2018 FloodWarn Training

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National Weather Service- Houston/Galveston, TX

Outline

Flooding Importance

Flooding Types and Causes

Flood Products

River Flooding

Partners

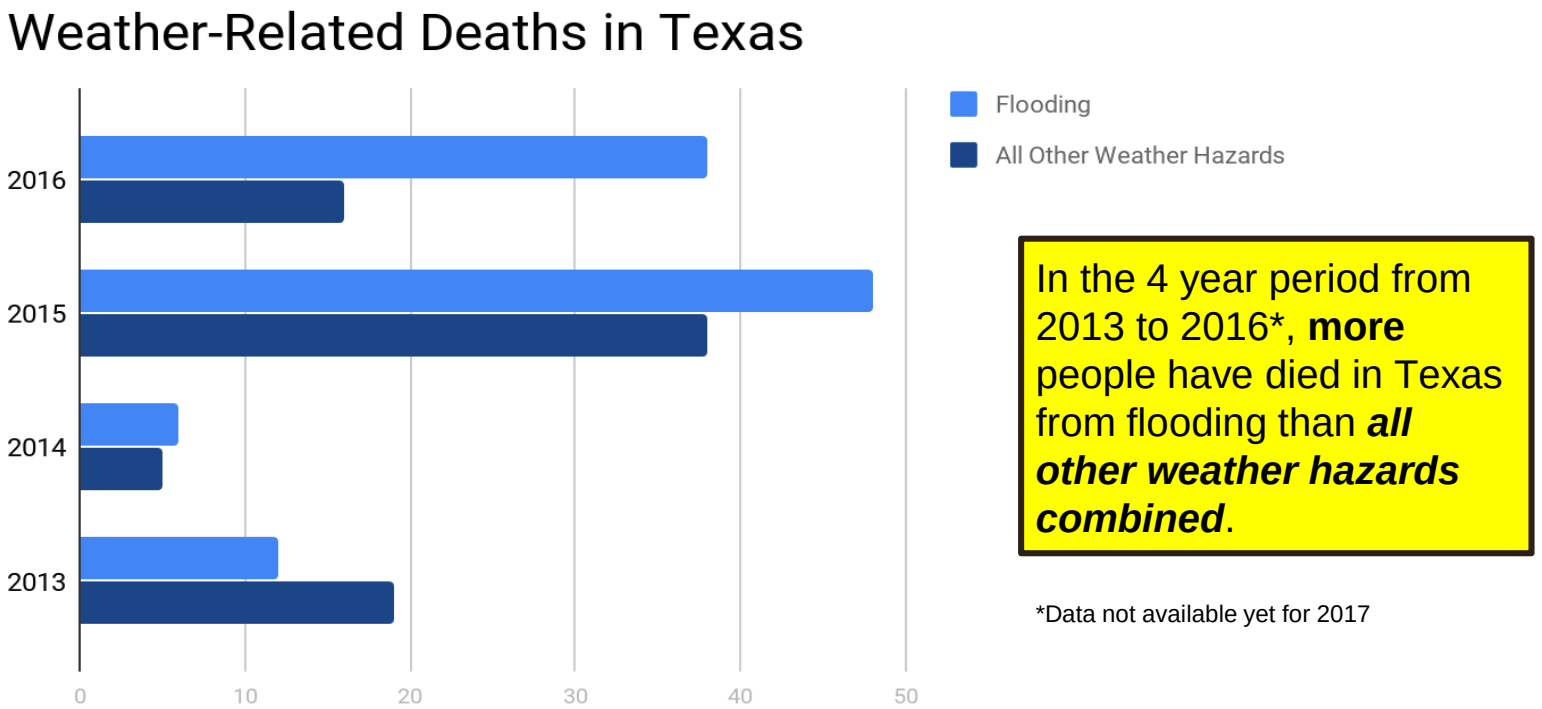
Flood Risk

Flood Safety

Reporting Flooding

Flooding Importance

Flooding is Deadly!

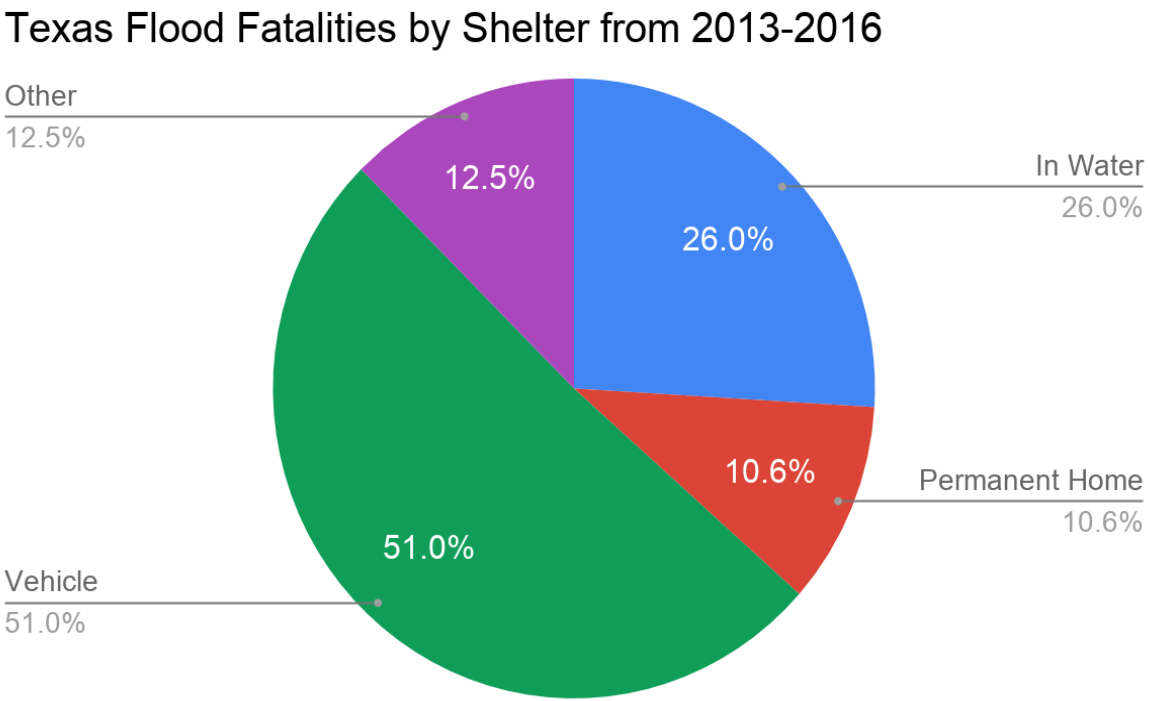


In the 4 year period from 2013 to 2016*, **more** people have died in Texas from flooding than ***all other weather hazards combined***.

*Data not available yet for 2017

Data from NWS National Hazard Statistics

Flood Fatalities



Over half of the flood fatalities in Texas occurred while people were in their car.

Data from NWS National Hazard Statistics

Houston Floods: April 18, 2016

Recent Big Floods…

Memorial Day 2015

Tax Day 2016

Brenham 2016

Harvey 2017

And other historic floods…

Tropical Storm

Allison 2001

1994 Flood

Tropical Storm Claudette

Flooding Types and Causes

What Causes Flooding?

- Intense rainfall
- Rain over several days
- Dam/levee failures
- High tides or storm surge
- Snowmelt
- Ice or debris jams

Types of Flooding

Ponding & Sheet Flow Flooding

Flooding that occurs gradually over time, usually 6 hours after the rain begins or longer (longer duration)

Flash Flooding

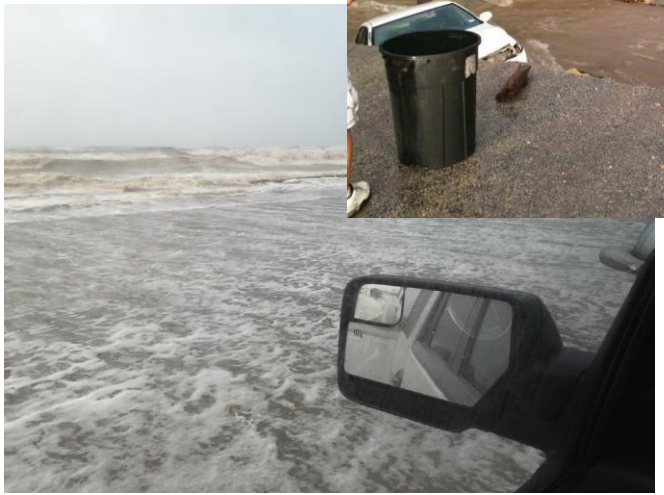
Flooding that develops quickly (typically 6 hours or less) either from heavy rainfall or dam/levee failure (shorter duration).

River Flooding

Flooding that occurs from water escaping river banks.

Coastal Flooding

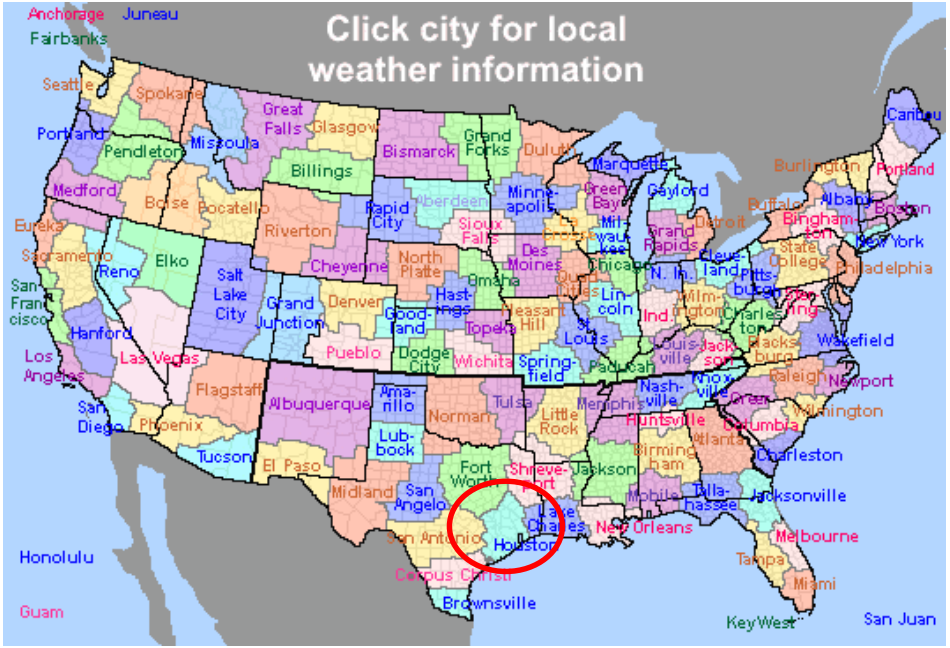
Flooding along a coastline either from high tides or storm surge during a tropical storm or hurricane



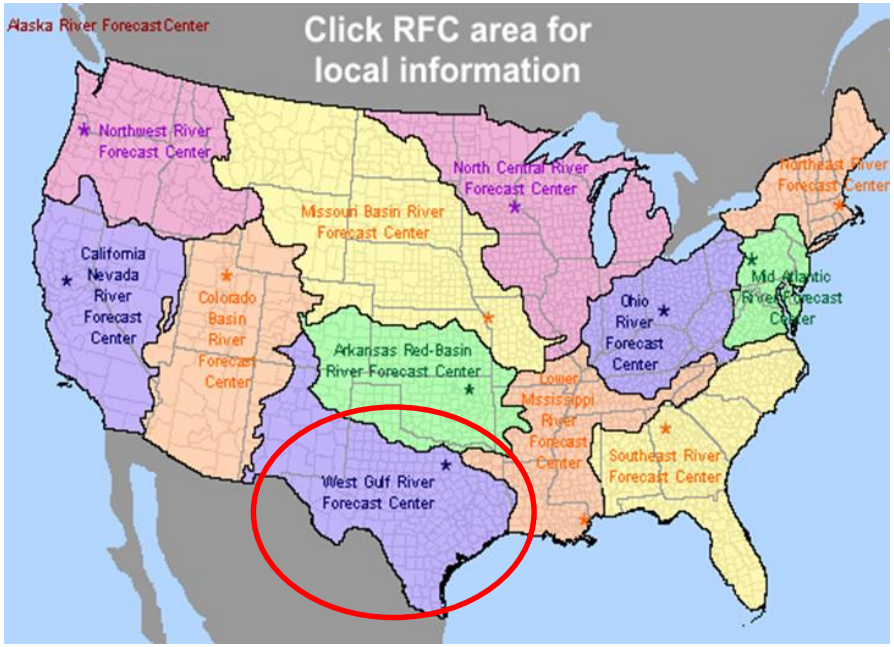
Flood Products

National Weather Service

Weather Forecast Offices



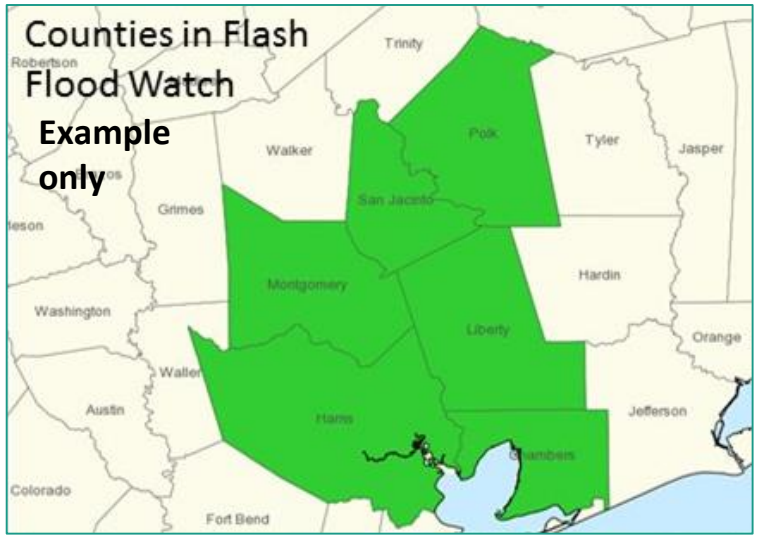
River Forecast Centers

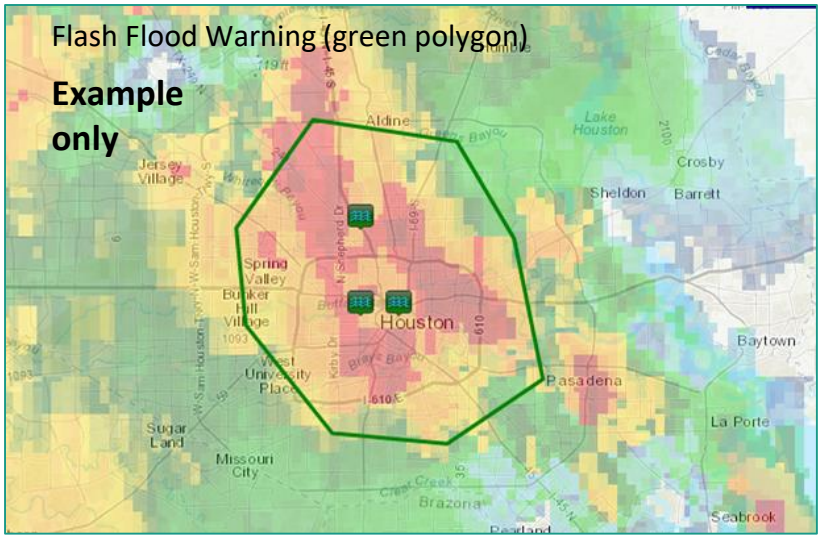


Watch vs Warning

A Watch is issued when conditions are favorable to occur.

A Warning is issued when the threat is *occurring or imminent*, threatening life or property.





Flood vs. Flash Flood

A **Flood** is an overflow of water onto normally dry land likely caused by rising water in a river/bayou or poor drainage. Flooding is a longer term event than flash flooding: it may last days or weeks.

A **Flash Flood** is a flood caused by heavy or excessive rainfall in a short period of time, typically 6 hours or less. Flash floods are defined as:

- ≥ 3 feet of standing water (less if threatening life or property), and/or
- ≥ 6 inches of fast flowing water across a road or bridge, or
- Water in a stream or bayou flowing rapidly out of its banks, or
- A dam break (even on a sunny day)

Understanding Flooding

Urban / Small Stream Advisory	*Flood Watch*	*Flash Flood Watch*	*Flood Warning*	*Flash Flood Warning*	*Flash Flood Emergency*
WHAT IS IT? Flooding of small streams, streets and low-lying areas. **WHAT TO DO?** Stay away from areas that are prone to flooding and stay clear of rapidly moving water	**WHAT IS IT?** Flooding is possible – typically within a 6 to 48 hours before rain is expected to reach the area. **WHAT TO DO?** Stay tuned to local river forecasts; prepare for areas near rivers to spread towards nearby roads and buildings	**WHAT IS IT?** Flash flooding is possible –typically 6 to 48 hours before rain is expected to reach the area. **WHAT TO DO?** Have a way to receive local warnings, expect hazardous travel conditions and have alternate routes available	**WHAT IS IT?** Flooding impacts are occurring or imminent. **WHAT TO DO?** Stay ***alert*** for inundated roadways and follow all local signage! Additional impacts include homes and structures could become flooded and need to be evacuated	**WHAT IS IT?** Flash flooding impacts are occurring or imminent. **WHAT TO DO?** Conditions will ***rapidly*** become hazardous! Do not cross flooded roadways or approach inundated areas as water may still be rising	**WHAT IS IT?** Flash flood situation that presents a clear threat to human life due to extremely dangerous flooding conditions **WHAT TO DO?** ***Immediately*** reach higher ground by any means possible

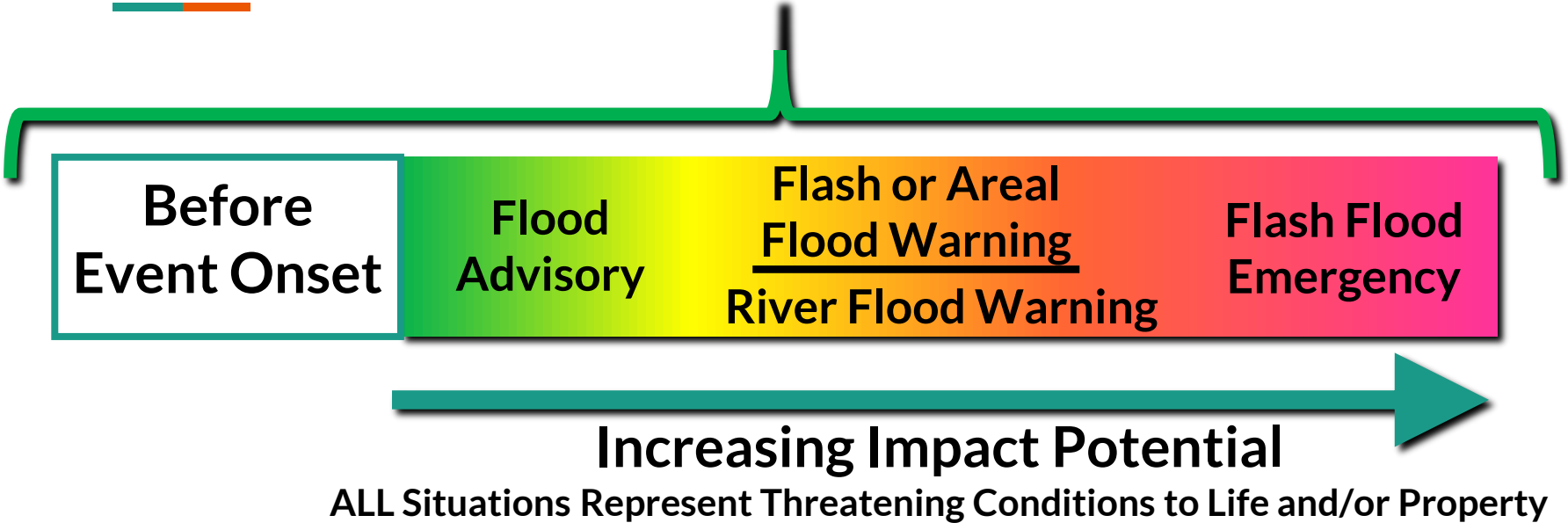
Urban / Small Stream Flood Advisory

Flash Flood Warning

Flash Flood Emergency

Flood Warning (Areal/ River/ Bayou)

Flood Timeline



Note: Flooding can (and does) occur without a Flash Flood Watch!

Ways to Receive a Warning

NOAA Weather Radio

Wireless Emergency Alerts and Weather Apps

TV and Radio

Social Media

NWS Website: https://www.weather.gov/hgx/

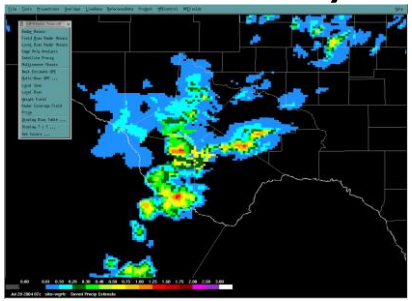
River Flooding

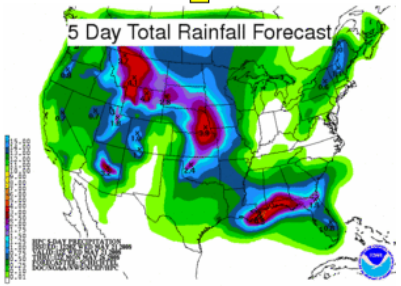
River Flooding

River flooding occurs when water escapes the river banks. There are different thresholds for river flooding: action, minor, moderate, major and record flooding. This image depicts what a river flooding looks like.

River Forecast Process

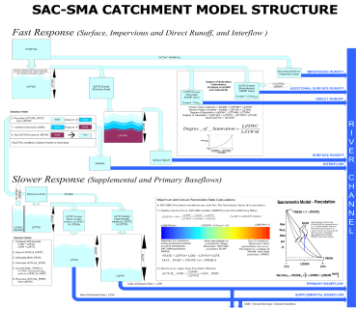
Rainfall Analysis

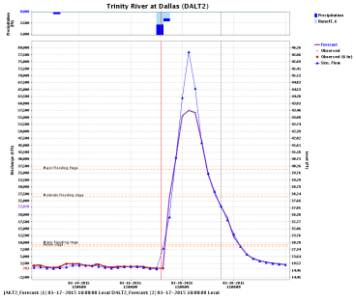




Precipitation estimates and forecasts merged into continuous dataset

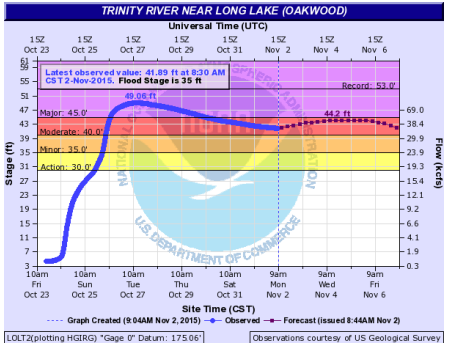
Hydrologic Modeling





Precipitation dataset ingested into hydrologic model. Forecasters adjust model parameters in real time

Forecast



Warning

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FLOOD WARNING
NATIONAL WEATHER SERVICE HOUSTON/GALVESTON, TX
926 PM CDT THU MAY 26 2016

...The National Weather Service in Houston/Galveston has issued a flood warning
for the following rivers...

Brazos River In Richmond affecting the following counties in Texas...Austin
and Fort Bend

TXC015-039-157-473-271425-
/O.NEW.KHGX.FL.W.0149.160529T0730Z-000000T0000Z/
/RMOT2.1.ER.160529T0730Z.160531T0600Z.000000T0000Z.NO/
926 PM CDT THU MAY 26 2016

The National Weather Service in Houston/Galveston has issued a

* Flood Warning for
  The Brazos River In Richmond.
* from late Saturday night until further notice...or until the warning is
  canceled.
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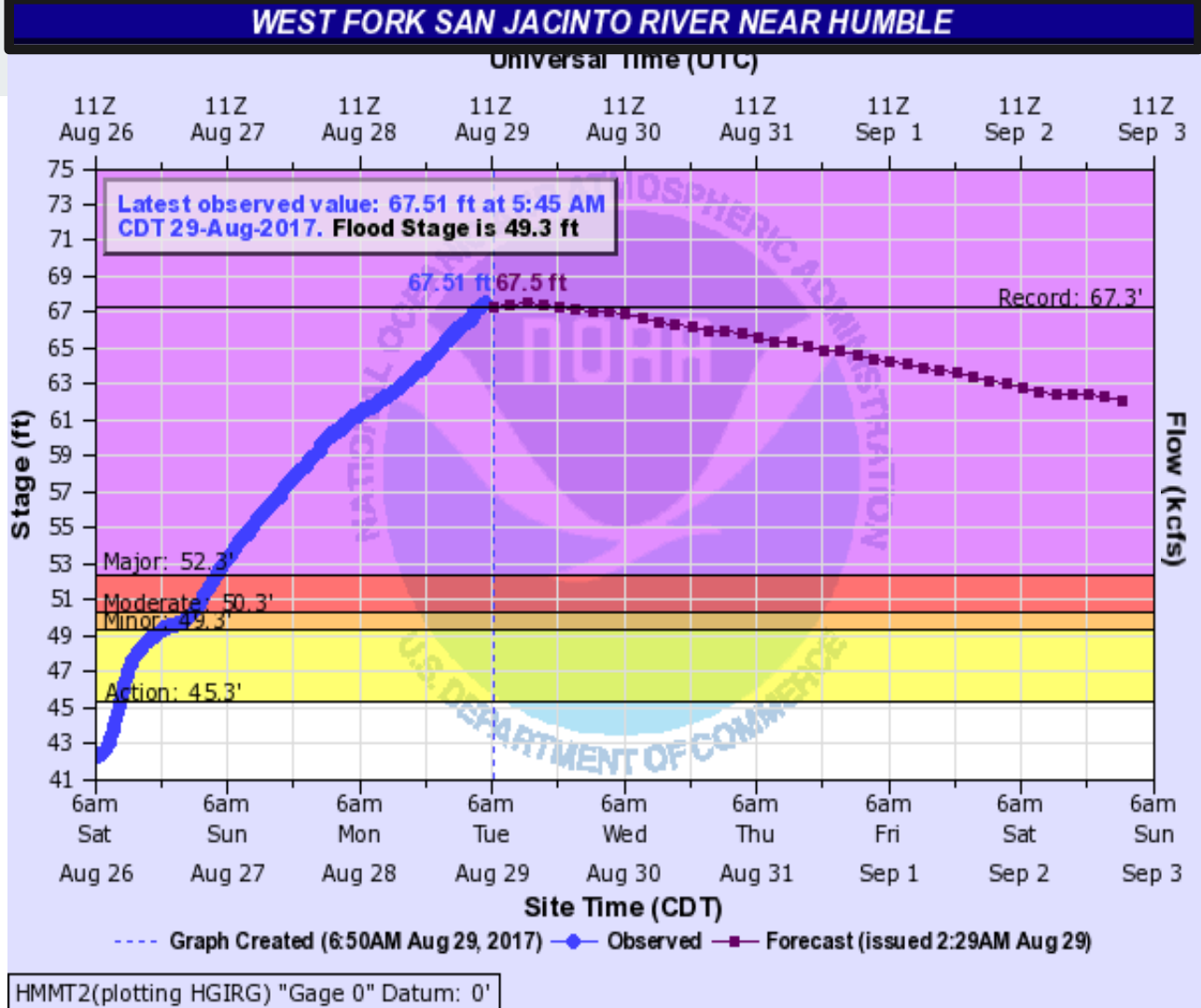
Hydrograph Basics

LOCATION:
Of the gage the forecast is made, AT means the gage is in the limits of the town/city, NEAR or NR means that town/city has the closest post office

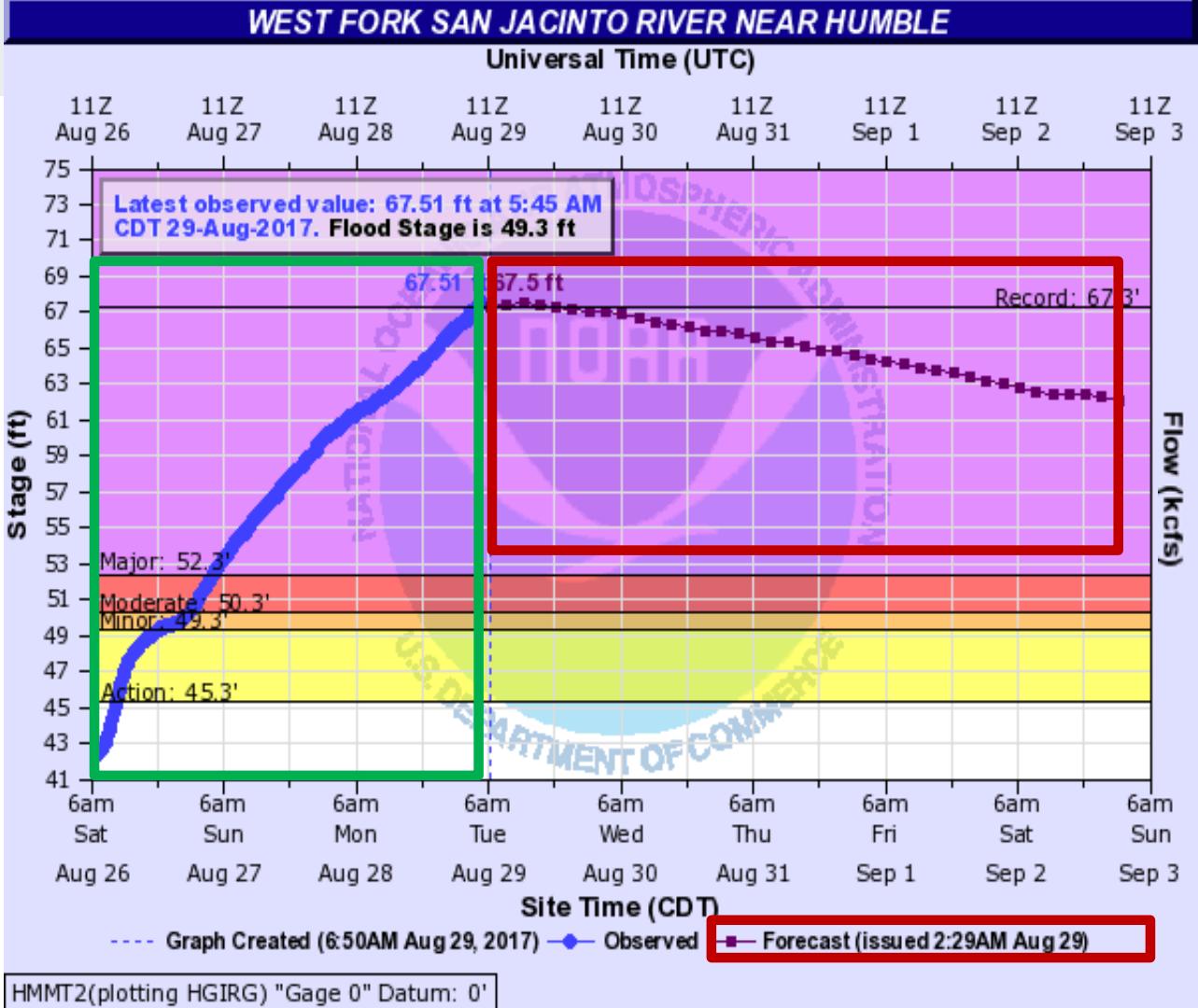


Hydrograph Basics

OBSERVATIONS:
Past river stages

FORECAST:
Forecast River Stages

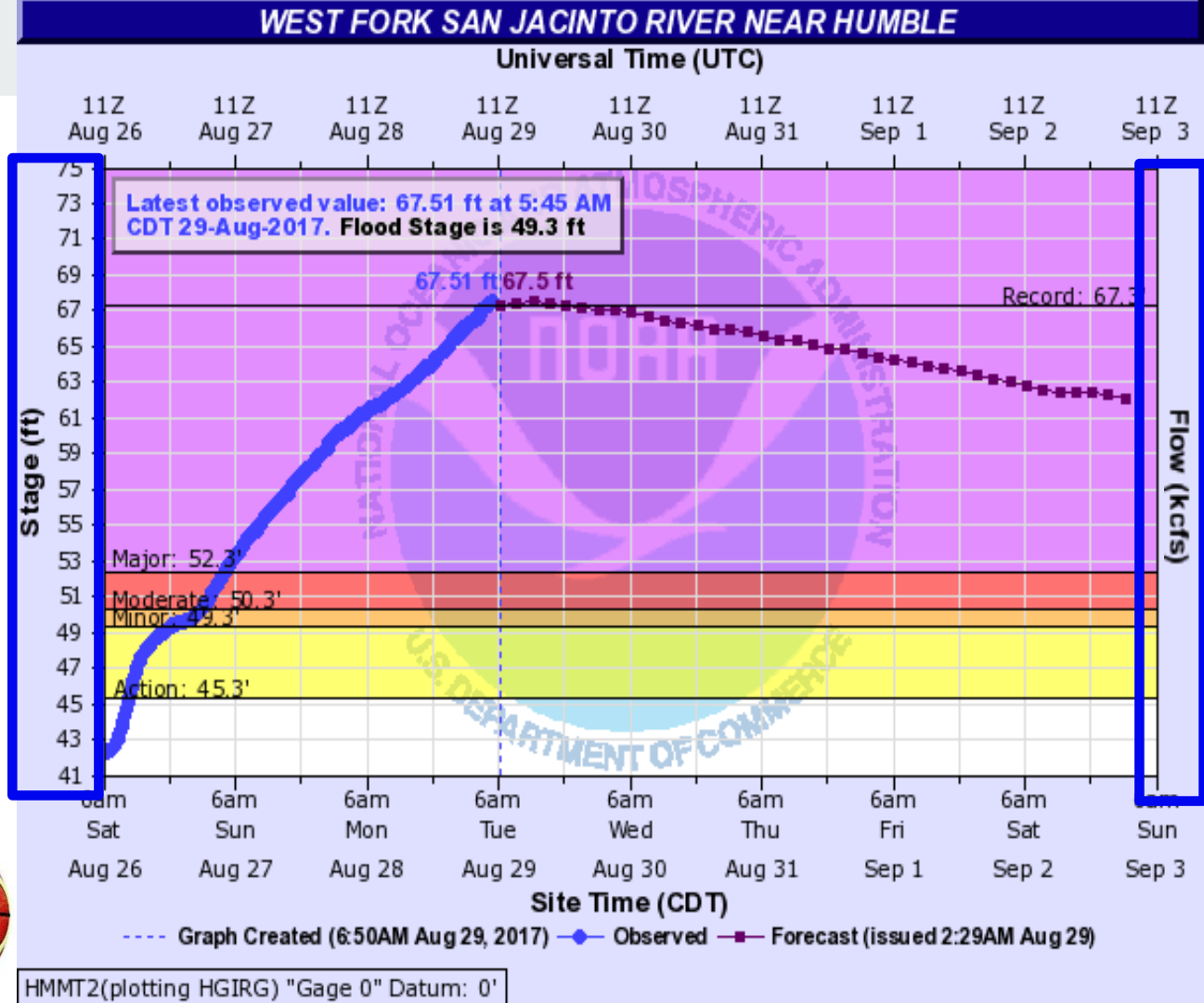
CREST:
Peak Stage



Hydrograph Basics

STAGE VS FLOW:
Hydrologists, models, reservoirs work in flow. Emergency managers, media, general public work in stage.

WHAT IS FLOW OR A CUBIC FOOT PER SECOND?
A basketball is roughly a cubic foot, so 20,000cfs is 20,000 basketballs of water passing the gage every second.



Understanding River Criteria Levels

BELOW CRITERIA

Impact: Water is within the banks of the river with no impacts to the surrounding area. Flow speeds may still be high during rainfall or releases which could impact recreational activities

ACTION

Impact: Water is over the banks and into the flood plain, but not a threat to structures or roadways. Some action may be required such as moving farm equipment or increasing awareness

MINOR

Impact: Typically water is impacting areas inside of floodplain which can vary by location. Some low water crossings covered by water, agricultural flooding, water approaching public areas (parks, sidewalks etc.). Areas frequently flooded can expect to be impacted

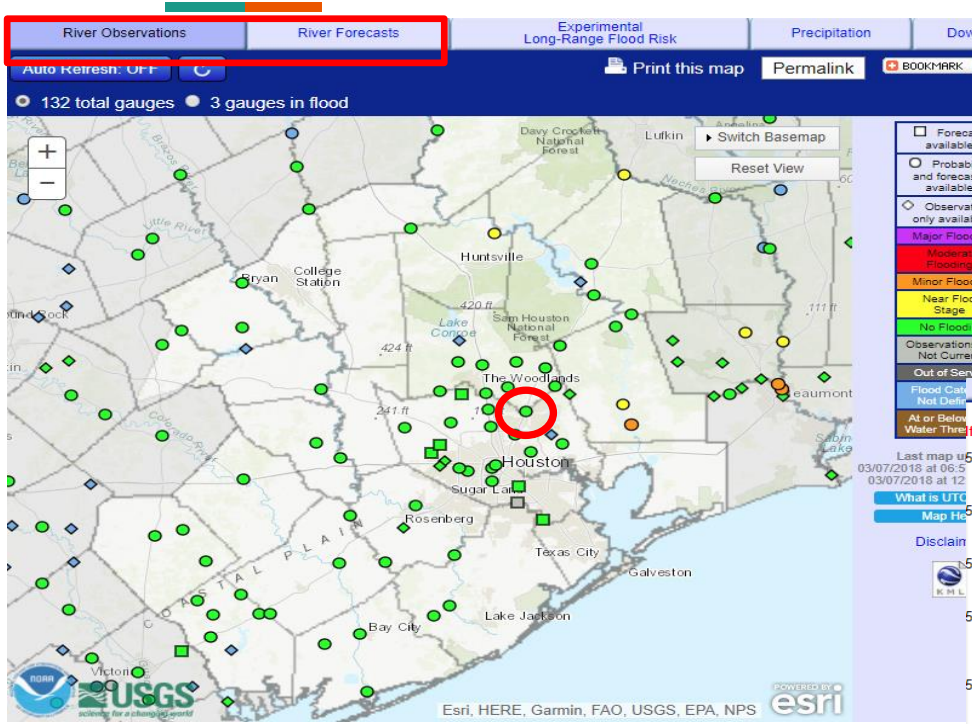
MODERATE

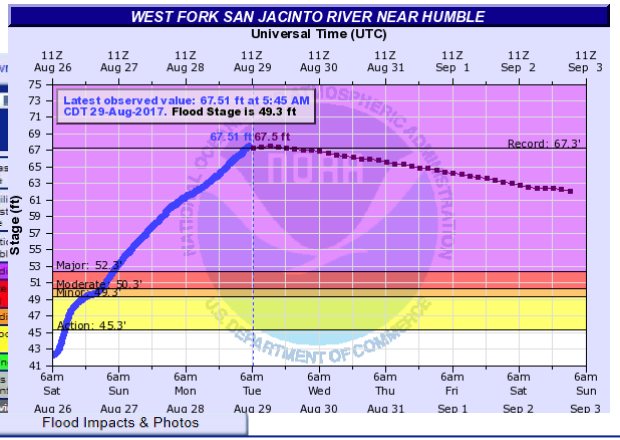
Impact: Water now reaching areas only impacted by significant rain events. Structures can be inundated, several roads covered with water, water may cut off certain areas, widespread agricultural flooding.

MAJOR

Impact: Water is near the highest it's ever been representing rare flooding and significant widespread impacts. Most roads will be covered by water in the area cutting off if not completely flooding subdivisions, rivers can be several miles wide in areas. Homes and structures underwater, bridges inundated and in danger of being hit by debris. Impacts may be greater than ever experienced.

Advanced Hydrologic Prediction System





Flood Categories (in feet)

Major Flood Stage:	52.3
Moderate Flood Stage:	50.3
Flood Stage:	49.3
Action Stage:	45.3
Low Stage (in feet):	0

Historic Crests
(1) 69.18 ft on 08/29/2017
(2) 67.30 ft on 10/18/1994
(3) 63.20 ft on 05/31/1929
(4) 62.80 ft on 09/14/2008
(5) 62.20 ft on 11/26/1940
Show More Historic Crests

(P): Preliminary values subject to further review.

Recent Crests
(1) 69.18 ft on 08/29/2017
(2) 61.95 ft on 05/29/2016
(3) 57.32 ft on 04/21/2016
(4) 50.11 ft on 06/21/2015
(5) 53.65 ft on 05/29/2015
Show More Recent Crests

If you notice any errors in the below information, please contact our Webmaster

55.2 Major lowland flooding continues with up to 6 inches of water is over the 800 block Hamblen Cove Country Club Golf Course with many homes in the Bellau Woods and Treasure Cove subdivision are flooded.

54.4 Major lowland flooding continues with homes along Riverview Drive in River Ridge subdivision upstream of the gauge begin to flood.

53.3 Major lowland flooding continues with water is in homes on Lake Lane West and Southshore Drive in the Bellau Woods subdivision and Homes in the Treasure Cove subdivision and along Aqua Vista Drive begin flooding.

52.3 Major lowland flooding begins as homes on Lake Lane West and Southshore Drive in the Belleau Woods subdivision begin flooding. Roads into the Treasure Cove subdivision are inundated and homes along Aqua Vista Drive threatened. Water is in many homes on Lake Point Drive in the Northshore subdivision.

51.5 Moderate lowland flooding continues with up to one foot of water is over the road at the intersection of Bellau Wodd and Riviera and many homes in the Northshore subdivision are flooded.

50.3 Moderate lowland flooding begins as homes on Lake Point Drive in the Northshore subdivision begin flooding and roads in the Bellaeu Woods subdivision are inundated.

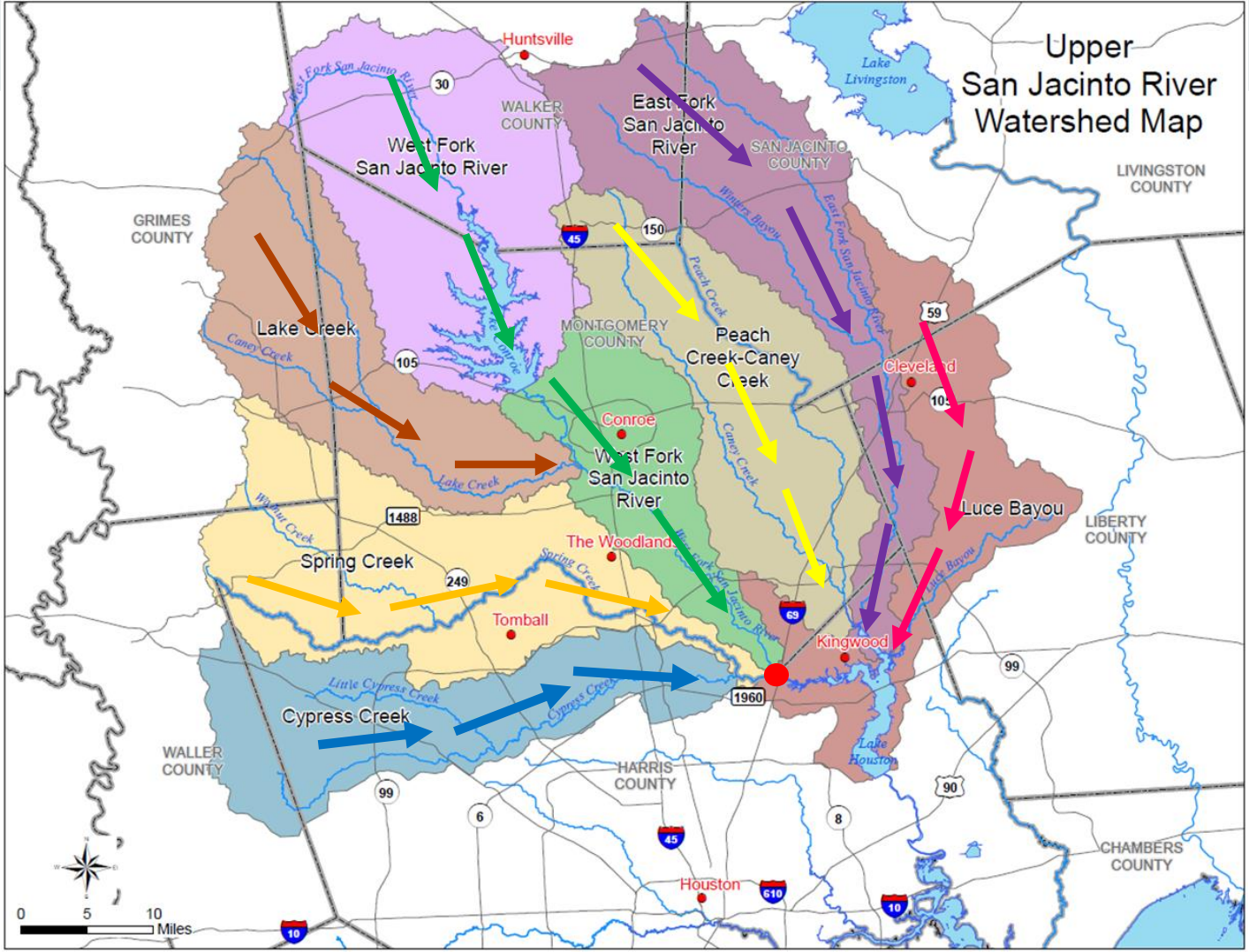
49.3 49.5 feet MSL...Minor lowland flooding begins in the vicinity of the gage. North side turnaround at US 59 begins to flood. Low points on Thelma Road, Aqua Vista Drive, and Riverview Drive begin to flood.

http://water.weather.gov/ahps2/index.php?wfo=hgx

Watershed

- A watershed is an area of land that drains runoff from rainfall, also known as stormwater, to a body of water, either a river, bayou, creek, or lake.
- Harris County has 22 watersheds that all drain to the Gulf. This includes the San Jacinto River.
- A watershed can flow into another watershed.
- Several watersheds flow into the San Jacinto River.
- Watersheds vary in shape and size which ultimately lead to unique challenges.
- Topography plays a big role in how watershed boundaries are defined.

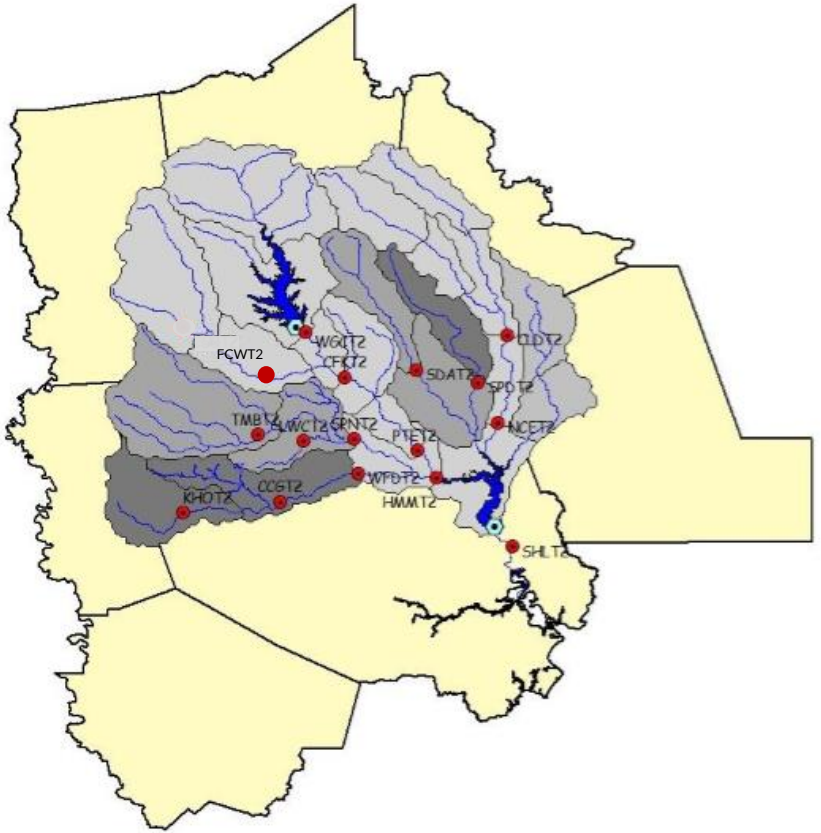
Upper San Jacinto River Watershed



West Fork San Jacinto River at Humble, TX

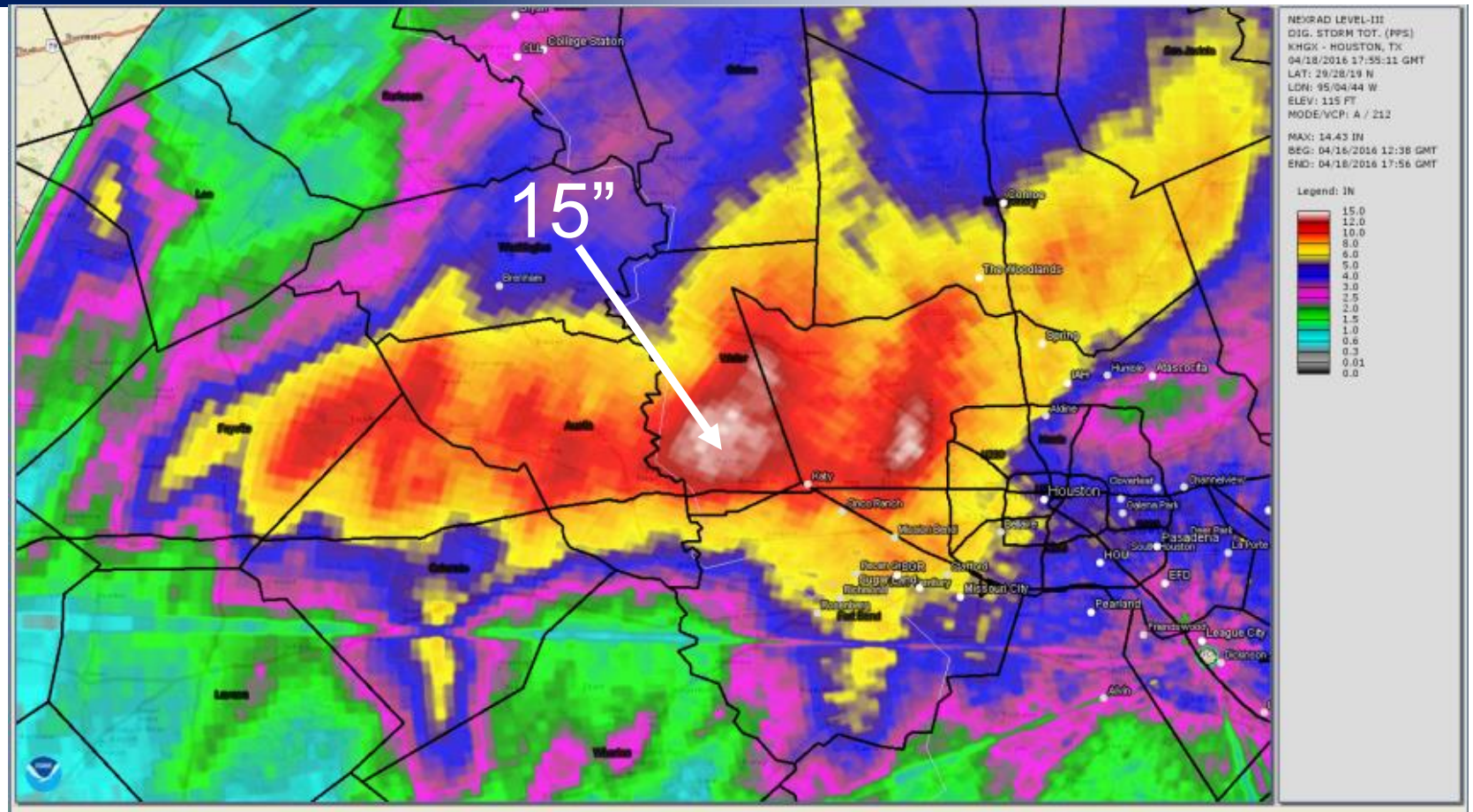
Forecasting the San Jacinto River

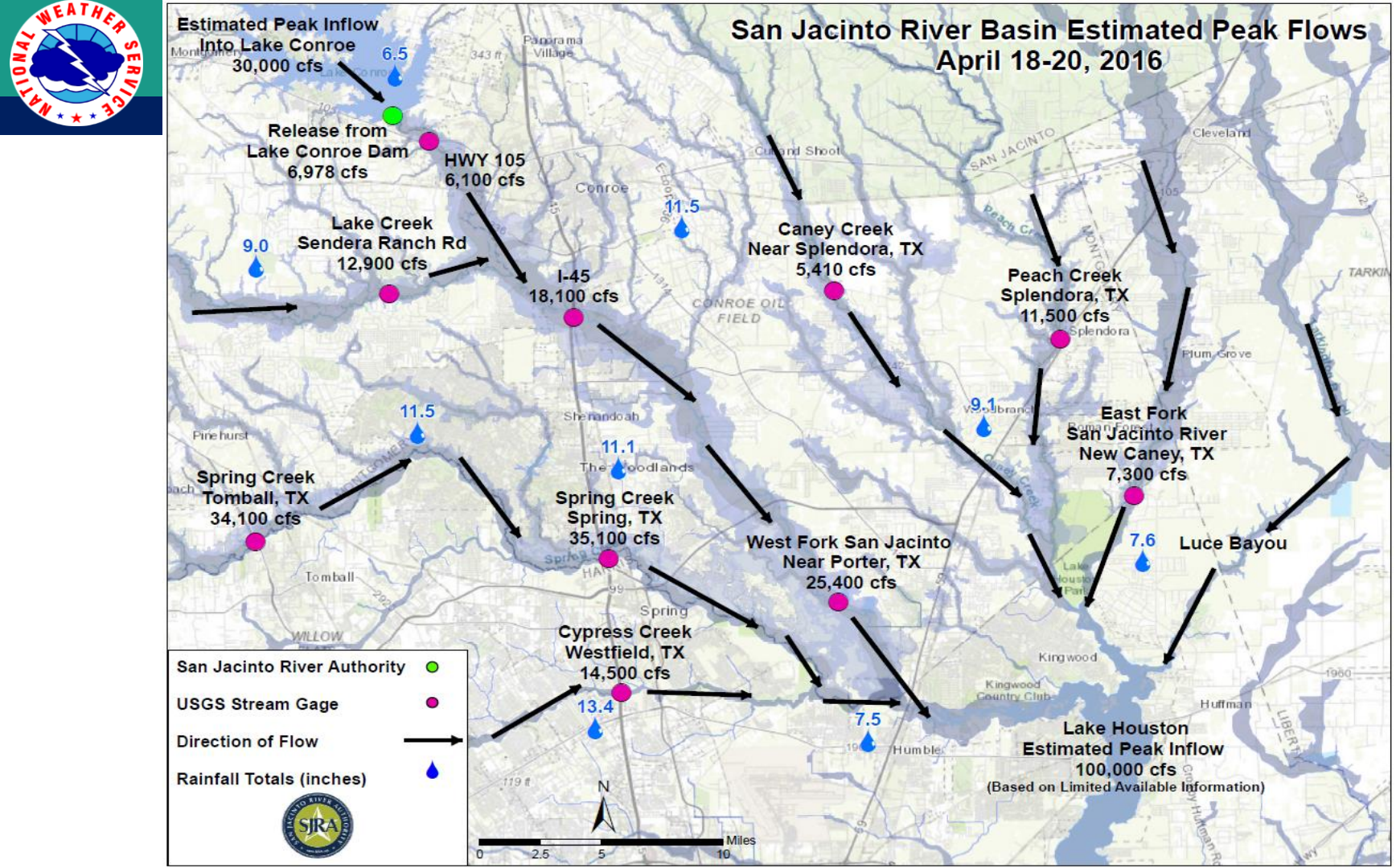
- 9 Basins
- 15 Forecast Points
  - 1 on Lake Creek
  - 3 on West Fork of San Jacinto River
  - 3 on Spring Creek
  - 3 on Cypress Creek
  - 2 on East Fork of San Jacinto River
  - 1 on Peach Creek
  - 1 on Caney Creek
  - 1 on San Jacinto River
- 2 Reservoirs:
  - Lake Conroe
  - Lake Houston



Tax Day 2016 Event

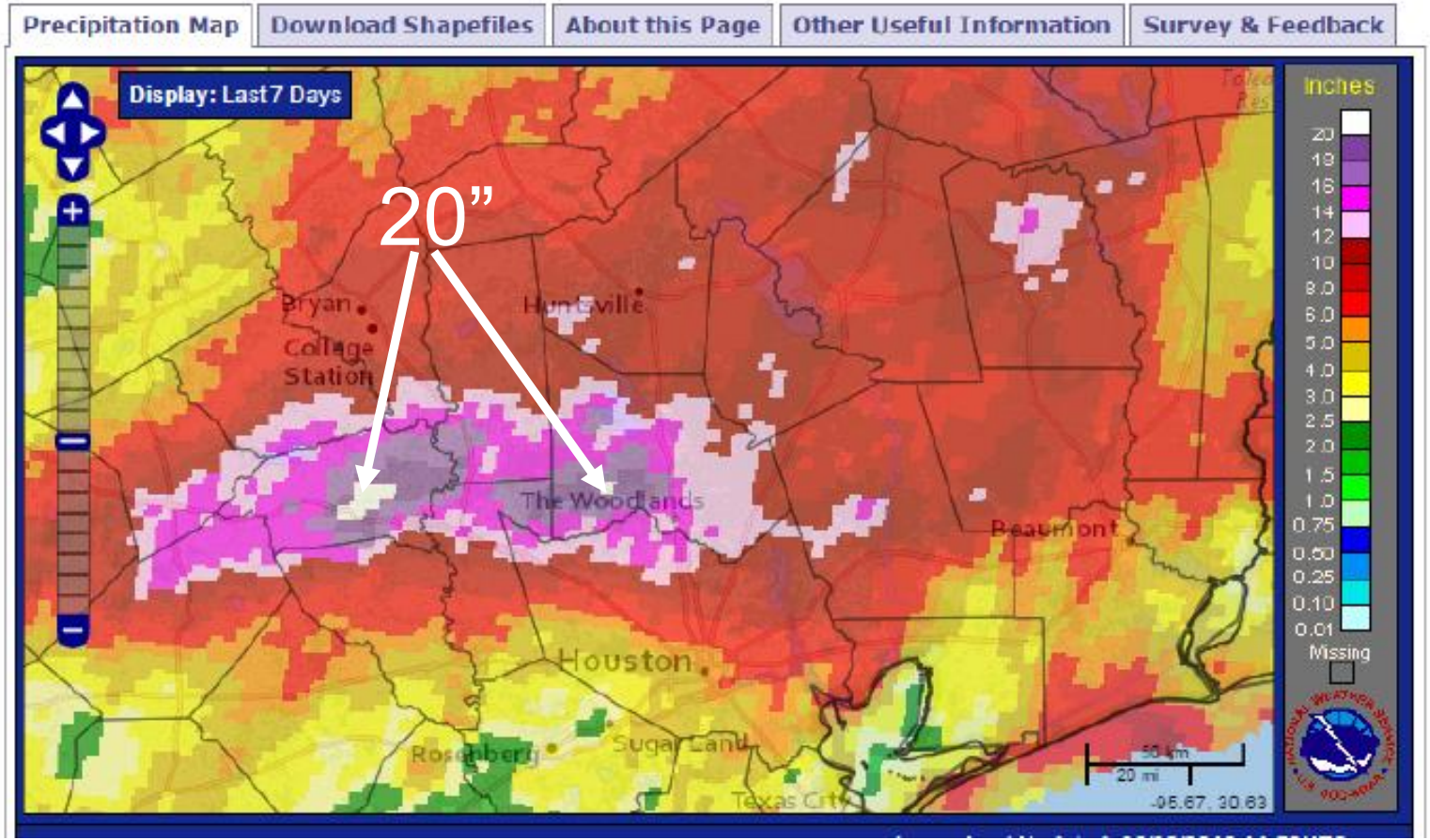
National Weather Service Houston/Galveston

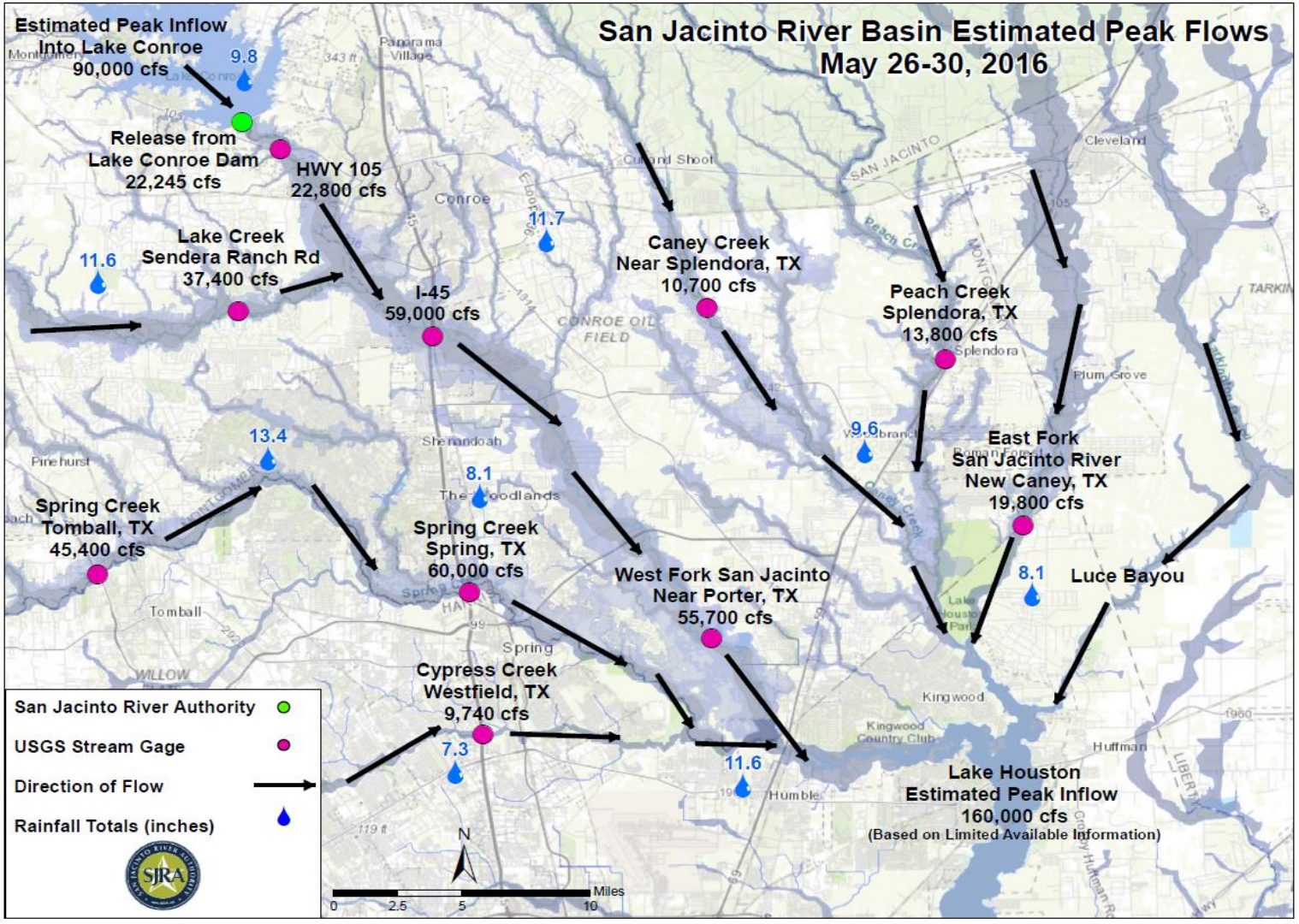


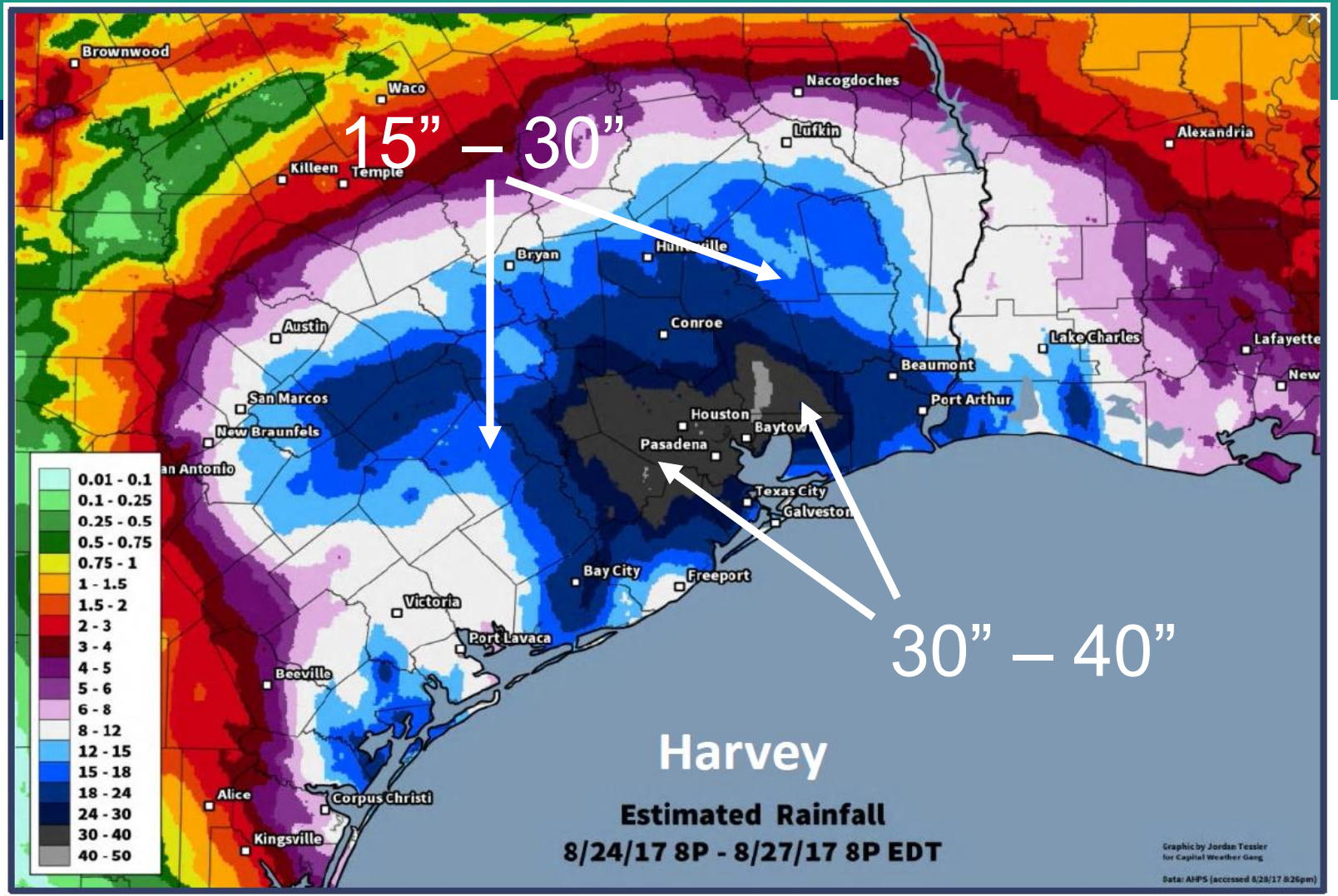

San Jacinto River Basin Estimated Peak Flows
April 18-20, 2016
Estimated Peak Inflow Into Lake Conroe 30,000 cfs
6.5
Release from Lake Conroe Dam 6,978 cfs
HWY 105 6,100 cfs
Lake Creek Sendera Ranch Rd 12,900 cfs
9.0
I-45 18,100 cfs
11.5
Caney Creek Near Splendora, TX 5,410 cfs
Peach Creek Splendora, TX 11,500 cfs
9.1
East Fork San Jacinto River New Caney, TX 7,300 cfs
7.6
Luce Bayou
11.5
Spring Creek Tomball, TX 34,100 cfs
11.1
Spring Creek Spring, TX 35,100 cfs
West Fork San Jacinto Near Porter, TX 25,400 cfs
Cypress Creek Westfield, TX 14,500 cfs
13.4
7.5
Lake Houston Estimated Peak Inflow 100,000 cfs
(Based on Limited Available Information)
San Jacinto River Authority
USGS Stream Gage
Direction of Flow
Rainfall Totals (inches)
N
0 2.5 5 10 Miles
Conroe
Cleveland
Splendora
Plum Grove
Shenandoah
The Woodlands
Pinehurst
Tomball
Spring
Kingwood
Huffman
Humble
Panorama Village
CONROE OIL FIELD
WILLOW

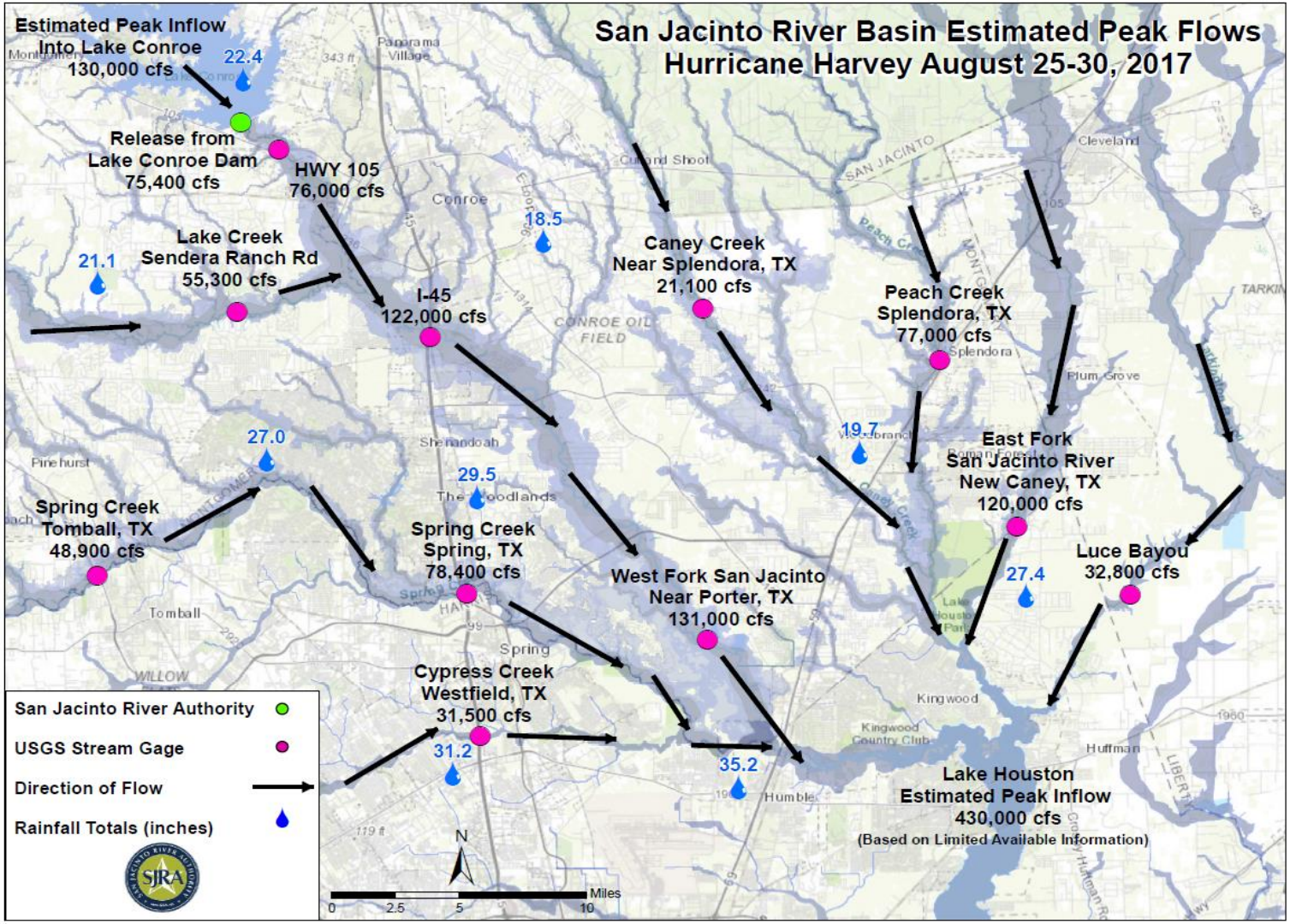
Memorial Day 2016 Event

National Weather Service Houston/Galveston




San Jacinto River Basin Estimated Peak Flows
May 26-30, 2016
Estimated Peak Inflow
Into Lake Conroe
90,000 cfs
9.8
Release from
Lake Conroe Dam
22,245 cfs
HWY 105
22,800 cfs
Lake Creek
Sendera Ranch Rd
37,400 cfs
11.6
I-45
59,000 cfs
11.7
Caney Creek
Near Splendora, TX
10,700 cfs
Peach Creek
Splendora, TX
13,800 cfs
9.6
East Fork
San Jacinto River
New Caney, TX
19,800 cfs
8.1
Luce Bayou
13.4
Spring Creek
Tomball, TX
45,400 cfs
8.1
Spring Creek
Spring, TX
60,000 cfs
West Fork San Jacinto
Near Porter, TX
55,700 cfs
Cypress Creek
Westfield, TX
9,740 cfs
7.3
11.6
Lake Houston
Estimated Peak Inflow
160,000 cfs
(Based on Limited Available Information)
San Jacinto River Authority
USGS Stream Gage
Direction of Flow
Rainfall Totals (inches)
SJRA
N
0
2.5
5
10
Miles
Conroe
Cleveland
Splendora
Plum Grove
Shenandoah
The Woodlands
Pinehurst
Tomball
Spring
Kingwood
Kingwood Country Club
Huffman
Humble
Panorama Village
CONROE OIL FIELD
Lake Houston Park


15” – 30”
30” – 40”
Brownwood
Waco
Killeen
Temple
Nacogdoches
Lufkin
Alexandria
Bryan
Austin
Conroe
Lake Charles
Lafayette
Beaumont
Port Arthur
San Marcos
New Braunfels
Houston
Pasadena
Texas City
Galveston
Bay City
Freeport
Victoria
Port Lavaca
Beeville
Alice
Corpus Christi
Kingsville
0.01 - 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 8
8 - 12
12 - 15
15 - 18
18 - 24
24 - 30
30 - 40
40 - 50
Harvey
Estimated Rainfall
8/24/17 8P - 8/27/17 8P EDT
Graphic by Jordan Tessler
for Capitol Weather Gang
Data: AHPS (accessed 8/28/17 8:26pm)


San Jacinto River Basin Estimated Peak Flows
Hurricane Harvey August 25-30, 2017
Estimated Peak Inflow Into Lake Conroe 130,000 cfs
22.4
Release from Lake Conroe Dam 75,400 cfs
HWY 105 76,000 cfs
Lake Creek Sendera Ranch Rd 55,300 cfs
21.1
I-45 122,000 cfs
18.5
Caney Creek Near Splendora, TX 21,100 cfs
Peach Creek Splendora, TX 77,000 cfs
19.7
East Fork San Jacinto River New Caney, TX 120,000 cfs
27.4
Luce Bayou 32,800 cfs
27.0
Spring Creek Tomball, TX 48,900 cfs
29.5
Spring Creek Spring, TX 78,400 cfs
West Fork San Jacinto Near Porter, TX 131,000 cfs
Cypress Creek Westfield, TX 31,500 cfs
31.2
35.2
Lake Houston Estimated Peak Inflow 430,000 cfs
(Based on Limited Available Information)
San Jacinto River Authority
USGS Stream Gage
Direction of Flow
Rainfall Totals (inches)
N
0
2.5
5
10
Miles
Conroe
Cleveland
Splendora
Plum Grove
Shenandoah
The Woodlands
Pinehurst
Tomball
Spring
Kingwood
Humble
Huffman
Panorama Village
CONROE OIL FIELD
WILLOW

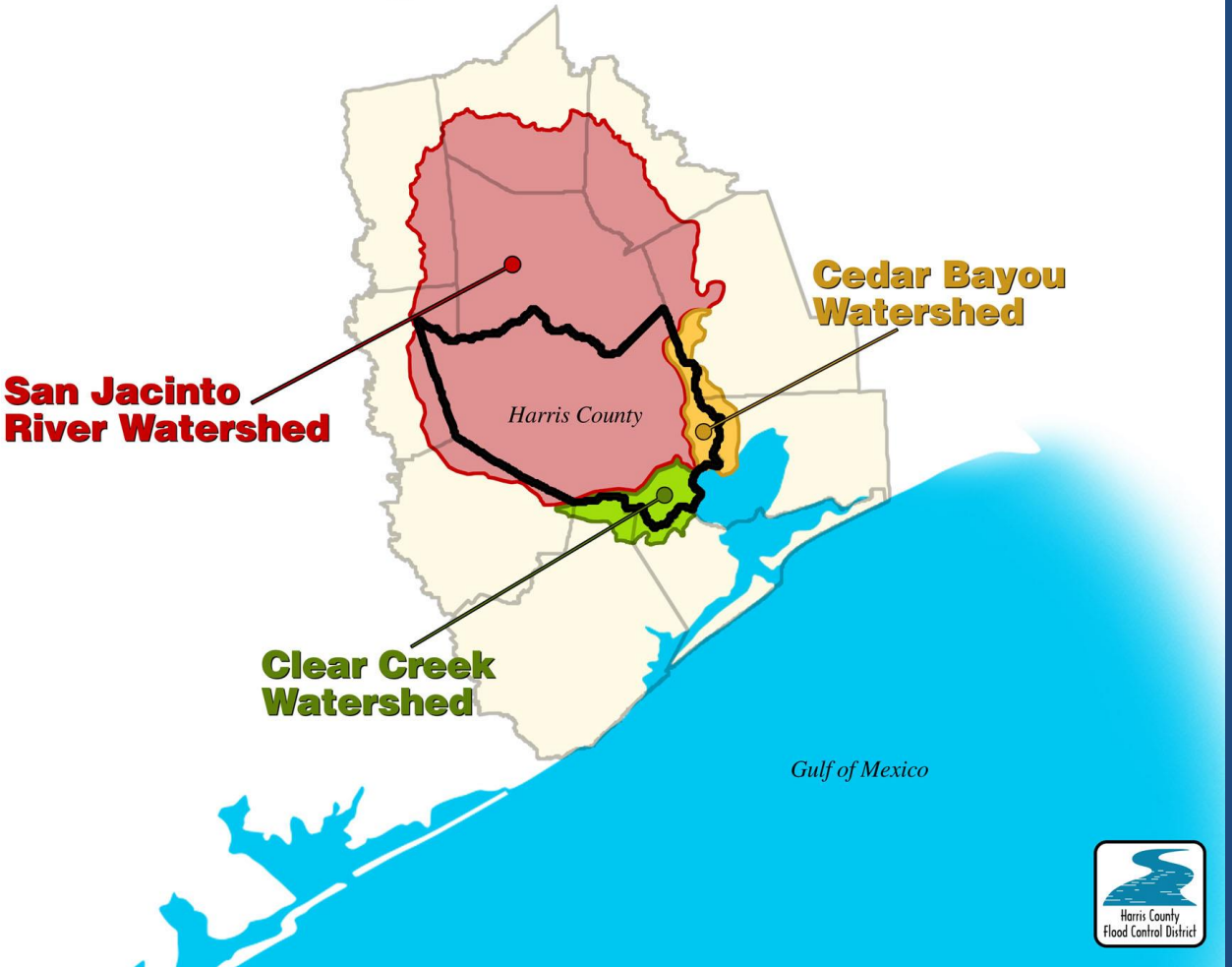
Partners

Hydrology in Harris County

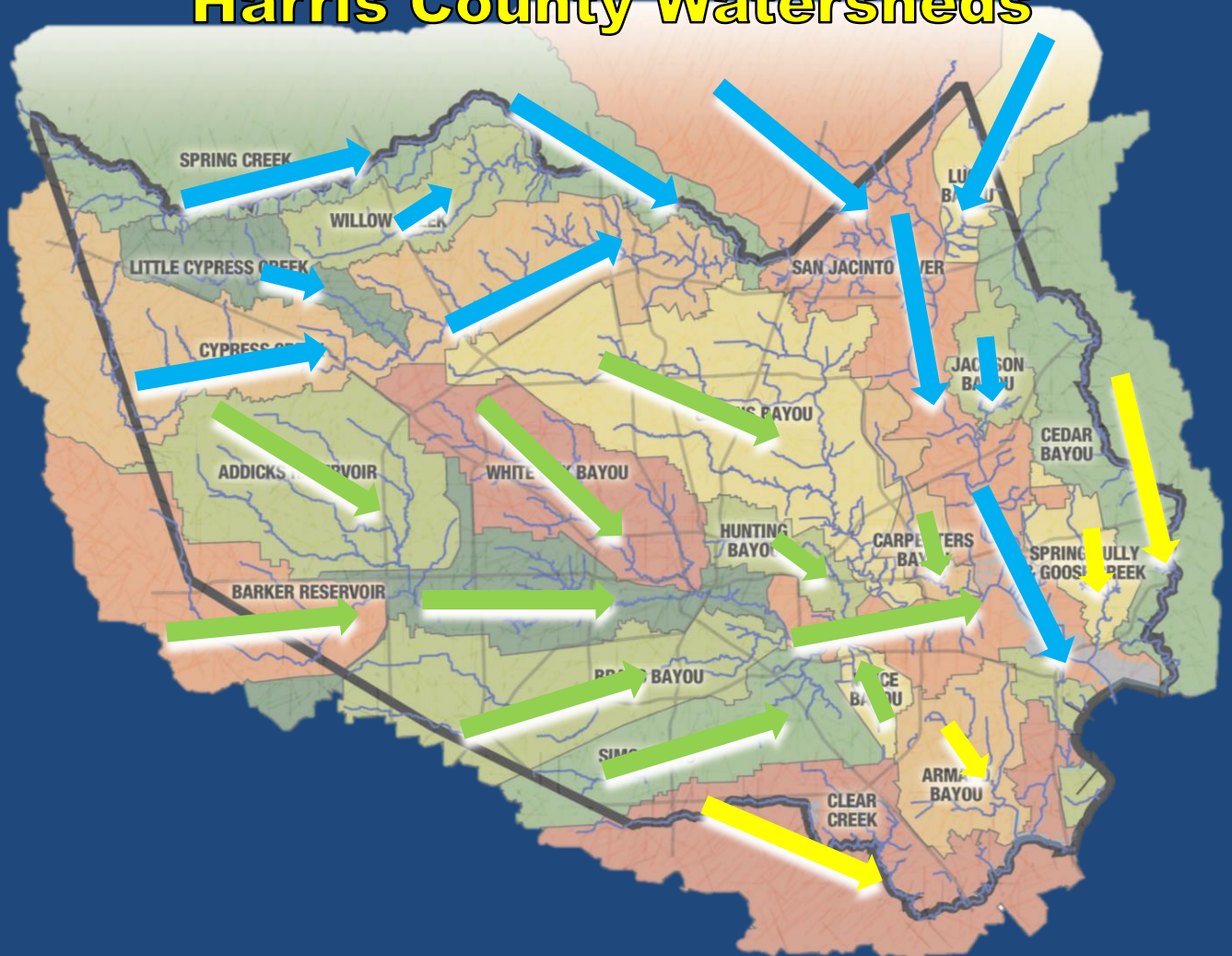
Jeff Lindner
Meteorologist/Director, Hydrologic Operations Division
Harris County Flood Control District

Southeast Texas Watersheds

Harris County Local Watersheds

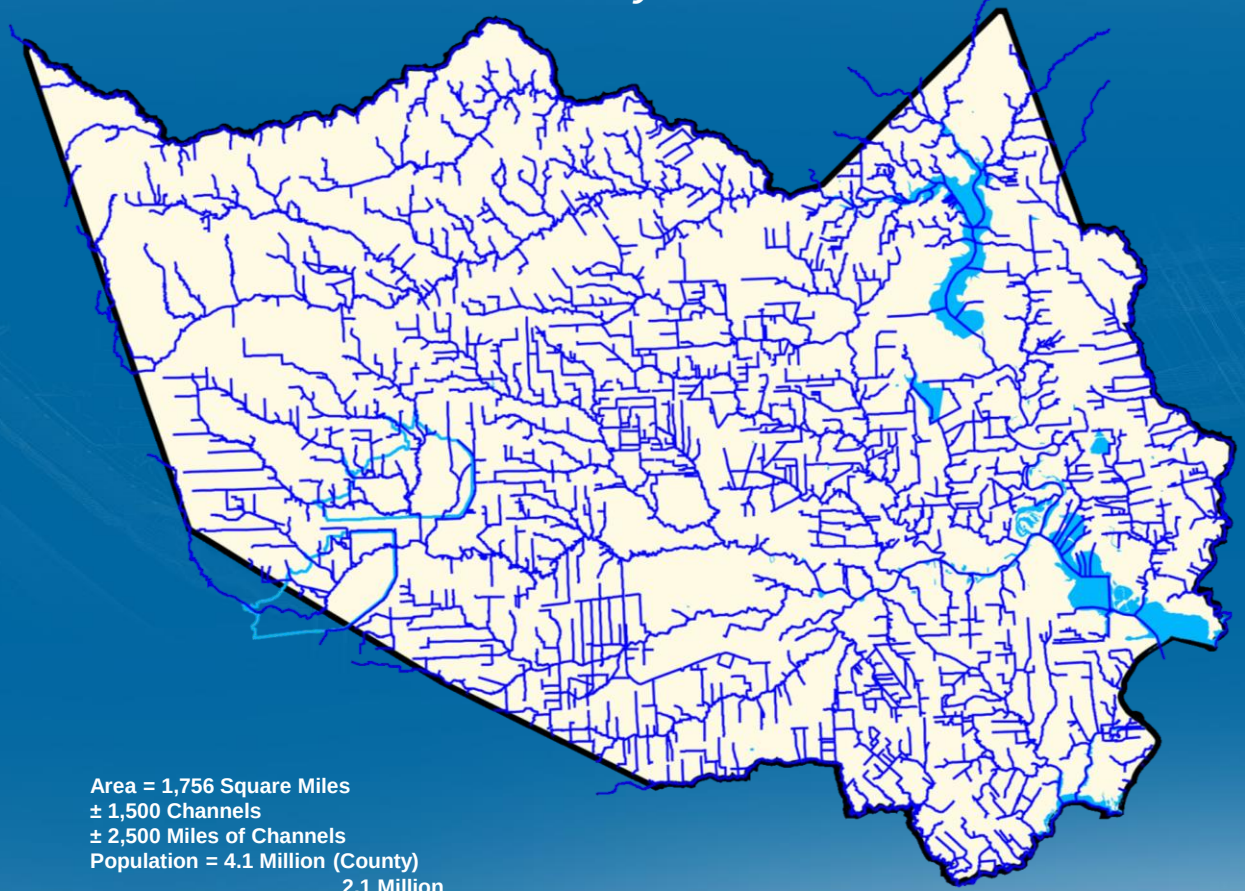


Harris County Watersheds



Harris County Open Channel Network

2,500 Miles of Bayous and Creeks

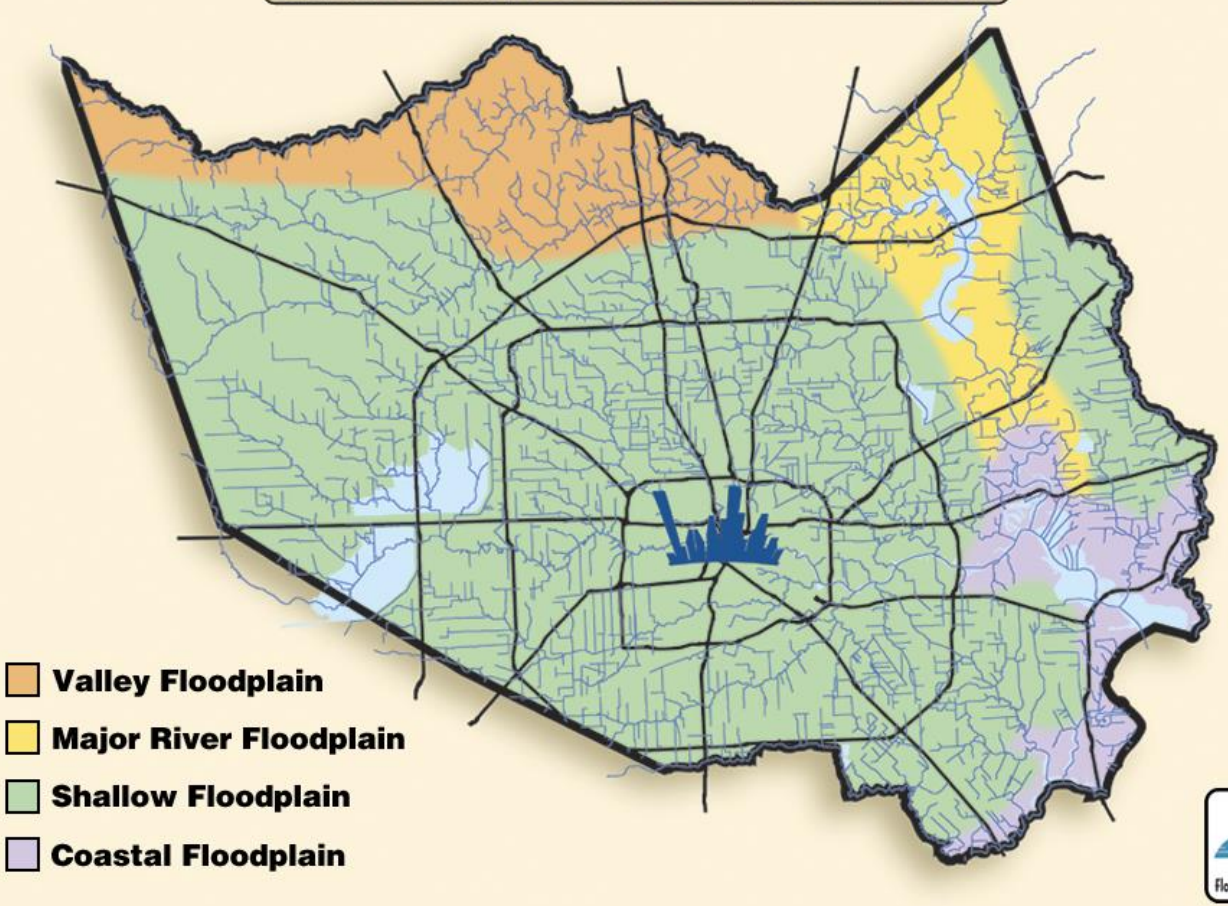


Area = 1,756 Square Miles
± 1,500 Channels
± 2,500 Miles of Channels
Population = 4.1 Million (County)
2.1 Million (Houston)

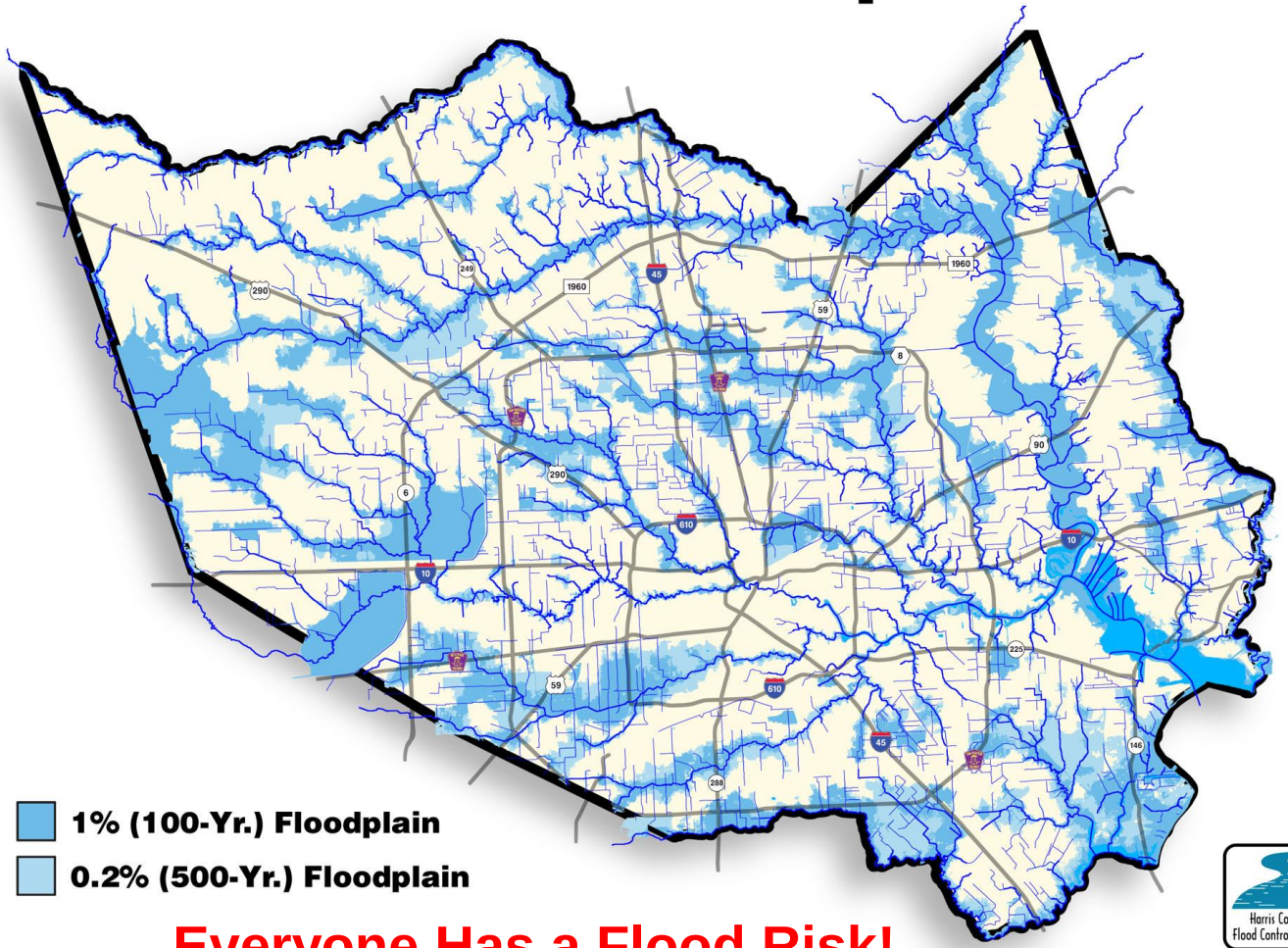
HARRIS COUNTY FLOOD CONTROL DISTRICT

Understanding Our Flooding

HARRIS COUNTY'S 4 TYPES OF FLOODPLAINS



2007 FEMA Floodplains

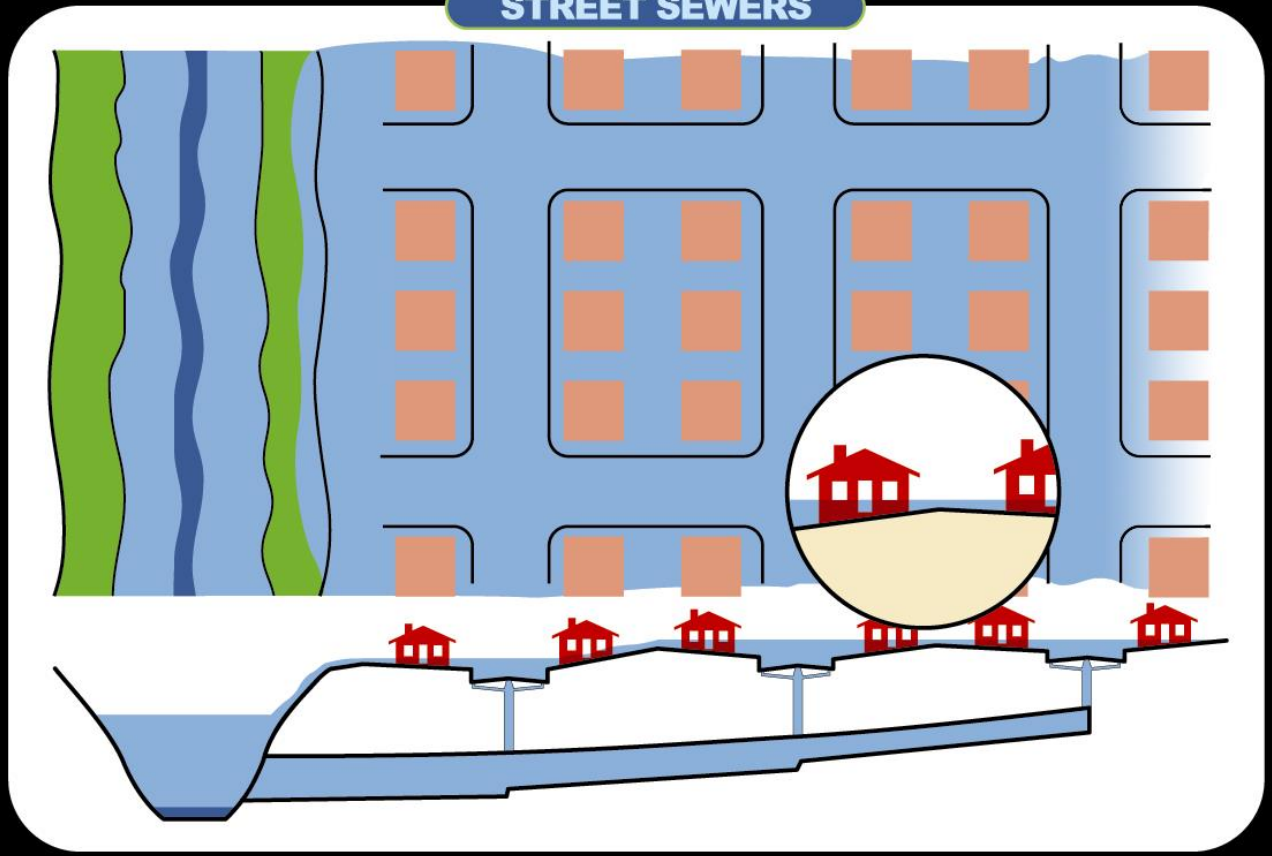


Harris County Flood Control District

Everyone Has a Flood Risk!

HARRIS COUNTY FLOOD CONTROL DISTRICT

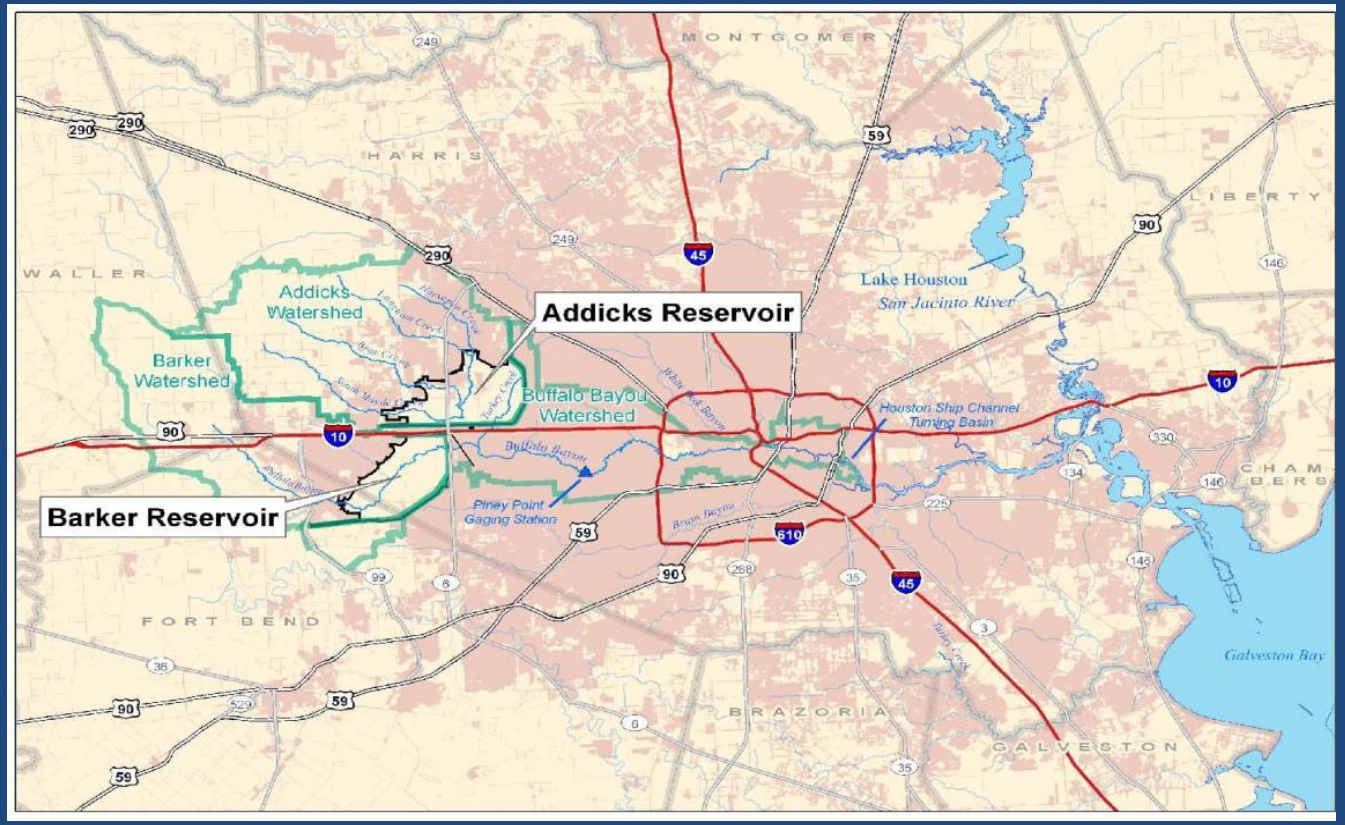
Ponding & Sheet Flow Flooding



FLOODING FROM INTENSE LOCAL RAINFALL
(Longer Duration)

HARRIS COUNTY FLOOD CONTROL DISTRICT

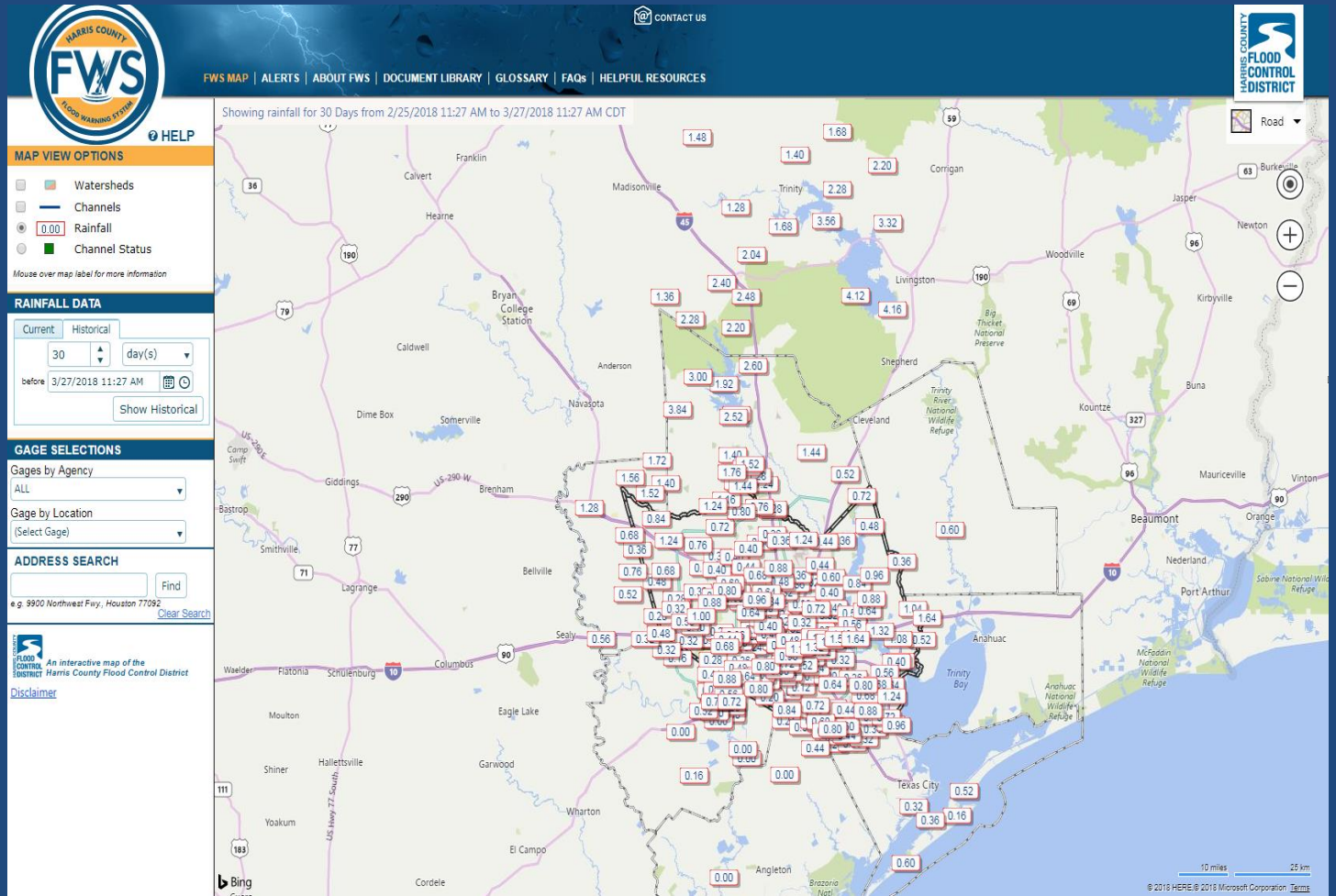
Addicks and Barker Watersheds



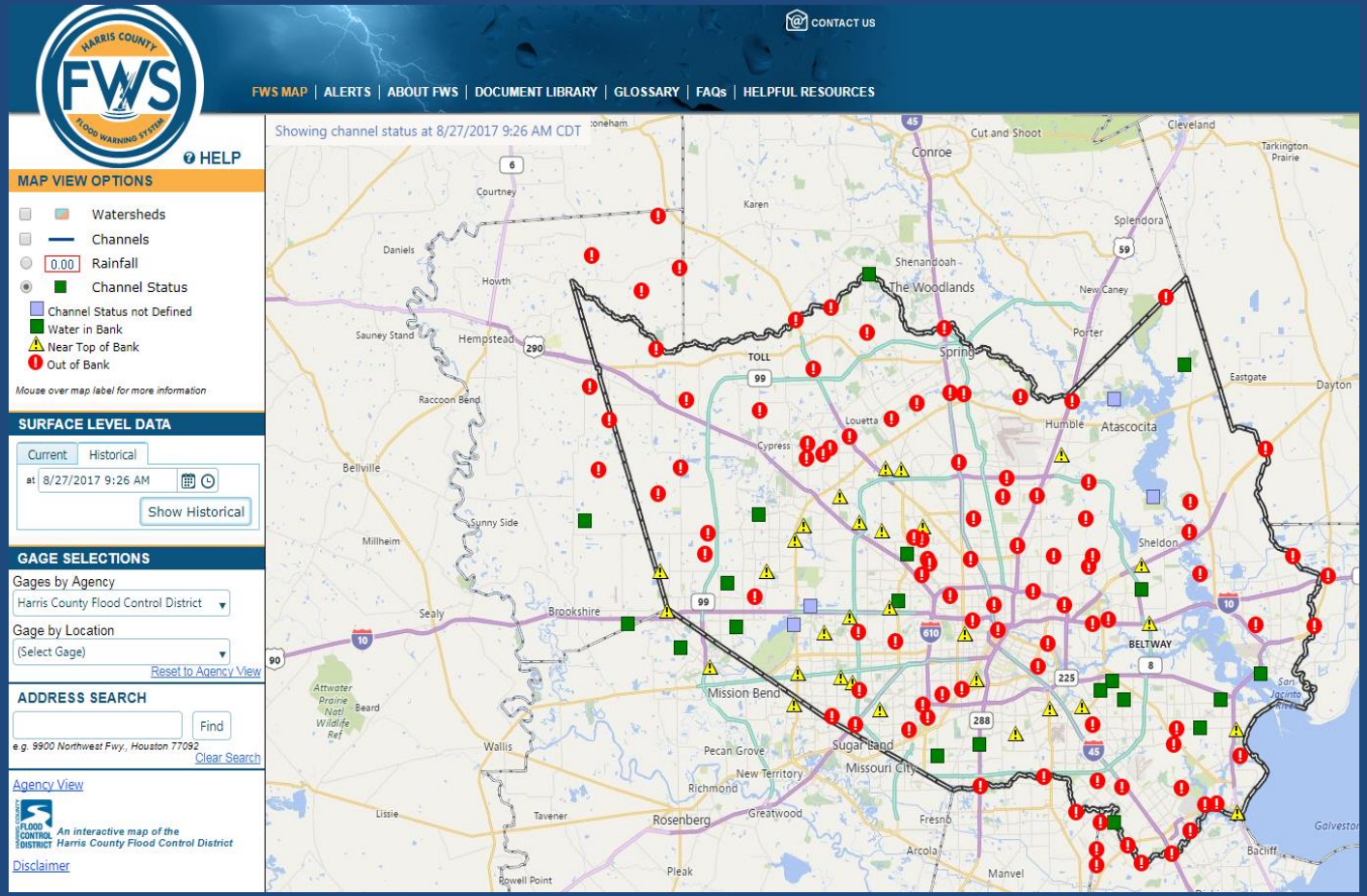
Flood Warning System


CONTACT US
FWS MAP | ALERTS | ABOUT FWS | DOCUMENT LIBRARY | GLOSSARY | FAQs | HELPFUL RESOURCES
HARRIS COUNTY FLOOD CONTROL DISTRICT
HELP
MAP VIEW OPTIONS
Watersheds
Channels
Rainfall
Channel Status
Mouse over map label for more information
RAINFALL DATA
Current
Historical
Rainfall in the last
24 Hours
Refresh Data
GAGE SELECTIONS
Gages by Agency
Harris County Flood Control District
Gage by Location
(Select Gage)
Reset to Agency View
ADDRESS SEARCH
Find
e.g. 9900 Northwest Fwy., Houston 77092
Clear Search
Agency View
An interactive map of the Harris County Flood Control District
Disclaimer
Showing rainfall for the last 24 Hours (before 10/7/2017 11:10 AM CDT)
Road
Conroe
Splendora
Shenandoah
New Caney
Porter
Eastgate
Dayton
Liberty
Tarkington Prairie
Courtney
Karen
Howth
Sunny Side
Brookshire
Wallis
Pecan Grove
New Territory
Richmond
Rosenberg
Greatwood
Tavener
Fresno
Arcola
Manvel
Pleak
Rowell Point
Needville
Dickinson
Trinity Bay
Galveston Bay
TOLL
Bing
© 2017 HERE © 2017 Microsoft Corporation Terms
www.harriscountyfws.org

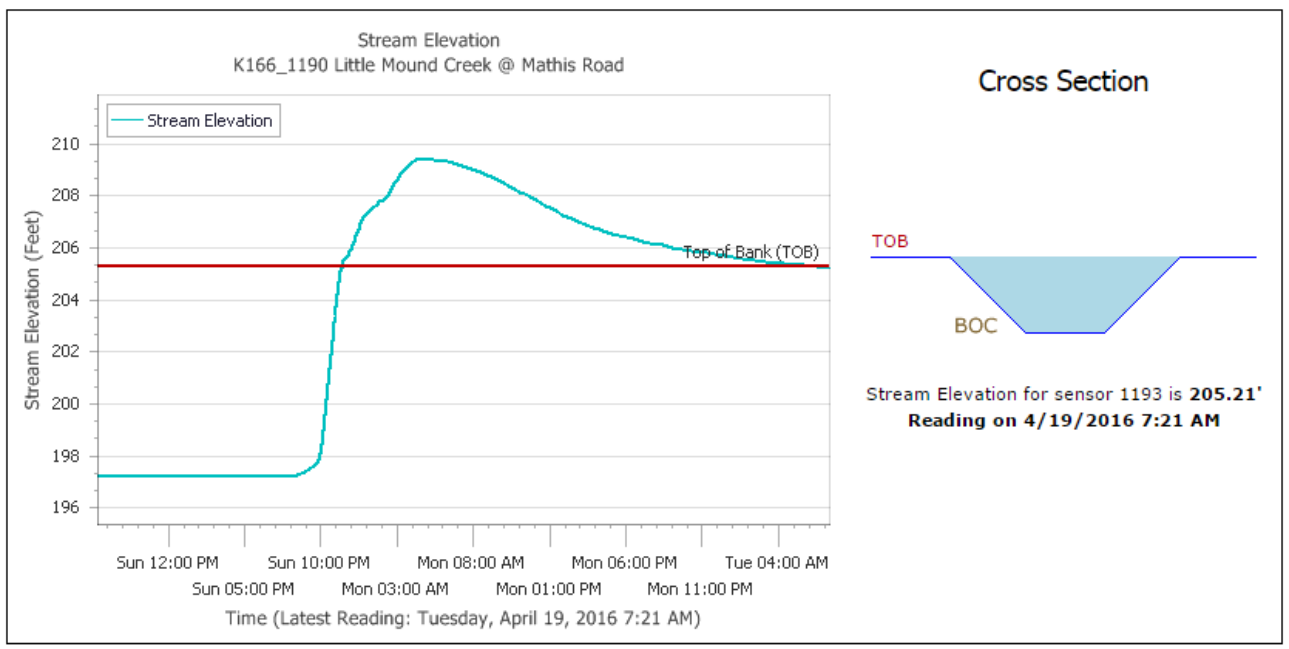
All FWS Gages



Public Website – Channel Status



Public Website – Water Level



Flood Frequency	Elevation
10% (10-year)	208.80'
2% (50-year)	209.70'
1% (100-year)	210.10'
.2% (500-year)	211.10'

Historical Storm

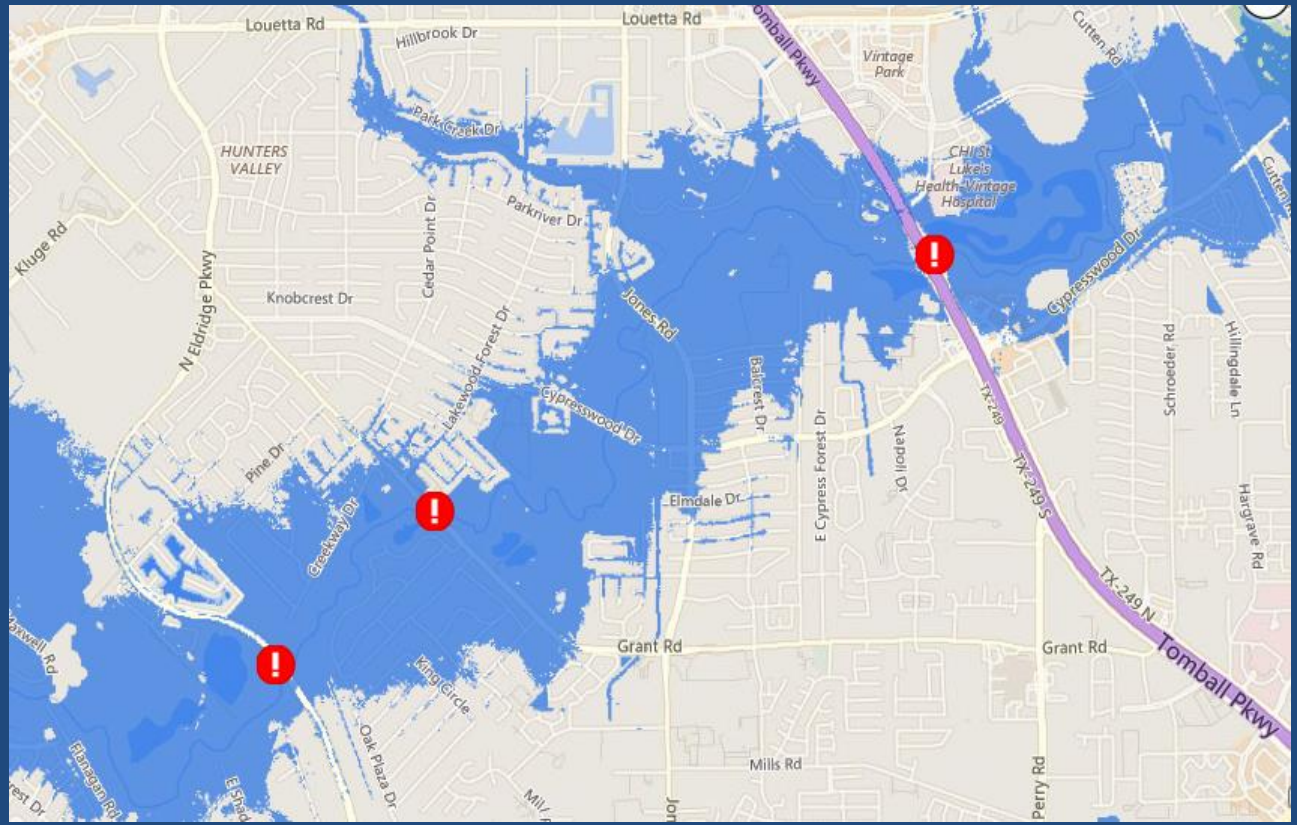
Date	Event	Elevation
7/12/2012		207.90'
4/18/2016		209.30'
5/27/2016		208.05'
8/27/2017	Harvey	208.90'

High water mark elevations are approximate.

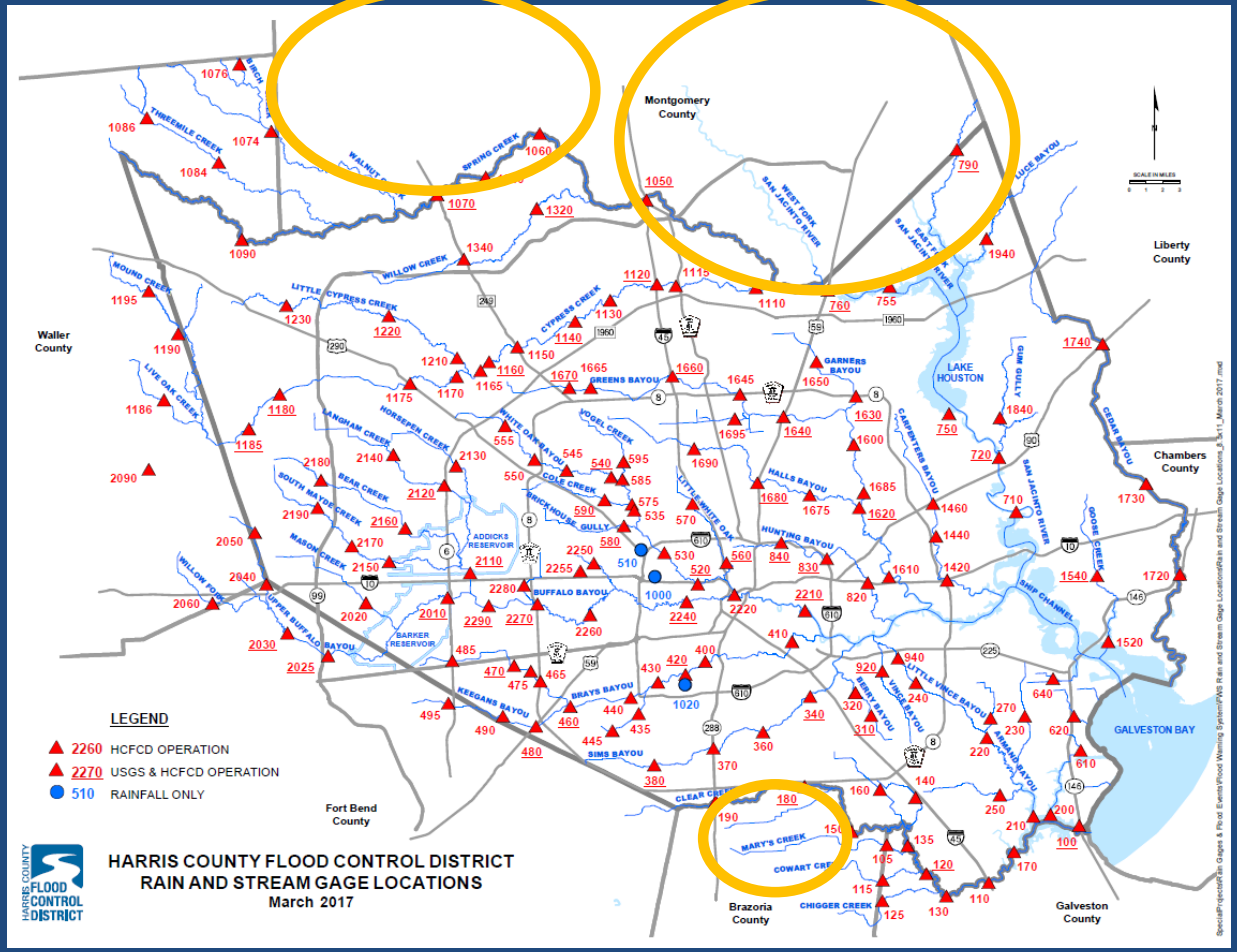
Future Enhancements

- Near real time inundation mapping
- Public customizable alarms
  - Rainfall and stage
  - Text or e-mail
- Expansion of FWS gages (regional)
- Add roadway flooding (transtar)

Inundation Mapping



Gage Network Expansion



Important Information Sources

- Harris County Flood Control District
- City of Houston
- Harris County Office of Emergency Management
- National Weather Service
- San Jacinto River Authority

Important Twitter Handles

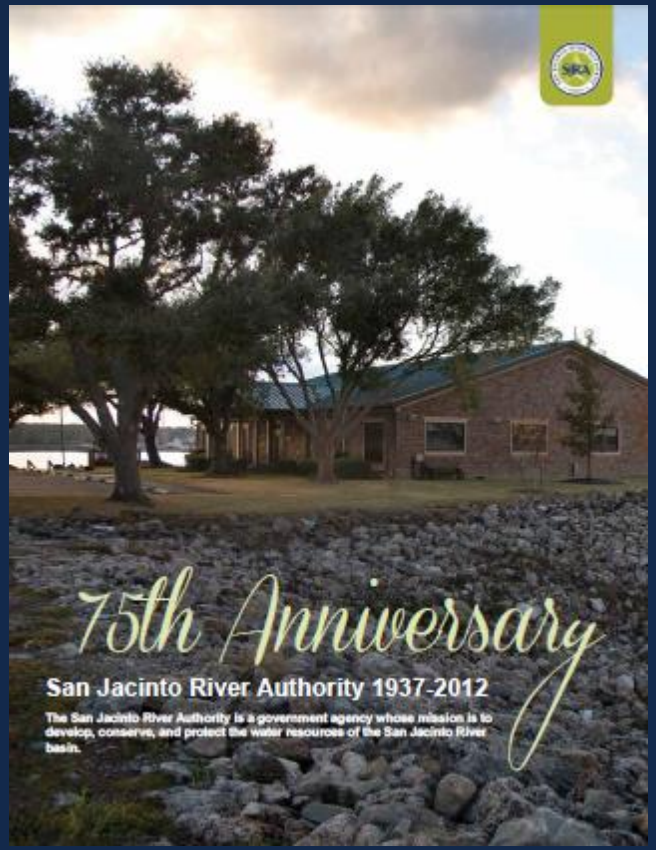
@hcfcd
@sjra
@readyharris
@houstonOEM
@nwshouston
@jefflindner1

Briefing Regarding Lake Conroe Operations

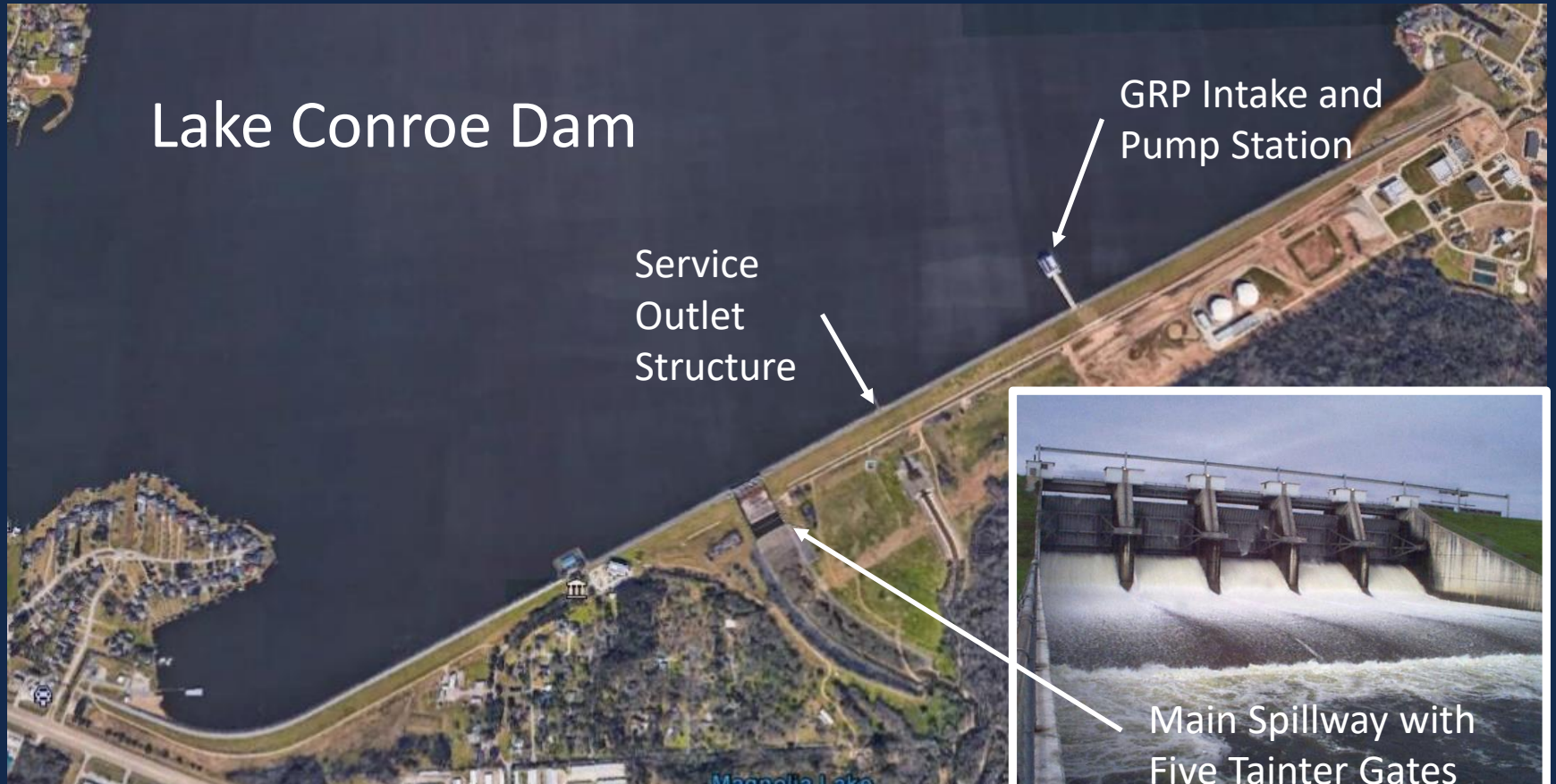
May 1, 2018

San Jacinto River Authority

- Created in 1937
- Statutory purpose – Long-term, regional water resource planning and development
- One of about two dozen river authorities in Texas
- Five operating divisions – Highlands, Woodlands, Lake Conroe, GRP, and Flood Management

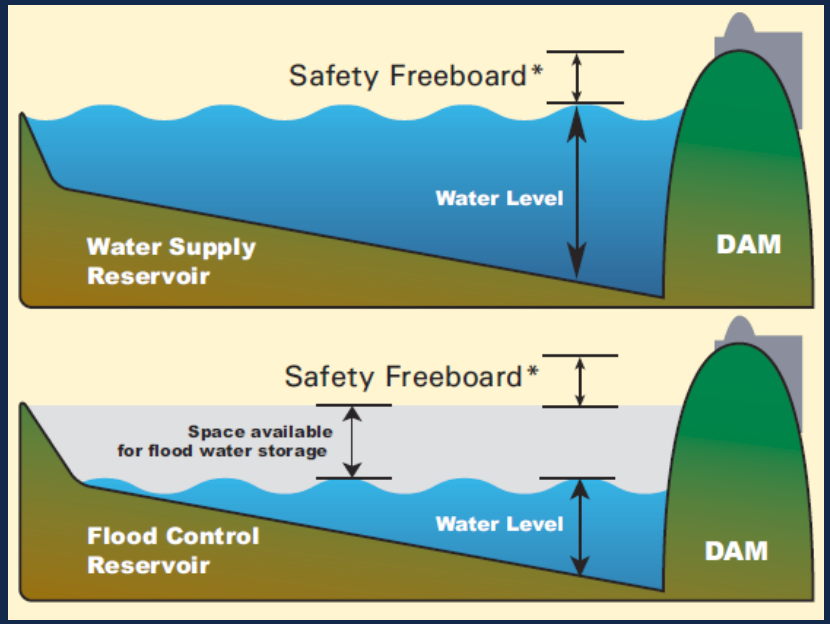


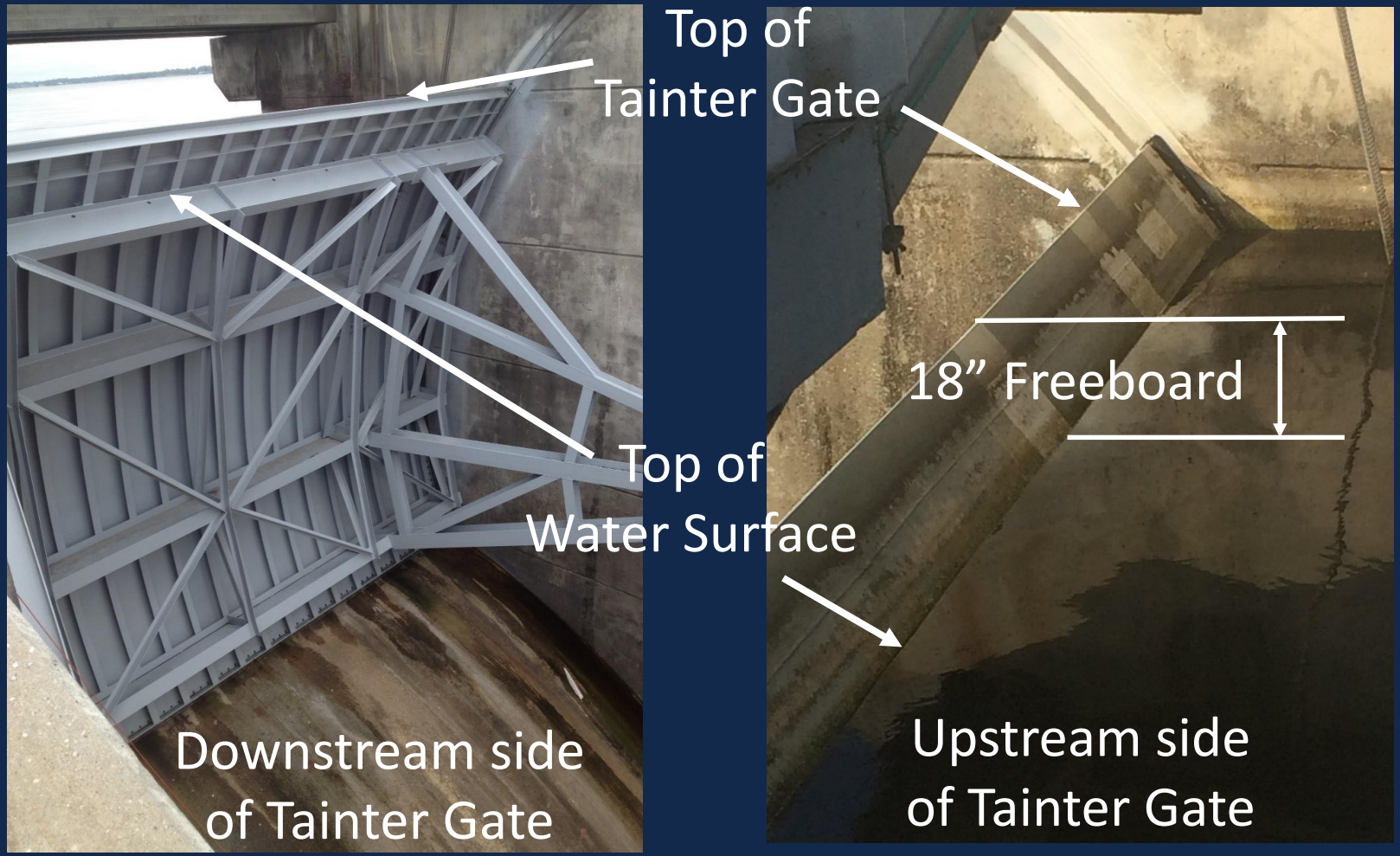
Key Points Regarding Lake Conroe Operations



Water supply reservoirs are designed to stay full

- Lake Houston and Lake Conroe are both water supply reservoirs
- Very limited capacity to capture storm inflows
- Designed to pass inflows from storms (with some reduction in peak flow)
- Structurally, the gates must open gradually as lake rises



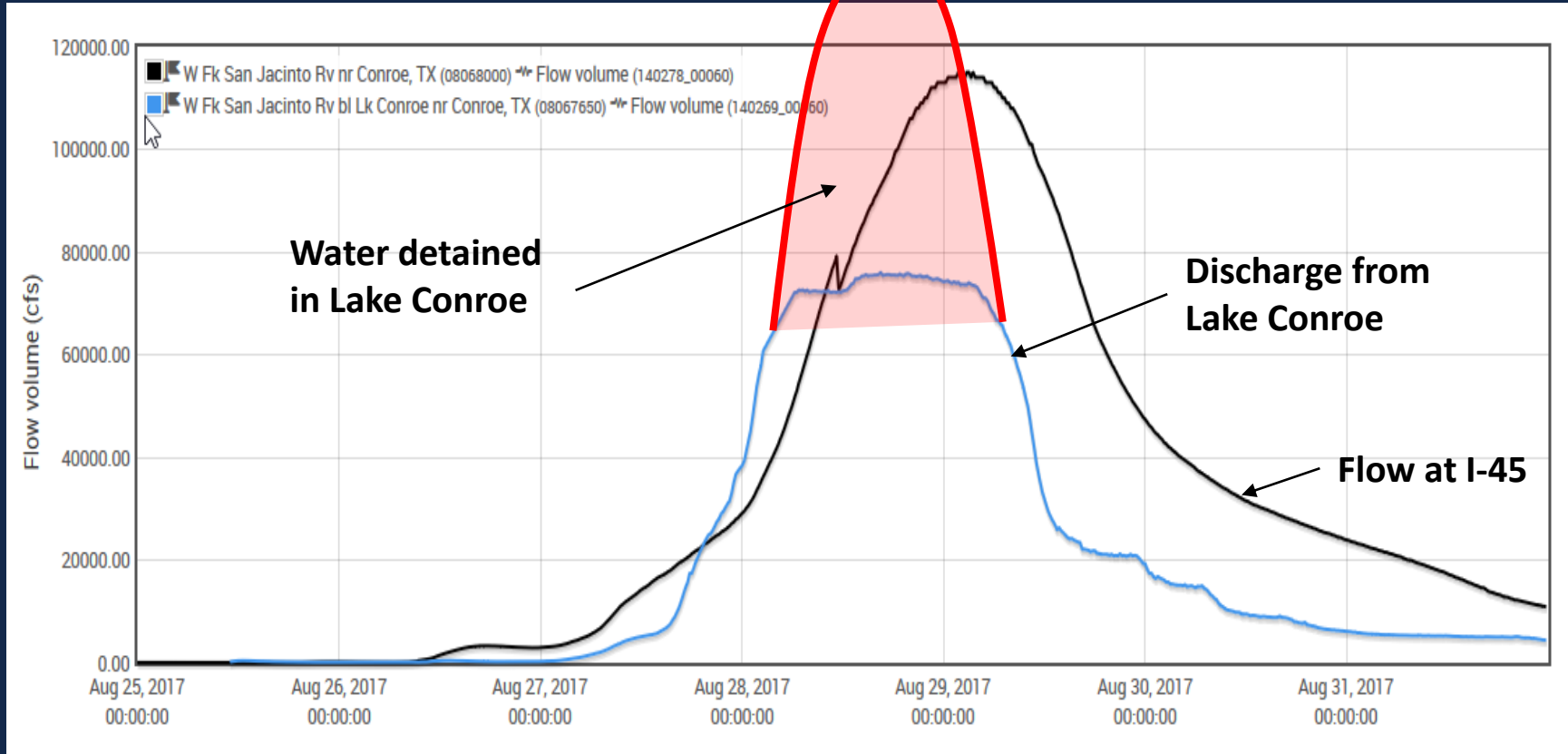

Top of
Tainter Gate
Top of
Water Surface
Downstream side
of Tainter Gate
18” Freeboard
Upstream side
of Tainter Gate

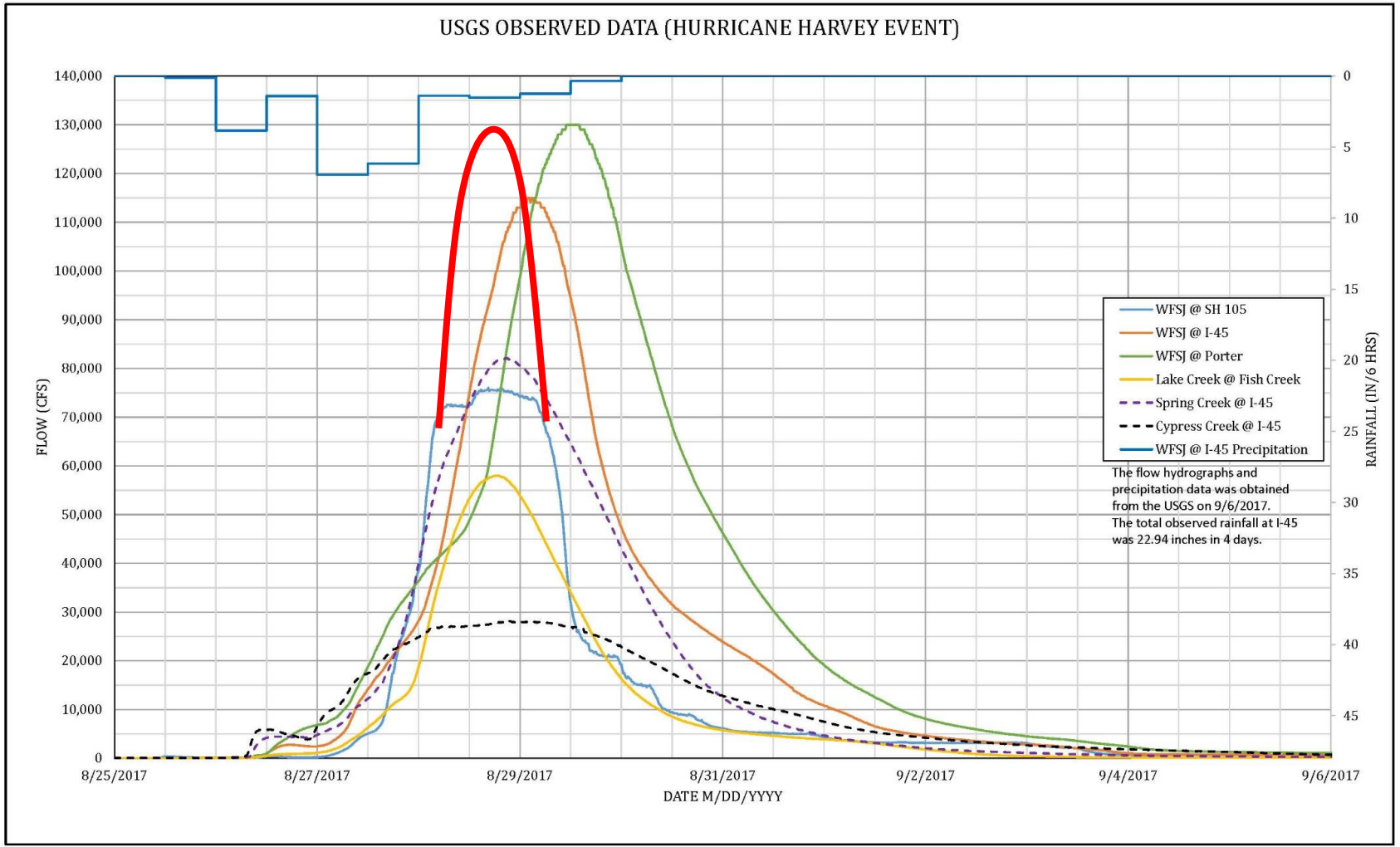
Water supply reservoirs REDUCE downstream flooding

- Even though there is no dedicated flood capacity, water supply reservoirs reduce peak flow via temporary storage
- Lake Conroe has a six-foot flowage easement for temporary flood storage
- Operating protocol balances inflow reduction and lake level rise

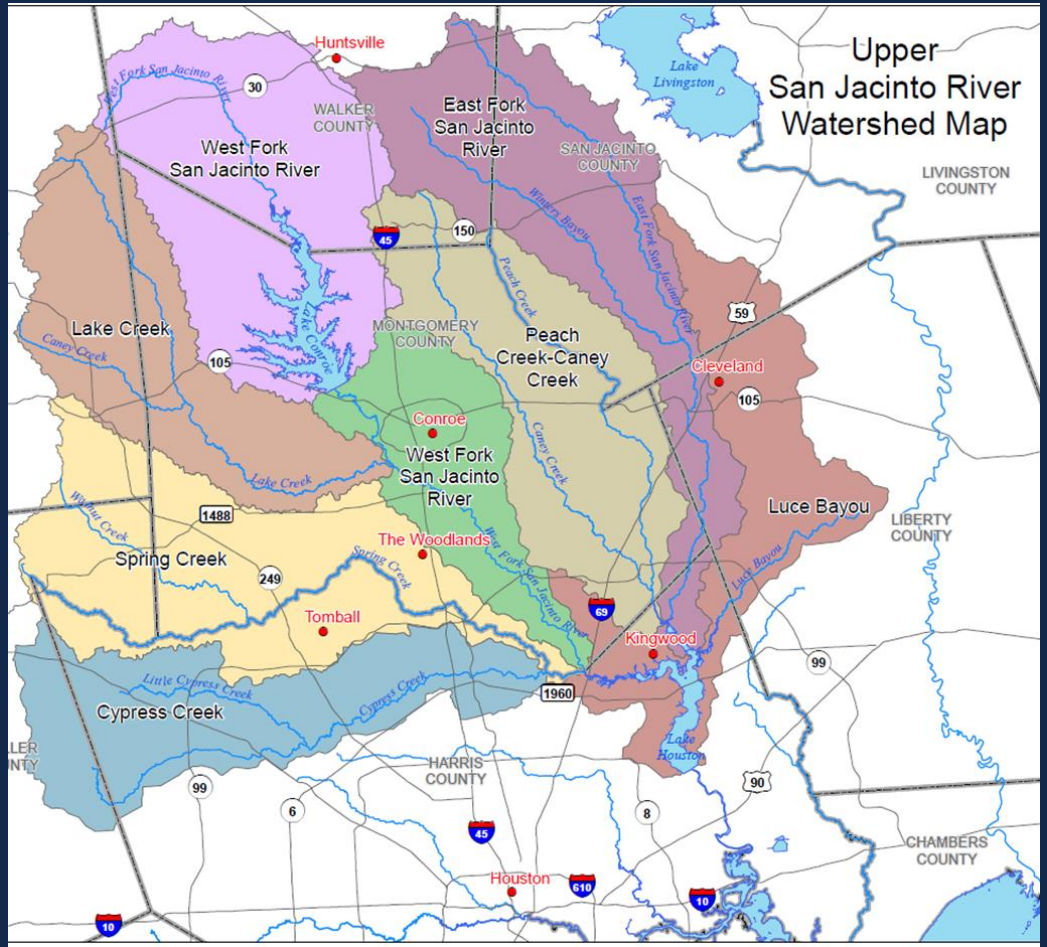
~130,000 cfs

Peak Flow Into Lake Conroe




USGS OBSERVED DATA (HURRICANE HARVEY EVENT)
FLOW (CFS)
RAINFALL (IN/6 HRS)
DATE M/DD/YYYY
8/25/2017
8/27/2017
8/29/2017
8/31/2017
9/2/2017
9/4/2017
9/6/2017
WFSJ @ SH 105
WFSJ @ I-45
WFSJ @ Porter
Lake Creek @ Fish Creek
Spring Creek @ I-45
Cypress Creek @ I-45
WFSJ @ I-45 Precipitation
The flow hydrographs and precipitation data was obtained from the USGS on 9/6/2017.
The total observed rainfall at I-45 was 22.94 inches in 4 days.

Lake Conroe makes up roughly 10 to 20 percent of the flows into Lake Houston

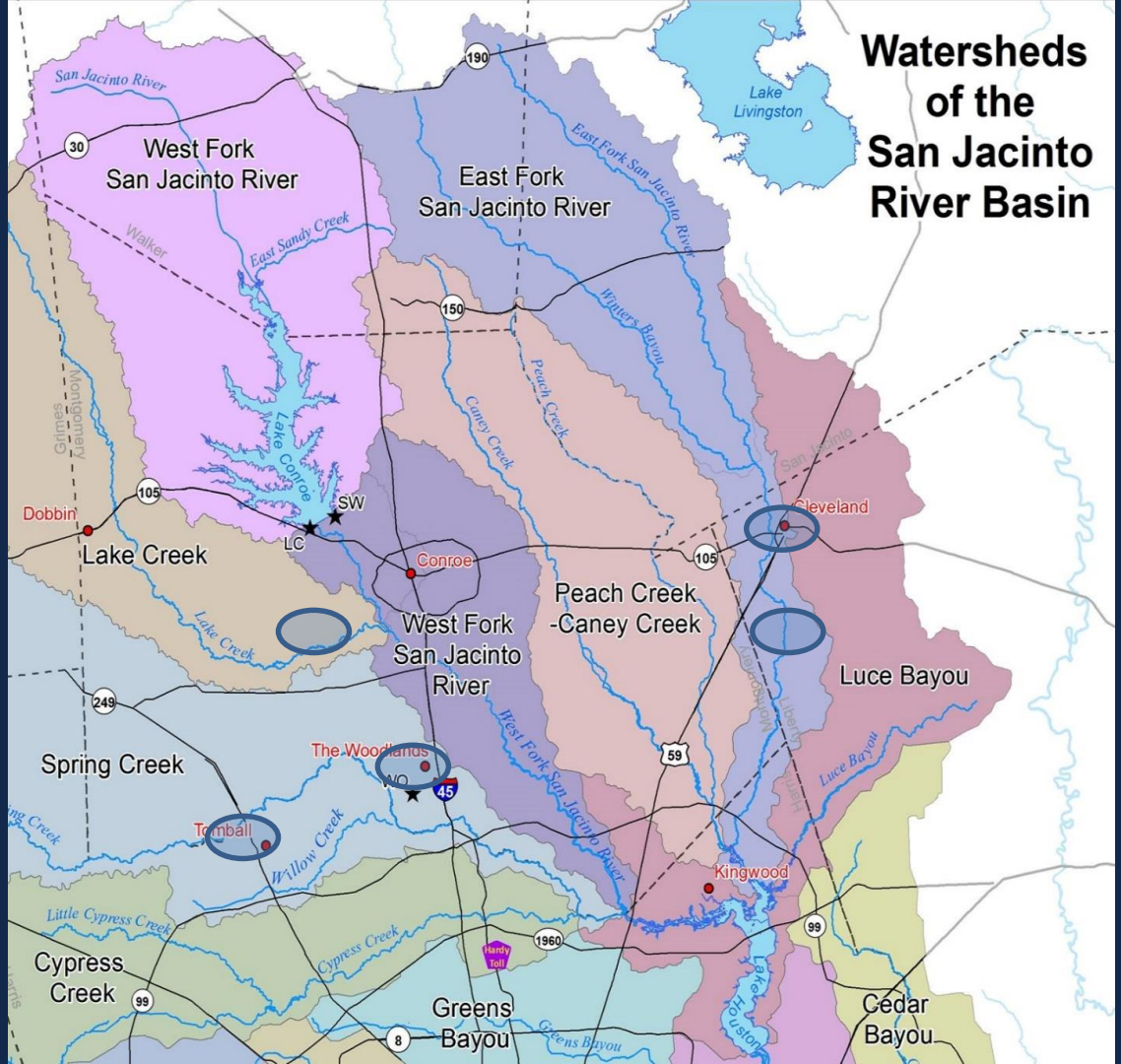


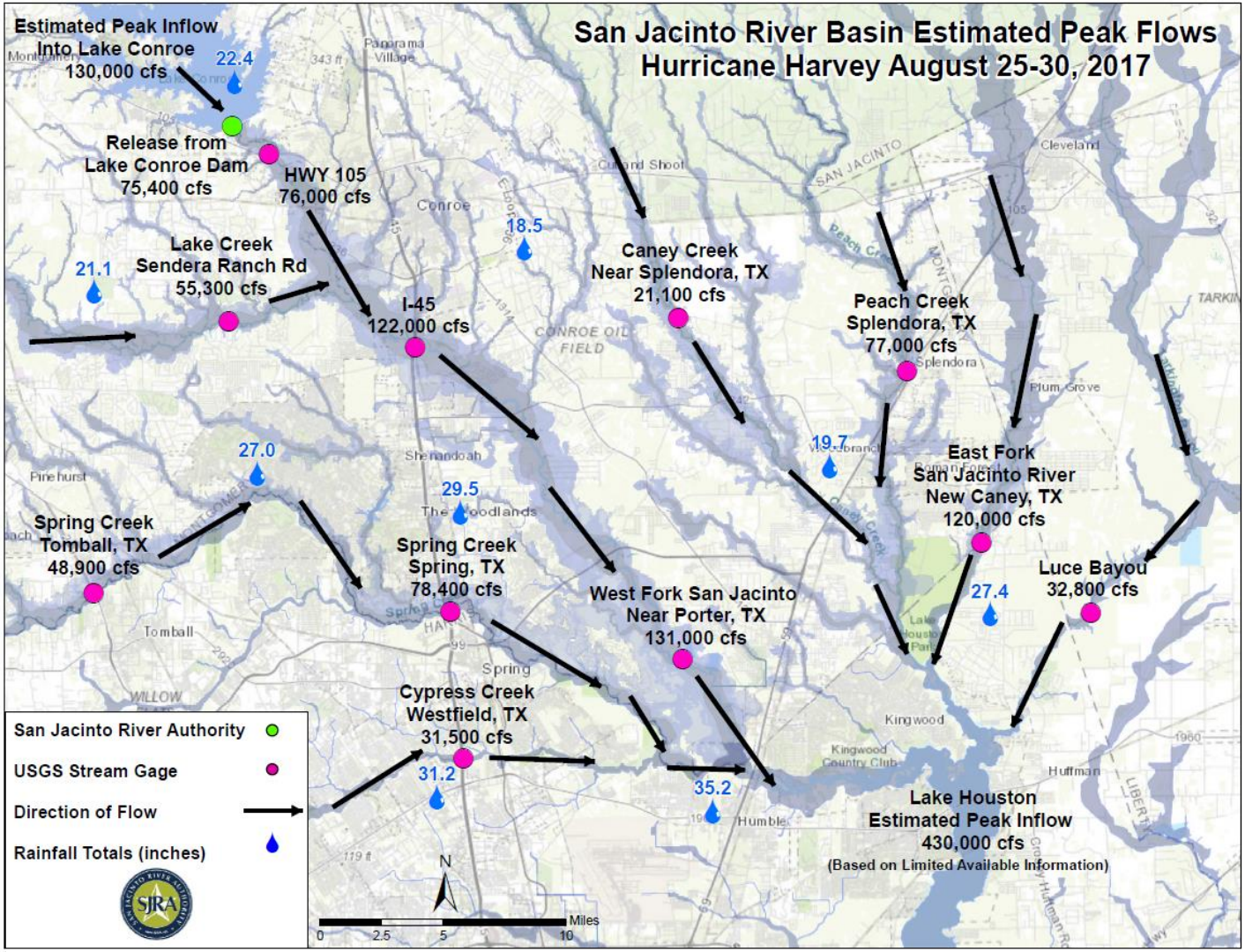
Impact from Lake Conroe watershed:

- Lake Houston = 10-20%
- The Woodlands
  W of I-45 = 0%
- Tomball = 0%
- Woodforest = 0%
- Cleveland = 0%
- Plum Grove = 0%

Jeff Lindner, HCFCD

https://www.youtube.com/watch?v=SowuK0T41Rc



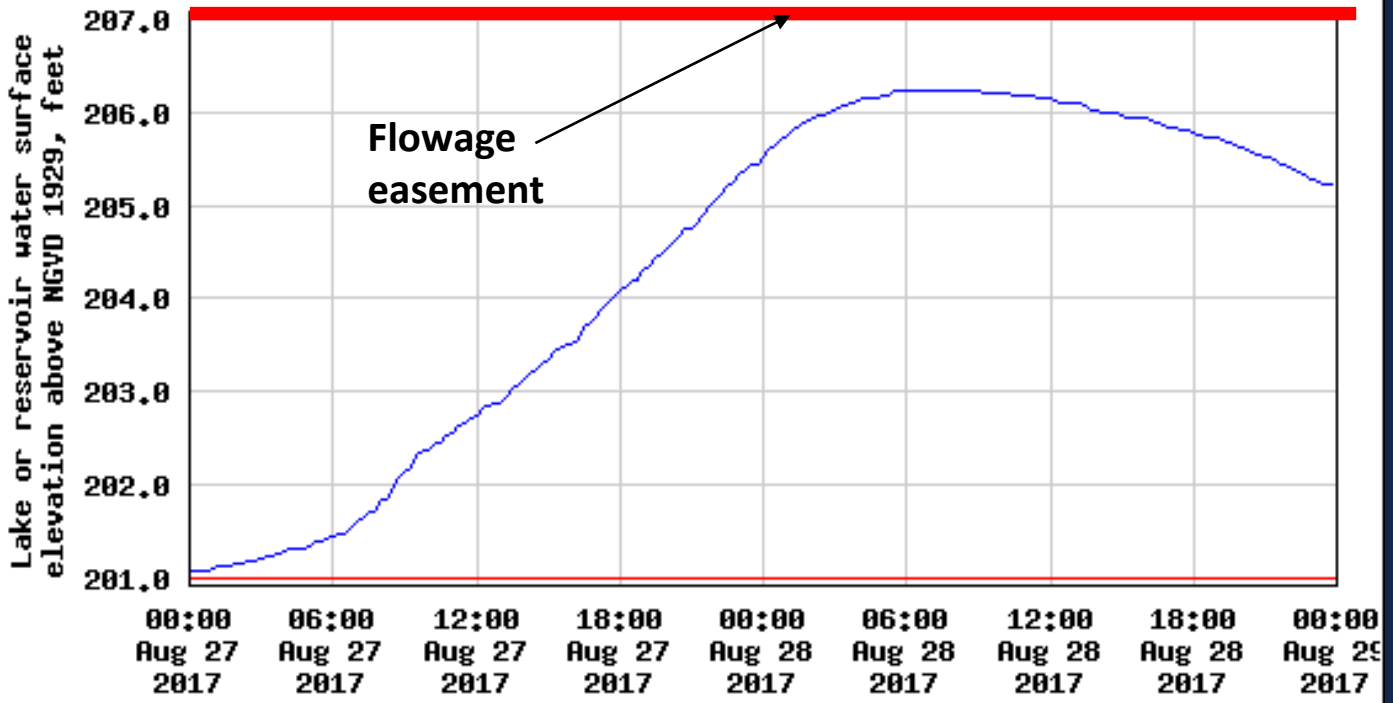

San Jacinto River Basin Estimated Peak Flows
Hurricane Harvey August 25-30, 2017
Estimated Peak Inflow
Into Lake Conroe
130,000 cfs
22.4
Release from
Lake Conroe Dam
75,400 cfs
HWY 105
76,000 cfs
Lake Creek
Sendera Ranch Rd
55,300 cfs
21.1
I-45
122,000 cfs
18.5
Caney Creek
Near Splendora, TX
21,100 cfs
Peach Creek
Splendora, TX
77,000 cfs
19.7
East Fork
San Jacinto River
New Caney, TX
120,000 cfs
Luce Bayou
32,800 cfs
27.4
27.0
Spring Creek
Tomball, TX
48,900 cfs
29.5
Spring Creek
Spring, TX
78,400 cfs
West Fork San Jacinto
Near Porter, TX
131,000 cfs
Cypress Creek
Westfield, TX
31,500 cfs
31.2
35.2
Lake Houston
Estimated Peak Inflow
430,000 cfs
(Based on Limited Available Information)
San Jacinto River Authority
USGS Stream Gage
Direction of Flow
Rainfall Totals (inches)
N
0
2.5
5
10
Miles
Conroe
Cleveland
Splendora
Plum Grove
Shenandoah
The Woodlands
Pinehurst
Tomball
Spring
Kingwood
Humble
Huffman
Panorama Village
CONROE OIL FIELD
WILLOW

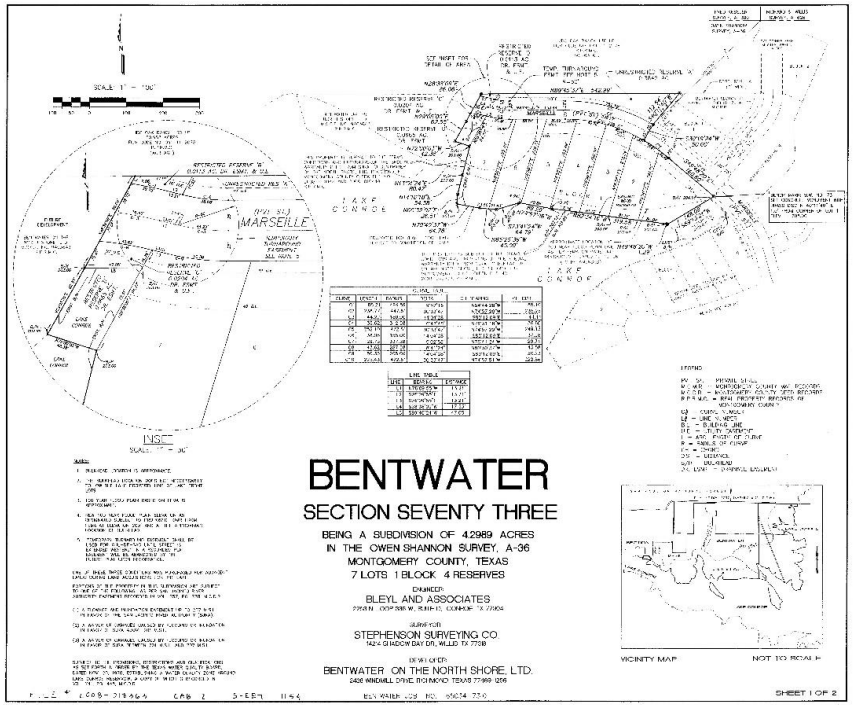
Lake Conroe used almost all of its authorized flowage easement

- Six-foot flowage easement acquired when lake was constructed
- Recorded in deed records
- Authorizes inundation up to 207’ msl
- During Harvey, peak elevation was 206.24’ msl

USGS

USGS 08067600 Lk Conroe nr Conroe, TX





BENTWATER

SECTION SEVENTY THREE

BEING A SUBDIVISION OF 4.2989 ACRES
IN THE OWEN SHANNON SURVEY, A-36
MONTGOMERY COUNTY, TEXAS
7 LOTS 1 BLOCK 4 RESERVES

ENGINEER:
BLEYL AND ASSOCIATES

SURVEYOR:
STEPHENSON SURVEYING CO.

DEVELOPER:
BENTWATER ON THE NORTH SHORE, LTD.

VICINITY MAP NOT TO SCALE

SHEET 1 OF 2

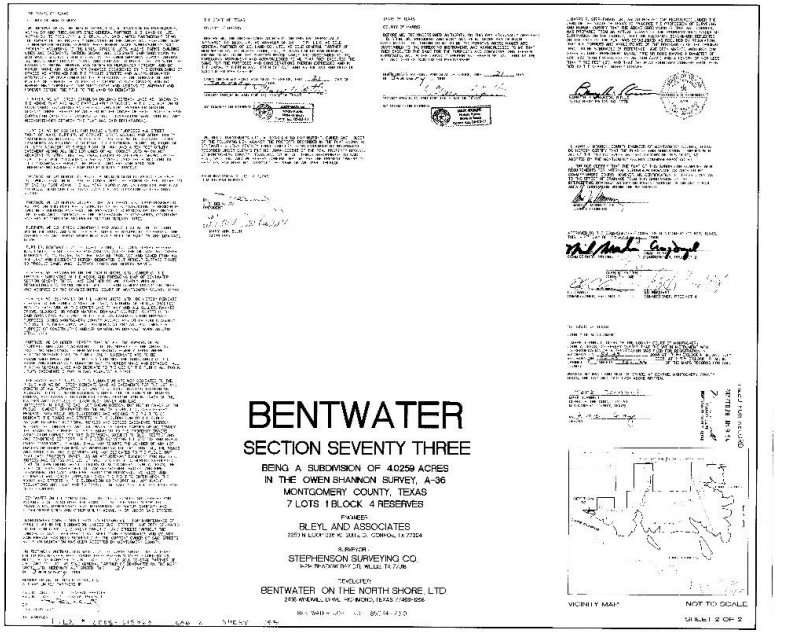
ONE OF THESE THREE CONDITIONS WAS PURCHASED FOR ADJACENT LANDS DURING LAND ACQUISITIONS FOR THE LAKE.

PORTIONS OF THE PROPERTY IN THIS SUBDIVISION ARE SUBJECT TO ONE OF THE FOLLOWING: AS PER SAN JACINTO RIVER AUTHORITY EASEMENT RECORDED IN VOL. 657, PG. 788, M.C.D.R.

(1) A FLOWAGE AND INUNDATION EASEMENT UP TO 207 M.S.L. IN FAVOR OF THE SAN JACINTO RIVER AUTHORITY (SJRA).

(2) A WAIVER OF DAMAGES CAUSED BY FLOODING OR INUNDATION IN FAVOR OF SJRA ABOVE 201 M.S.L.

(3) A WAIVER OF DAMAGES CAUSED BY FLOODING OR INUNDATION IN FAVOR OF SJRA BETWEEN 201 M.S.L. AND 207 M.S.L.



BENTWATER

SECTION SEVENTY THREE

BEING A SUBDIVISION OF 4.0259 ACRES
IN THE OWEN SHANNON SURVEY, A-36
MONTGOMERY COUNTY, TEXAS
7 LOTS 1 BLOCK 4 RESERVES

ENGINEER:
BLEYL AND ASSOCIATES

SURVEYOR:
STEPHENSON SURVEYING CO.

DEVELOPER:
BENTWATER ON THE NORTH SHORE, LTD.

VICINITY MAP NOT TO SCALE

SHEET 2 OF 2

Most water supply reservoirs in Texas do not pre-release prior to storm events

- Primary reason – high risk of making downstream flooding problems worse
- Downstream partners want empty rivers prior to a storm
- It would take weeks to safely lower Lake Conroe any significant amount
- Small increase in storage makes almost no difference in large storm event like Harvey
- Weather predictions not accurate enough

Time required to safely lower Lake Conroe

Release Rate (cfs)	Daily Volume Released (acre-feet)	Daily Reduction in Lake Level (inches)	Retained daily rainfall for entire watershed assuming 50% infiltration (inches)
625	1,250	0.75	0.1
1,250	2,500	1.5	0.2
2,500	5,000	3	0.4

Saturday, August 19, 2017 - 6 Days Prior to Landfall

Storm dissipated from forecasts six days from ultimate landfall.

August 22 (three days from landfall), NWS announced:

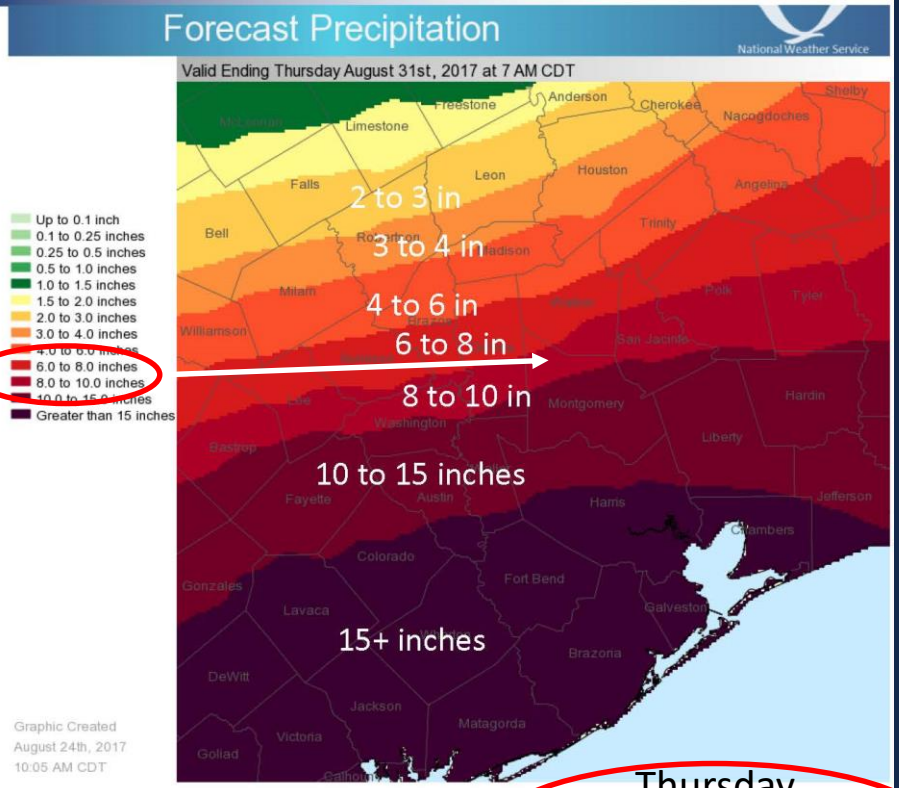
- “remnants of Harvey centered over Yucatan.”

- “likely to redevelop into a tropical storm or hurricane over the warm waters of the Bay of Campeche.”

Rainfall, Flood Threat

National Weather Service Houston/Galveston

- Timing of onset and end of heavier rains uncertain
- Most likely start Matagorda, Jackson Counties, closest to the hurricane, Friday/Friday night continuing
- Bands east of the center to set up into areas farther east Saturday and Sunday
- Could be sharp gradient north to south with coastal counties seeing most rain over the multiday period



Thursday

Image 8/24/2017
Created 10:57 AM

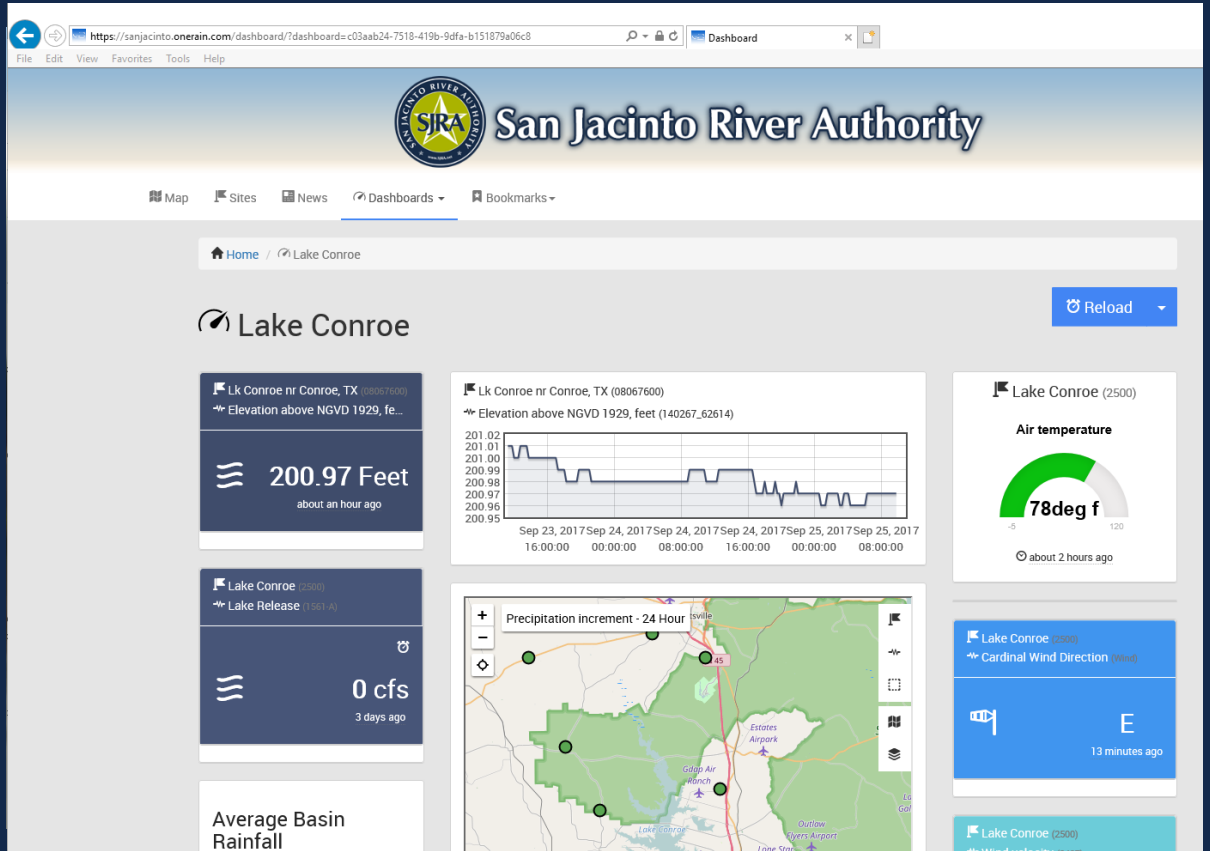
@NWSHouston
weather.gov/houston

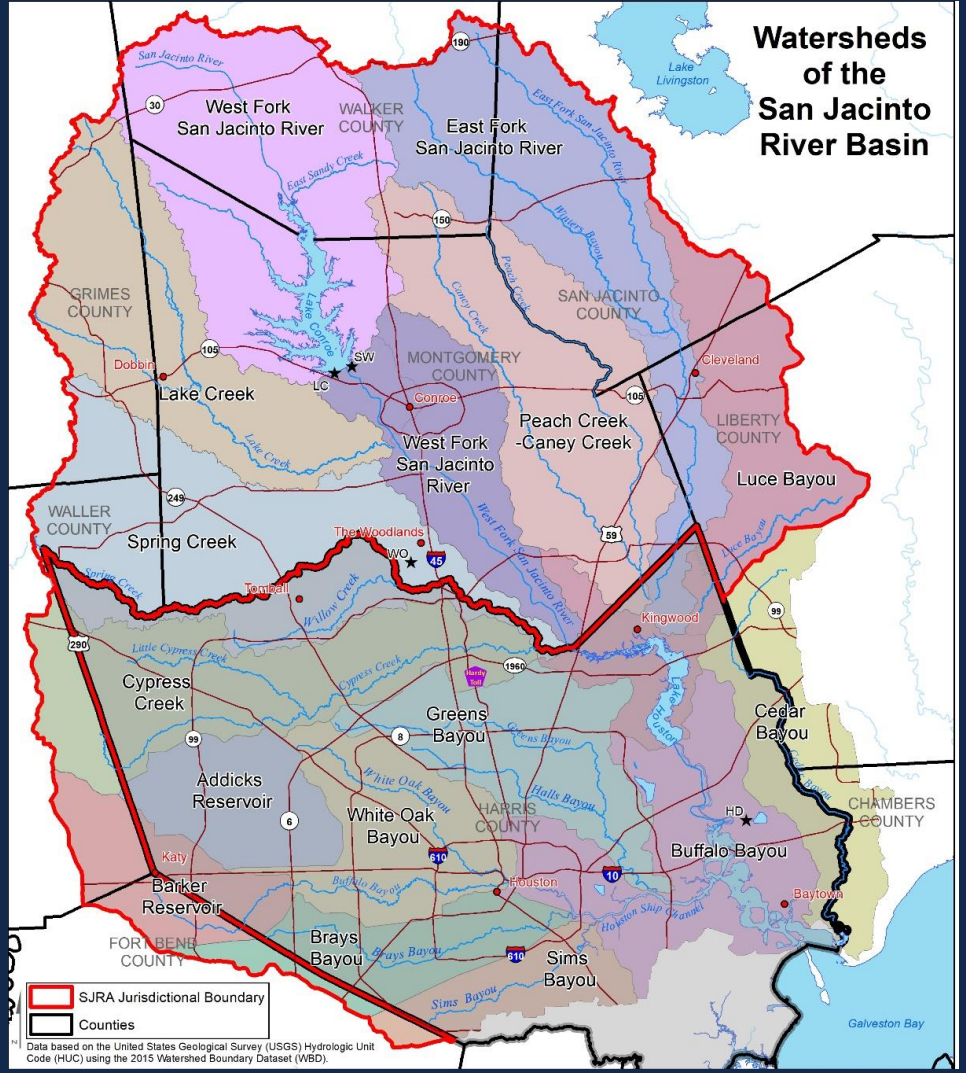
One day before landfall, heavier rainfall projected downstream of Lake Conroe

Reservoir operators follow pre-planned emergency communications protocols

- ROs partner with emergency response agencies who are the gatekeepers for emergency actions
- ROs have no authority to order or control evacuations or to serve as emergency response
- Role of ROs is to operate the dam and notify appropriate emergency officials
- ROs conduct periodic table top exercises with local emergency agencies

SJRA provides real-time data throughout storm events





Regional Flood Management Initiative

- Taking leadership role regarding flood management.
- Regional partner with HCFCD.
- Modelling, studies, communications, mitigation strategies, and project implementation.
- Limited by funding.

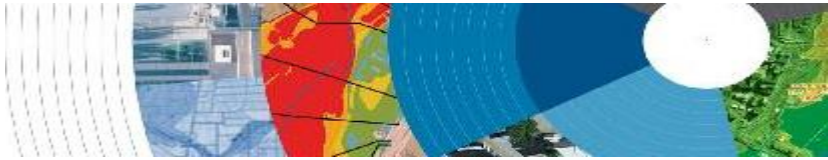
Flood Risk

FloodWarn Workshop

May 2, 2018

Diane Cooper
FEMA Floodplain Management and Insurance

Topics



- What is Flood Risk?
- Flood Hazard Mapping and FIRMS
- NFIP – National Flood Insurance Program.

FEMA

Flood Risk?

Any situation involving exposure to a Flood danger, harm or loss.

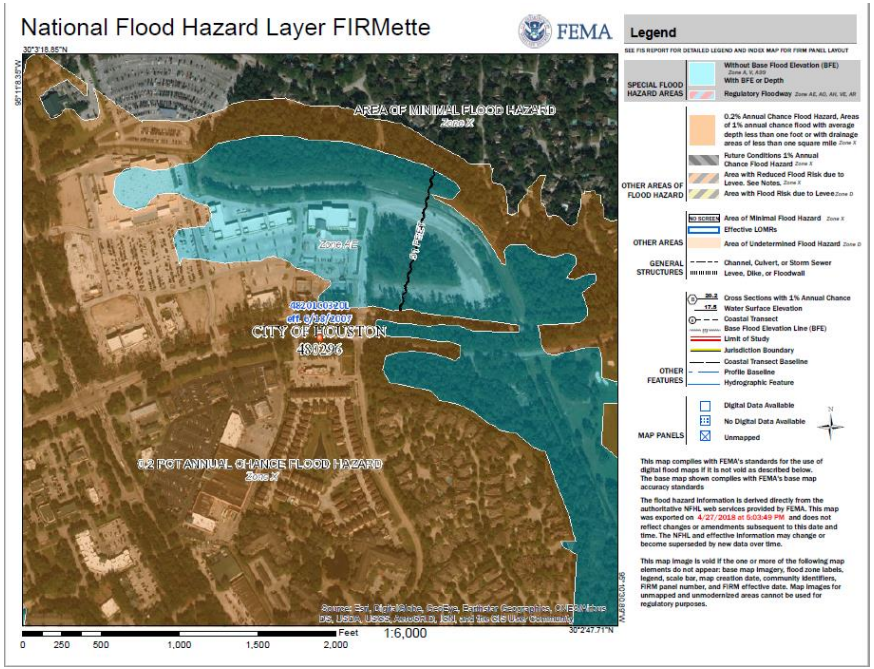
"While levees can help reduce flood risk…they do not eliminate the risk."

FEMA

What is a FIRM?

Flood Insurance **Rate** Map

- Identifies the Special Flood Hazard Area (SFHA) and Non-SFHA's
- Used for rating flood insurance policies
- Mandatory purchase requirement if property is in SHFA **AND** is a federally backed mortgage.

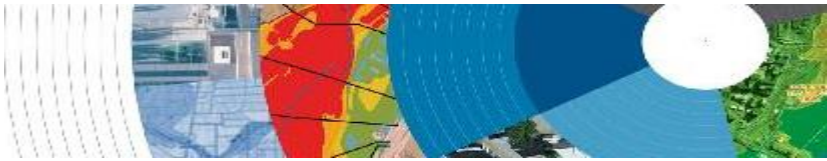


FIRM for Kingwood Town Center

FIRM's show Riverine flood risk.

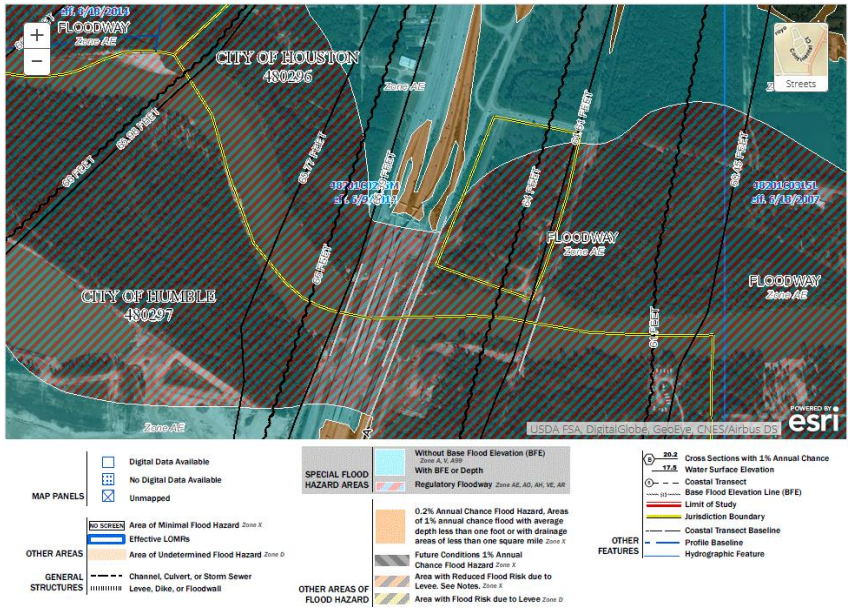
FEMA

What is a Flood Zone?



Zones on a FIRM:

- SFHA (high risk)
  - A, AE, AO, AH, VE, V etc. (Aqua)
    - 1% annual chance flood
    - 26% chance of flooding in a 30-yr mortgage
- Non-SFHA (low to moderate risk)
  - B, C and X (Shaded – orange or gray color & non-Shaded)
    - Even the non-shaded is a flood zone – a minimal risk..



FIRM for US 59 Bridge over W Fork of San Jacinto

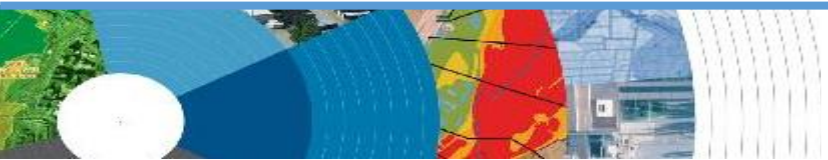
Find your zone at https://msc.fema.gov/portal

FEMA

Flood Hazard Mapping

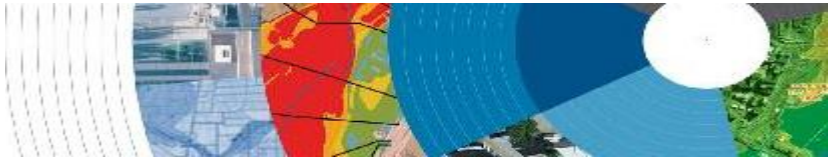
- The maps are **NOT** a prediction or forecast.
- Flood waters are not confined to the at the 1% risk line (aka 100yr flood) on the FIRM.

"Yes, this is a beautiful river. But it wasn't here when we purchased the land. Maybe we should've checked to see if it was in a flood zone before investing in it."



FEMA

Flood Hazard Mapping



- FIRMs are a single snapshot for one scenario.
- FIRMS are subdivided by panels to cover a jurisdictional boundary (each has a unique panel number.)
- Assumptions are made in the modeling
  - Precipitation input the 100 year/24 hr design storm *(actual events rain intensities vary - not consistent rate over a 24 hr period.)*
  - Assumptions about the vegetation in the flood plain – do differentiate dead vs growing vegetation (increased friction during growing season)
  - Snapshot of land use when the models were developed – a challenge in rapidly developing areas
- One event is never the same as another, FIRMS will not exactly match an individual event.

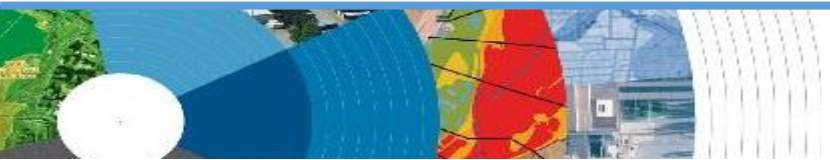
FEMA

Misconception: Only 100yr Floodplain is at Risk

- **Misconception:**

  "I don't live in a flood zone."

- **Facts:**
  - Floods are the #1 natural disaster in the United States.
  - If it can rain, it can flood.
  - FIRMS do not show localized flooding from drainage ditches/sewers/road ponding.
  - To some degree overland flooding but not property to property drainage problems.



FEMA

Misconception: Homeowners Insurance is Enough

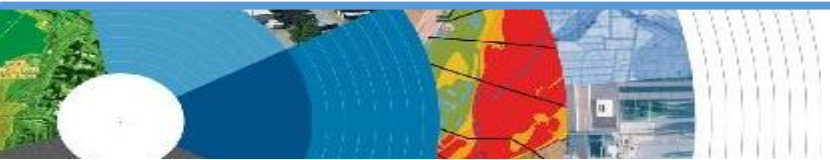
- **Misconception:**

  "I'm already covered—my homeowners policy covers flooding."

- **Fact:**

  Most insurance policies do not cover flooding; only flood insurance covers flood damage.

  Renters and Business owners should also consider flood insurance for contents.



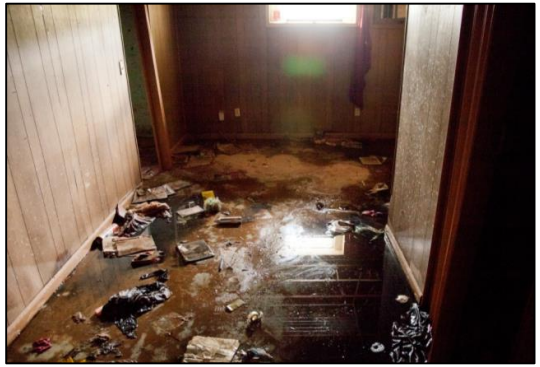
FEMA

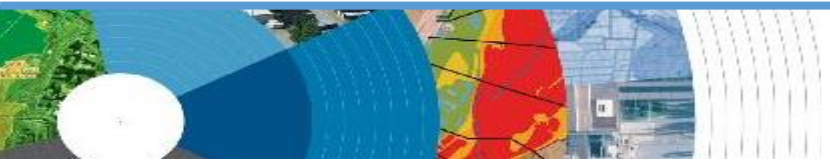
Flood Insurance

A tool for individuals to manage risk.

NATIONAL FLOOD INSURANCE PROGRAM

- Everyone is at risk for flooding.
  - *For most events 26% of NFIP claims are outside the SHFA.*
- A few inches can cause tens of thousands in damage.
- If you mortgage company “forced” you to buy flood insurance, check that structure and CONTENTS are covered. Most cover structure only.





FEMA

Structure Elevation Impact Insurance Rates

High Risk = $$$

Medium Risk = $$

Lower Risk = $

The elevation is just one factor, others include: when was the structure, has it flooded in the past, etc.

EVERY Structure has a risk…

generally the higher the structure the less the risk.

EMA

Harvey Numbers

Insurance claims in Houston

- 26,511 insurance claims
- 55.2% of claims were **OUTSIDE** of the 100 yr.

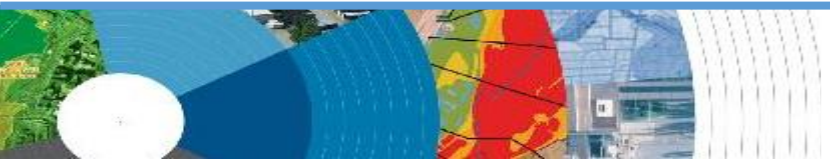
*estimated 17% of Houstonians had flood insurance

Numbers from City of Houston

- 30,500 structures in 1% risk area
- 29K in the 0.2% risk area
- Total of ~ 150K structures impacted city wide

~ 90K structures OUTSIDE of the 0.2% Risk Area Impacted

Kingwood Torchy's



FEMA

Group Flood Insurance Policy (GFIP)

IF in the 1% risk area (100yr floodplain)

AND received FEMA Individual Assistance(IA),

A GFIP policy was purchased

(if they did not have flood insurance.)

GFIP is a 3 yr. abridged Flood Insurance Policy. The policy is paid for from the IA funds.

You can purchase the standard NFIP policy to increase your coverage. *(GFIP cancels)*

Group Flood Insurance Policy (GFIP)

FEMA Group Flood Insurance Policy
Making Survivors More Resilient

Requirement *- property owner MUST purchase and maintain a traditional NFIP policy when GFIP expires.*

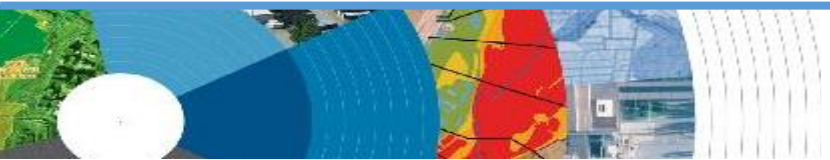
If not…they are not eligible for IA that would cover the replacement of real or personal property for the damaged location with a future event.

The insurance requirement is forever – including new homeowners.

FEMA

Summary

- Living in Texas means we have a flood risk even with heavy rain.
  - Tax Day 2016 and Memorial Day 2015 – not with a tropical system
- Flood Risk is from multiple sources.
  - FIRMs focus on river flooding and some overland flow.
- Flood insurance allows individual property owners to manage their risk.
  - **Buy policies that cover the structure AND contents**.



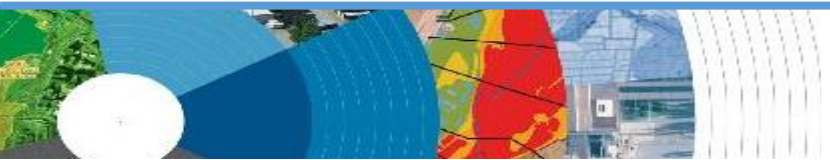
FEMA

Houston Ordinance Questions

Houston Floodplain Management Office

832-394-8854

FMO@Houstontx.gov



FEMA

Flood Safety

What to do during and after a flooding event

If a Flash Flood Warning is in effect

- Turn around, don’t drown when encountering flooded roads. Most flood deaths occur in vehicles.
- Be especially cautious at night when it is harder to recognize the dangers of flooding.
- Stay away or be swept away. River banks and culverts can become unstable and unsafe.
- You should monitor the latest forecasts and be prepared to take action should additional Flash Flood Warnings be issued.

If a Flash Flood Warning is in effect

- Avoid areas that are already flooded, especially if the water is flowing fast.
- **NEVER** stand around in flood waters as chemicals, fire ants, and animals could all be found in flood waters.
- **NEVER** drive across flooded roadways or into flooded underpasses
  - If your vehicle is caught in rising water, leave it immediately and seek higher ground
- Have multiple ways to receive weather information (cell phone, NOAA weather radio, television, etc.)

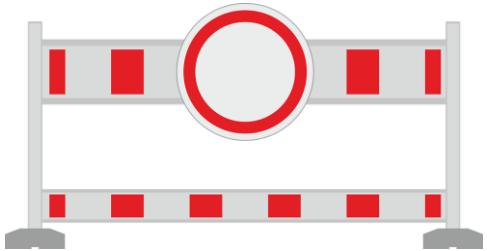
Turn Around, Don't Drown!

- It only takes six inches of water for a vehicle to lose contact with the road surface.
- Most vehicles can be swept away in just 18 to 24 inches of water!
- Flooded roads may have hidden dangers, such as washed out road beds or underwater obstructions.

Minnesota road damaged by flood waters, courtesy of FEMA.

Safety During The Flood – Do NOT Sightsee!

- Do not sightsee!
  - Evacuations are ongoing and first responders are working hard to get people to safety. Do not get in their way!
  - Flood waters from creeks, bayous and rivers will be swiftly moving. *Do not go near the flood waters!* They will sweep you away if you go in the water.
  - Roads may still be closed as they could be damaged or still under water. Barricades are for your protection; do not drive around them!



Don’t put yourself in danger

- Return home only when authorities indicate it is safe
- Stay away from damaged areas unless your assistance has been specifically requested by police, fire, or a relief organization
- Use extreme caution when entering buildings; there may be hidden damage, particularly in foundations

Stay out of the flood waters!

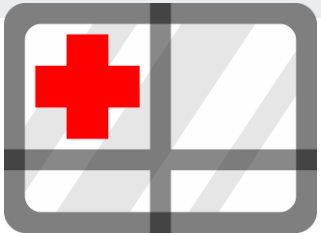
- Floodwaters can contain chemicals, sewage, disease, and animals
- Unseen underwater debris can be sharp and cause injury
- Downed power lines under the water could lead to death or injury from electrocution
- Water depth can change unexpectedly (storm drains, washed-out roads)

weather.gov/flood

Safety at home after a flood

- Don’t leave lit candles unattended
- Cut power to flooded areas of your home
- Only use generators in well-ventilated areas—never in a closed garage!
- Take breaks and drink plenty of fluids
- Do not use power tools while standing in water
- If you smell or hear gas, call the Fire Department

Flood Preparedness



Good preparation before a flood strikes, and knowing what to do when a flood occurs, will increase your family's safety...and possibly its survival. Some flood safety preparation tips include:

- Prepare a family disaster plan.
- Check if your insurance covers flood damages. If not, get flood insurance.
- Keep insurance and other important documents, such as copies of driver's licenses and credit cards, and other valuable items, in a safe deposit box.
- Assemble a disaster supplies kit. Be sure to include prescription medications, food, and water.
- Find out where you can go if ordered to evacuate.
- Arrange to keep in contact with relatives and friends.

Reporting/Wrap Up

What to Report

Flash Flooding

- Underpasses filling with water
- Impassible roadways
- Any fast-moving water greater than 6 inches in depth

Any River or Bayou Flooding

Flooding, Washington County (2016)

Formatting Reports

Reports should include the following information:

WHO is calling

WHERE the flooding is located

WHAT type of flooding is occurring (flash, river, or bayou)

WHEN the flooding occurred (is it ongoing?)

HOW deep is the water (if you can *safely* evaluate this)

The Good

"I'm a storm spotter located in Sealy at the intersection of Meyer and FM 2187. Water is flowing over curbs; it's at least 6-8 inches deep in some locations on the road."

The Bad

"Hey, we got some flooding here a few minutes ago!"

The Ugly

"My sister-in-law said the bayou got really closer to her house, did you have a warning out for that?"

How to Report

Call us!

Spotter line: 1-800-846-1828

Report via amateur radio

Call sign WX5HGX

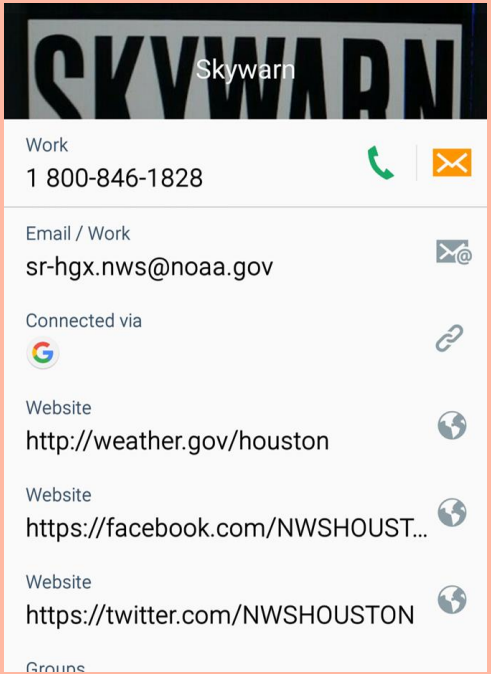
Email

sr-hgx.nws@noaa.gov

Social Media

Twitter: @NWSHouston

Facebook: NWSHouston



Spotter Tip

Set up SKYWARN as a contact in your smartphone

Questions

National Weather Service
Harris County Flood Control District
San Jacinto River Authority
FEMA