

# NOAA WATER INITIATIVE



## Transforming Water Prediction for a Water-Prepared Nation

**Tom Graziano, Ph.D.**

**Acting Director,  
National Water Center**

**National Weather  
Service, NOAA**

**Mary Erickson**

**Director, National  
Centers for Coastal  
Ocean Science**

**National Ocean  
Service, NOAA**

**Peter Colohan**

**Director, Service  
Innovation and  
Partnership, National  
Water Center**

**National Weather  
Service, NOAA**

**Ed Clark**

**Director,  
Geointelligence  
Division, National  
Water Center**

**National Weather  
Service, NOAA**

# Outline

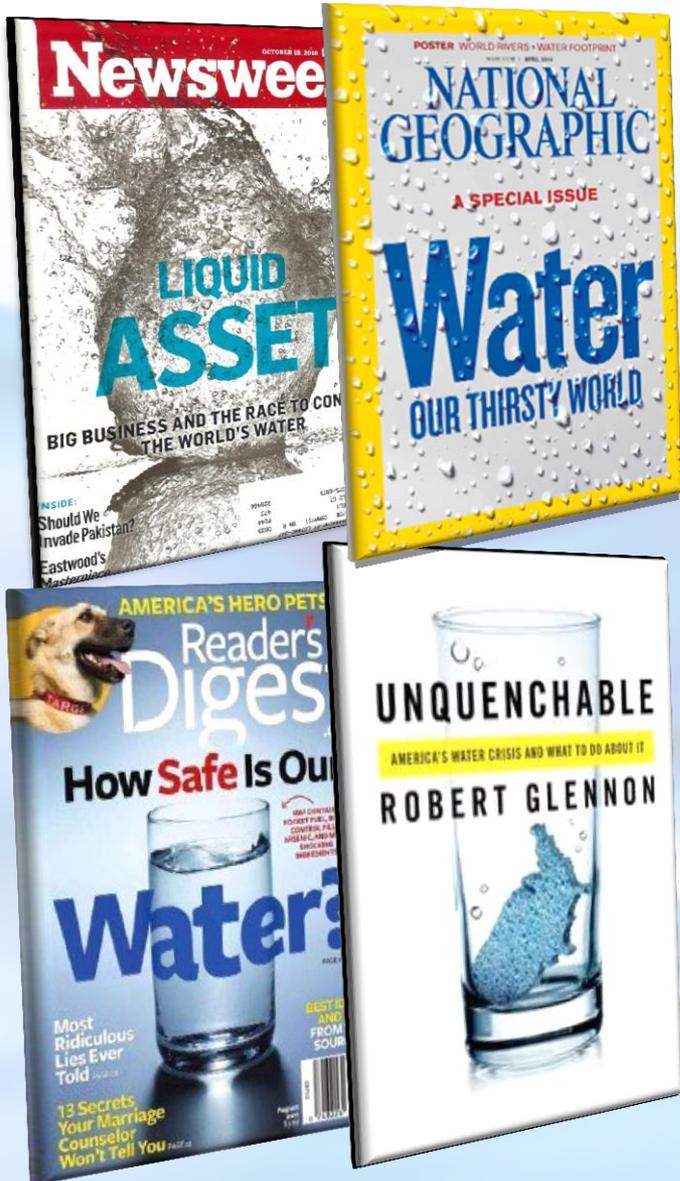
- **Impetus for Change**
  - Economic Security
  - Grand Challenges in Water
  - Stakeholder Priorities
- **Key Elements of NOAA Water Initiative**
- **NWC Status and Plans**
- **Deep Dive into New Prediction Capabilities**
- **Partnering to Accelerate R20**
- **Summary**



TOO MUCH  
TOO LITTLE  
POOR QUALITY

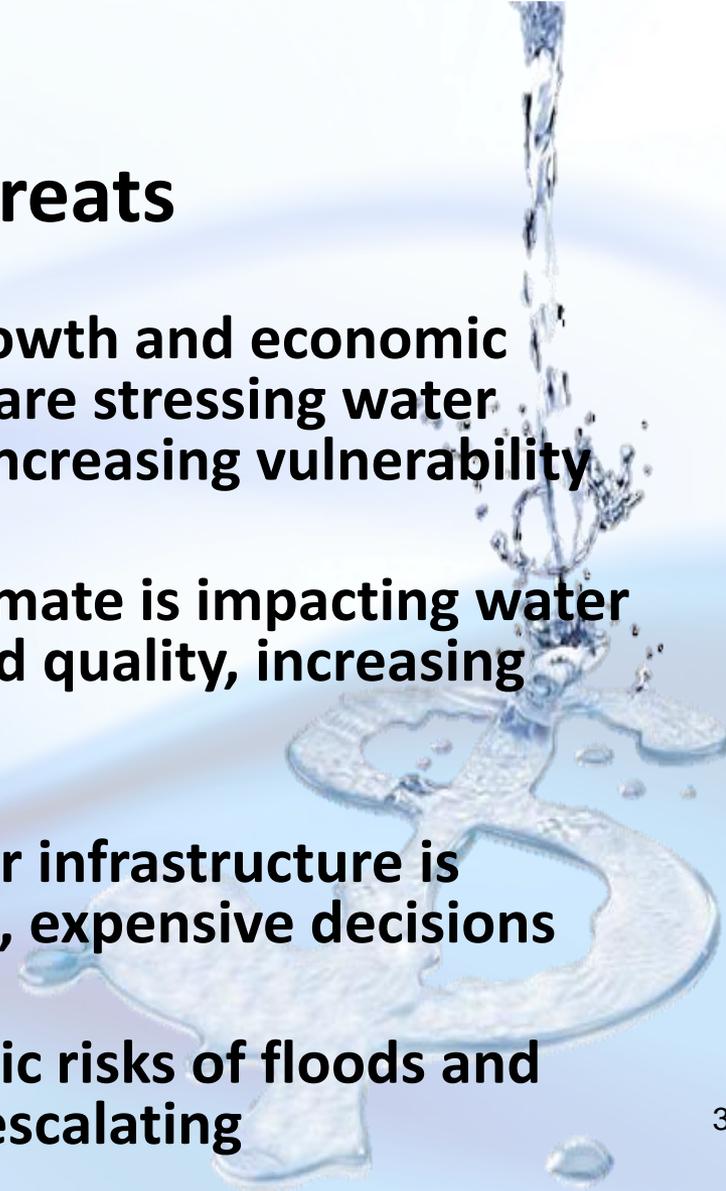
# Impetus for Change

## Growing Water Challenges

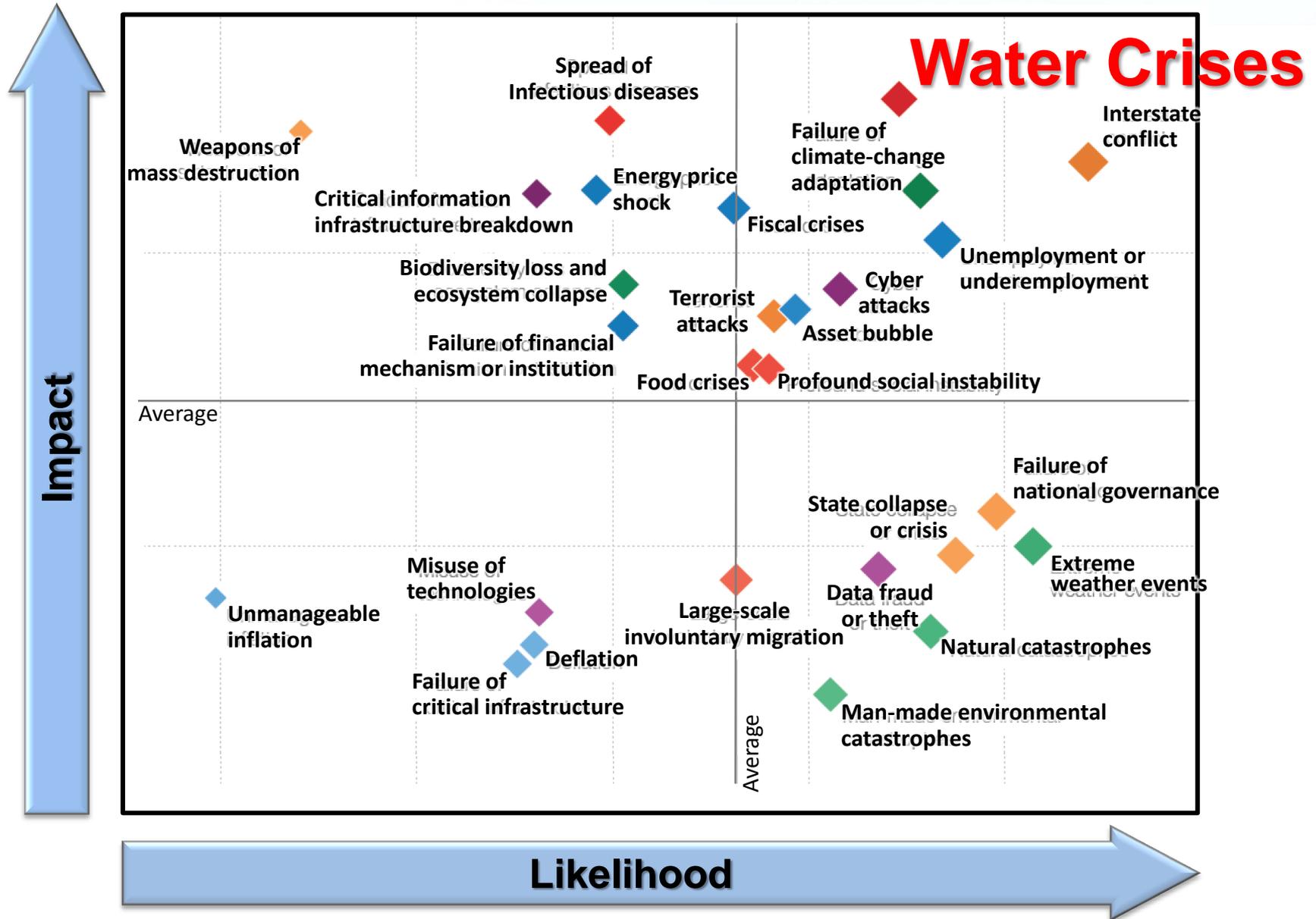


### Multiple Threats

- Population growth and economic development are stressing water supplies and increasing vulnerability
- A changing climate is impacting water availability and quality, increasing uncertainty
- An aging water infrastructure is forcing critical, expensive decisions
- Socio-economic risks of floods and droughts are escalating



# Global Economic Risks Landscape 2015



# **NATIONAL CLIMATE ASSESSMENT**

[nca2014.globalchange.gov](http://nca2014.globalchange.gov)

**Heavy precipitation and flood risk**

**Intensifying droughts, and reduced groundwater availability, risks to local aquifers**

**Water quality risks to lakes & rivers**



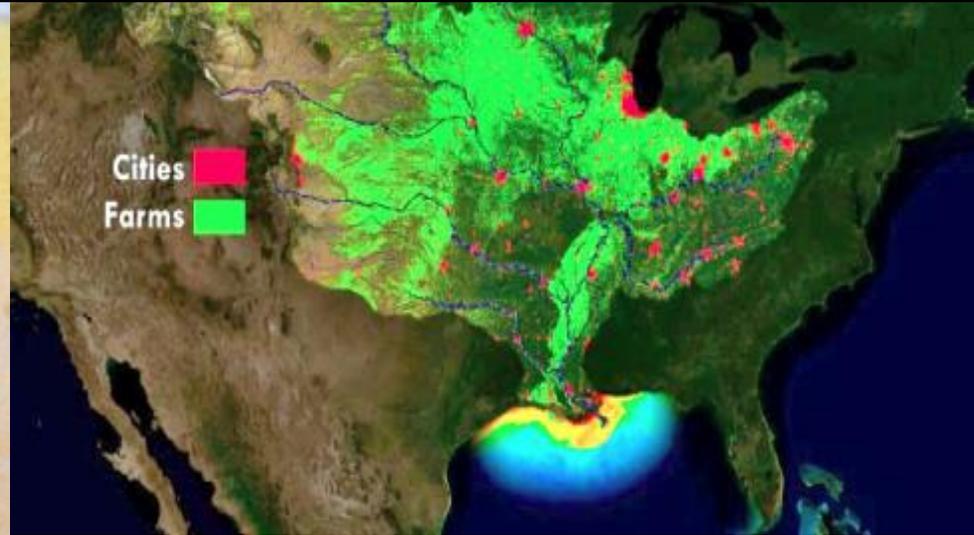
# WATER EXTREMES



# WATER SECURITY



# WATER QUALITY



# Interrelated Grand Challenges

# Example of Grand Challenge: Mississippi River Above Memphis, TN

May, 10, 2011



25 miles

November 28, 2012



# Hurricane Sandy

**BEFORE**

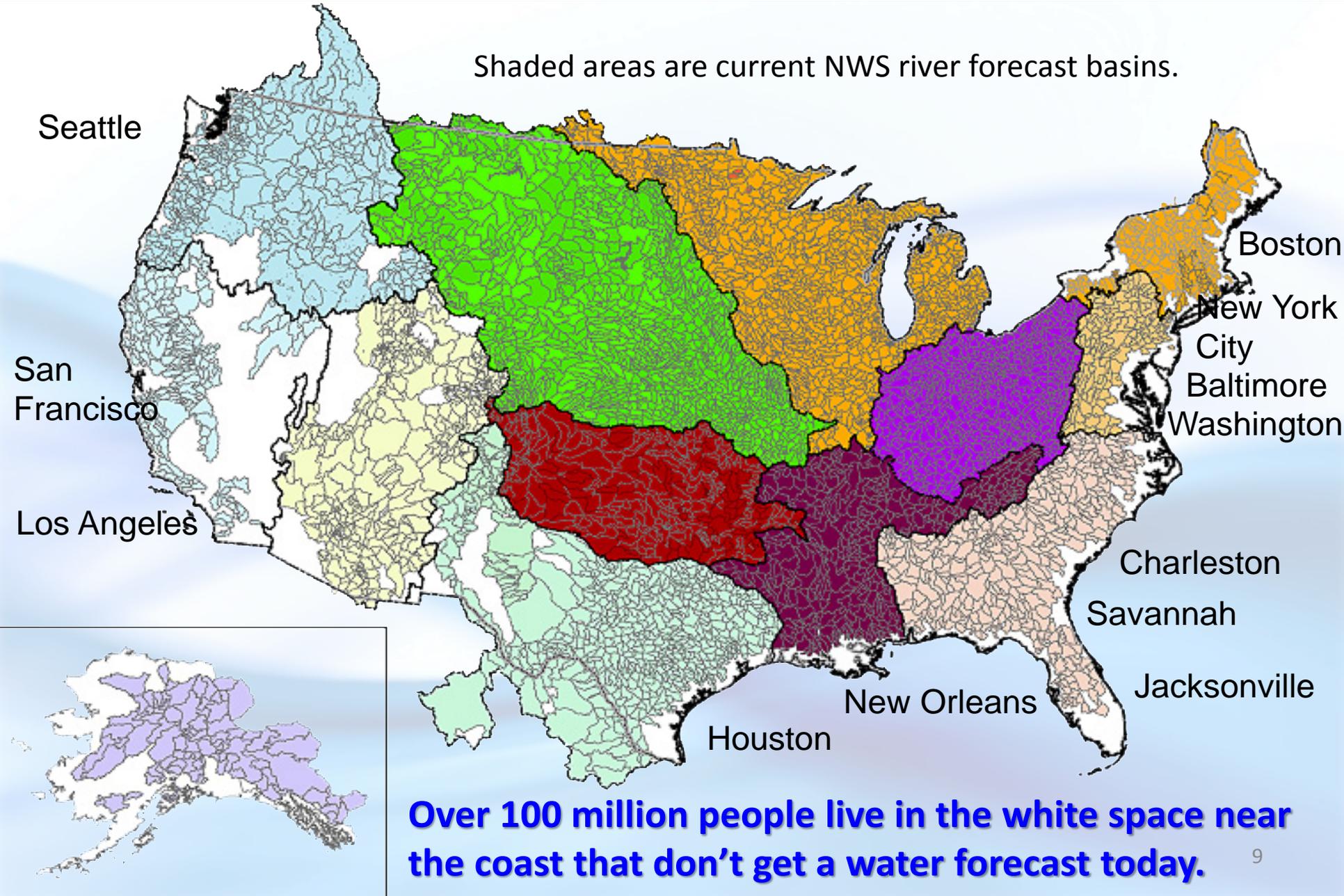


**AFTER**



# NWS River Forecast Centers

Shaded areas are current NWS river forecast basins.



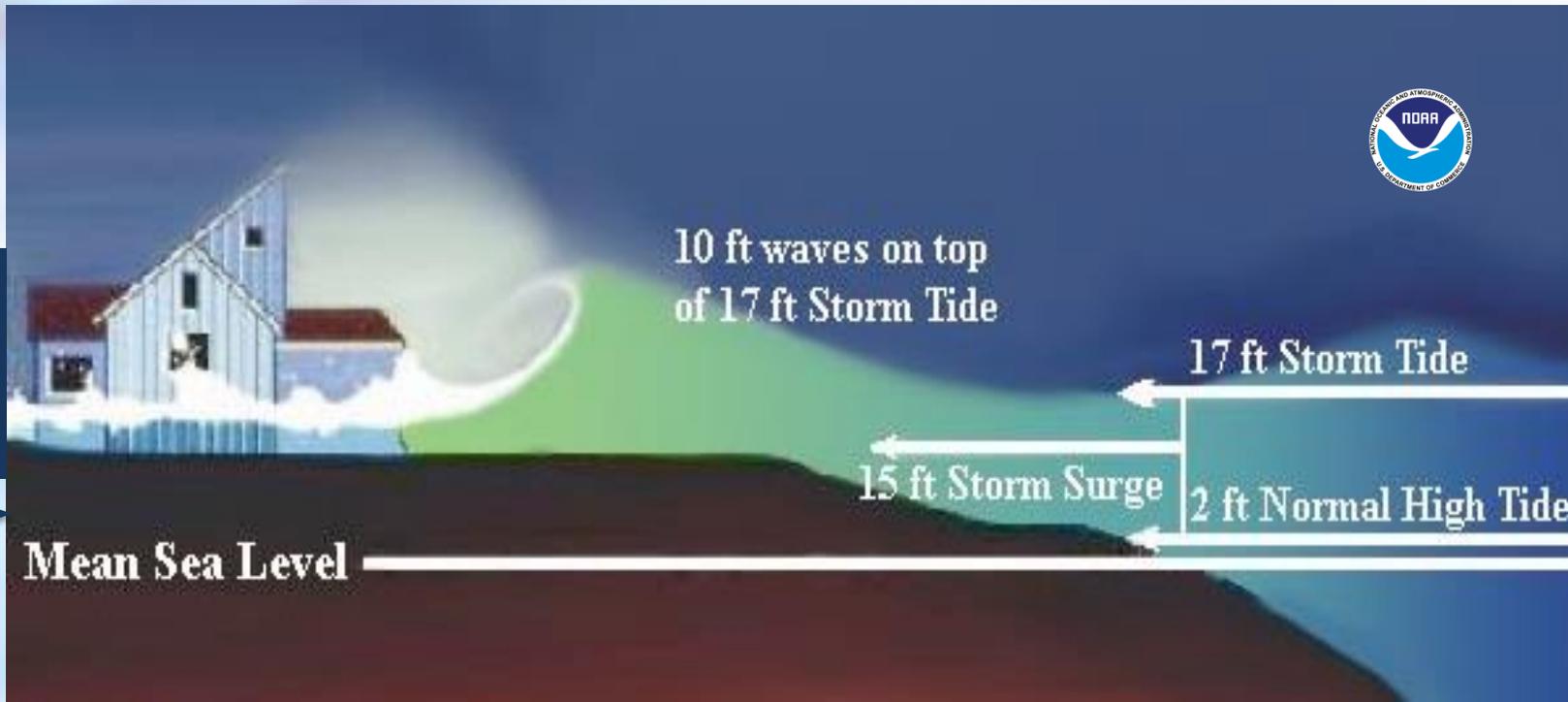
**Over 100 million people live in the white space near the coast that don't get a water forecast today.**

# NOAA's Water Initiative Enables Total Water Predictions in the Coastal Zone

## Integrated accounting for all sources of coastal flood inundation within the National Water Model

- Inland freshwater runoff, tides, storm surge and wave action
- Couple terrestrial hydrology and coastal/estuarine modeling systems within Earth System framework

5 ft Inland  
Freshwater  
Runoff  
(floodwave)



# Stakeholder Priorities



**Flooding**



**Water  
Quality**



**Water  
Availability**



**Drought**



**Climate  
Variability**

**Need integrated understanding of near- and long-term outlook and risks**

## Actionable Water Intelligence

**High Resolution, Integrated Water Analyses, Predictions and Data**

*Transform information into intelligence by linking hydrologic, infrastructural, economic, demographic, environmental, and political data*

# NOAA WATER INITIATIVE

USE-INSPIRED

INTEROPERABLE  
AGILE & NIMBLE

USER-ORIENTED

***INTEGRATED***

WATER PREDICTION  
DECISION SUPPORT TOOLS  
SERVICE DELIVERY



# Key Elements of the NOAA Water Initiative

## Centralized Water Forecasting Demonstration (FY15):

### National Water Model (NWM) Development and Demonstration

- Implement and enhance first-ever NWM
- Increase from current 4000 forecast locations to 2.7 million stream reaches across CONUS
- Simultaneous, CONUS scale modeling of the nation's entire river network<sup>1</sup>
- Forecast all hydrologic parameters which define the water budget, from summit-to-sea (not just flow/stage)

### Centralized Water Resources Data Services (CWRDS)

- Internal and external provision of enhanced water forecasts and information to core partners and stakeholders

### Water Resources Test and Evaluation Service (WRTEs)

- Comprehensive objective verification and validation of the skill and utility of the NWM
- Inter-comparison of skill between current operational forecast paradigm and new NWM

<sup>1</sup> National implementation pending availability of NHD Plus for Alaska

## Enhanced Water Prediction Capability (FY16):

### Hyper-Resolution Modeling

- Enhance NWM with nested hyper-resolution zoom capability to capture urban and other fine-scale hydrologic processes
- Heighten focus on regions of interest (e.g. follow storms/issue of the day)

### Real-Time Flood Forecast Inundation Mapping

- Develop, demonstrate and implement real-time street-level flood inundation forecasts
- Provide critical information on areal extent, depth and timing of flood waters

### Enhance Impact-Based Water Resources Decision Support Services

- Evolve NWM-based guidance to NWS field offices to improve consistency and services for flash floods
- Forecasts linked to geospatial information to assess impacts/risks
- NWC and NWS field offices generate actionable water intelligence to provide enhanced IDSS at appropriate scales

## Integrated Water Prediction (FY17 Proposed):

### New and improved water prediction services

- Stand up the National Water Center Operations Center to coordinate Federal water prediction activities and provide water intelligence to national level stakeholders
- Generate total water predictions in the coastal zone accounting for the combined impacts of surge, tide, wave and freshwater contributions

### New service delivery model for coastal and inland communities

- Engage technical experts from multiple disciplines to provide integrated, high fidelity water resource information and services needed by a spectrum of stakeholders
- Routine engagement with stakeholders to strengthen partnerships, deliver and continually enhance actionable water intelligence

### Model integration and forecast assessment

- Link state-of-the science terrestrial freshwater and coastal estuary models to create fully coupled "summit-to-sea" IWP modeling system
- Begin development of the next generation integrated Earth System model for IWP
- Secure the high performance computing, storage and networking necessary to evolve the NWM

# Service Delivery Model

Can we share your story?  
We think others can learn  
from what we've done.

What is the challenge?

Who is your audience?

What are your risks  
and vulnerabilities?

What tools do you  
have already?

How do you  
use the data  
you have?

What data do you  
need? When?

How does this product  
look? What do you  
need changed?

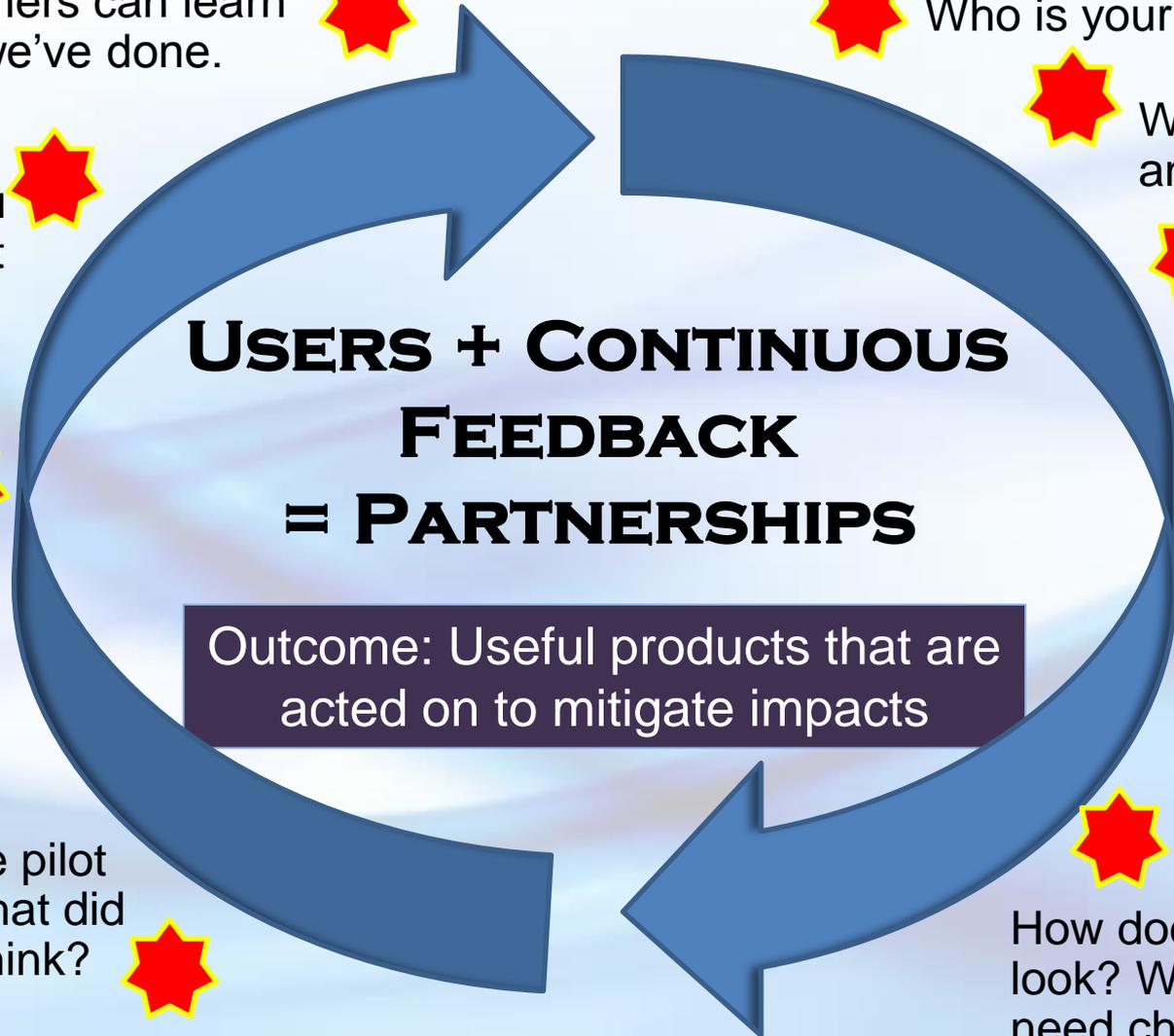
I'm glad you  
brought that  
up. How  
about this?

Let's train  
the first  
group on it.

How did the pilot  
test go? What did  
the users think?

**USERS + CONTINUOUS  
FEEDBACK  
= PARTNERSHIPS**

Outcome: Useful products that are  
acted on to mitigate impacts



# National Water Center (NWC)

Initial Operating Capacity: May 26, 2015



A catalyst to transform NOAA's water prediction program



## ***Mission: Nationally Integrated Water Prediction***

- Earth system modeling and geo-intelligence for water prediction
- Operations Center for water resources common operating picture
- Decision support services for spectrum of water stakeholders
- Proving ground to accelerate research to operations
- Interagency and Academia Collaboration



# Transforming NOAA Water Prediction

TODAY	THE FUTURE
Approximately 4000 forecast locations at points	Approximately 2,700,000 forecast stream reaches
Forecast river flow/stage, from summit to coastal zone	Forecast all hydrologic parameters which define the water budget, from summit-to-sea
Driven by large catchment “lumped” modeling	Driven by high/hyper resolution Earth System modeling
Forecaster “in the loop” – serial, basin to basin, modeling of flow through the river network	Forecaster “over the loop” – simultaneous modeling of the nation’s entire river network
Average basin size greater than 420 square miles	Average basin size ~1 square mile
13 River Forecast Centers (RFCs) developing separate versions of the same regional model	13 RFCs, NWC, academia, and federal partners developing/evolving same state-of-the-science national, community-based, model (working with NSF, CUASHI, and other Federal agencies to establish community development version of NWM)
RFC-generated river forecasts coordinated with Weather Forecast Offices (WFOs) to deliver Impact-based forecasts at selected points	National Water Model-based predictions coordinated among NWC, RFCs, and WFOs and linked with detailed local infrastructure data to communicate street level impacts

**For the hydrology community, the implementation of the NWM and the leap ahead capability it provides parallels the implementation of mesoscale atmospheric models in the 1970s (i.e., model resolution substantially greater than available observational network)**

# NWM V1.0 Experimental Output

(FY16 Q4)

- **Hydrologic Output**

- River channel discharge and velocity at 2.7 million river reaches
- Reservoir inflow, outflow, elevation
- Surface water depth and subsurface flow (250 m CONUS+ grid)

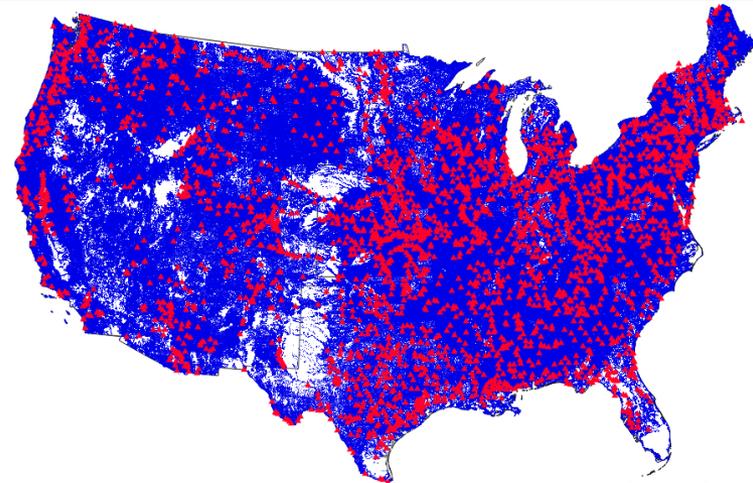
- **Land Surface Output**

- 1km CONUS+ grid
- Soil and snow pack states
- Energy and water fluxes

- **Direct-output and derived products**  
(e.g. stream flow anomalies)

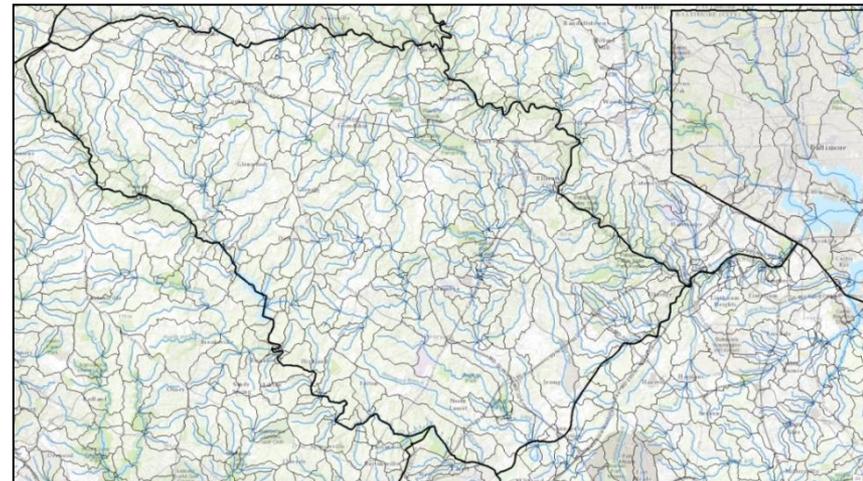
- **Three pronged dissemination strategy**

- Public-facing NWC website
- Data feed to River Forecast Centers
- NOMADS data service (NOAA National Operational Model Archive & Distribution System)



Current NWS AHPS points (**red**)  
NWM output points (**blue**)

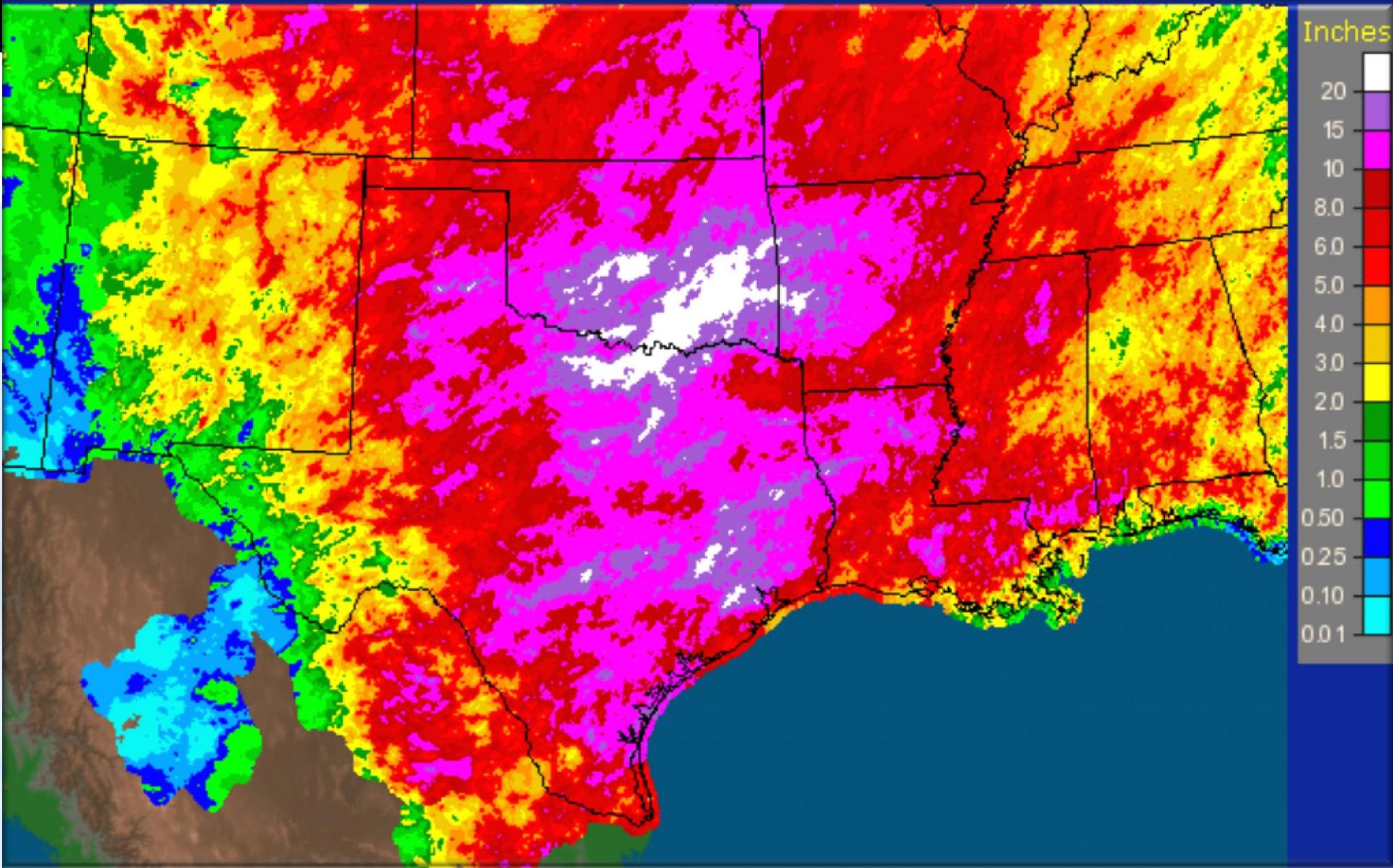
Howard County, Maryland (300k People)



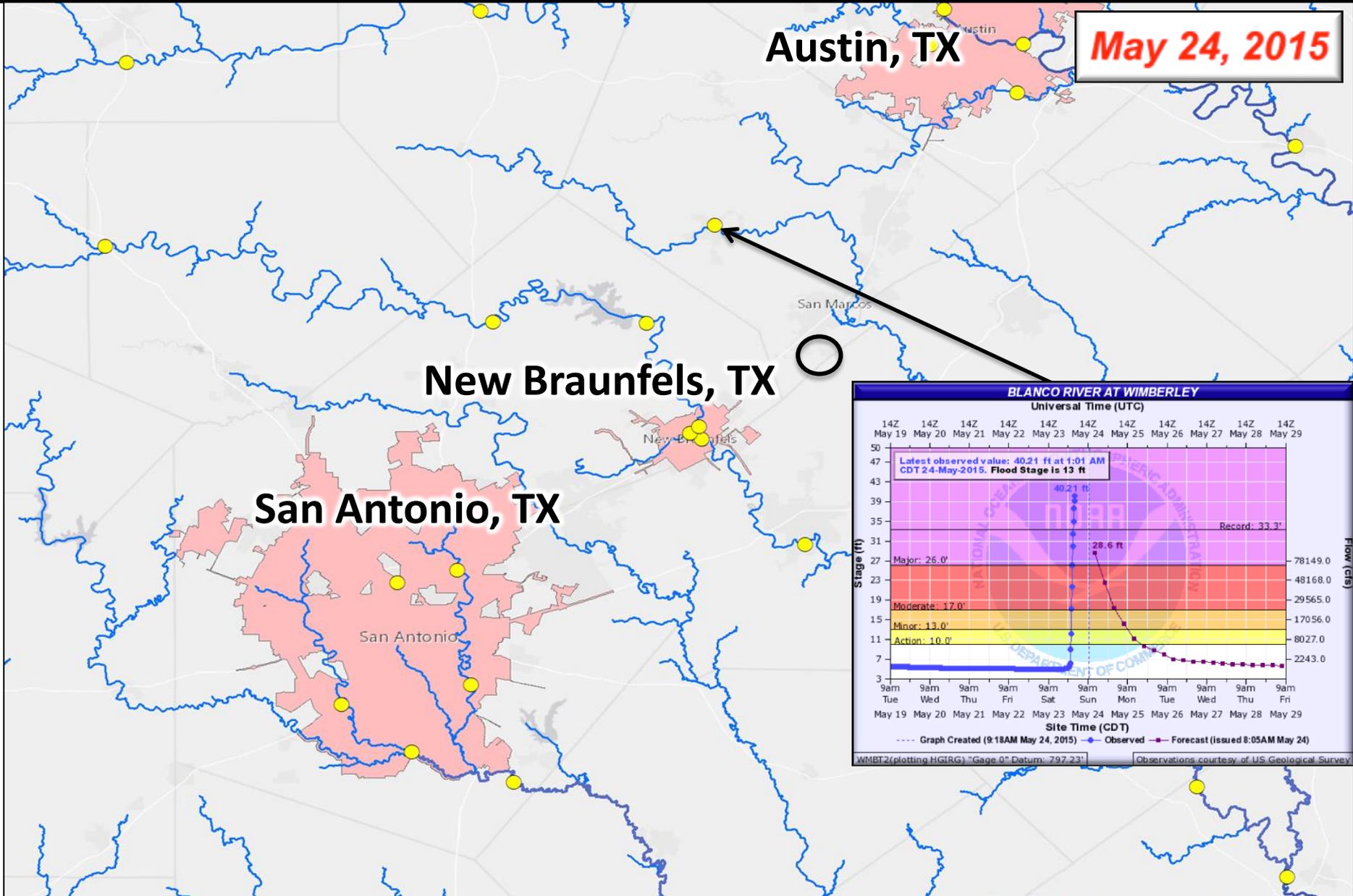
Current River Forecast Locations: Zero  
NWM Forecast Locations: 300+

# Southern Plains Observed Precipitation

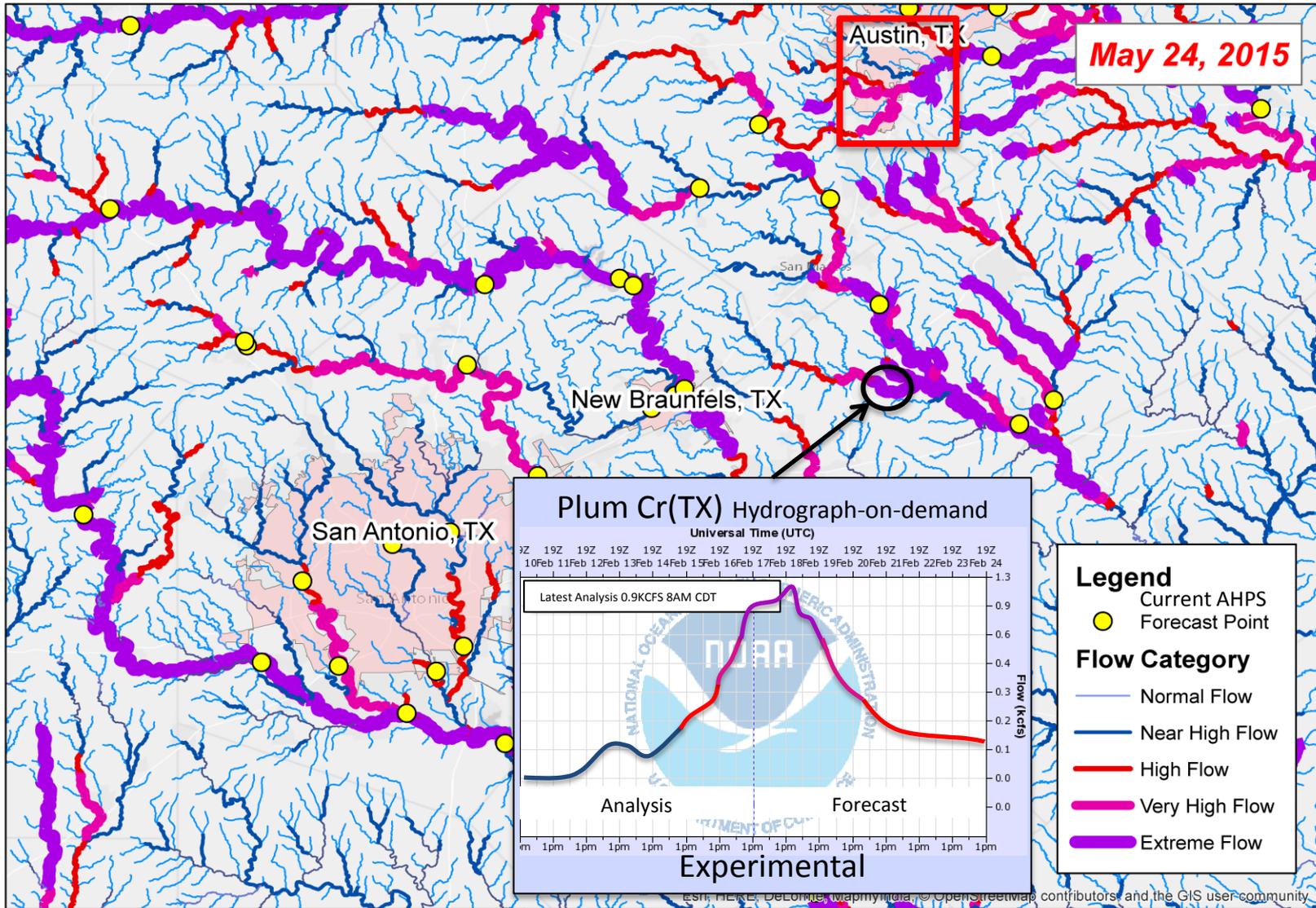
May 2015



# Current Advanced Hydrologic Prediction Services (AHPS) Streamflow Information

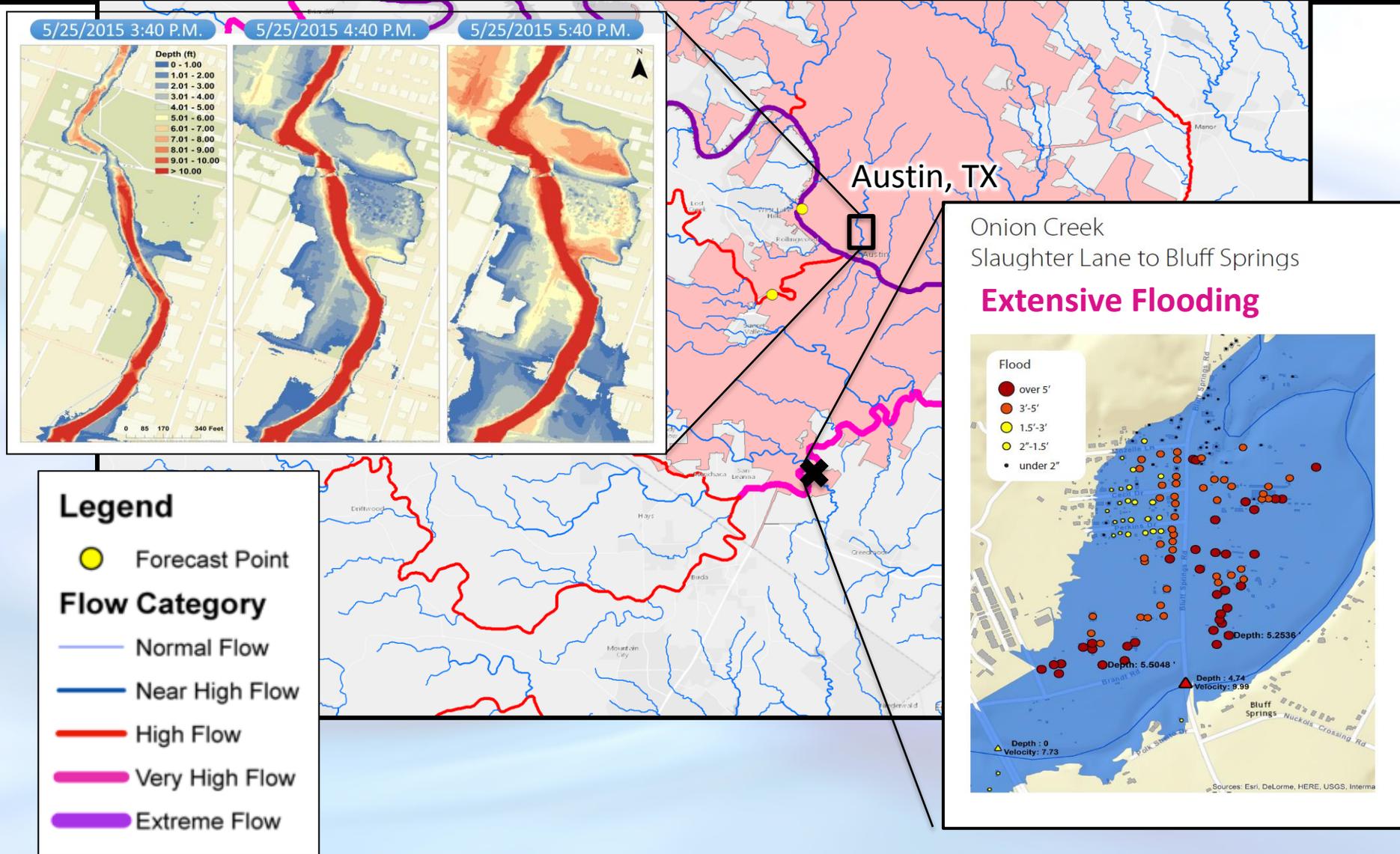


# National Water Model Model Streamflow Analysis and Forecast



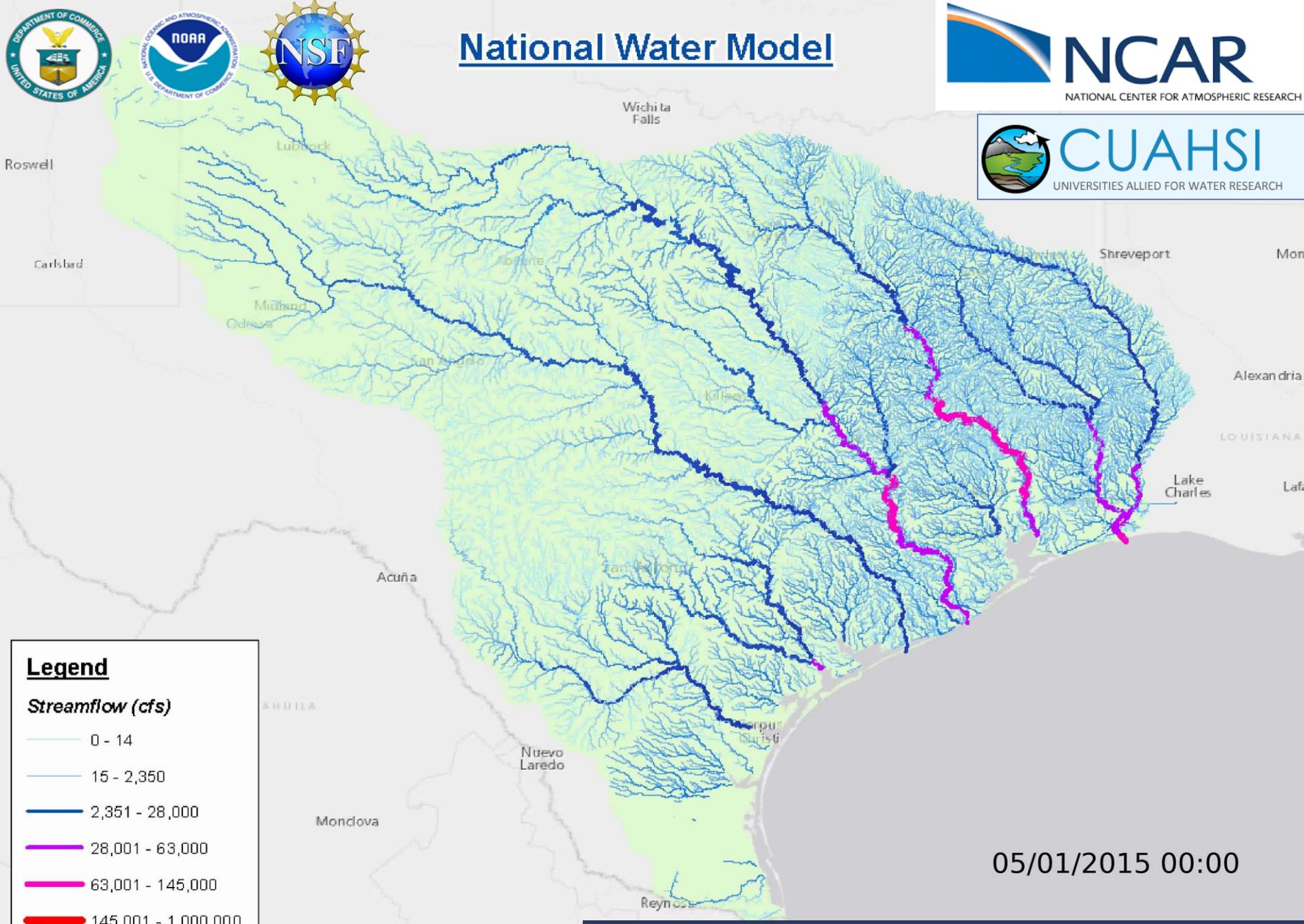
# Experimental Flood Depth and Extent Mapping

*Converting High Resolution Forecasts into Actionable Water Intelligence*





# National Water Model



**Legend**

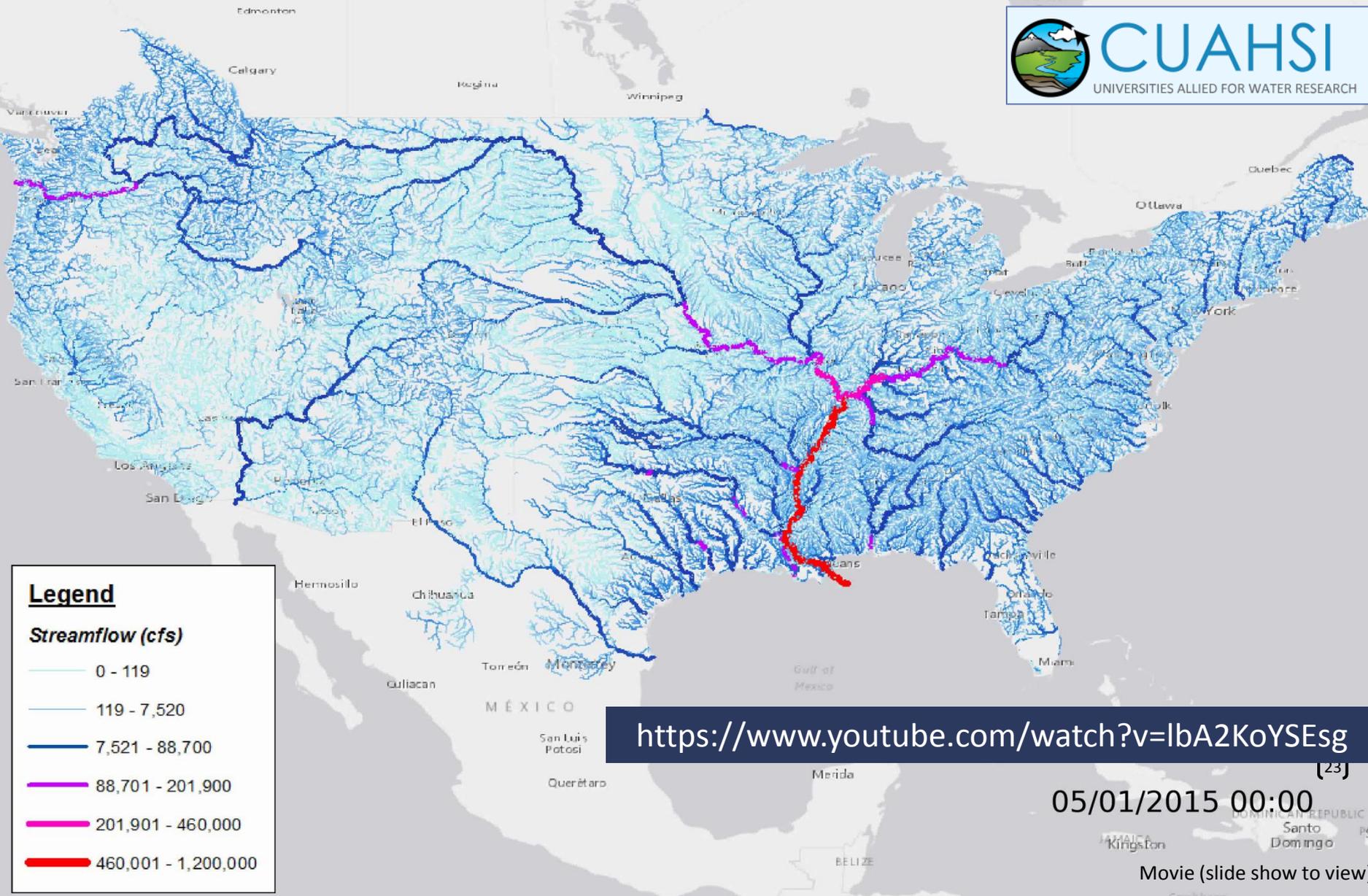
*Streamflow (cfs)*

- 0 - 14
- 15 - 2,350
- 2,351 - 28,000
- 28,001 - 63,000
- 63,001 - 145,000
- 145,001 - 1,000,000

05/01/2015 00:00



# National Water Model



**Legend**

**Streamflow (cfs)**

- 0 - 119
- 119 - 7,520
- 7,521 - 88,700
- 88,701 - 201,900
- 201,901 - 460,000
- 460,001 - 1,200,000

<https://www.youtube.com/watch?v=lbA2KoYSEsg>

05/01/2015 00:00

Movie (slide show to view)

# NWC Innovators Program

- Partnership between **NWS and the academic community** (Interagency Agreement between NSF and NOAA)
- Two Thematic Goals
  - Provide a **framework for collaboration** between the federal and academic communities that fosters innovation and creativity, and enables a pathway for that innovation to transition into operational water prediction
  - **Target emerging technologies** such as advanced water resources modeling capabilities, cutting edge data and interoperability services, or interdisciplinary techniques aligned with NOAA and the NWC's strategic Science and Service



# National Flood Interoperability Experiment (NFIE)

(Sept 2014 to August 2015)

- First instance of the **NWC Innovators Program**
- Included a **Summer Institute** for 44 graduate students from 19 Universities at the National Water Center, June 1 to July 17, 2015 on the University of Alabama Campus and NWC
- Demonstrated ability to **simultaneously model the entire continental United States** river network at high spatial resolution, in near real-time for 2.7 million stream reaches
- A more elaborate version of this prototype is being made operation as the **National Water Model** in June 2016 at the National Water Center



# Summary

- **NOAA's Water Services are Evolving**
  - Deliver comprehensive, integrated actionable water intelligence
  - Compliment current services with new information spanning Summit-to-Sea, Floods to Droughts, Treetops to Bedrock
- **Implementing State-of-the-Art Technical Approach**
  - Water prediction through state-of-the-science earth system modeling
  - Impact-based decision support services underpinned by geo-intelligence
- **Scale Change: Orders of Magnitude More Data**
  - Reach-based "Street Level" prediction
  - High Performance Computing
- **New Organization, Cornerstone Facility and Philosophy**
  - National Water Center
  - Collaborative, cross-NOAA, interagency, academic partnerships



TOO MUCH  
TOO LITTLE  
POOR QUALITY

# NOAA WATER INITIATIVE



[www.noaa.gov](http://www.noaa.gov)

For additional information or an individual office  
briefing, please contact Frances Bothfeld,  
[Frances.Bothfeld@noaa.gov](mailto:Frances.Bothfeld@noaa.gov)