



# Resilience in a Post Harvey Houston

June 21, 2018  
June Luncheon Meeting | TAEP

Lisa Gonzalez  
President

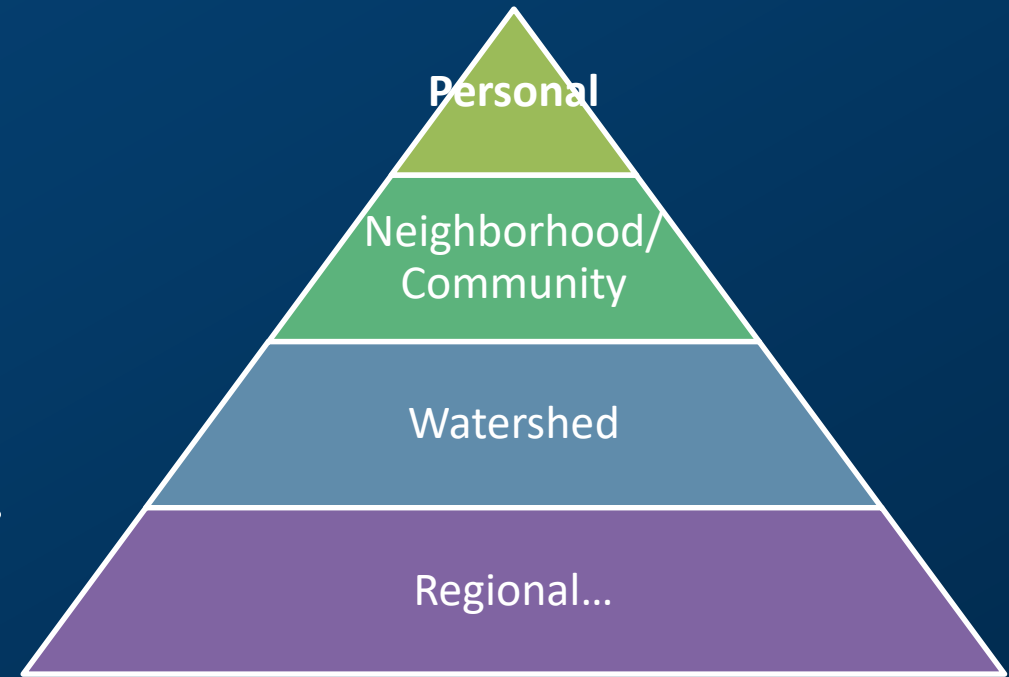


**Resilient communities are able to...**

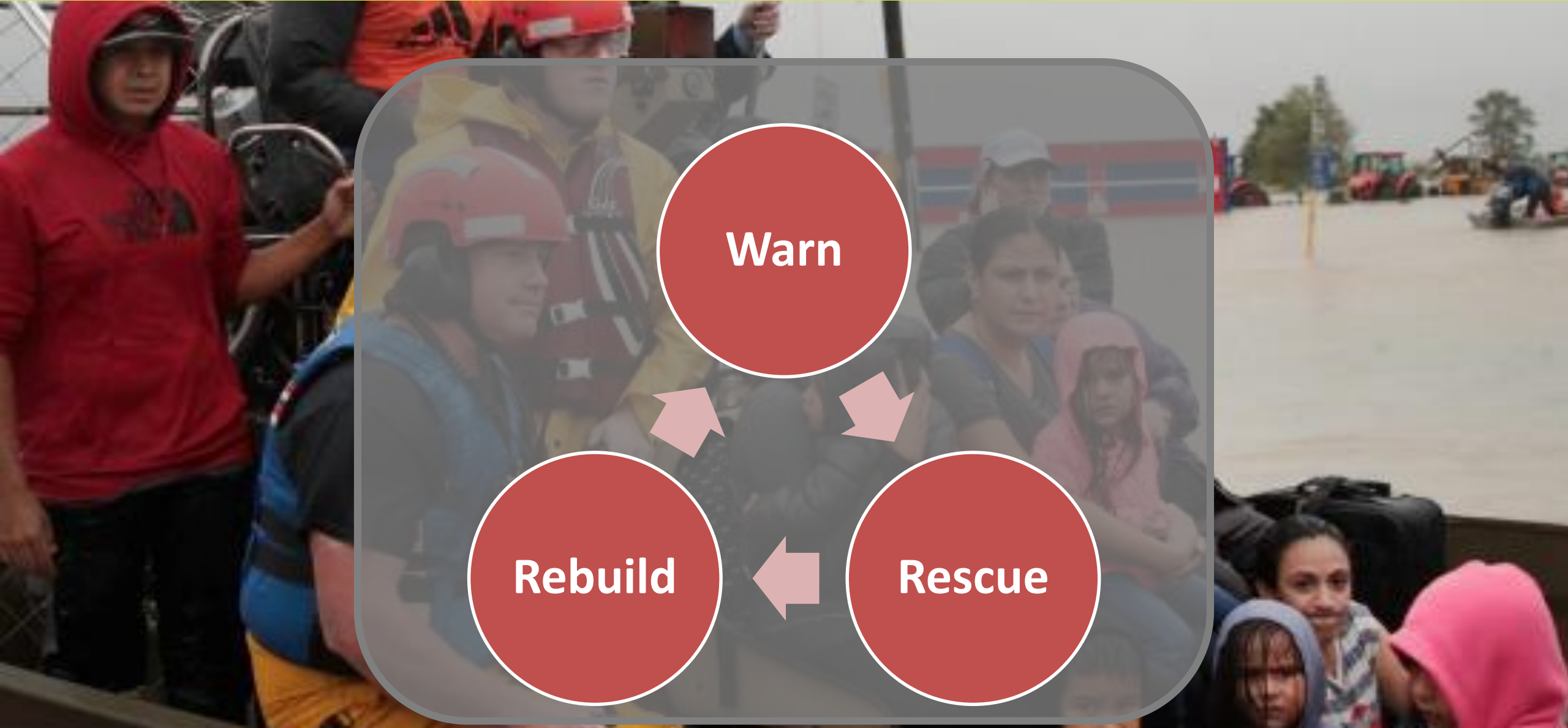
**Prepare for,  
Adapt to, and  
Withstand adverse events.**

**In ways that allow systems to...**

**Maintain essential functions and  
Bounce back relatively quickly.**



# Traditional Response & Recovery



Warn

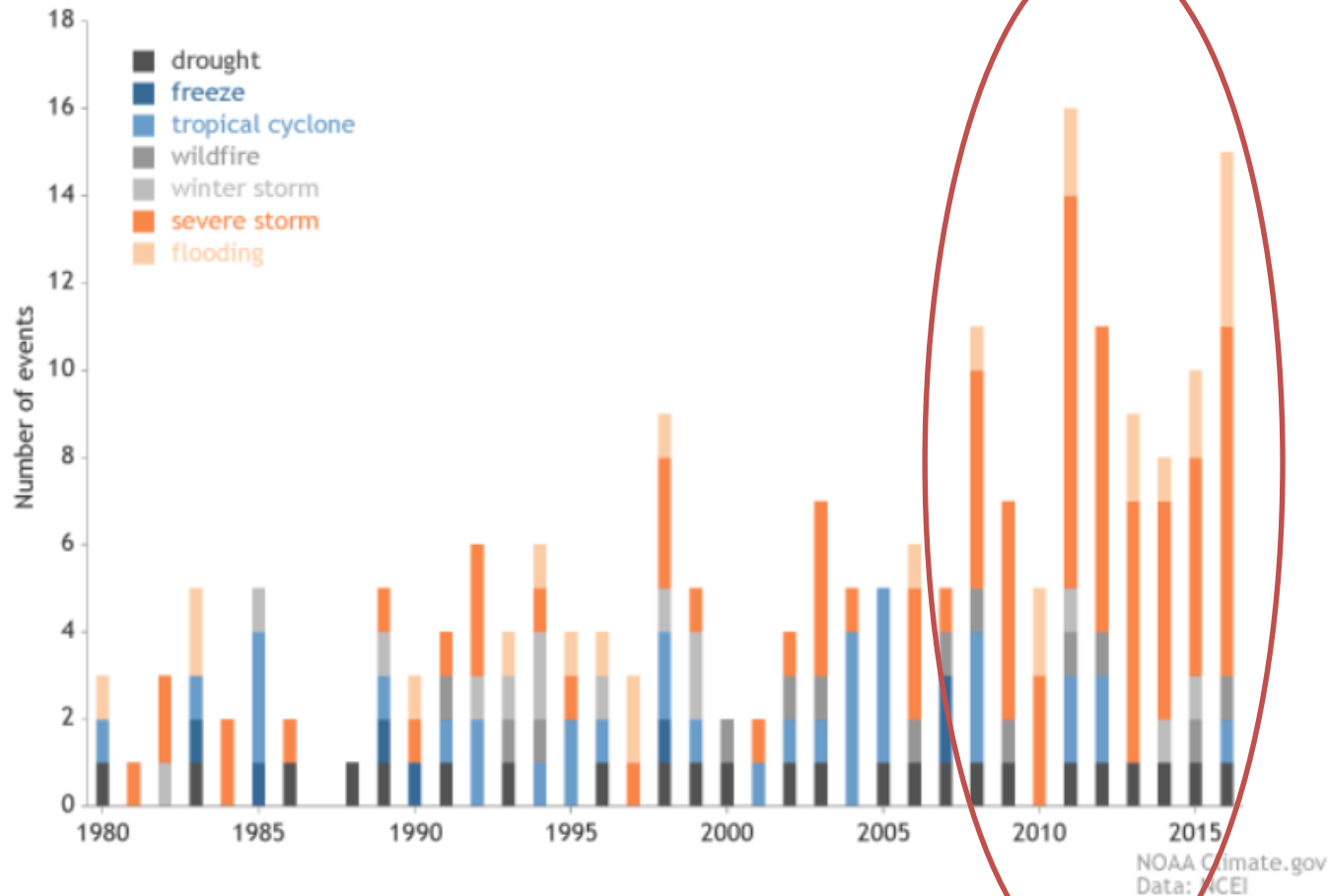
Rebuild

Rescue



# Future Likelihood of Extreme Events

Billion-dollar disasters by type, from 1980-2016



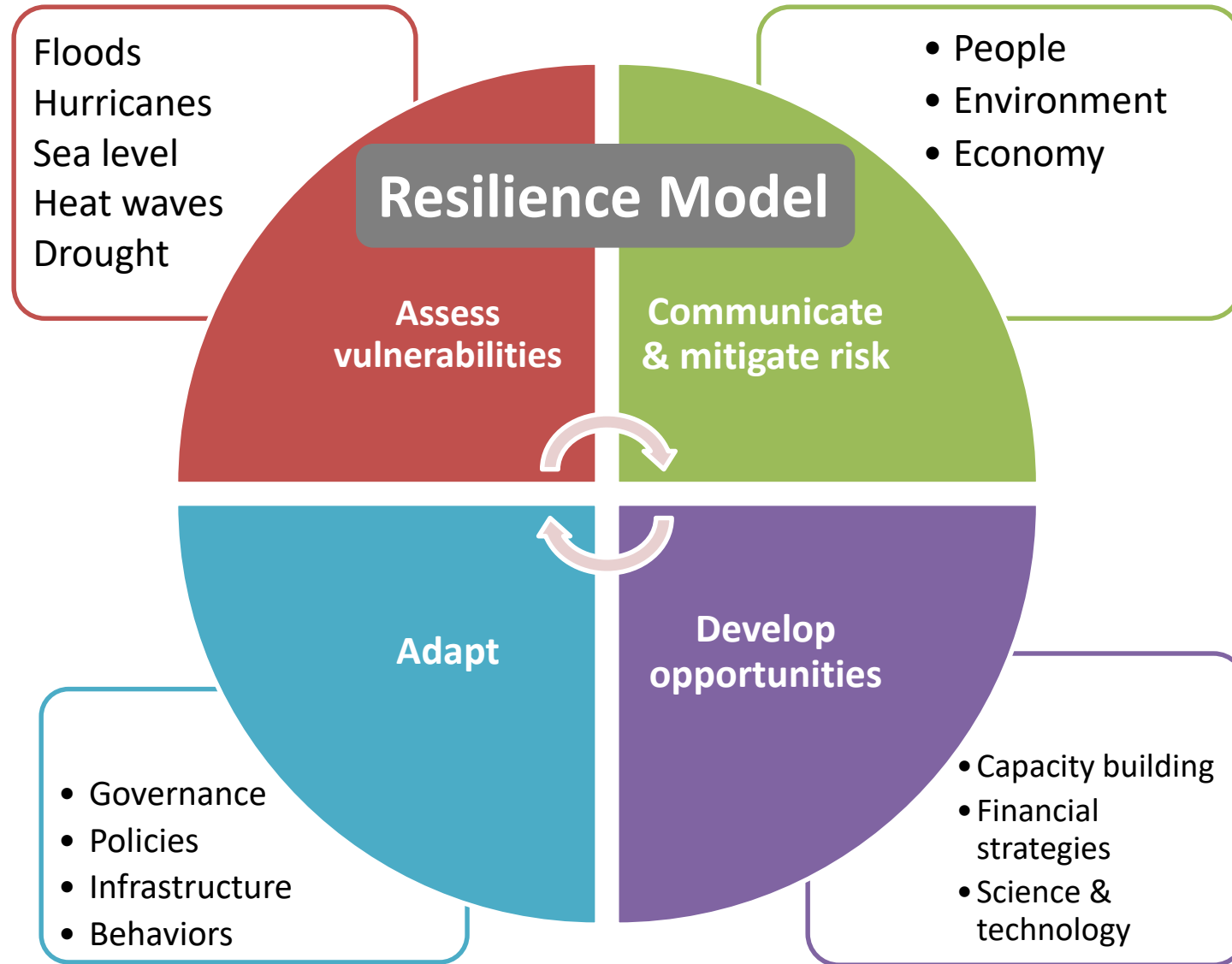
- Intensity of rainfall extremes increasing by ~15%
- Probability increasing by a factor of 3

*Van Oldenborgh et al. 2017. Attribution of extreme rainfall from Hurricane Harvey, August 2017. Env. Research Letters.*

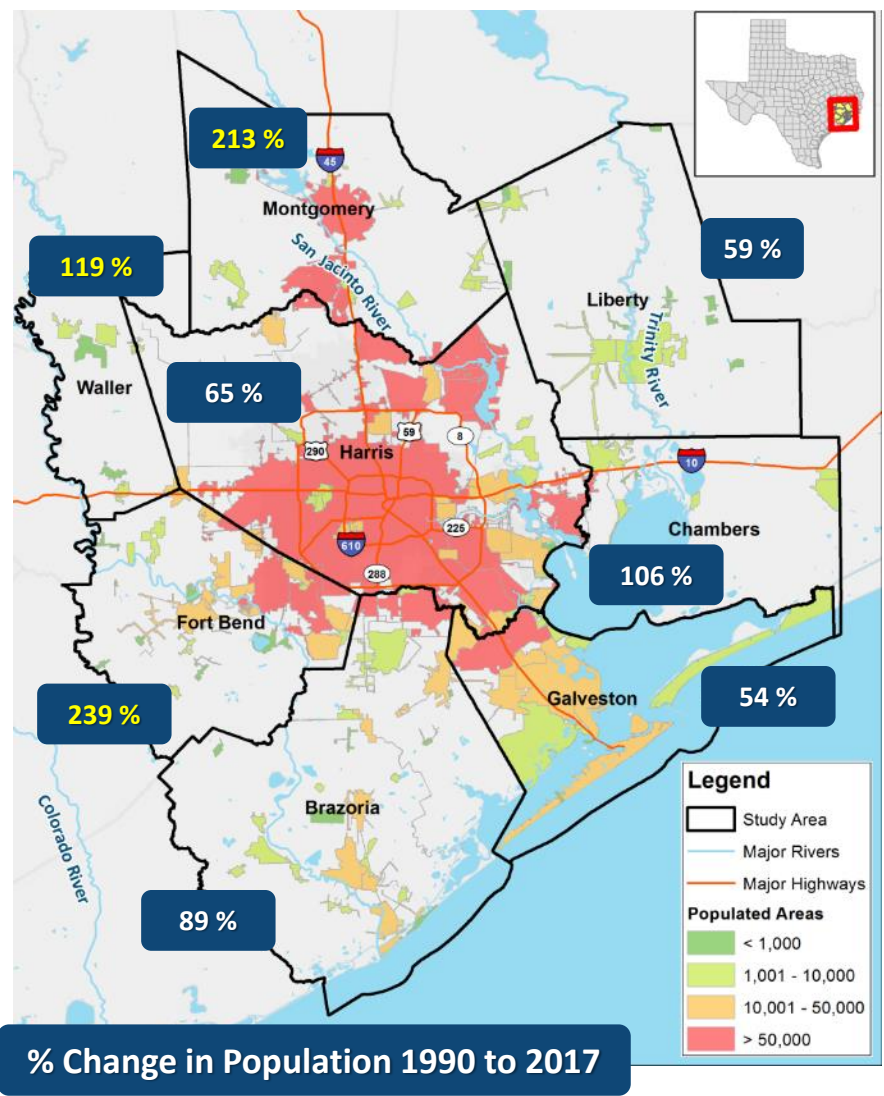
- Increasing annual likelihood of Texas rainfall events > 20 inches:
  - Yr 2000 ~ every 100 years
  - Yr 2017 ~ every 16 years
  - Yr 2100 ~ every 5.5 years

*K. Emanuel. 2017. Assessing the present and future probability of Hurricane Harvey's rainfall. Proc Nat. Acad. Sci.*

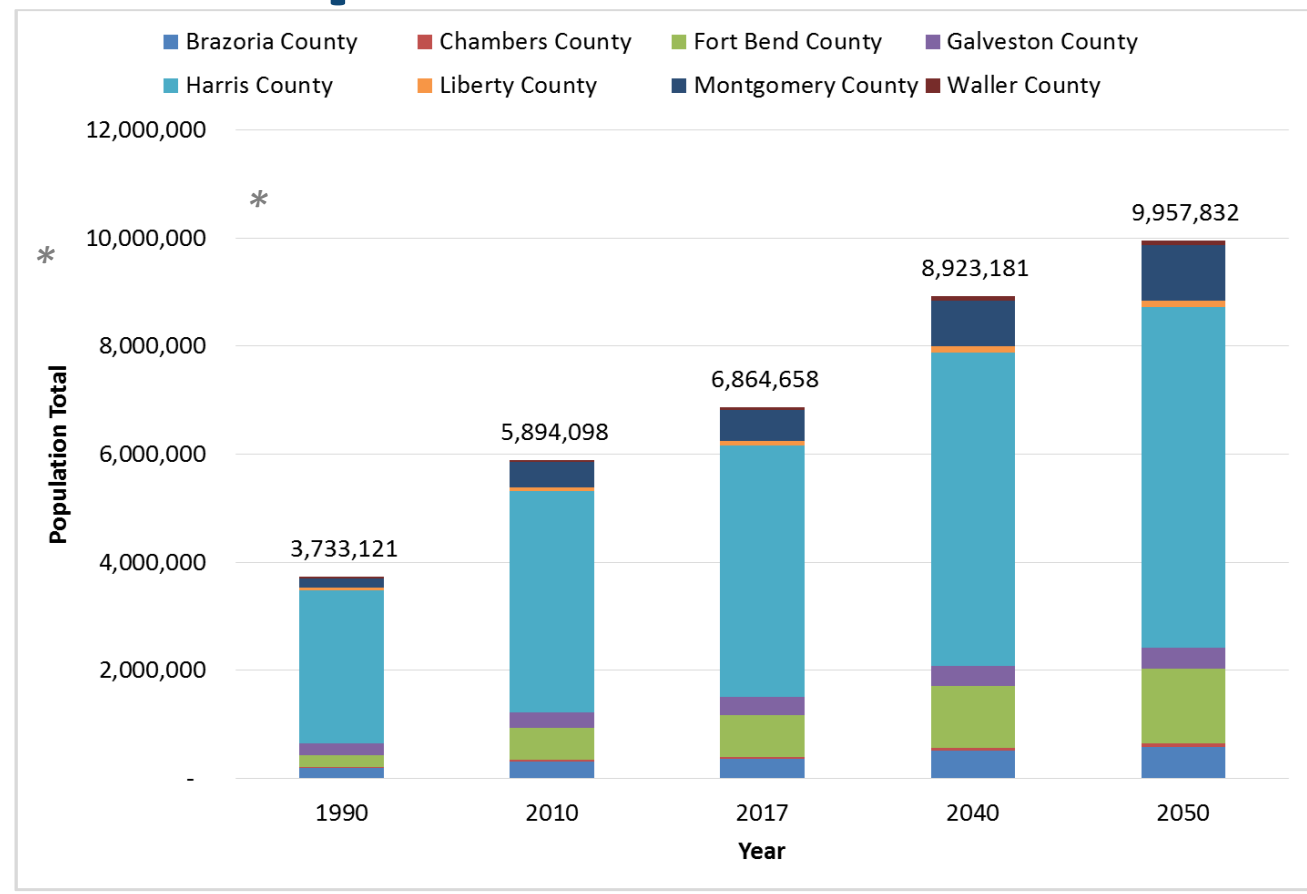
# Resilience: Going Beyond Recovery



# Growing Urban Coastal Region



## Population Growth



Data Source: U.S. Census, \*Texas Demographic Center Population Projection



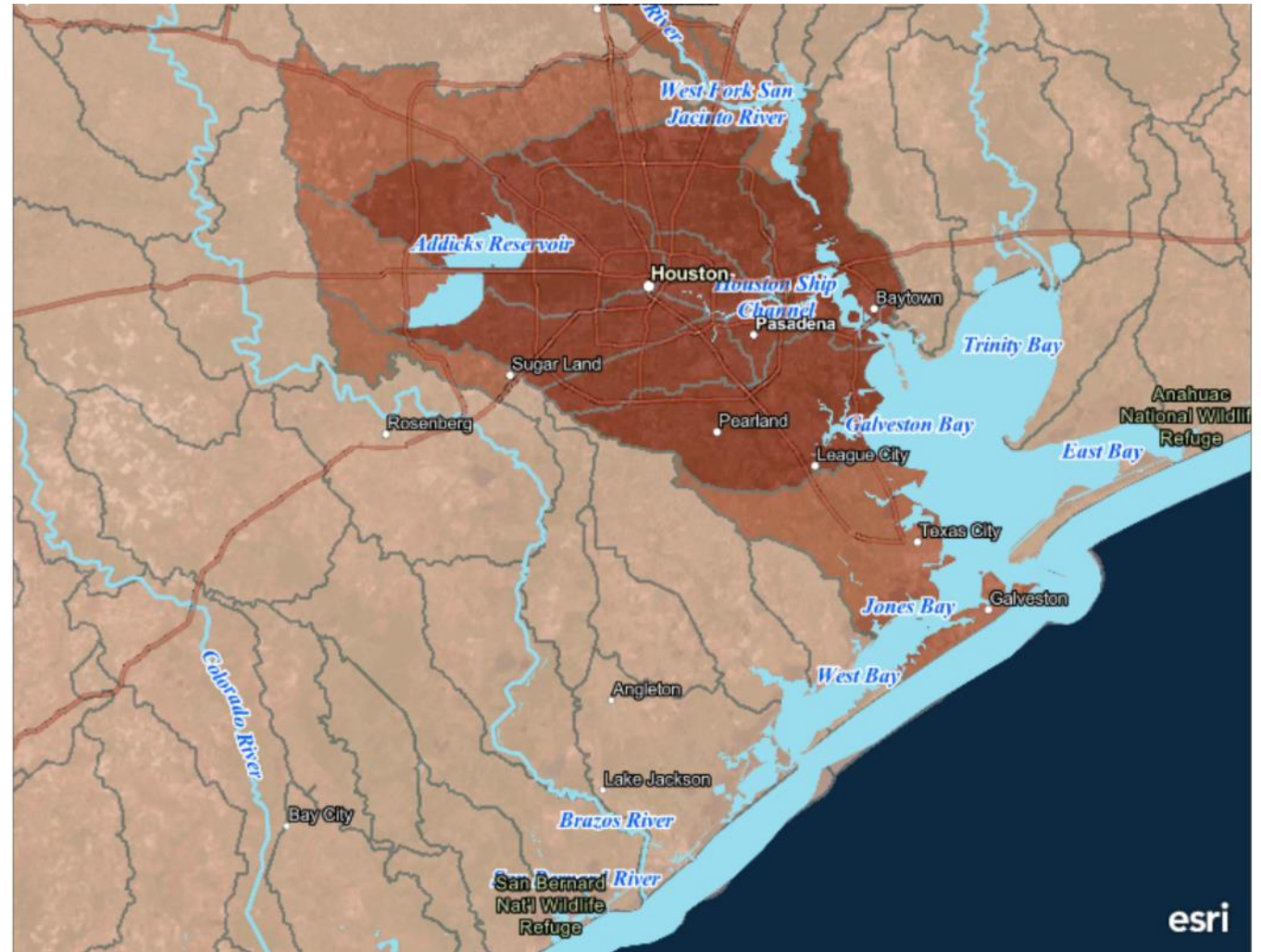
# Regional Imperviousness

- Sensitive streams impacted by 5-10 % impervious surface area
- Greater impairments when rates exceed 20-25 percent

**USGS Watersheds HUC10  
Imperviousness (2011)**

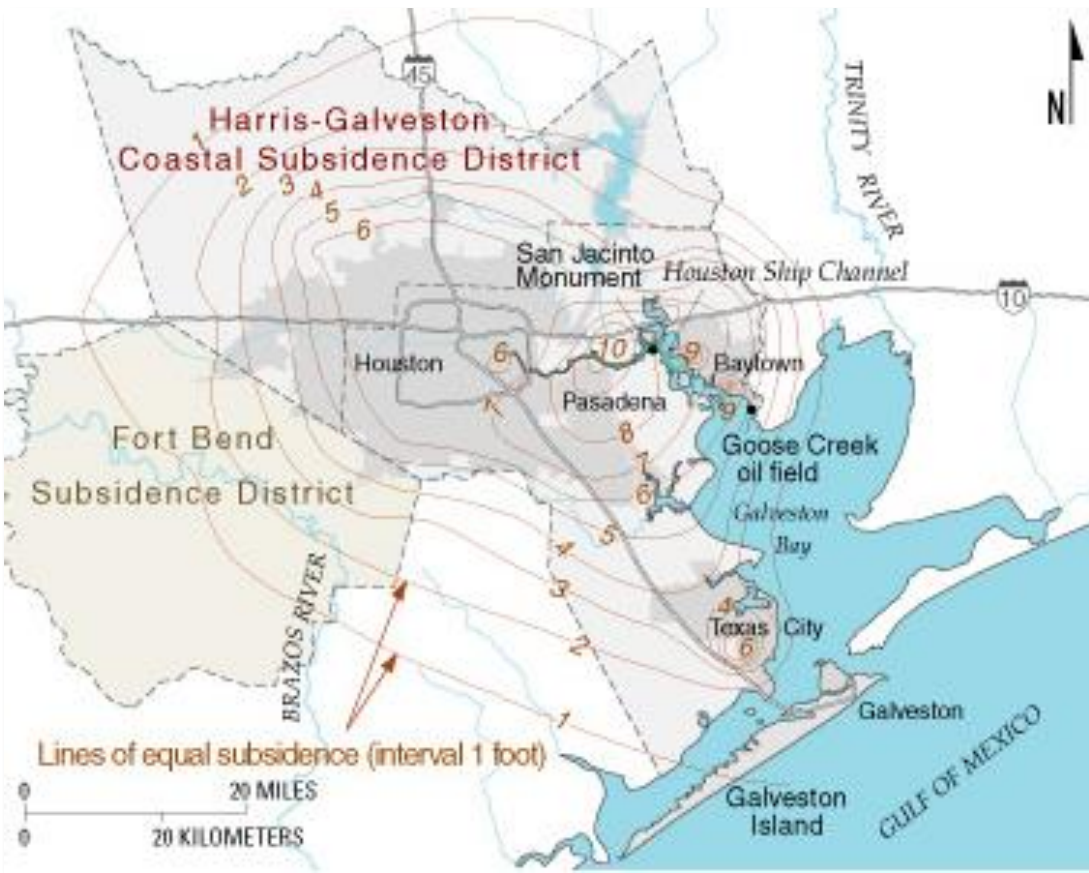
Watershed Imperviousness  
(2011)

- Greater Than 20%
- 10% to 20%
- Less Than 10%



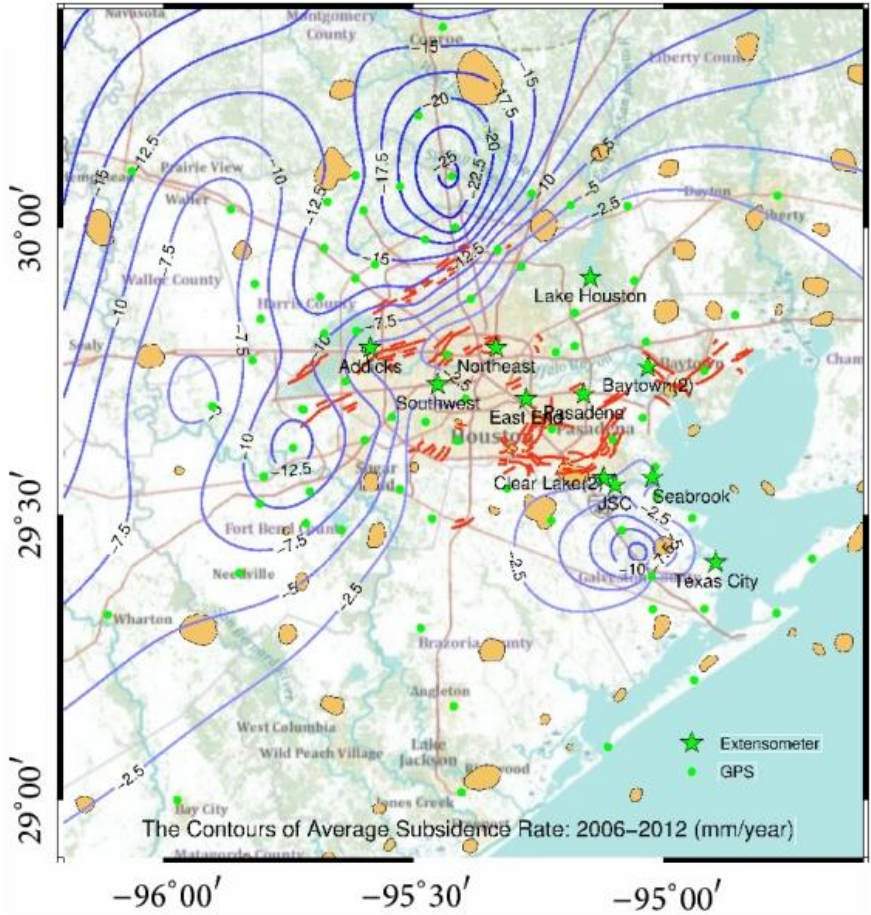
# Regional Subsidence

*Extent of subsidence in the Houston-Galveston Bay area (ft/year); 1906–95.*



USGS Report # FS-051-00

*Average subsidence rate (mm/year); 2006-12*



Yu J., G. Wang, T.J. Kearns, and L. Yang. 2014. International Journal of Geophysics.



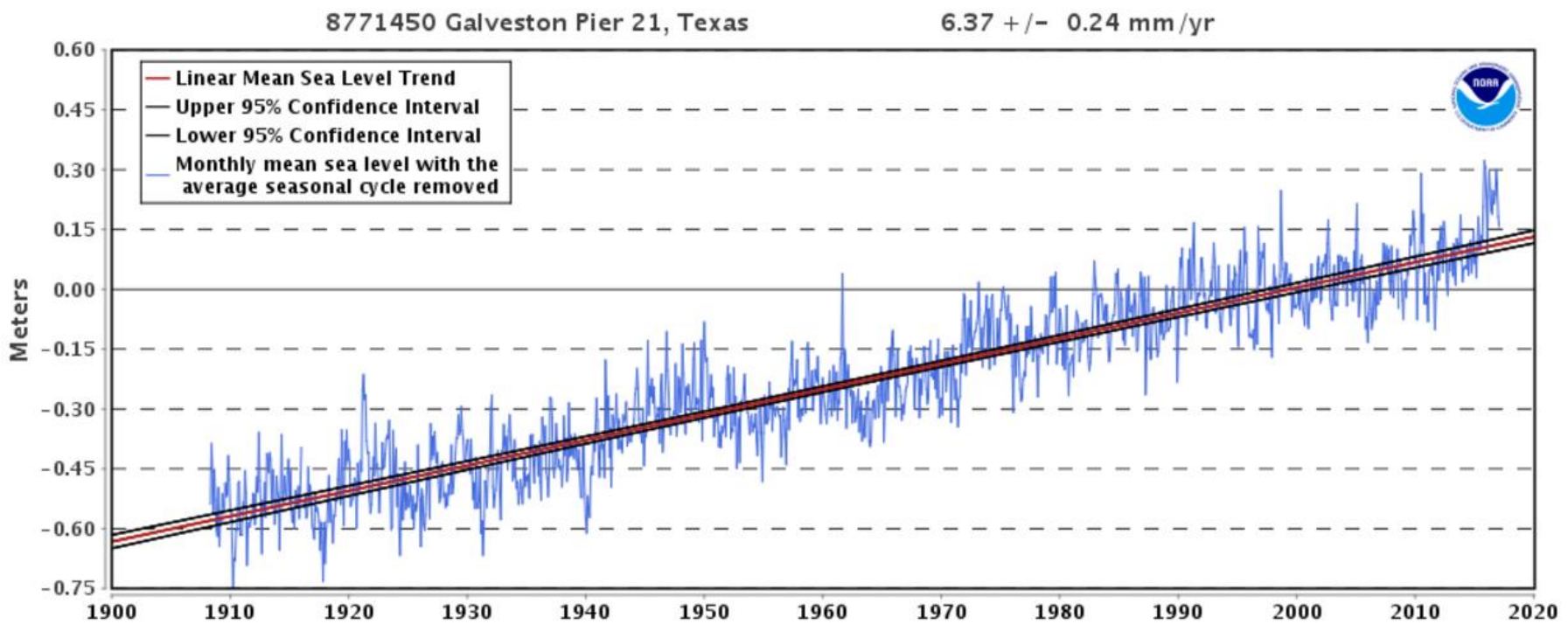


# Relative Sea Level Rise

**NOAA Nuisance Flooding Projections:**

- Port Isabel: 30+ days/year by 2020
- Galveston: 30+ days/year by 2041-2060

Mean Sea Level Trend  
8771450 Galveston Pier 21, Texas

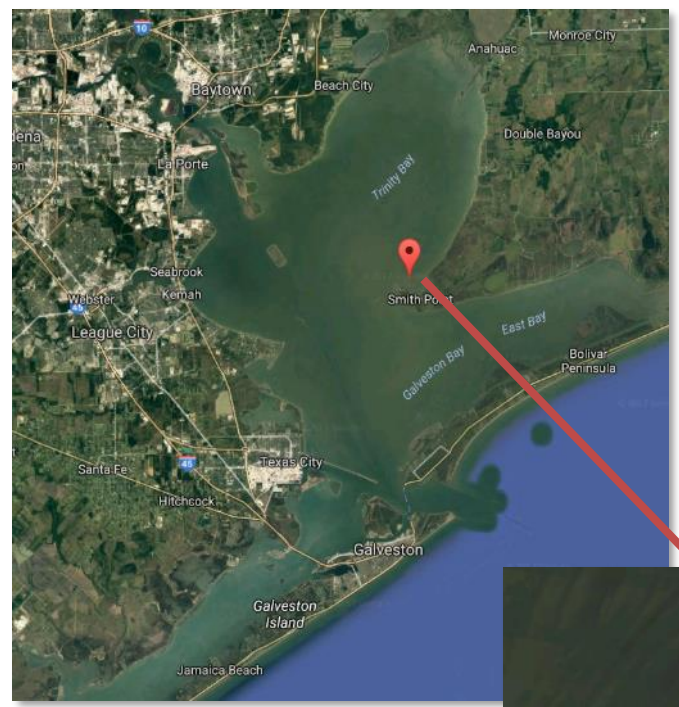


*The mean sea level trend based on monthly mean sea level data from 1908 to 2015:  
**2.09 feet in 100 years.***

Source: NOAA Tides & Currents



# Impacts of Relative Sea Level Rise



Vingt-et-un “21” Islands waterbird rookery



*Brownwood Subdivision in Baytown, TX abandoned in 1990s.*

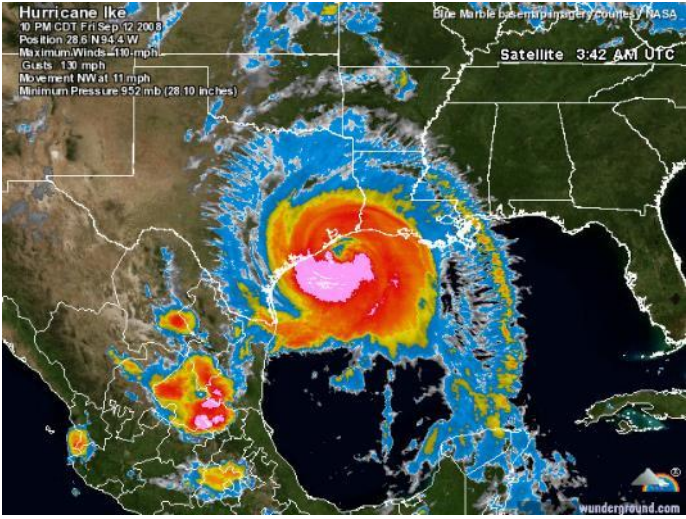


*Broadway Boulevard in Galveston after 9/1/2015 rain storm. Galveston County daily News*



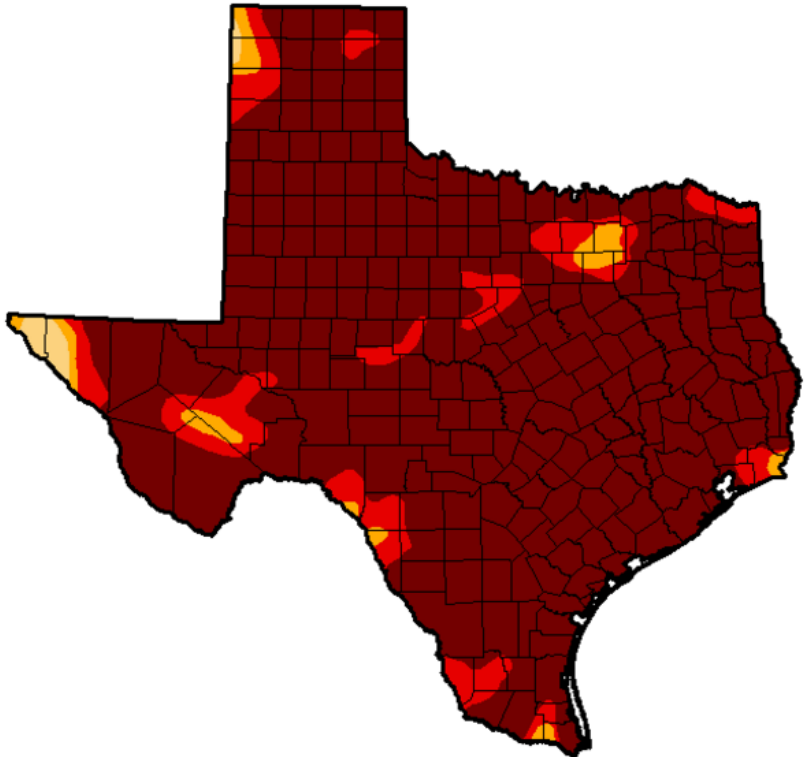
# Coastal Storms & Storm Surge

## 2008 Hurricane Ike

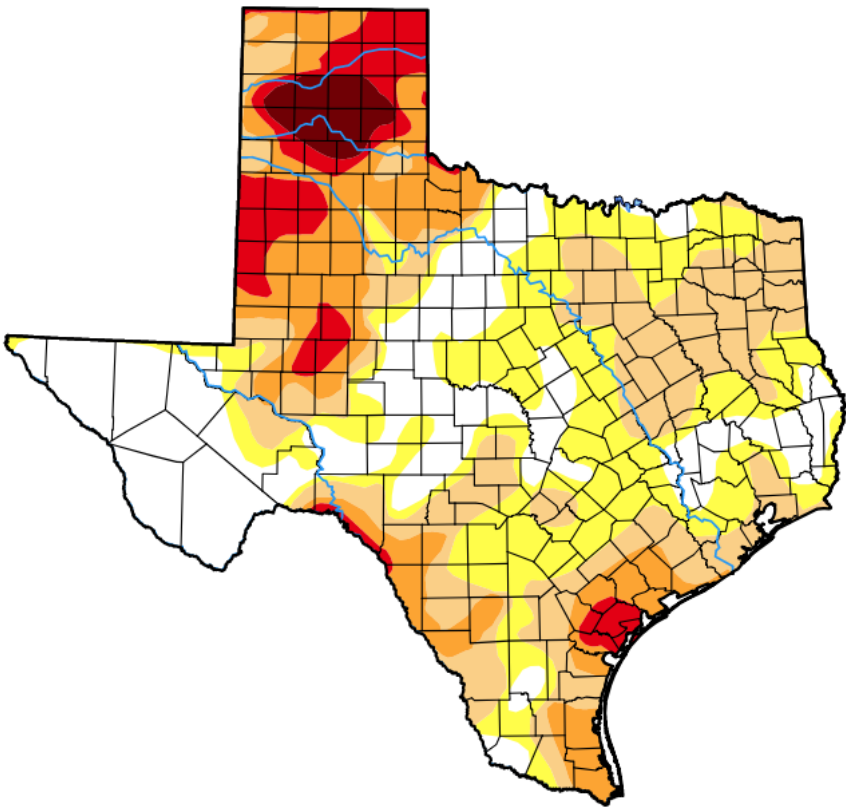








# Texas Drought

*Area with drought conditions:  
10/4/2011: 100% area (25 M people)*



*Area with drought conditions:  
6/12/2018: 76 % area (10.8 M people)*



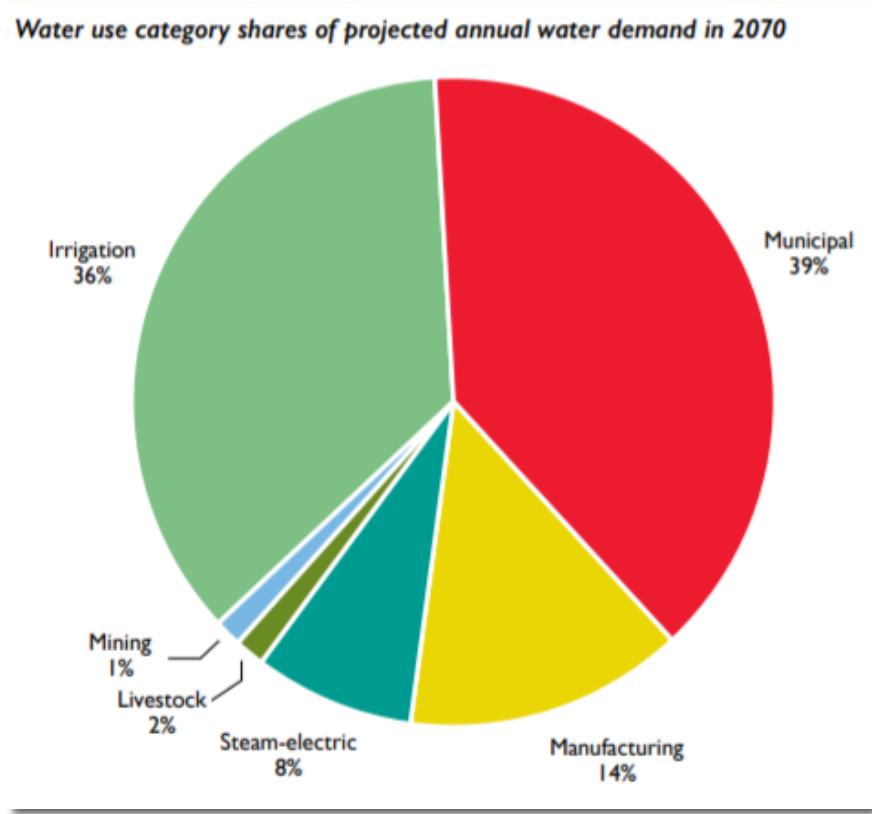
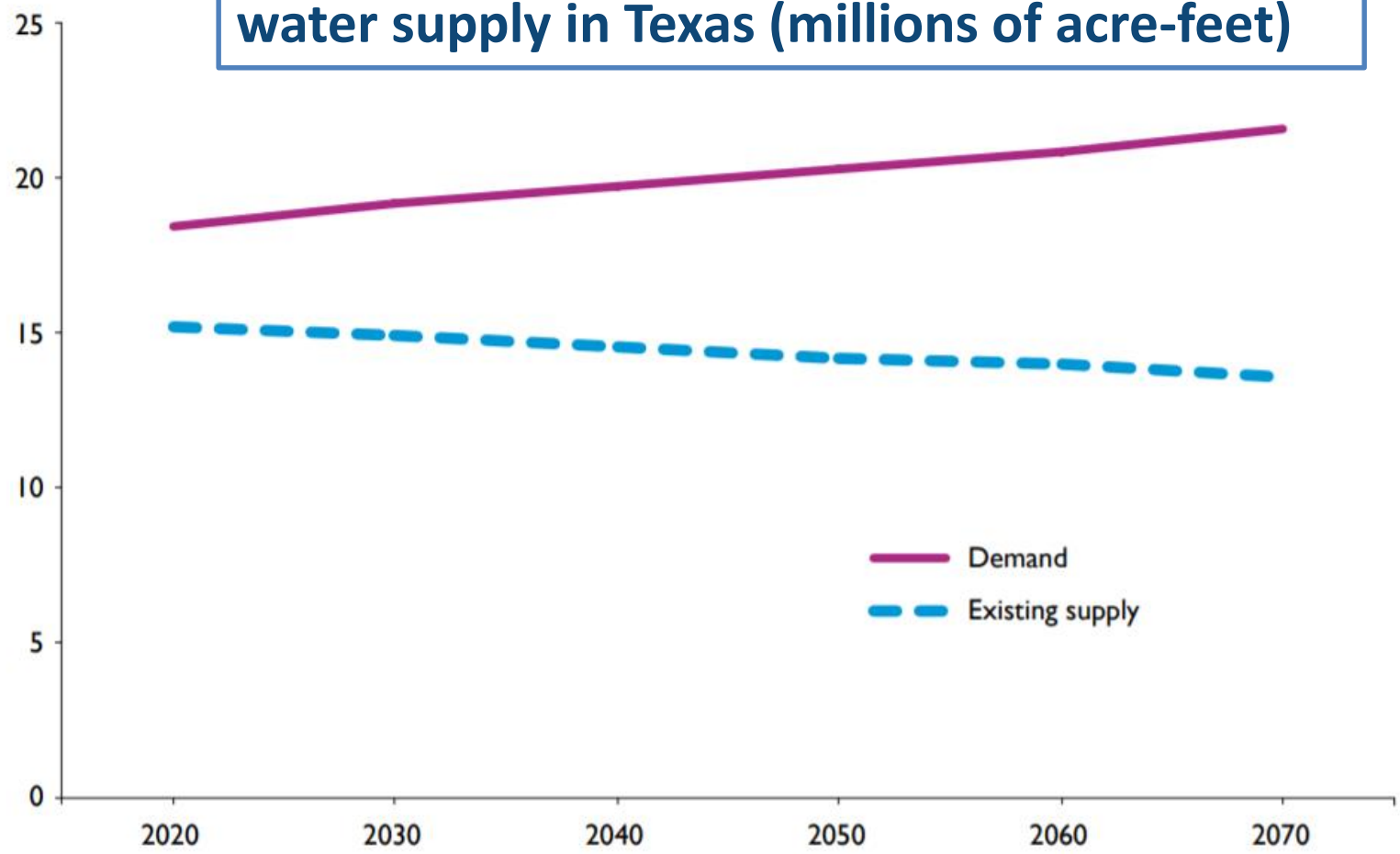
- Intensity:**
-  None
  -  D0 (Abnormally Dry)
  -  D1 (Moderate Drought)
  -  D2 (Severe Drought)
  -  D3 (Extreme Drought)
  -  D4 (Exceptional Drought)

*Texas Drought Monitor*



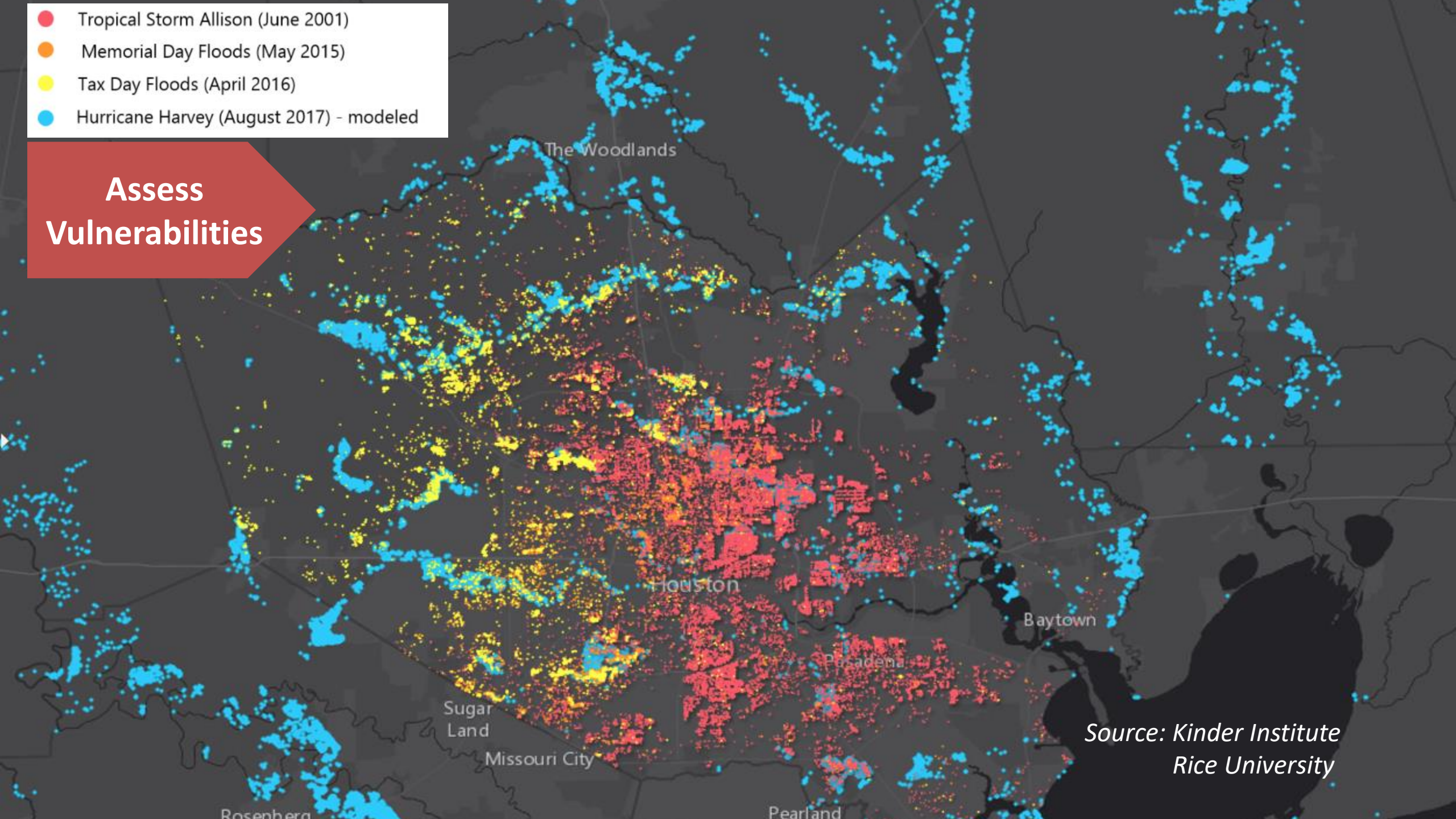
# Water Availability

Projected annual water demand and existing water supply in Texas (millions of acre-feet)



- Tropical Storm Allison (June 2001)
- Memorial Day Floods (May 2015)
- Tax Day Floods (April 2016)
- Hurricane Harvey (August 2017) - modeled

**Assess  
Vulnerabilities**



*Source: Kinder Institute  
Rice University*

# Harvey vs Other Major Floods

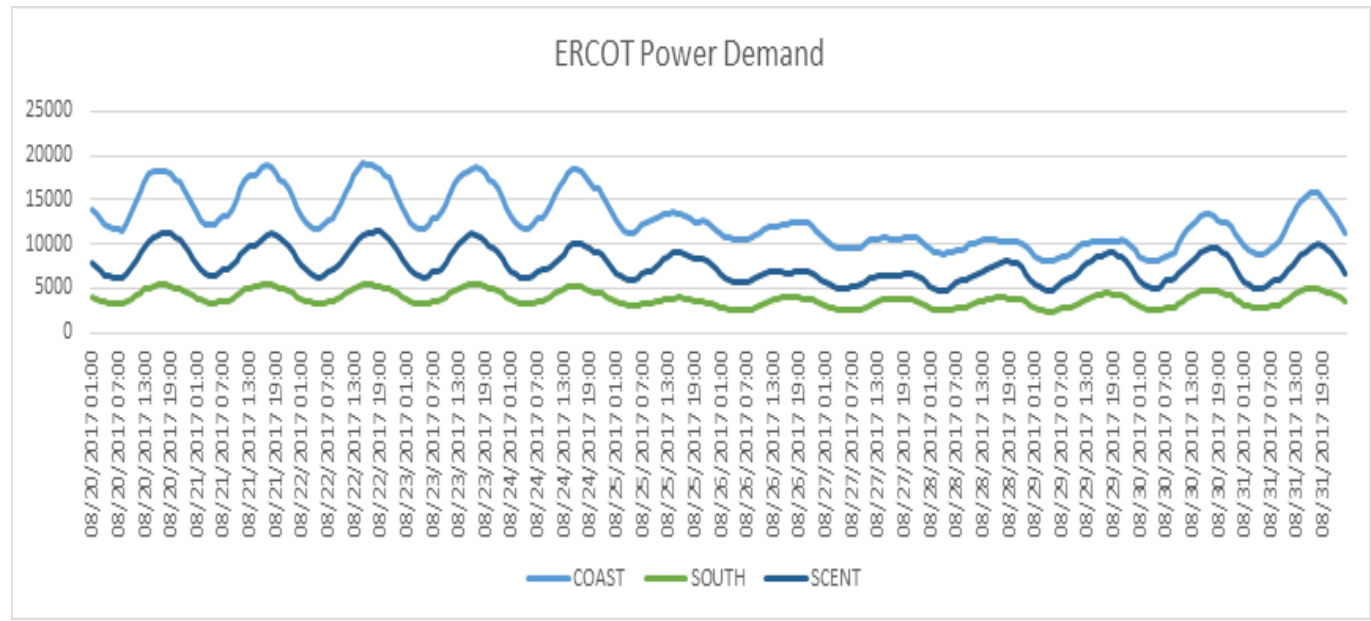
Duration	Harvey August 2017	Allison June 2001	Tax Day April 2016	October 1994
1-hr	<b>6.8</b>	5.7	4.7	3.7
2-hr	<b>11.9</b>	9.9	7.3	4.7
3-hr	<b>14.8</b>	13.5	8.3	5.3
6-hr	18.9	<b>21.2</b>	13.9	7.2
12-hr	20.9	<b>28.3</b>	16.7	12.0
24-hr	25.6	<b>28.4</b>	17.4	20.9
2 days	<b>35.2</b>	28.5	17.5	23.1
4 days	<b>47.7</b>	38.5	N/A	28.9

Source: Jeff Lindner, Harris County Flood Control District



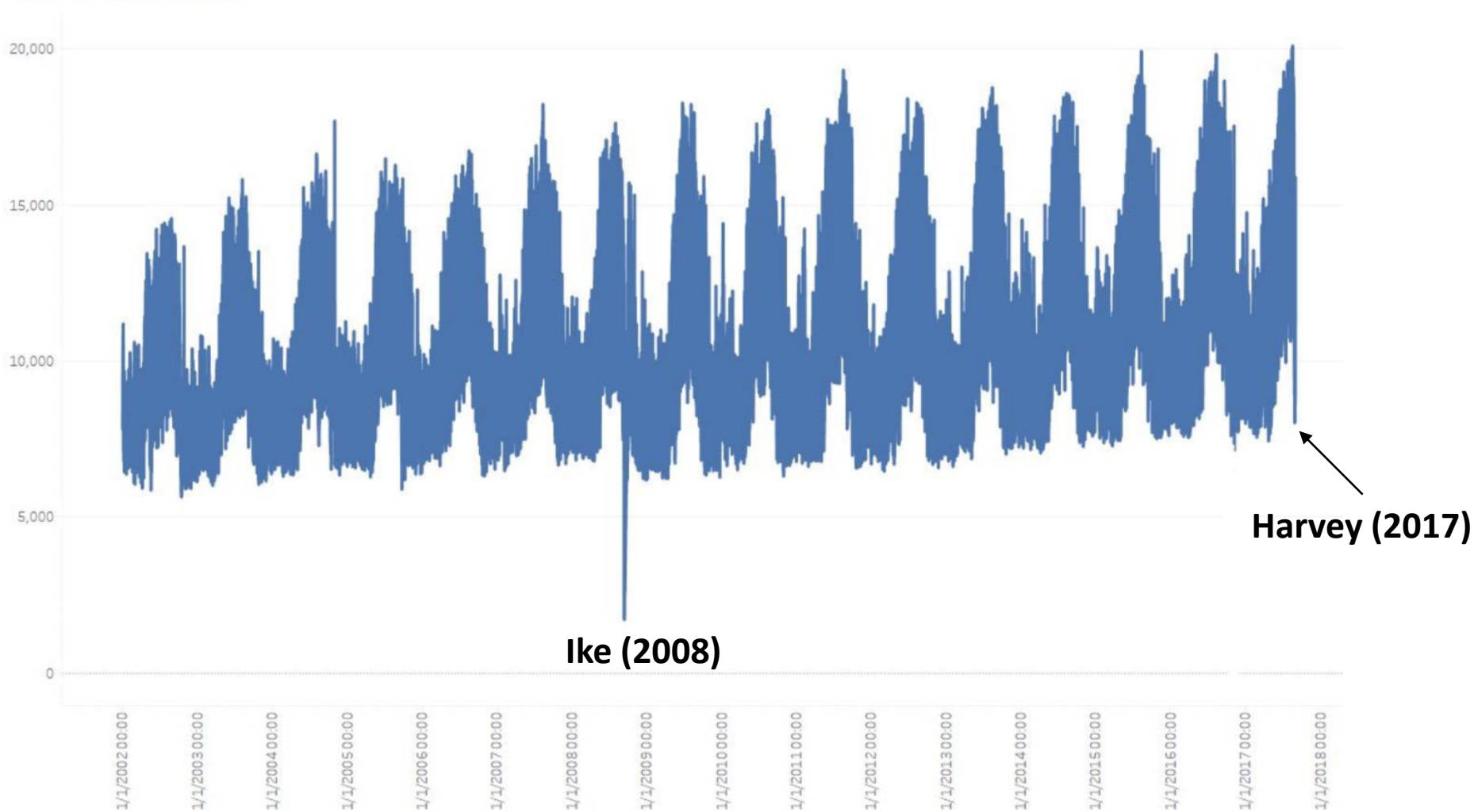
# Harvey's Impact on Power System

- Shuttering of refineries
- Power outages due to damage to transmission system
- Cooler temperatures

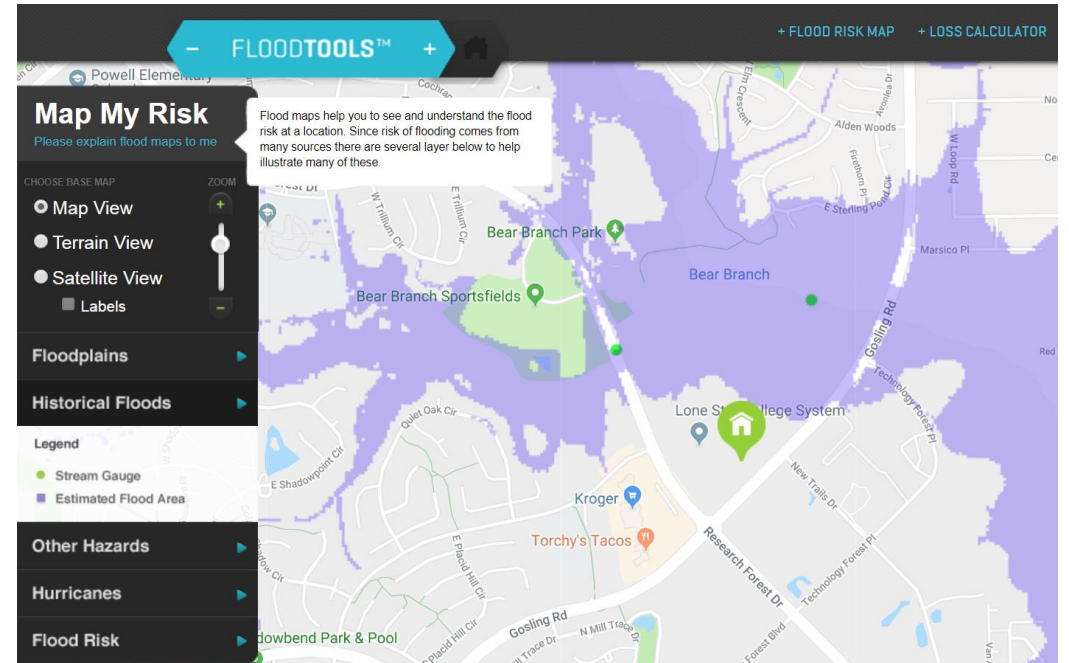
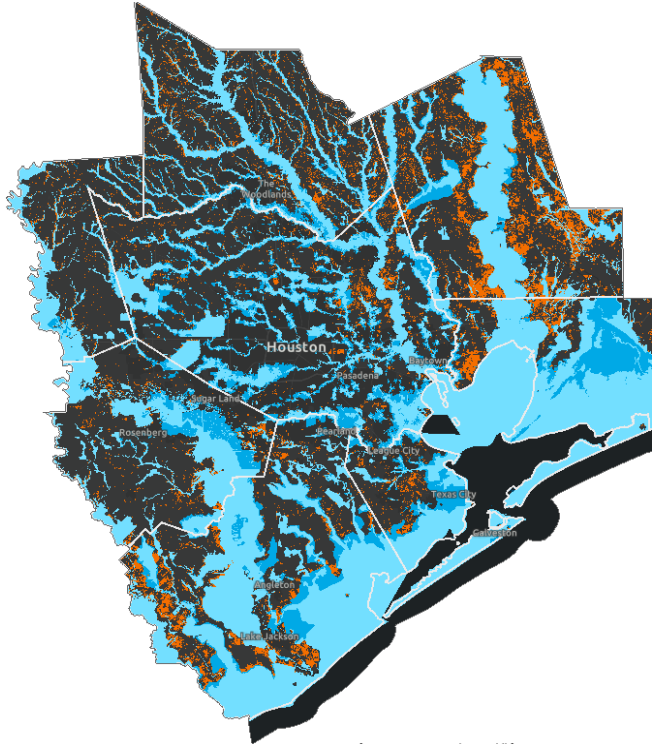




# ERCOT Power Demand: Texas Coast 2002-2017



# Who Lives in a Flood Zone?



*FloodTools.com; National Flood Services*

- Regional flood alert system
- Flood risk disclosures
- Flood insurance

Harris County Flood Education Mapping Tool  
[www.harriscountyfemt.org/](http://www.harriscountyfemt.org/) ▼

Montgomery County Flood Plain Viewer  
[gis.mctx.org/apps/floodplains/](http://gis.mctx.org/apps/floodplains/) ▼



# Engaging Communities

- Robust public engagement in decision making
- Coordinated watershed & community plans



You're seeing news from

CY-FAIR

IMPACTS TRANSPORTATION GOVERNMENT BUSINESS DINING THINGS TO DO E-NEWSLETTER

**Community meeting in Cypress Creek watershed yields massive turnout ahead of August bond referendum**



## Harris County pieces together flood bond projects, millions at a time, in Harvey's wake

By Zach Depart | June 15, 2018 | Updated: June 18, 2018 2:41am



Photo: Yi-Chin Lee / Houston Chronicle

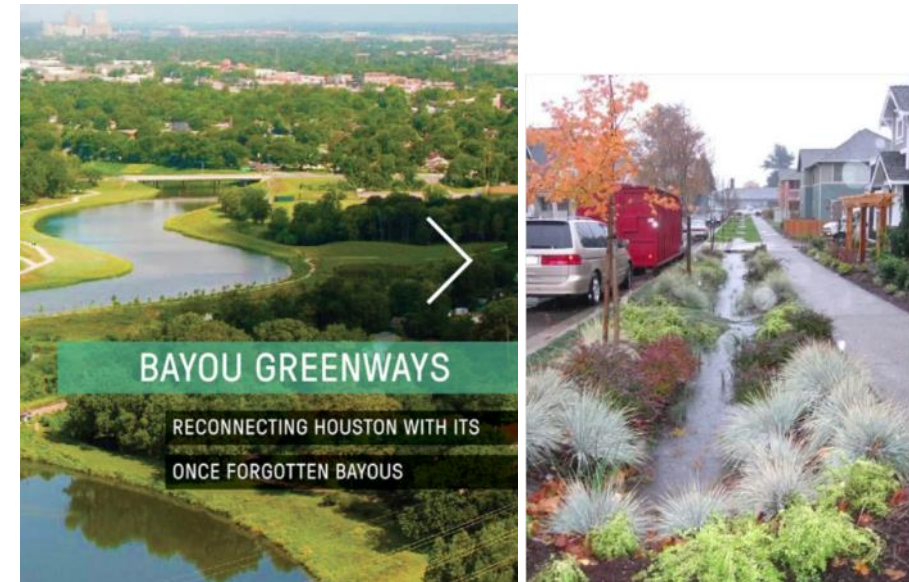
IMPACT 2018



- Total Harvey costs ~ \$125B
- Harvey, Irma & Maria exceed federal recovery capacity
- \$89B in federal funds for TX, LA, FL, PR for infrastructure & buyout projects

## What about resilience strategies & nature-based solutions?

- Innovative financing for resilience projects
  - Environmental Impact Bonds (with private sector investment)
  - Property Assessed Clean Energy (PACE Financing)



# Low Impact Development (LID)

- Alternative development strategy
- Preserves water flow and ecology to improve quality and reduce quantity of stormwater
- Often associated with preserving or replanting native vegetation
- Uses include new or existing development projects
  - Residential neighborhoods, commercial infrastructure, industrial facilities, roads, and public parks/green space

LID practices include:



- The microgrid market to reach 3.71 GW of operational capacity in 2020.
- Commercial scale natural gas gensets played a role in Harvey recovery.



# Exciting Examples of Power Resilience



## **TECO – 48 MW CHP**

Serves 20 million square feet of the  
Texas Medical Center

## **UTMB – 15 MW CHP**

7.5 MW – East Plant operational  
7.5 MW - West Plant commissioning



# Regional Adaptation & Resilience Collaborative

- National trend in resilience collaboratives
- **Goal:** Build long-term capacity
- Approach: multi-institutional & regional
  1. *Assess progress and barriers*
  2. *Science information network*
  3. *Regional framework of resilience and adaptation strategies*
  4. *Community of practice*





Adapt

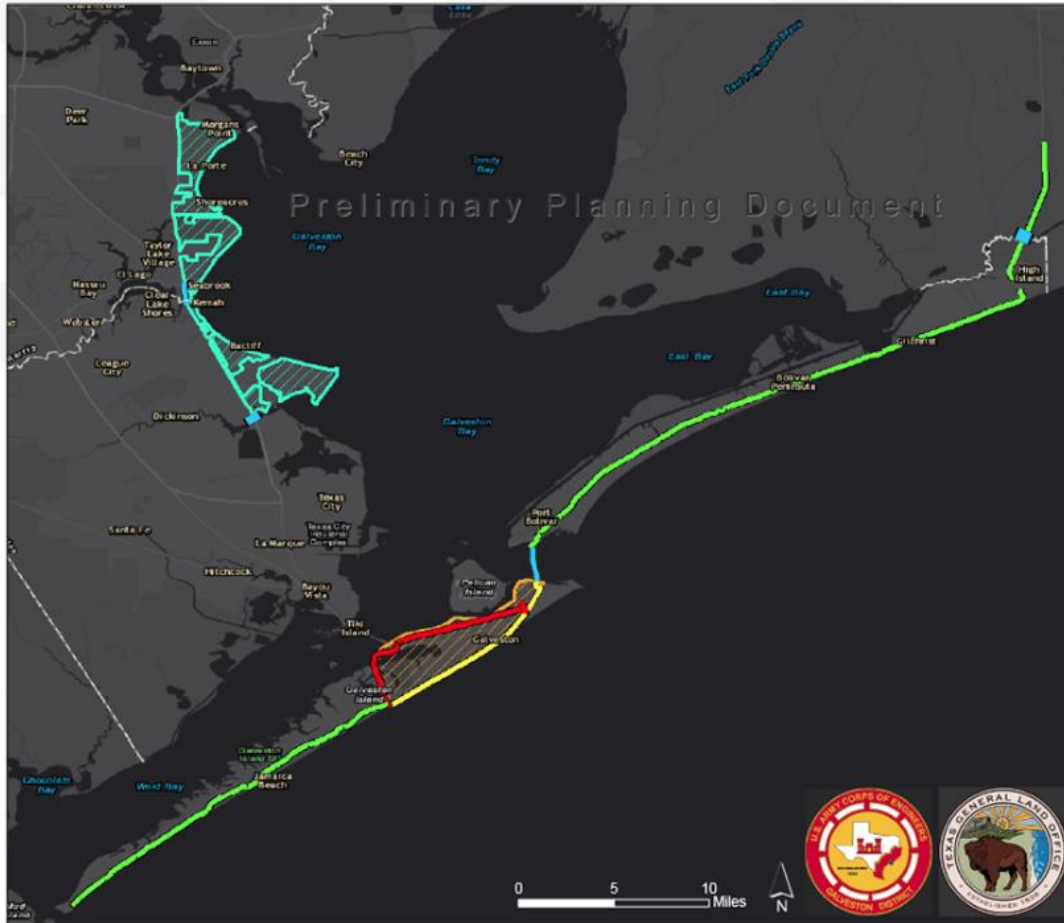
# Coastal Storm Surge Barriers

Coastal Texas  
Protection  
and Restoration  
Feasibility Study

## Alternative A

- Navigation and Environmental Gates
- Levee/Floodwall
- Galveston Ring Levee\*
- Galveston Seawall Improvements
- Galveston Island Nonstructural Improvements\*
- Nonstructural Improvements

\* One or both of these features may be selected.



How can storm surge solutions balance economic, social and environmental needs?



<http://coastalstudy.texas.gov>


Adapt

# Harris County Bond

## BOND PROGRAM

INFORMATION & COMMUNITY ENGAGEMENT

## PRELIMINARY DRAFT



**Step1: Find Your Watershed**

Enter Address

e.g. 9900 Northwest Fwy, Houston 77092

All Watersheds

### LEGEND

**PROPOSED BOND PROJECTS**

- ★ Buyout Areas
- ▲ Storm Repairs
- ◆ Subdivision Drainage Improvements
- Local Projects
- ✚ Partnership Projects
- ✳ Community Input

**WATERSHED BOUNDARIES**

- Watersheds

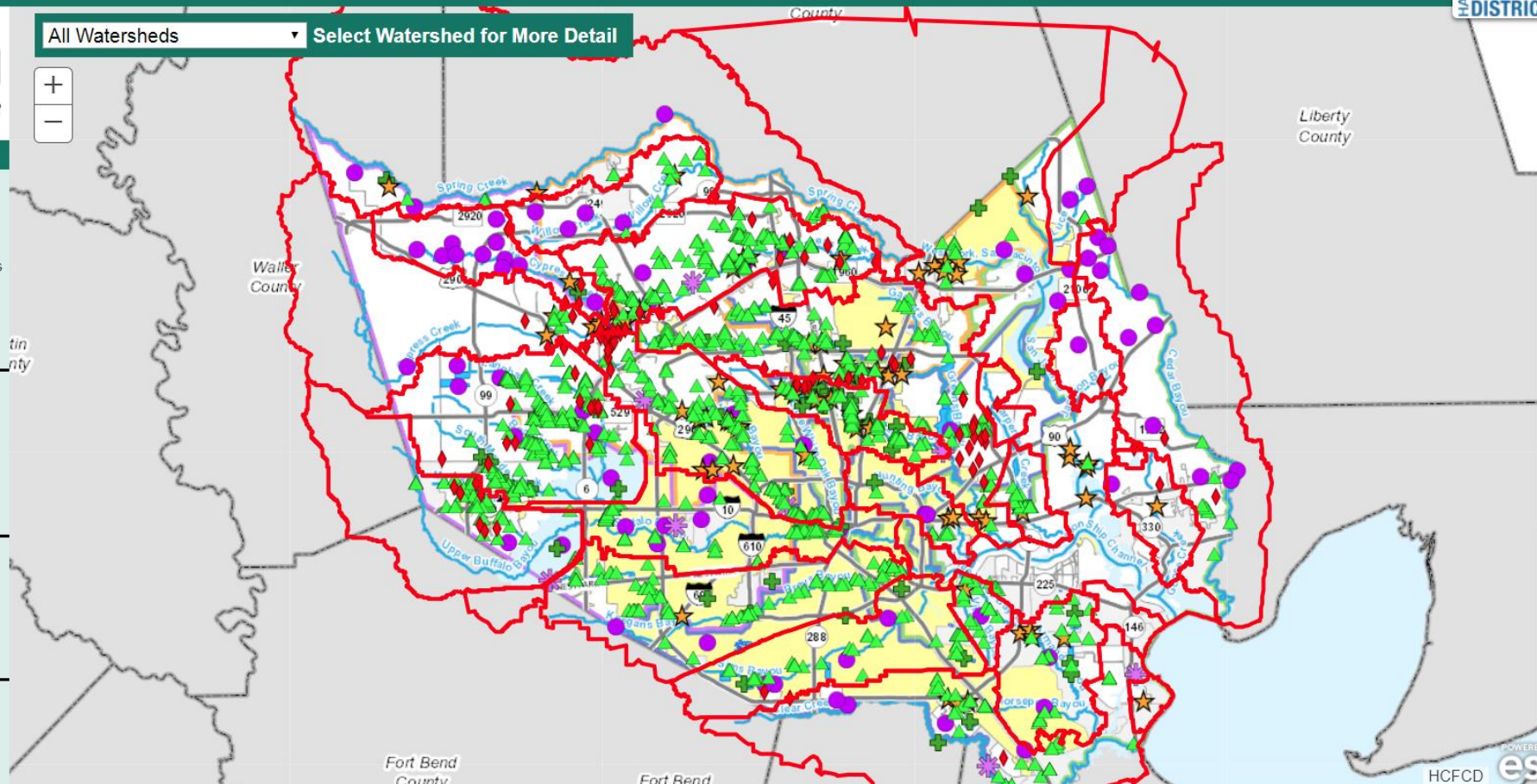
**JURISDICTIONS**

- Texas House Districts
- Texas Senate Districts
- US House of Representatives

**Harris County Precincts**

- Pct. 1 - Rodney Ellis
- Pct. 2 - Jack Morman
- Pct. 3 - Steve Radack
- Pct. 4 - R. Jack Cagle

- Existing Detention Basins
- Other Municipalities
- City of Houston
- Unincorporated Harris County




Liberty County

Walker County

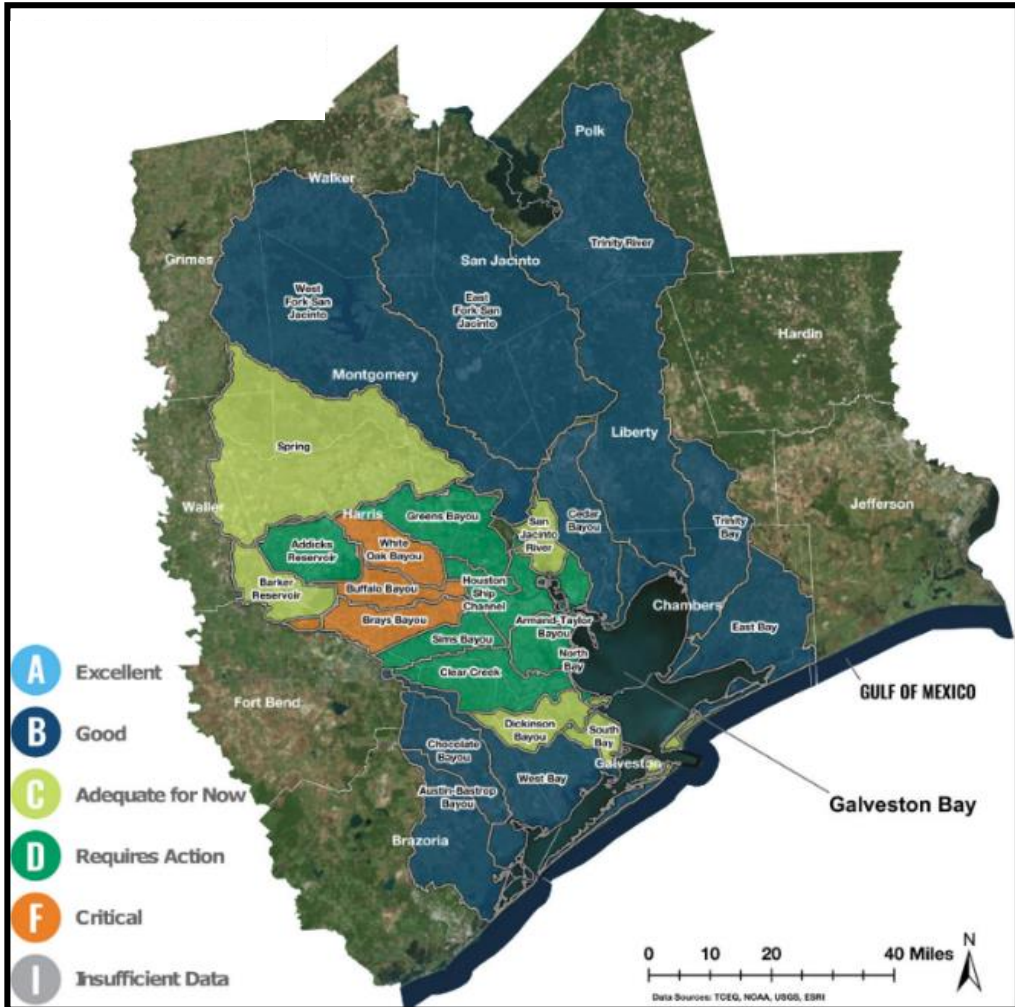
Fort Bend County

Fort Bend

HCFCD 

<http://www.harriscountyfemt.org>

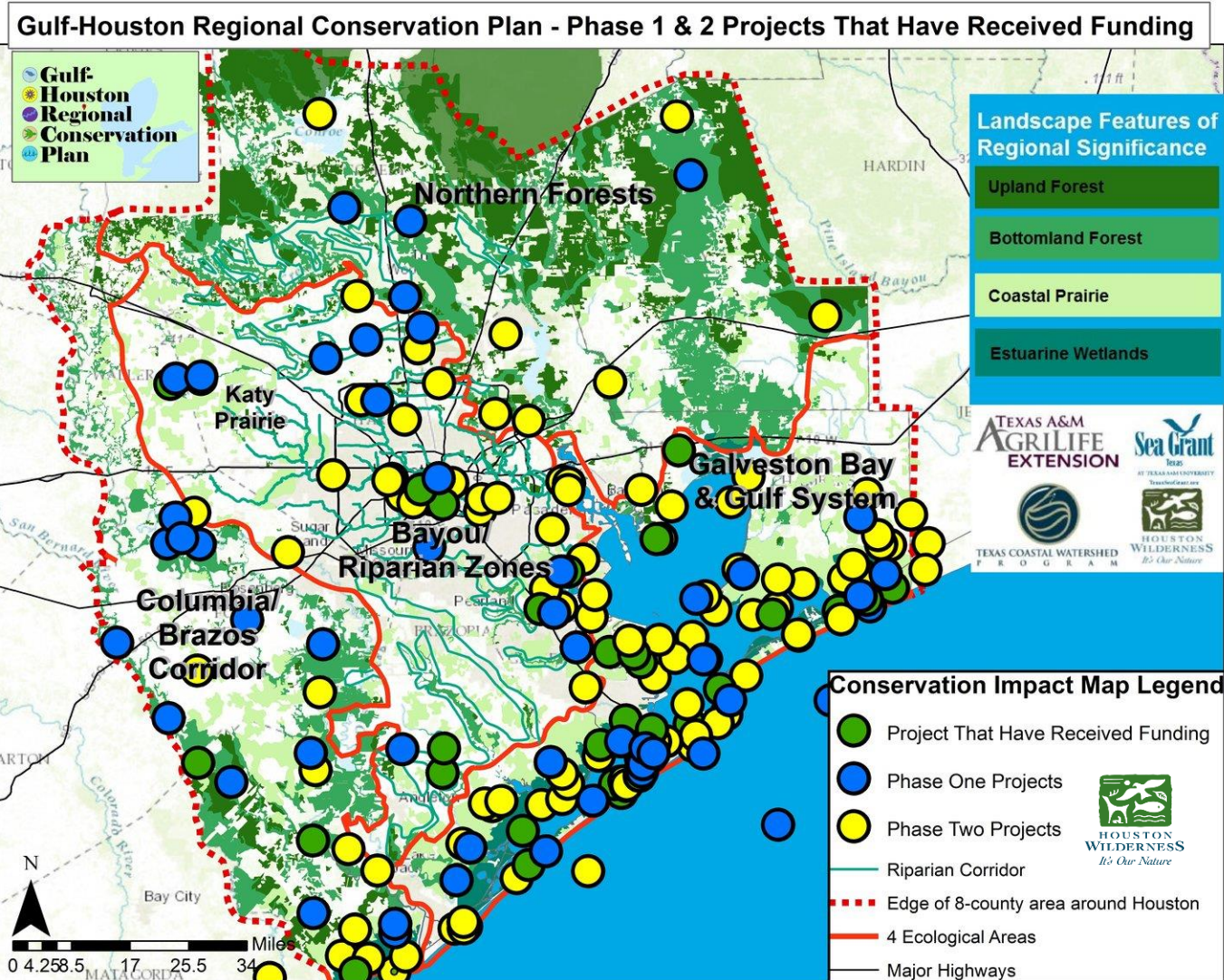
## Wetlands & Development



- Community-planned infrastructure projects
- Rethink development design practices, ordinances & building codes
- Low Impact Development (LID)
- Retrofit existing homes, buyouts/relocation
- Bayou greenways & buffers
- Stormwater detention with created wetlands
- Rain cisterns, gardens, barrels
- Wetland protection & conservation easements

Adapt

# Nature Based Infrastructure



Katy Prairie Conservancy

SCENIC GALVESTON



# Designing with Nature



*Drainage swales surrounded by preserved habitat*



*Natural bank ponds*

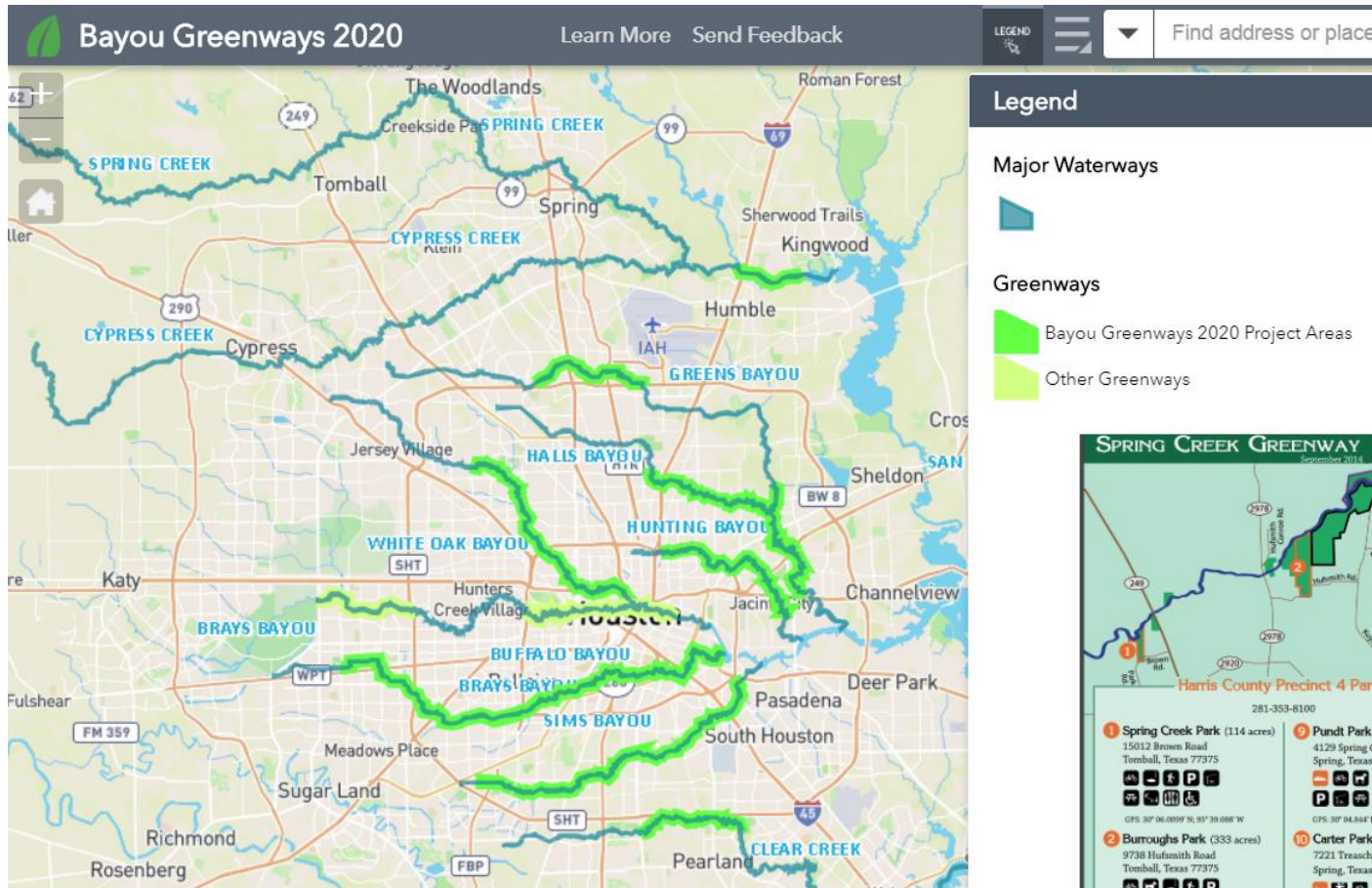
*Collector streets, check dams, water impoundment on soils with good infiltration capacity*

- Less stormwater runoff during 100-year storms
- Lower nutrient loadings
- Average of 2°C lower land surface temperature
- Higher walkability and pedestrian access to open space

*B. Yang & S. Li. 2015. Design with Nature: Ian McHarg's ecological wisdom as actionable and practical knowledge. Landscape & Urban Planning.*

Adapt

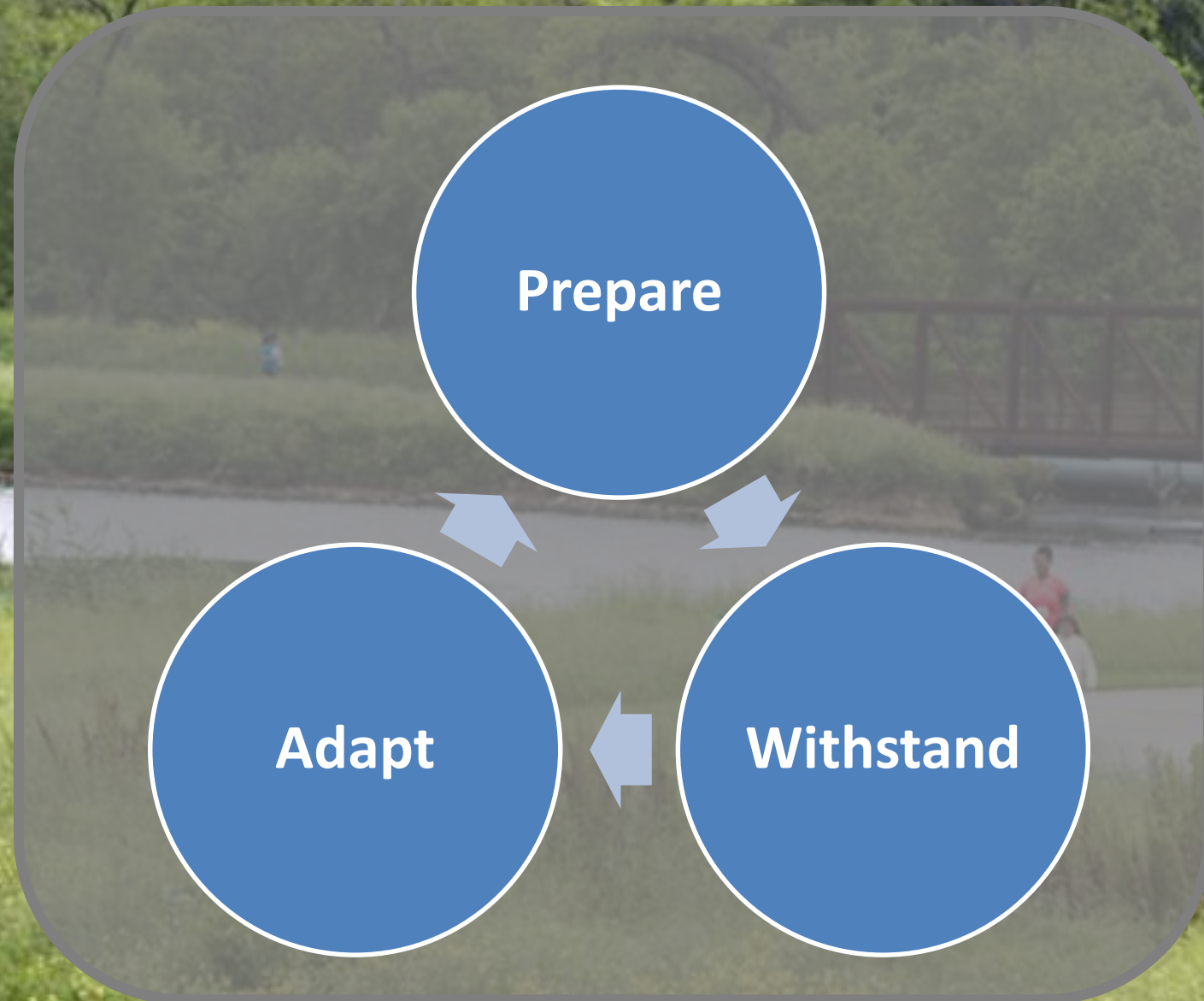
# Regional Bayou Greenways



# Does This Model Still Make Sense?



# OR... Can We Develop More Resilient Systems?





# Thank You

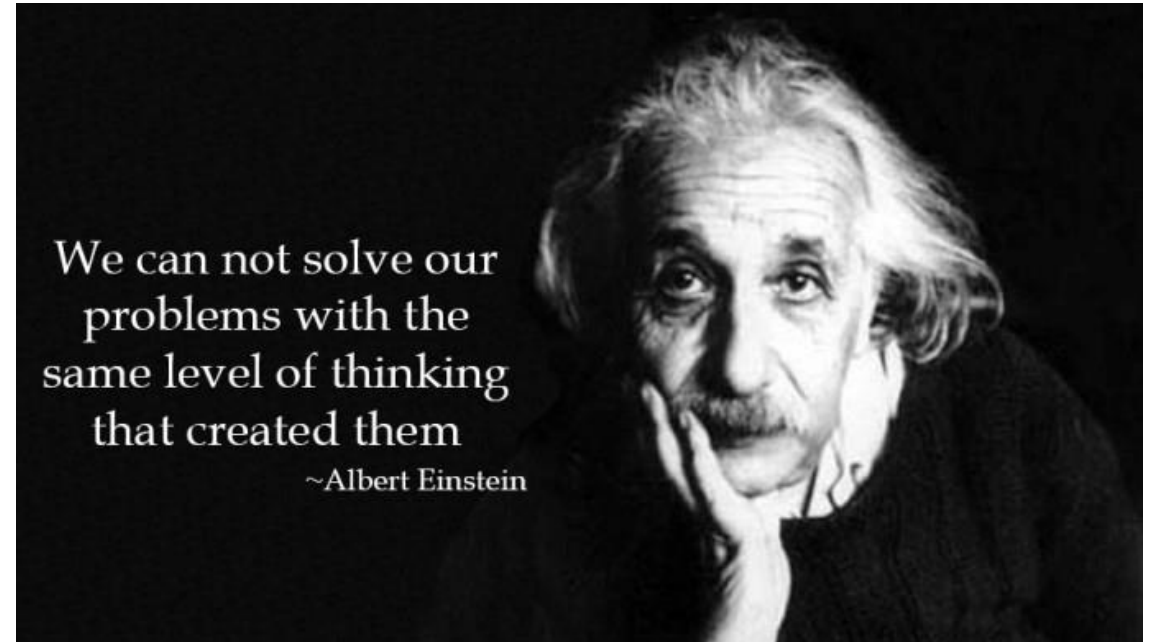


**Lisa Gonzalez**

Email: [Lgonzalez@harcresearch.org](mailto:Lgonzalez@harcresearch.org)

Phone: (281) 364-6044

**HARCresearch.org**



**HARC** (härk), *n.*

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hub helping people thrive  
and nature flourish.