# Utilizing Synthetic Aperture Radar Imagery for Flood Damage Assessment

## Hurricane Harvey Case Study

Beni Patel

4/7/2021

TESSELLATIONS

GIS Consulting and Training http://www.tessellations.us

8505 Technology Forest Place, Suite 1104, The Woodlands Texas 77381 Voice: 936.321.1998 Fax: 281.667.3253

# Topics

- Quick introduction to Tessellations Inc.
- Introduction to Synthetic Aperture Radar (SAR) Imagery
- Hurricane Harvey Case Study
  - Using Radar and Stream Gauge data to monitor high water areas
  - Using SAR to delineate flooded area
  - Combine results with other datasets to assess impact
- Q&A

# Tessellations Overview

- GIS consulting and training firm
- Experience
  - Custom training to ensure successful implementation
  - On-site/virtual support for short or long term engagements
  - Field data collection and validation
  - ETL development and automation of workflows
  - Optimization of Enterprise systems
  - Image processing and classification – UAV, aerial, satellite
  - Lidar data classification, QA/QC, hydrological modeling, contour generation
  - Spatial analysis (geostatistical expertise)
- Planet Partners - high frequency revisit times
- Certified FME Partners – utilize FME for spatial data integration with Esri products
- LinkIT – managing unstructured data repositories
- Analysts, Remote Sensors, IT professionals, Developers

esri Partner Network Silver

Release Ready Specialty

Federal Small Business Specialty

planet.orbit The Planet Partner Ecosystem SILVER PARTNER

SAFE SOFTWARE

Microsoft Partner

Microsoft

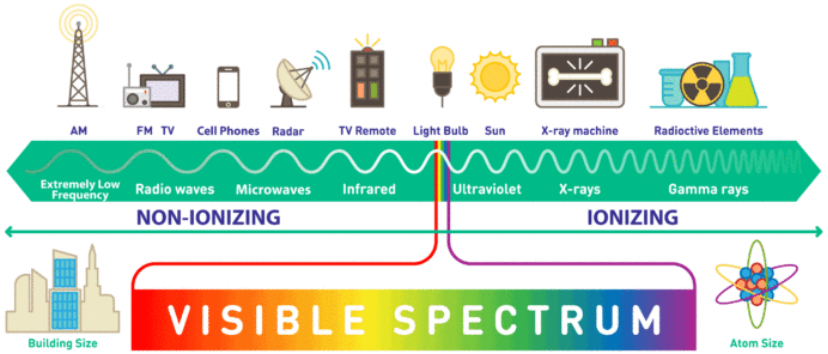
# Certifications

- State of Texas Hub – Historical Underutilized Business
- City of Houston - Woman owned Minority Business Enterprise
- SBA – Woman Owned Small Business
- Texas DIR Stratmap Vendor
- ISO 9001 Certified – Quality Management System

# Synthetic Aperture Radar

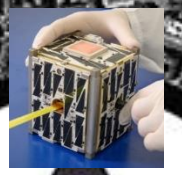
- RADAR – Radio Detection and Ranging
- Active sensor – sends a radio wave out and measures what comes back
- Looks like a monochrome image
- Intensity of the signal coming back is not based on the color of the object
- The material of the object, physical shape of the object and view angle define the incoming signal

## Electromagnetic Spectrum



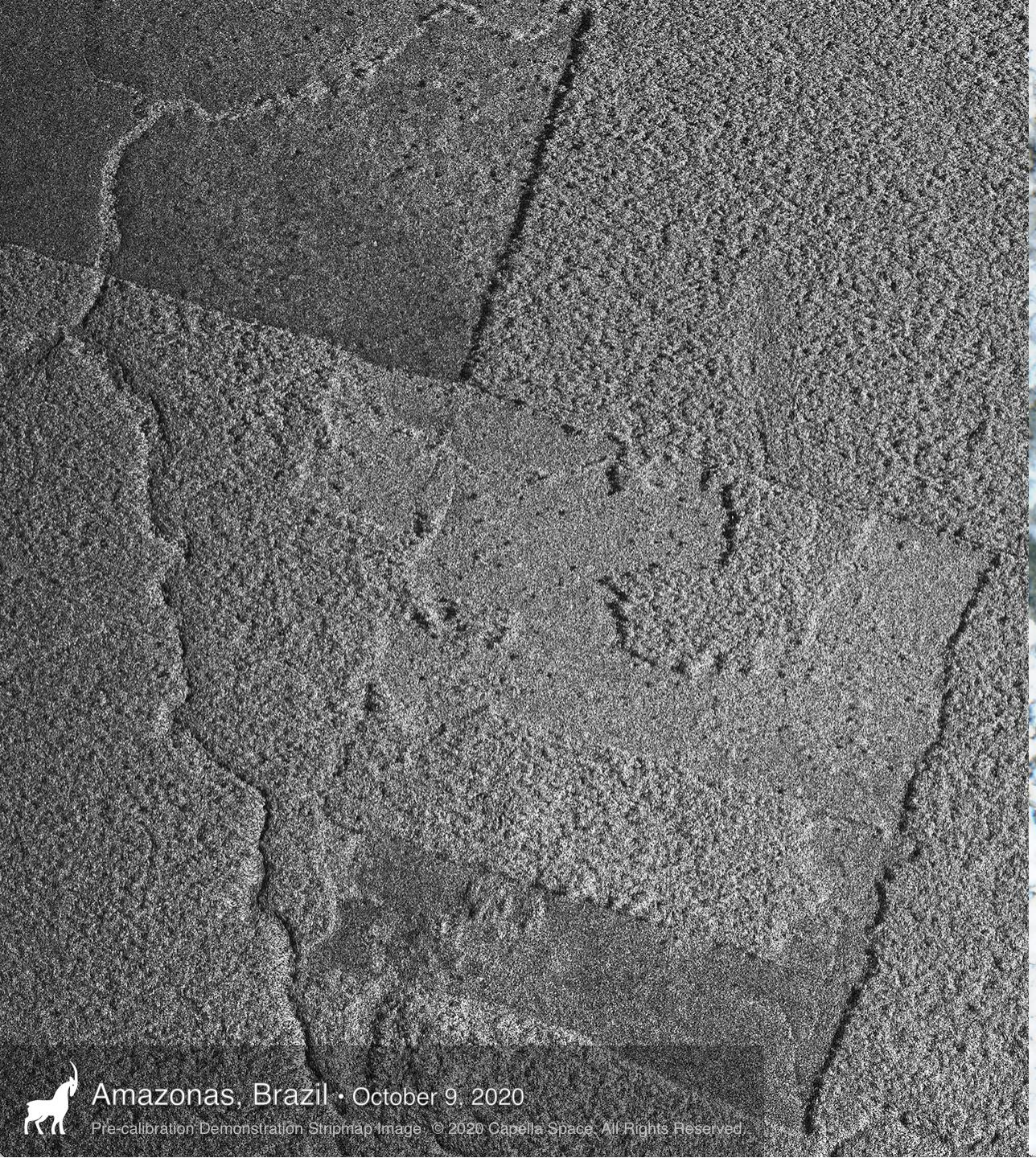

# OPTICAL vs SAR

DAYLIGHT



# SAR Pros and Cons

- Pros
  - Active sensor – emits it own energy
  - Can collect data in the day or night
  - Can penetrate and see through clouds and smoke
- Cons
  - Hard to interpret
  - Limited availability (this is changing rapidly)



Amazonas, Brazil • October 9, 2020

Pre-calibration Demonstration Stripmap Image. © 2020 Capella Space. All Rights Reserved.

India-Pakistan Border Sutlej River Punjab
Strip Image Acquired 07-Dec-2020 10:10 a.m.
Location (Lat,Lon) = 31.049°,74.593°
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Capella Space

Hurricane Eta Flooding La Lima Honduras
Strip Image Acquired 12-Nov-2020 03:06 a.m.
Location (Lat,Lon) = 15.463°,-87.920°
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Capella Space

# SAR Satellites

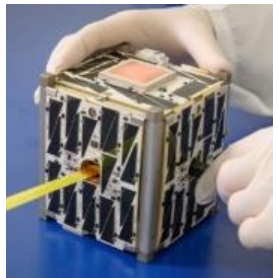
| Satellites/Constellations | Band | Resolution | Revisit Rate |
|---|---|---|---|
| **Capella Sequoia #1 & #2** | x-band | 0.5m - 2m | 2 hour |
| **ICEYE** | x-band | .25m - 3m | 3 hours |
| **XPRess** | x-band | 1m - 3m | rev 1-4 |
| **Sentinel 1a, 1b** | c-band | 5m - 25m | 12 day |
| **TerraSAR-X** | x-band | 0.25m-40m | 2-11 days |
| **TerraSAR-Tandem** | x-band | 0.25m-40m | 2-11 days |
| **PAZ** | x-band | 0.25m-40m | 2-11 days |
| **COSMOS SKYMED 1 & 2** | x-band | | 12 hours |

Total Number:

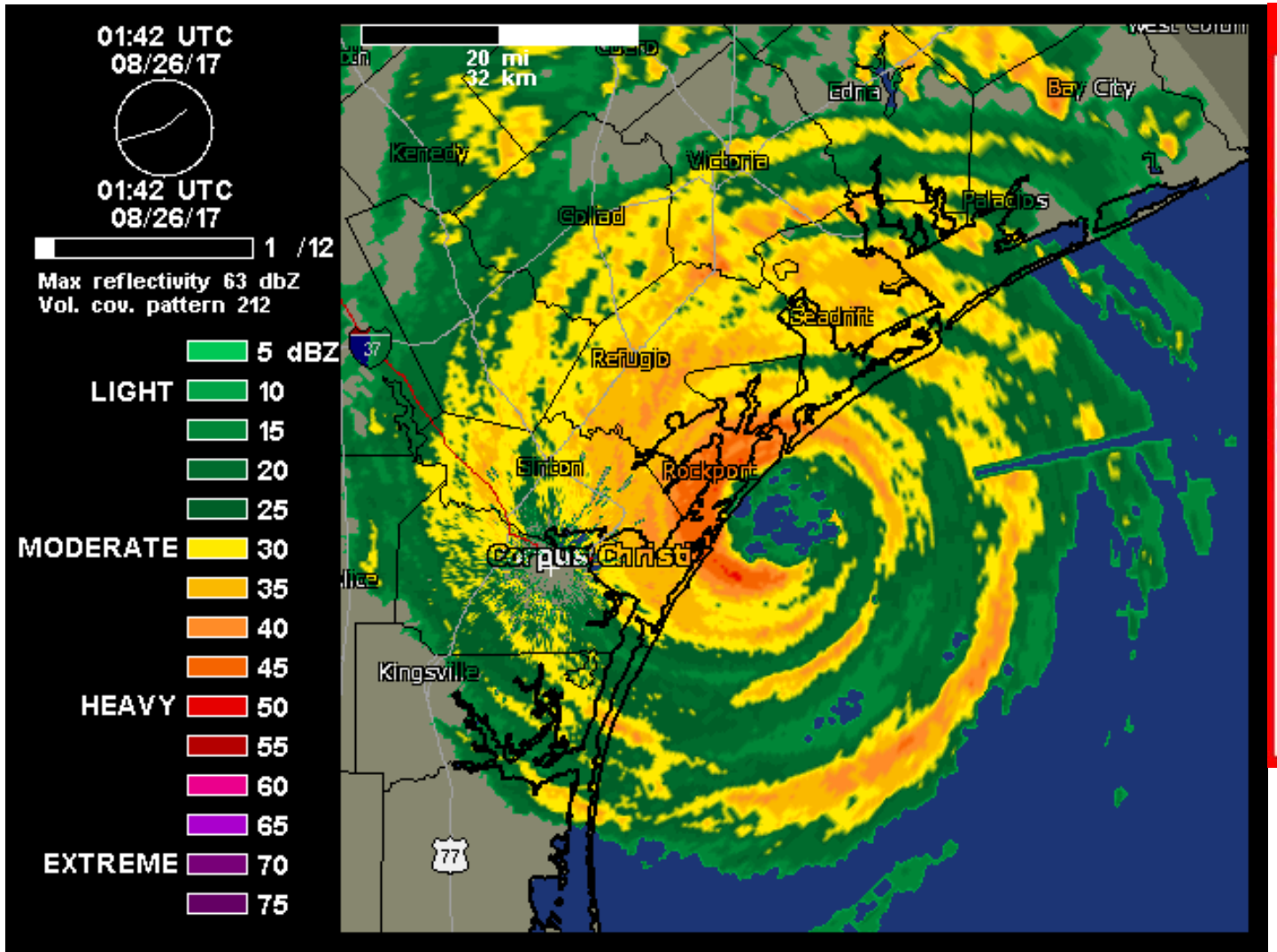
2020: 9

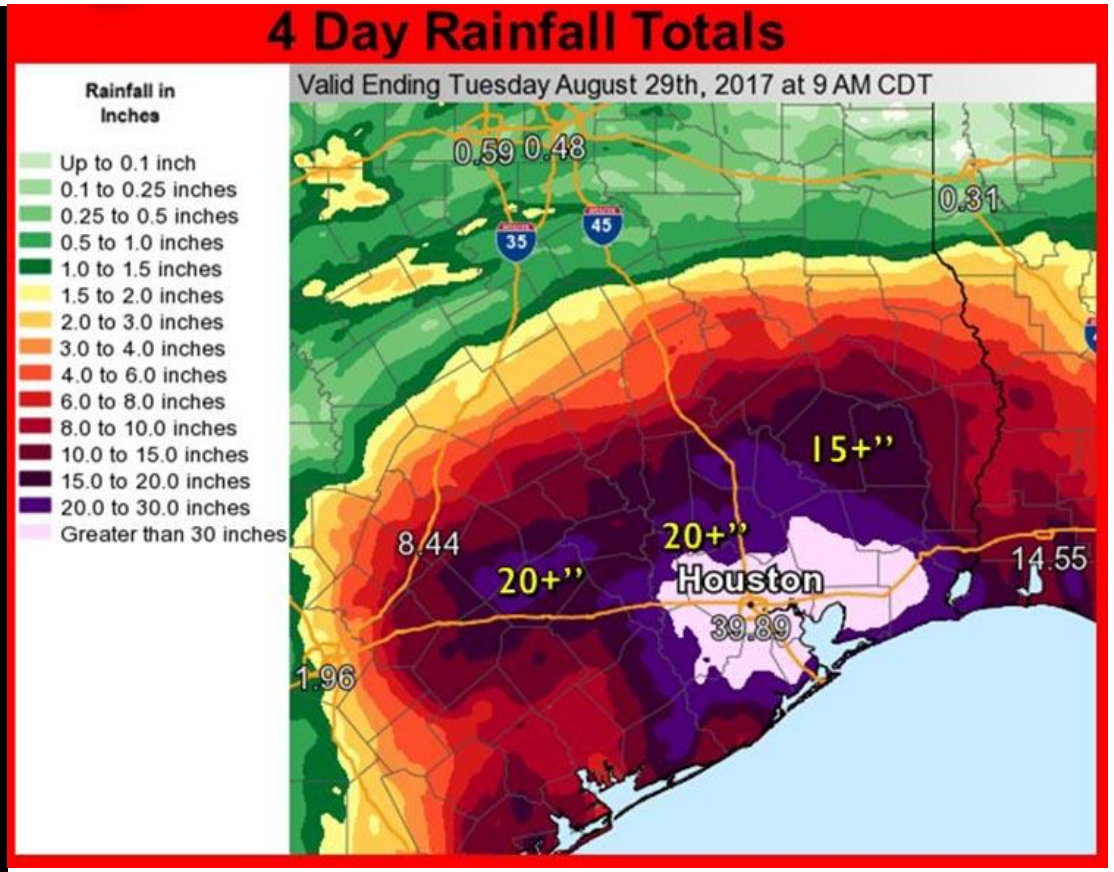
2021 – 2028: 22

2028: 159

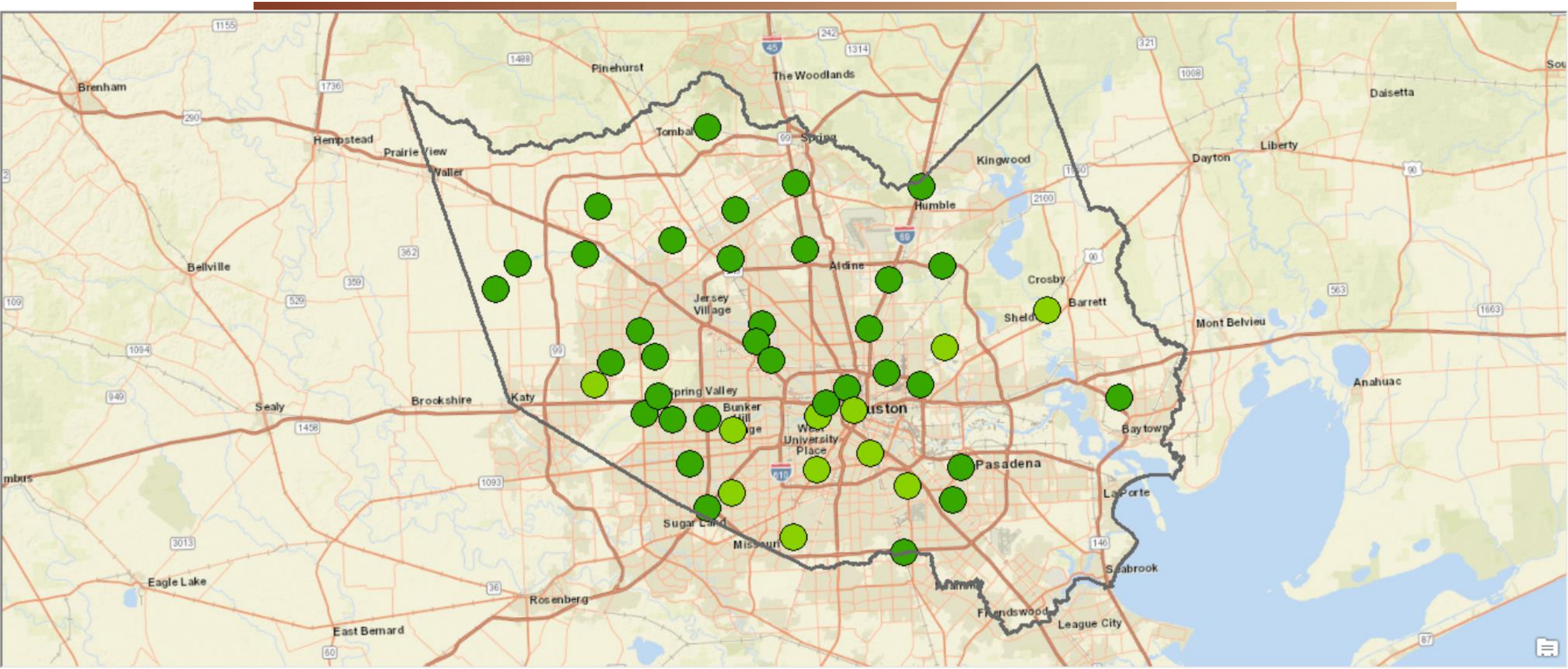


# Harvey Rainfall

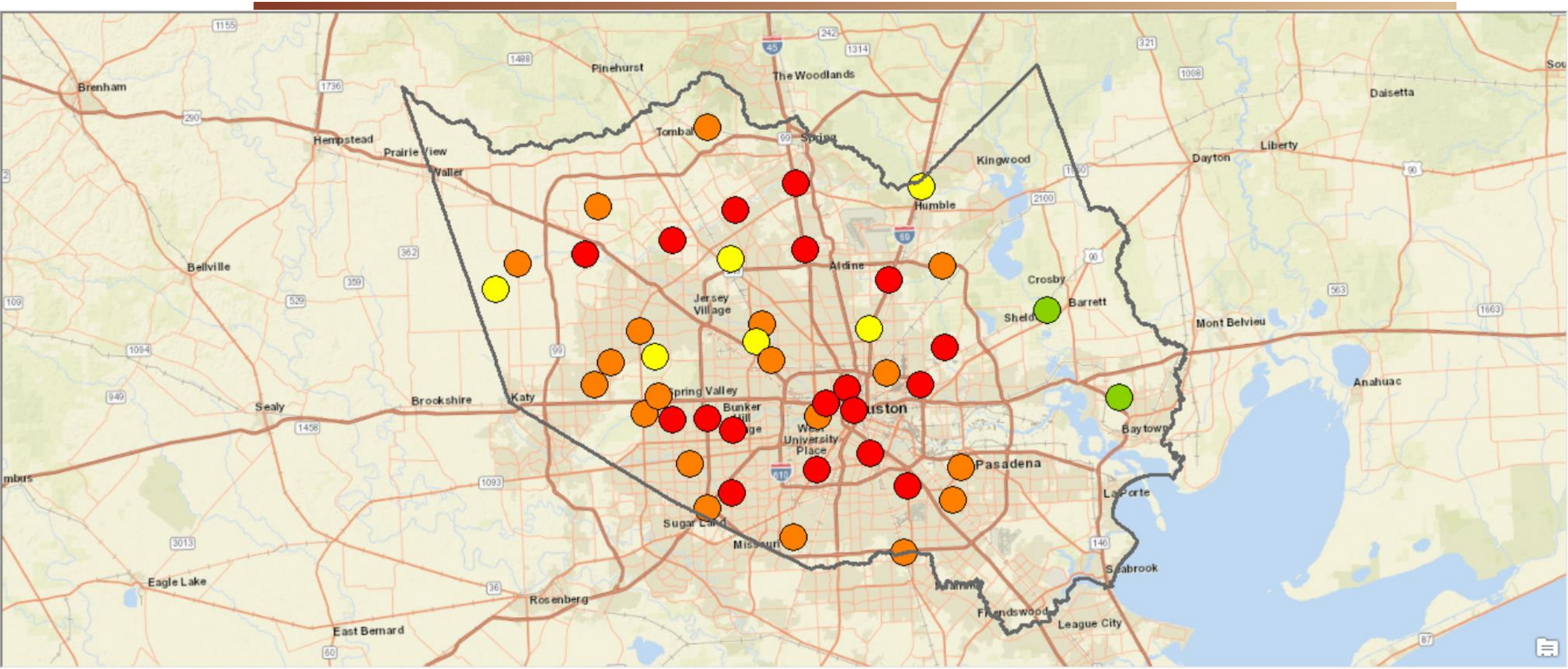


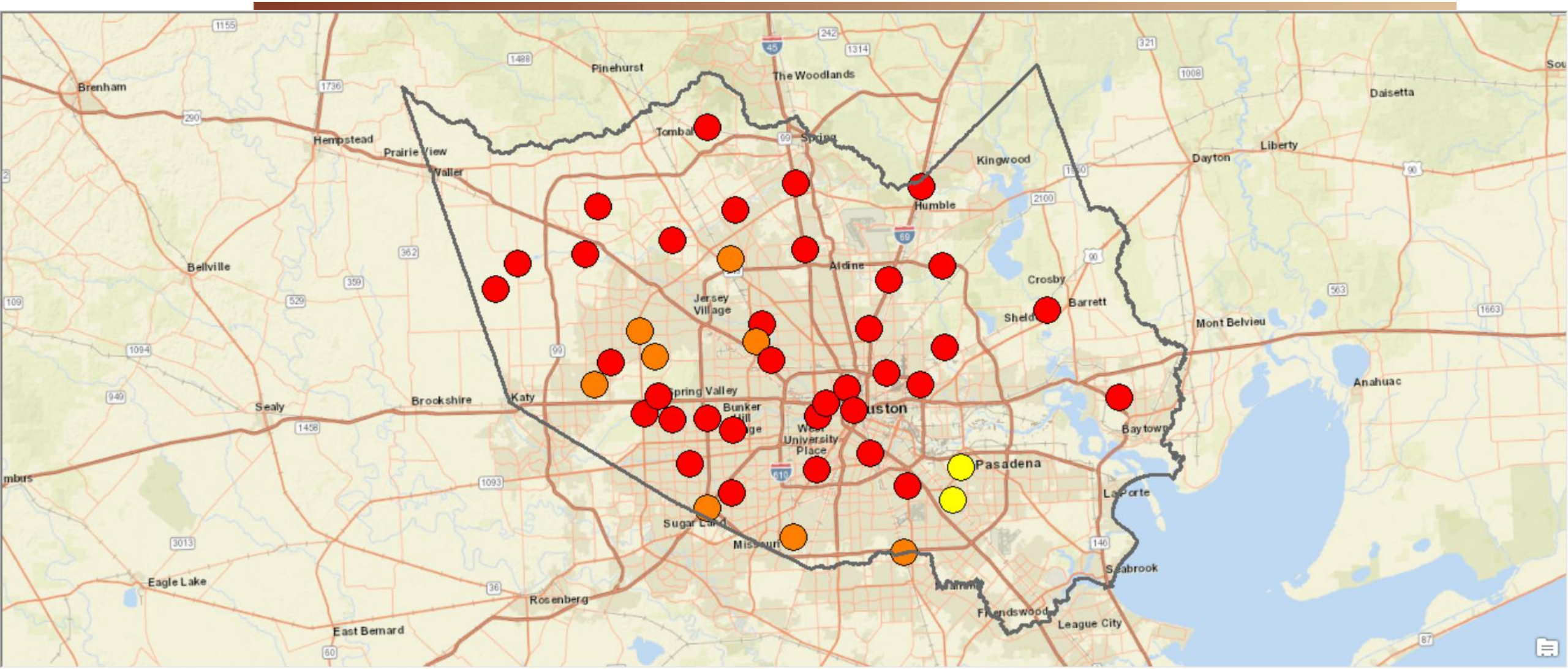
# Monday, August 26th



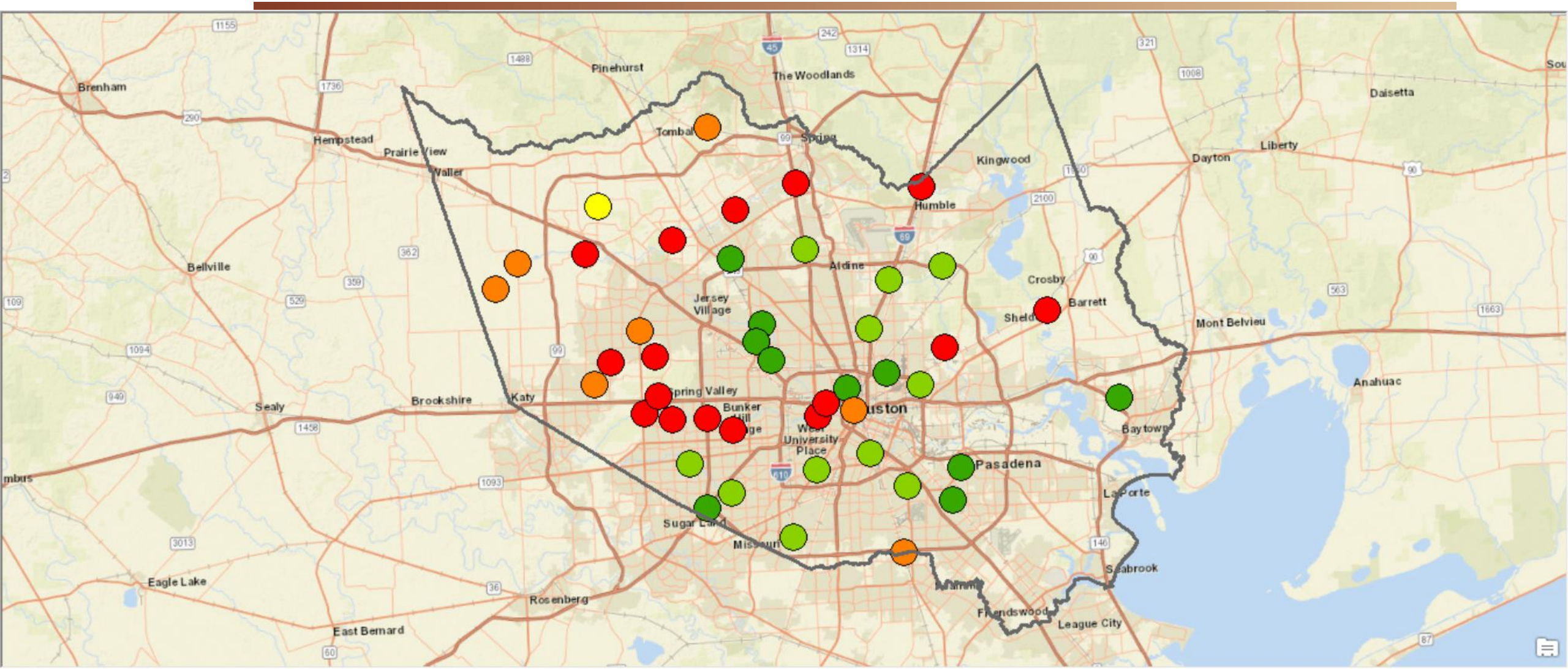
# Tuesday, August 27th



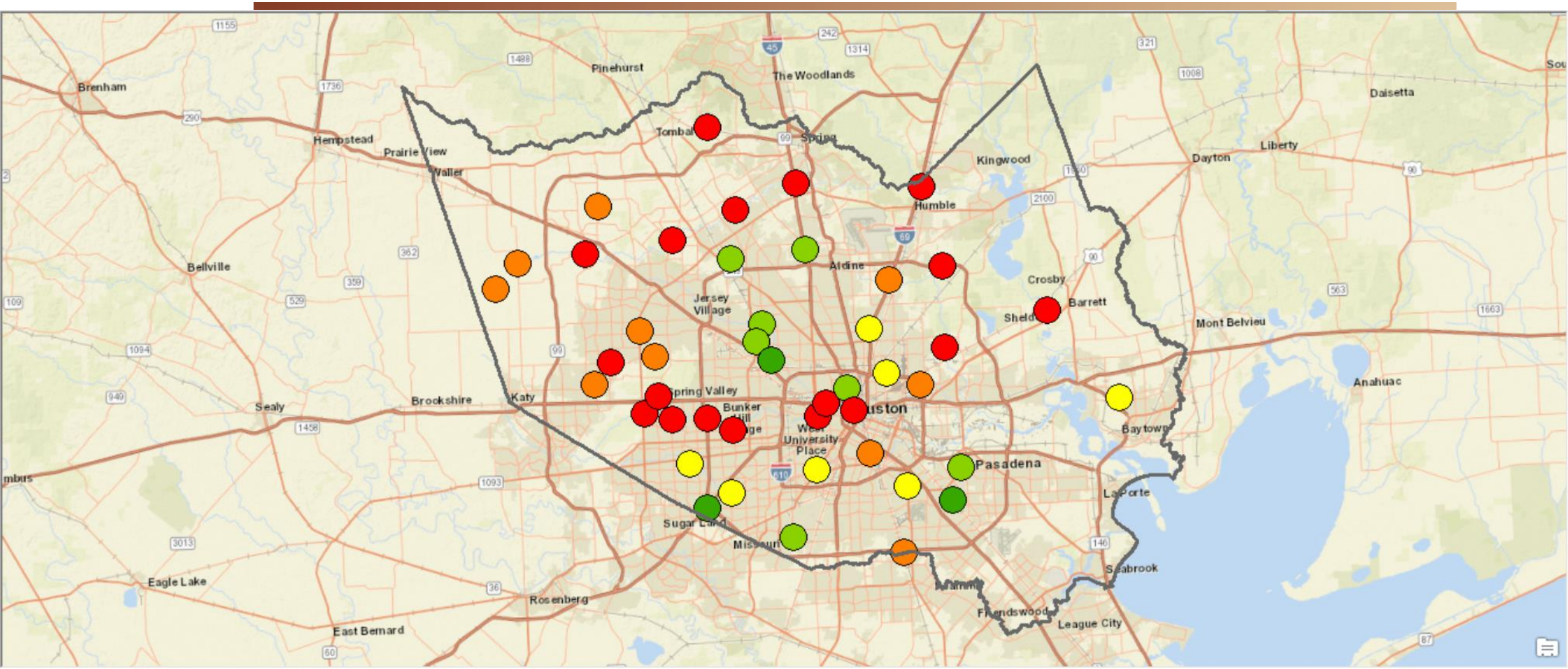
# Wednesday, August 28th



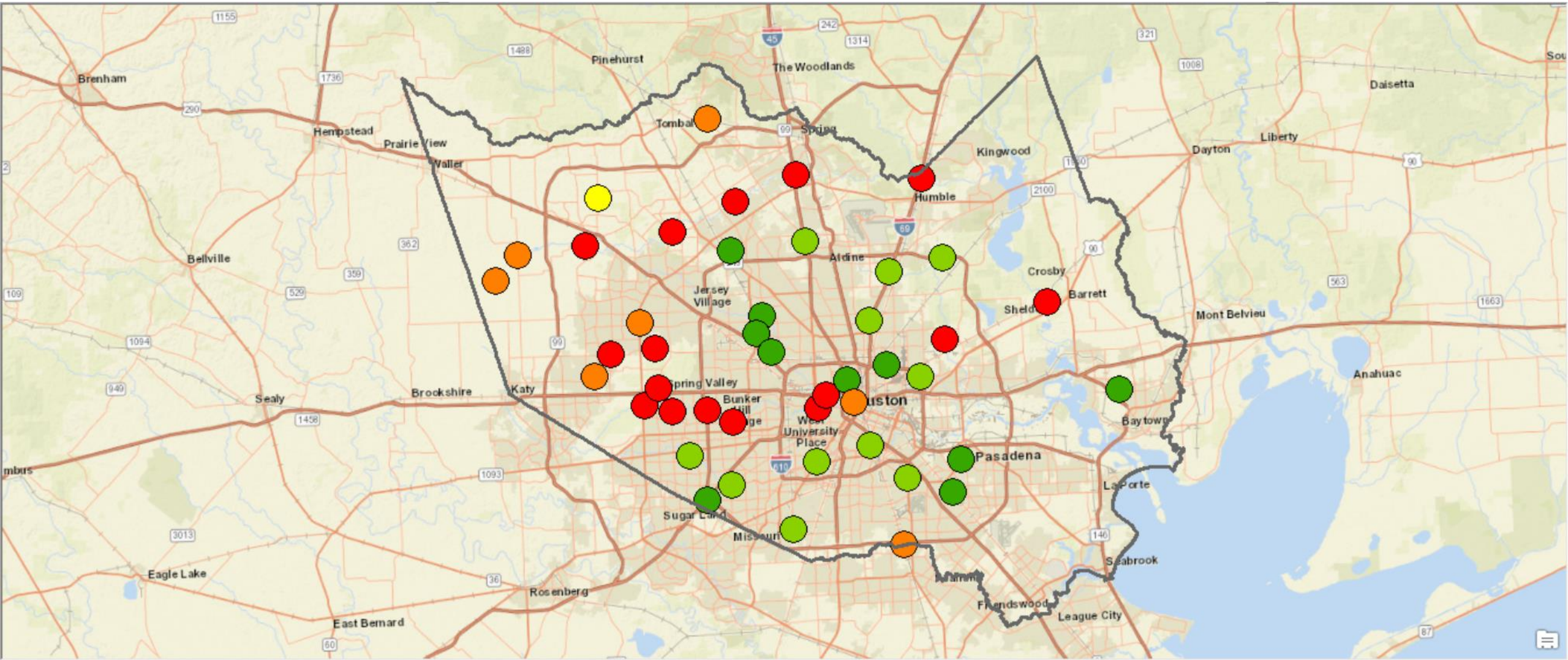
# Thursday, August 29th



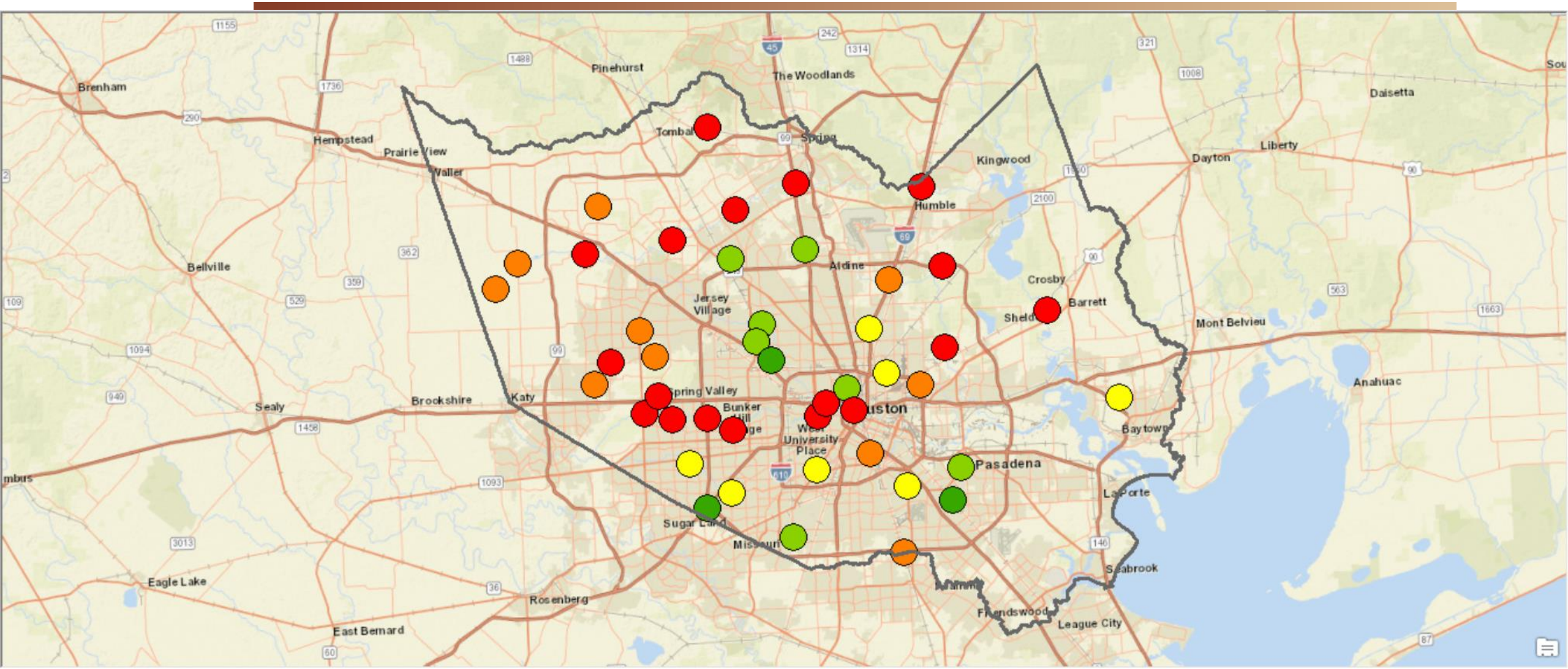
# Friday, August 30th



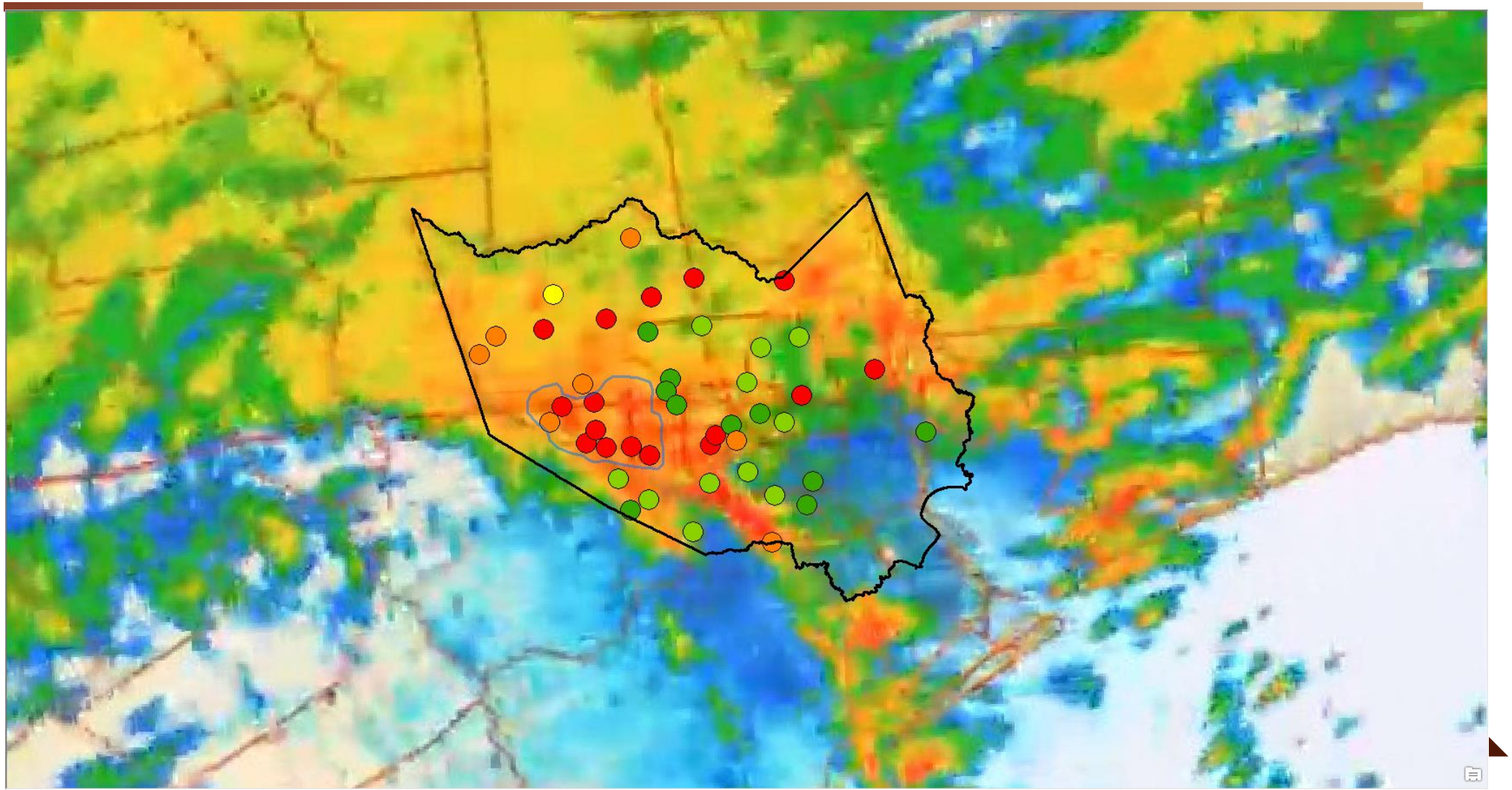
# Saturday, August 31st



# Sunday, September 1st



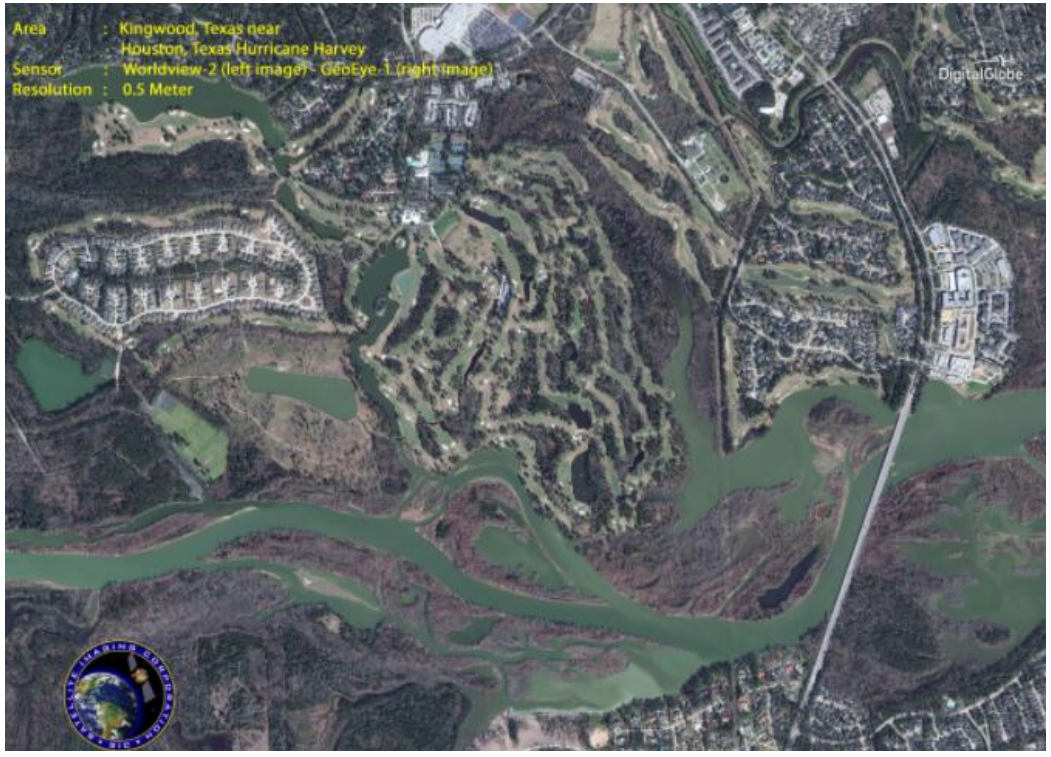
# Radar and Stream Gauge Data



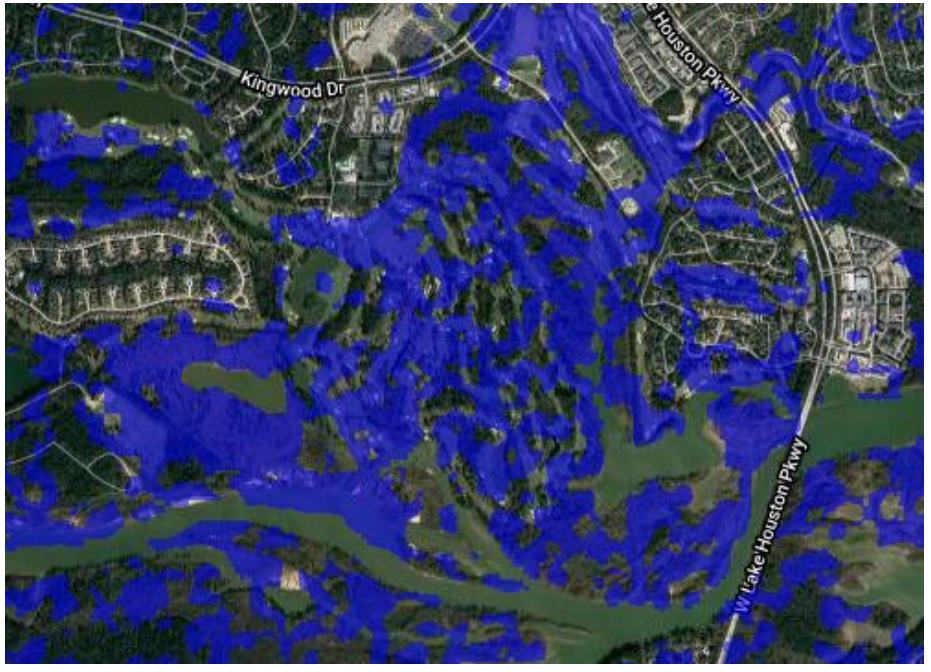
# Delineate Flooded Areas

- Derive areas of high risk utilizing stream guage and Radar data
- Use these areas to process SAR imagery
- Process while the event is occurring
- Identify flooded areas
  - Google Earth Engine – cloud computing for large datasets
  - Sentinel 1 SAR Imagery

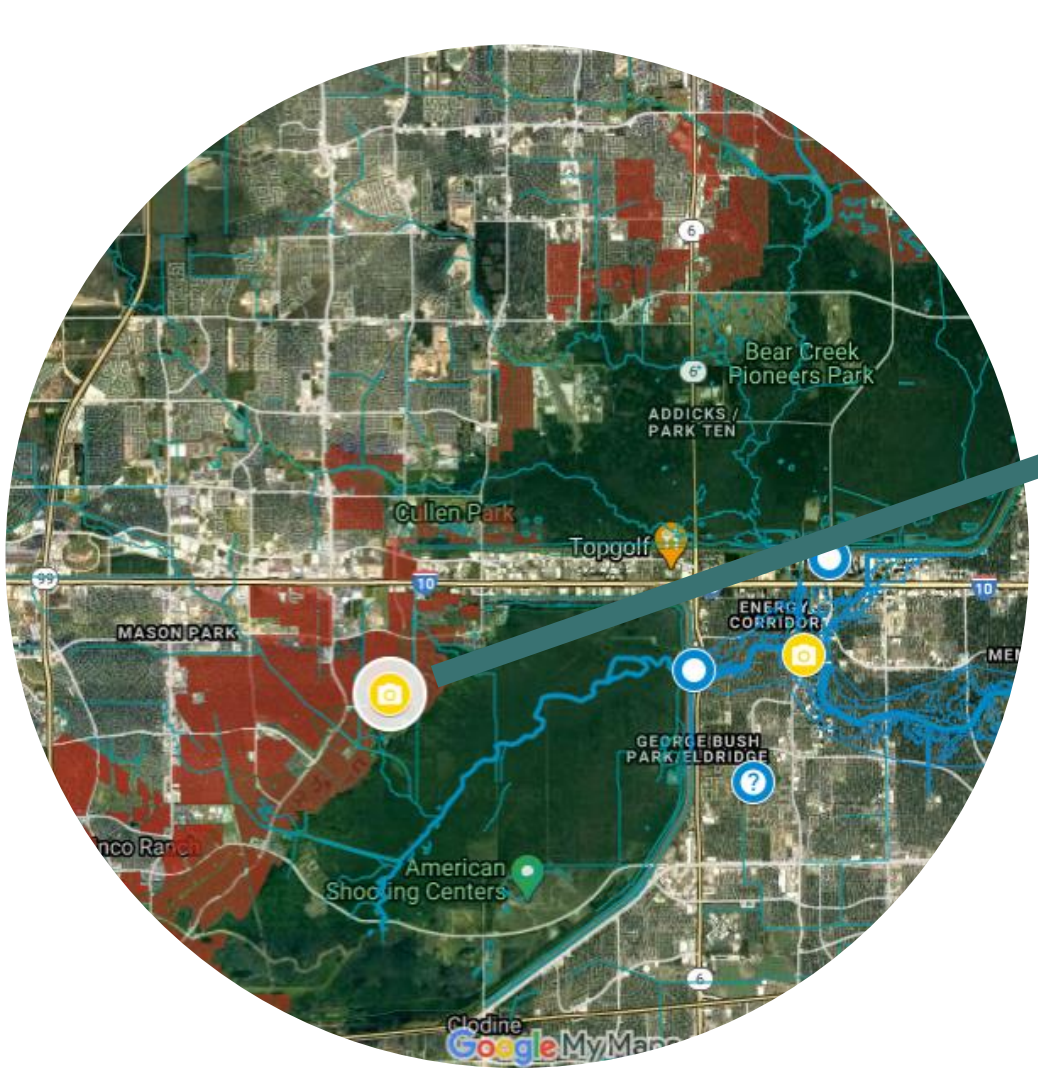
# Kingwood, TX

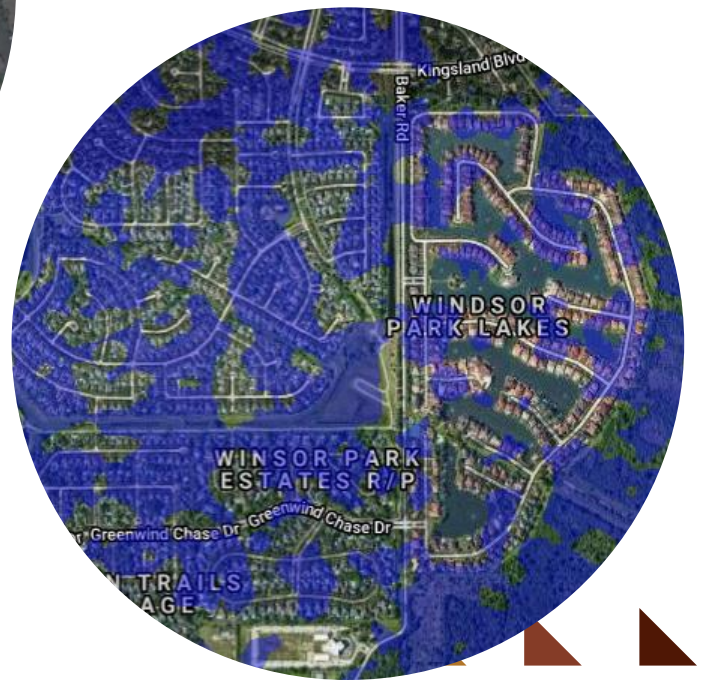

Area : Kingwood, Texas near
Houston, Texas Hurricane Harvey
Sensor : Worldview-2 (left image) - GeoEye-1 (right image)
Resolution : 0.5 Meter
DigitalGlobe

DigitalGlobe
Copyright © DigitalGlobe, All Rights Reserved

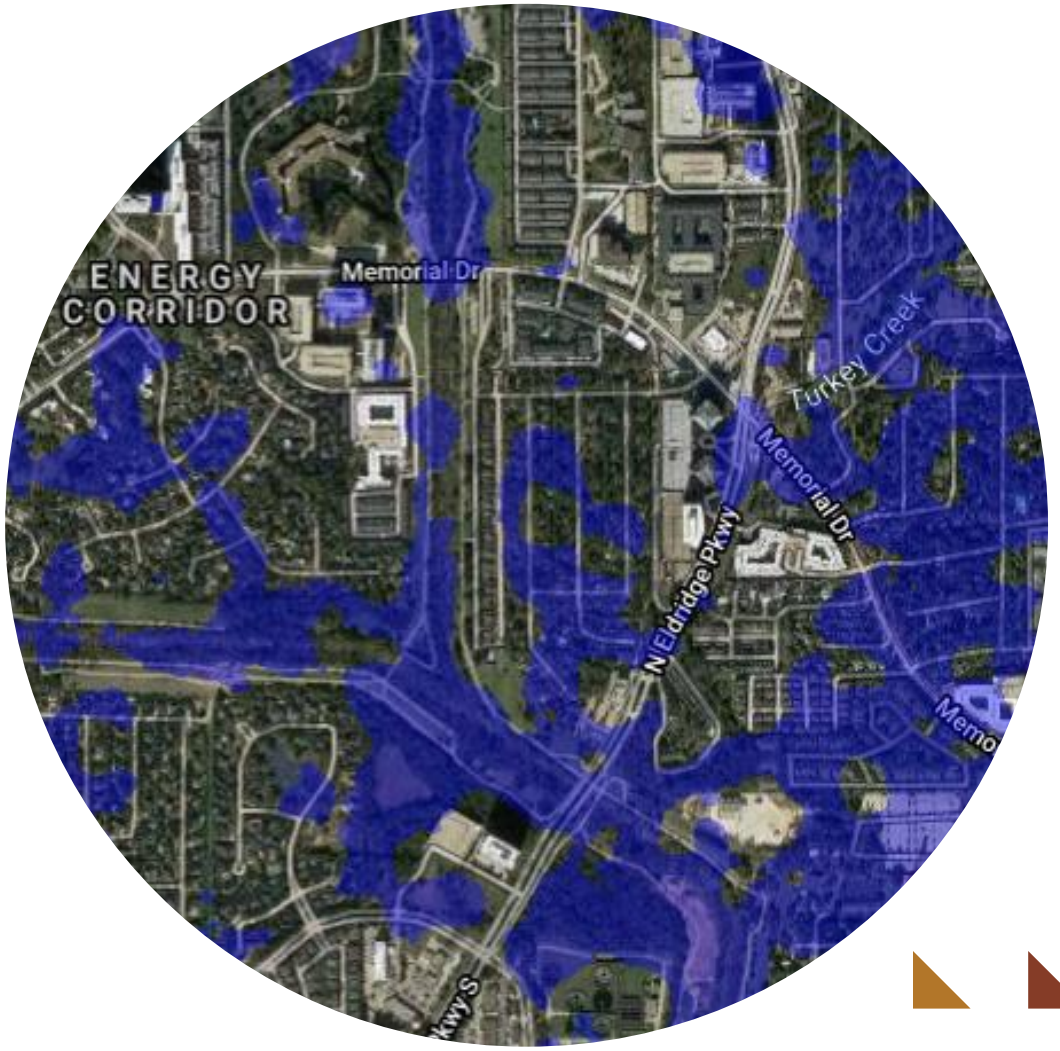

Kingwood Dr
Houston Pkwy
W Lake Houston Pkwy

# Validate Processed SAR Imagery with Actual Flooded Areas



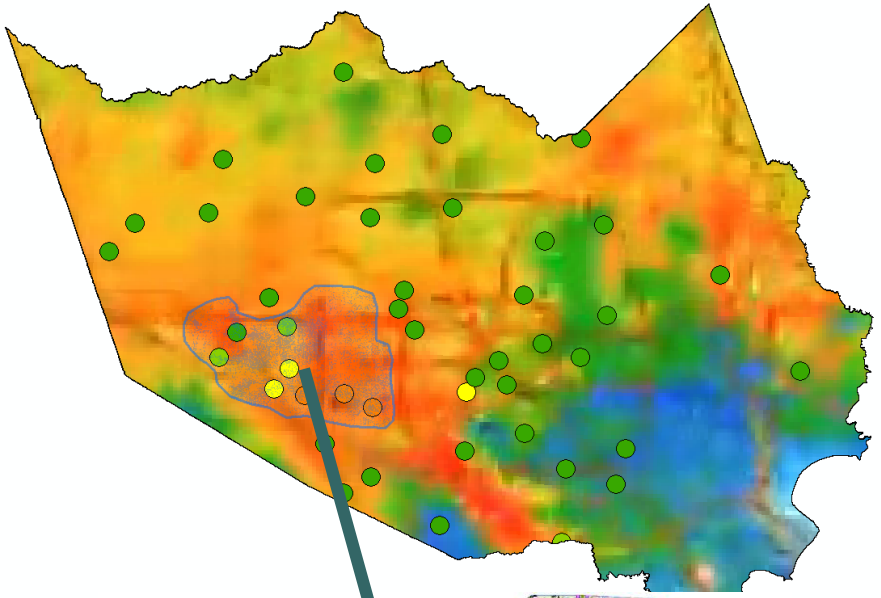


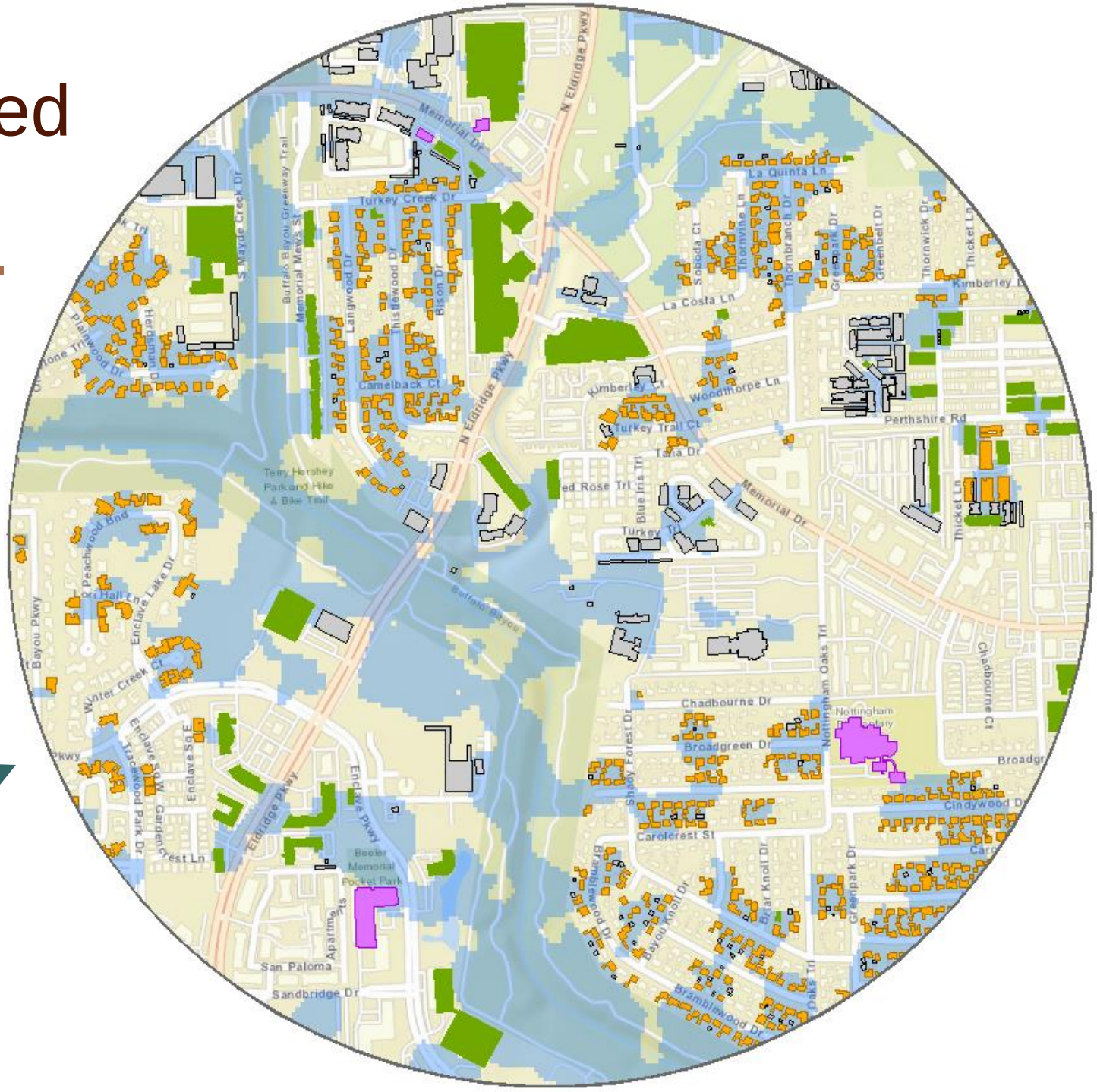
# Standing Water Areas

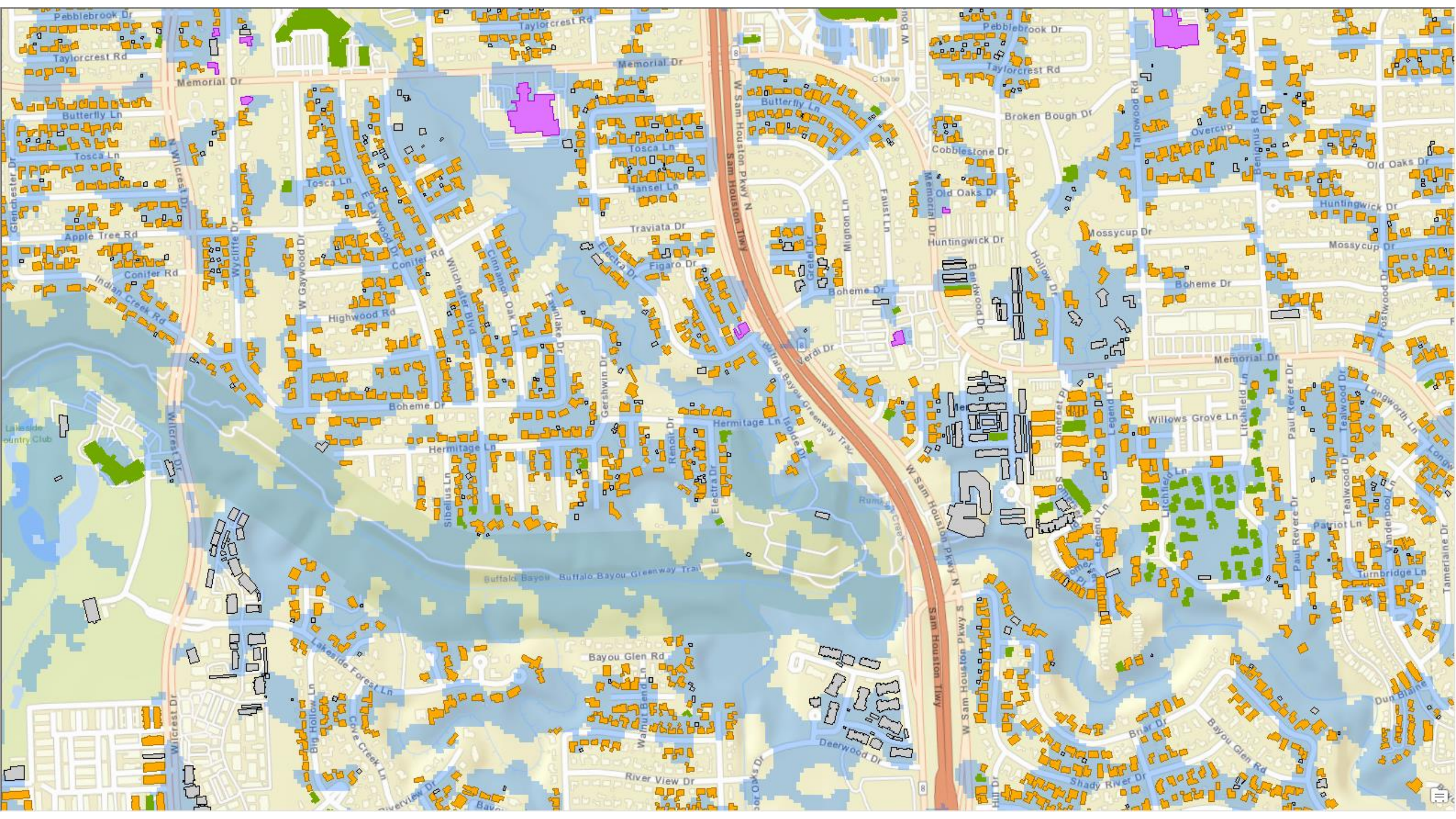


# Who Needs Us and Where?

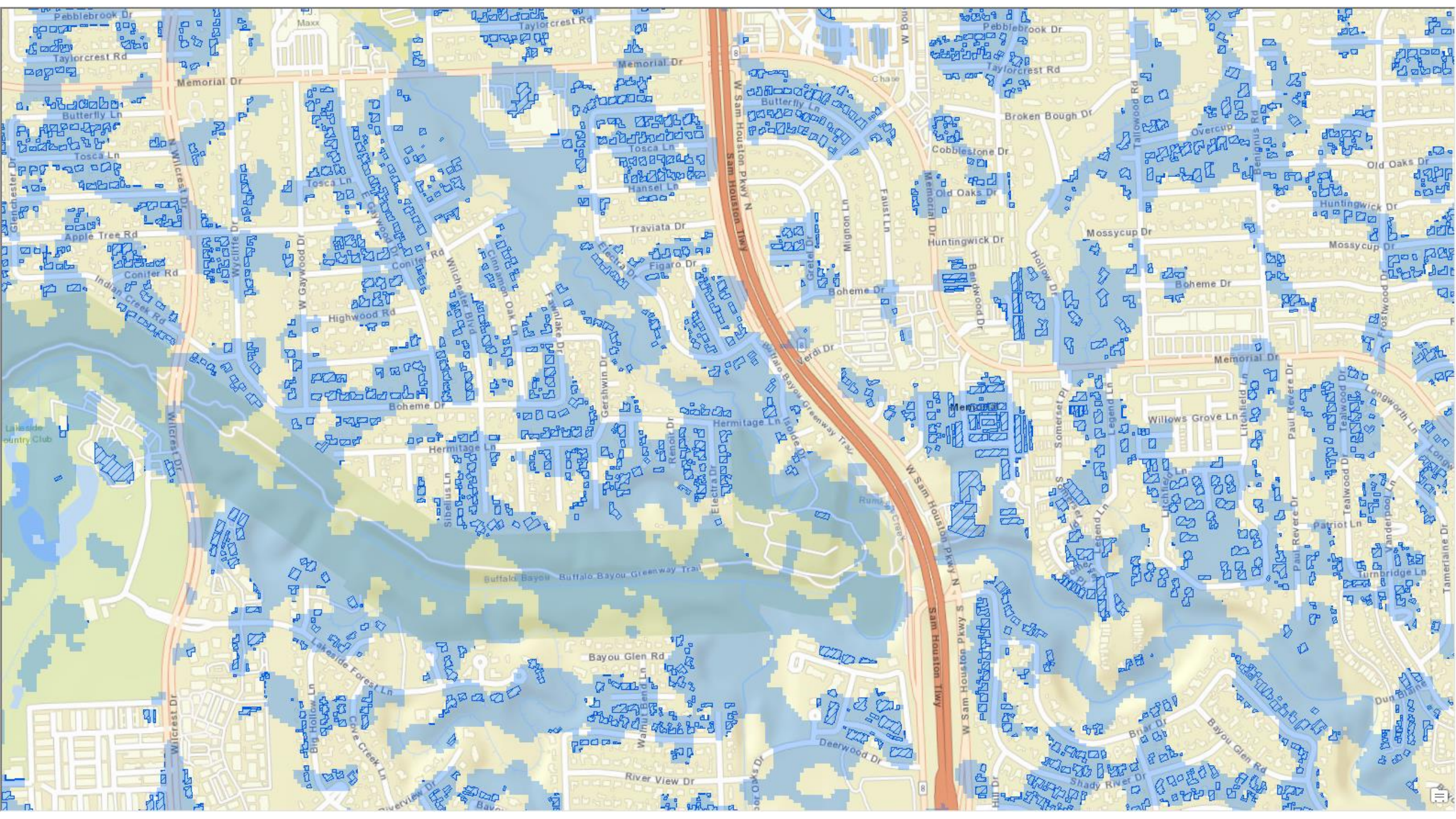
# Identify Impacted Areas







Pebblebrook Dr
Taylorcrest Rd
Memorial Dr
Butterfly Ln
Tosca Ln
Glenchester Dr
N Wilcrest Dr
Apple Tree Rd
Conifer Rd
Indian Creek Rd
Wycliffe Dr
W Gaywood Dr
E Gaywood Dr
Highwood Rd
Wilchester Blvd
Cinnamon Oak Ln
Fawnlake Dr
Gershwin Dr
Boheme Dr
Hermitage Ln
Sibelius Ln
Renoir Dr
Electra Dr
Hansel Ln
Traviata Dr
Figaro Dr
Buffalo Bayou Greenway Trail
Isolde Dr
Lakeside Country Club
Wilcrest Dr
Lakeside Forest Ln
Big Hollow Ln
Cove Creek Ln
Bayou Glen Rd
Walnut Bend Ln
River View Dr
Deerwood Dr
Sam Houston Pkwy N
W Sam Houston Tlwy
Sam Houston Pkwy S
Chase
Broken Bough Dr
Cobblestone Dr
Old Oaks Dr
Huntingwick Dr
Mignon Ln
Faust Ln
Gretel Dr
Bendwood Dr
Hollow Dr
Mossycup Dr
Tallowood Rd
Overcup
Benignus Rd
Frostwood Dr
Verdi Dr
Willows Grove Ln
Somerset Pl
Legend Ln
Litchfield Ln
Paul Revere Dr
Tealwood Dr
Longworth Ln
Patriot Ln
Vanderpool Ln
Turnbridge Ln
Tamerlaine Dr
Dun Blaine
Briar Dr
Shady River Dr
Hill Dr



Pebblebrook Dr
Taylorcrest Rd
Memorial Dr
Butterfly Ln
Tosca Ln
Apple Tree Rd
Conifer Rd
Indian Creek Rd
Highwood Rd
Wycliffe Dr
W Gaywood Dr
E Gaywood Dr
Wilchester Blvd
Cinnamon Oak Ln
Fawnlake Dr
Gershwin Dr
Boheme Dr
Hermitage Ln
Sibelius Ln
Renoir Dr
Electra Dr
Figaro Dr
Traviata Dr
Hansel Ln
Isolde Dr
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Buffalo Bayou Greenway Trail
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Cove Creek Ln
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Mossycup Dr
Hollow Dr
Bendwood Dr
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Mignon Ln
Gretel Dr
Verdi Dr
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Litchfield Ln
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Dun Blaine
Briar Dr
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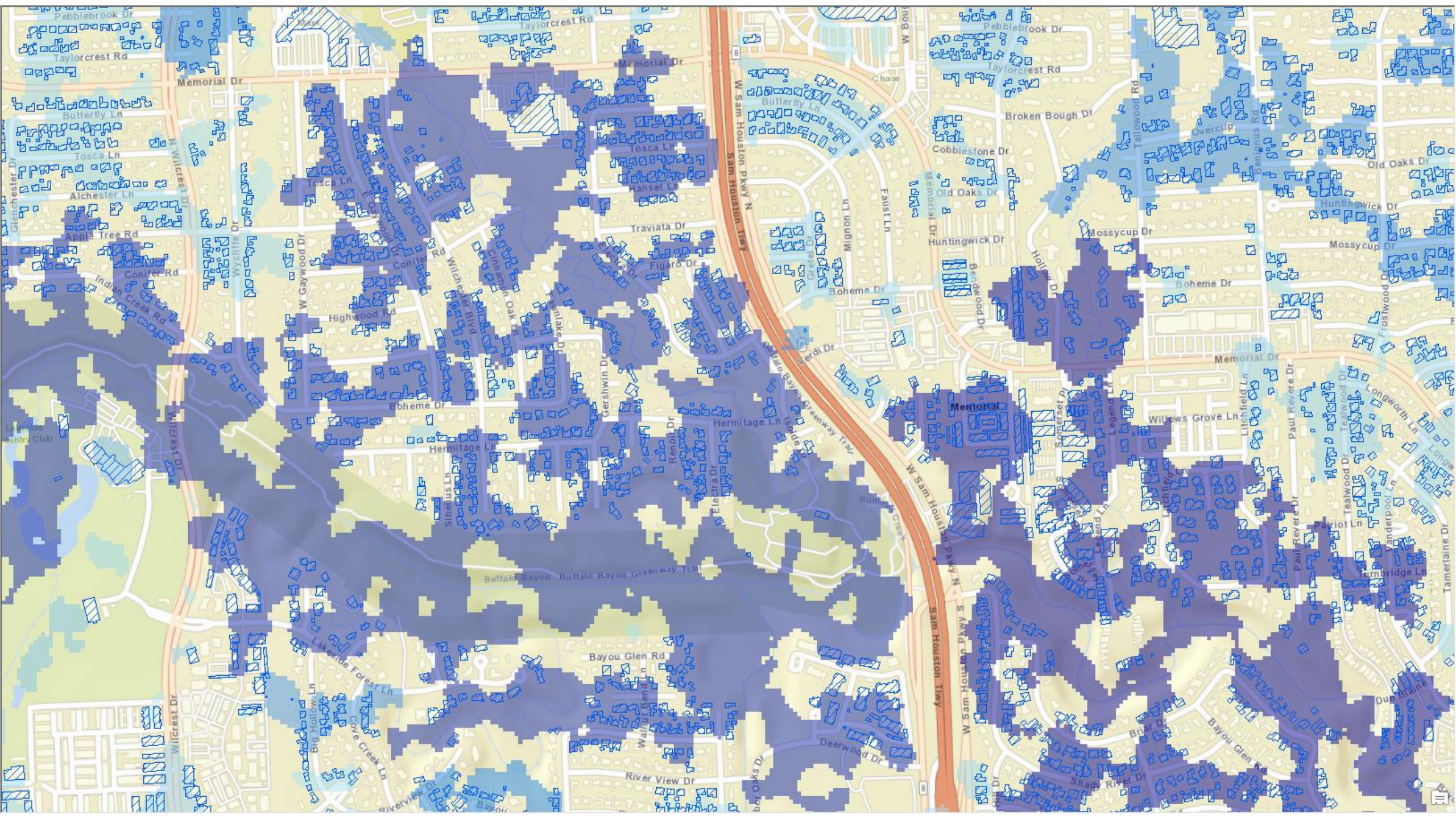
Hill Dr



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Rumlin Creek
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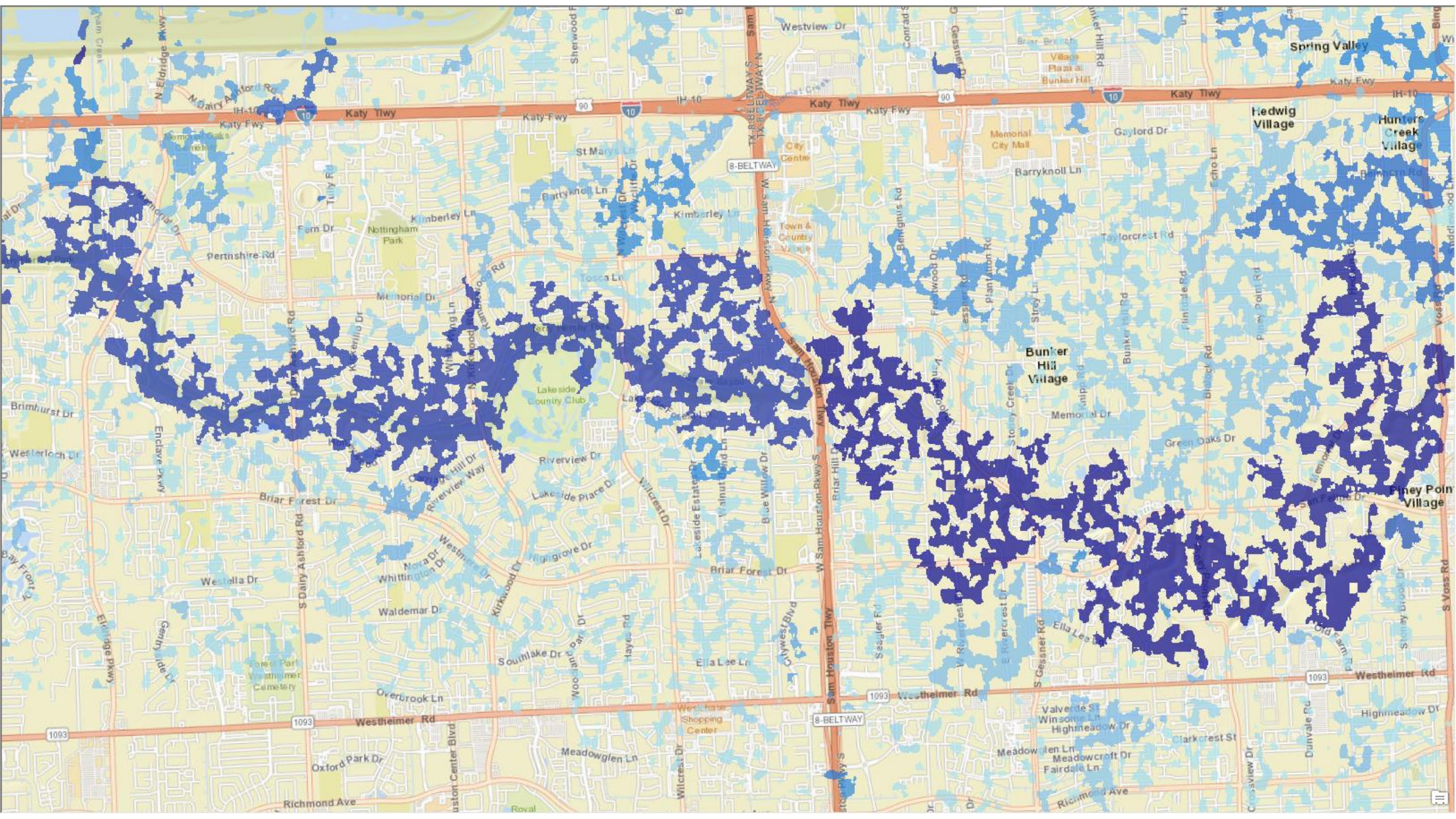
Wilcrest Dr
Country Club


Katy Fwy
IH-10
Katy Tlwy
8-BELTWAY
Westheimer Rd
1093
Bunker Hill Village
Hedwig Village
Spring Valley
Hunters Creek Village
Piney Point Village
Memorial City Mall
City Centre
Town & Country Village
Lakeside Country Club
Nottingham Park
Forest Park Westheimer Cemetery
Westchase Shopping Center
Westview Dr
St Marys Ln
Barryknoll Ln
Kimberley Ln
Fern Dr
Pertnshire Rd
Memorial Dr
Tosca Ln
Brimhurst Dr
Westerloch Dr
Briar Forest Dr
Riverview Dr
Lakeside Place Dr
Highgrove Dr
Waldemar Dr
Southlake Dr
Ella Lee Ln
Overbrook Ln
Meadowglen Ln
Oxford Park Dr
Richmond Ave
Gaylord Dr
Taylorcrest Rd
Green Oaks Dr
Highmeadow Dr
Meadowcroft Dr
Fairdale Ln
Clarkcrest St
Valverde St
Winsome Ln
Memorial Dr
Enclave Pkwy
Bay Front Dr
Glenn Side Dr
Elmridge Pkwy
S Dairy Ashford Rd
N Eldridge Pkwy
Tully Rd
Kirkwood Dr
Westmere Dr
Whittington Dr
Nora Dr
Westella Dr
Woodland Park Dr
Hayes Rd
Wilcrest Dr
Lakeside Estates Dr
Walnut Bend Ln
Blue Willow Dr
Briar Hill Dr
Citywest Blvd
Seagler Rd
Sam Houston Tlwy
W Sam Houston Pkwy S
TX-8 BELTWAY S
Sherwood Forest Dr
Bingnus Rd
Plantation Rd
Stacy Ln
Stacy Creek Dr
Bunker Hill Rd
Blalock Rd
Piney Point Rd
Flintdale Rd
Echo Ln
Conrad Sauer Dr
Gessner Rd
S Gessner Rd
Ella Lee
Old Farm Rd
Sunny Brook Dr
Dunvale Rd
Crossview Dr
S Voss Rd
Briar Branch
Village Plaza at Bunker Hill
Bunker Hill Rd
Memorial Oaks Cemetery
Memorial Dr
Tosca Ln
Kimberley Ln
Barryknoll Ln
Meadowglen Ln
Richmond Ave
Westheimer Rd
Katy Fwy
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8-BELTWAY
Sam Houston Tlwy
Spring Valley
Hedwig Village
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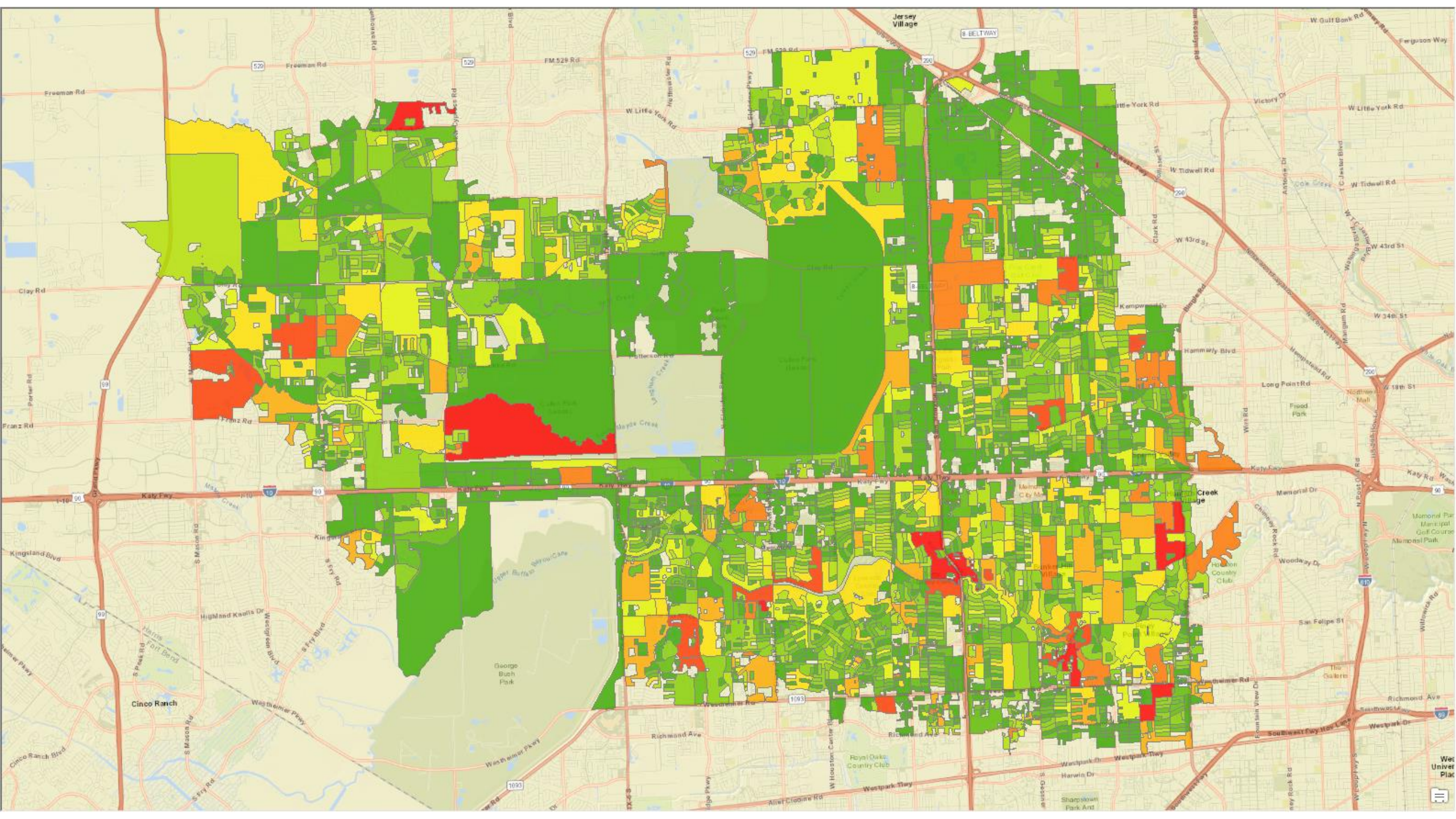
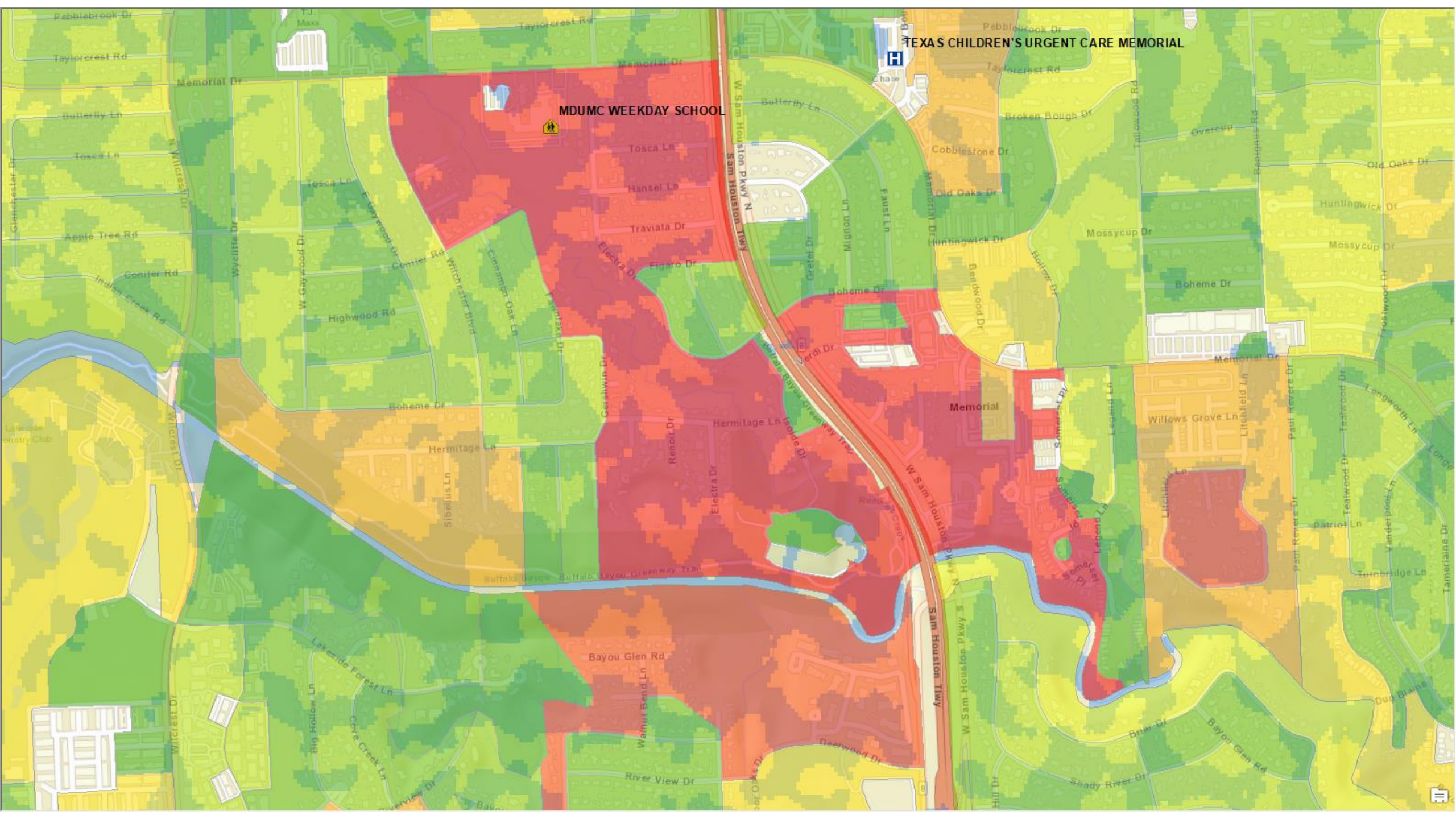
Bunker Hill Village
Piney Point Village



Jersey Village
8 BELTWAY
Freeman Rd
FM 529 Rd
W Little York Rd
Little York Rd
W Tidwell Rd
W 43rd St
Clay Rd
Kempwood Dr
Hammerly Blvd
Long Point Rd
Franz Rd
Katy Fwy
Memorial Dr
Kingsland Blvd
Highland Knolls Dr
Westheimer Pkwy
Westheimer Rd
Richmond Ave
Westpark Tlwy
Westpark Dr
Harwin Dr
Cinco Ranch
Cinco Ranch Blvd
George Bush Park
Royal Oaks Country Club
Memorial Park
Memorial Park Municipal Golf Course
Houston Country Club
San Felipe St
Woodway Dr
Richmond Ave
Southwest Fwy Hov Lane
Sharpstown Park And
Fred Park
Victory Dr
Antoine Dr
Mangum Rd
Hempstead Rd
Wirt Rd
Chinney Rock Rd
Wilmerdon Rd
Wilmerdon Rd
Fergusson Way
W Gulf Bank Rd
Kingsland Blvd
Porter Rd
S Mason Rd
S Fry Rd
S Peek Rd
Westgreen Blvd
Harris Fort Bend
Upper Buffalo Bayou Cane
Mayde Creek
Langham Creek
Clay Rd
Potterson Rd
Kempwood Dr
Bingle Rd
Clark Rd
Wirt Rd
Hempstead Rd
Mangum Rd
Katy Rd
Westheimer Rd
Westpark Dr
Westpark Tlwy
Alief Clodine Rd
Richmond Ave
Southwest Fwy
Westpark Dr
Fountain View Dr
Wilmerdon Rd
Wilmerdon Rd
Fergusson Way


TEXAS CHILDREN'S URGENT CARE MEMORIAL
MDUMC WEEKDAY SCHOOL
Memorial
Memorial Dr
Taylorcrest Rd
Butterfly Ln
Tosca Ln
Hansel Ln
Traviata Dr
Figaro Dr
Electra Dr
Boheme Dr
Hermitage Ln
Highwood Rd
Conifer Rd
Apple Tree Rd
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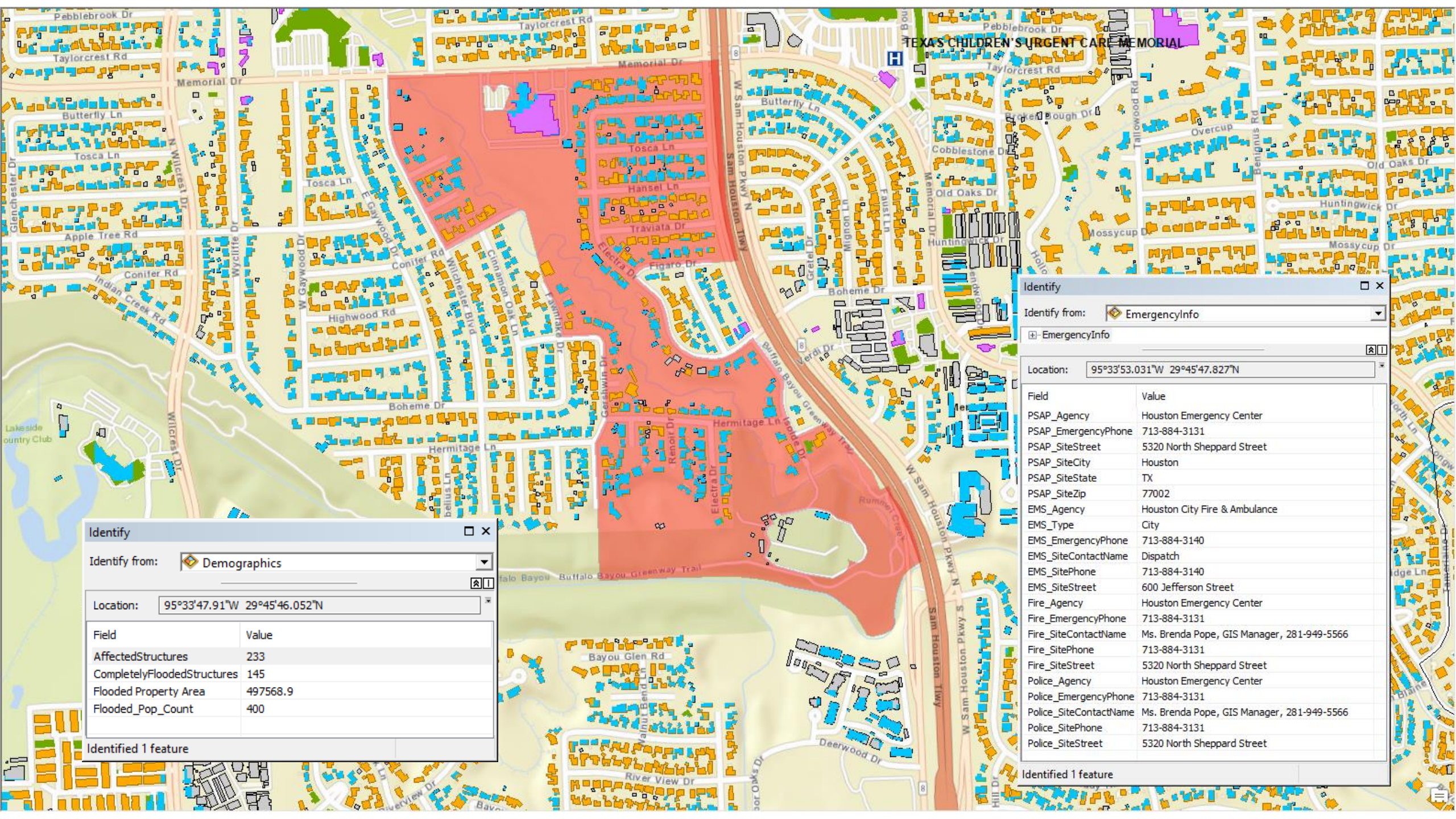
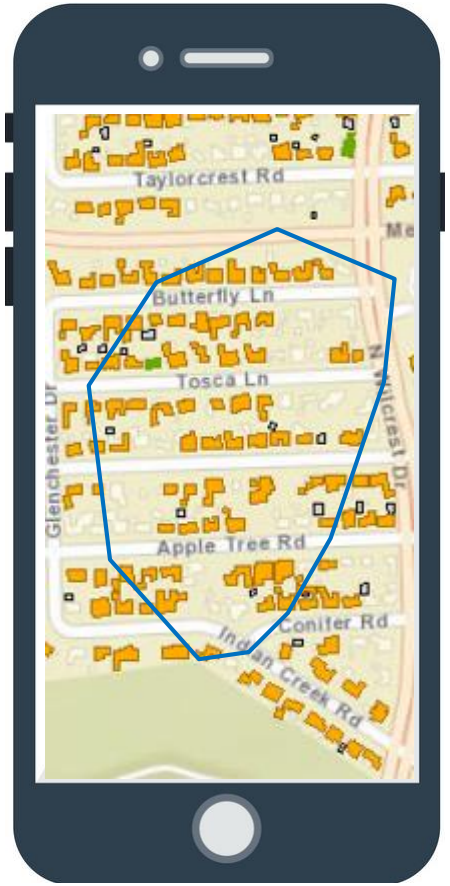
Pebblebrook Dr
Chase


TEXAS CHILDREN'S URGENT CARE MEMORIAL
Memorial Dr
Taylorcrest Rd
Butterfly Ln
Tosca Ln
Hansel Ln
Traviata Dr
Figaro Dr
Conifer Rd
Highwood Rd
Boheme Dr
Hermitage Ln
Bayou Glen Rd
River View Dr
Deerwood Dr
Old Oaks Dr
Huntingwick Dr
Mossycup Dr
Overcup
Cobblestone Dr
Sam Houston Pkwy N
W Sam Houston Pkwy S
Buffalo Bayou Greenway Trail
Identify
Identify from: Demographics
Location: 95°33'47.91"W 29°45'46.052"N
Field | Value
AffectedStructures | 233
CompletelyFloodedStructures | 145
Flooded Property Area | 497568.9
Flooded_Pop_Count | 400
Identified 1 feature
Identify
Identify from: EmergencyInfo
EmergencyInfo
Location: 95°33'53.031"W 29°45'47.827"N
Field | Value
PSAP_Agency | Houston Emergency Center
PSAP_EmergencyPhone | 713-884-3131
PSAP_SiteStreet | 5320 North Sheppard Street
PSAP_SiteCity | Houston
PSAP_SiteState | TX
PSAP_SiteZip | 77002
EMS_Agency | Houston City Fire & Ambulance
EMS_Type | City
EMS_EmergencyPhone | 713-884-3140
EMS_SiteContactName | Dispatch
EMS_SitePhone | 713-884-3140
EMS_SiteStreet | 600 Jefferson Street
Fire_Agency | Houston Emergency Center
Fire_EmergencyPhone | 713-884-3131
Fire_SiteContactName | Ms. Brenda Pope, GIS Manager, 281-949-5566
Fire_SitePhone | 713-884-3131
Fire_SiteStreet | 5320 North Sheppard Street
Police_Agency | Houston Emergency Center
Police_EmergencyPhone | 713-884-3131
Police_SiteContactName | Ms. Brenda Pope, GIS Manager, 281-949-5566
Police_SitePhone | 713-884-3131
Police_SiteStreet | 5320 North Sheppard Street
Identified 1 feature

# Next Steps

- Automate process/Integrate
- Utilize cloud computing
- Draw your area on a mobile app in near real time
- Augment data with local authoritative datasets



# Credits

- USGS – Live stream gauge data
- NOAA – Radar Images
- Google Earth Engine
  - Cloud computing
  - Sentinel1
- Esri
  - Living Atlas
  - ArcGIS Online
- Precisely
  - Cameo USA
  - Building Footprints
  - EmergencyInfo. Pro
  - World Points of Interest – Premium Plus
- Capella
  - Sample Imagery Slides

# Q&A

- Who needs this information?
- What is missing?

# Contact Information

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