

# Water Modeling for Texas



Dr. Tim Whiteaker  
The University of Texas at Austin

Brazos Water Operations Model

National Water Model

Texas Flood Forecasting

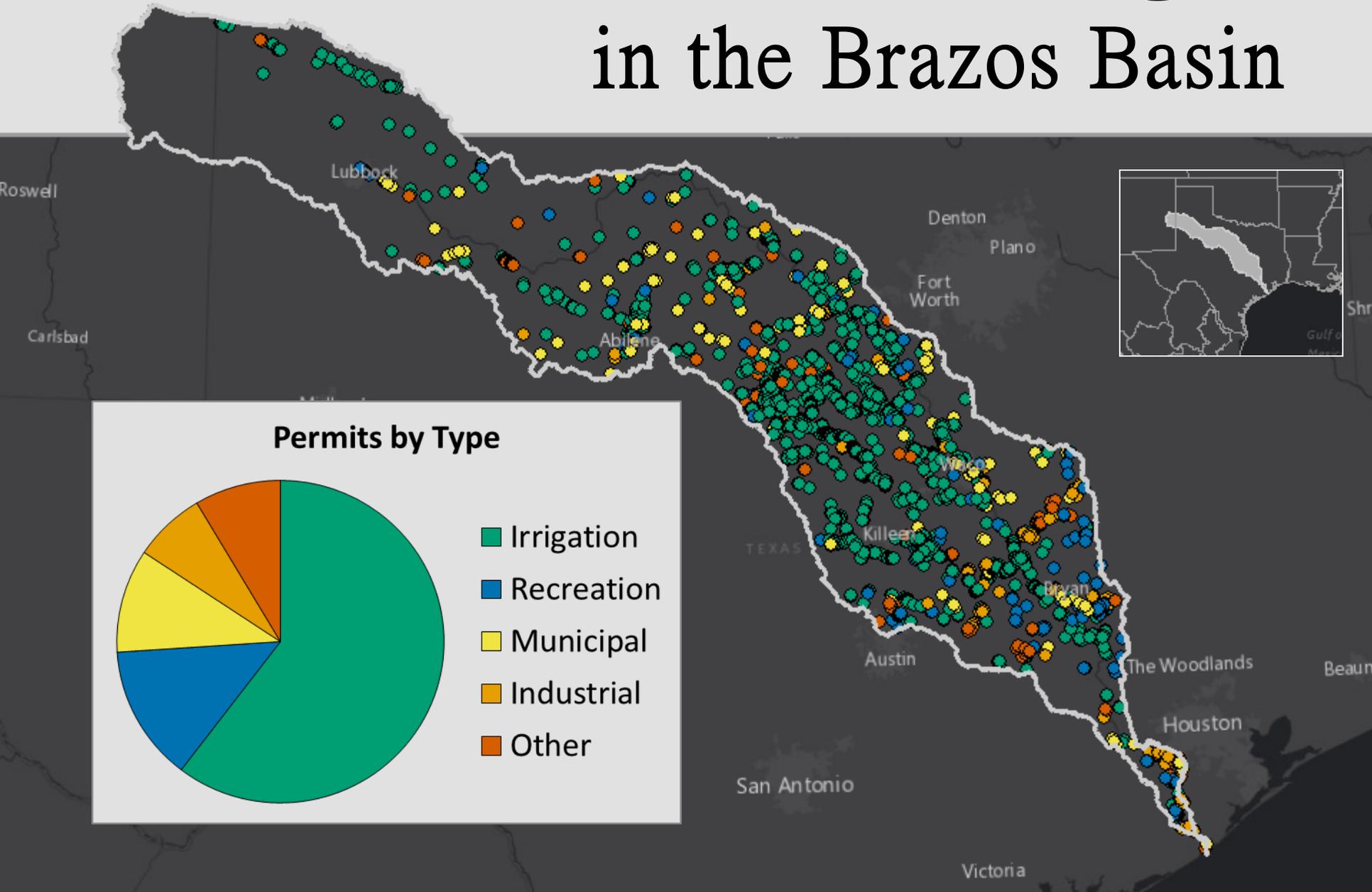
# Texas Owns Its Surface Water



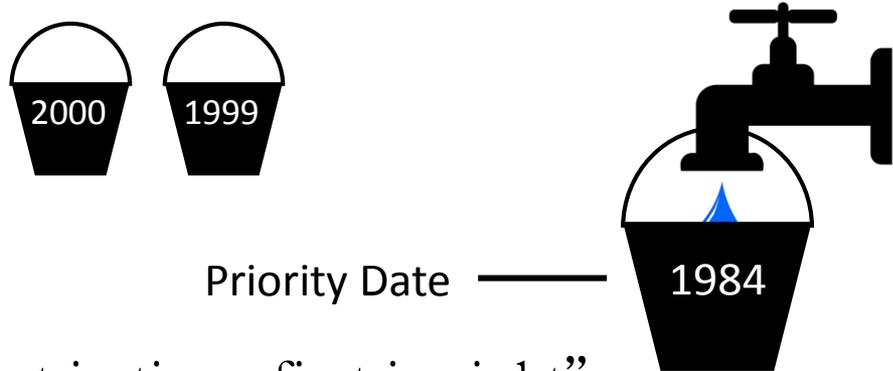
# Texas Grants Rights To Use Water



# 2000+ Water Rights in the Brazos Basin



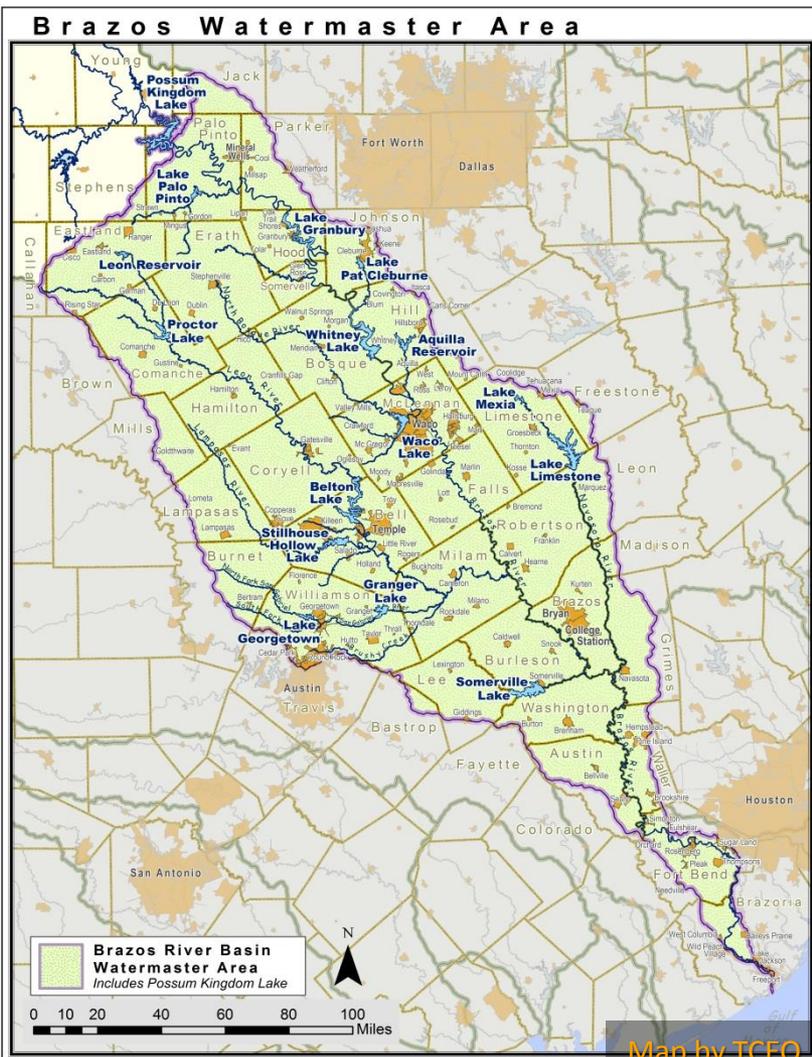
# A Watermaster Regulates Use



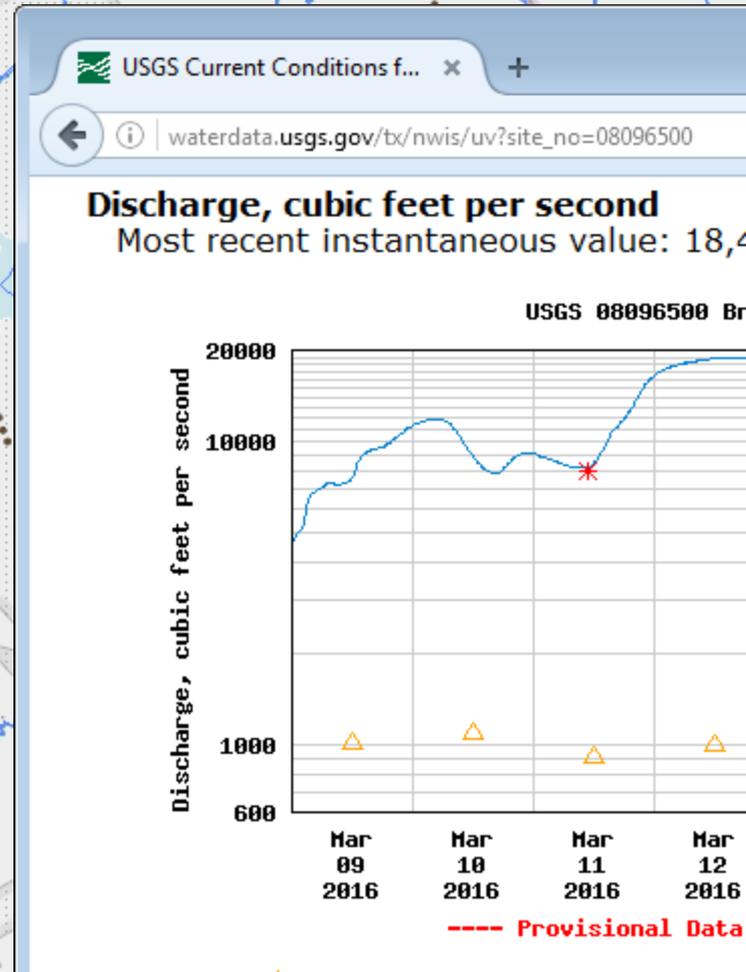
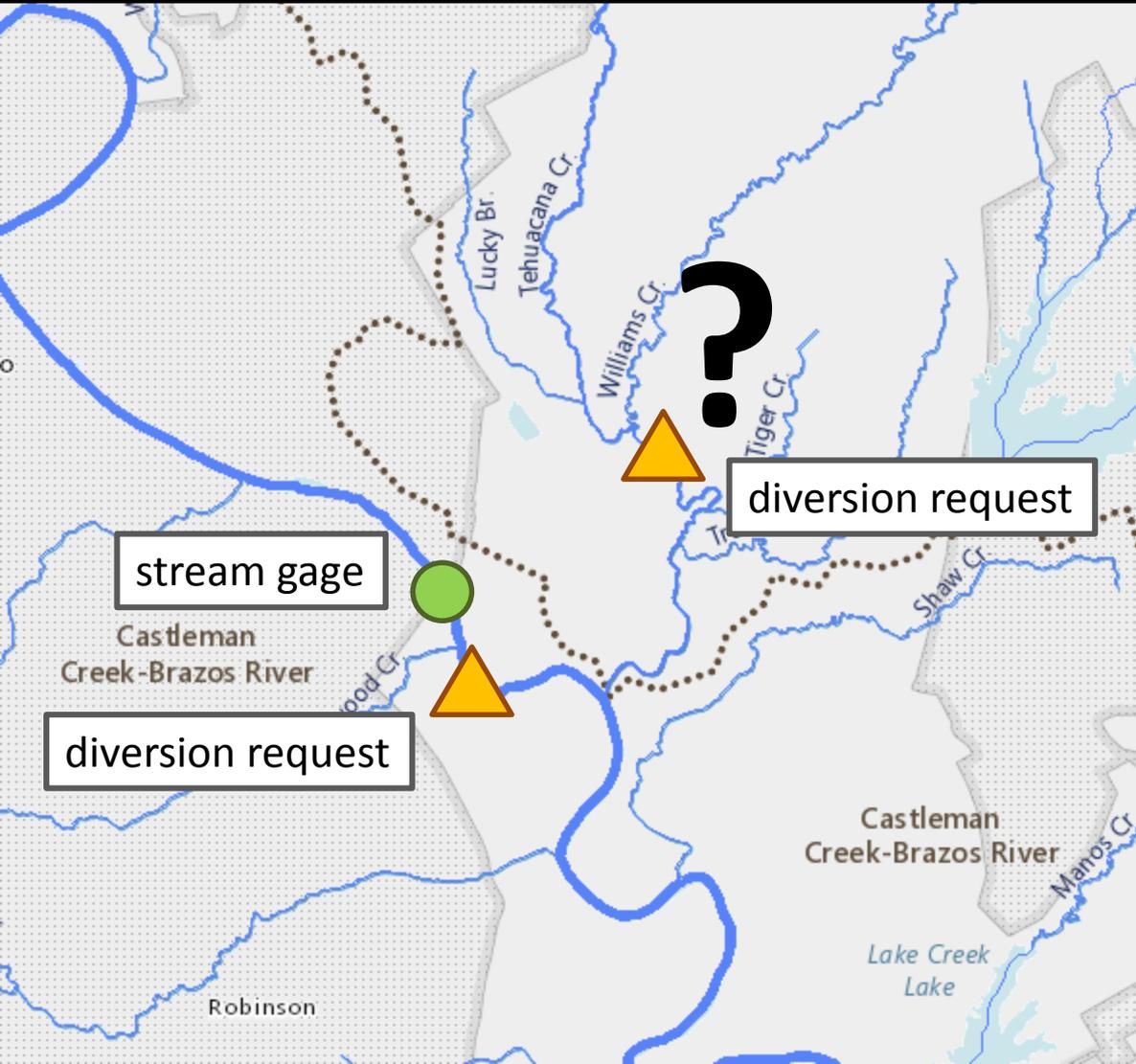
“First in time, first in right”



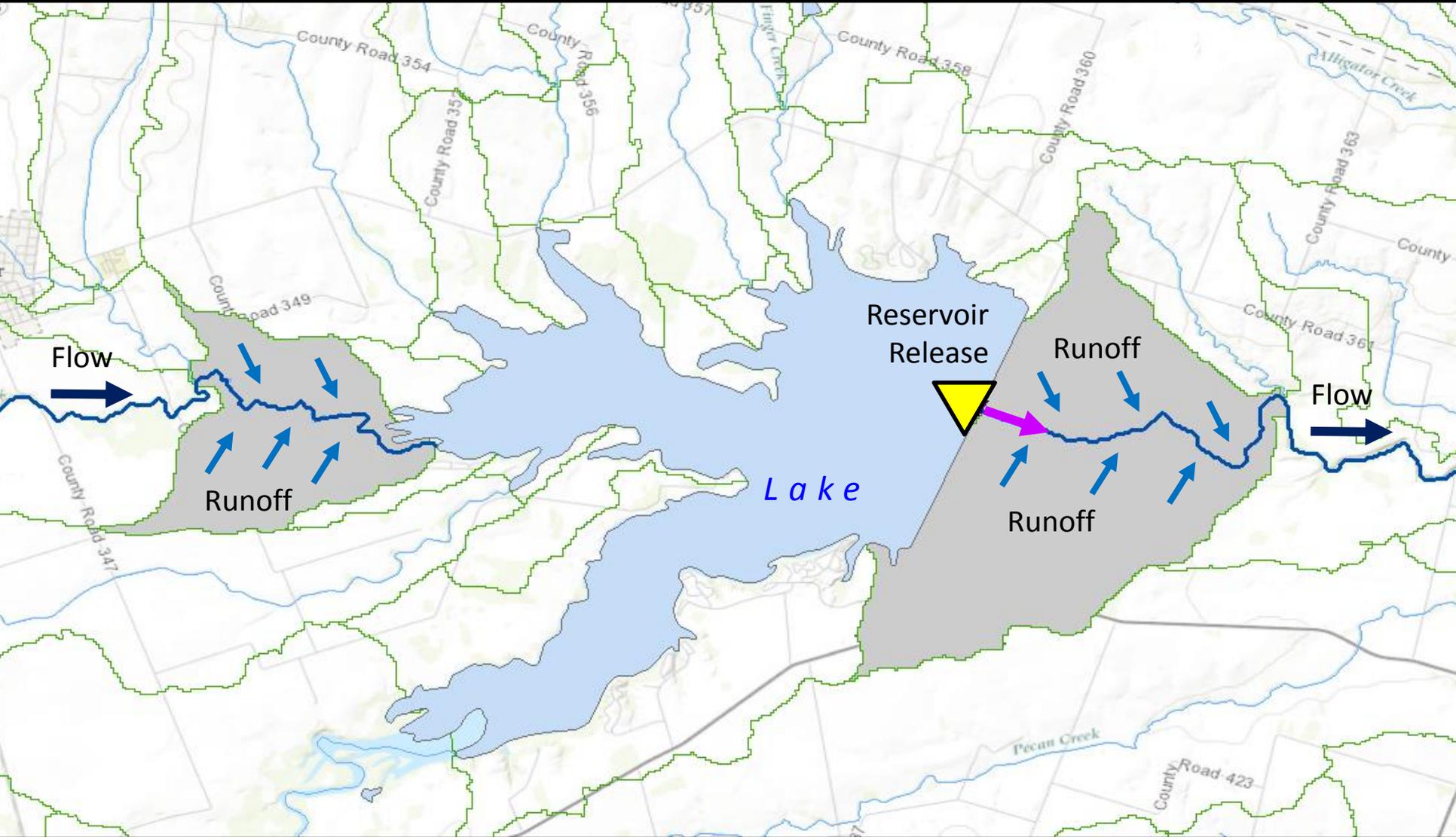
Photo courtesy of Molly Mohler



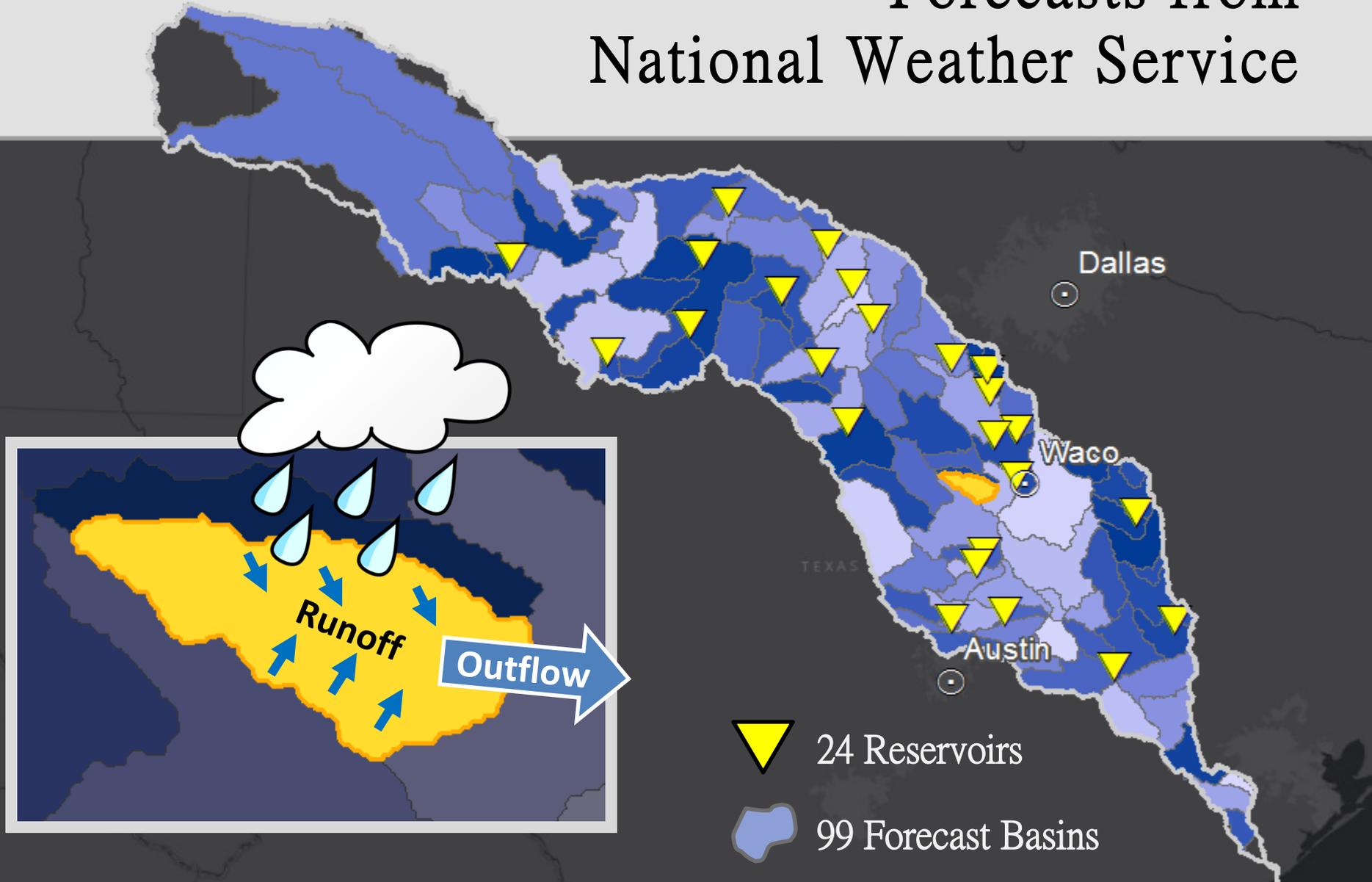
# Is there enough water?



# A Model Can Fill the Gaps



# Forecasts from National Weather Service



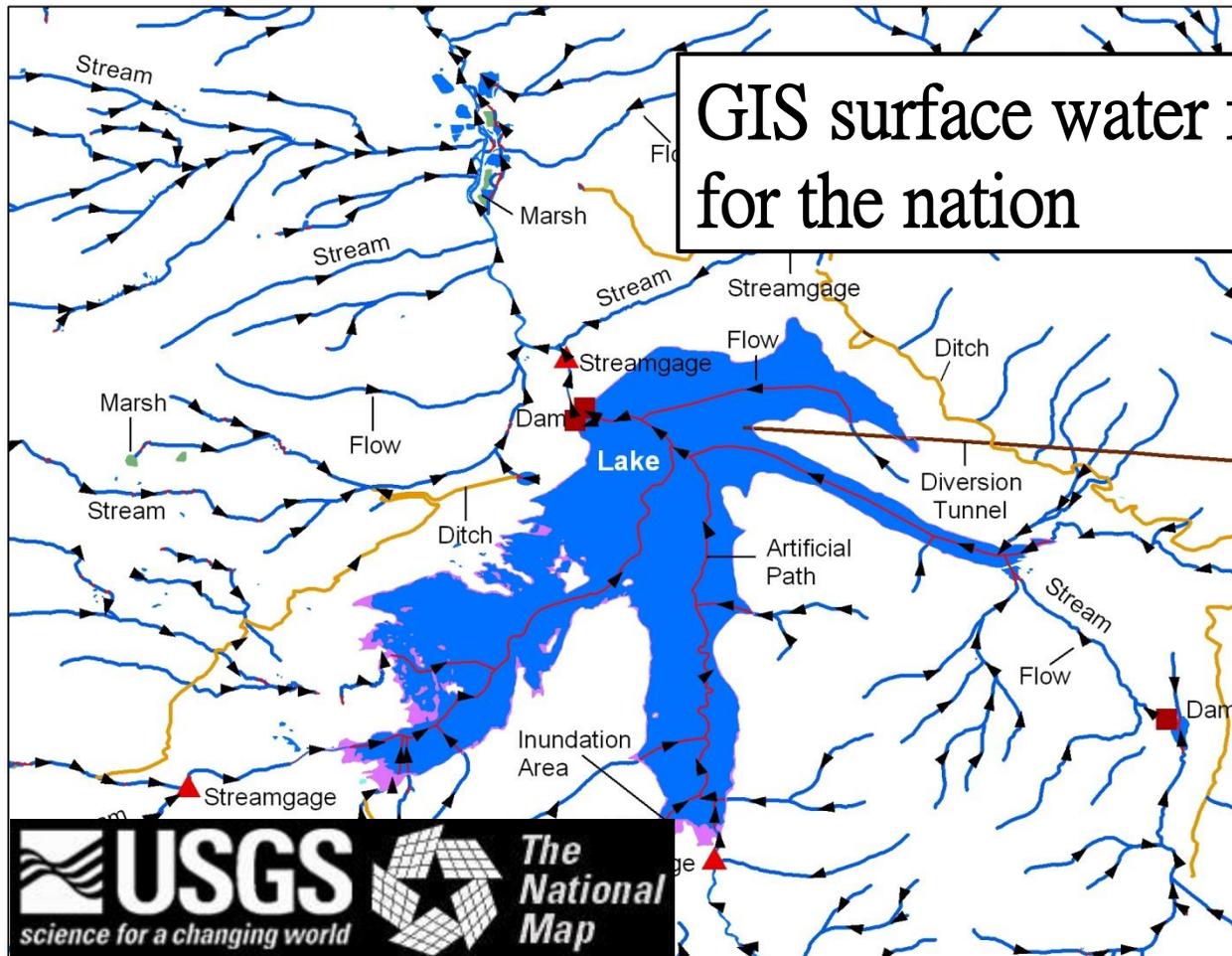
Outflow = Reservoir  
Release



With basin runoff and reservoir releases, we now need to move water through the river network

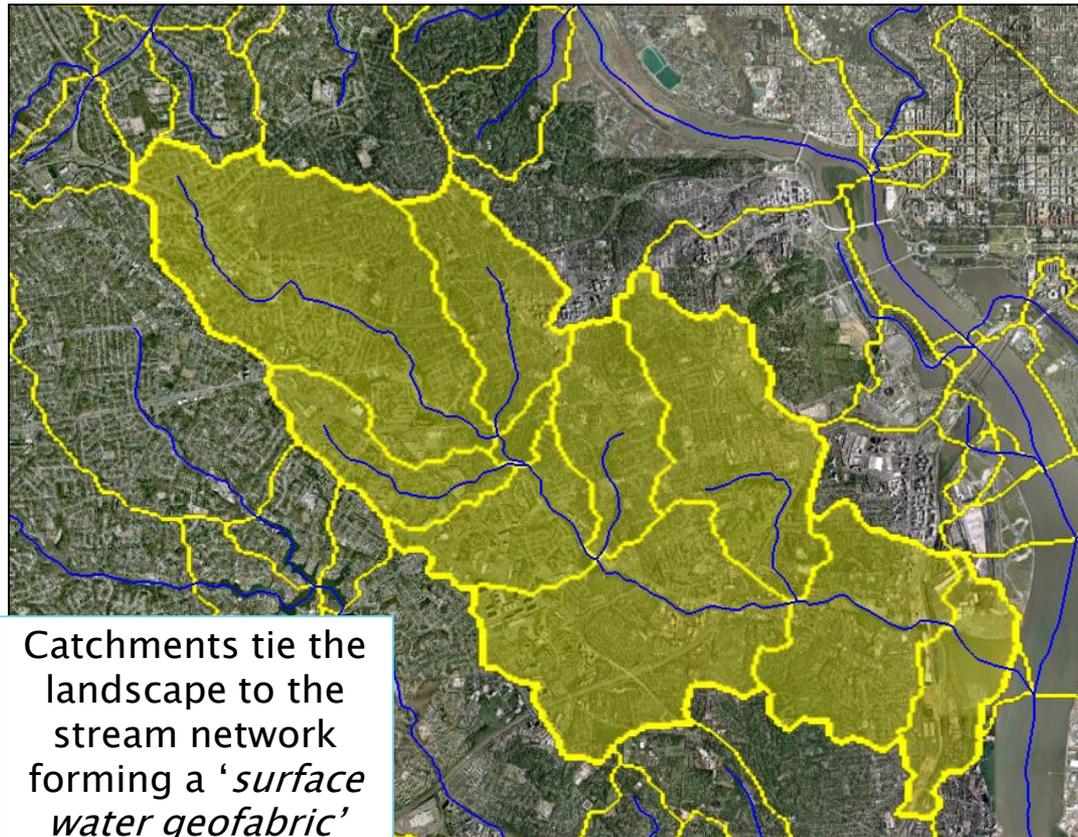


# The National Hydrography Dataset is the foundation



# NHDPlus is ready for Hydrology

Developed by USEPA and USGS–Water to provide flow volume and velocity estimates for pollution dilution modeling on the NHD network



Catchments tie the landscape to the stream network forming a '*surface water geofabric*'

- River attributes
  - Mean Streamflow
  - Mean Velocity
  - Drainage area
  - ...and more

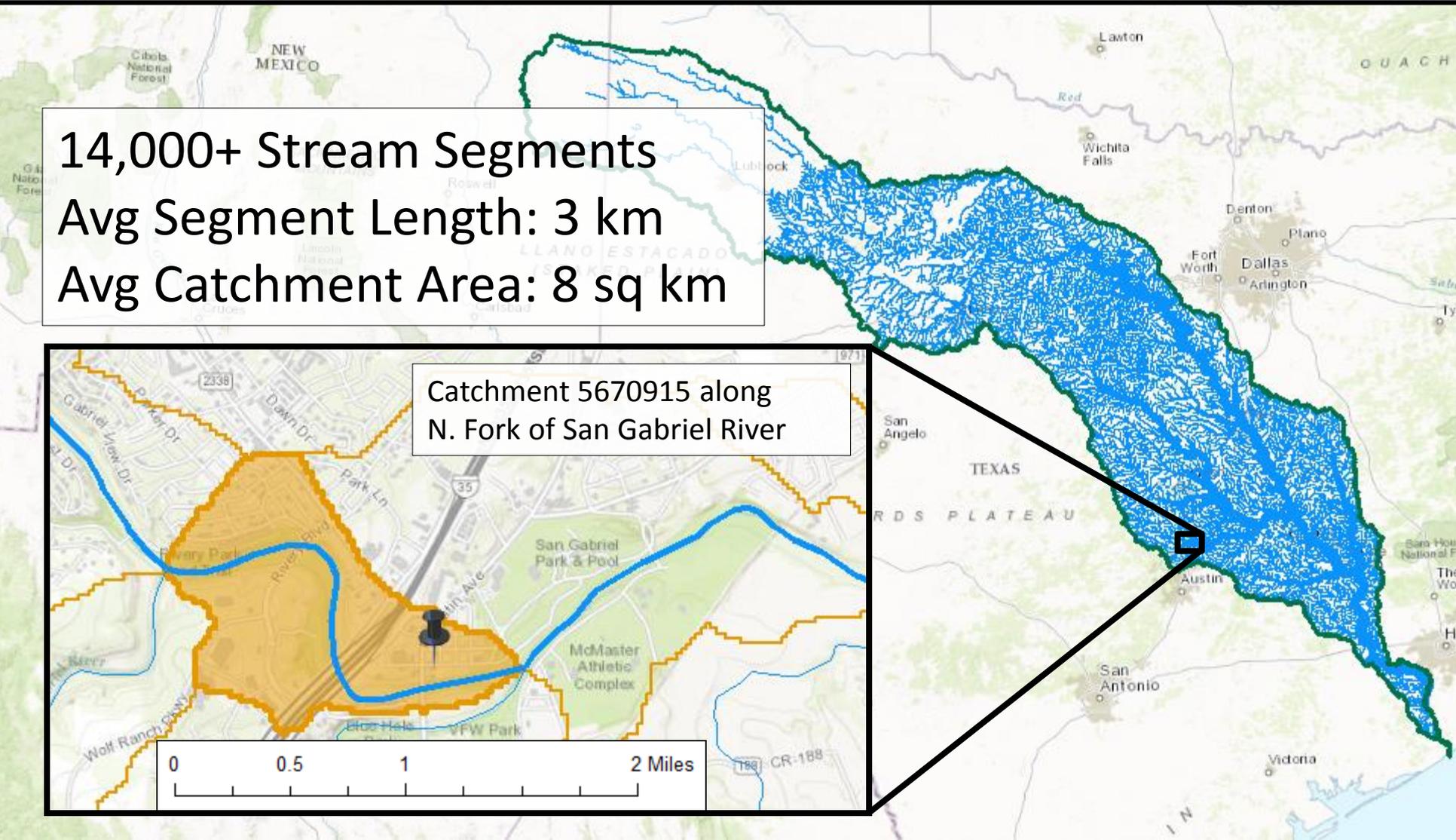
Modified from Tommy Dewald, EPA  
Presented at 2015 Esri User Conference

# NHDPlus in the Brazos Basin

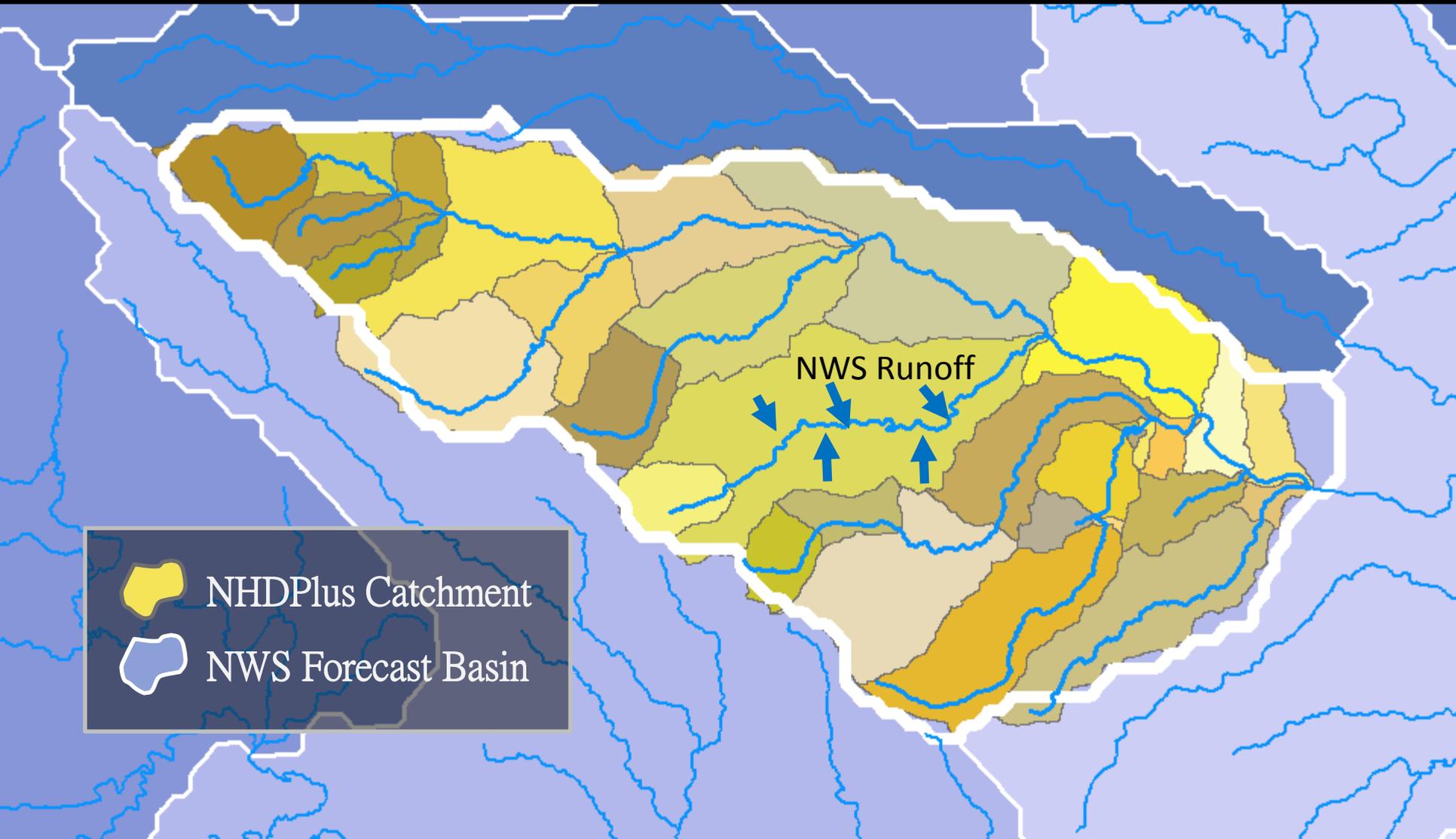
14,000+ Stream Segments  
Avg Segment Length: 3 km  
Avg Catchment Area: 8 sq km

Catchment 5670915 along  
N. Fork of San Gabriel River

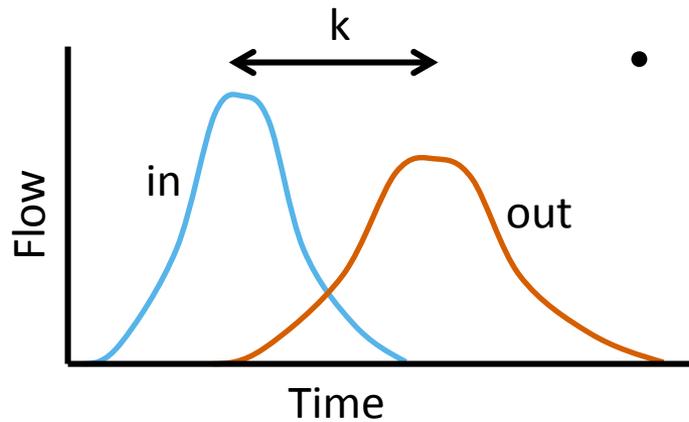
0 0.5 1 2 Miles



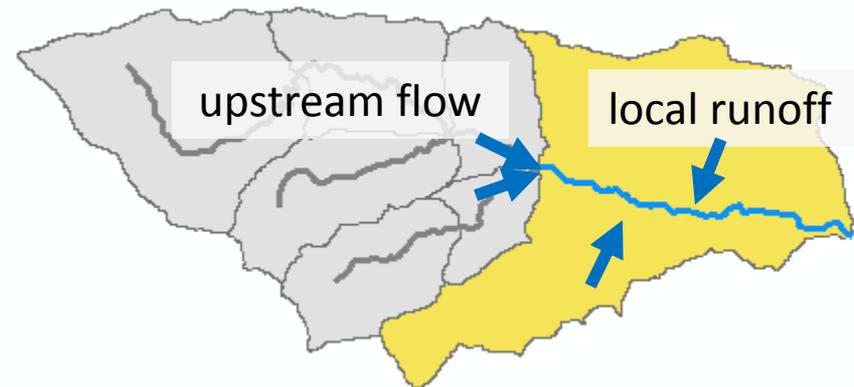
# From Basin Runoff to Rivers



# RAPID River Routing Model



- Matrix based Muskingum routing
- Parameters:  $k$  (celerity) and  $x$  (diffusion)
- Inputs: Runoff, Reservoir Releases

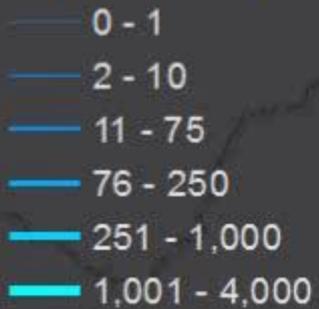


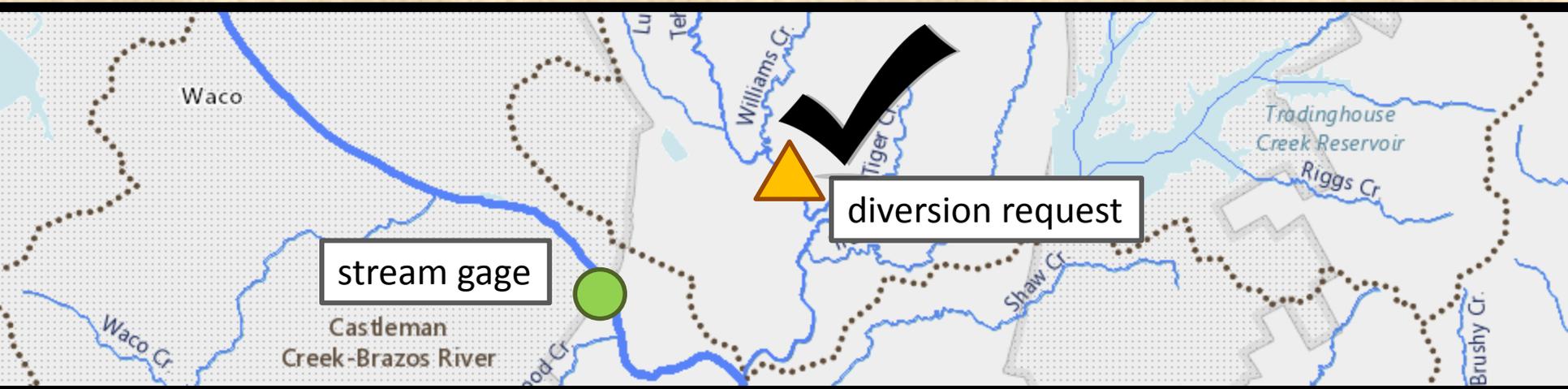
David, et al. (2011), DOI: 10.1175/2011JHM1345.1

# October-March Simulation

2015-10-20

Streamflow (cms)



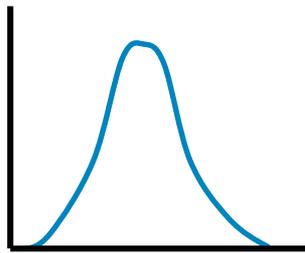


2000+ water rights

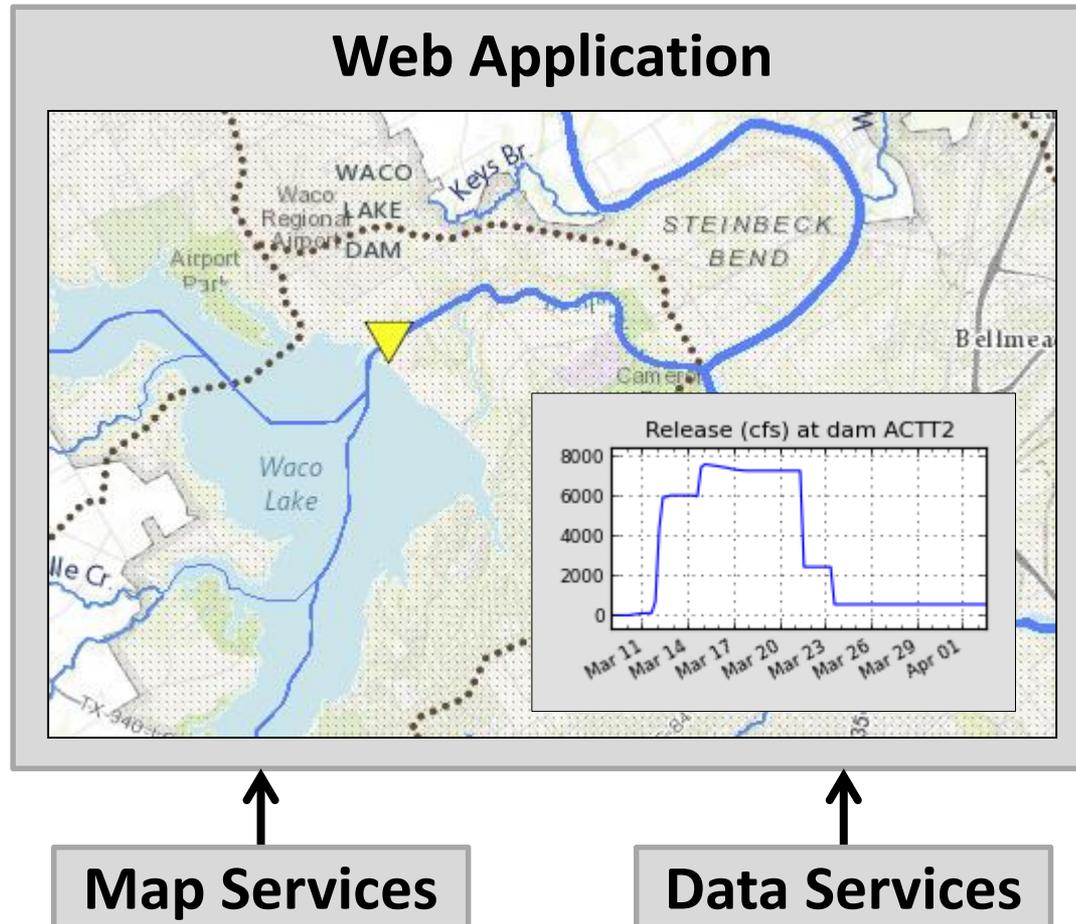
82 stream gages

14,000+ rivers with modeled flow

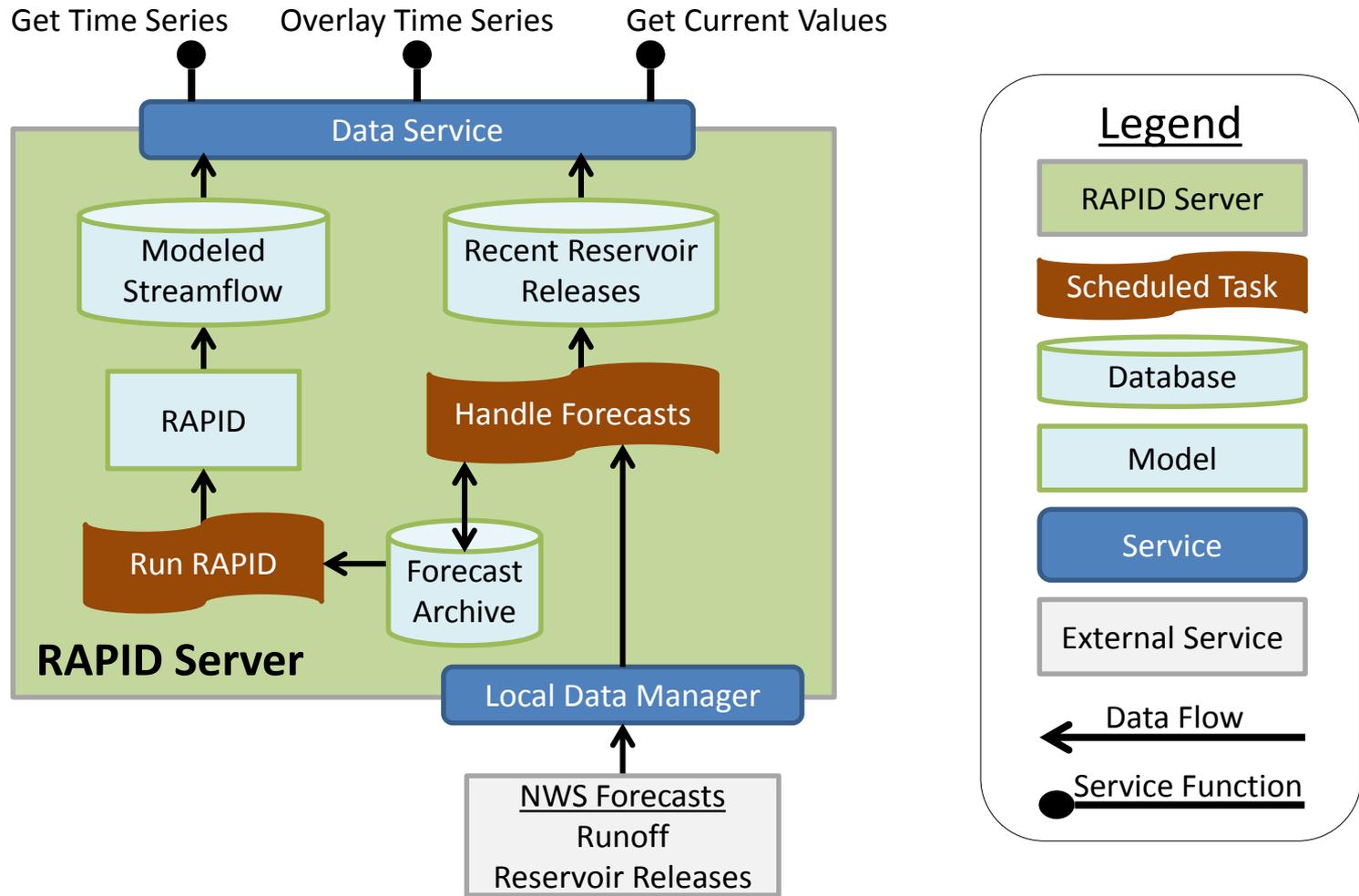
# Now Web-enable it



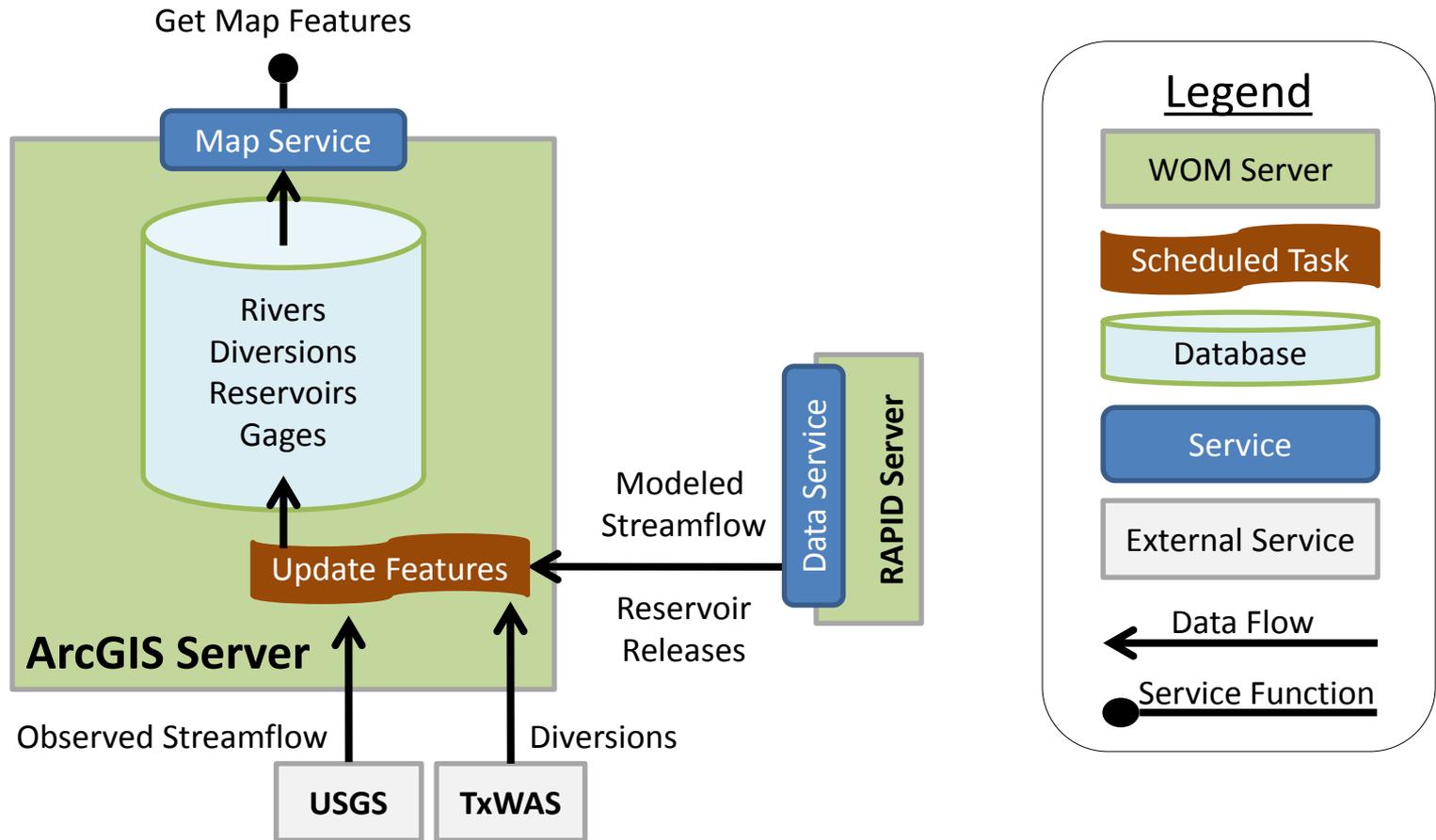
# Vision: An Interactive Web Map



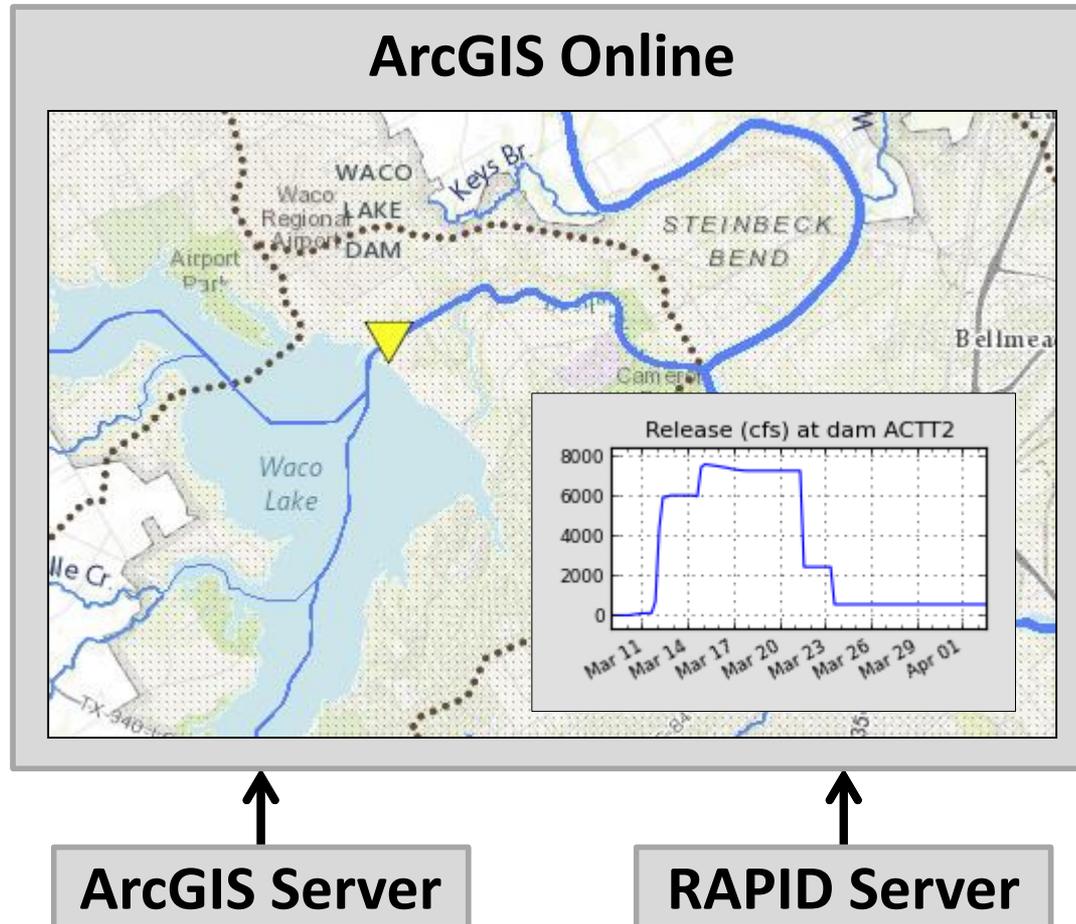
# RAPID Server for Data Service



# ArcGIS Server for Map Service



# ArcGIS Online for the Web App



# Feature Popups Link to Data

ArcGIS ▾ Brazos Water Operations Model

Modify Map Sign In

Details | Basemap | Share | Print | Measure | Find address or place

Legend

**Brazos**

Active Diversion

- ▲ Normal Diversion
- BRA Contract

Reservoir

- ▼

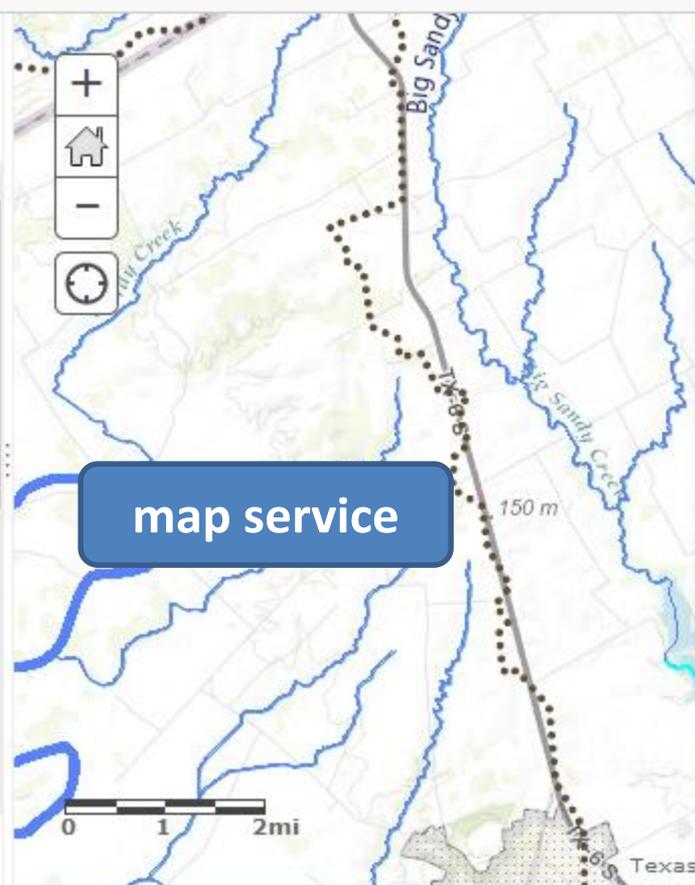
Stream Gage

- 

Streamflow

- 0 - 10 cfs
- 10 - 50 cfs
- 50 - 150 cfs
- 150 - 300 cfs
- 300 - 500 cfs
- 500 - 1000 cfs

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**Streamflow: Big Sandy Creek**

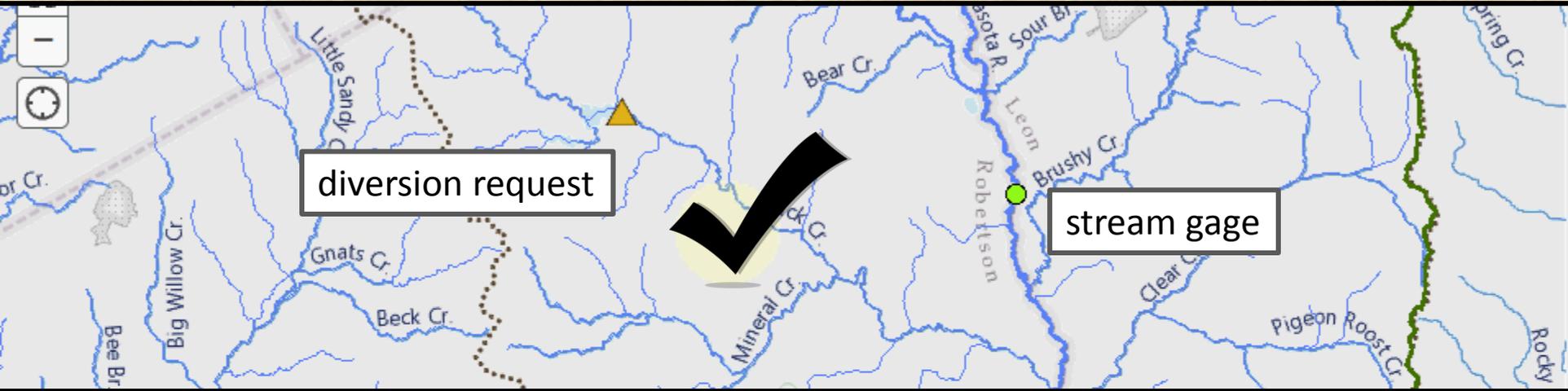
COMID: 5555454  
Type: ArtificialPath  
Modeled Streamflow (cfs): 6.00  
Datetime: 2016-03-17 16:00  
[Download recent data](#)

Streamflow (cfs) for reach 5555454

data service

Zoom to

POWERED BY esri



2000+ water rights

82 stream gages

14,000+ rivers with modeled flow

# Why not do this nationally



# The Opportunity

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

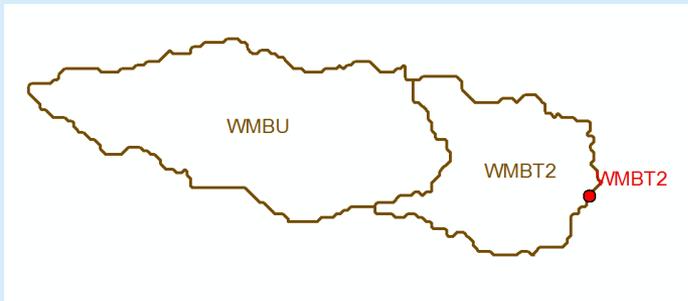
Has a mission to assess hydrology in a new way at the **continental scale** for the United States



# Current and New Forecast Systems

Blanco River at Wimberley

Two basins and one forecast point

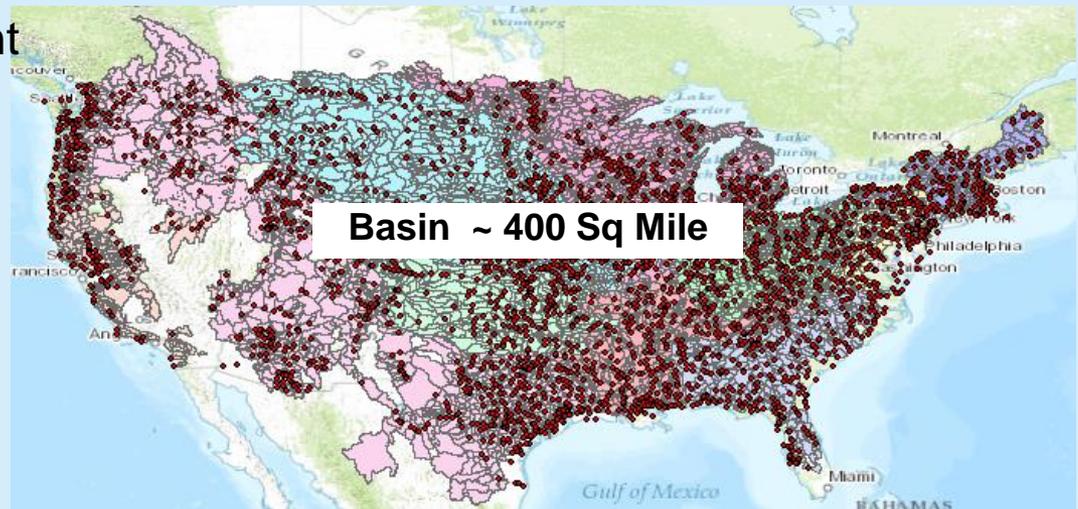


becomes ↓



130 catchments and flowlines

Current: 3600 forecast points



NFIE: 2.7 million stream reaches and catchments



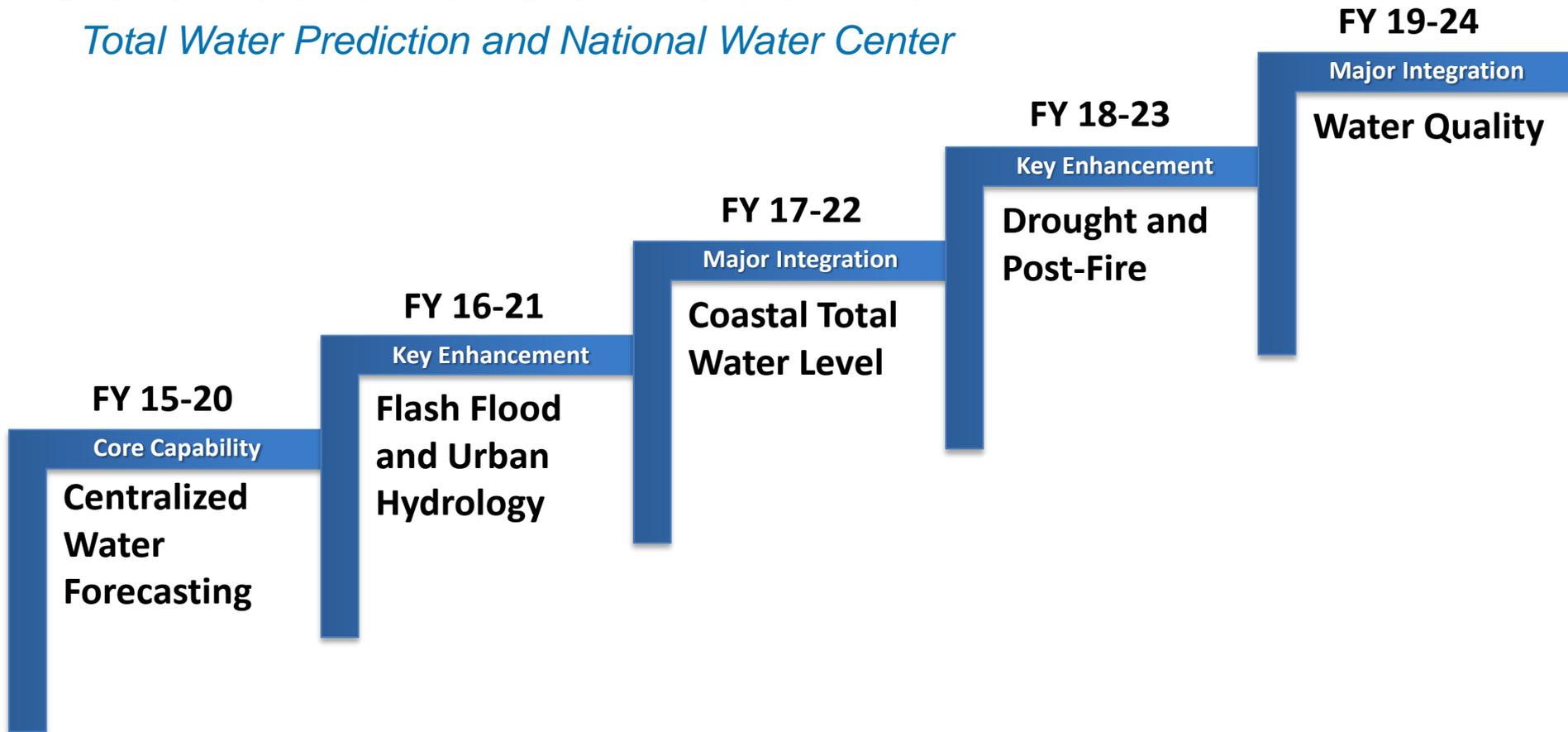


# National Water Model

- [water.noaa.gov/about/nwm](http://water.noaa.gov/about/nwm)
- Officially released August 16, 2016
- Weather, land surface, streamflow, velocity
- Forecasts: now to 30 days (with ensembles)

# Multi-Year Strategic Science and Services Plan

*Total Water Prediction and National Water Center*



# What Does NWM Give Us?

## 4 NWM Products:

Analysis and assimilation (“now”)  
Short range (18 hr)  
Medium range (10 day)  
Long range (30 day ensemble)

## 4 File Types for Each Product:

**channel** – streamflow, velocity, inflow  
land – land surface and forcing  
terrain – ponded water, saturation  
reservoir – reservoir outflows

Files represent a single time step:

Name	Last modified	Size
<a href="#">Parent Directory</a>		-
<a href="#">nwm.t06z.medium_range.channel_rt.f003.conus.nc.gz</a>	12-Jul-2016 12:09	33M
<a href="#">nwm.t06z.medium_range.channel_rt.f006.conus.nc.gz</a>	12-Jul-2016 12:09	33M
<a href="#">nwm.t06z.medium_range.channel_rt.f009.conus.nc.gz</a>	12-Jul-2016 12:09	33M

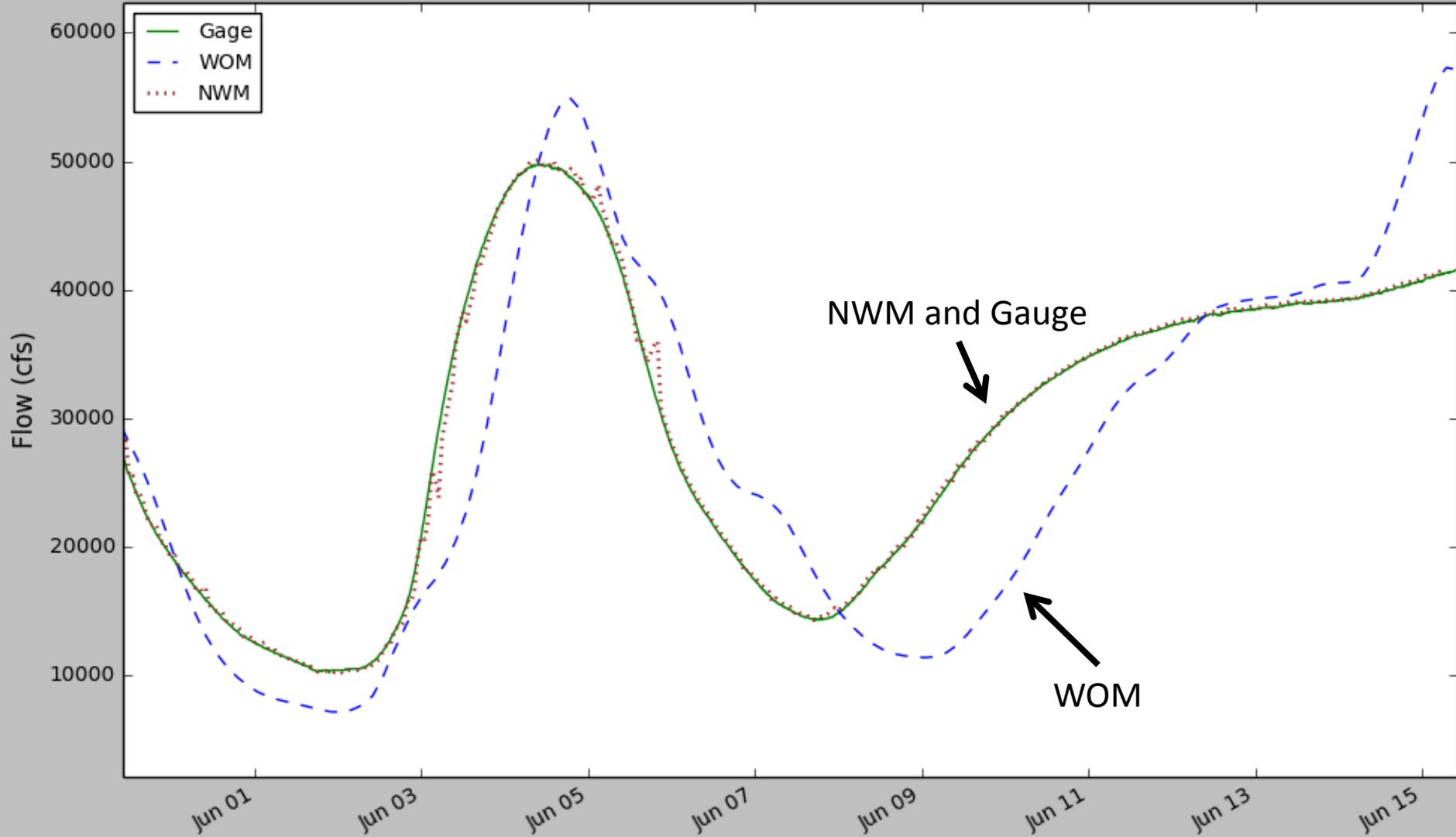
Each channel file has a single value for each NHD river feature (~2.7 million of them)

NWM Product Test

# **ANALYSIS AND ASSIMILATION**

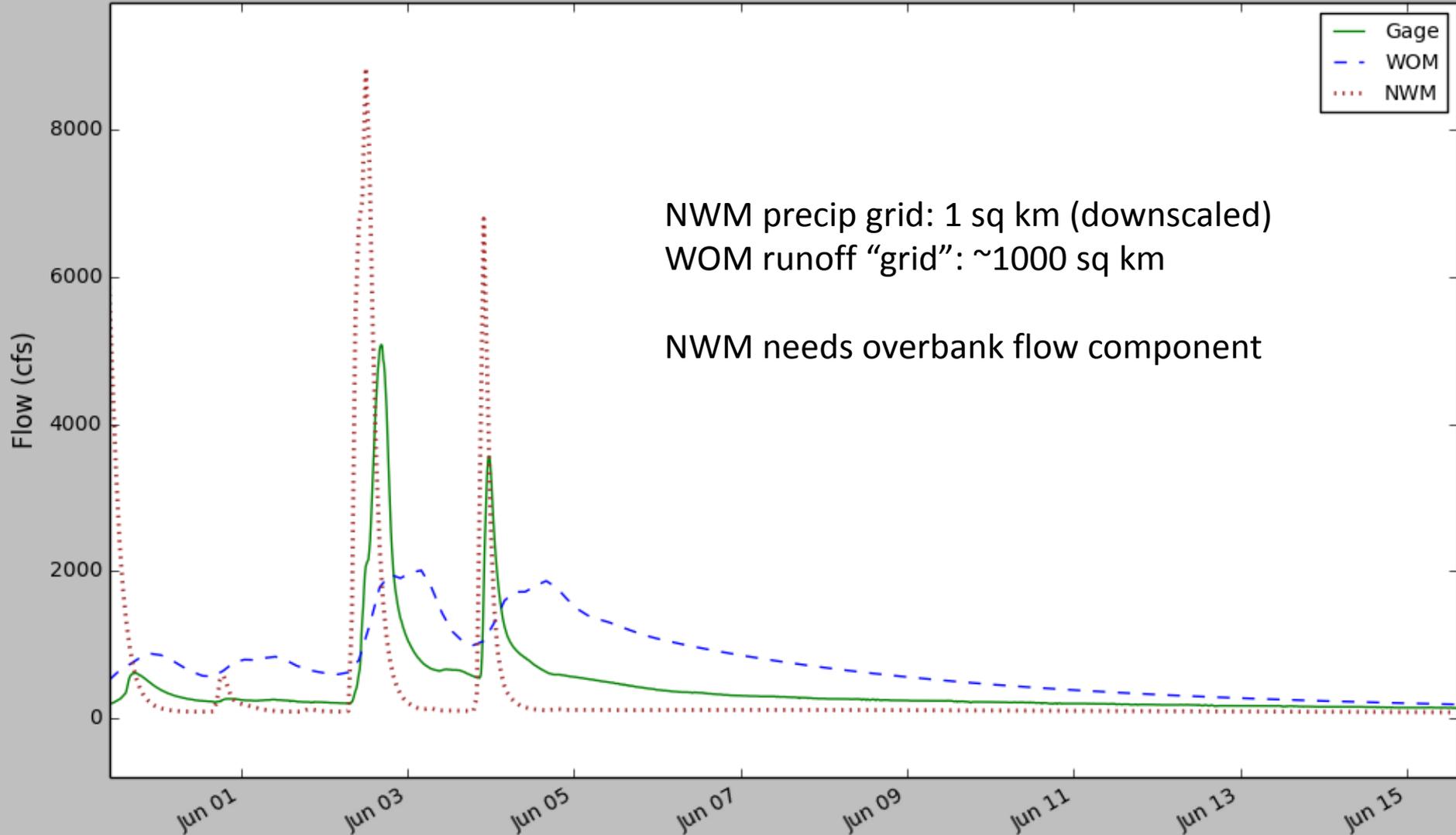
# NWM nudges flow at gauges

Brazos Rv at SH 21 nr Bryan, TX



# NWM is peaky, WOM is mellow

N Fk San Gabriel Rv at Reagan Blvd nr Leander, TX

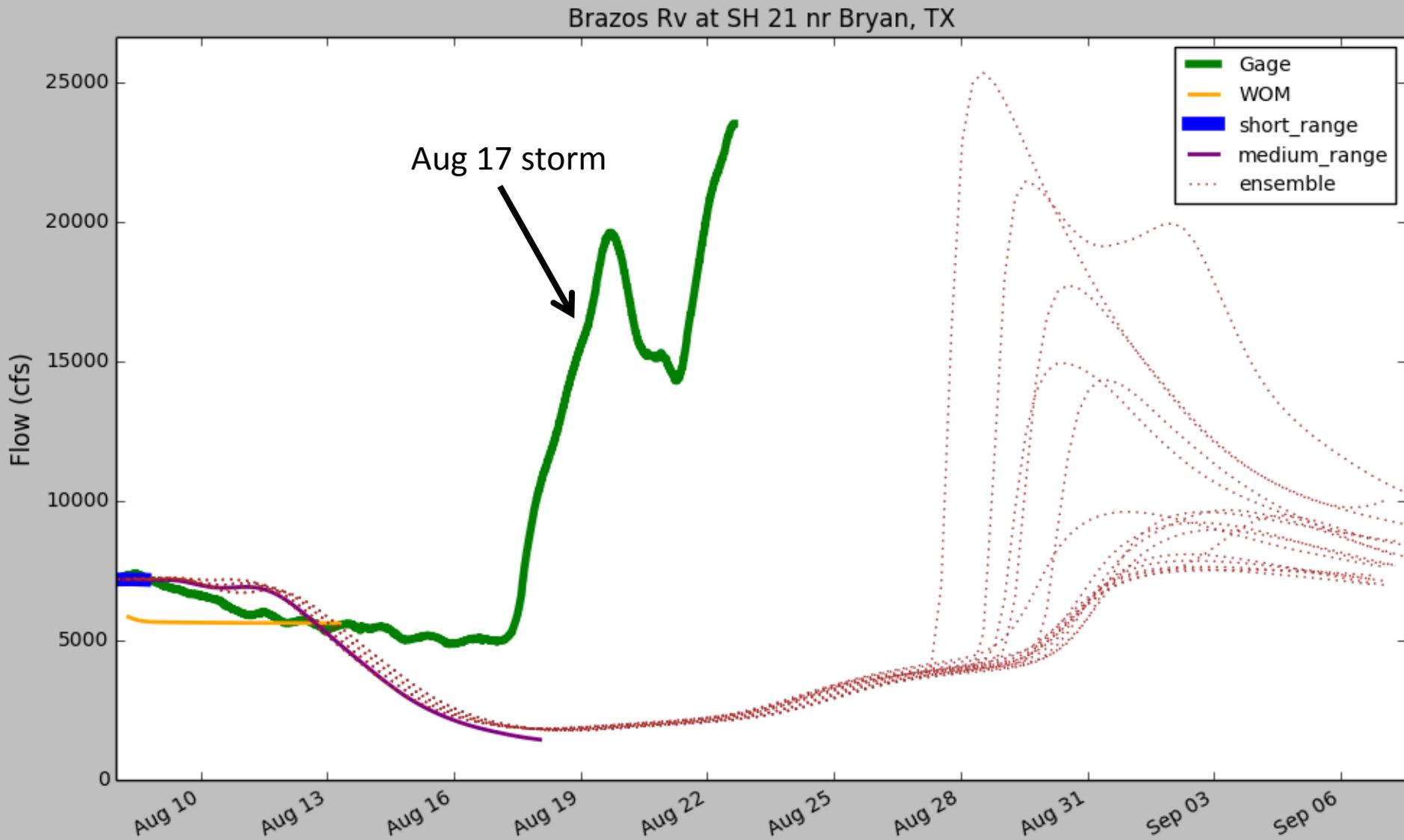


NWM Product Test

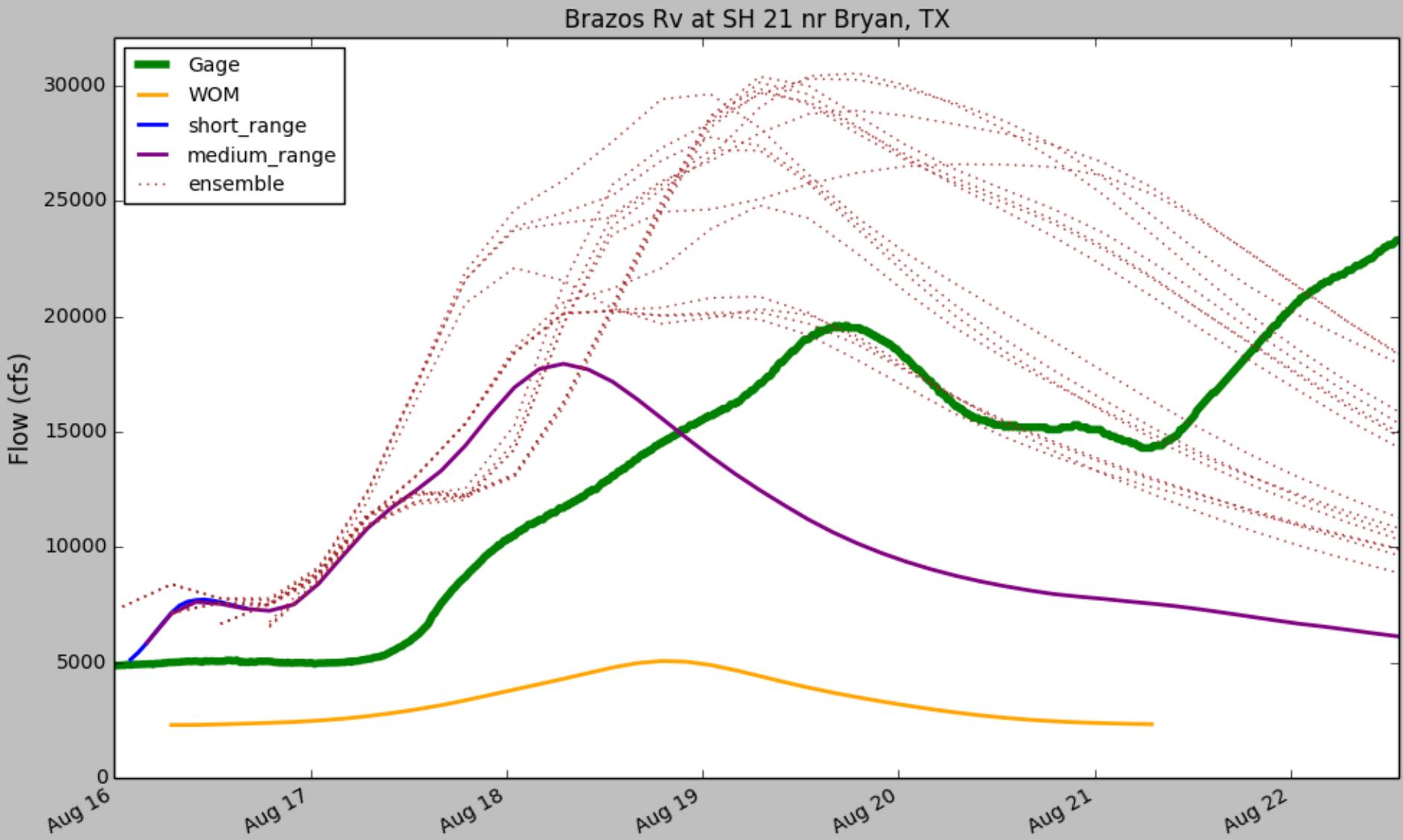
# FORECASTS

...compared to gauge data as of 8/22/2016

# Brazos River – Aug 8 Forecast

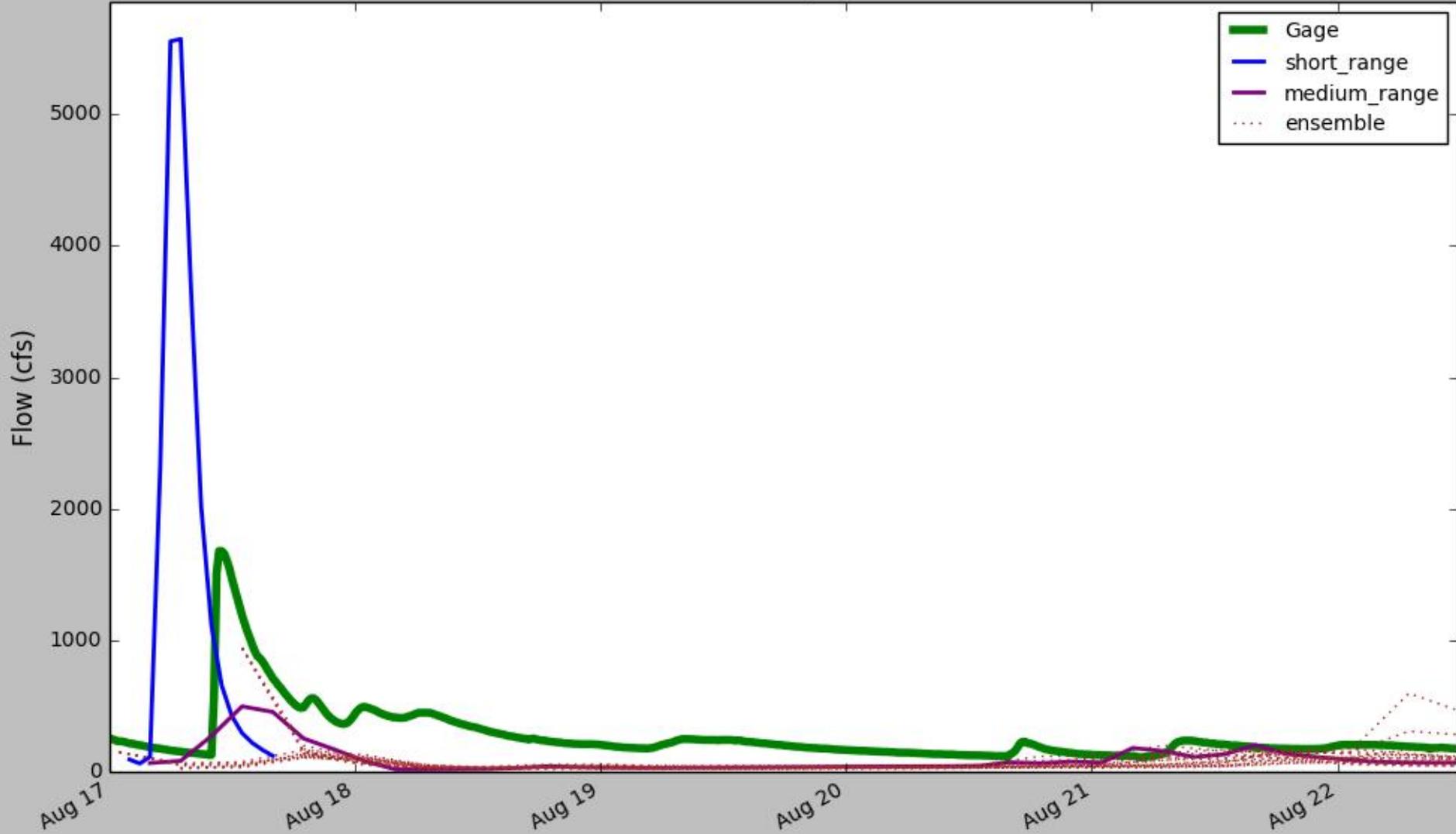


# Brazos River – Aug 16 Forecast

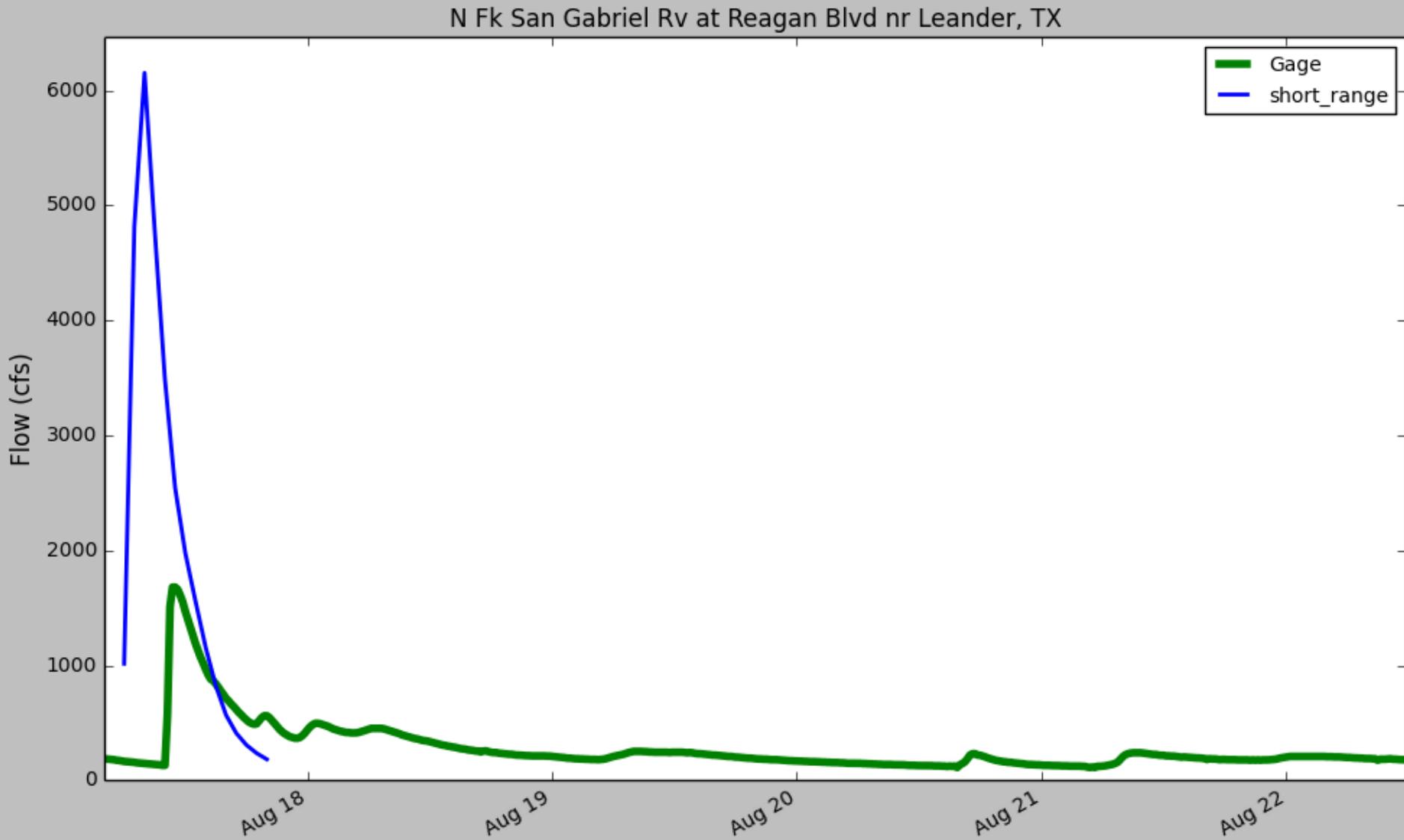


# San Gabriel – Aug 17 0:00 Forecast

N Fk San Gabriel Rv at Reagan Blvd nr Leander, TX

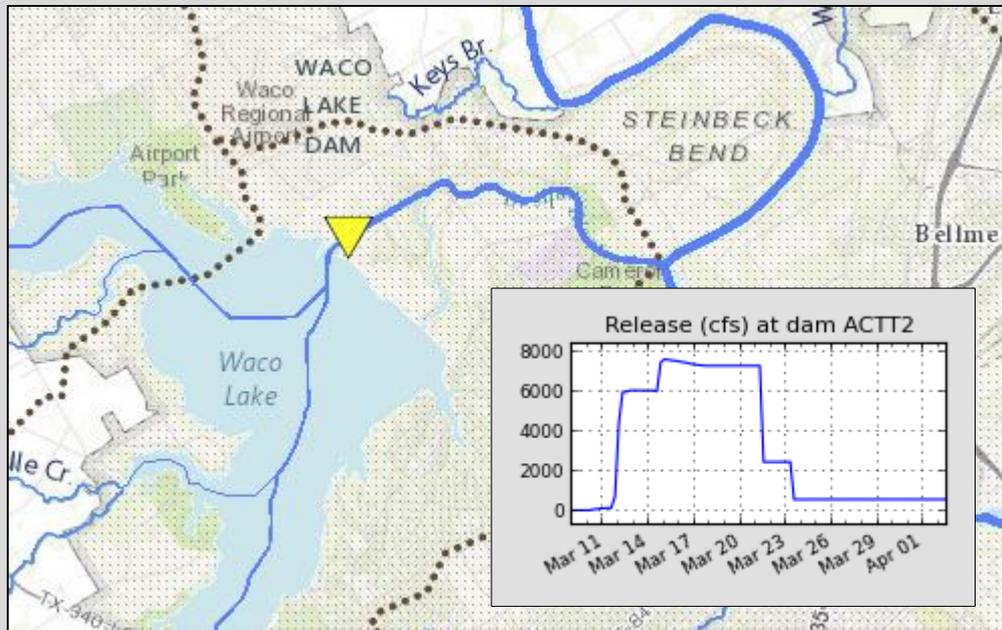


# San Gabriel – Aug 17 6:00 Forecast



# How would NWM help me?

## Web Application



ArcGIS Server

National  
Water Model

~~RAPID Server~~

# How could NWM help you?

Too much water



Not enough water



Dirty water

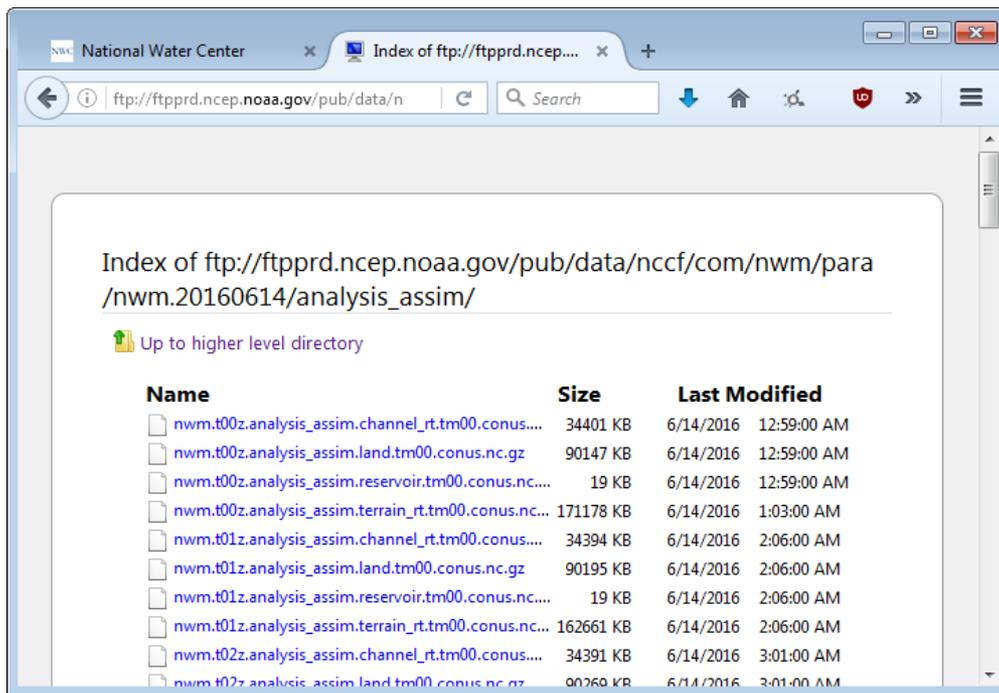


Environmental Issues



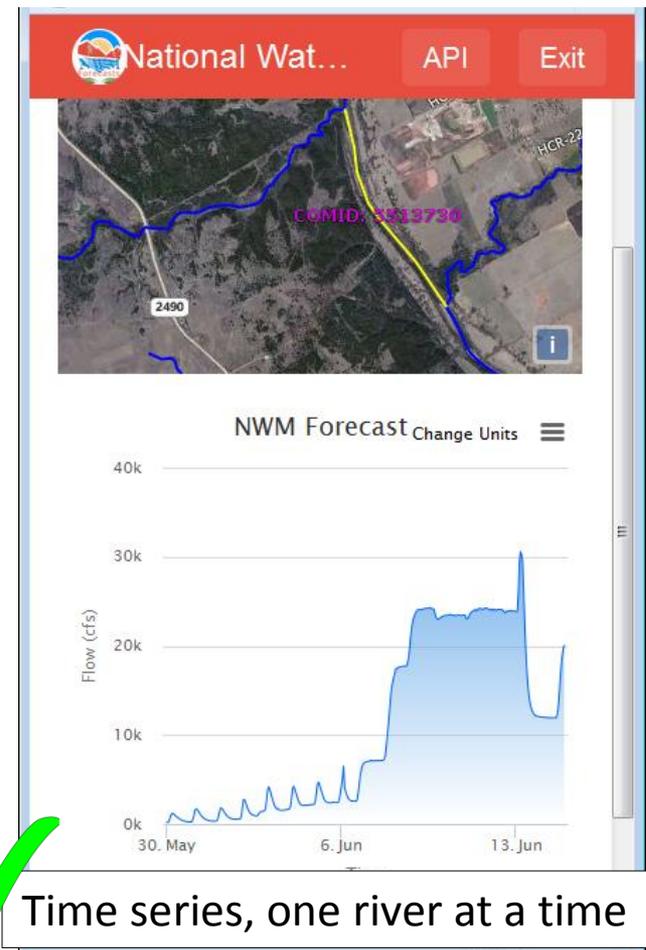
# How I Got NWM Results

## From NOAA FTP



One time step per file for 2.7m rivers **✗**

## From HydroShare



# https://apps.hydroshare.org/apps/

The screenshot shows the 'National Water Model Forecast Viewer' web application. The browser address bar displays the URL: [https://apps.hydroshare.org/apps/nwm-forecasts/?config=medium\\_range&geom=channel\\_rt&](https://apps.hydroshare.org/apps/nwm-forecasts/?config=medium_range&geom=channel_rt&). The application header features the HydroShare logo and the title 'National Water Model Forecast Viewer'. A yellow circle highlights the 'API' button in the top right corner of the header, with an 'Exit' button next to it.

On the left side, there is a configuration panel with the following fields:

- Enter Geometry:** Channel
- Enter Variable:** Streamflow
- Enter COMID:** 5671187
- Enter Beginning Date:** 2016-06-24

A 'Submit' button is located below these fields.

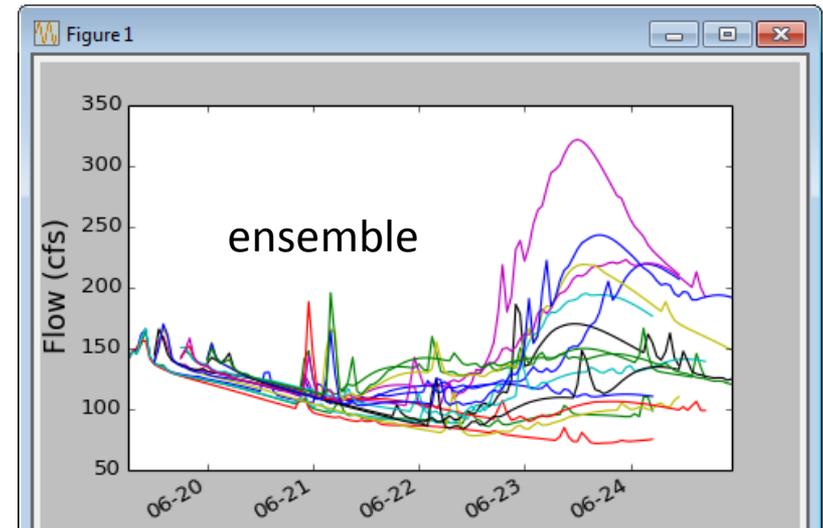
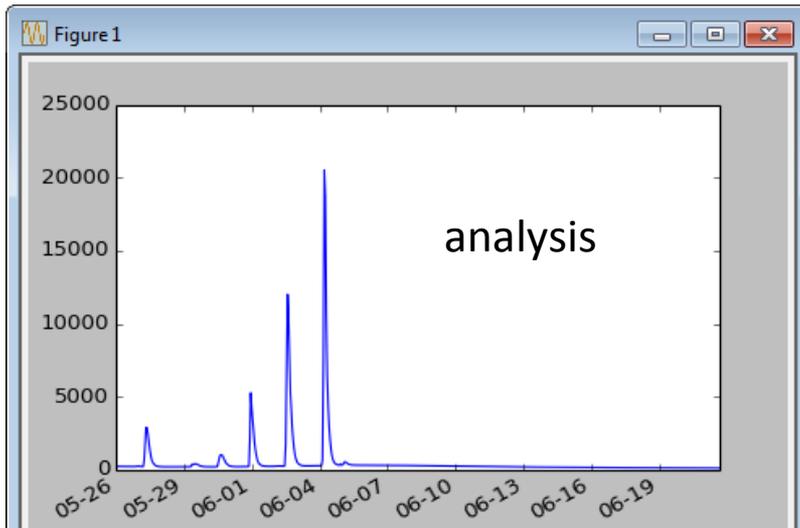
The main content area displays a satellite map of a watershed with blue streamlines. Labels on the map include Liberty Hill, Georgetown, Spanish Oaks, and Hidden Glen.

Below the map is a line graph titled 'NWM Forecast' showing 'Flow (cfs)' on the y-axis (ranging from 50 to 300) over time. The graph shows a steady flow around 100 cfs with a significant peak reaching approximately 240 cfs.

In the top right corner of the graph area, there is a 'Change Units' button with a dropdown menu icon.

# [github.com/twhiteaker/pynwm](https://github.com/twhiteaker/pynwm)

## A Python module to access the National Water Model





# What's Next

# Texas Flood Response Study



Harry R. Evans  
David R. Maidment  
David K. Arctur  
Xing Zheng  
Center for Research in Water Resources  
University of Texas at Austin  
Dean Djokic, ESRI  
Matt Ables, Kisters

Briefing for TDEM and collaborators, 30 September 2016

Acknowledgements: Austin Fire Department, COA Watershed Protection, e-911 Coordinators, CSEC  
National Weather Service, TDEM, USGS, National Science Foundation, Tim Whiteaker

# Real-Time Flood Inundation Mapping

## Existing



## Proposed



	Existing	Proposed	Ratio
Number of Mapped Reaches	130	2691344	
Total Mapped Length (Km)	2256	5192824	2302
Average Reach Length (Km)	17.4	1.93	0.11
Total Mapped Length (Mile)	1402	3226671	2302
Average Reach Length (Mile)	10.8	1.20	0.11

# Experiment for 2016:

Combine hydrography and elevation to define river channel geometry and flood inundation extent for 5 million km of stream reaches over continental US



**National Hydrography Dataset**

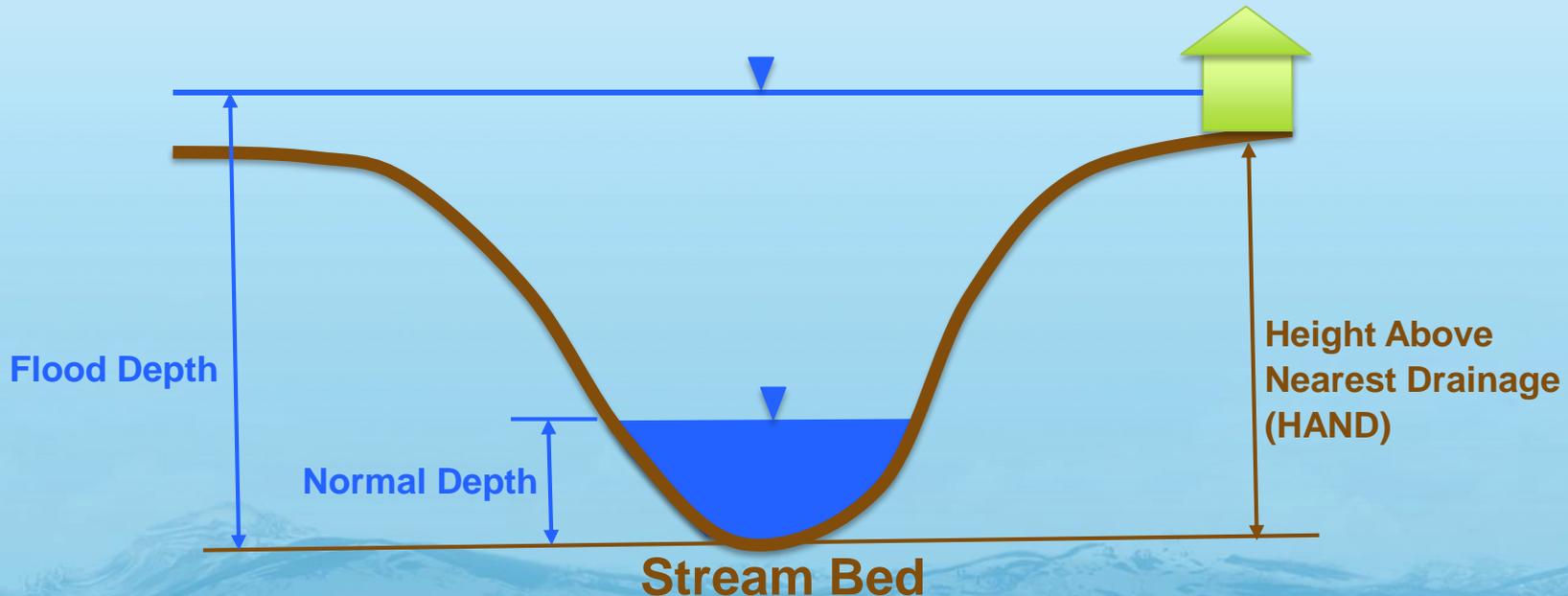


**National Elevation Dataset**

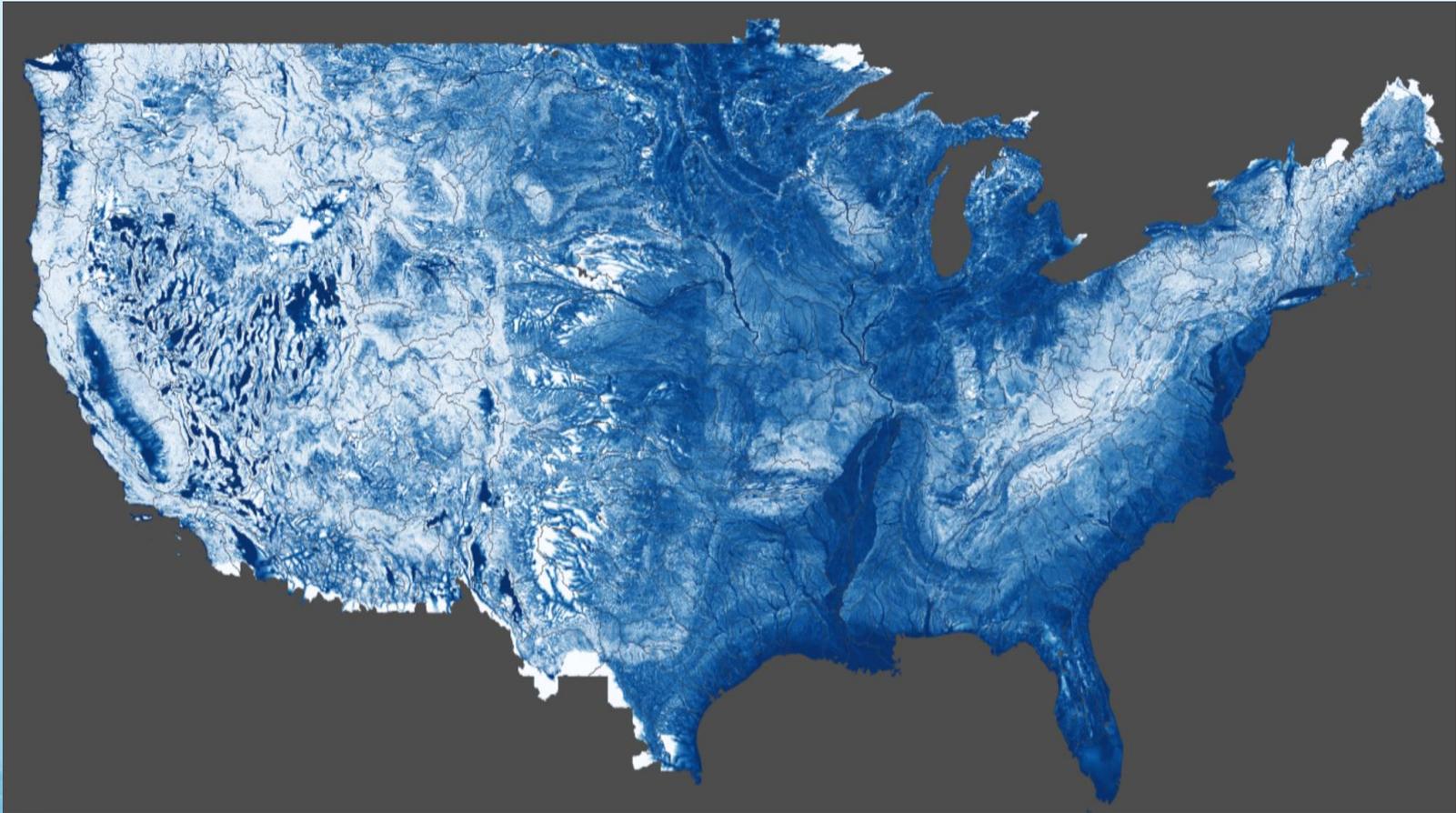
Use the [CyberGIS](#) computing facility  
at the University of Illinois at Urbana-Champaign

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

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



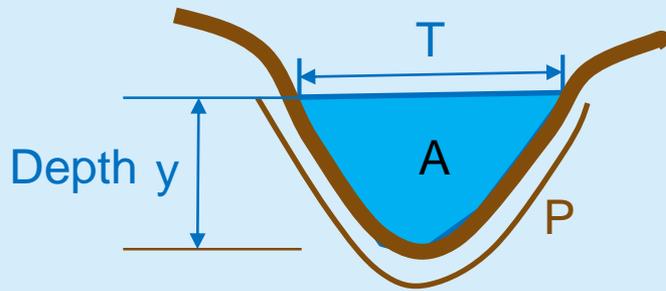
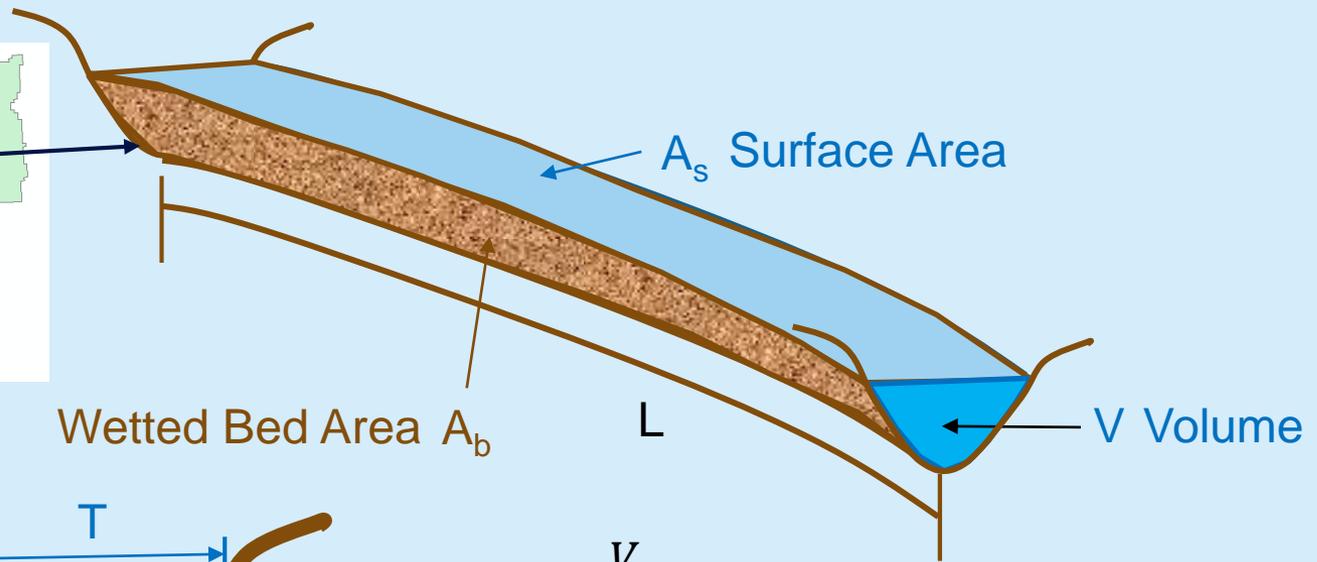
# Height Above Nearest Drainage for the Continental United States



**A continuous foundation for flood inundation mapping**

# Reach Hydraulic Parameters

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



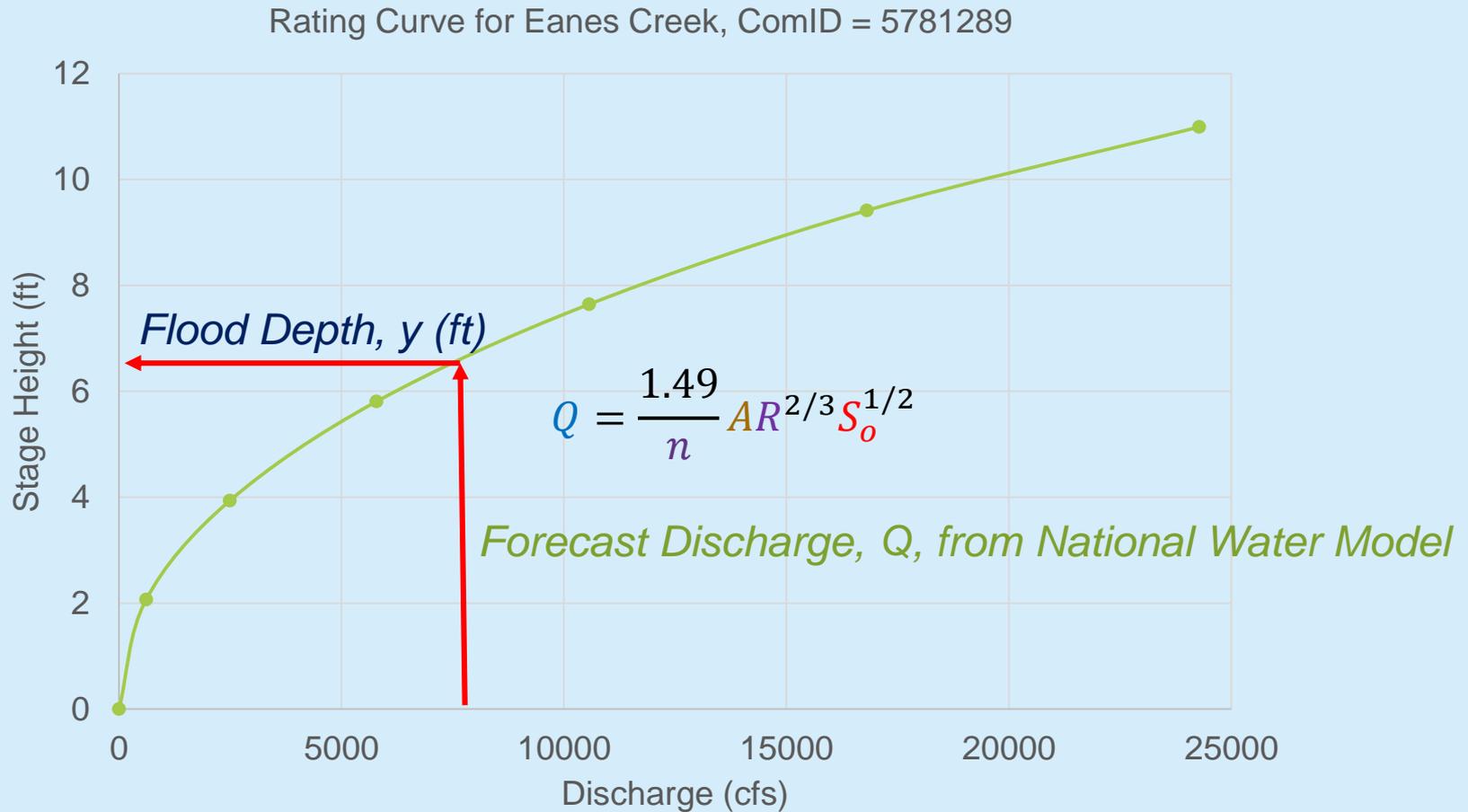
$$A = \frac{V}{L} \quad \text{Cross Section Area}$$

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

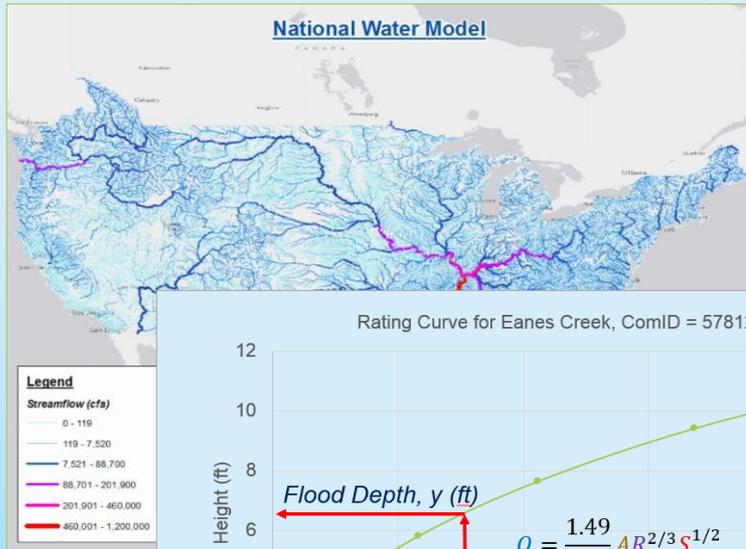
$$T = \frac{A_s}{L} \quad \text{Top Width}$$

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

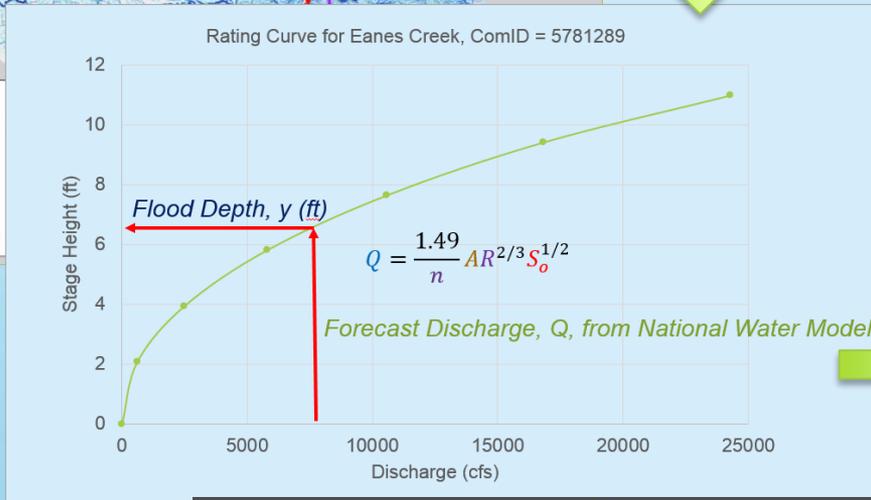
# Rating Curve for Eanes Creek



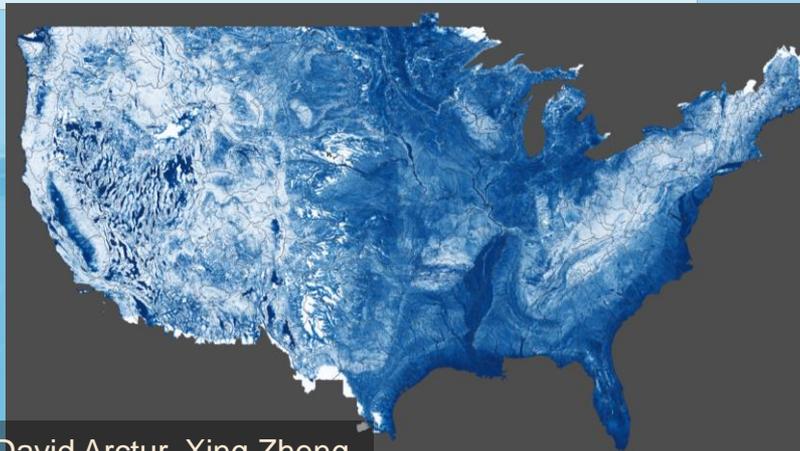
# Continental-Scale Flood Inundation Mapping



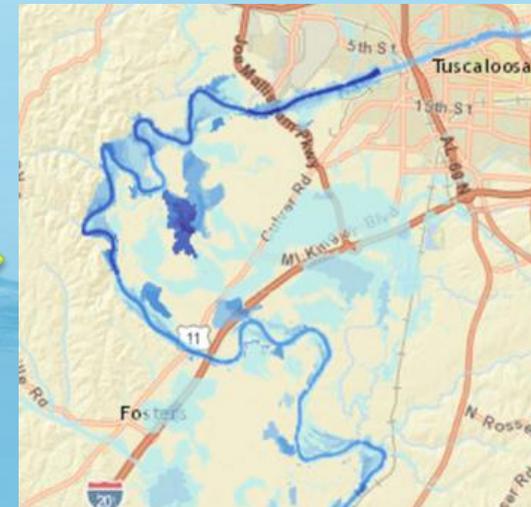
1



2

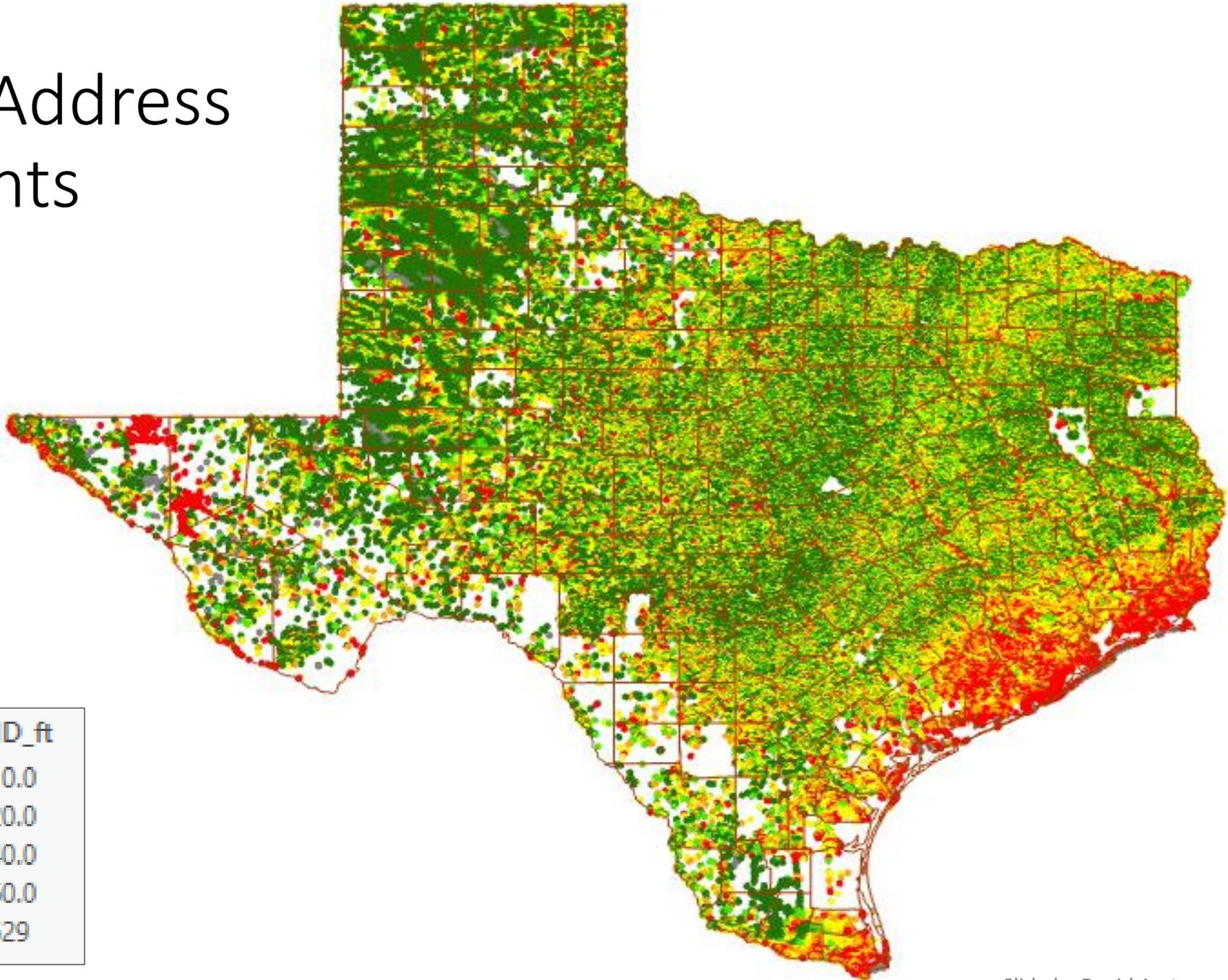
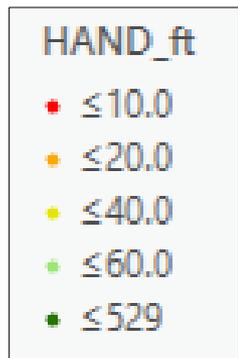


3

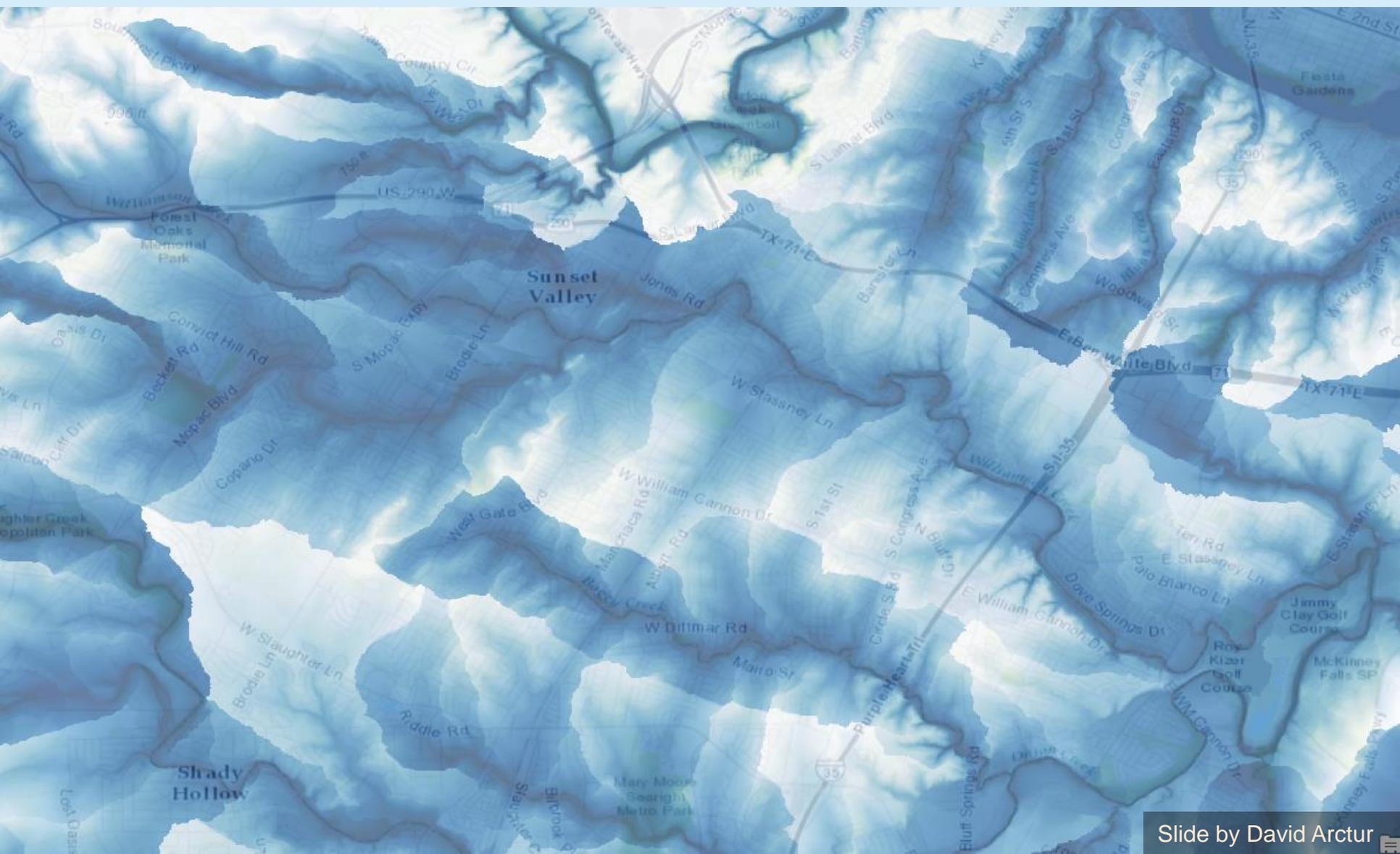


1. Forecast **discharge** with National Water Model
2. Convert discharge to **depth** using rating curve
3. Convert depth to **inundation** using HAND

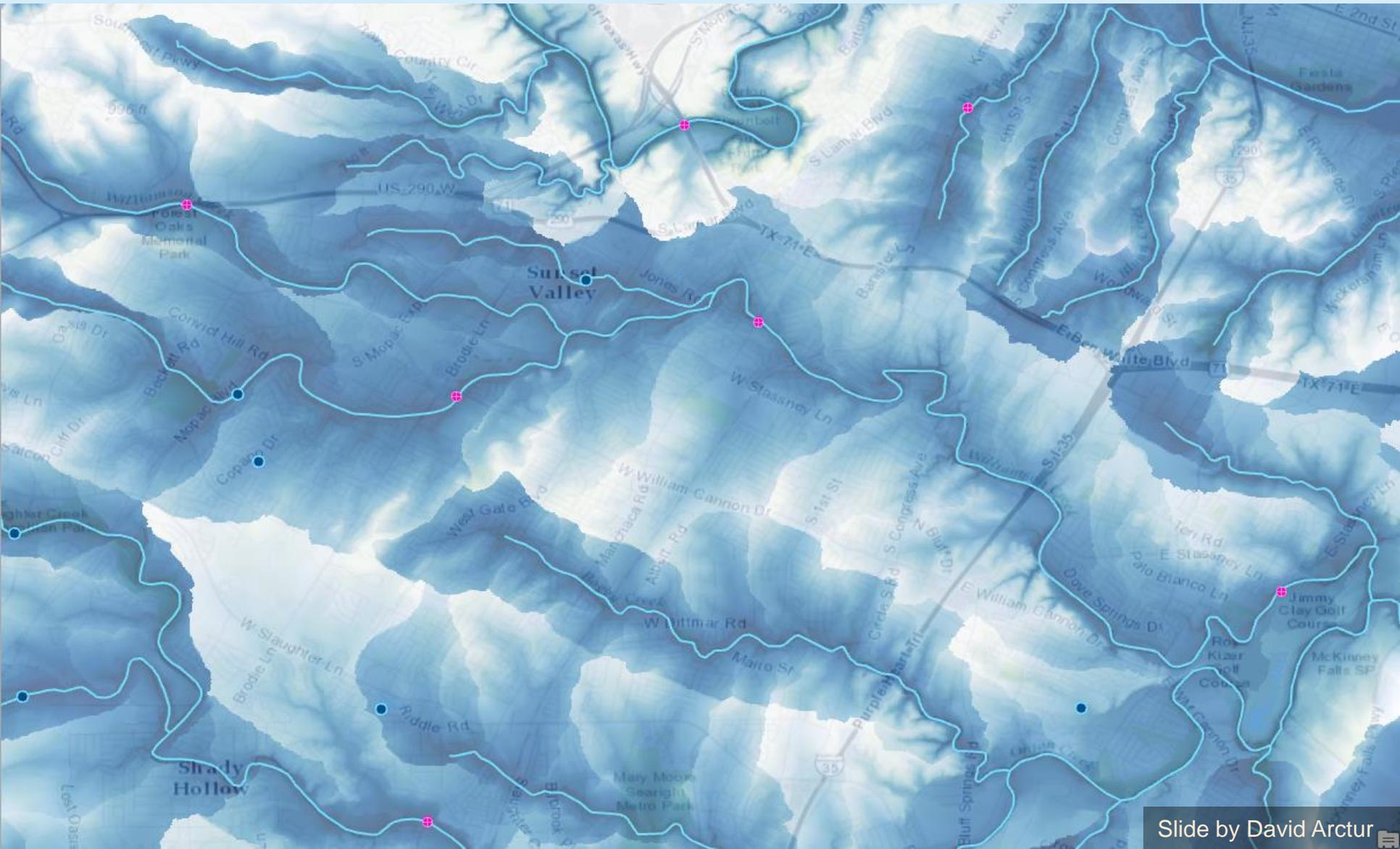
# TX Address Points



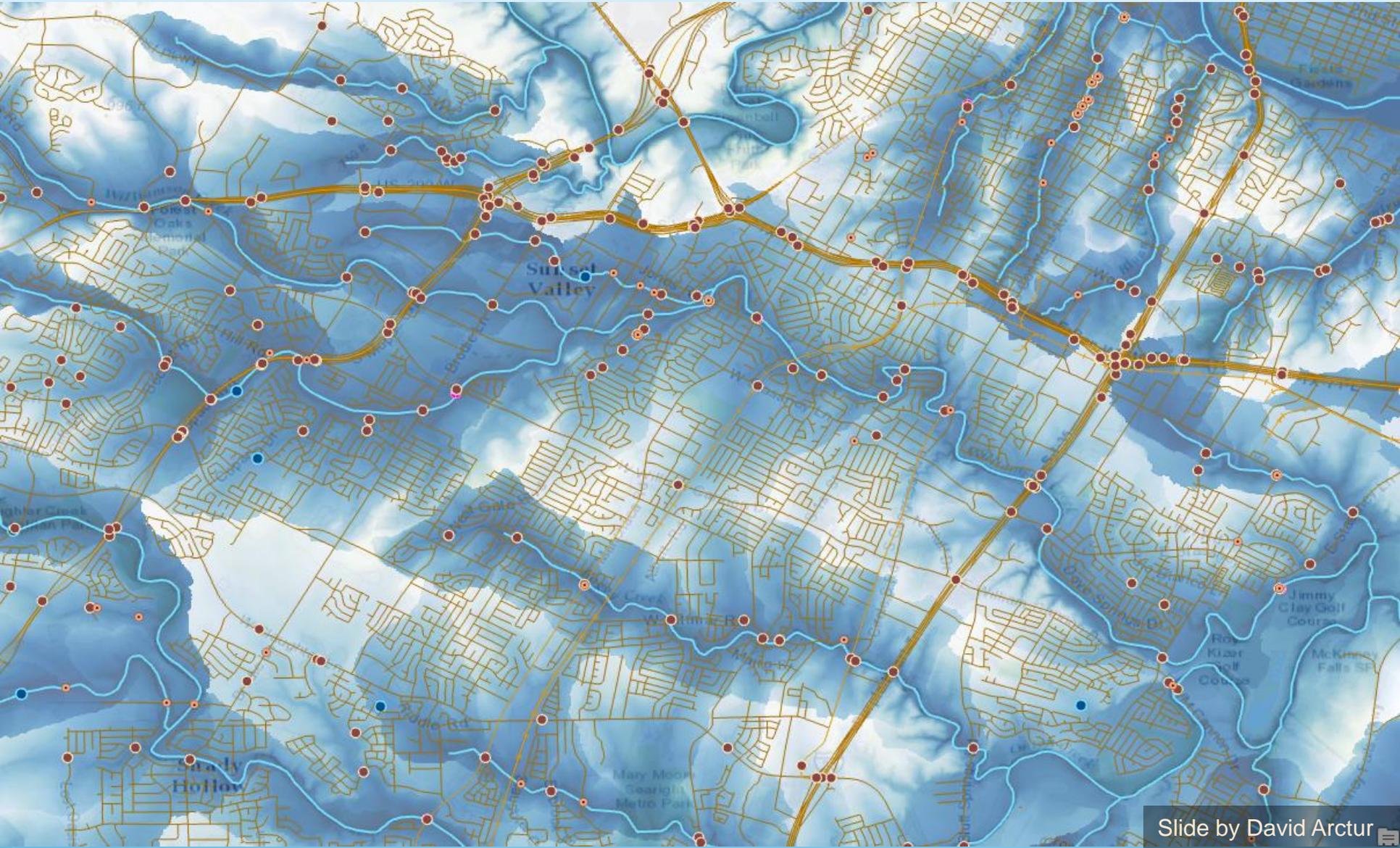
# Williamson Creek, South Austin: Basemap + HAND ...



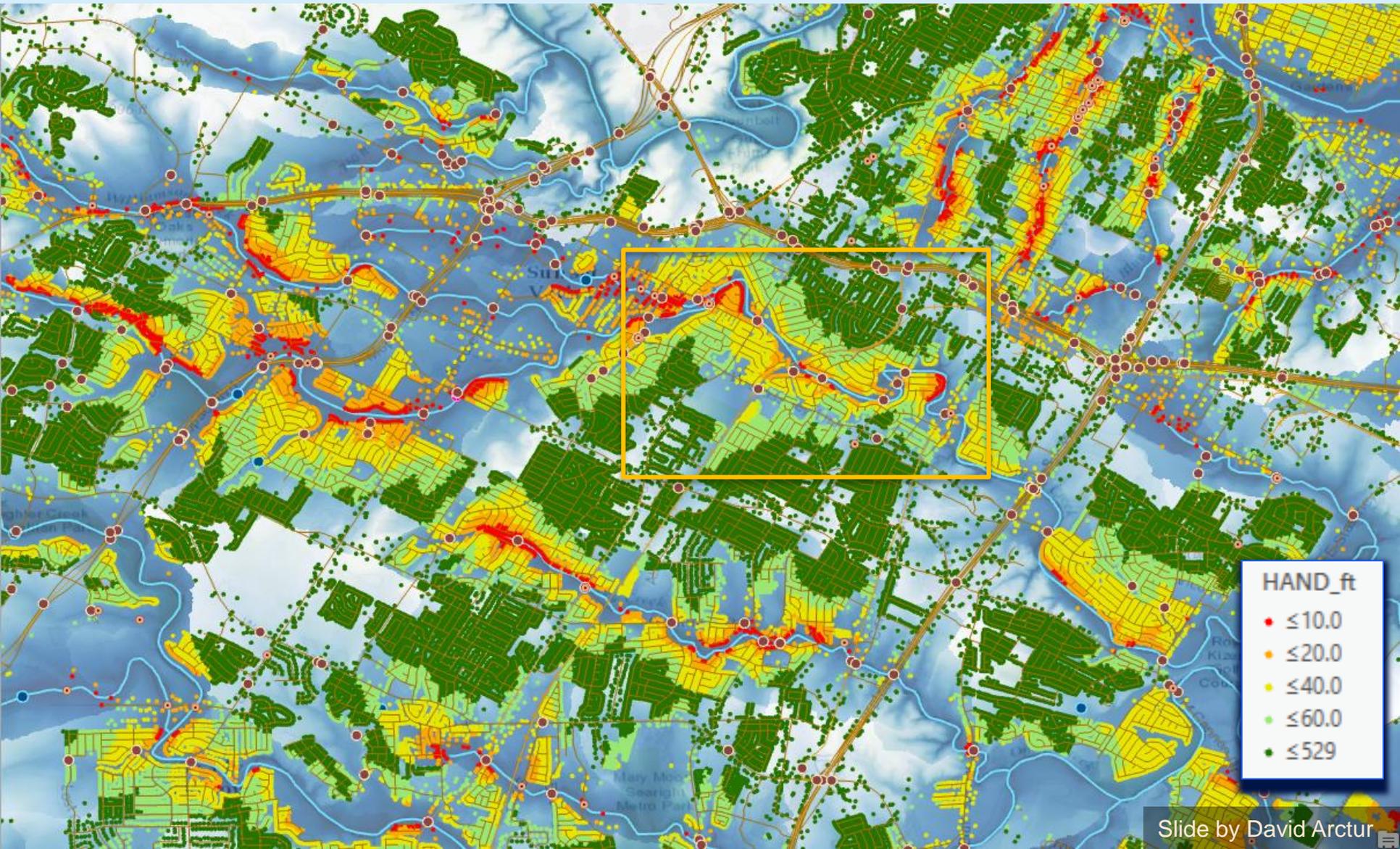
# Williamson Creek, South Austin: flowlines, gages, dams ...



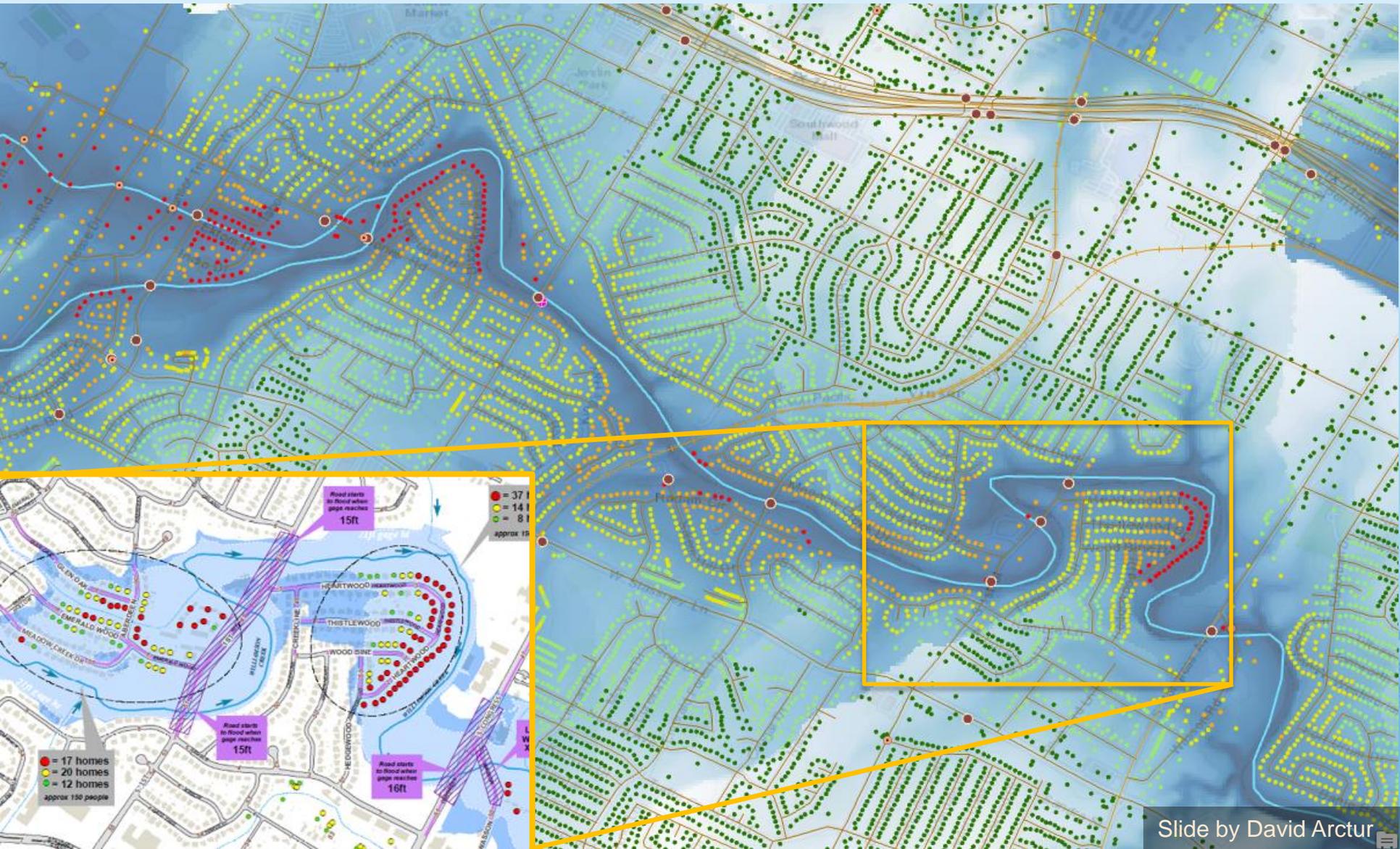
# Williamson Creek, South Austin: transportation, bridges, low-water crossings ...



# Williamson Creek, South Austin: address points attributed with HAND



# Williamson Creek, South Austin: address points – Heartwood Rd



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# Water Modeling for Texas



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photo by Nicolas Henderson