

# Hurricane Harvey: A call for new data, science and services

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



Dirksen Senate Office Building, Washington DC, 25 September 2017

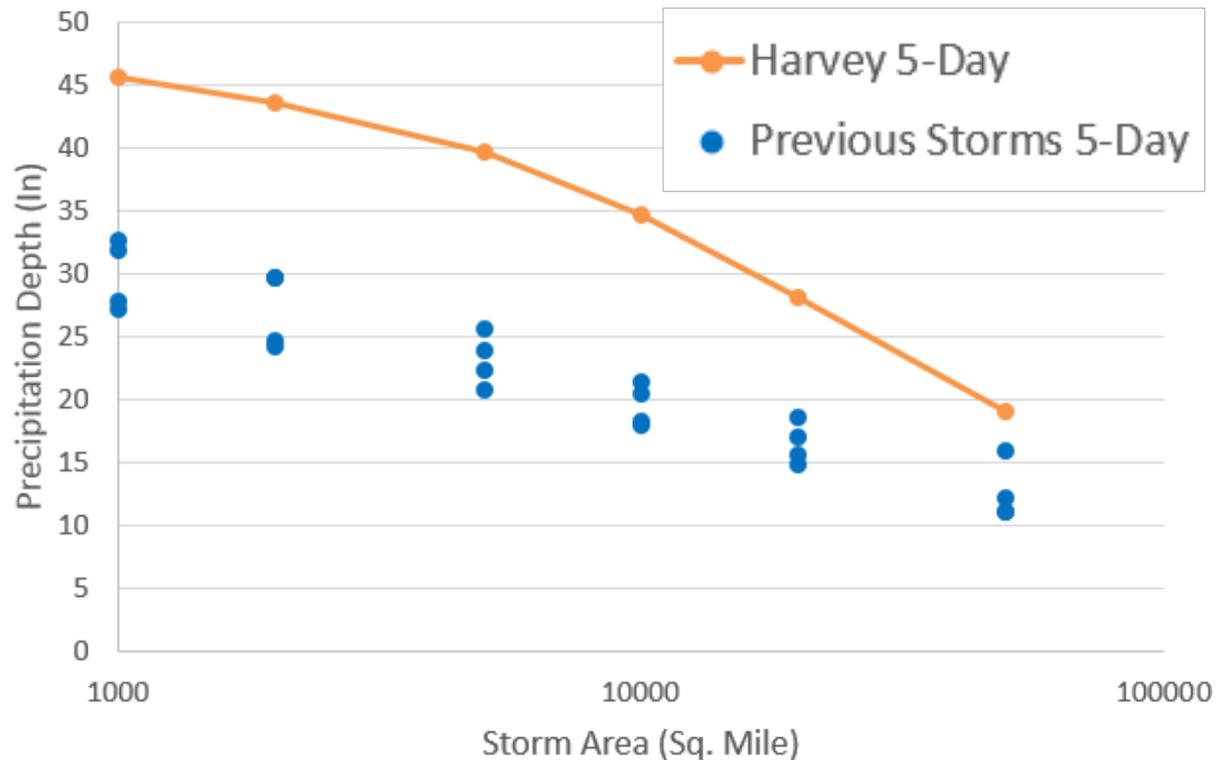
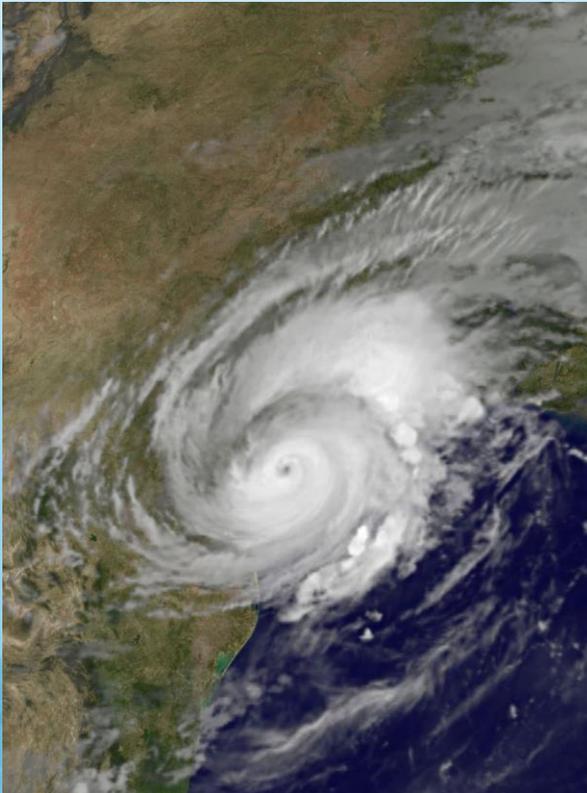
Acknowledgements: Texas Division of Emergency Management, Chief Nim Kidd, Jeff Newbold, Michael Ouimet, Warren Weidler, Jeanette Chamorro; ESRI, Kisters, TACC; colleagues and students at UT Austin, Harry Evans, Xing Zheng, David Arctur, Erika Boghici, Lukas Godbout, Jeff Zheng

# Hurricane Harvey Precipitation

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

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

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



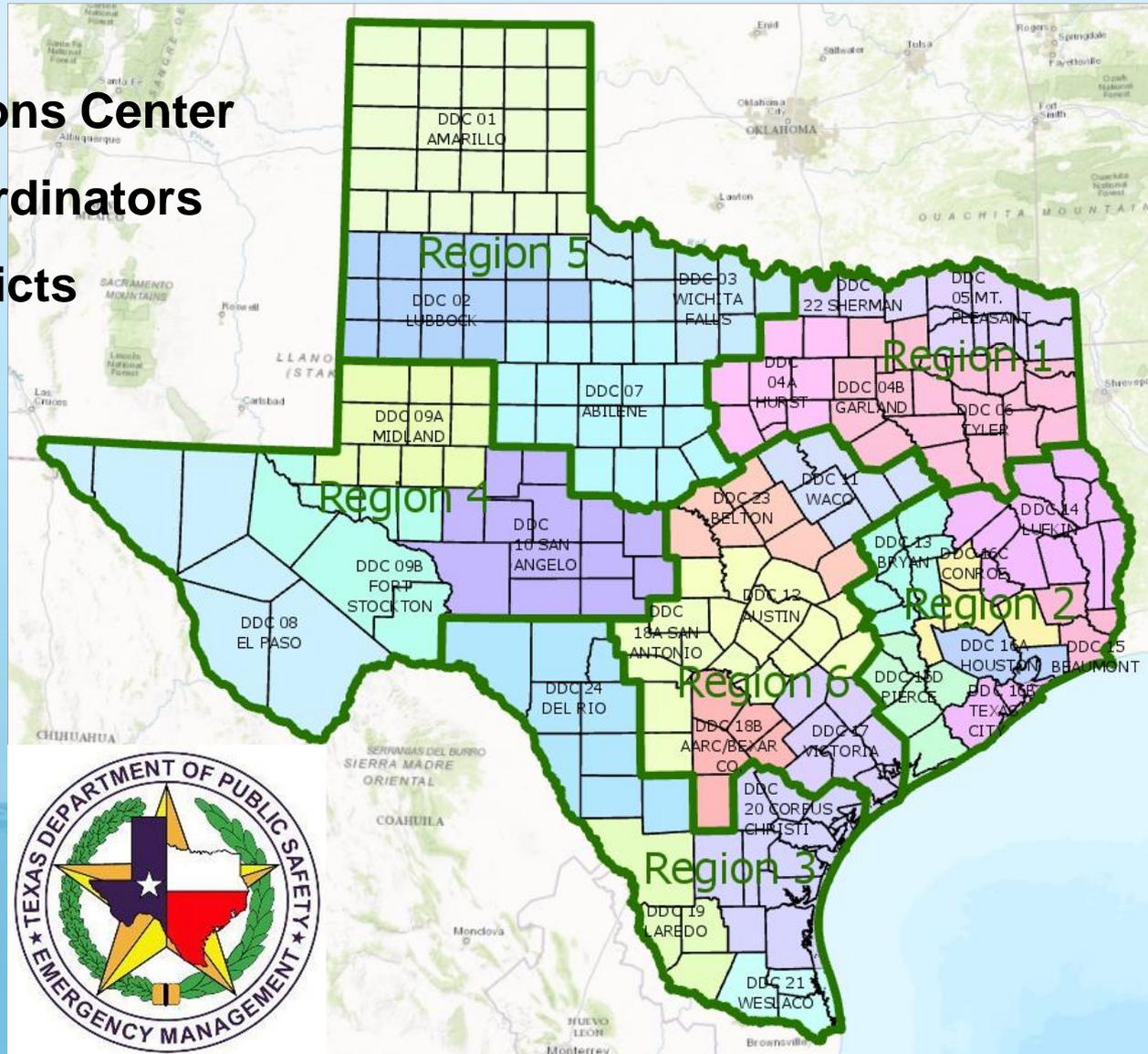
Data Sources: NWS River Forecast Centers; Applied Weather Associates, Inc., NASA.  
Analysis: John Nielsen-Gammon and Brent McRoberts, Texas A&M University

# Texas Division of Emergency Management

- State Operations Center
- Regional Coordinators
- Disaster Districts
- Counties



Chief Nim Kidd  
Director, TDEM

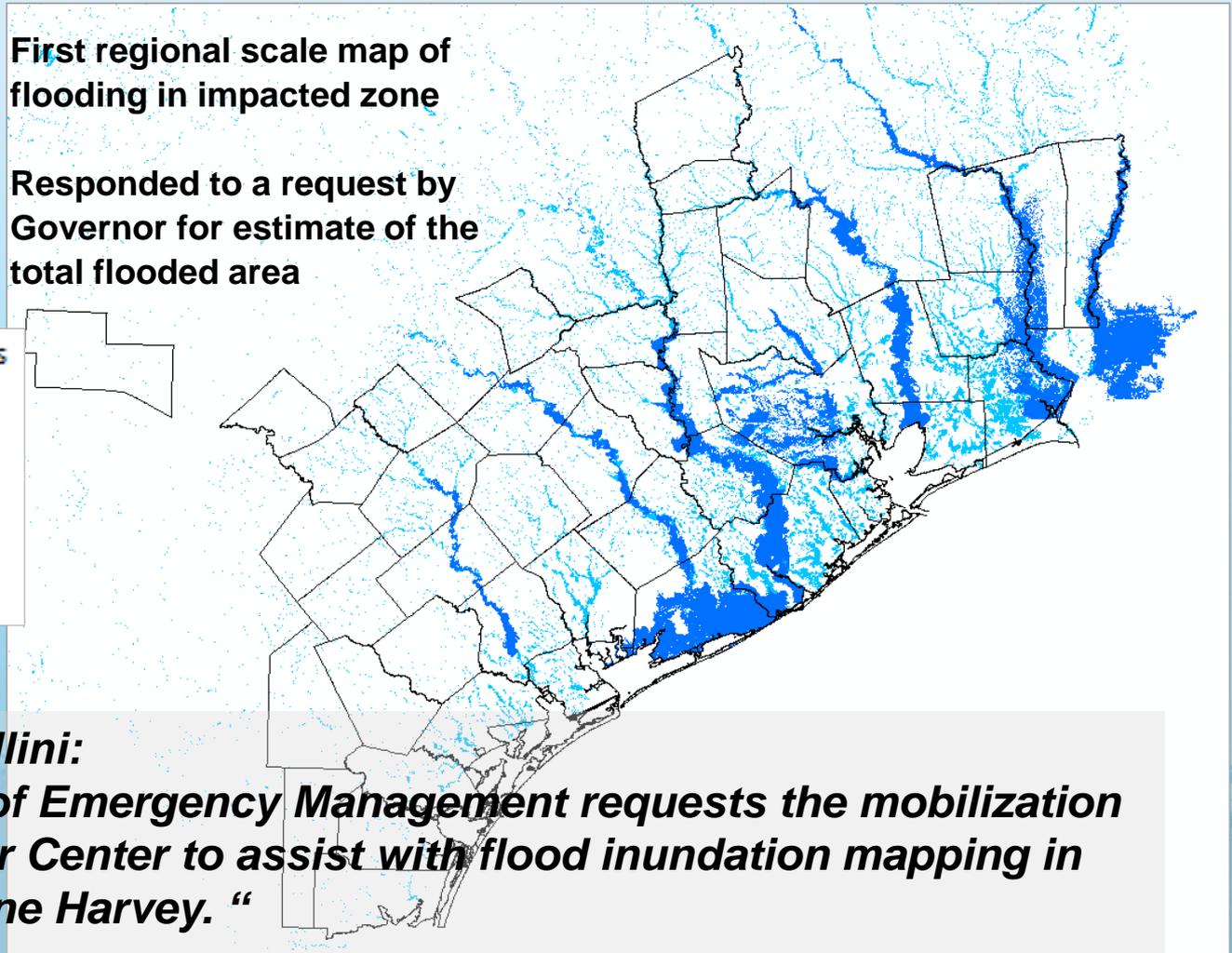


# Maximum Flood Inundation Extent from Hurricane Harvey

First regional scale map of flooding in impacted zone

Responded to a request by Governor for estimate of the total flooded area

- Declared Disaster Counties
- 
- MaxFloodExtentUSACE
- National Water Model



***“Dear Director Uccellini:  
The Texas Division of Emergency Management requests the mobilization of the National Water Center to assist with flood inundation mapping in response to Hurricane Harvey. “***

***-- Chief Kidd; Sunday, August 27, 2017***

# 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.”



STEVEN C. McCRAW  
DIRECTOR  
DAVID G. BAKER  
ROBERT J. BODISCH, SR.  
DEPUTY DIRECTORS

## TEXAS DEPARTMENT OF PUBLIC SAFETY

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512/424-2000

[www.dps.texas.gov](http://www.dps.texas.gov)



COMMISSION  
STEVEN P. MACH, CHAIRMAN  
MANNY FLORES  
A. CYNTHIA LEON  
JASON K. PULLIAM  
RANDY WATSON

Thursday, August 31

August 31, 2017

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

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

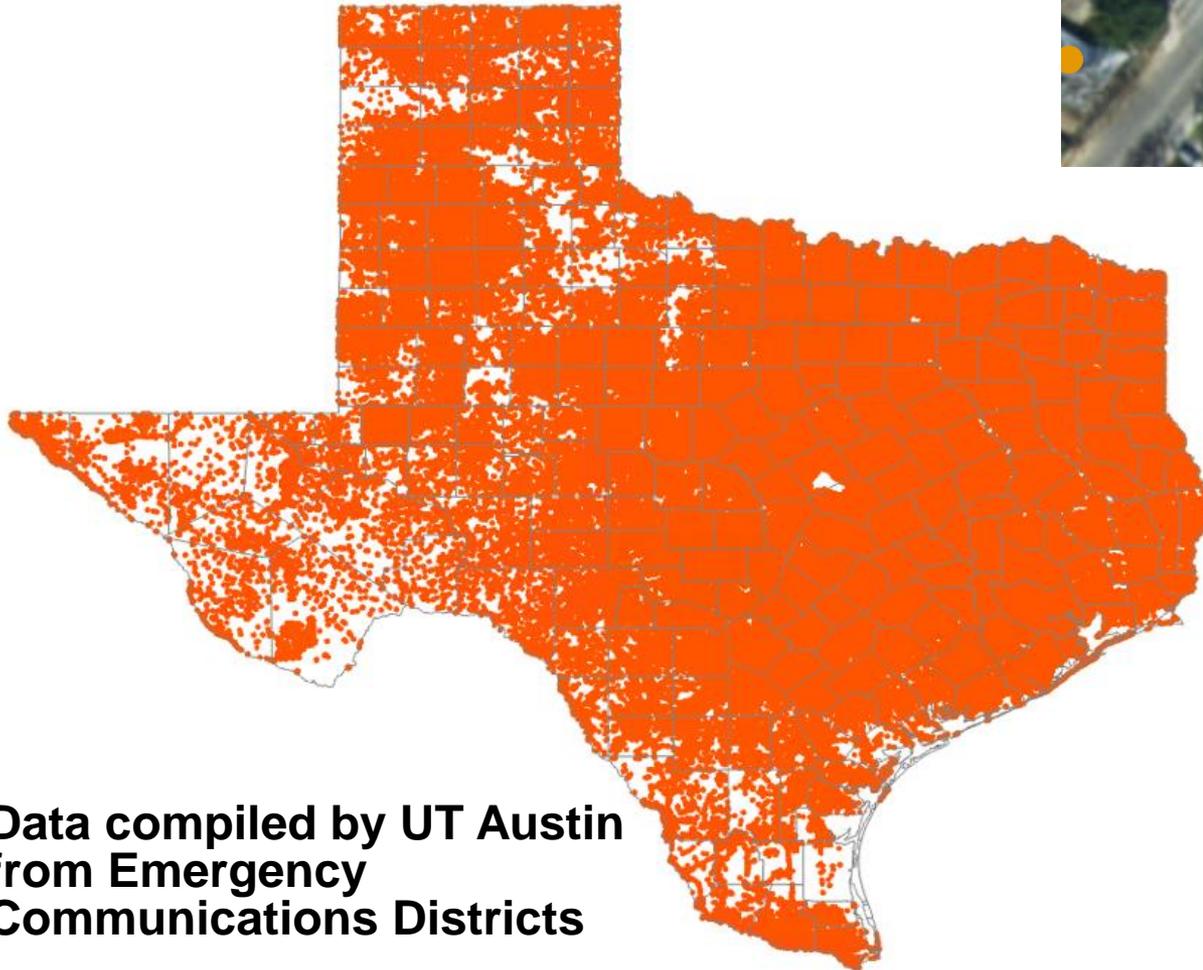
cc: Sharon Wood, Dean, Cockrell School of Engineering

# Texas Address Points

9.2 million points



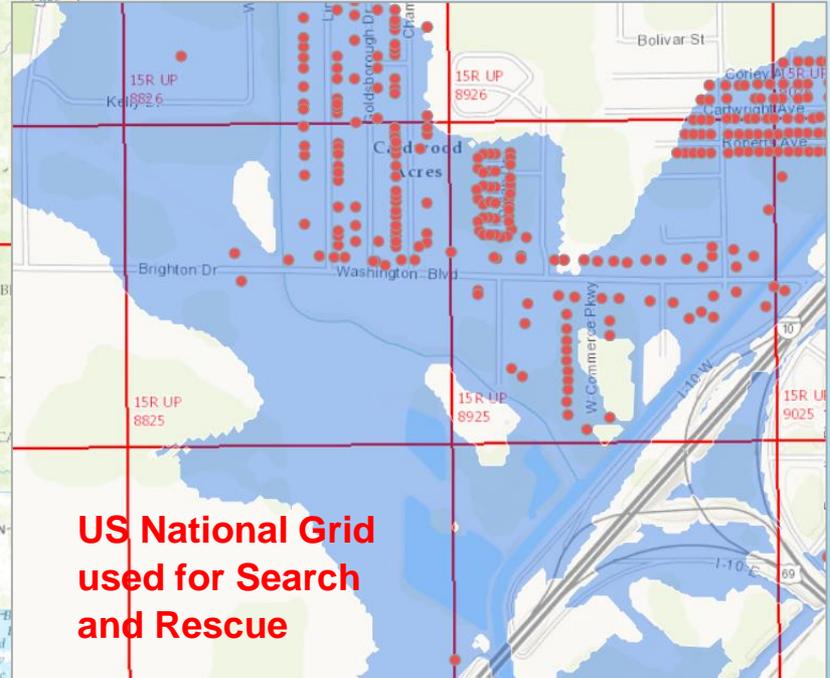
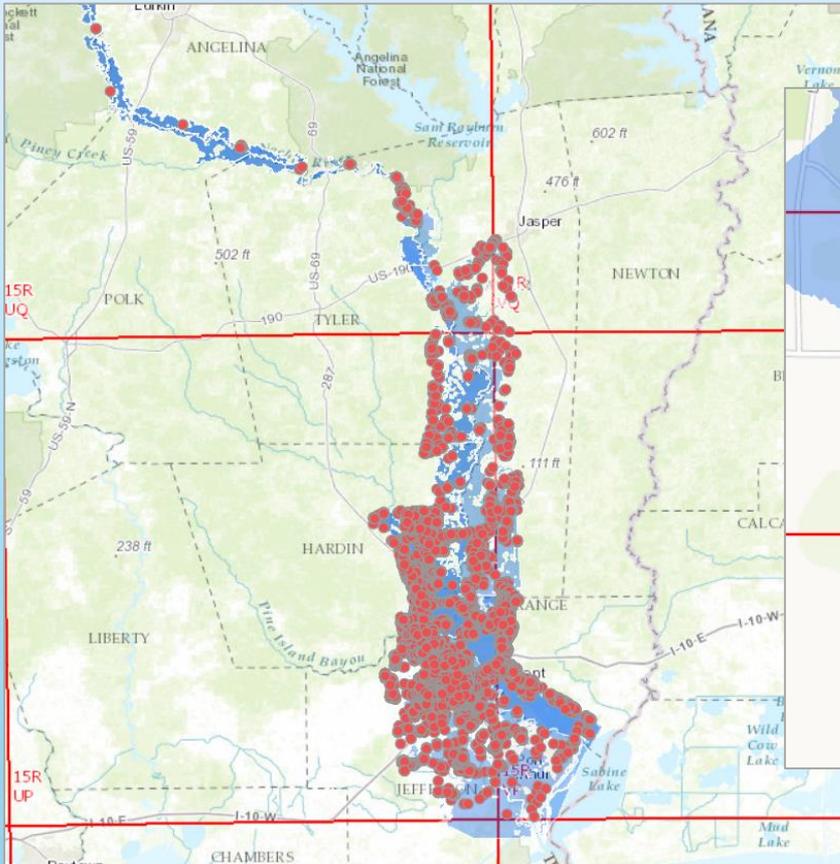
Point on every building  
used for dispatching  
emergency response  
vehicles by 911 systems



Data compiled by UT Austin  
from Emergency  
Communications Districts



# Inundation Maps for Search and Rescue



**US National Grid  
used for Search  
and Rescue**

**Experimental product, not confirmed by local observation**

**Observations from the U.S. Geological Survey**

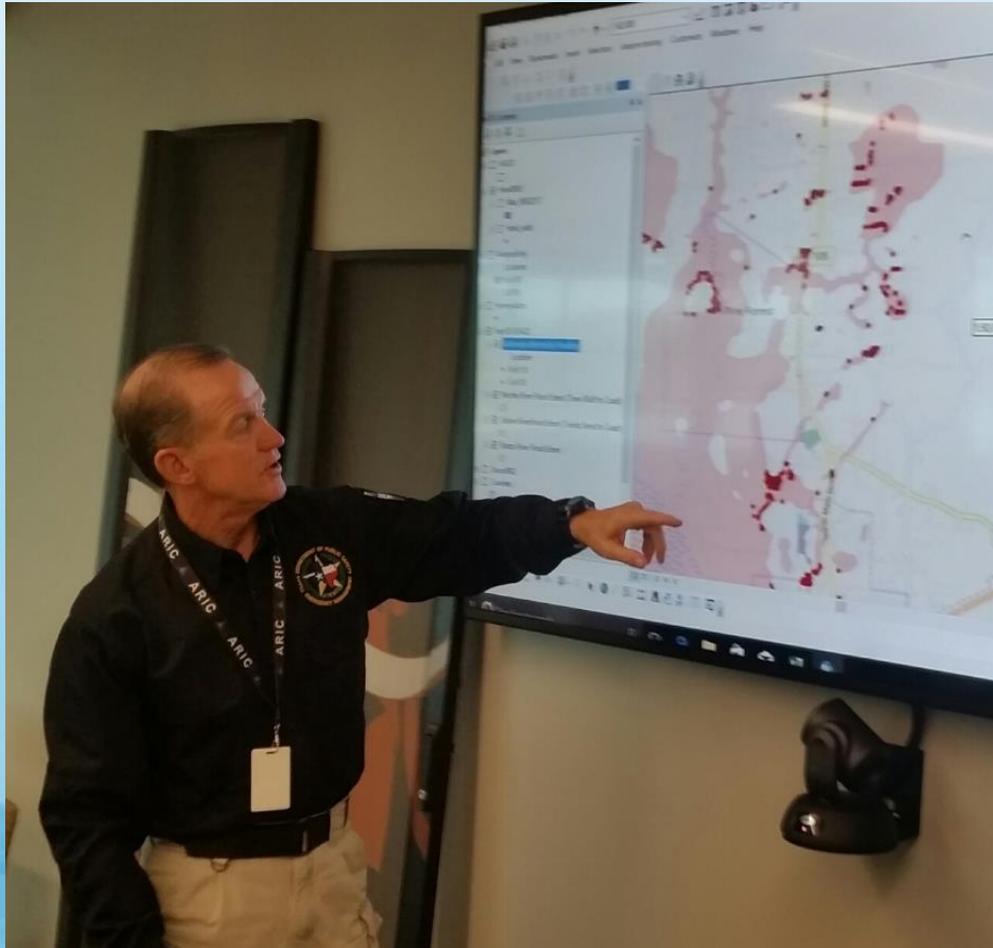
**Guidance from NOAA and the National Water Center**

**Forecasting by NWS West Gulf River Forecast Center**

**Inundation Mapping by US Army Corps of Engineers**

**Overlay on Address Points by University of Texas at Austin**

# Goal: Real-Time Flood Inundation Mapping for Texas at Local Scale



**STAMPEDE**  
SUPERCOMPUTER

# National Water Center Innovators Program

- Successful partnership between **federal water agencies and the academic community** to accelerate Research to Operations
- **Summer Institutes** for graduate students at National Water Center in 2015, 2016, 2017, involved **105 students** from **49 universities**
- Establishes a **community of practice** around the National Water Model and the National Water Center.
- **Annual cycle** of innovation, research and assessment spanning USGS, USACE, NOAA and the academic community



# Conclusions



- Harvey was an unprecedented and devastating storm
- **Real-time inundation maps** are required now more than ever
  - Flood predictive capability is within grasp at National Water Center
  - Continued investment in rainfall prediction is needed
  - Observational capability is woefully inadequate requiring renewed investments in USGS stream gages and other networks
- Academic community can make a significant contribution
  - Research to operations spans federal and research communities
  - Computational support in development and processing
  - Summer Institute research at National Water Center

# National River Hydraulic Framework for Flood Inundation Mapping

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



Subcommittee on Spatial Water Data, 22 September 2017

Acknowledgements: USACE Fort Worth District, Helena Mosser, Jerry Cotter, Colleagues and students at UT Austin, Harry Evans, Xing Zheng, David Arctur, Erika Boghici, Lukas Godbout, Jeff Zheng



# First Composite Map of Flood Inundation Extent

First regional scale map of flooding in impacted zone

Responded to a request by Governor for estimate of the total flooded area

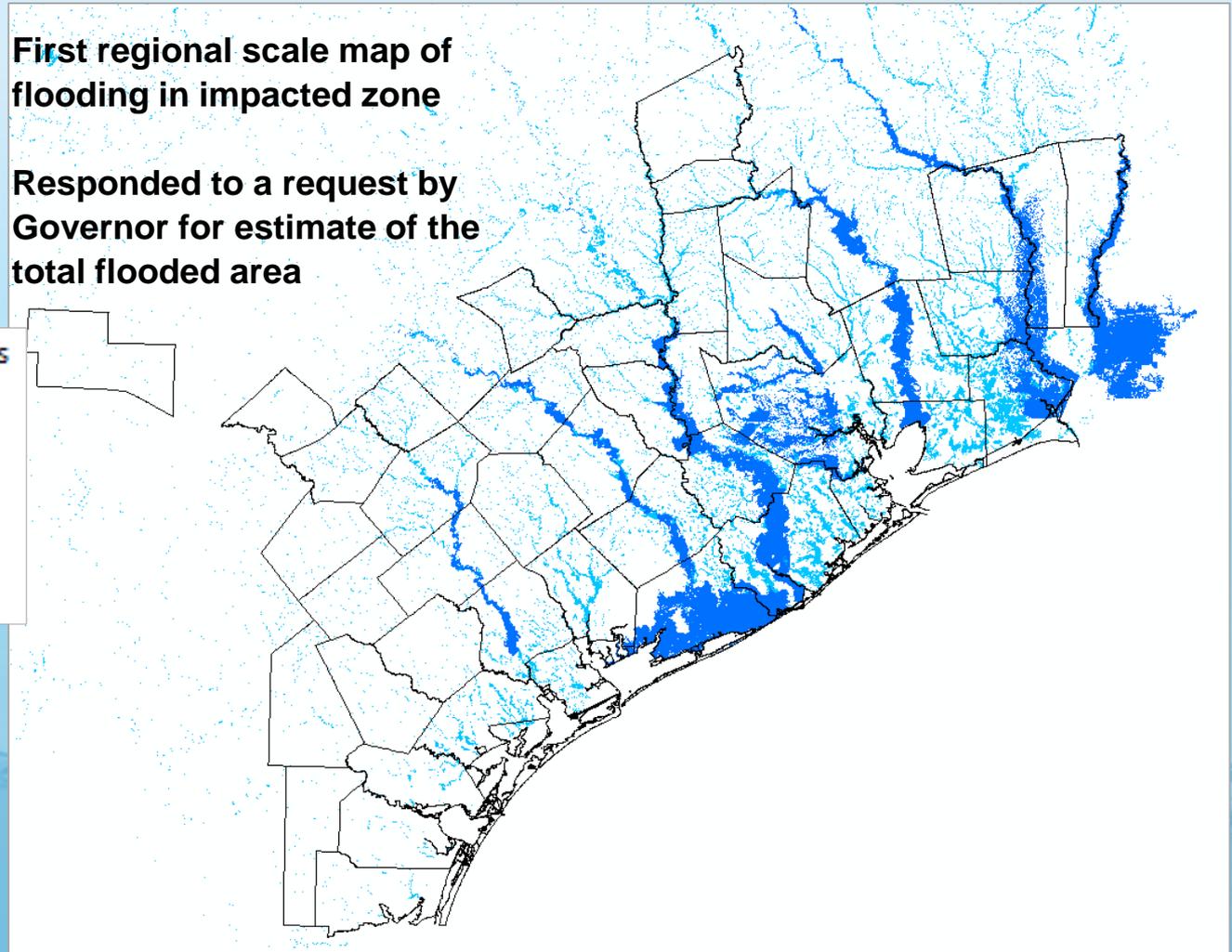
Declared Disaster Counties



MaxFloodExtentUSACE



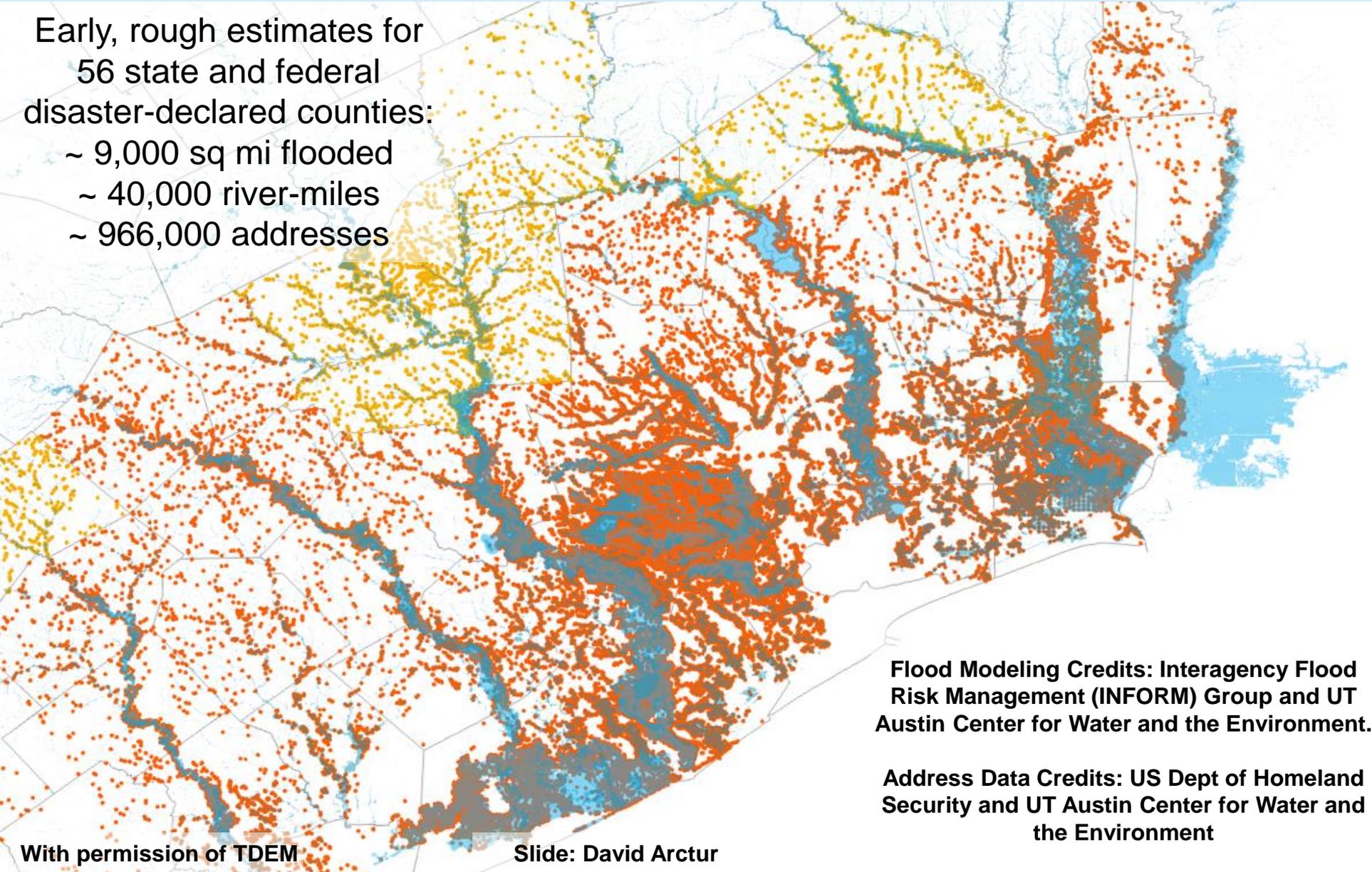
National Water Model



# Provisional flooding impacts

Early, rough estimates for  
56 state and federal  
disaster-declared counties:

- ~ 9,000 sq mi flooded
- ~ 40,000 river-miles
- ~ 966,000 addresses



**Flood Modeling Credits: Interagency Flood Risk Management (INFORM) Group and UT Austin Center for Water and the Environment.**

**Address Data Credits: US Dept of Homeland Security and UT Austin Center for Water and the Environment**

# Harvey: Before ... and After

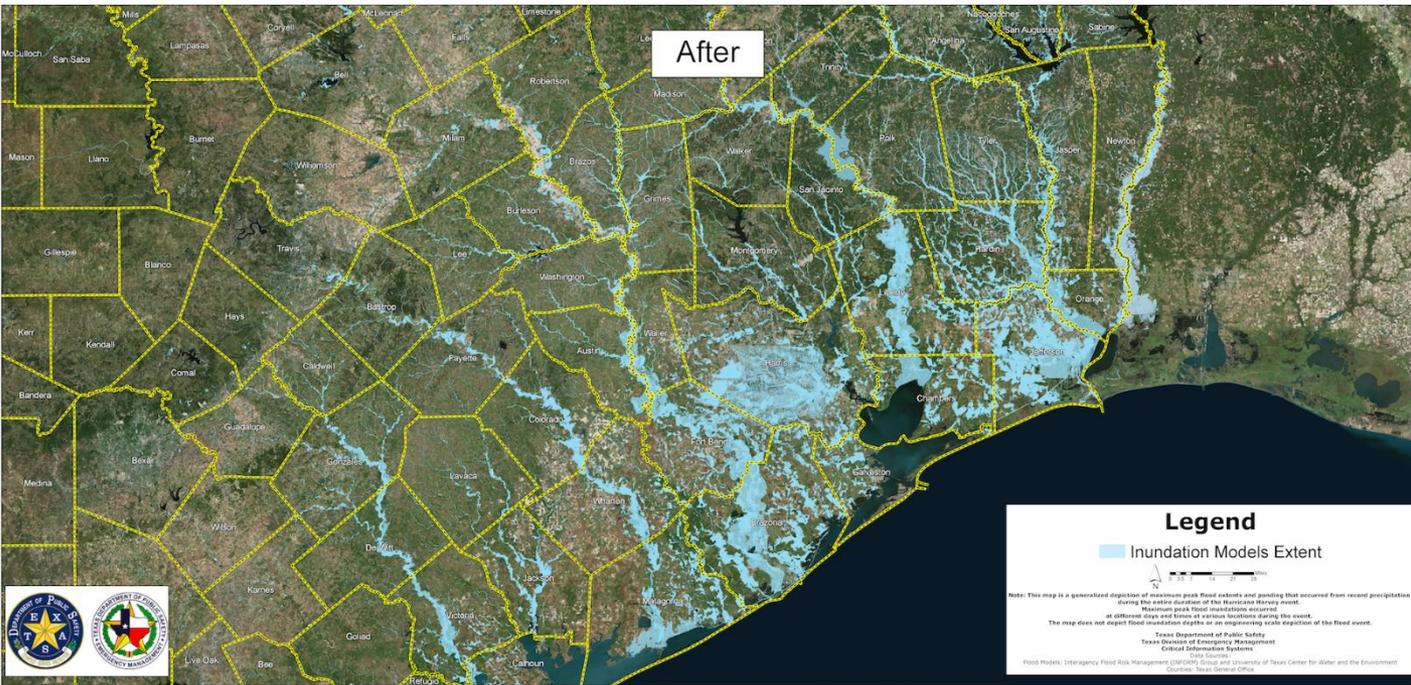
Unprecedented rainfall and flooding. Texas Flood Response System project helped get valuable resources in place.

Major test for National Water Model. Need to improve coastal flood modeling, include ponding, and have *library of inundation polygons ready in advance*.

Slide: David Arctur  
With permission of TDEM



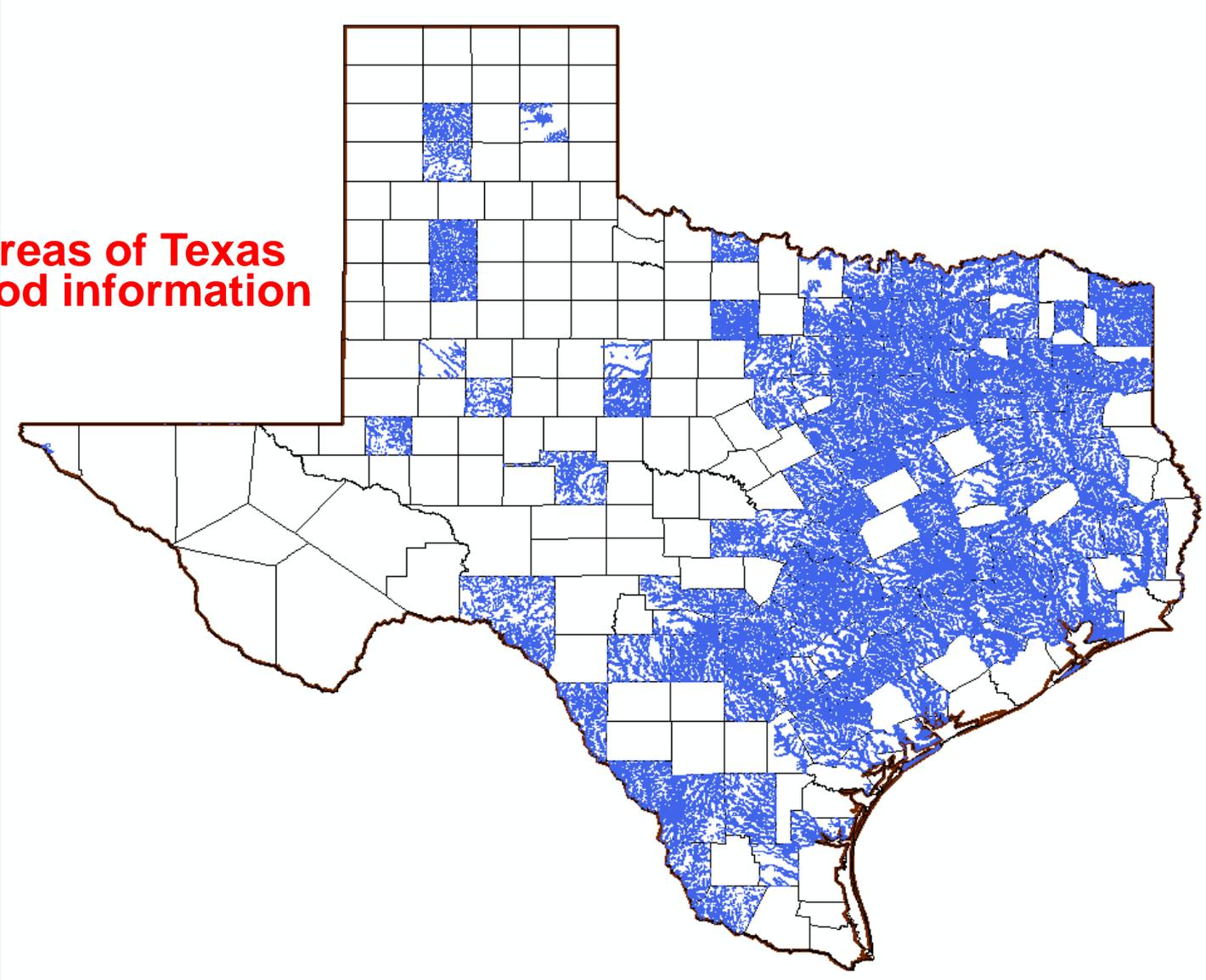
Hurricane Harvey Flood Inundations



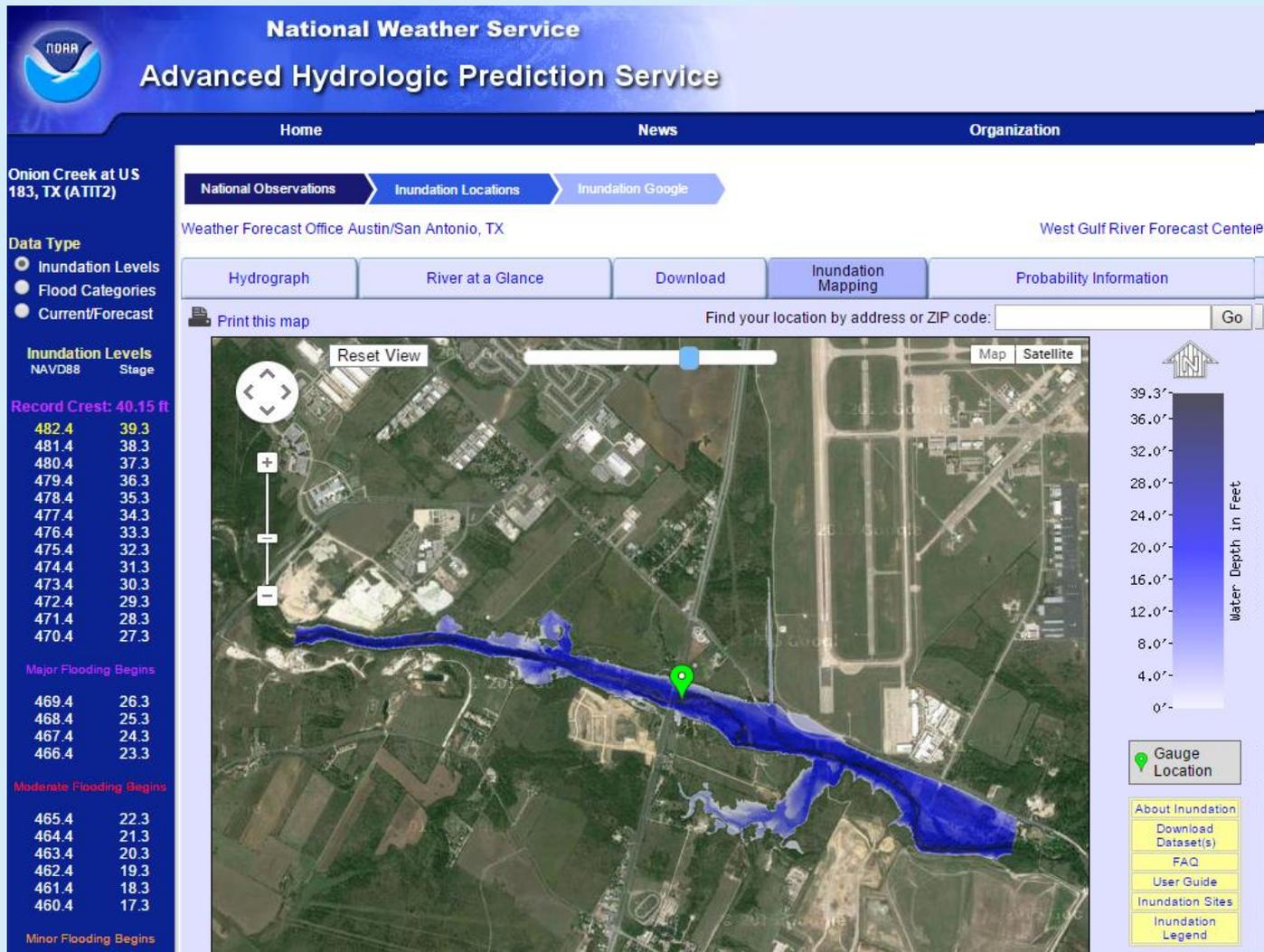
This map is for informational purposes and is not suitable for legal, engineering or surveying purposes. For full disclaimer see: <https://olympus.sos.texas.gov/files/gismap/disclaimer.html> Date: 9/21/2017 Document Path: Z:\Events\Incidents\201711-021 Hurricane Harvey\MXD\Inundation\Imagery

## FEMA National Flood Hazard Layer in Texas (~ 120 counties)

**Large areas of Texas  
lack flood information**



# Real-Time Flood Inundation Mapping Onion Creek at Highway 183

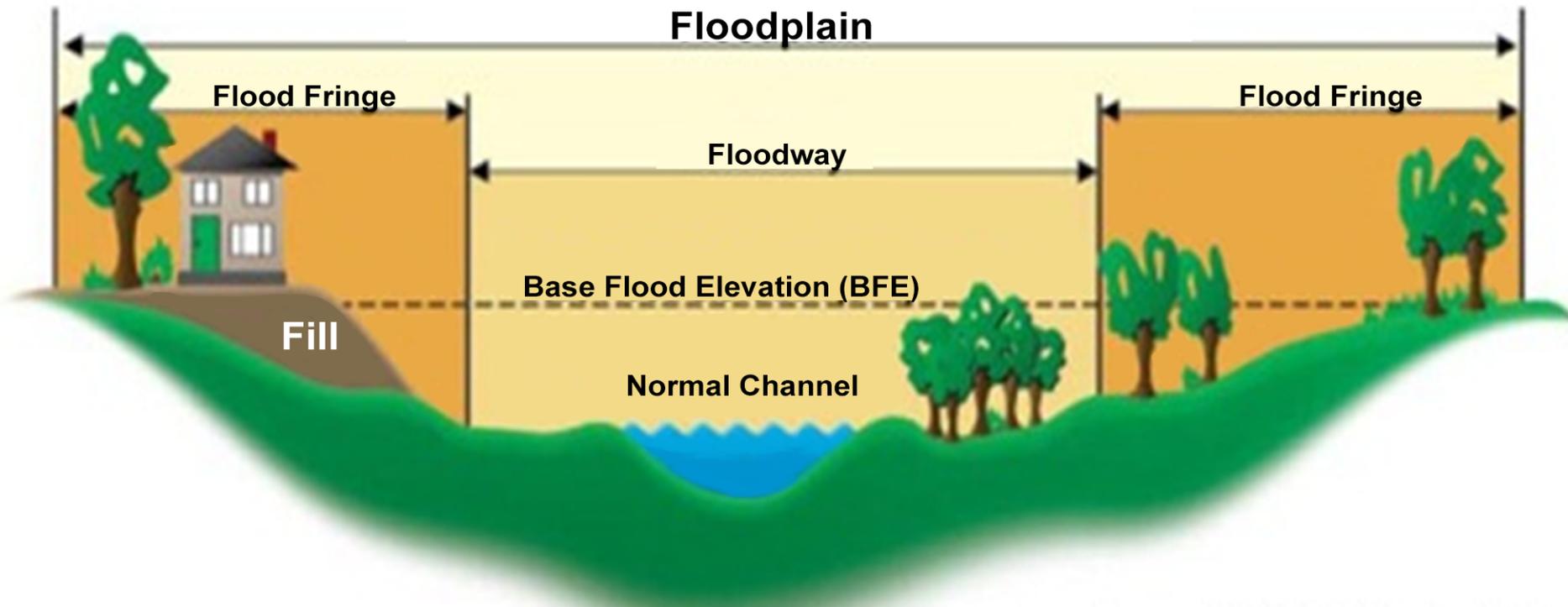


[http://water.weather.gov/ahps2/inundation/inundation\\_google.php?gage=atit2](http://water.weather.gov/ahps2/inundation/inundation_google.php?gage=atit2)

Cost per map: \$40,000 – \$160,000

# What is a Floodplain?

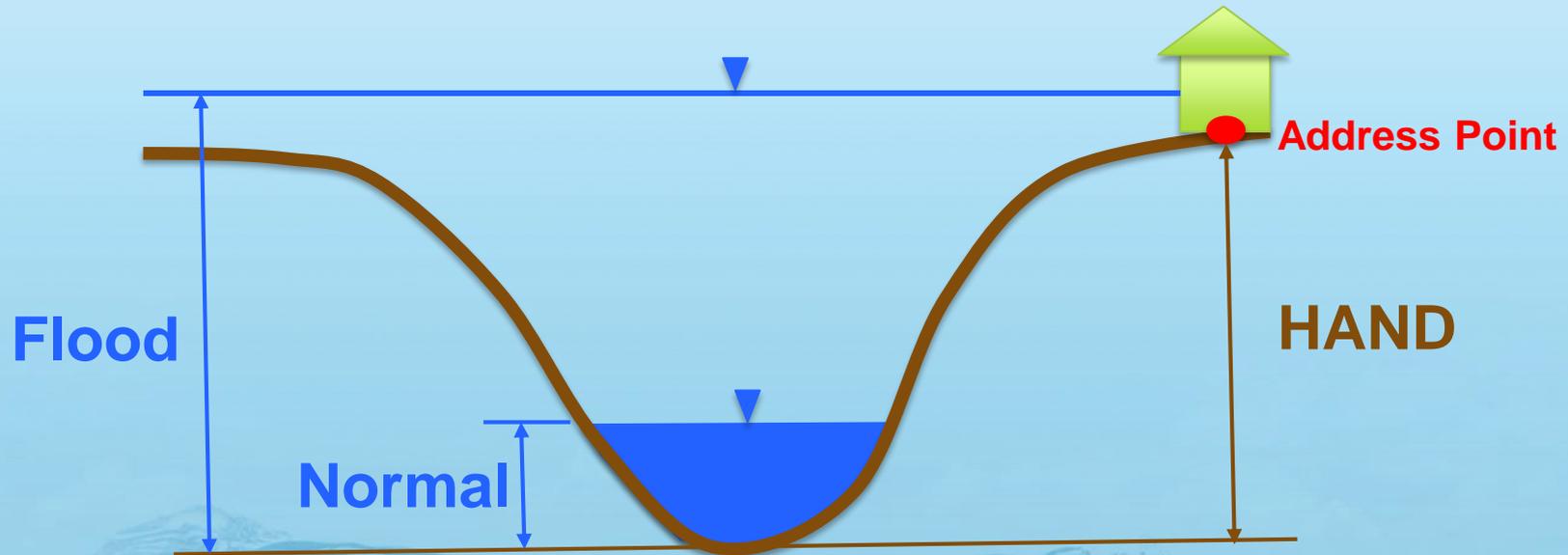
## Characteristics of a Floodplain



Source: NFIP Guidebook, FEMA

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

*Flooding occurs when **Water Depth** is greater than **HAND***



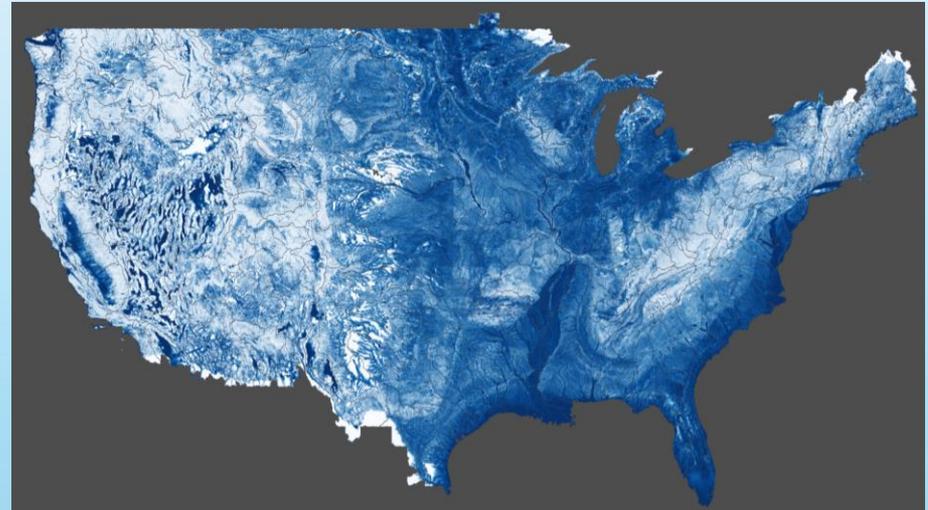
# Continental-Scale Flood Inundation Mapping



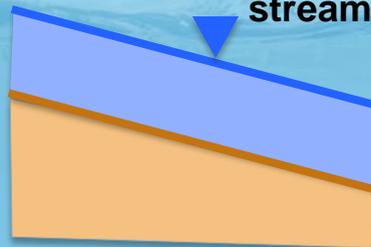
Catchments and Flowlines



Digital Elevation Model



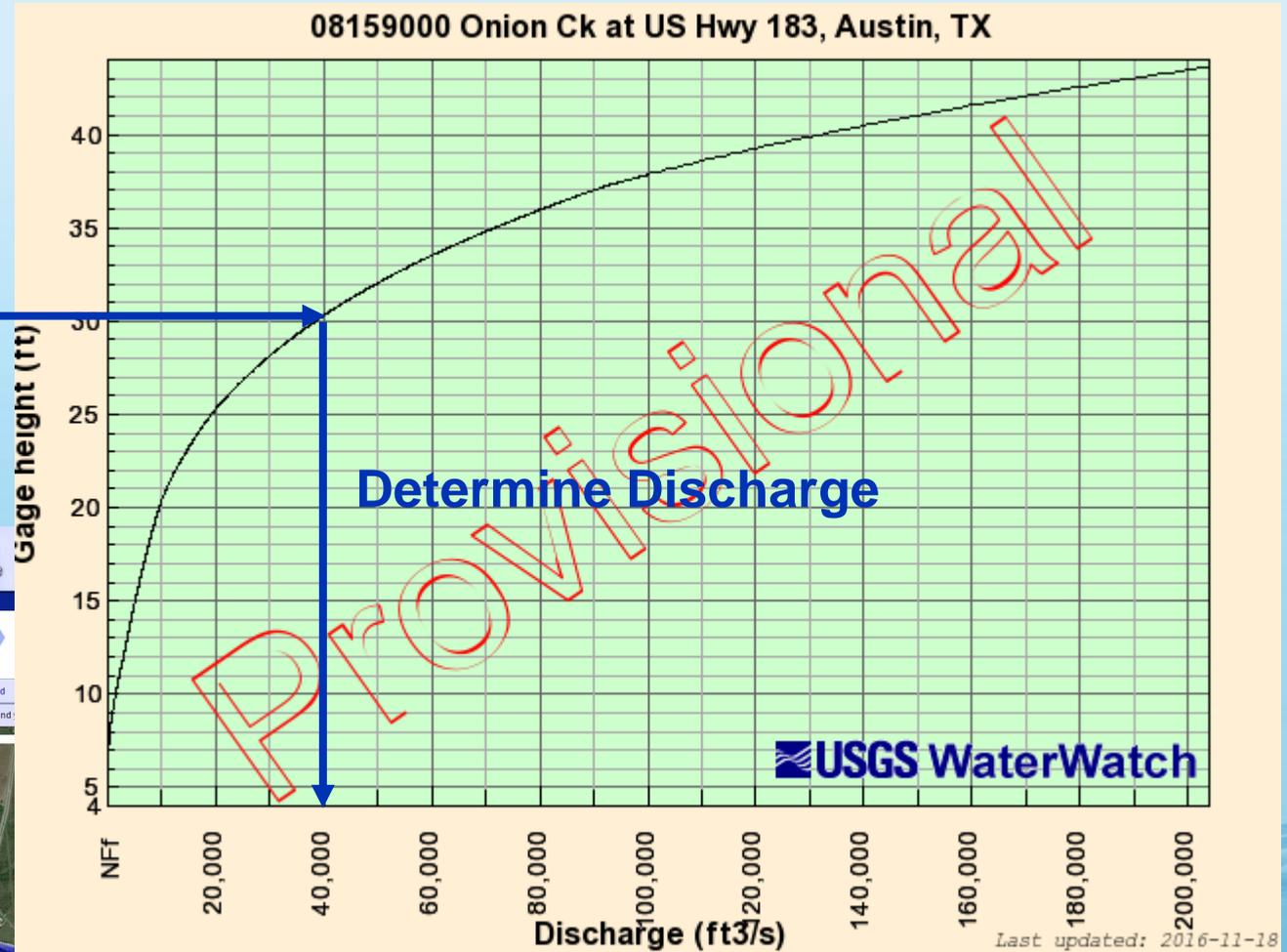
Height Above Nearest  
Drainage (HAND)  
(relative elevation of land  
surface cell above cell in  
stream to which it flows)



# USGS Rating Curve at a Stream Gage

## Union Creek at Highway 183

Measure Water Level



Determine Discharge

National Weather Service  
Advanced Hydrologic Prediction Service

Onion Creek at US Hwy 183, TX (AT112)

Data Type  
● Inundation Levels  
● Flood Categories  
● Current Forecast

Inundation Levels  
NAVD83 Stage

Record Crest: 49.55 ft	Stage
482.4	39.3
481.4	38.3
480.4	37.3
479.4	36.3
478.4	35.3
477.4	34.3
476.4	33.3
475.4	32.3
474.4	31.3
473.4	30.3
472.4	29.3
471.4	28.3
470.4	27.3

Major Flooding Begins

469.4	26.3
468.4	25.3
467.4	24.3
466.4	23.3

Minor Flooding Begins

465.4	22.3
464.4	21.3
463.4	20.3
462.4	19.3
461.4	18.3
460.4	17.3

Hydrograph River at a Glance Download

Print this map Find

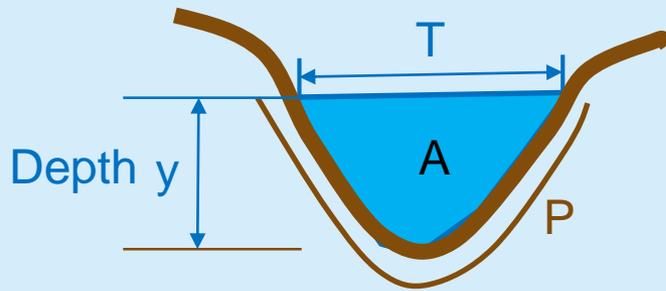
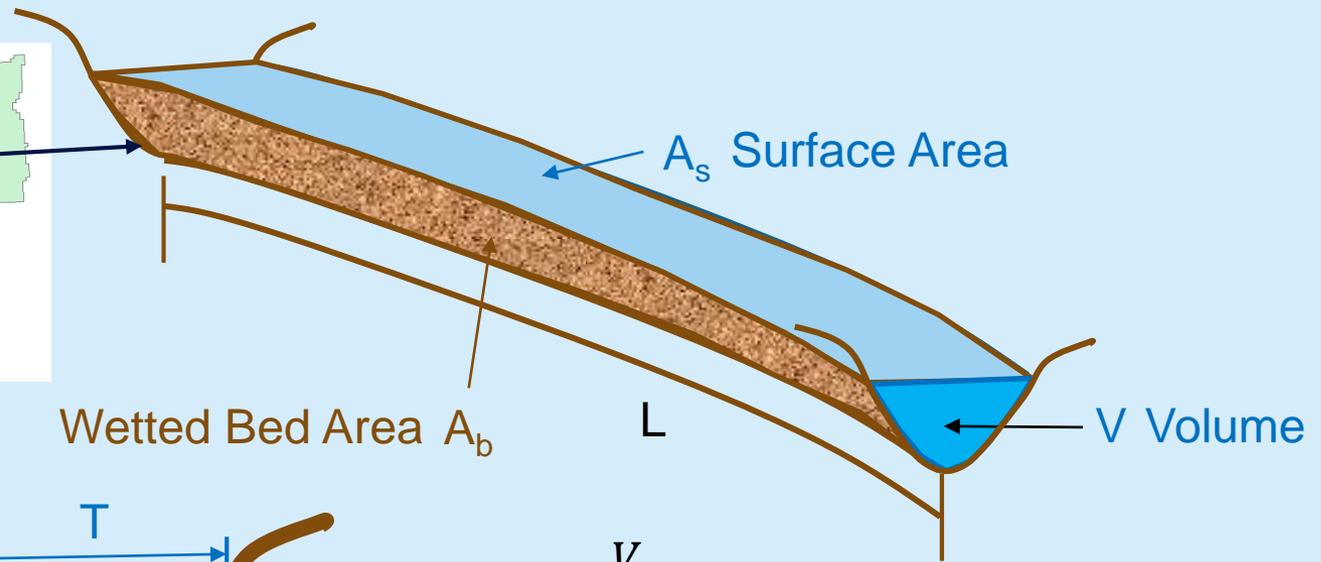
Reset View

Gauge Location

About Inundation  
Download Data(s)  
FAQ  
User Guide  
Inundation Sites  
Inundation Legend

# Reach Hydraulic Parameters

Comid	y	A	R	P	T	V	Ab	As
5781175	3							
5781175	4							



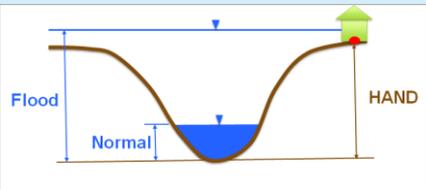
$$A = \frac{V}{L} \quad \text{Cross Section Area}$$

$$P = \frac{A_b}{L} \quad \text{Wetted Perimeter}$$

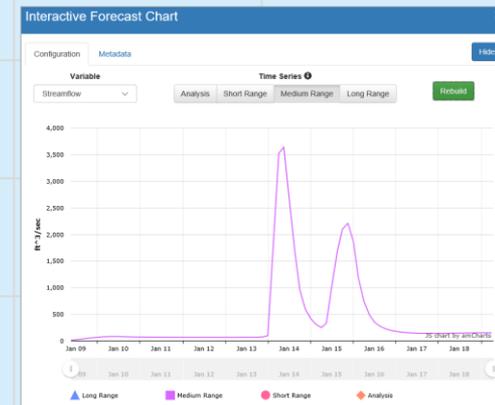
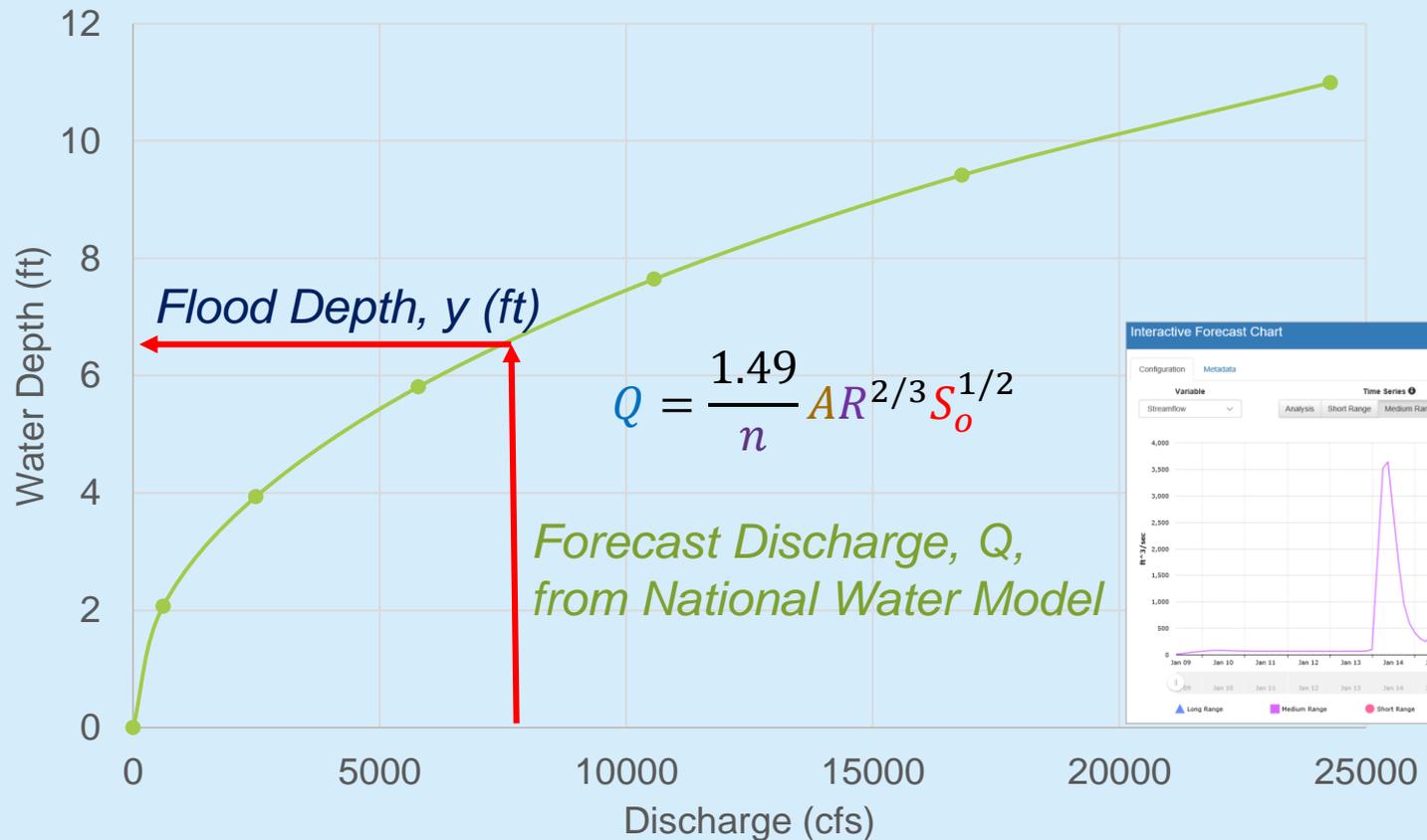
$$T = \frac{A_s}{L} \quad \text{Top Width}$$

$$R = \frac{A}{P} \quad \text{Hydraulic Radius}$$

# Rating Curve – Connects Discharge with Depth

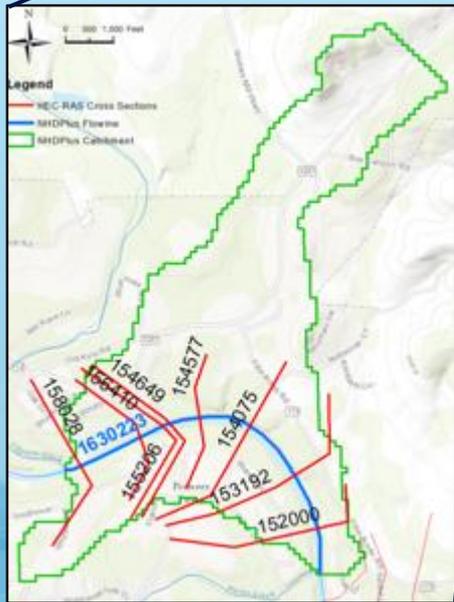
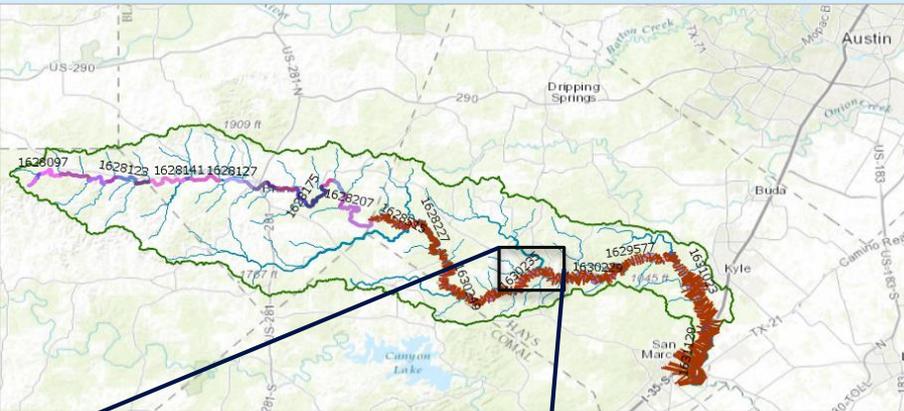


Rating Curve for Eanes Creek, ComID = 5781289

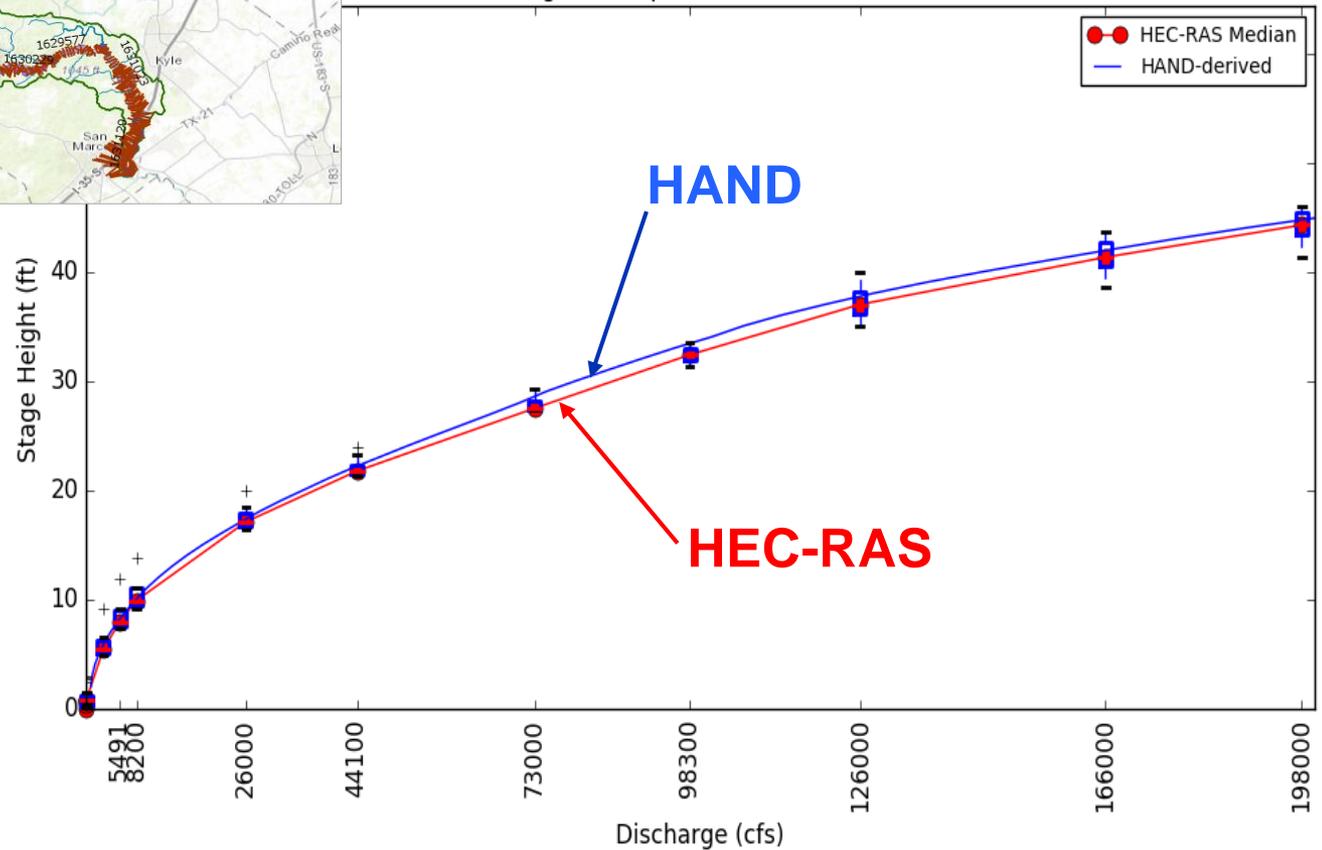




# Synthetic Rating Curves for Reach 1630223

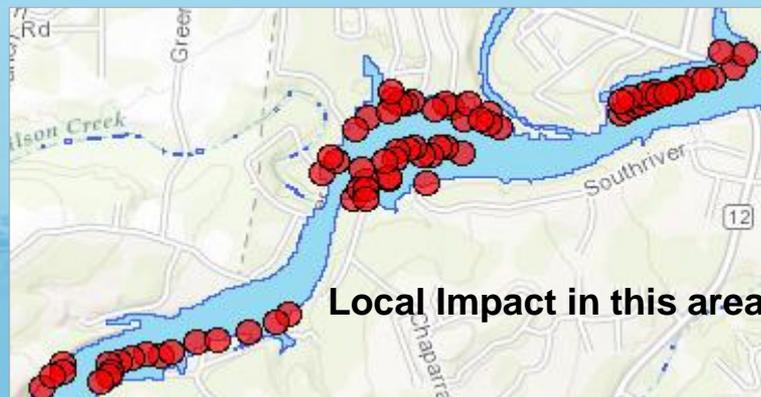


Rating Curve Space of Reach 1630223



# First Responder Input to Inundation Mapping

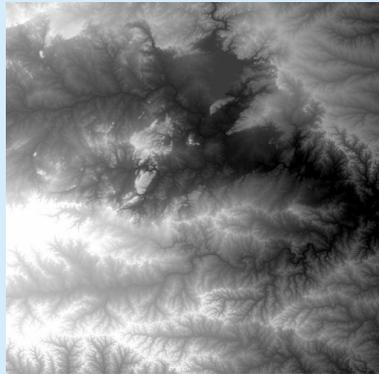
Rock on road at current water level → Point location sent in by text → Inundation map



Chief Todd Pomroy, Austin Fire Department

# NHDPlus Version 2.1

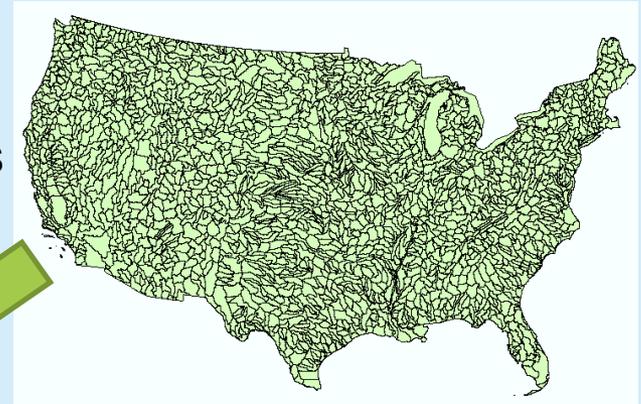
Foundation for a Geospatial Hydrologic Framework for the United States



National Elevation Dataset

**NHDPlus**

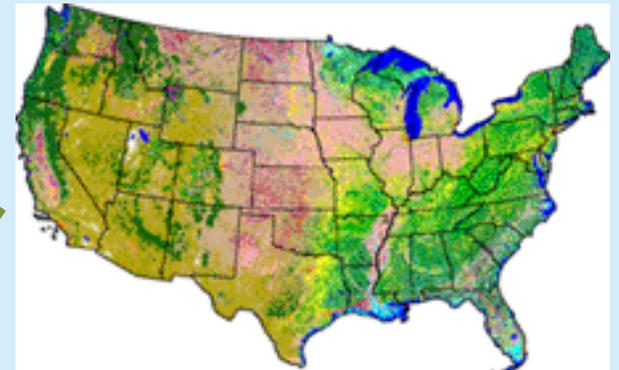
2.7 million reach catchments in US  
average area 3 km<sup>2</sup>  
reach length 2 km  
Uniquely labelled



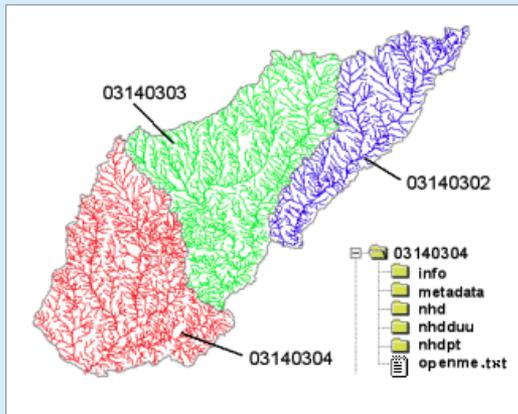
Watershed Boundary Dataset



National Land Cover Dataset



National Hydrography Dataset



# National River Hydraulic Framework

- NHDPlus Version 2.1 is the **hydrologic basis** for the National Water Model
- **Reach lengths vary** a lot from < 100m to more than 10km
- For flood inundation mapping need **regular reach lengths** defined on high resolution NHD
- Each reach needs a **flood inundation map library** defined using increments of water depth
- Need to define a **schema** for this
- A task for the **Subcommittee on Spatial Water Data?**

NHF_Reach	
ReachID	Long Integer
Reach_Start	Double
Reach_End	Double
Depth	Double
Discharge	Double
ReachCode	Text
Upstream_ReachID	Double
Downstream_ReachID	Double
Reach_Length	Double
Downstream_Length_to_River_End	Double
Upstream_Reach_M	Double
Downstream_Reach_M	Double
Upstream_Min_Elev	Double
Downstream_Min_Elev	Double
GNIS_ID	Text
GNIS_Name	Text

NHF_Reach_Properties	
ReachID	Long Integer
Depth	Double
Reach_XSection_Area	Double
Wetted_Perimeter	Double
Top_Width	Double
Slope	Double
Mannings_Roughness	Double
Hydraulic_Radius	Double
Reach_Discharge	Double
Total_Wetted_Bed_Area	Double
Total_Wetted_Surface_Area	Double
Total_Water_Volume	Double
Reach_Thalweg_Length	Double