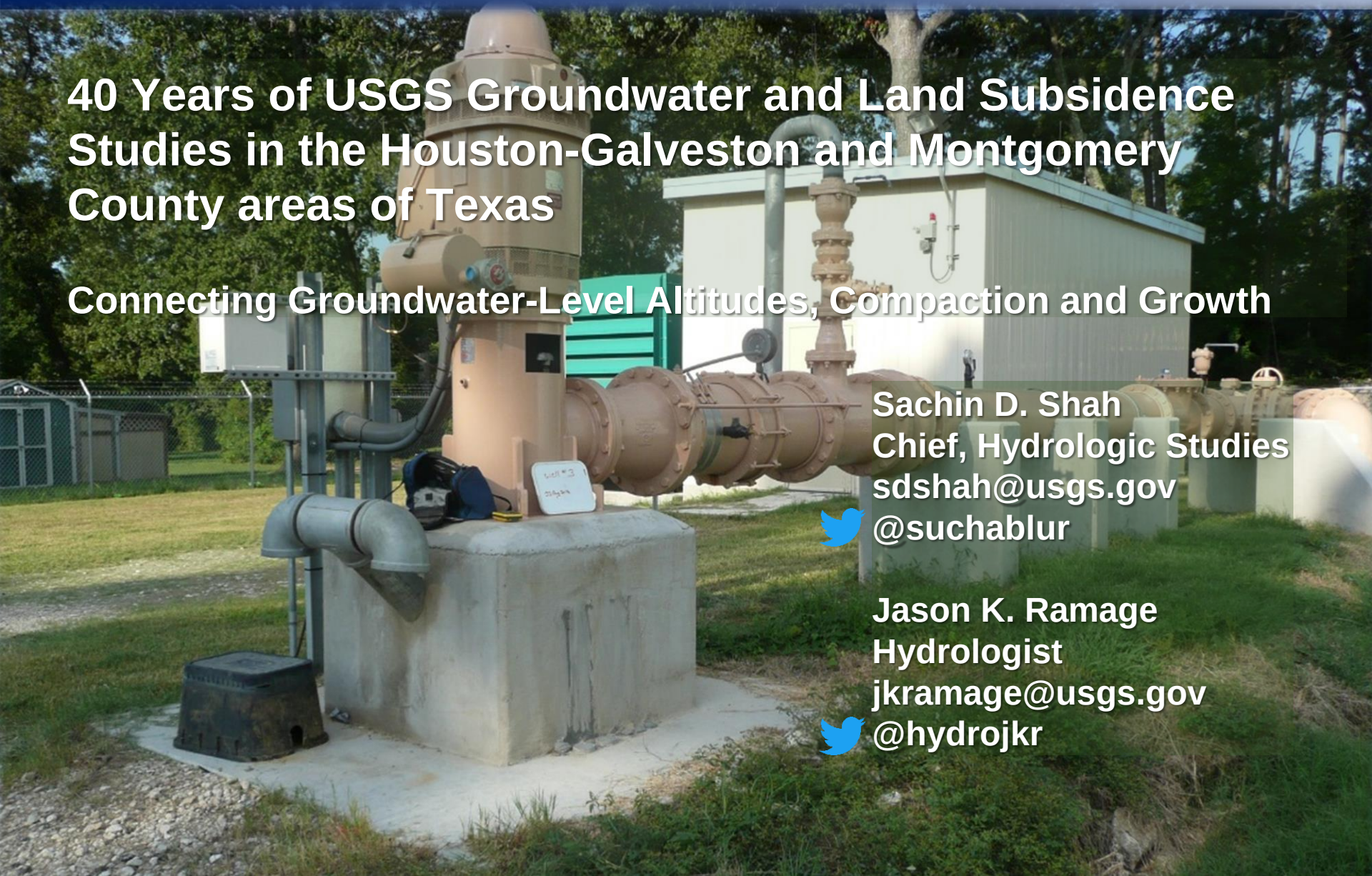
USGS science for a changing world

@USGS_Texas

40 Years of USGS Groundwater and Land Subsidence Studies in the Houston-Galveston and Montgomery County areas of Texas

Connecting Groundwater-Level Altitudes, Compaction and Growth



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@suchablur

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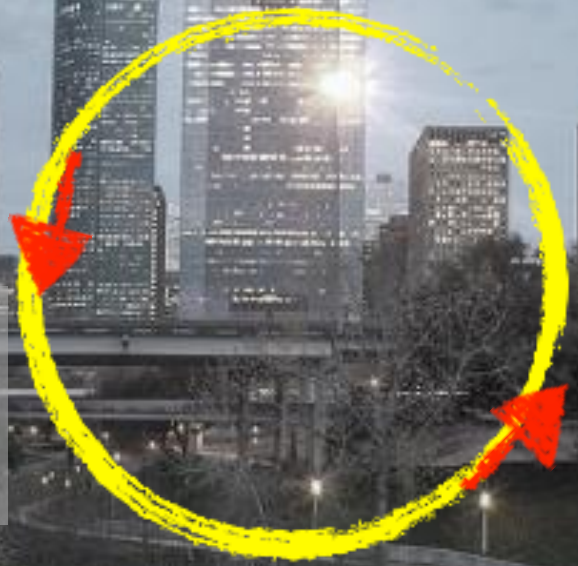
@hydrojkr

The Scientific Story

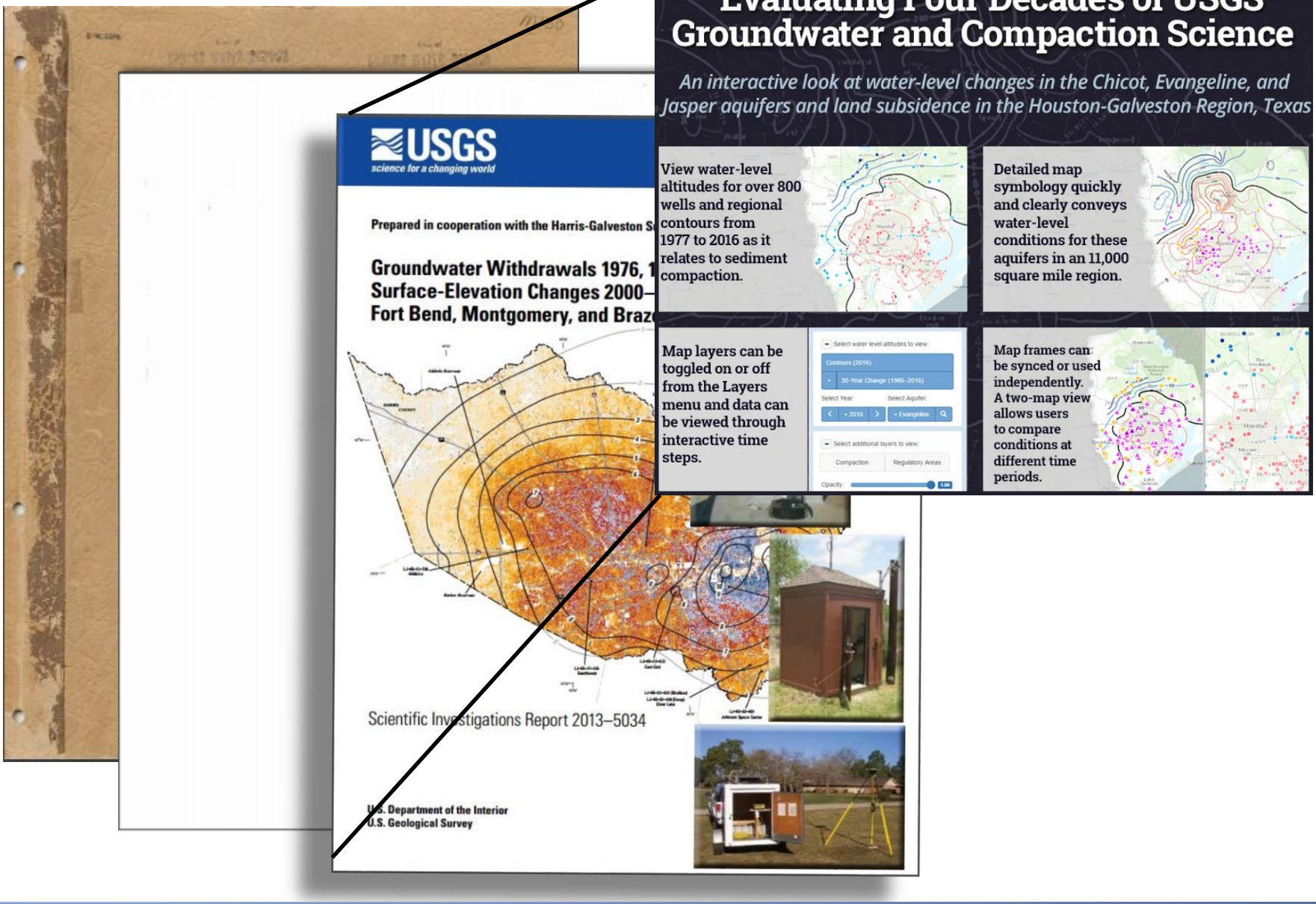
Drivers

- Population growth
- Groundwater withdrawal



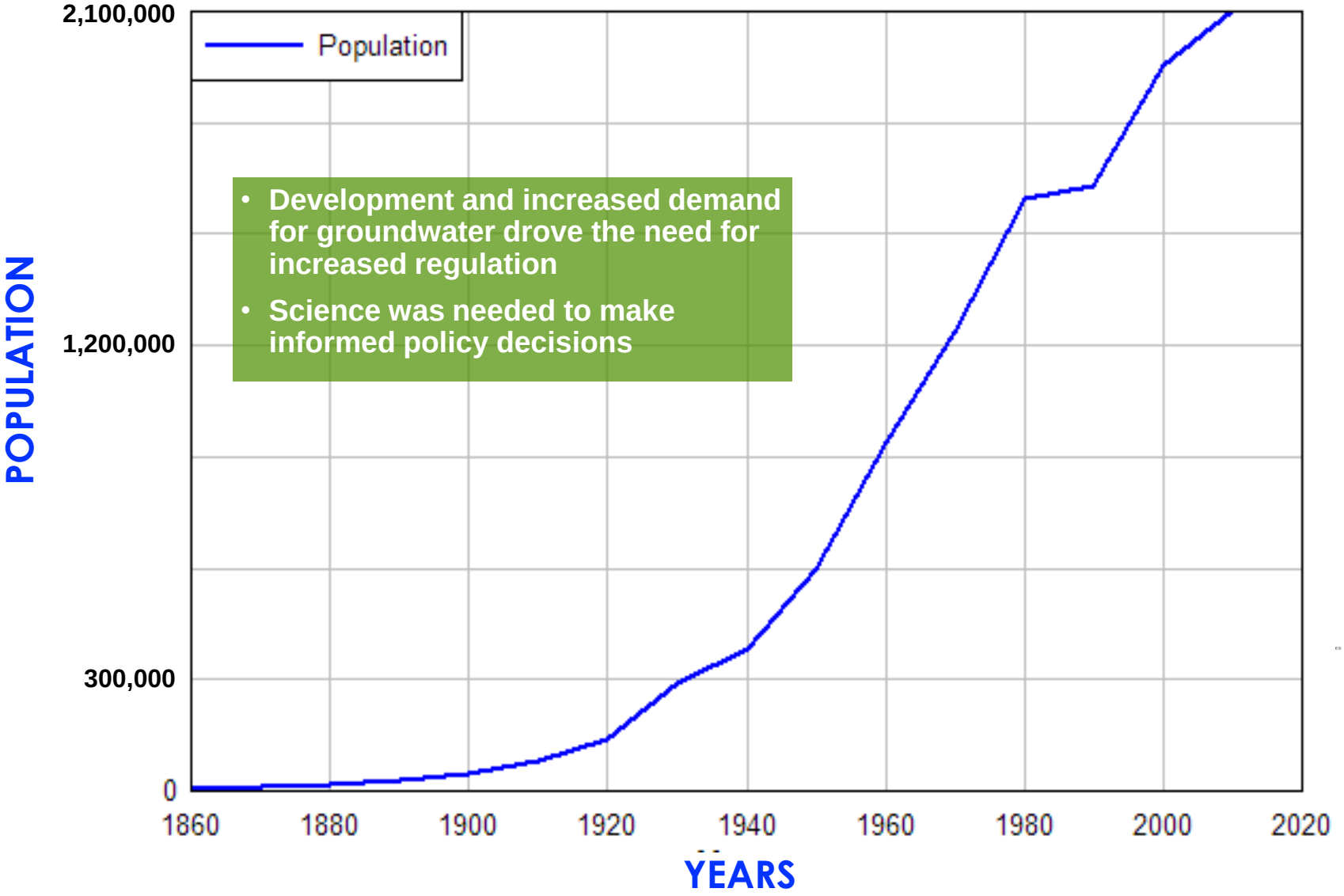
Science

- Regional depiction
- Scientific role: developing the story over time
- Data collection
- Scientific communication - Why has it changed?


USGS
science for a changing world
Prepared in cooperation with the Harris-Galveston S
Groundwater Withdrawals 1976, 1
Surface-Elevation Changes 2000–
Fort Bend, Montgomery, and Braz
Scientific Investigations Report 2013–5034
U.S. Department of the Interior
U.S. Geological Survey
Evaluating Four Decades of USGS Groundwater and Compaction Science
An interactive look at water-level changes in the Chicot, Evangeline, and Jasper aquifers and land subsidence in the Houston-Galveston Region, Texas
View water-level altitudes for over 800 wells and regional contours from 1977 to 2016 as it relates to sediment compaction.
Detailed map symbology quickly and clearly conveys water-level conditions for these aquifers in an 11,000 square mile region.
Map layers can be toggled on or off from the Layers menu and data can be viewed through interactive time steps.
Select water level altitudes to view:
Contours (2016)
30-Year Change (1986–2016)
Select Year:
Select Aquifer:
2016
Evangeline
Select additional layers to view:
Compaction
Regulatory Areas
Opacity:
Map frames can be synced or used independently. A two-map view allows users to compare conditions at different time periods.

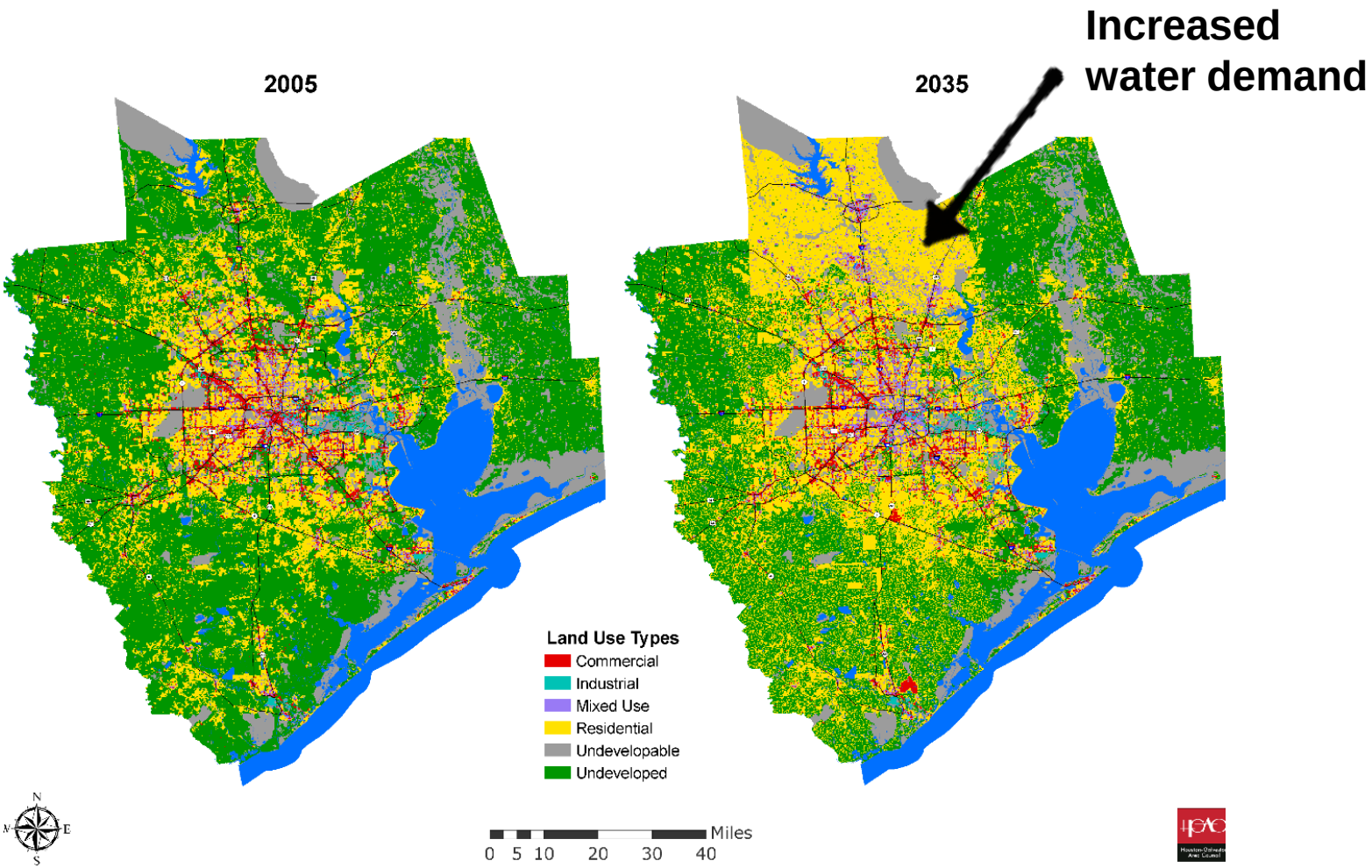
Long-Term Monitoring

Population Growth in Houston, Growth



- Development and increased demand for groundwater drove the need for increased regulation
- Science was needed to make informed policy decisions

Land Use


Increased water demand
2005
2035
Land Use Types
Commercial
Industrial
Mixed Use
Residential
Undevelopable
Undeveloped
N
S
E
W
Miles
0 5 10 20 30 40

History of Water Use and USGS involvement

Groundwater Withdrawals Begin

Primarily from the Chicot and Evangeline aquifers.

1836

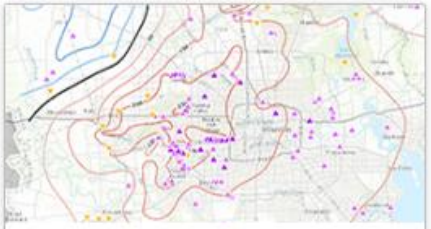
Groundwater Withdrawals Exceed 450 Million Gallons per Day

1975

Groundwater Withdrawal from Jasper Aquifer Increases

Withdrawals increase as urban growth spreads northward.

2000



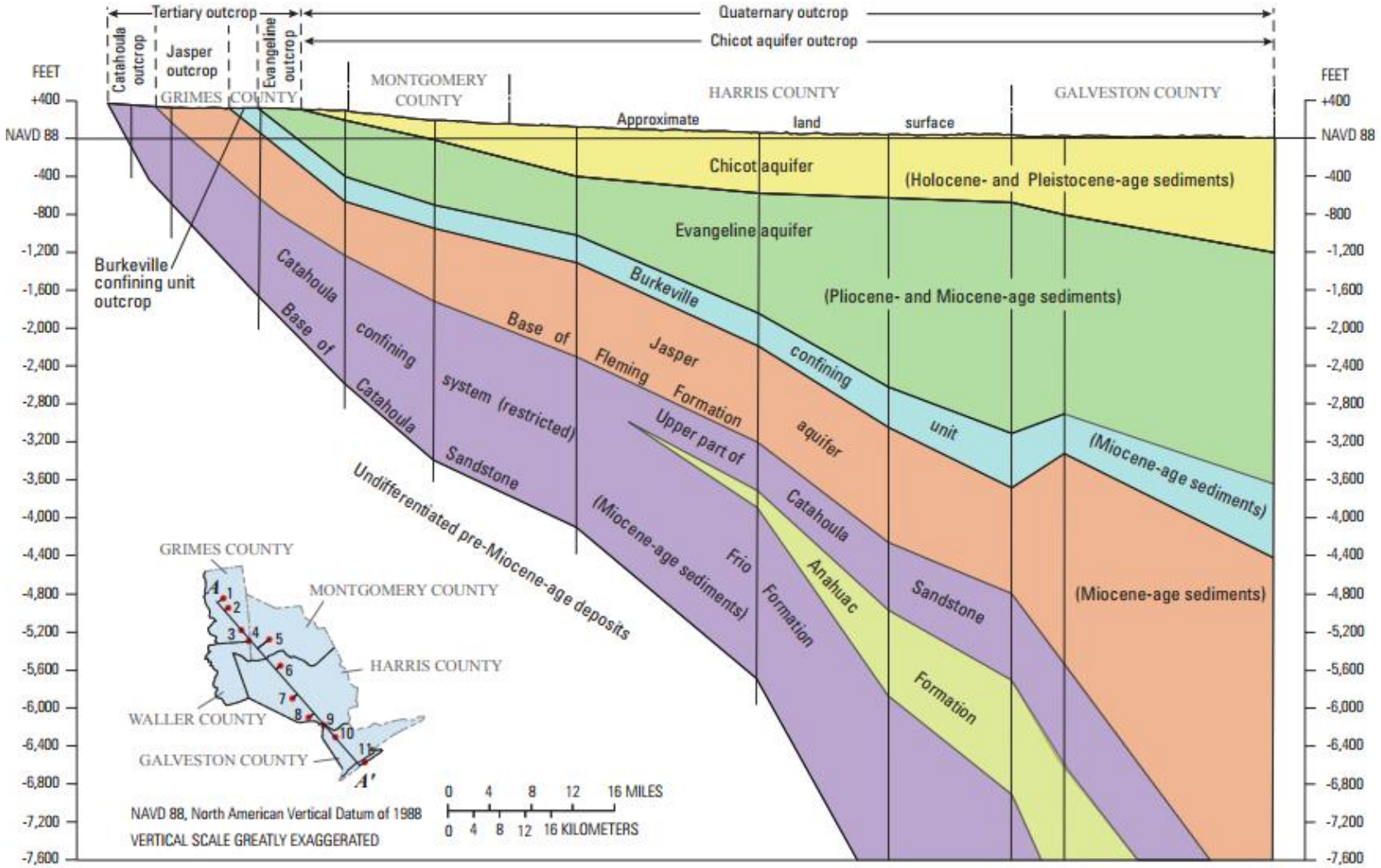
Groundwater Levels Rise and Fall

Groundwater levels rise: 100 ft (Chicot) and 200 ft (Evangeline). Groundwater levels decline: 100 ft (Jasper).

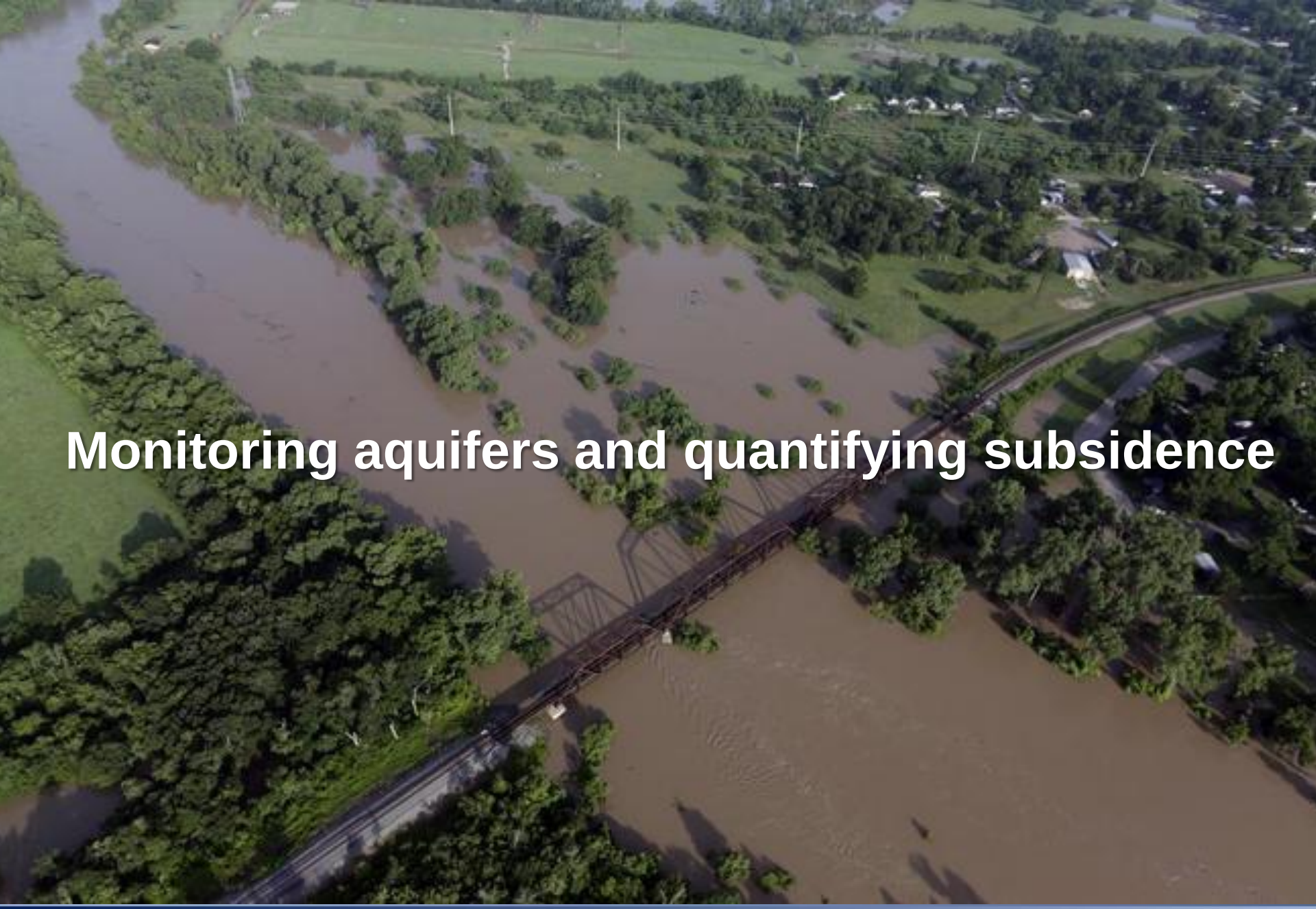
2015

Increase in Jasper aquifer water use

Hydrogeology

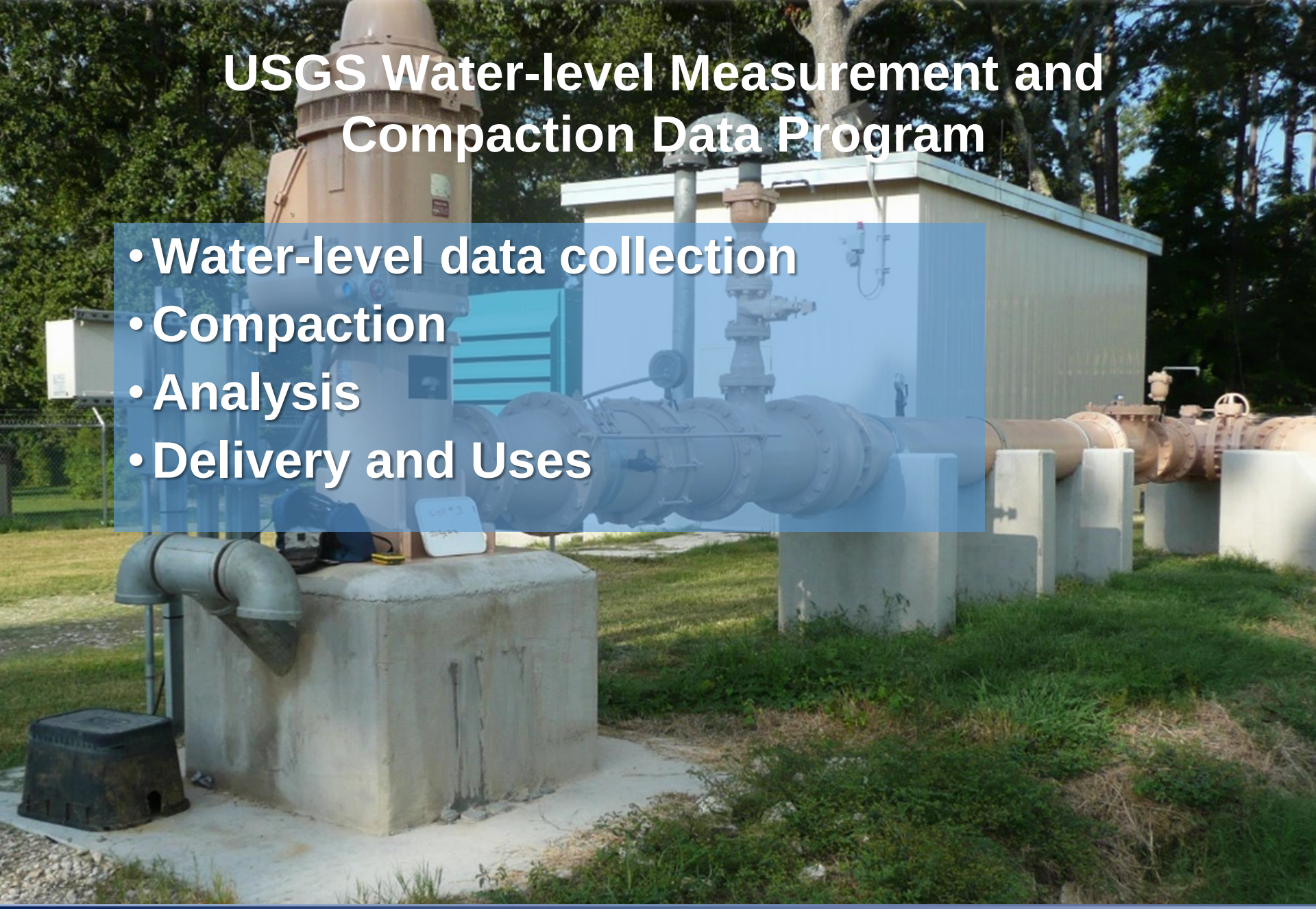


Modified from Baker (1979)



USGS

USGS Water-level Measurement and Compaction Data Program



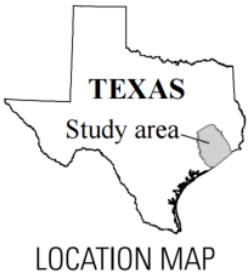
- Water-level data collection
- Compaction
- Analysis
- Delivery and Uses

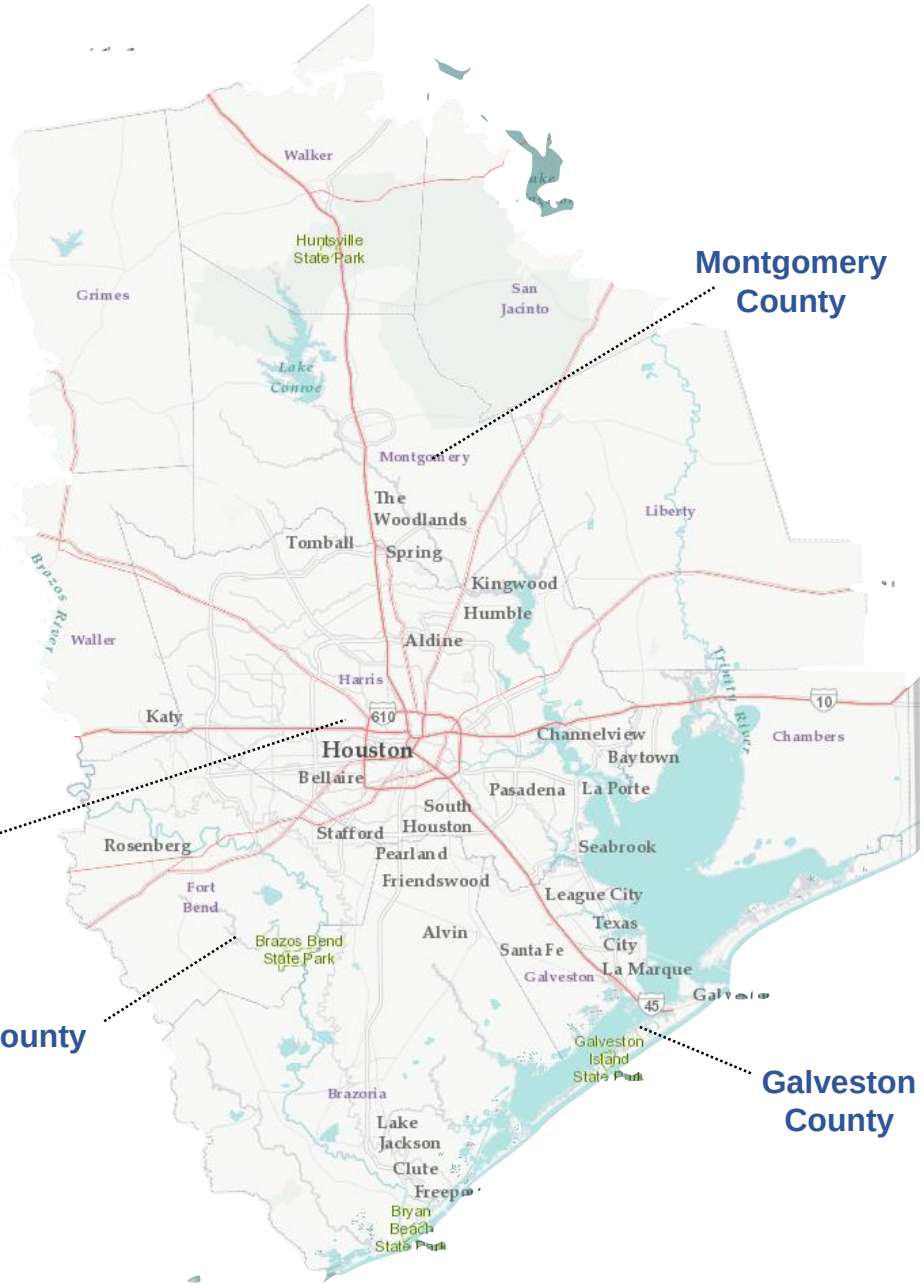
USGS

Overview of Study

- **Approach and Methodology**
  - Collect approximately 700 water-levels
  - Gulf Coast Aquifer System (Chicot, Evangeline, Jasper)
  - 11,000 square mile area

- **Aquifer Map Interpretations**
  - Annual water-level altitude
  - 1-year water-level change
  - Long-term water-level change
  - Measured cumulative compaction


TEXAS
Study area
LOCATION MAP


Montgomery County
Harris County
Fort Bend County
Galveston County
Walker
Huntsville State Park
Grimes
San Jacinto
Lake Conroe
Montgomery
The Woodlands
Liberty
Tomball
Spring
Kingwood
Humble
Aldine
Waller
Brazos River
Harris
Katy
610
Houston
Channelview
Baytown
Chambers
Trinity River
10
Bellaire
Pasadena
La Porte
South Houston
Stafford
Rosenberg
Seabrook
Pearland
Friendswood
League City
Fort Bend
Alvin
Texas City
Brazos Bend State Park
Santa Fe
La Marque
Galveston
45
Galveston Island State Park
Brazoria
Lake Jackson
Clute
Freeport
Bryan Beach State Park

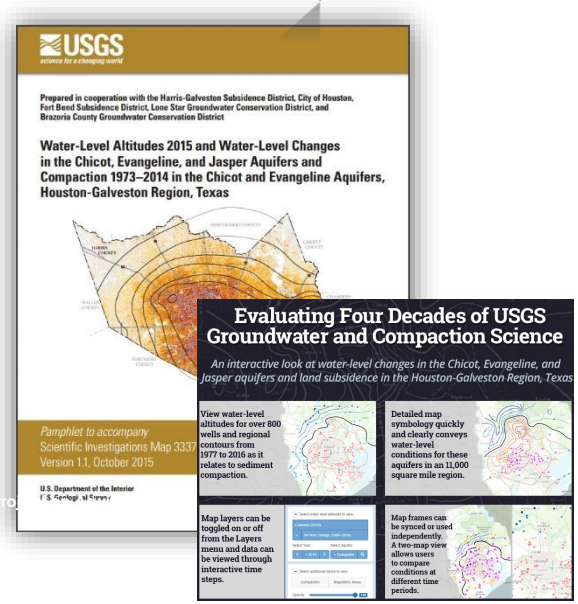
Annual Groundwater and Subsidence Program

Initial planning:
Field maps, Software, Logistics

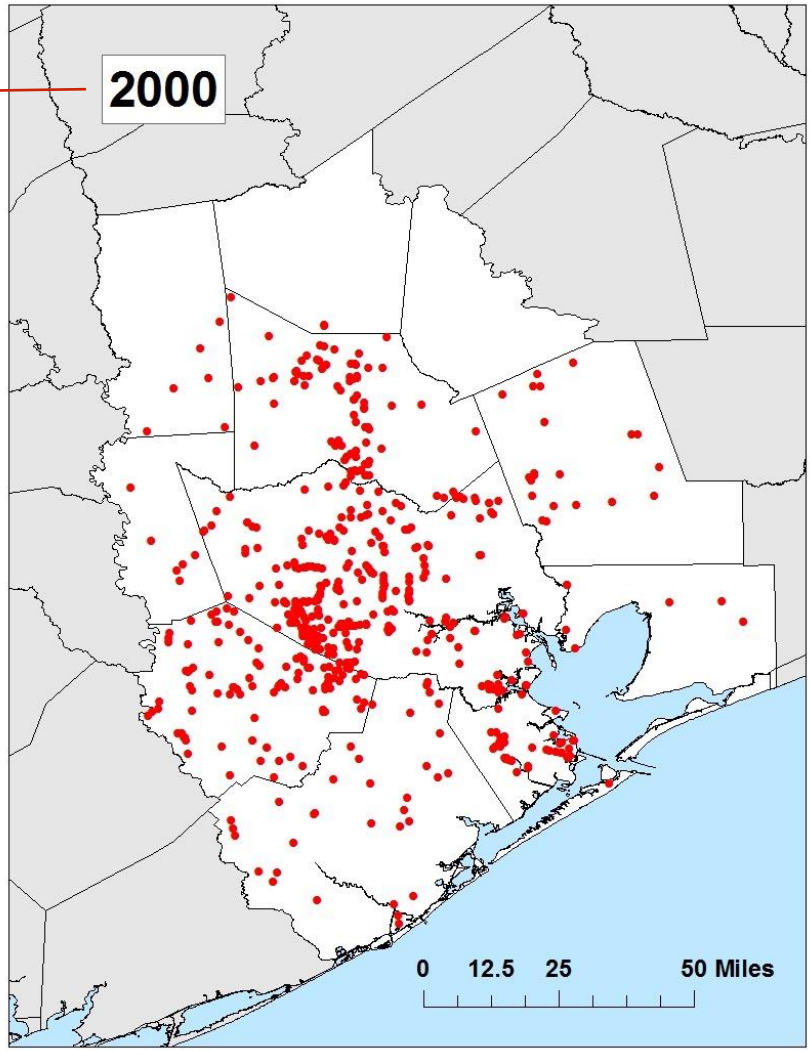
Data gathering

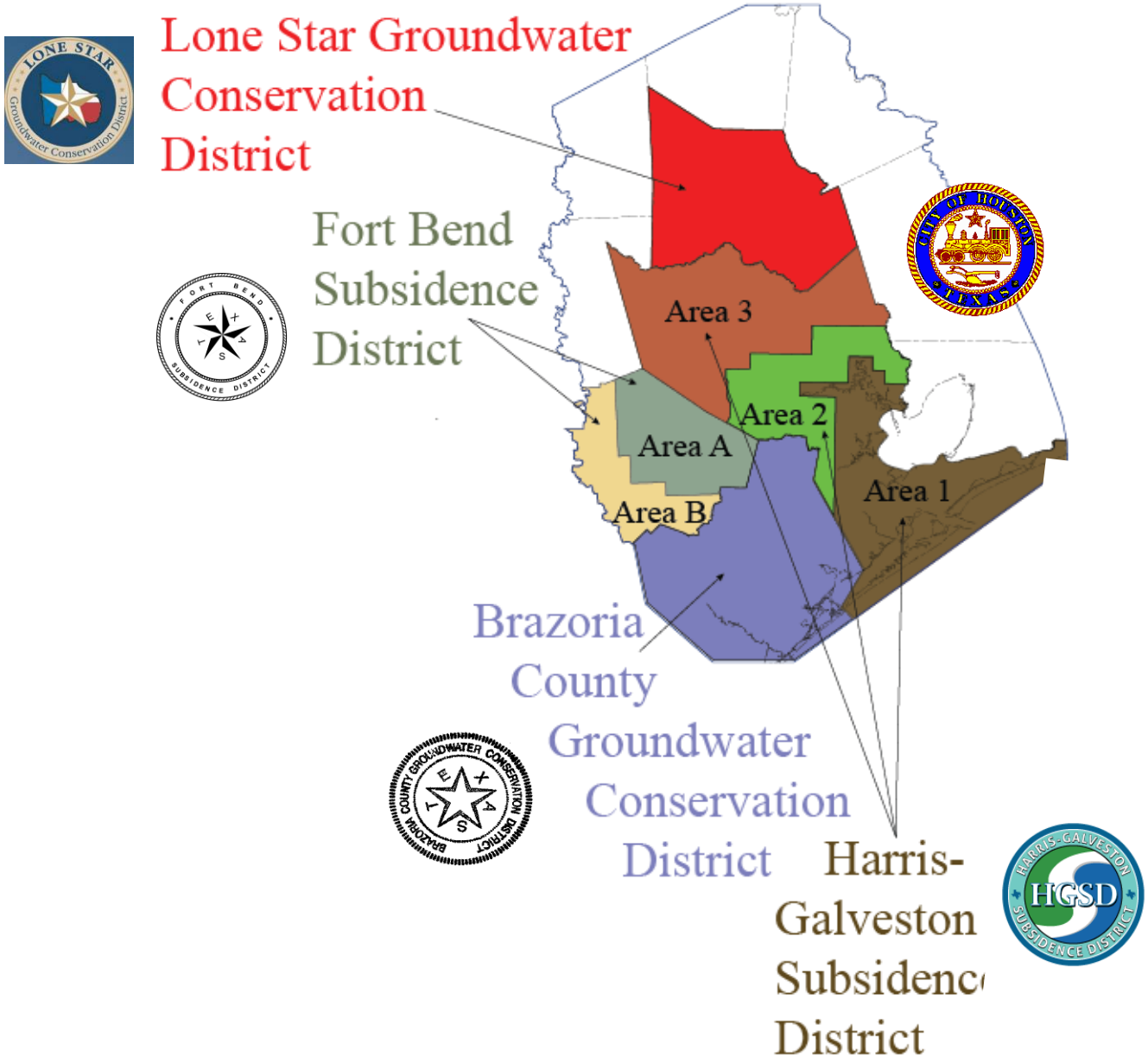
Data management QA/QC

Results and Products
- Altitude maps
- 1-year changes
- 5-year changes
- Long term changes
- Publication



Lone Star Groundwater Conservation District



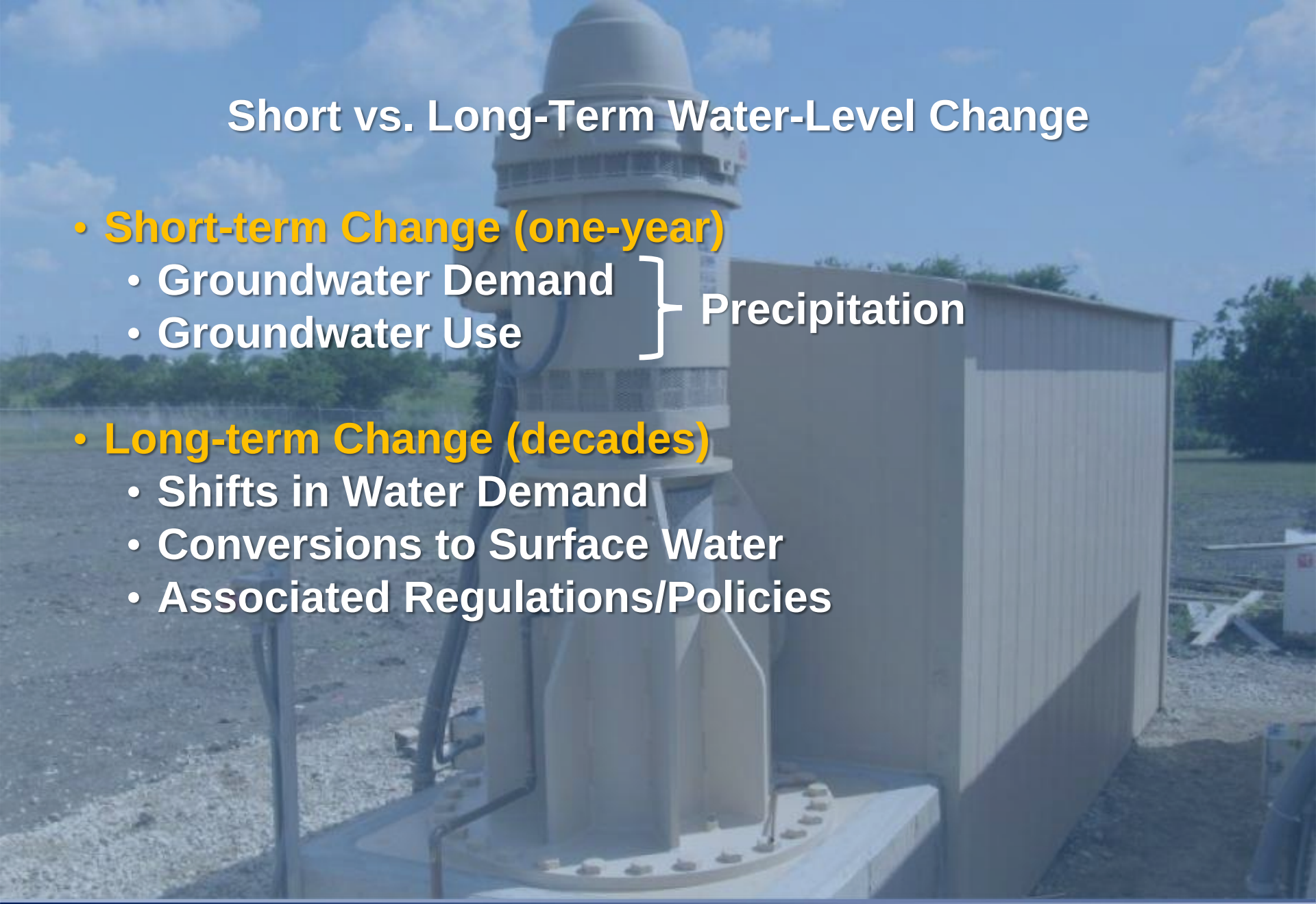

Lone Star Groundwater Conservation District
Fort Bend Subsidence District
Area 3
Area 2
Area A
Area B
Area 1
Brazoria County Groundwater Conservation District
Harris-Galveston Subsidence District

Short vs. Long-Term Water-Level Change

- **Short-term Change (one-year)**
  - Groundwater Demand
  - Groundwater Use

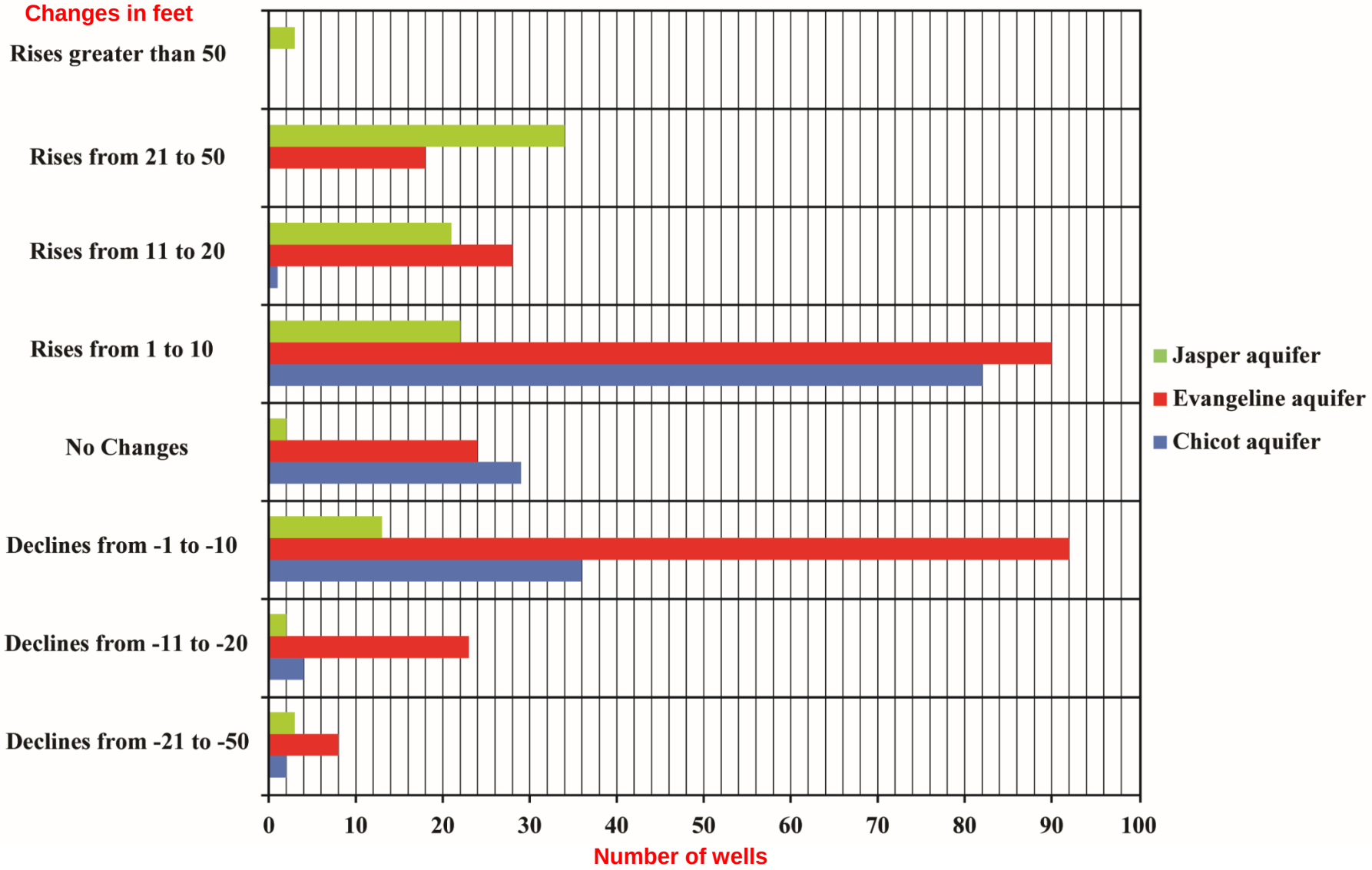
  } Precipitation

- **Long-term Change (decades)**
  - Shifts in Water Demand
  - Conversions to Surface Water
  - Associated Regulations/Policies

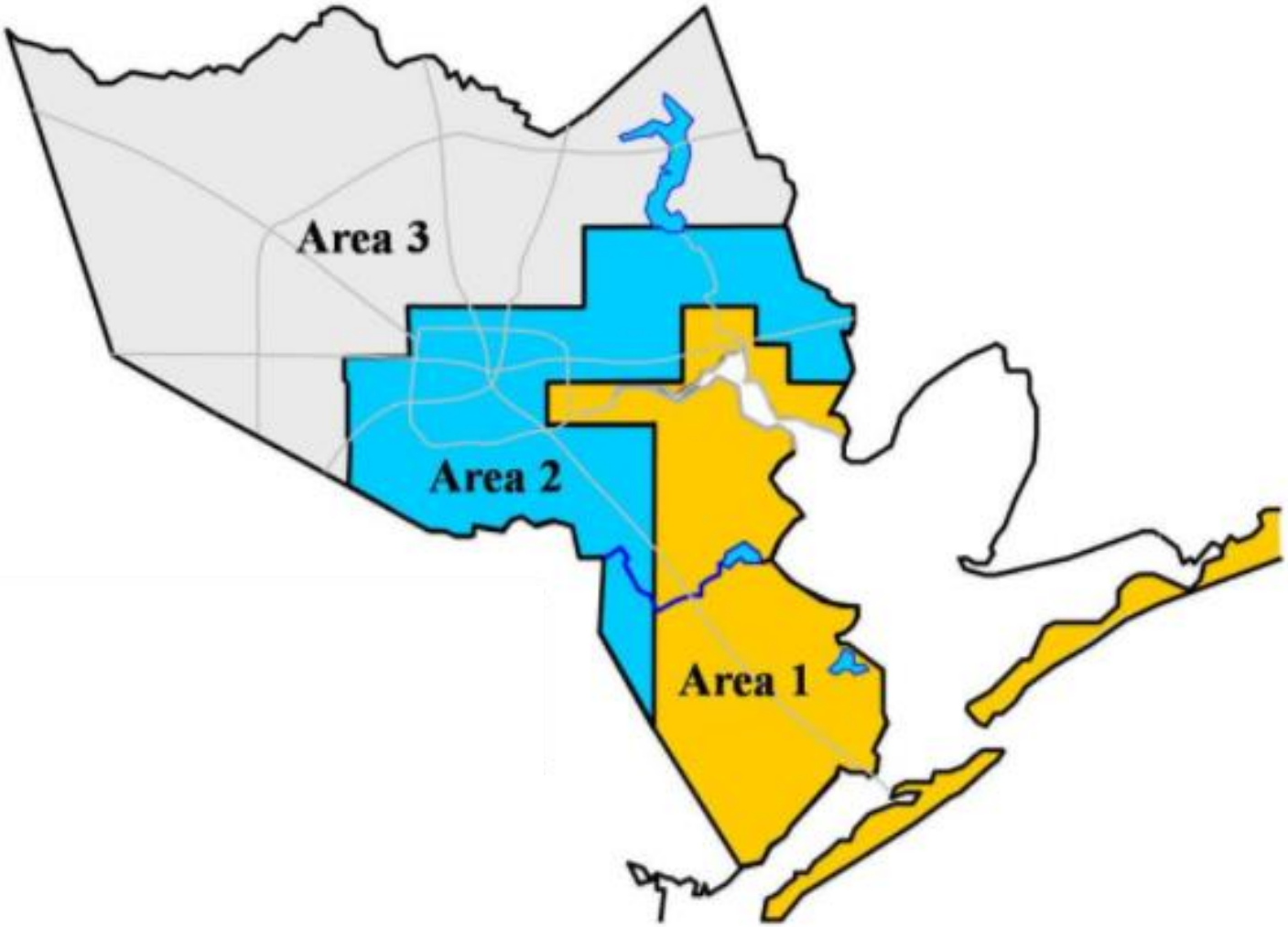


USGS

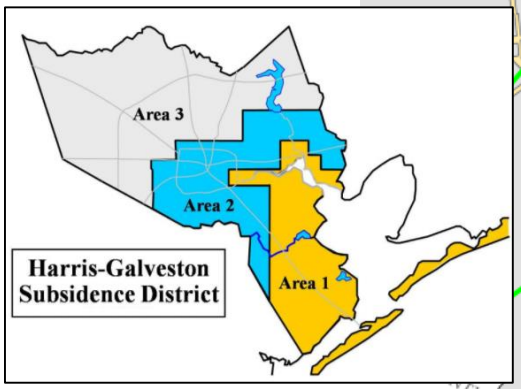
2016–2017 Water-Level-Change Summary



Harris-Galveston Subsidence District



Chicot Aquifer 1977–2017 Water-Level Change

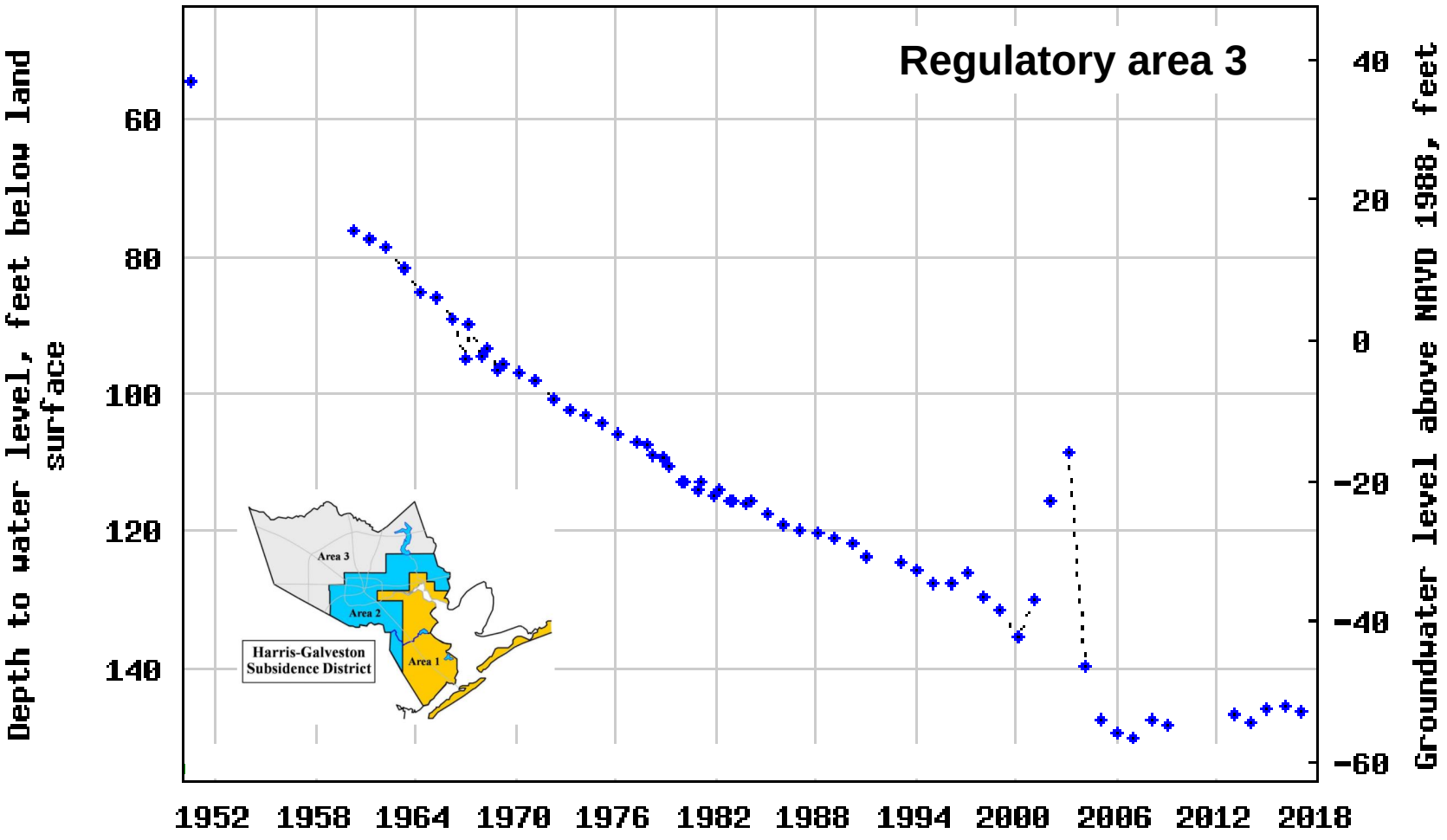


declines

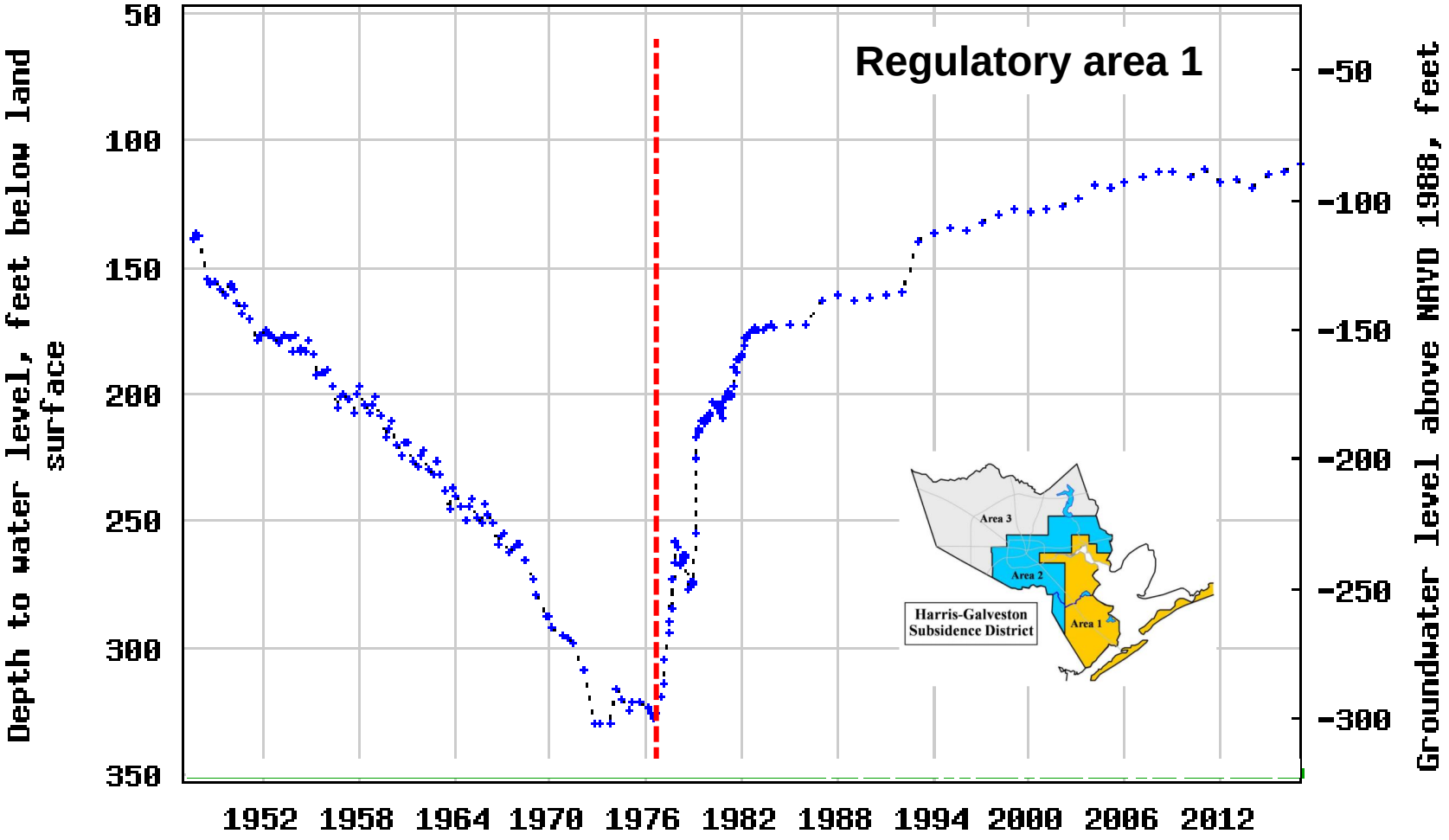
rises

-120 to 200 feet
Contour Interval = 20 ft

Hydrograph of Well LJ-65-19-201 Screened in Chicot Aquifer



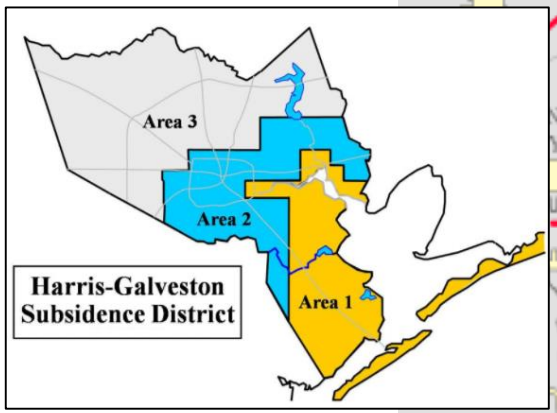
Hydrograph of Well LJ-65-24-501 Screened in Chicot Aquifer



Evangeline Aquifer 1977–2017 Water-Level Change

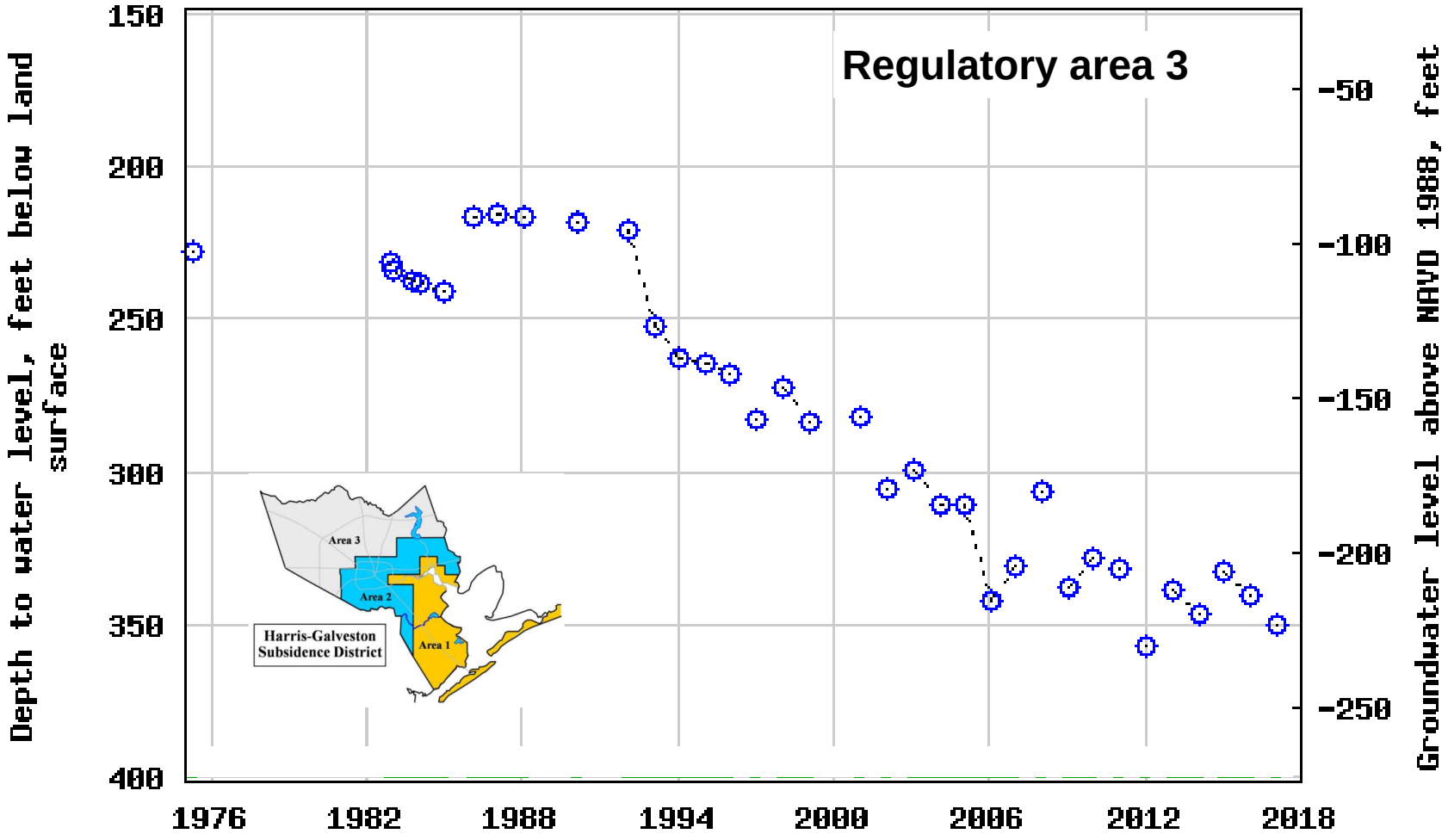
declines

rises

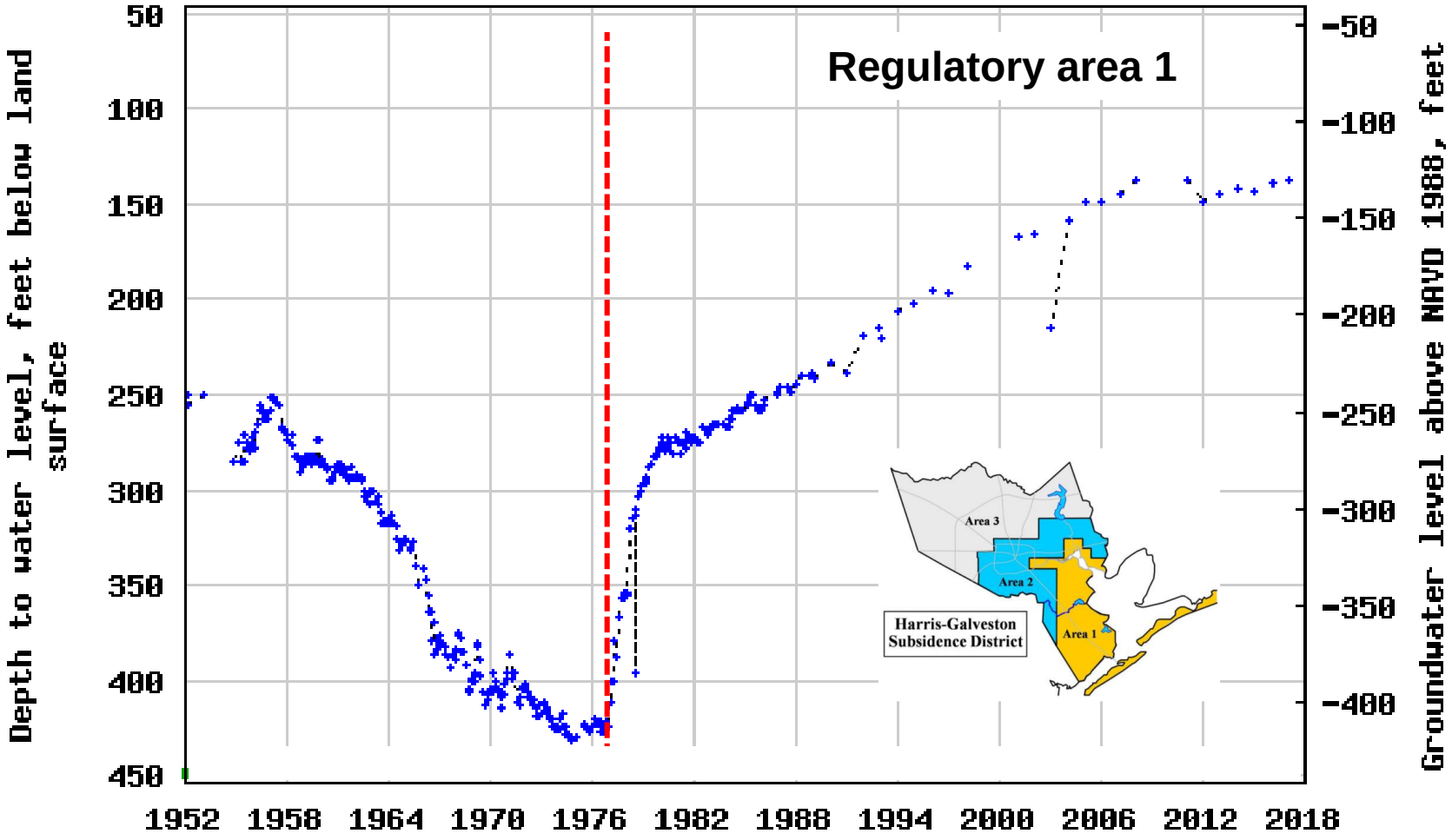


-280 to 240 feet
Contour interval = 40 feet

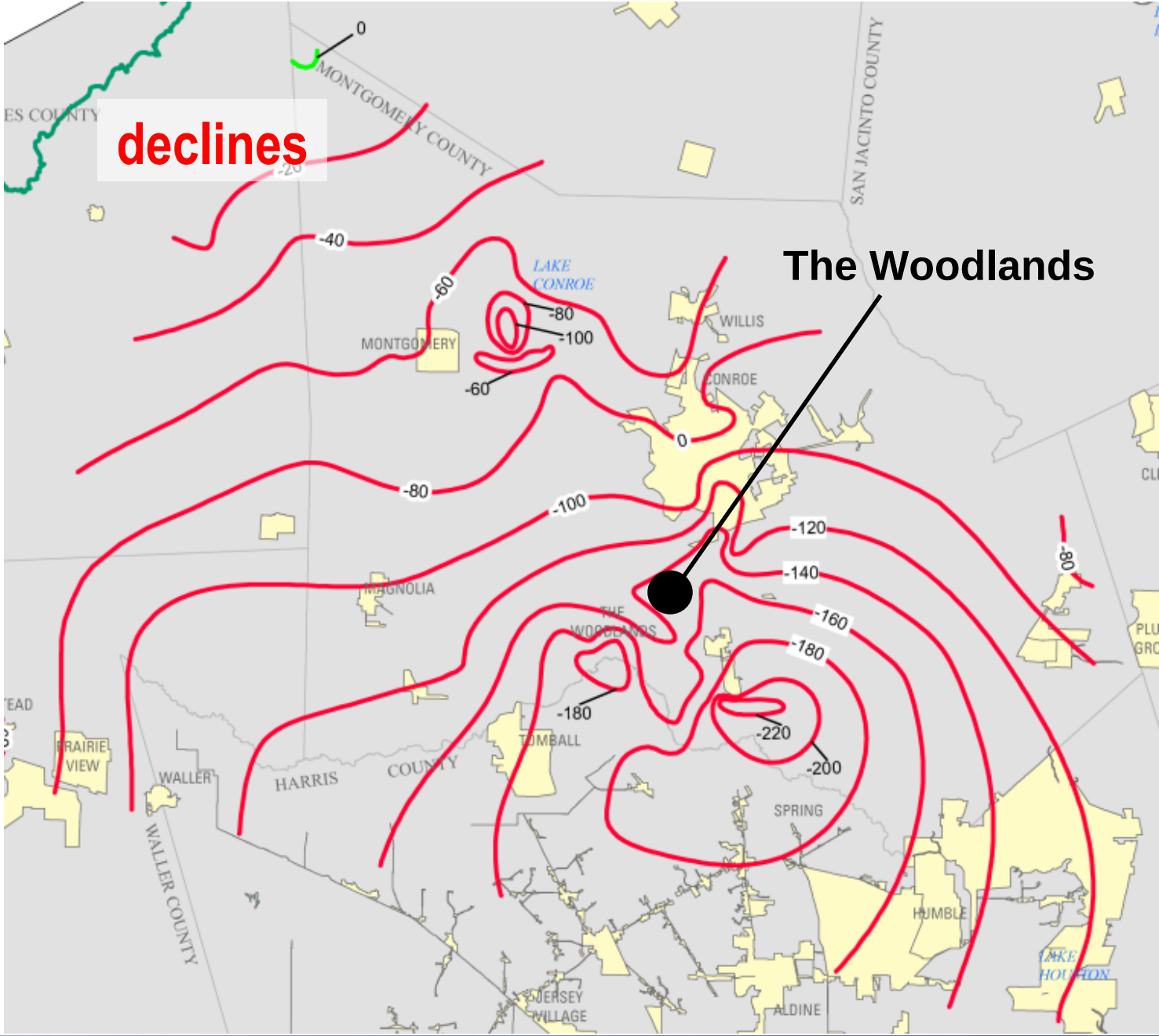
Hydrograph of Well LJ 65-11-407 Screened in Evangeline Aquifer



Hydrograph of Well LJ 65-23-219 Screened in Evangeline Aquifer



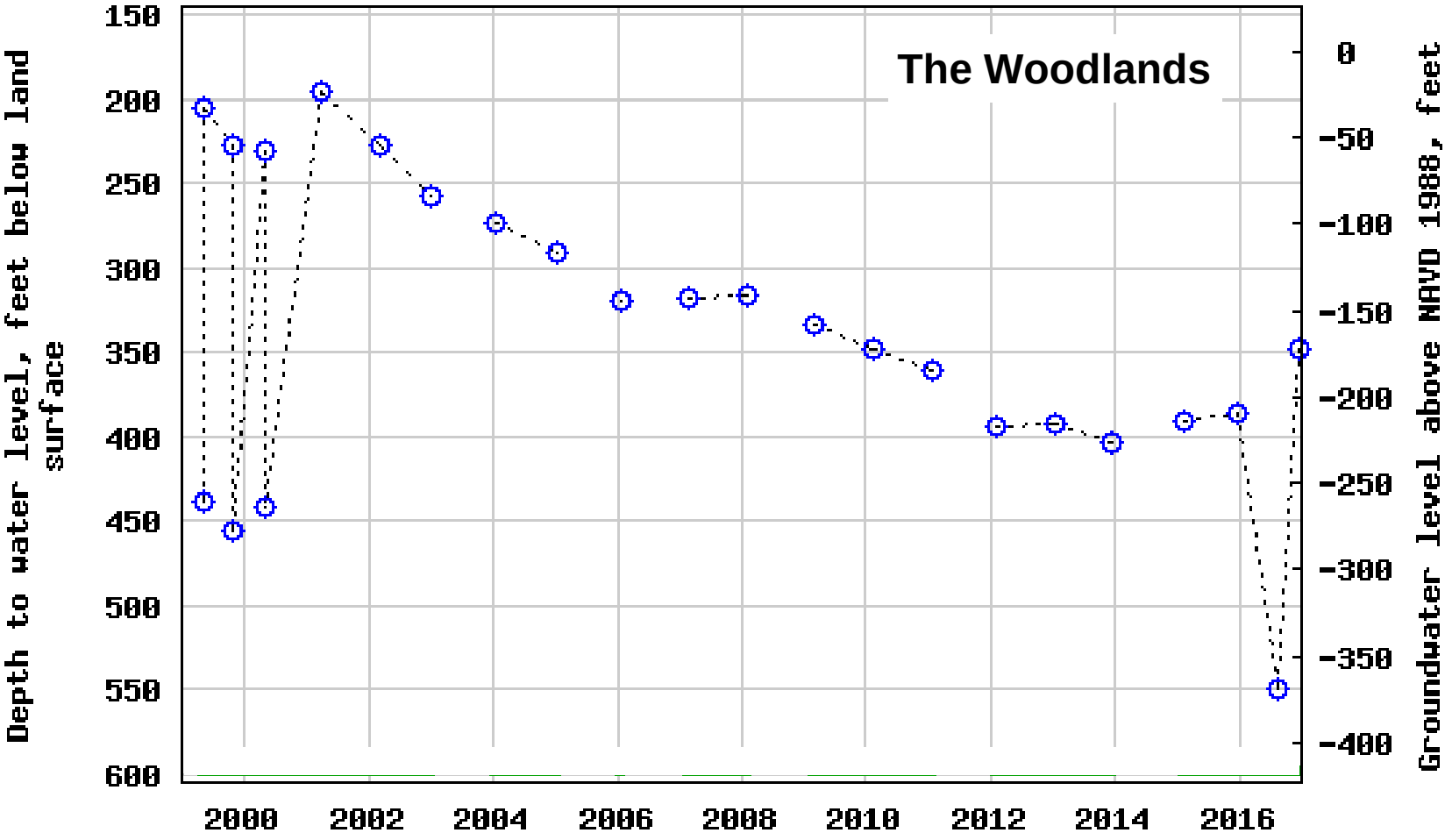
Jasper Aquifer 2000–2017 Water-Level Change



-220 to no change, feet
Contour interval = 20 feet

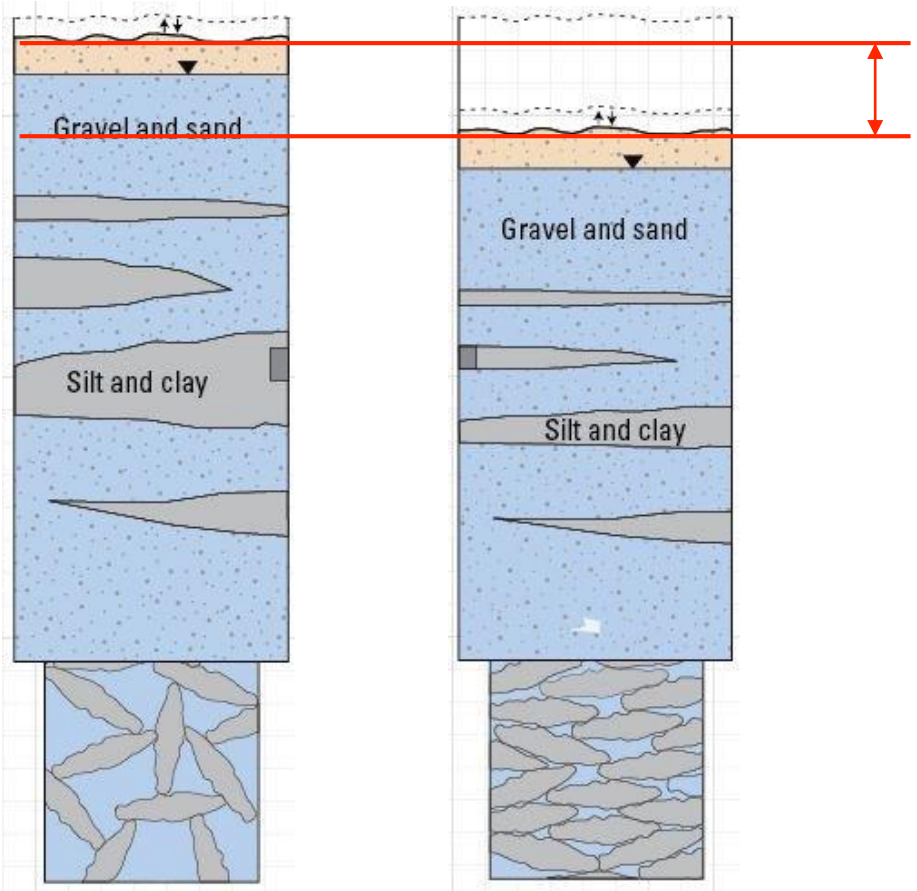
USGS

Hydrograph of Well TS-60-52-608 Screened in Jasper Aquifer



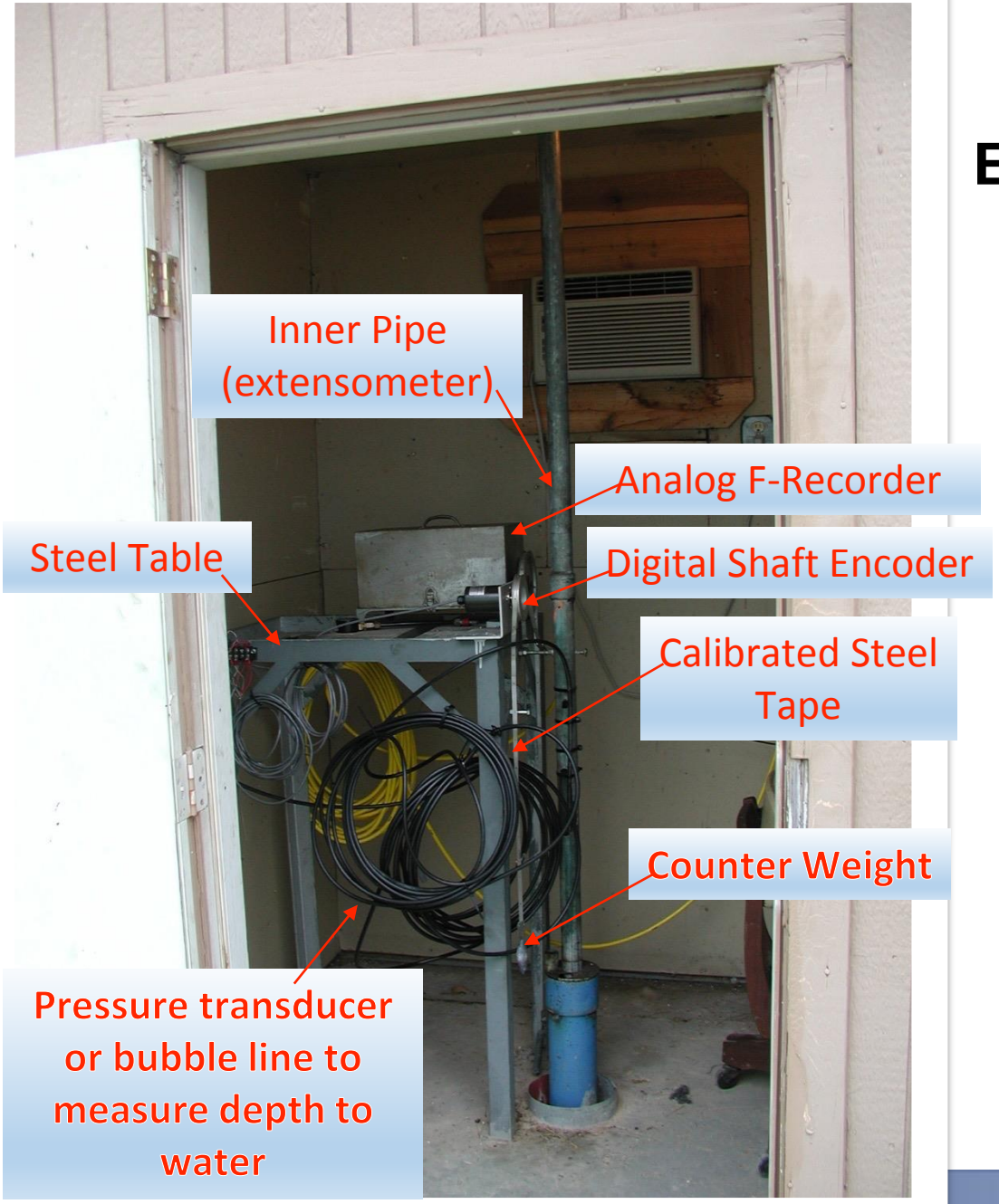
Mechanism of Subsidence

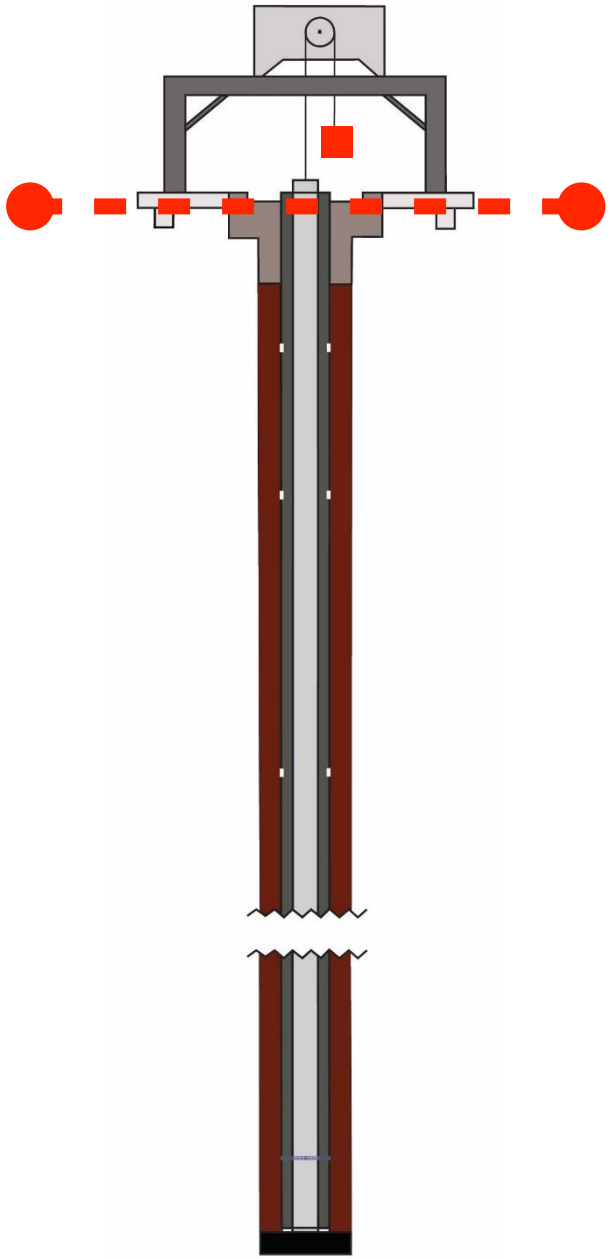
Water Levels → Compaction



- Withdrawal reduces pore fluid pressure
- Supporting matrix collapses
- Reduction in initial volume
- **Volume loss becomes significant; land surface subsides**

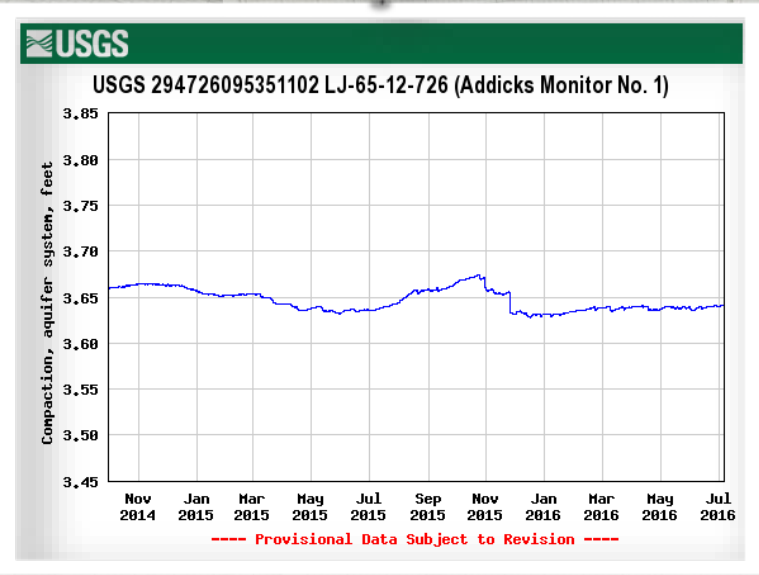
Extensometer



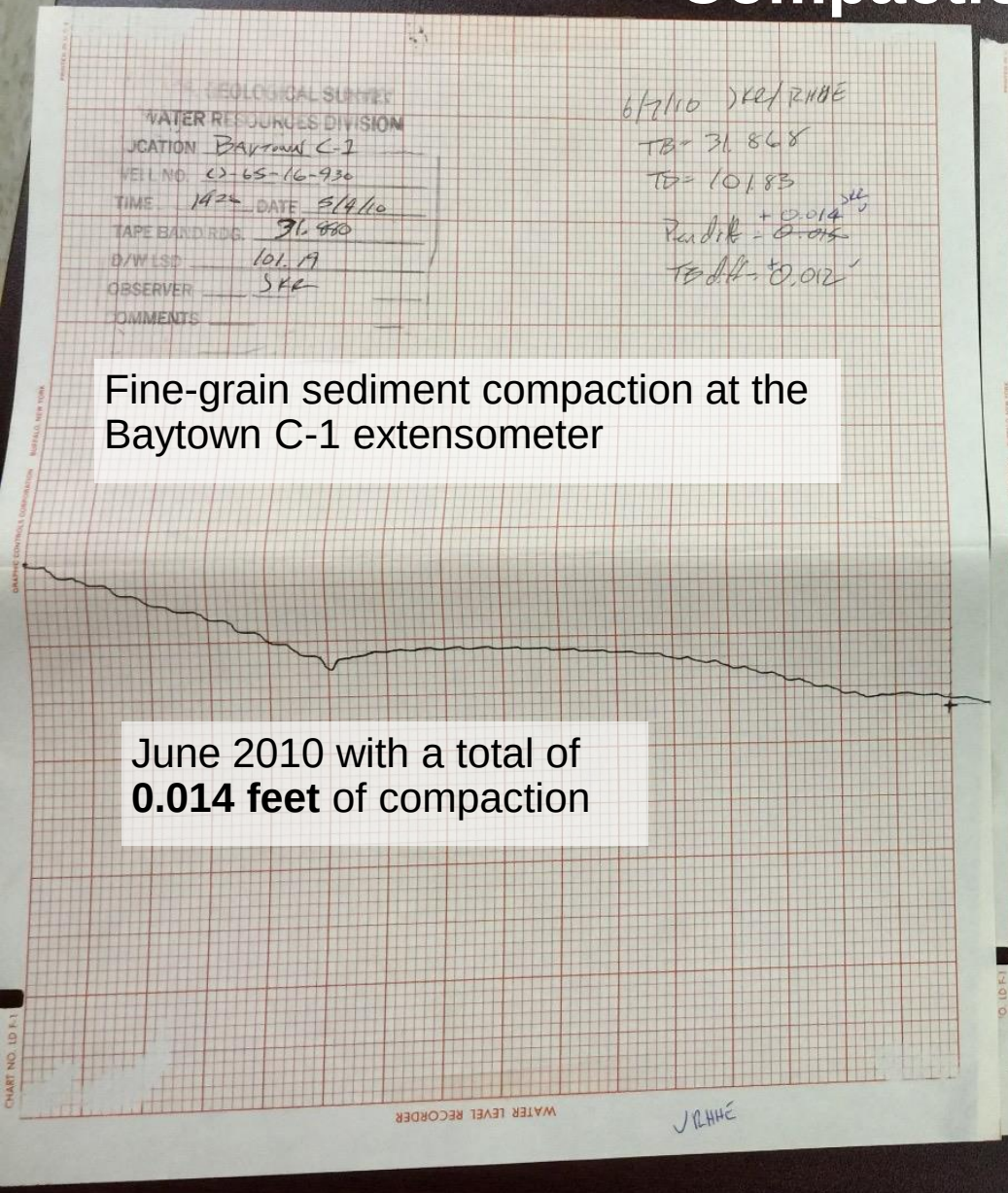


- Continuous measurement of land surface elevation changes
- As land surface changes, concrete slab, steel table, and instrument move with it.
- Instrument is tied to inner casing by a steel tape and counterweight over a pulley wheel
- Changes in land surface rotate pulley and drum with chart and draws a line across chart
- Creates a continuous profile of land elevation changes

Measured Compaction

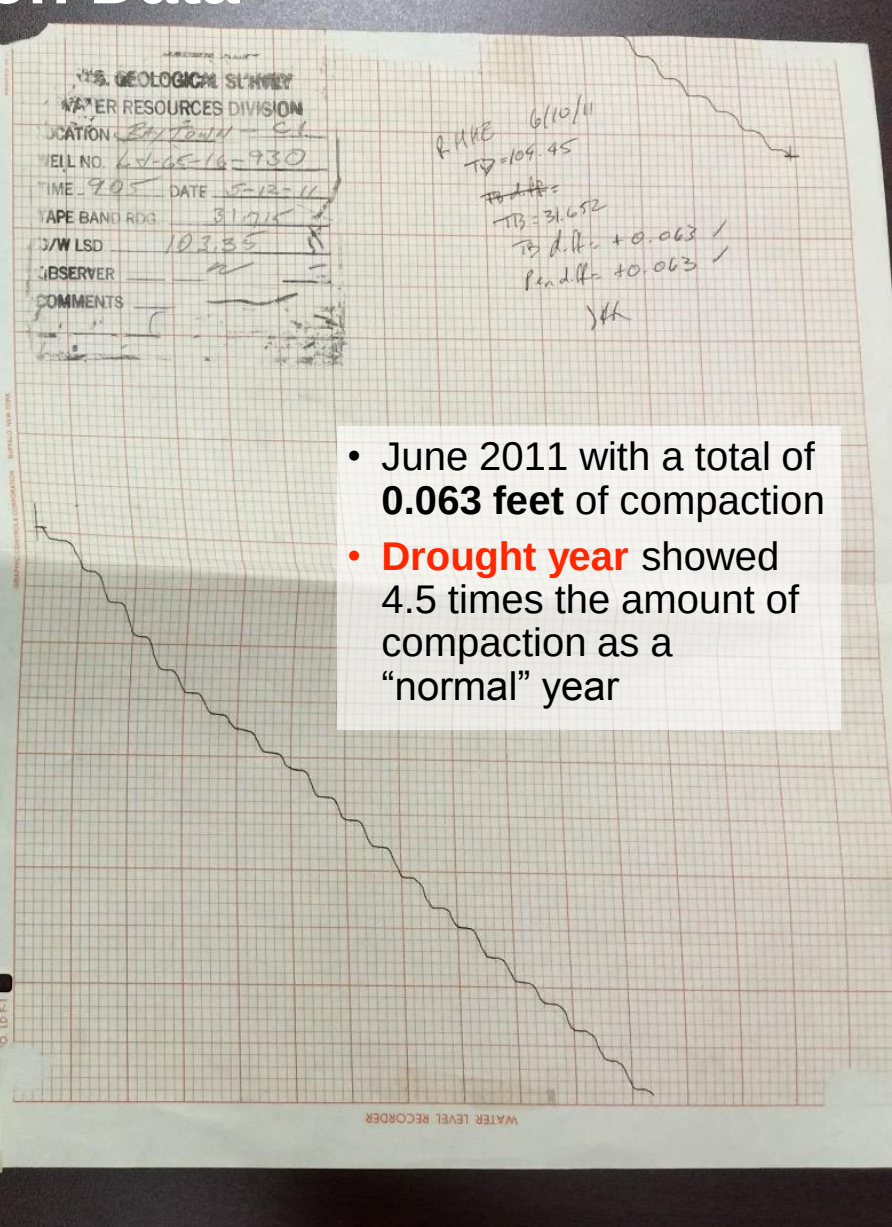


Compaction Data

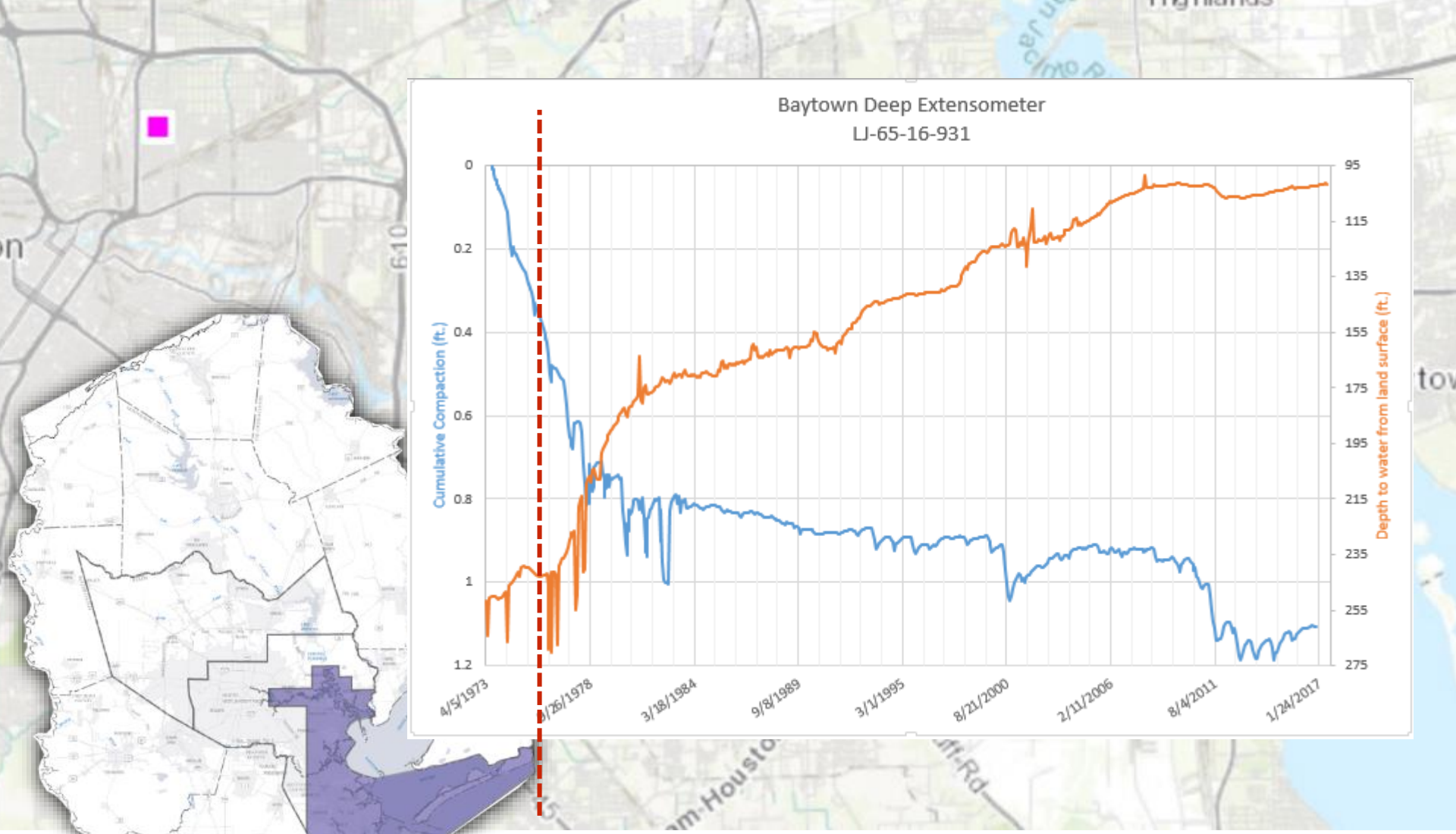


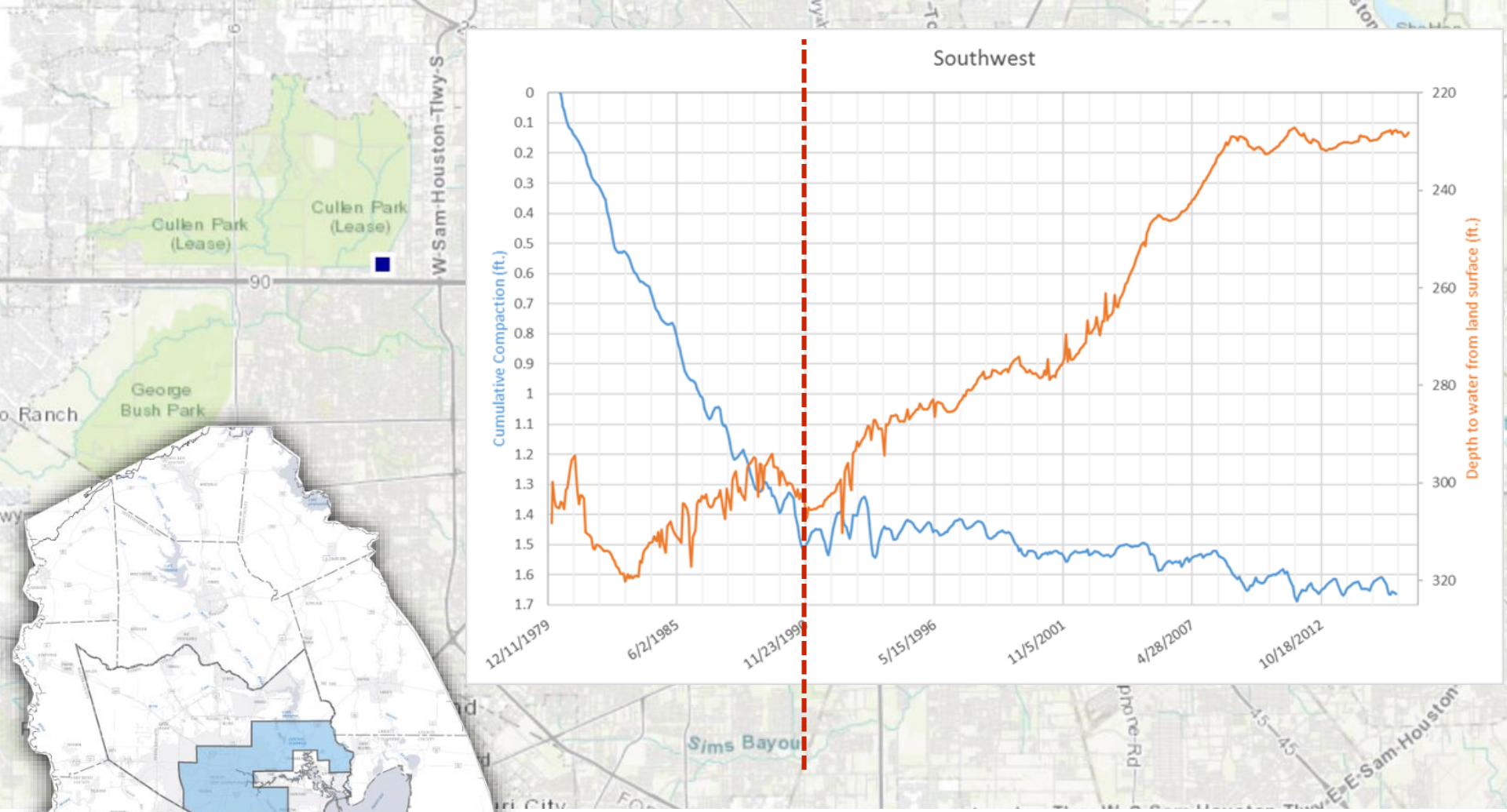
Fine-grain sediment compaction at the Baytown C-1 extensometer

June 2010 with a total of **0.014 feet** of compaction



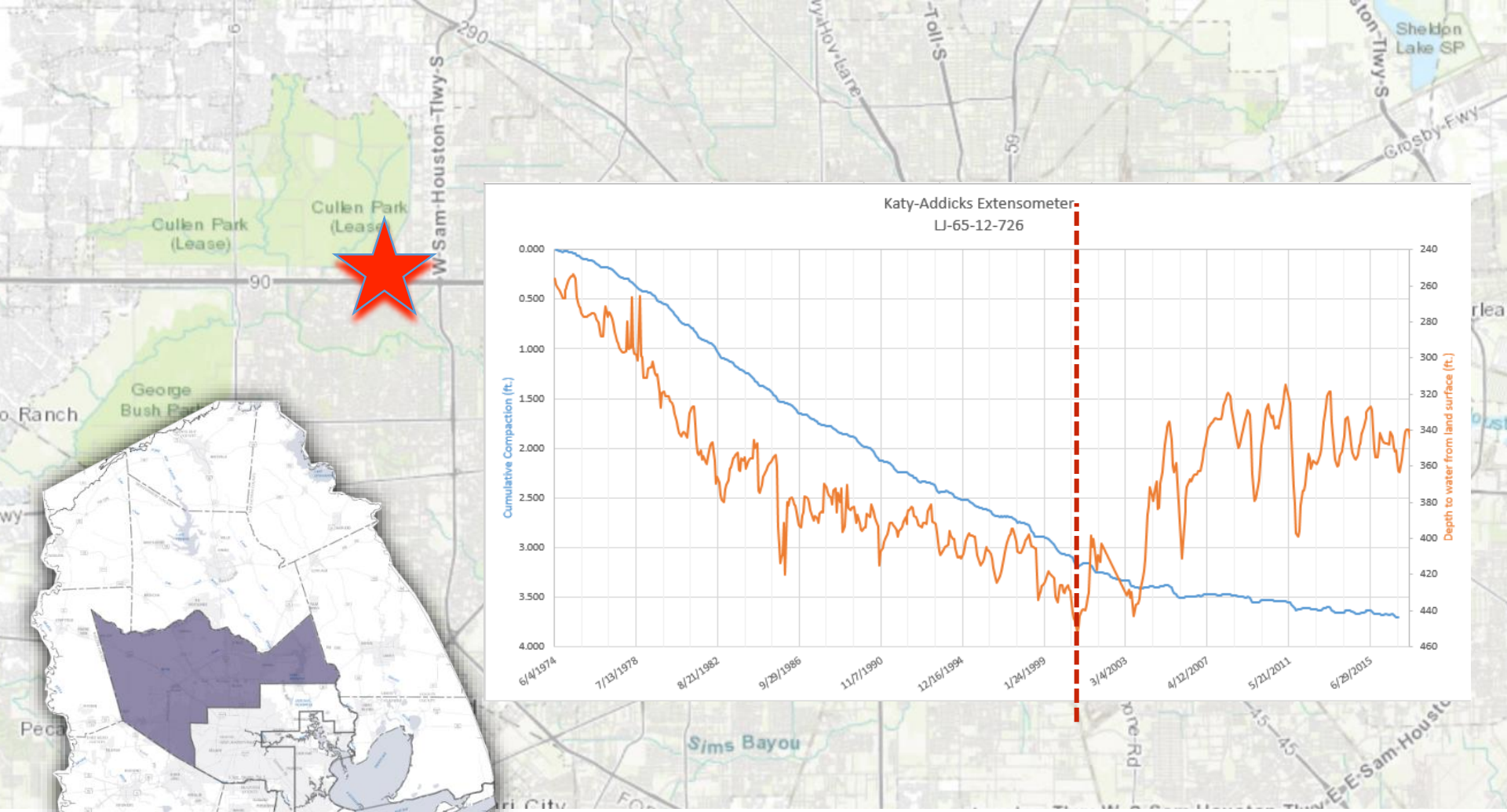
- June 2011 with a total of **0.063 feet** of compaction
- **Drought year** showed 4.5 times the amount of compaction as a “normal” year


Baytown Deep Extensometer
LJ-65-16-931
Cumulative Compaction (ft.)
Depth to water from land surface (ft.)
0
0.2
0.4
0.6
0.8
1
1.2
95
115
135
155
175
195
215
235
255
275
4/5/1973
3/18/1984
9/8/1989
3/1/1995
8/21/2000
2/11/2006
8/4/2011
1/24/2017



- **Within a COH groundwater plant**
- **Rates of subsidence decreasing**

USGS

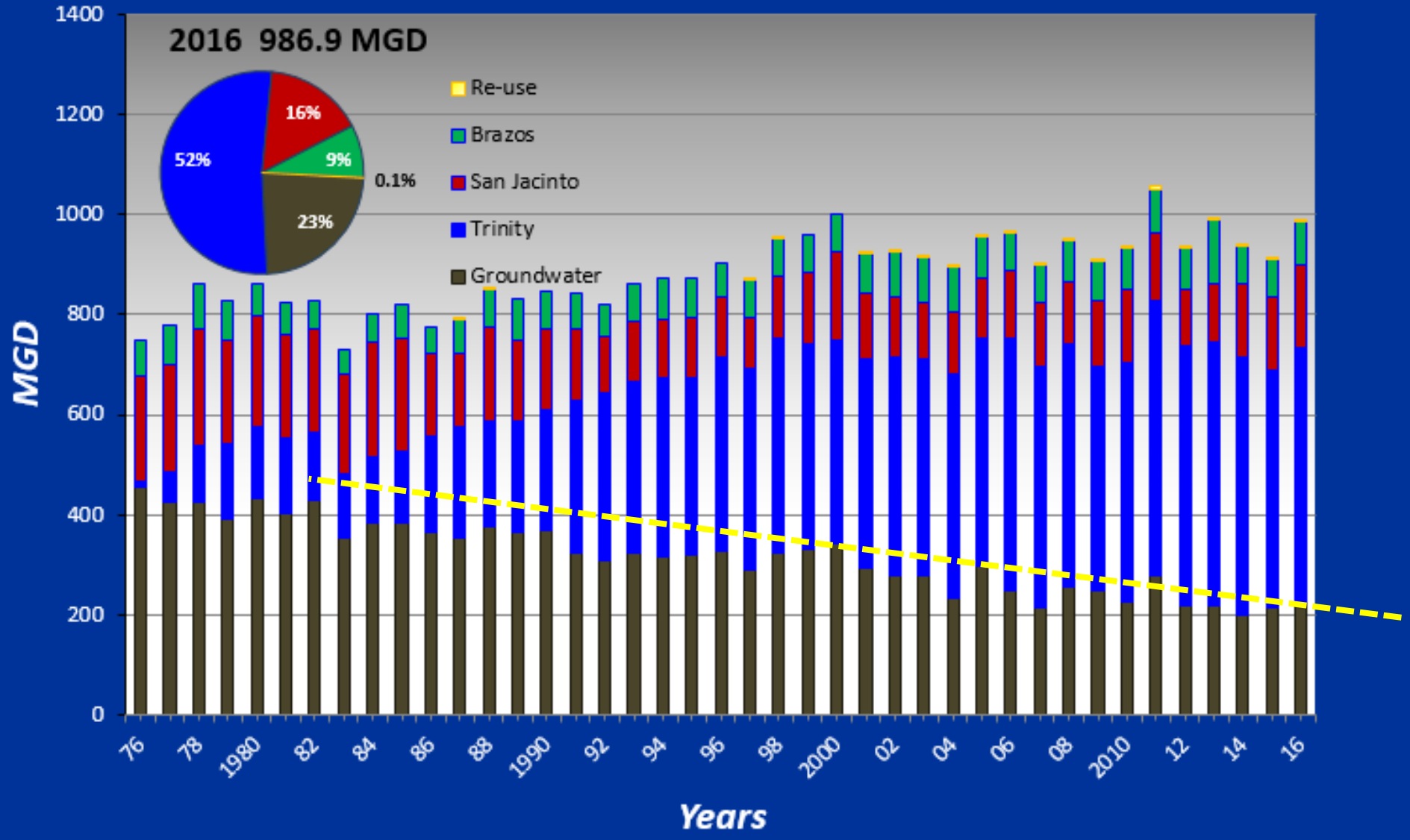


Katy-Addicks

- **Recent westward development (early 2000s)**
- **Fluctuating water management (surface and groundwater)**

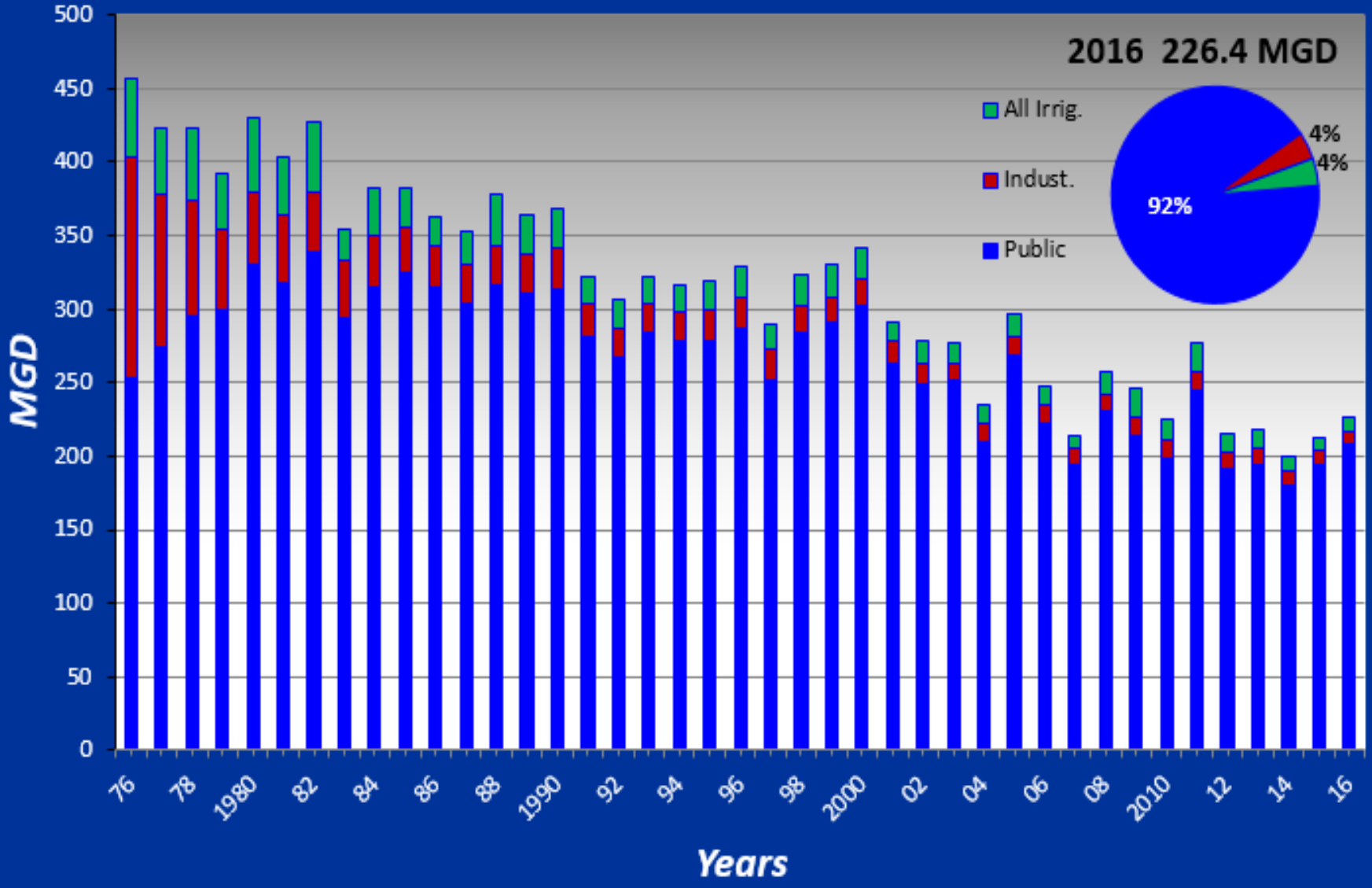
Total Water Demand

Grouped By Source - Entire District



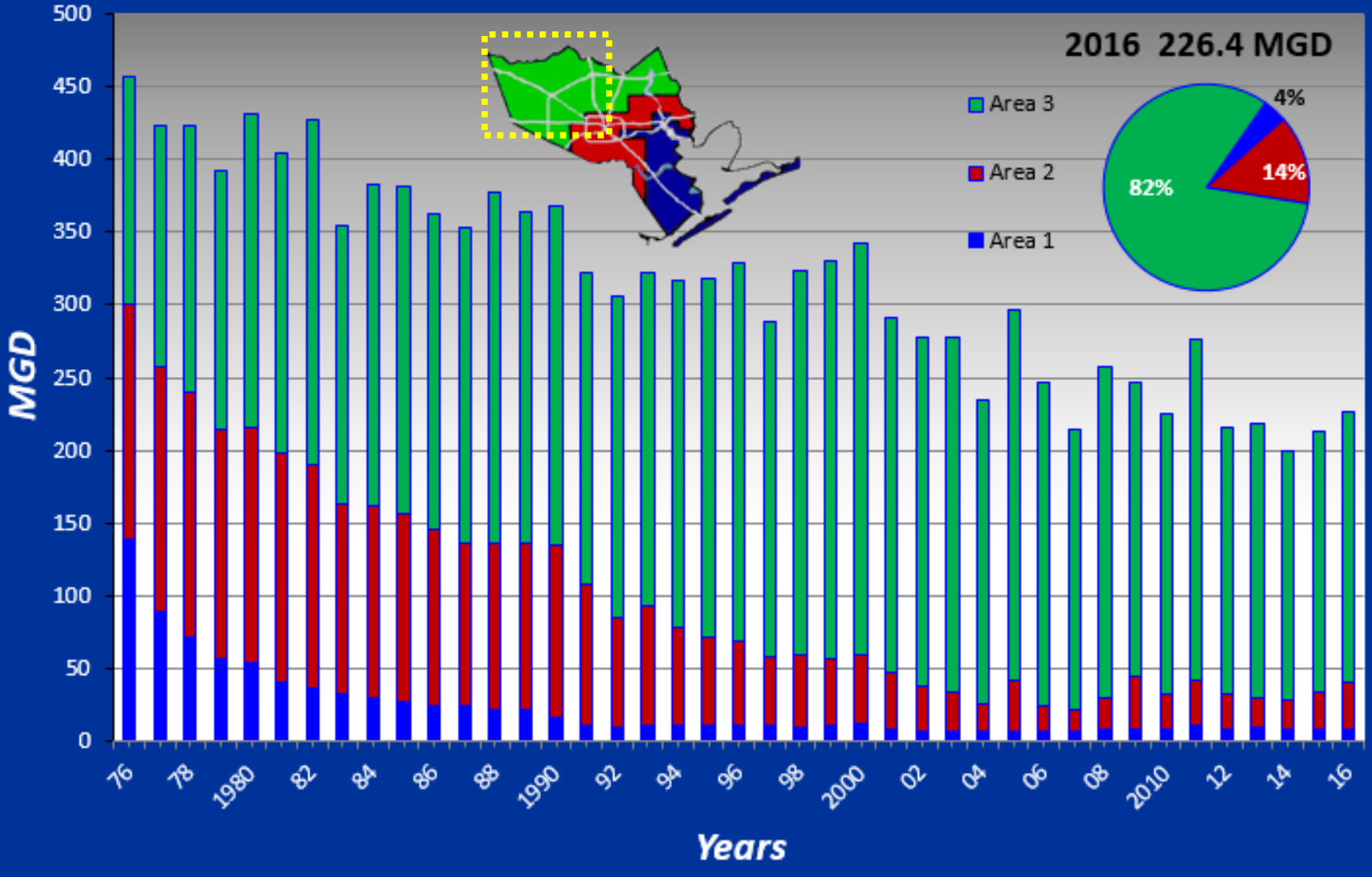
Groundwater Withdrawals

Grouped By Use - Entire District



Groundwater Withdrawals

Grouped By Regulatory Area - Entire District



https://txpub.usgs.gov/houston_subsidence/home/