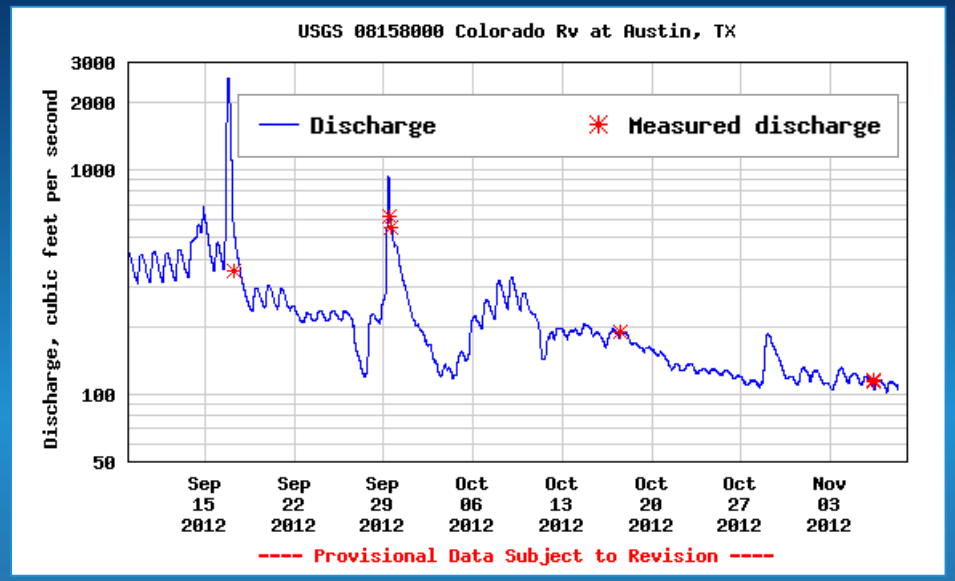
Densified forecasting requires densified measurement

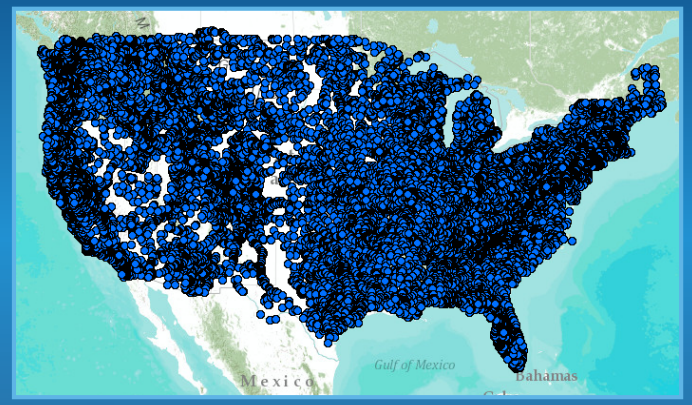
Radar Streamflow Measurement on I-10



“Internet of Water” using the WaterML language

Colorado River at Austin



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24/7/365 service
For daily and real-time data

WaterML2 is the international standard internet language for water resources times series…

http://waterservices.usgs.gov/nwis/iv/?format=waterml,2.0&sites=08158000&period=P1D&parameterCd=00060

Internet of Water for New Zealand

National synthesis without centralizing data

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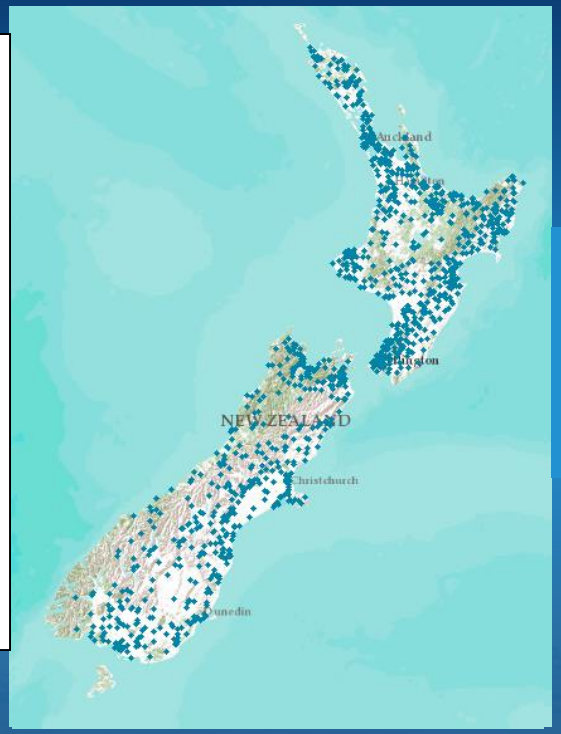
- Auckland Council
- Bay of Plenty Regional Council
- Environment Canterbury
- Environment Southland
- Gisborne District Council
- Greater Wellington Regional Council
- Hawkes Bay Regional Council
- Horizons Regional Council
- Marlborough District Council
- National Institute of Water and Atmospheric Research
- North Shore City Council
- Northland Regional Council
- Otago Regional Council
- Taranaki Regional Council
- Tasman District Council
- Waikato Regional Council
- West Coast Regional Council

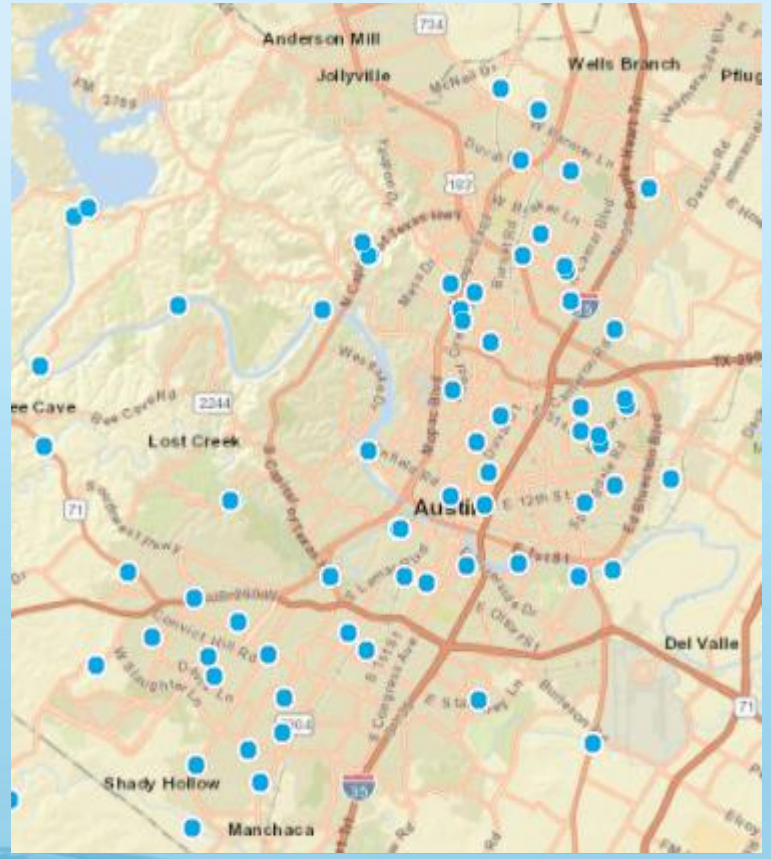


New Zealand
Water Information System

Data from 16 regions and one national agency. . .
. . . all accessible through water data services

City of Austin Flood Alert System

- City of Austin gages
- LCRA gages
- USGS gages
- All gages accessed by water data services



Rainfall and Water Level gages

```
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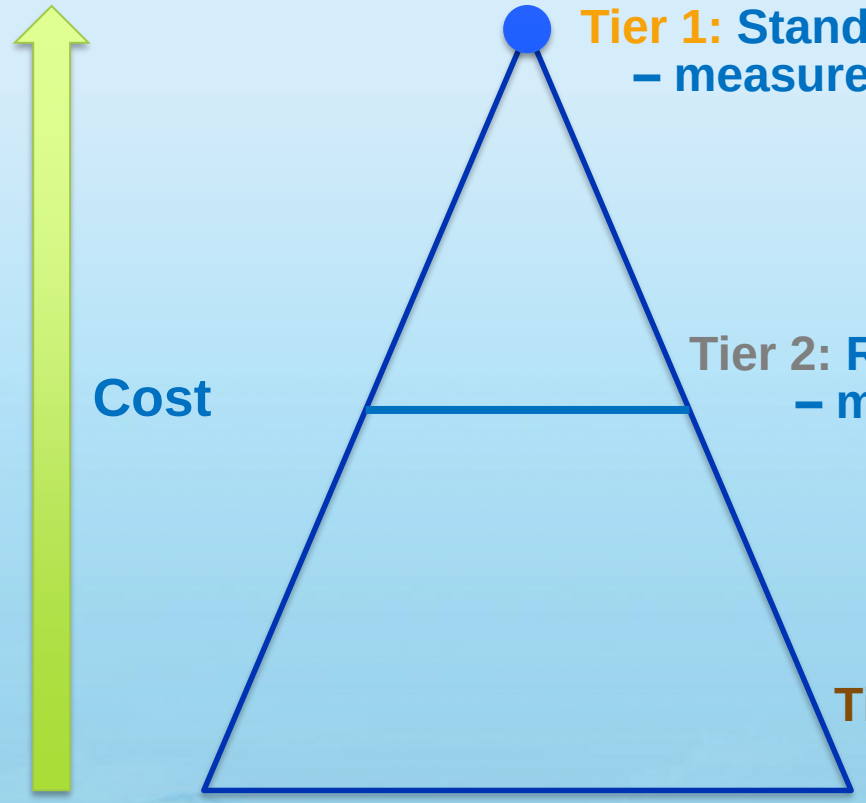
Three-Tier Flood Alert System



Tier 1: Standard USGS Gages
– measure everything

Tier 2: Radar Sensors on Bridges (TxDOT)
– medium and high flows

Tier 3: Water Level Sensors
– local flood alert systems

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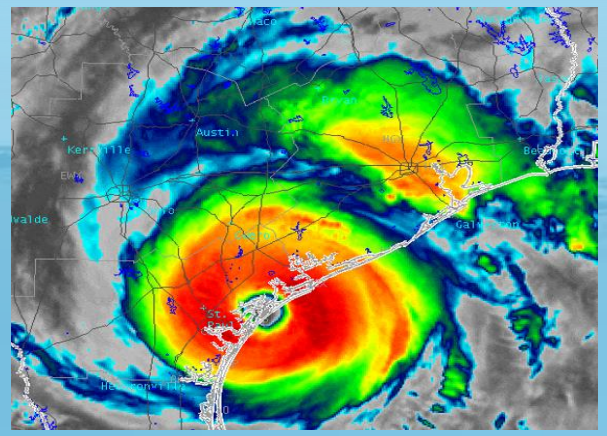
All connected using WaterML data services

Hurricane Harvey and National Water Model

- **What happened?**
  - For 3-5 days duration, largest rainfall in US history
- **What did we learn?**
  - Texas Flood Response System accurately forecast spatial pattern of damage before hurricane landfall
- **Where to from here?**
  - Better connection with social media
  - "Internet of Water" for Texas
    - ***Real-time flood alert system for all of Texas***



Q & A Panel

David Maidment
Professor,
Civil Engineering
Univ. of Texas

Sarah Labowitz
Sr. Advisor on
Recovery
City of Houston

Melissa Huffman
National Weather
Service

Suzanne Pierce
Texas Advanced
Computing Center

City of Houston Housing and Community Development Department

- >$1 billion in long-term recovery programs
- Incident command for the George R. Brown Convention Center mega-shelter during Harvey
- Lead agency for expanding affordable housing and vibrant communities in Houston

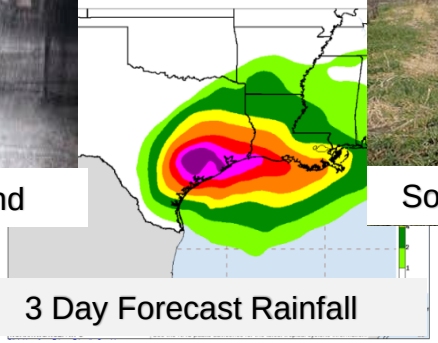
National Weather Service

Weather Forecast Offices

Hurricane Harvey Shift Change - 8/26/17

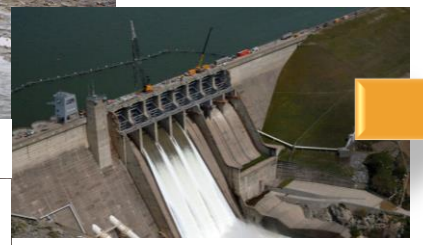
River Forecast Centers

Rain on the Ground

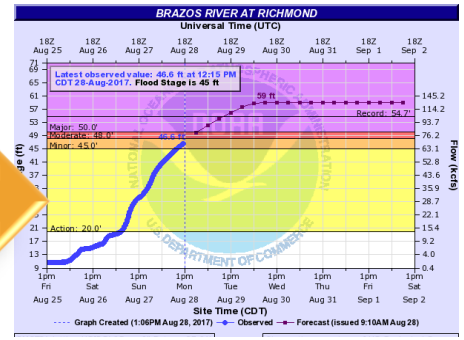


3 Day Forecast Rainfall

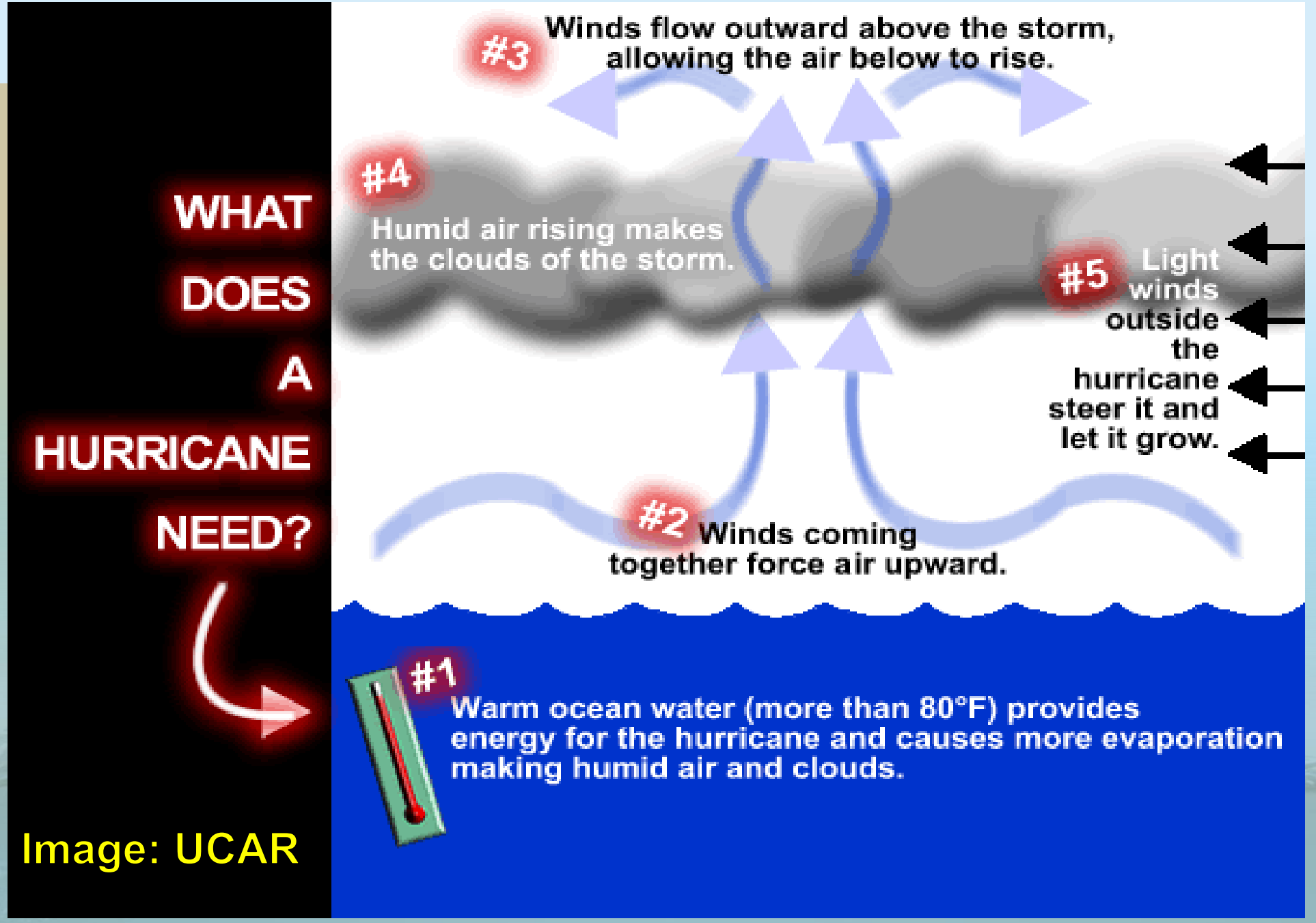
Soil Conditions



Lake Releases



River Forecast & Warnings


WHAT DOES A HURRICANE NEED?
#3 Winds flow outward above the storm, allowing the air below to rise.
#4 Humid air rising makes the clouds of the storm.
#5 Light winds outside the hurricane steer it and let it grow.
#2 Winds coming together force air upward.
#1 Warm ocean water (more than 80°F) provides energy for the hurricane and causes more evaporation making humid air and clouds.
Image: UCAR