Geologic Characterization of the Corpus Christi Aquifer Storage and Recovery Conservation District

July 12, 2012

Texas Water Development Board

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Water Science and Conservation
Innovative Water Technologies

Statutory authority for TWDB in ASR studies

- TWDB shall participate in pilot projects
- Pilot projects eligible for grants from the water loan assistance fund
- TWDB may authorize use of money from the research and planning fund for pilot projects
- TWDB shall make other studies, investigations, and surveys of the aquifers in the state as it considers necessary

Texas Water Code §11.153, 11.154, 11.155

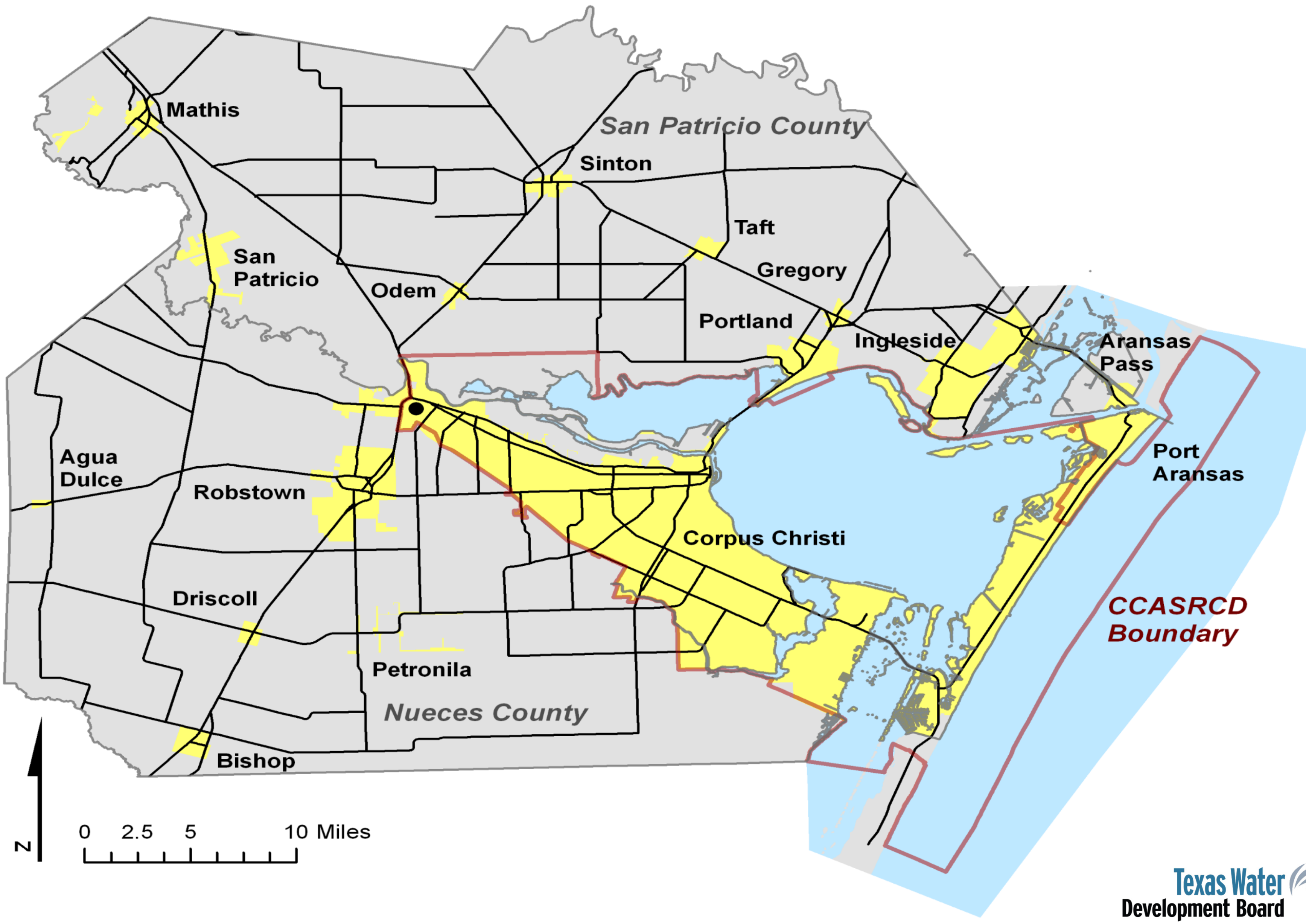
Corpus Christi Aquifer Storage and Recovery Conservation District

- Created in 2005 by the 79th Texas Legislature
  (enactment SB 1831, Section 1, Subtitle H, Title 6)
- Groundwater management plan approved in 2008
- District is committed to maintaining a sustainable, adequate, reliable, cost-effective and high quality source of groundwater to promote the vitality, economy, and environment of the district
- Five-year plan for district operation and ASR evaluation prepared in 2009

Study objectives

- Collect existing well data
- Add data to database
- Characterize geology of the District:
  - sand and clay layers
  - water chemistry
  - aquifer parameters
  - potential problems:
    hydrocarbons
    radionuclides
- Focus on the Evangeline Aquifer (part of the Gulf Coast Aquifer) around the Stevens Water Treatment Plant—west end of the District
- Provide database, GIS datasets, raw well data, and summary report
- Report completed on February 29, 2012

Study area



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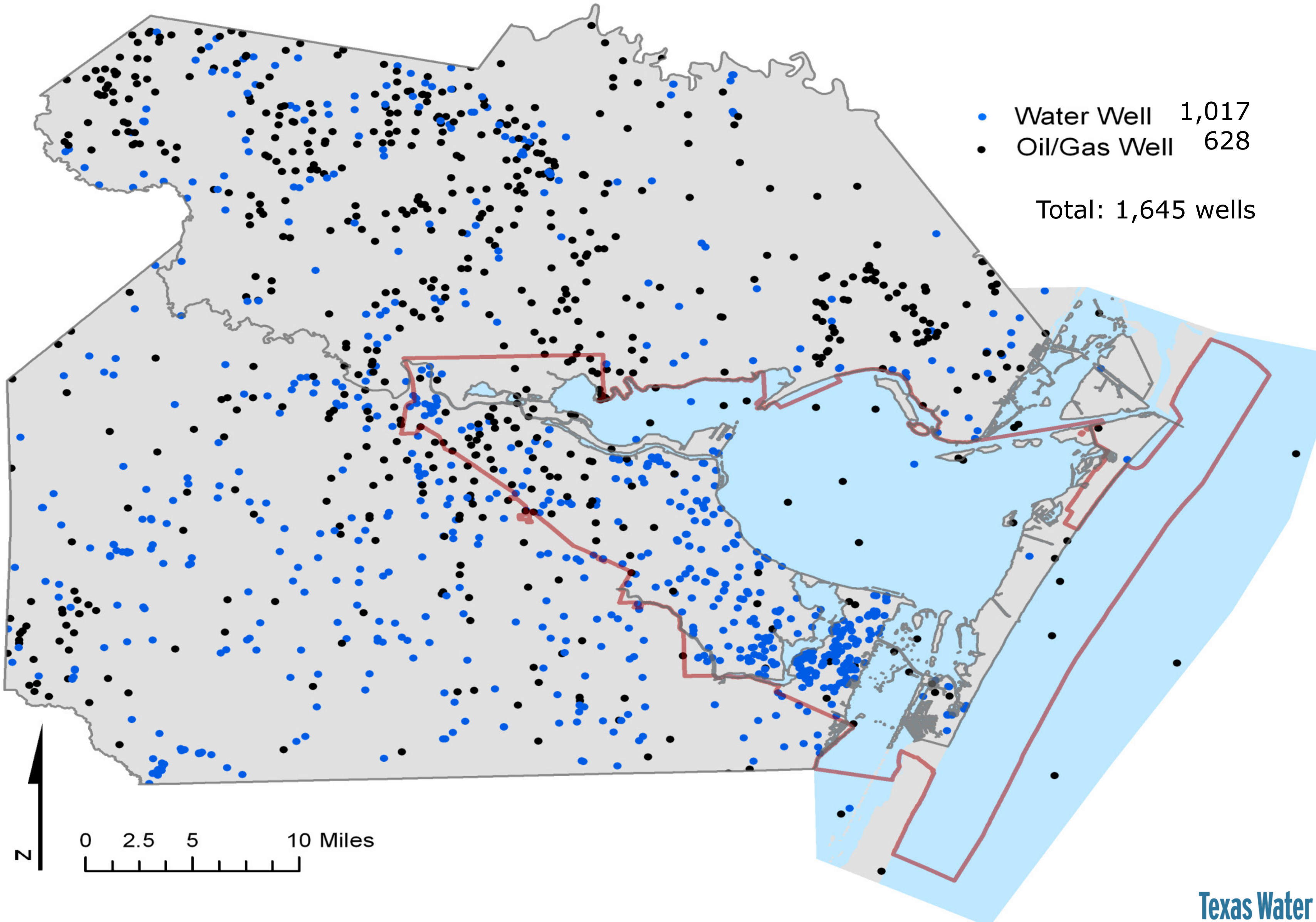
Study area well control



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District geology

<table>
<tr><th>Age (millions of years before present)</th><th>Geologic Formation</th><th colspan="2">Hydrogeologic Unit</th></tr>
<tr><td rowspan="2">Pleistocene (1.8-present)</td><td>Beaumont</td><td></td><td></td></tr>
<tr><td>Lissie</td><td rowspan="2">Chicot Aquifer</td><td rowspan="5">Coast Aquifer</td></tr>
<tr><td>Pliocene (5.6-1.8)</td><td>Willis</td></tr>
<tr><td rowspan="6">Miocene (23.8-5.6)</td><td>Upper Goliad</td><td rowspan="3">Evangeline Aquifer</td></tr>
<tr><td>Lower Goliad</td></tr>
<tr><td>Upper Lagarto</td></tr>
<tr><td>Middle Lagarto</td><td>Burkeville Confining Unit</td><td></td></tr>
<tr><td>Lower Lagarto</td><td rowspan="2">Jasper Aquifer</td><td rowspan="2">Gulf</td></tr>
<tr><td>Oakville</td></tr>
<tr><td rowspan="2">Oligocene</td><td>(upper) Catahoula</td><td></td><td></td></tr>
<tr><td>(lower) Catahoula</td><td>Catahoula Confining Unit</td><td></td></tr>
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Based on hydrostratigraphy of the Gulf Coast Aquifer developed for the TWDB groundwater availability model program (Young and others, 2010)

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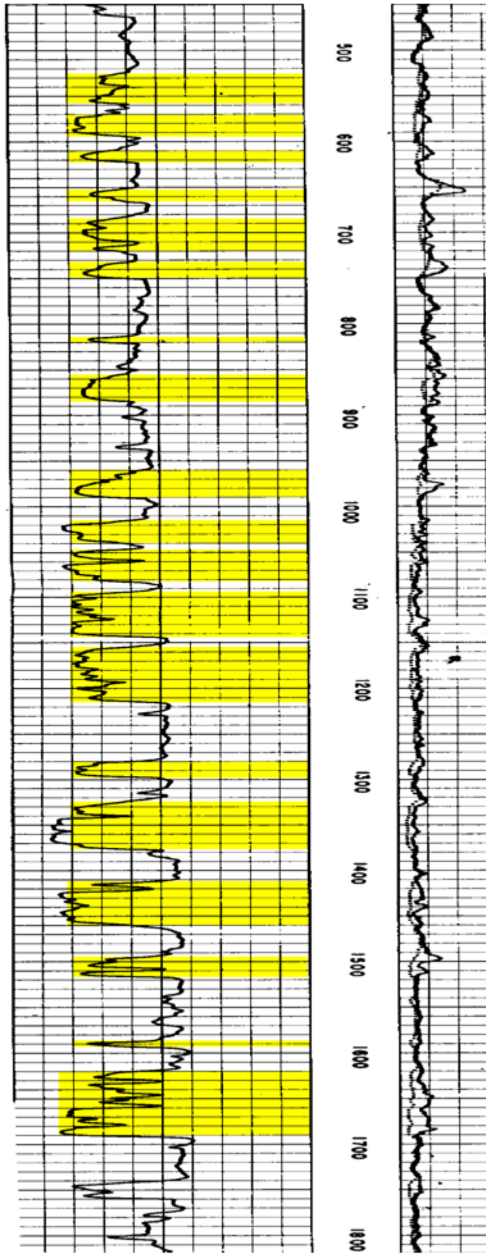

Upper Goliad Sands (yellow; SP response) in the upper Evangeline Aquifer

Geophysical well log interpretation

Simplified lithology from geophysical well logs was interpreted from base of surface casing to several hundred feet below the Oakville Formation (base of Jasper Aquifer).

This information was loaded into the database. Water well driller formation descriptions was also loaded.

Elevated gamma ray “spikes” and potential hydrocarbon zones were noted in the database.

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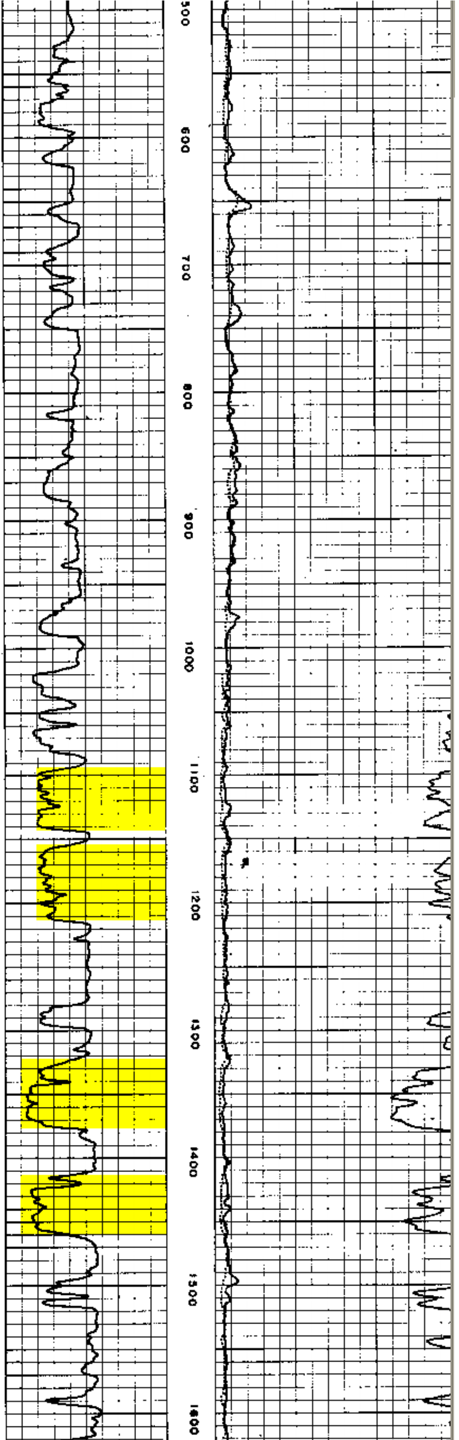
Net sand analysis and map creation

- Net sand analysis conducted using approach of Young and others (2010)
- Data collected in much finer detail than Young and others (2010) with bed thicknesses of 10 feet or less
- Used formation top/bottom data from Young and others (2010) to group the sands
- Net-sand data can be queried (from MS Access) and viewed (in GIS) in a number of ways, depending on the questions being asked
- We did not prepare an exhaustive collection of net-sand maps across the study area for the nine Gulf Coast Aquifer formations
- But, we did prepare an example of how this data can be presented
- Once ASR parameters are established on the ideal sand thickness, depth, bounding clay unit thicknesses, and potential well field location, custom maps can be prepared by a future contractor



Upper Goliad Formation

Example of sand analysis: Well 4504

Net Sand	601 ft
Upper Goliad Thickness	1,134 ft
Sand Percent	53%

All Sands

Sands 30 ft thicker

Top Depth	Bottom Depth	Thickness
560	585	25
595	614	19
640	659	19
669	700	31
704	710	6
722	741	19
803	812	9
846	877	31
950	982	32
1005	1032	27
1038	1049	11
1053	1074	21
1084	1135	51
1145	1206	61
1269	1289	20
1313	1368	55
1402	1452	50
1484	1497	13
1501	1508	7
1576	1585	9

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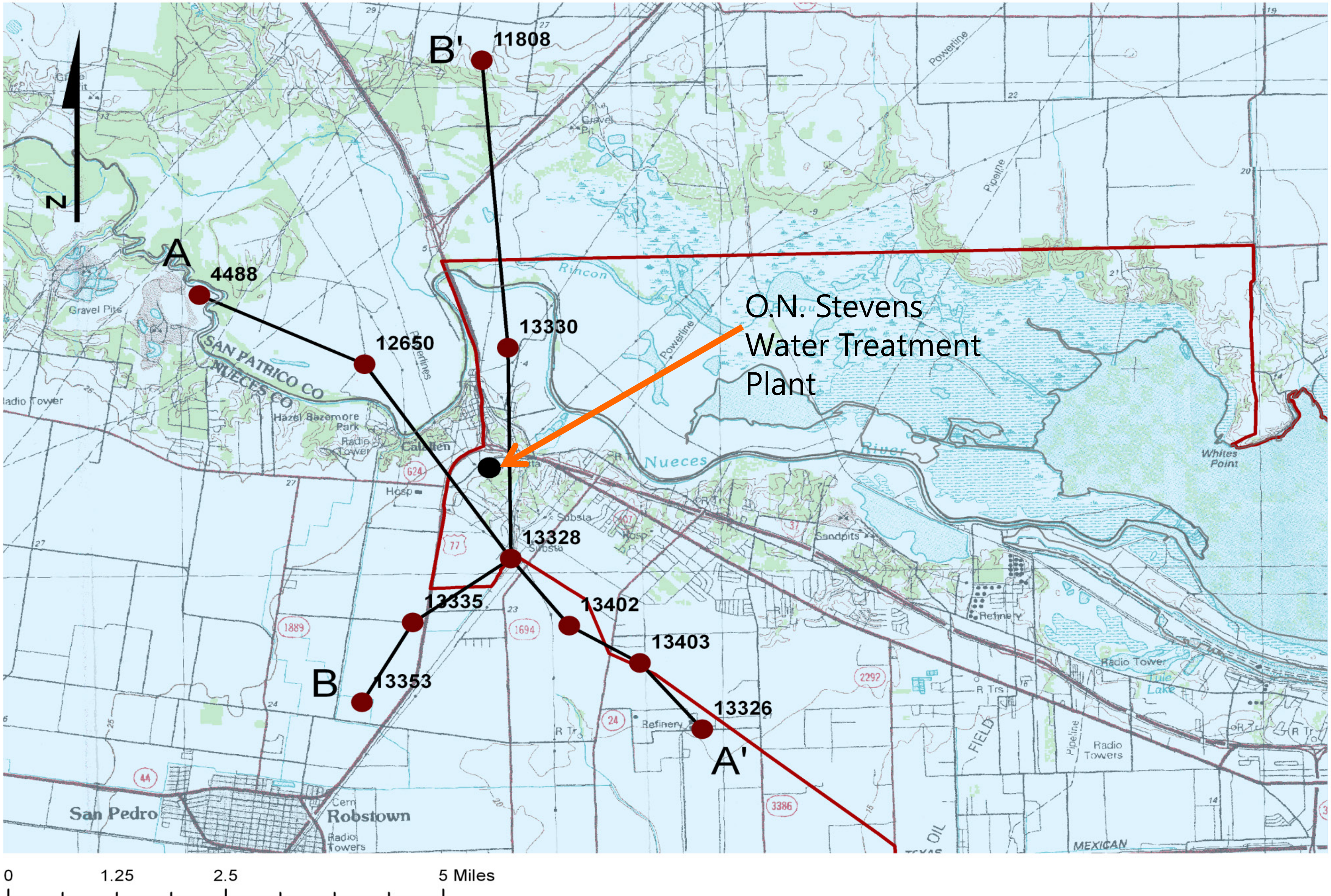
Cross-section location



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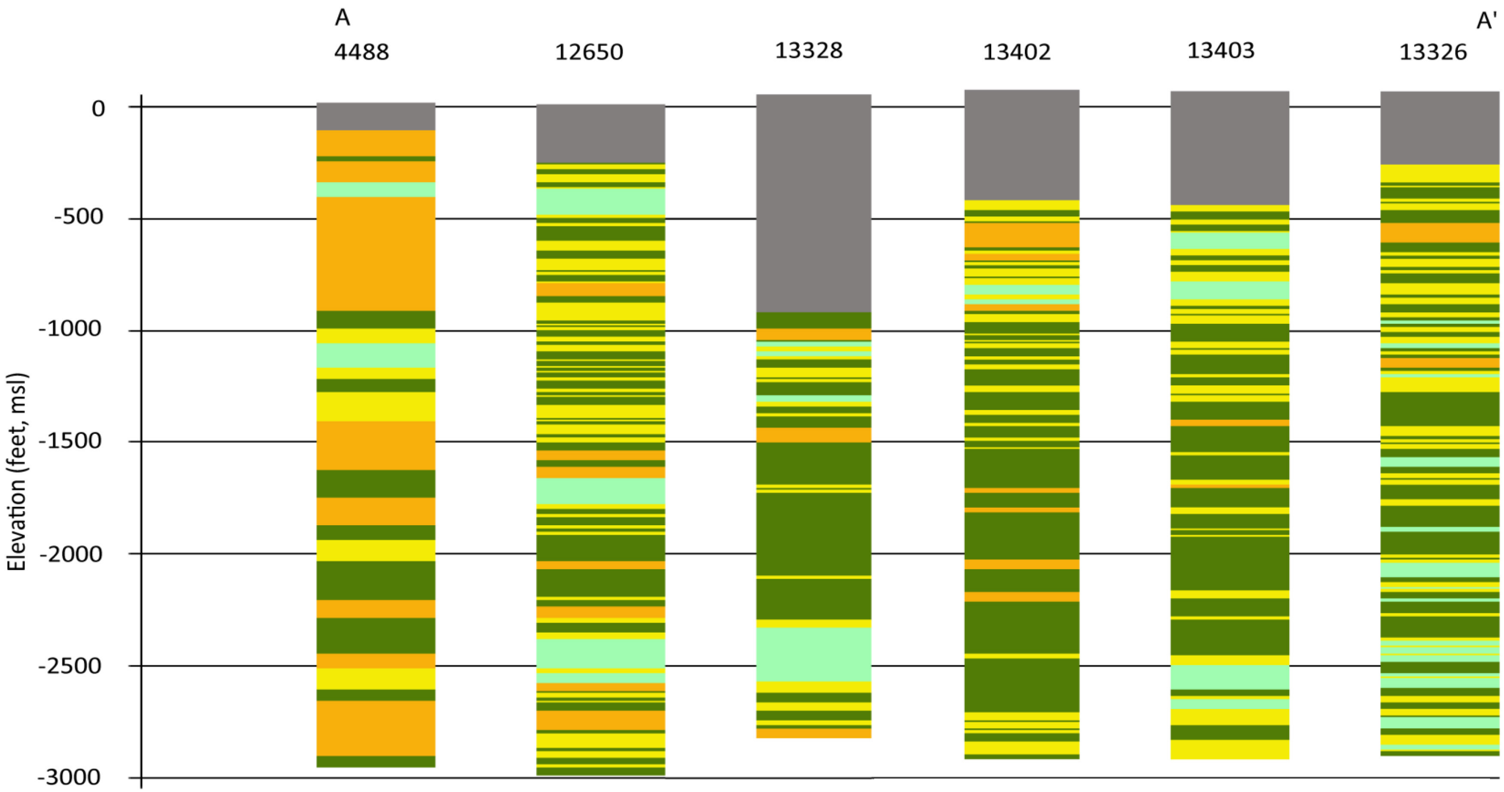
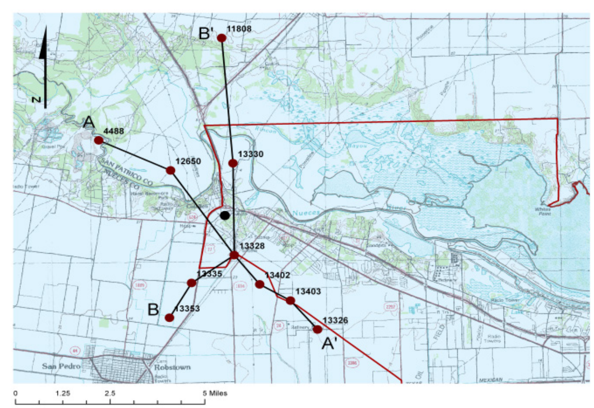
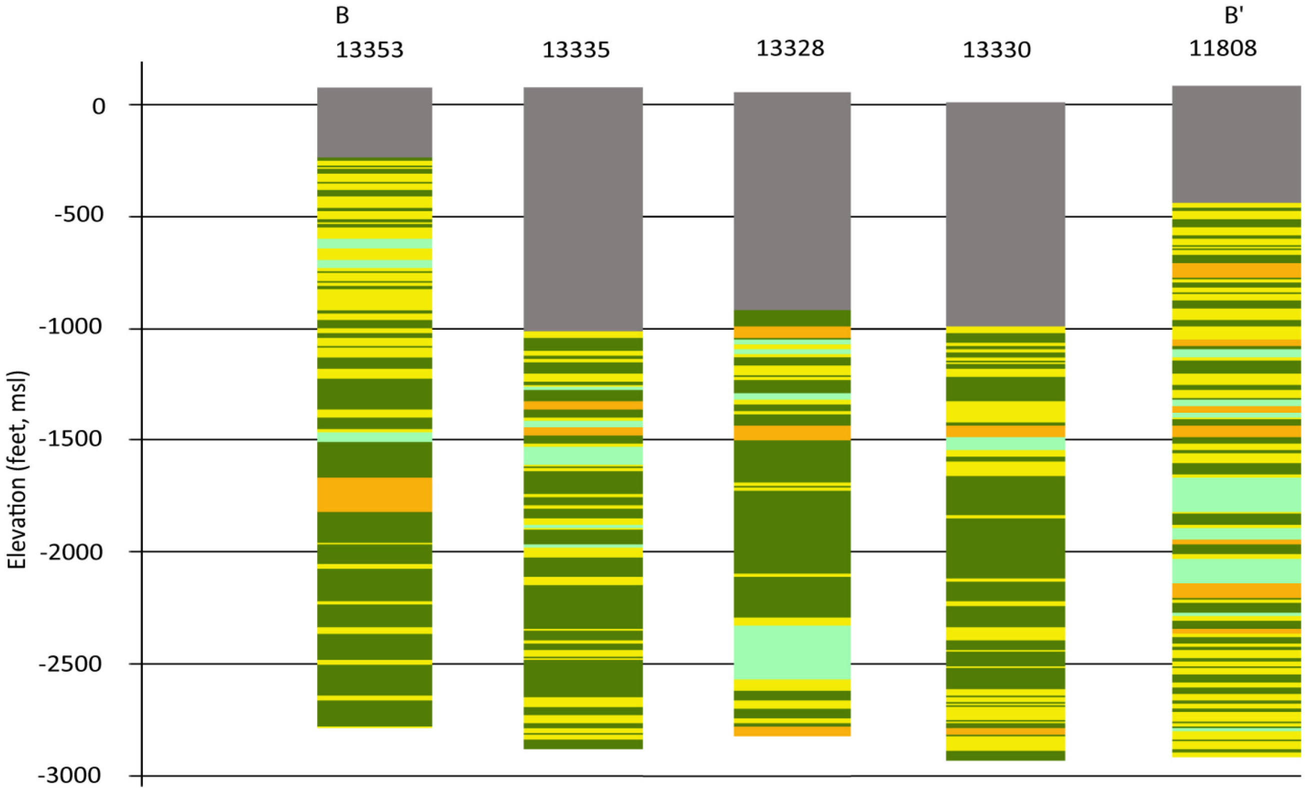
Cross-section A-A'

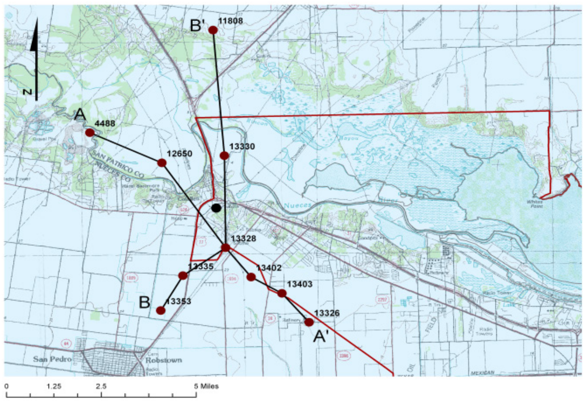




Cross-section B-B'



Lithology
- No Record
- Sand
- Clay
- Sand with Clay
- Clay with Sand



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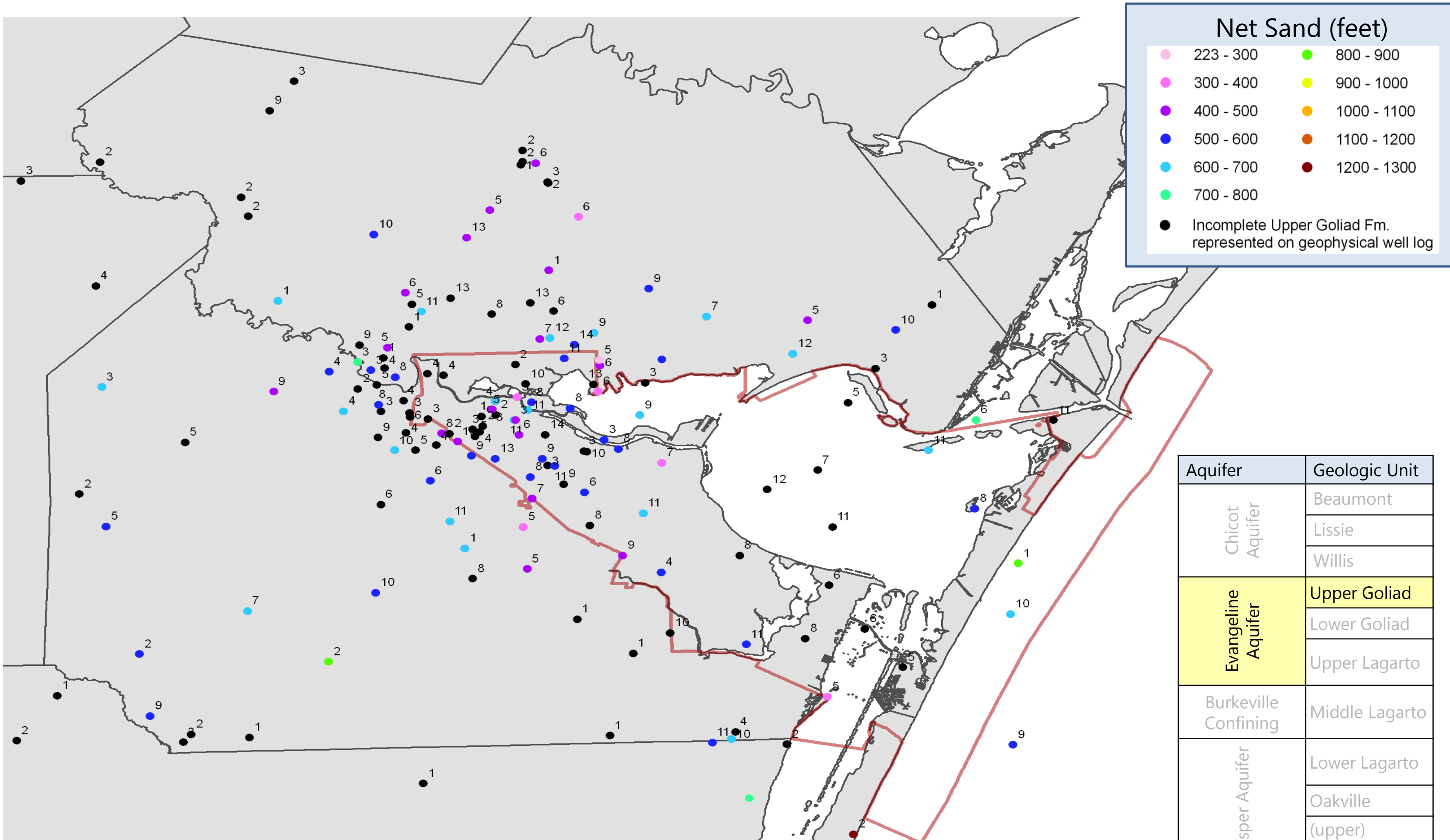
Example: Upper Goliad Formation net sand map



Aquifer	Geologic Unit
Chicot Aquifer	Beaumont
	Lissie
	Willis
Evangeline Aquifer	Upper Goliad
	Lower Goliad
	Upper Lagarto
Burkeville Confining	Middle Lagarto
Jasper Aquifer	Lower Lagarto
	Oakville
	(upper) Catahoula
Catahoula Confining	(lower) Catahoula

integers refer to number of sand layers thicker than 20 feet

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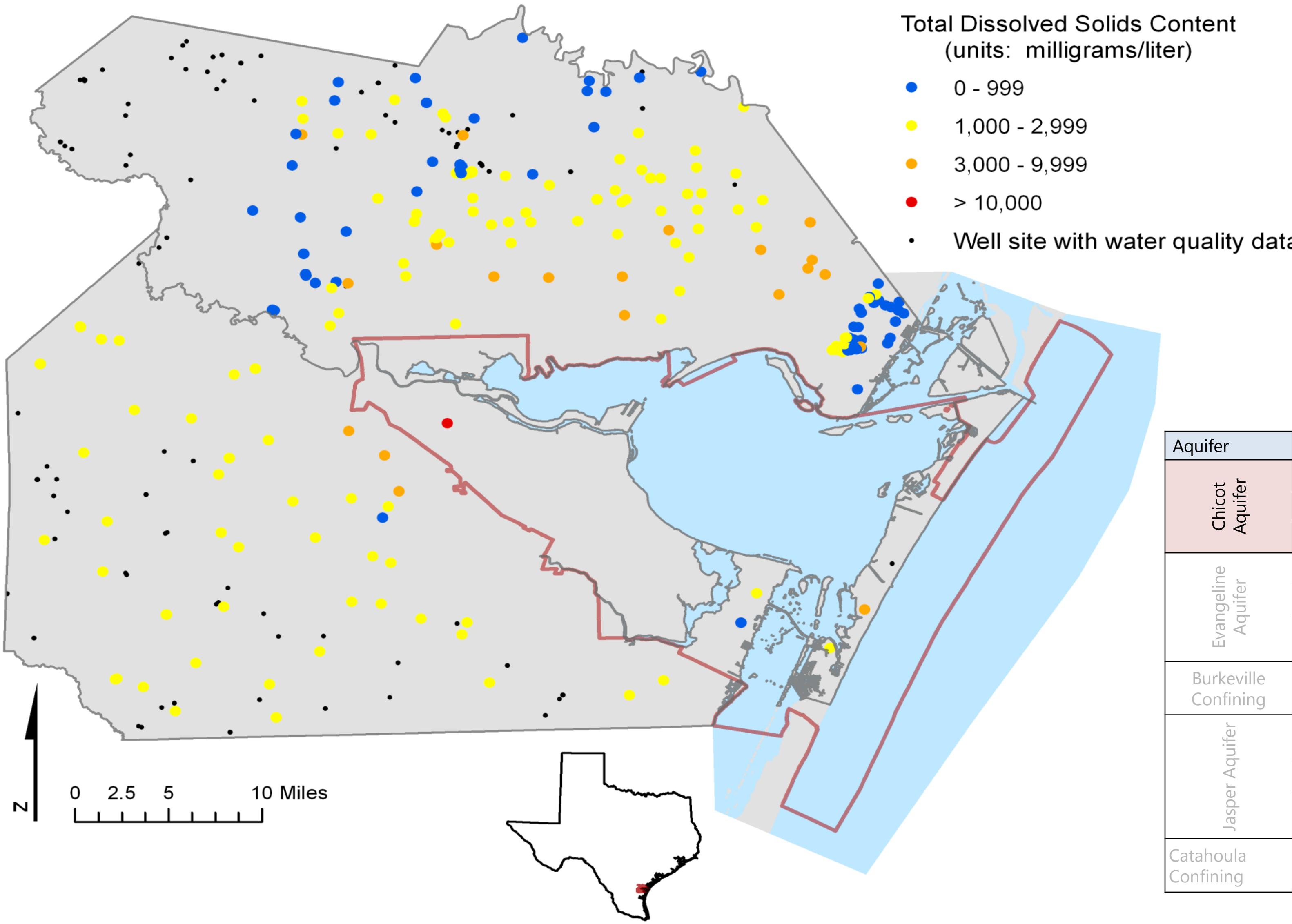
Chicot Aquifer total dissolved solids



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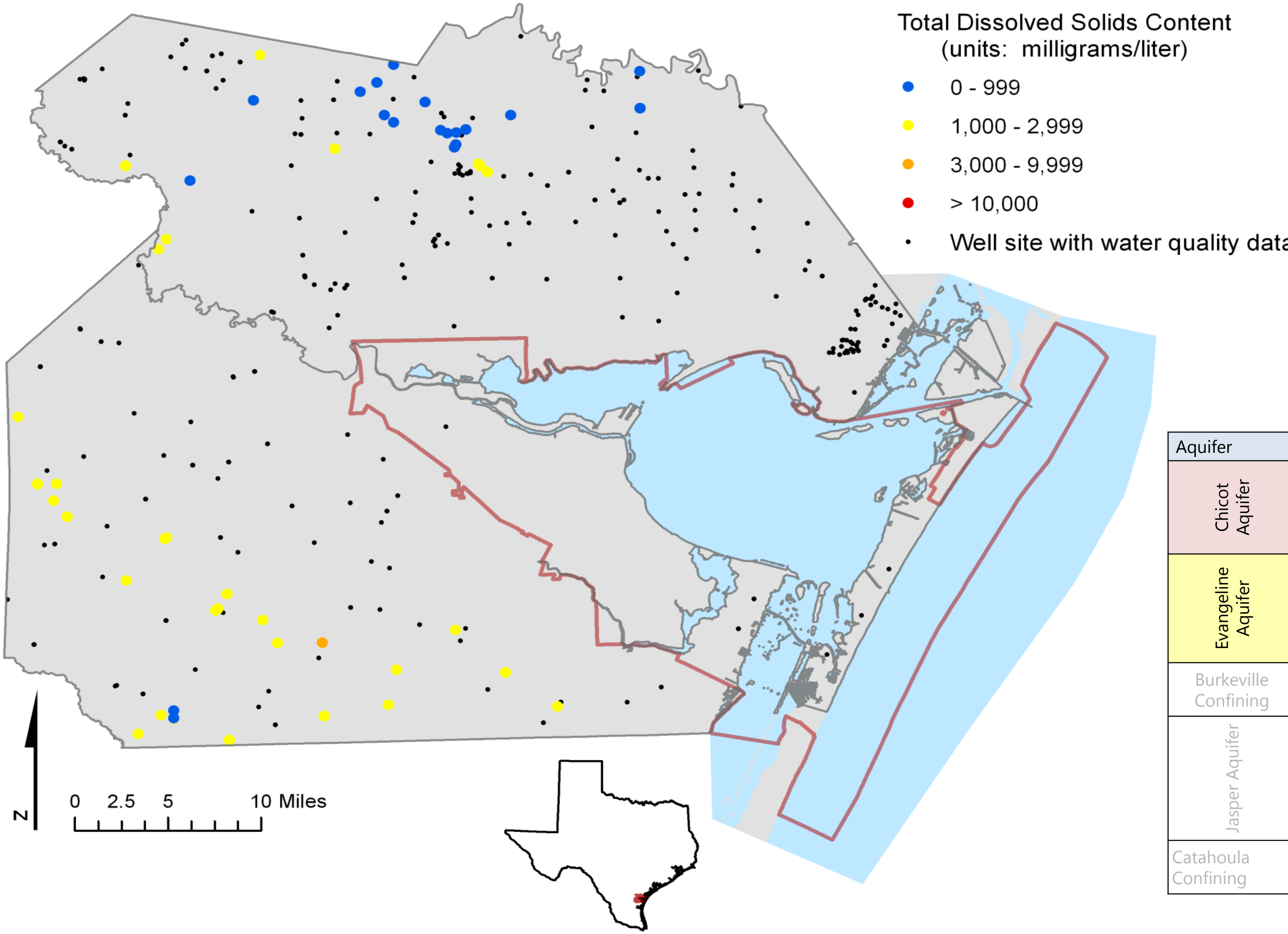
Chicot-Evangeline Aquifer total dissolved solids



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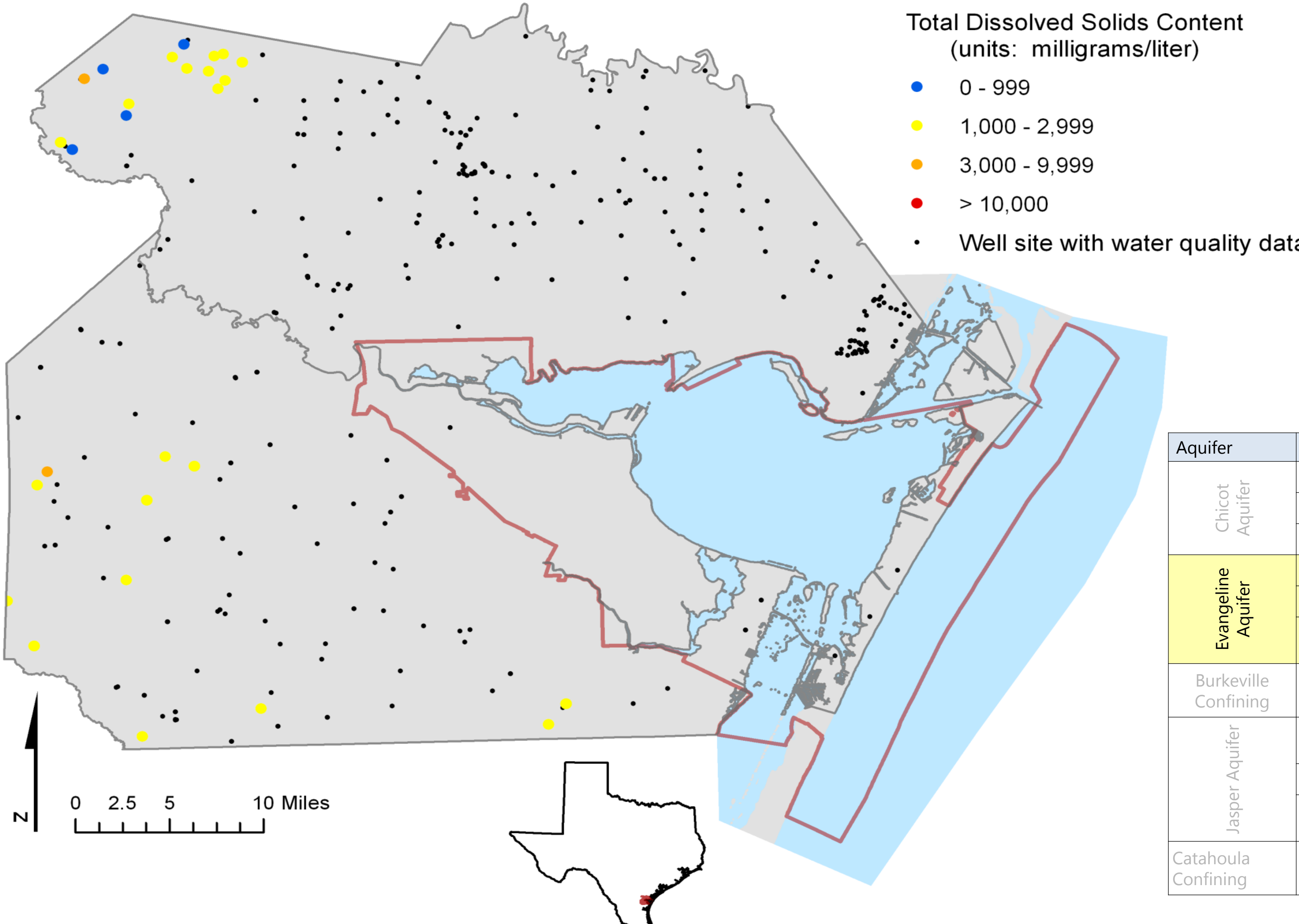
Evangeline Aquifer total dissolved solids



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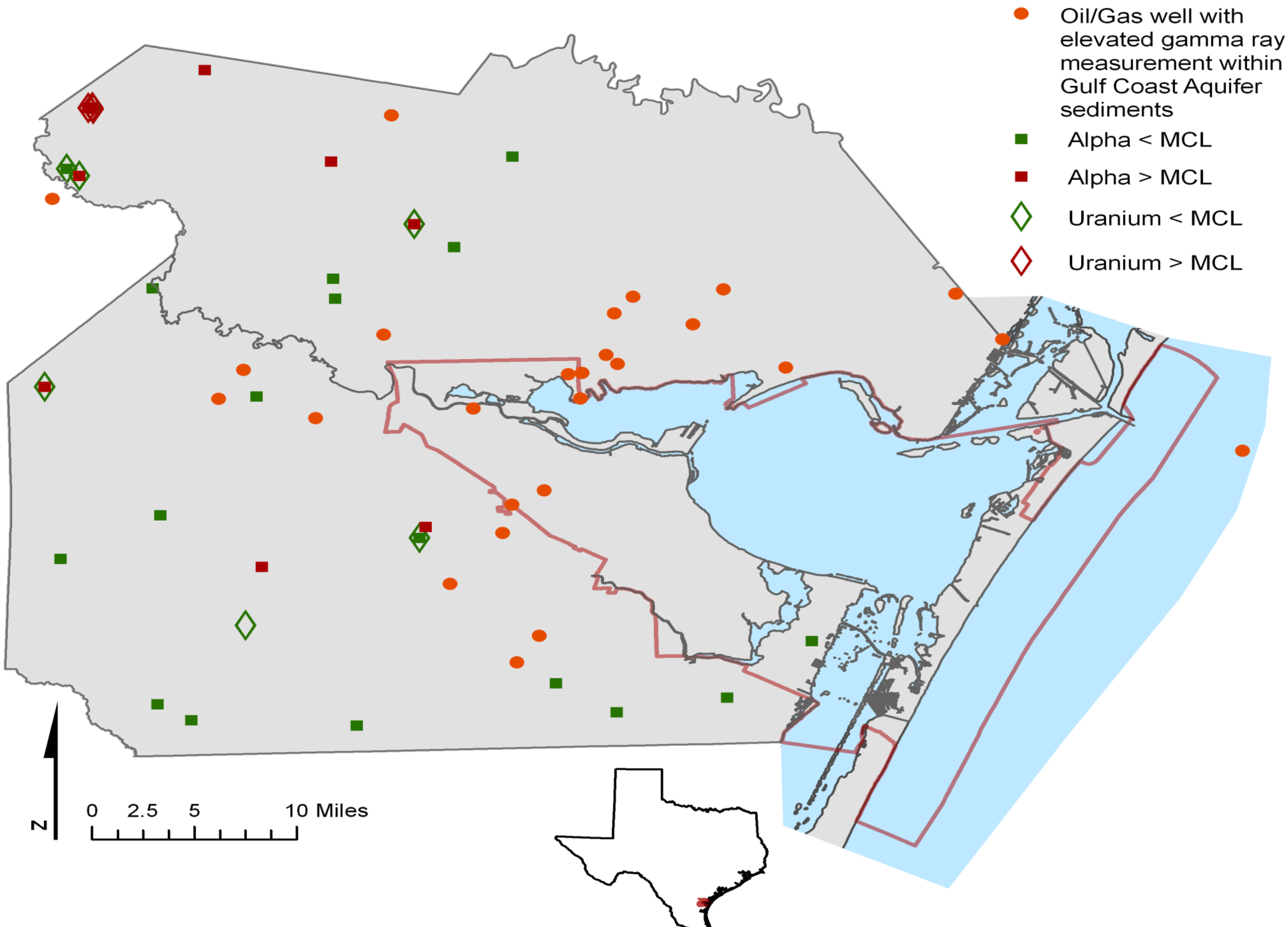
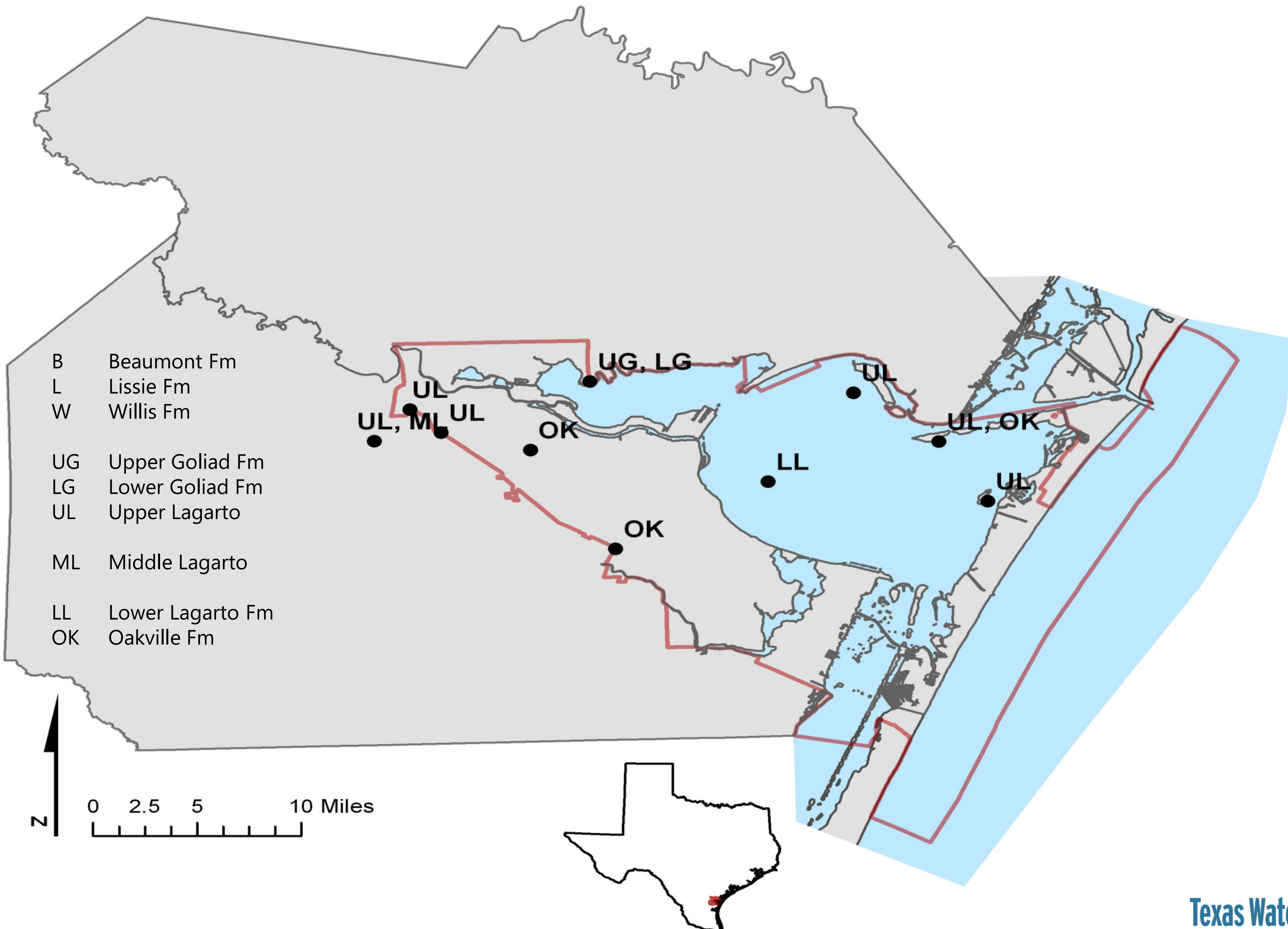
Radioactivity in the Gulf Coast Aquifer



Hydrocarbons in the Gulf Coast Aquifer



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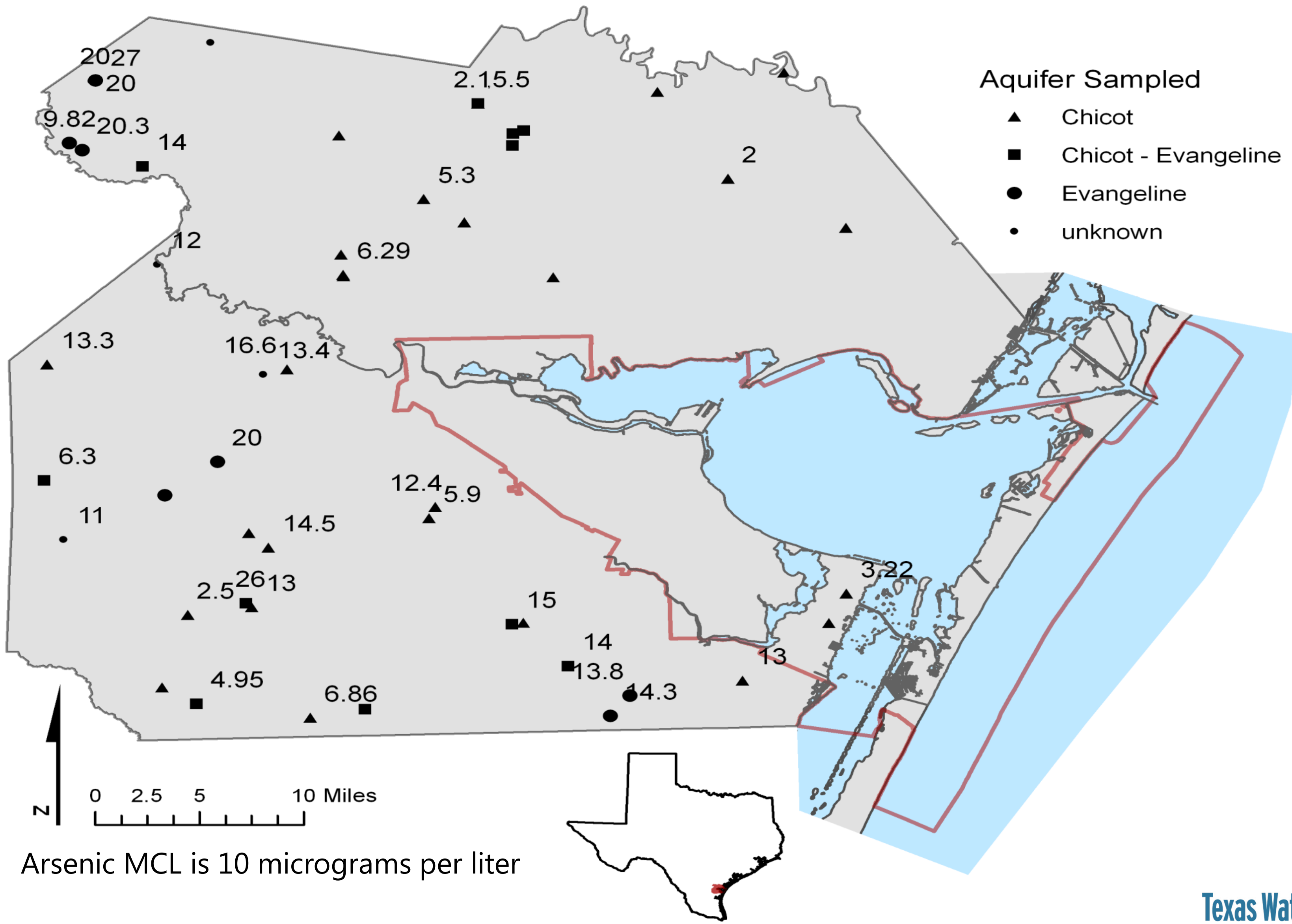
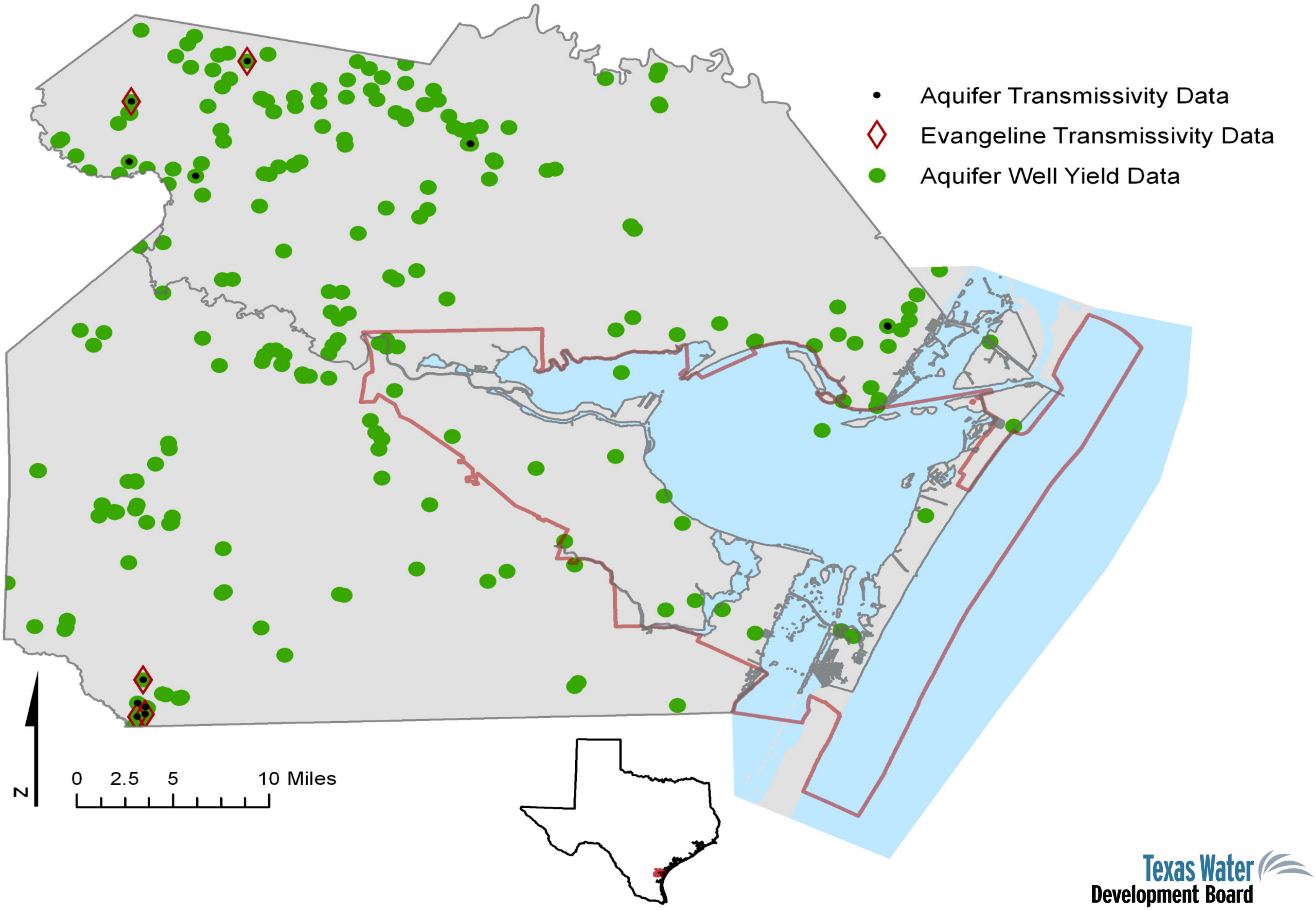
Arsenic in the Gulf Coast Aquifer



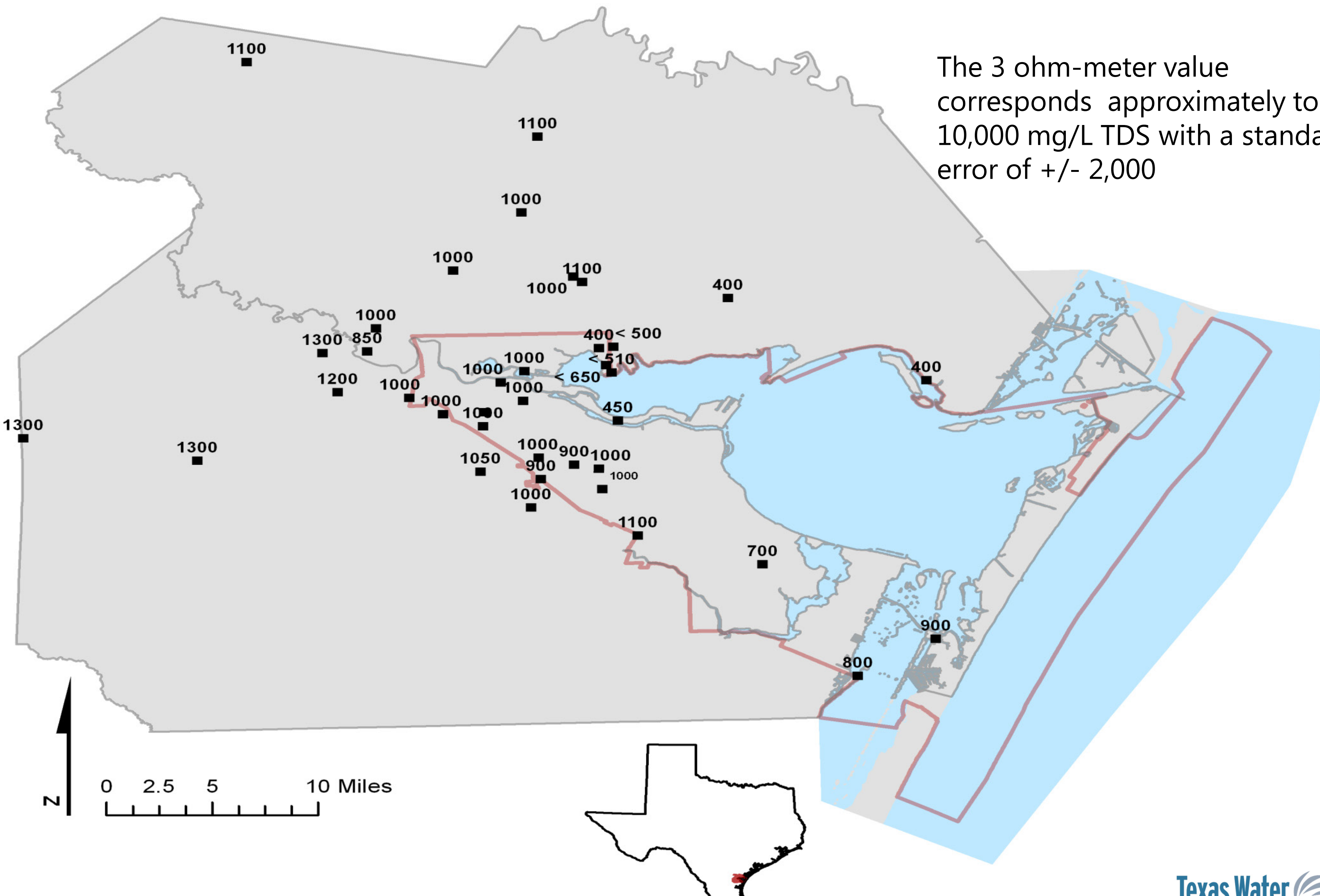
Arsenic MCL is 10 micrograms per liter

Hydraulic properties information, Gulf Coast Aquifer



Approximate depth (feet) to 10,000 mg/L TDS

The 3 ohm-meter value corresponds approximately to 10,000 mg/L TDS with a standard error of +/- 2,000



Highlights of methodology

- The study was structured to collect and evaluate as much data as possible for the entire Gulf Coast Aquifer sequence to allow the District flexibility in selecting site and target depth
- Additional well data can be loaded into the database to evaluate adjoining areas in more detail, including test well drilling information
- All information collected was non-confidential; additional confidential data is available if needed
- The variability of geophysical log quality, age, and completeness precluded automated analysis of net sand using LAS files
- Techniques of geophysical well log resistivity analysis are still being evaluated and results have limited application

Summary

- Numerous sand layers of varying thickness are present within the Gulf Coast sequence
- Formation water quality ranges from brackish to saline
- Extreme caution should be used to extrapolate—into the District—the limited water quality data that is available
- Similarly, only limited aquifer hydraulic property information can be extrapolated to the District
- Test well drilling and a comprehensive evaluation of geology and water quality will be essential to fully characterize the area
- Radioactivity, arsenic, and hydrocarbons are known contaminants in the area that must be thoroughly evaluated during test drilling

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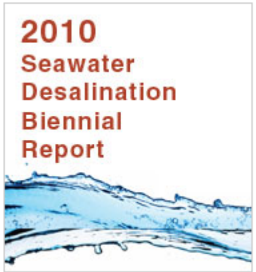

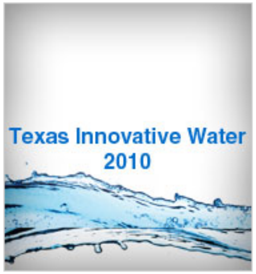

Report

An Assessment of Aquifer Storage and Recovery in Texas

February 2011

Malcolm Pirnie, Inc.
ASR Systems, LLC
Jackson, Sjoberg, McCarthy & Wilson, LLP

Innovative Water Technologies

- Aquifer Storage and Recovery
- BRACS
- Desalination
- Rainwater Harvesting
- Water Reuse

Innovative Water Technologies

The mission of the Innovative Water Technologies is to educate the water community on the use of nontraditional water supplies. This mission is accomplished by participating in research needed to advance technology demonstration projects; developing publications and educational materials; making presentations to the public; and, actively participating in key water organizations.

To promote and advance the use of non-traditional water supply development and management technologies such as desalination; rainwater and stormwater harvesting; water reuse; and aquifer storage and recovery in Texas, Innovative Water Technologies:

- funds and participates in research and demonstration projects; and,
- disseminates information through outreach activities.

Innovative Water Technologies (IWT) is primarily involved in the areas of nontraditional water supply and management activities including: desalination, rainwater and stormwater harvesting, water reuse, and aquifer storage recovery.

Through our desalination program, we administer grants for brackish groundwater desalination projects and seawater desalination pilot studies. To date, TWDB has funded eight brackish groundwater desalination demonstration projects worth a total of about $2.2 million, and two seawater desalination pilot plant studies worth approximately $3.13 million.

We promote rainwater and stormwater harvesting and water reuse through grants for research and demonstration projects and outreach activities.

Texas Water Development Board, 1700 North Congress Avenue, Austin, TX 78711 | TEL: 512-463-7847

Questions?

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