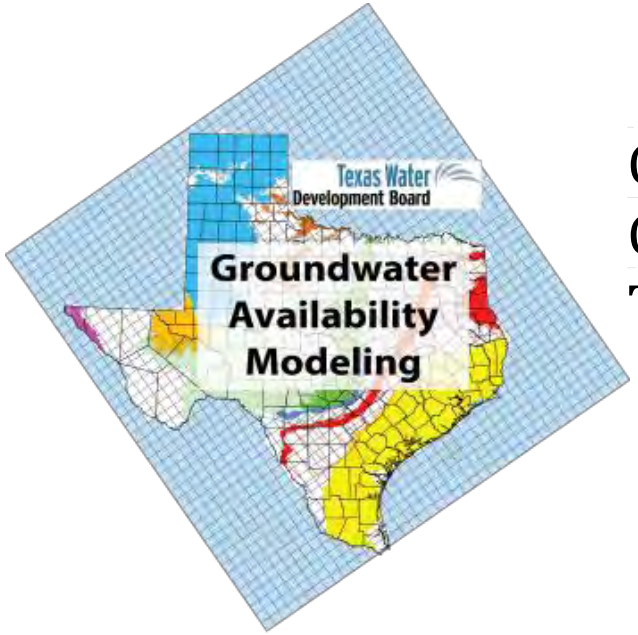
Texas Water Development Board (TWDB) Groundwater Availability Modeling (GAM) Program



Cindy Ridgeway (Manager)
Groundwater Availability Modeling Program
Texas Water Development Board

What is the Texas Water Development Board?

Not regulatory agency like Texas Commission on Environmental Quality.

Science: Groundwater, surface water, innovative water technology, conservation, education, flooding.

Planning: Assist with regional planning and state planning (drought and flood plans)

Funding: We assist with implementing water projects with funding

Groundwater Availability Modeling (GAM) Program

Aim: Develop groundwater flow models for the major and minor aquifers of Texas.

Purpose: Tools that can be used to aid in groundwater resources management by stakeholders.

Public process: Stakeholder involvement during model development process.

Models: Freely available, standardized, thoroughly documented. Reports, data, models are available for download from TWDB download page for models.

Living tools: Periodically updated.

Why Stakeholder Advisory Forums?

Keep stakeholders updated about progress of the modeling project

Inform how the groundwater model can, should, and should not be used

Provide stakeholders with the opportunity to provide input and data to assist with model development

Contact Information

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Manager of Groundwater Availability Modeling Section
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Cindy.ridgeway@twdb.texas.gov

Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711-3231

Web information:
https://www.twdb.texas.gov/groundwater/models/gam/czwx_s/czwx_s.asp

DRAFT CONCEPTUAL MODEL

UPDATE OF GROUNDWATER AVAILABILITY MODEL FOR THE SOUTHERN PORTION OF THE CARRIZO-WILCOX, QUEEN CITY, SPARTA AQUIFERS

TWDB Contract No. 1948312321

Stakeholders Advisory Forum
March 4, 2021

Staffan Schorr, Montgomery & Associates

MONTGOMERY & ASSOCIATES

GSI ENVIRONMENTAL

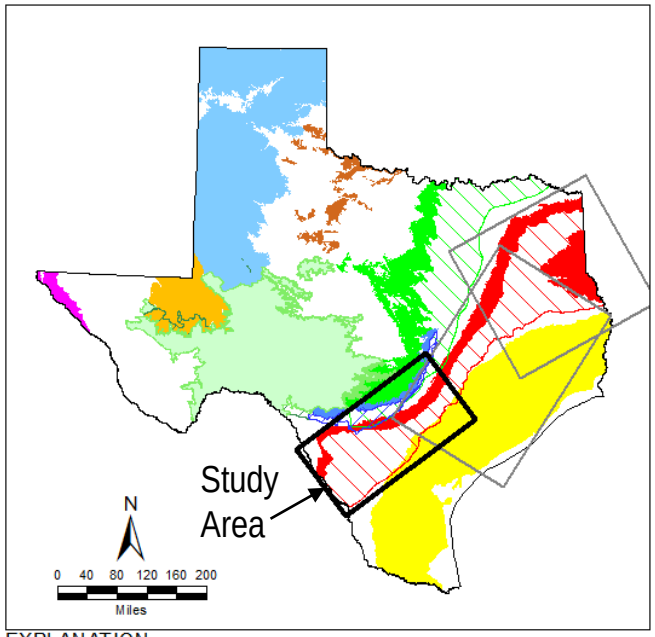
esi Environmental Simulations Inc.

TOPICS

- Brief Overview of Project
- Overview of Conceptual Model
  - Objectives
  - Hydrogeologic Setting
  - Aquifer Inflows and Outflows
  - Groundwater Salinity
- Next Steps
- Questions, Input, Comments from Stakeholders

BACKGROUND

Major Aquifers

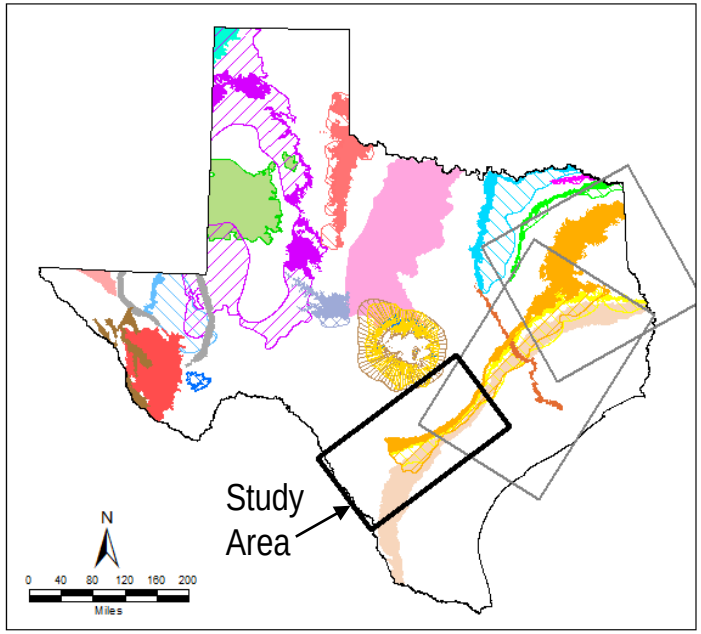


EXPLANATION

Major Aquifers Defined by TWDB (updated July 2019)

- Pecos Valley
- Seymour
- Gulf Coast
- Carrizo - Wilcox (outcrop)
- Carrizo - Wilcox (subcrop)
- Hueco - Mesilla Bolson
- Ogallala
- Edwards - Trinity Plateau (outcrop)
- Edwards - Trinity Plateau (subcrop)
- Edwards Balcones Fault Zone (outcrop)
- Edwards Balcones Fault Zone (subcrop)
- Trinity (outcrop)
- Trinity (subcrop)
- State Boundary

Minor Aquifers



EXPLANATION

Minor Aquifers Defined by TWDB (updated July 2019)

- Brazos River Alluvium
- West Texas Bolsons
- Lipan (outcrop)
- Lipan (subcrop)
- Yegua Jackson
- Igneous
- Sparta (outcrop)
- Sparta (subcrop)
- Queen City (outcrop)
- Queen City (subcrop)
- Nacatoch (outcrop)
- Nacatoch (subcrop)
- Blossom (outcrop)
- Blossom (subcrop)
- Woodbine (outcrop)
- Woodbine (subcrop)
- Rita Blanca
- Edwards - Trinity (High Plains)
- Dockum (outcrop)
- Dockum (subcrop)
- Rustler (outcrop)
- Rustler (subcrop)
- State Boundary
- Capitan Reef Complex
- Blaine (outcrop)
- Blaine (subcrop)
- Bone Spring - Victorio Peak
- Marble Falls
- Marathon
- Ellenburger - San Saba (outcrop)
- Ellenburger - San Saba (subcrop)
- Hickory (outcrop)
- Hickory (subcrop)
- Cross Timbers

EXISTING GROUNDWATER AVAILABILITY MODEL

- GAM for southern portion of Carrizo-Wilcox aquifer completed in 2003
- Updated in 2004 when Queen City and Sparta aquifers were added to Carrizo-Wilcox GAM
- Transient model calibration period: 1980-1989
- Model verification period: 1990-1999
- Grid cell dimensions: 1 sq. mi.

OBJECTIVES

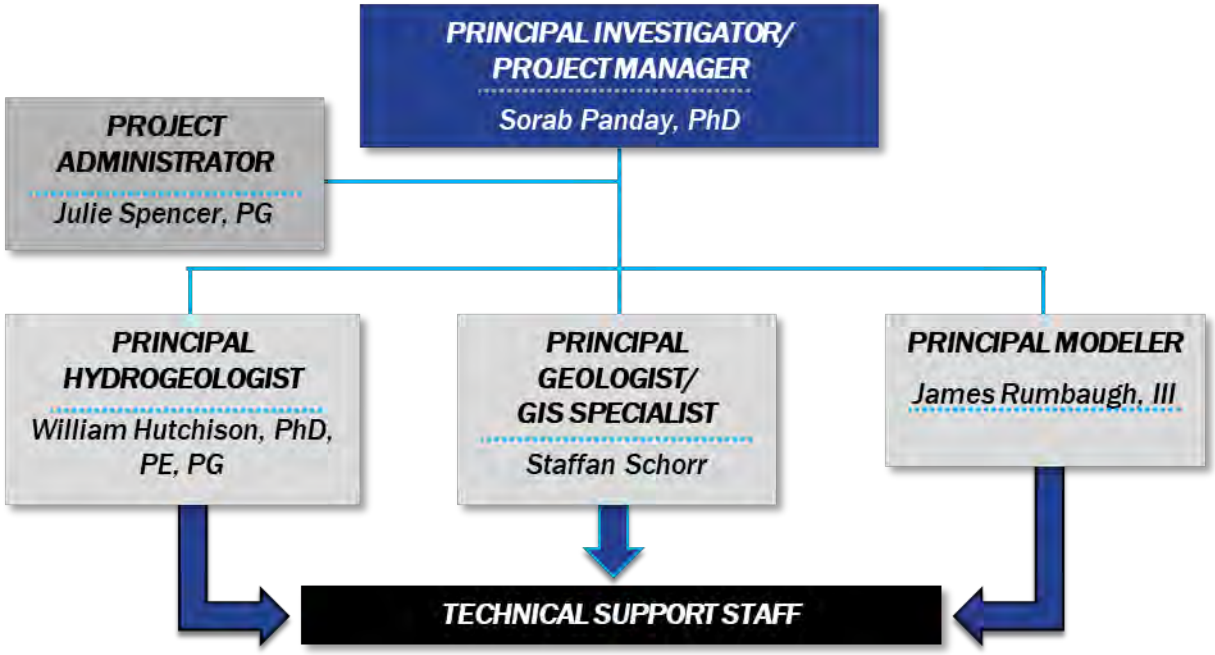
- The primary objective of this project is to update the existing Groundwater Availability Model (GAM)
- Upgrade model code
- Update model framework (layering) with recent interpretations and data
- Update model components with data through 2017 (ie, pumping, recharge, ET)
- Update calibration with data through 2017 (ie, water levels, streamflows)

PROJECT SCHEDULE

- ✓ Contract Signed by TWDB
  - May 17, 2019
- ✓ Interim Framework Completed
  - January 31, 2020
- ✓ Interim Draft Conceptual Model Completed
  - January 15, 2021
- Interim Draft Model Design Deadline
  - June 30, 2021
- Calibrated Model Deadline
  - January 31, 2022
- Final Report Deadline
  - June 30, 2022

GSI ENVIRONMENTAL TEAM

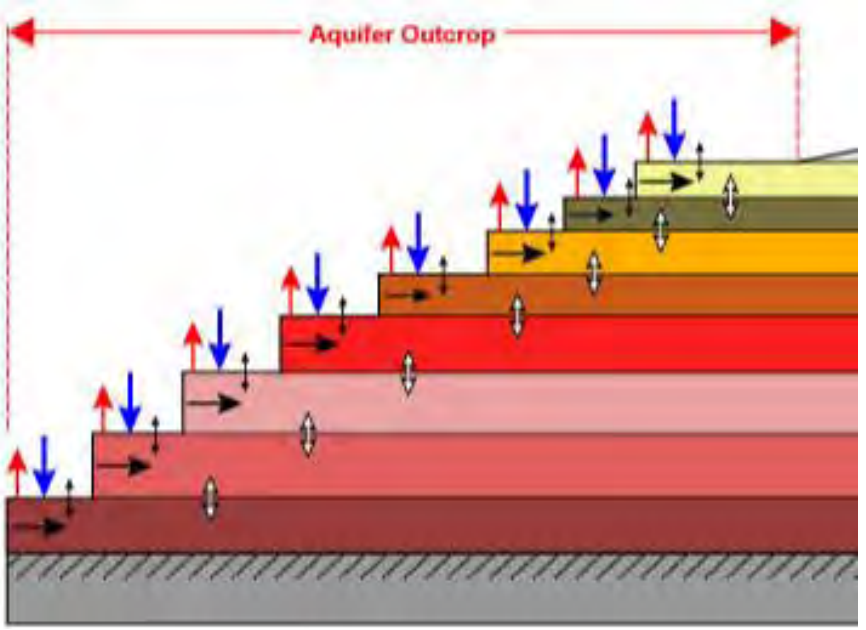
- Sorab Panday
- Julie Spencer
- Jim Rumbaugh
- Bill Hutchison
- Staffan Schorr



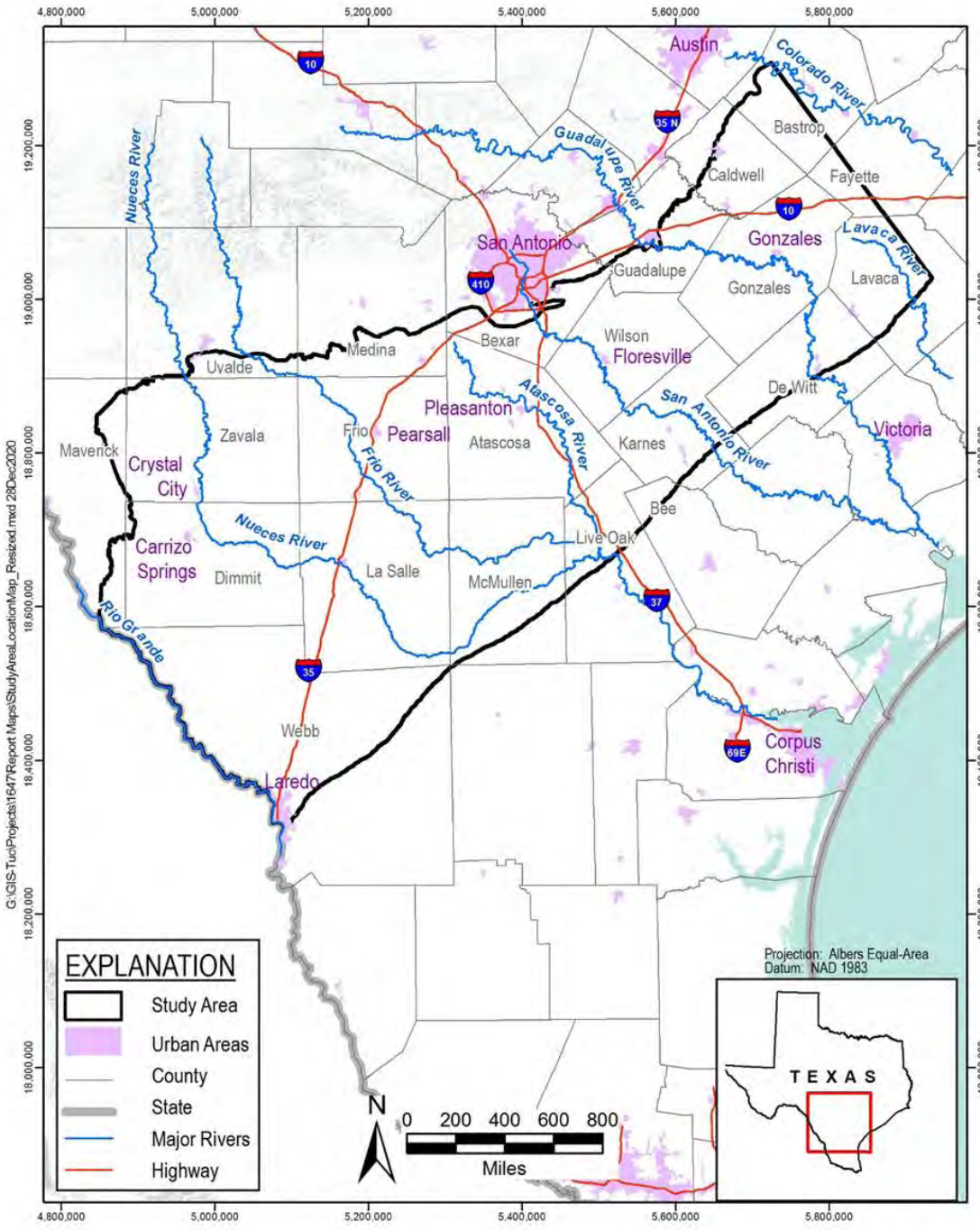
OVERVIEW OF CONCEPTUAL MODEL

CONCEPTUAL MODEL DEVELOPMENT

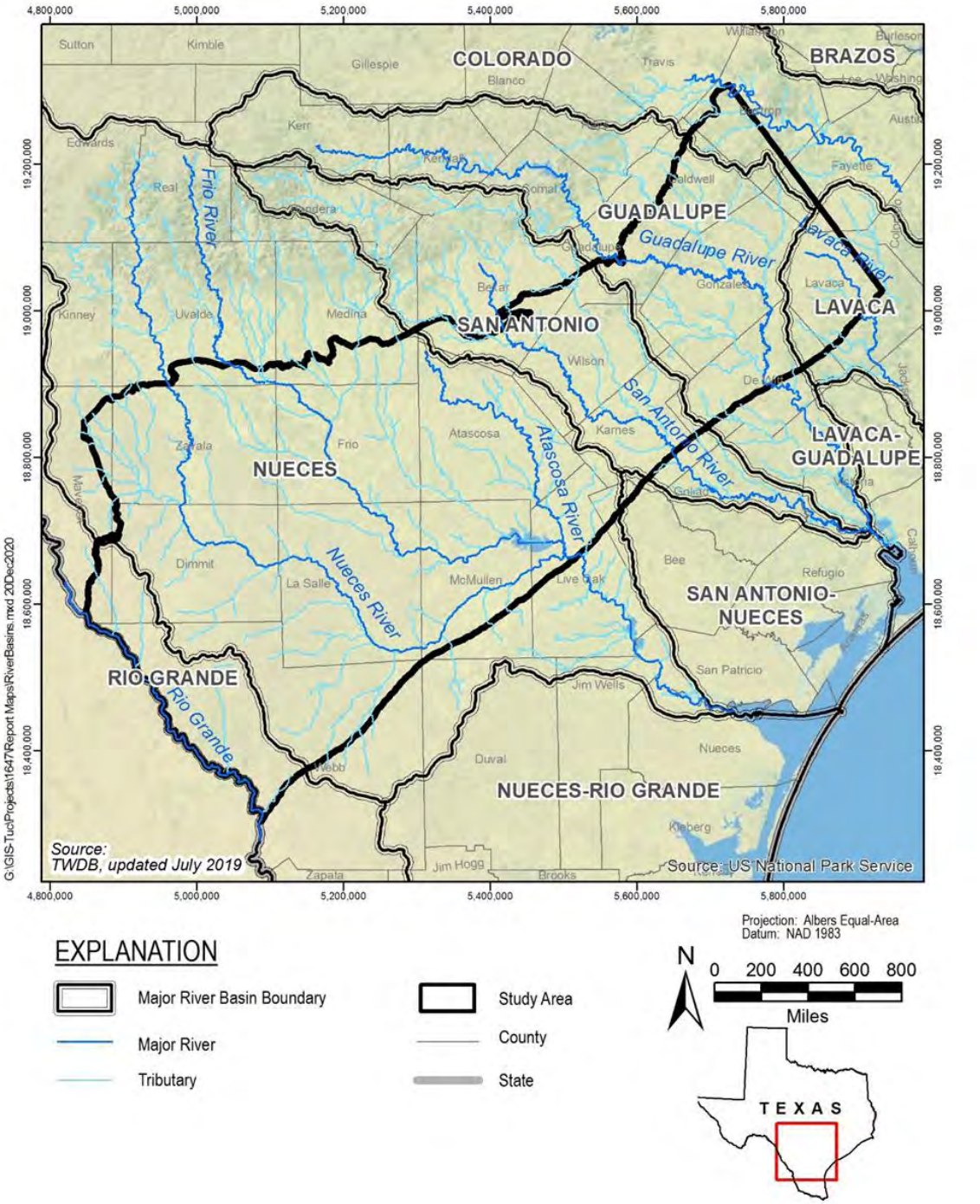
- Provides hydrogeologic framework and characterization of the groundwater system for input to groundwater model
  - Hydrostratigraphy and aquifer framework
  - Groundwater levels and regional flow
  - Groundwater pumping
  - Hydraulic properties
  - Physiography and climate
  - Rivers, springs, and reservoirs
  - Groundwater recharge
  - Evapotranspiration
  - Water quality



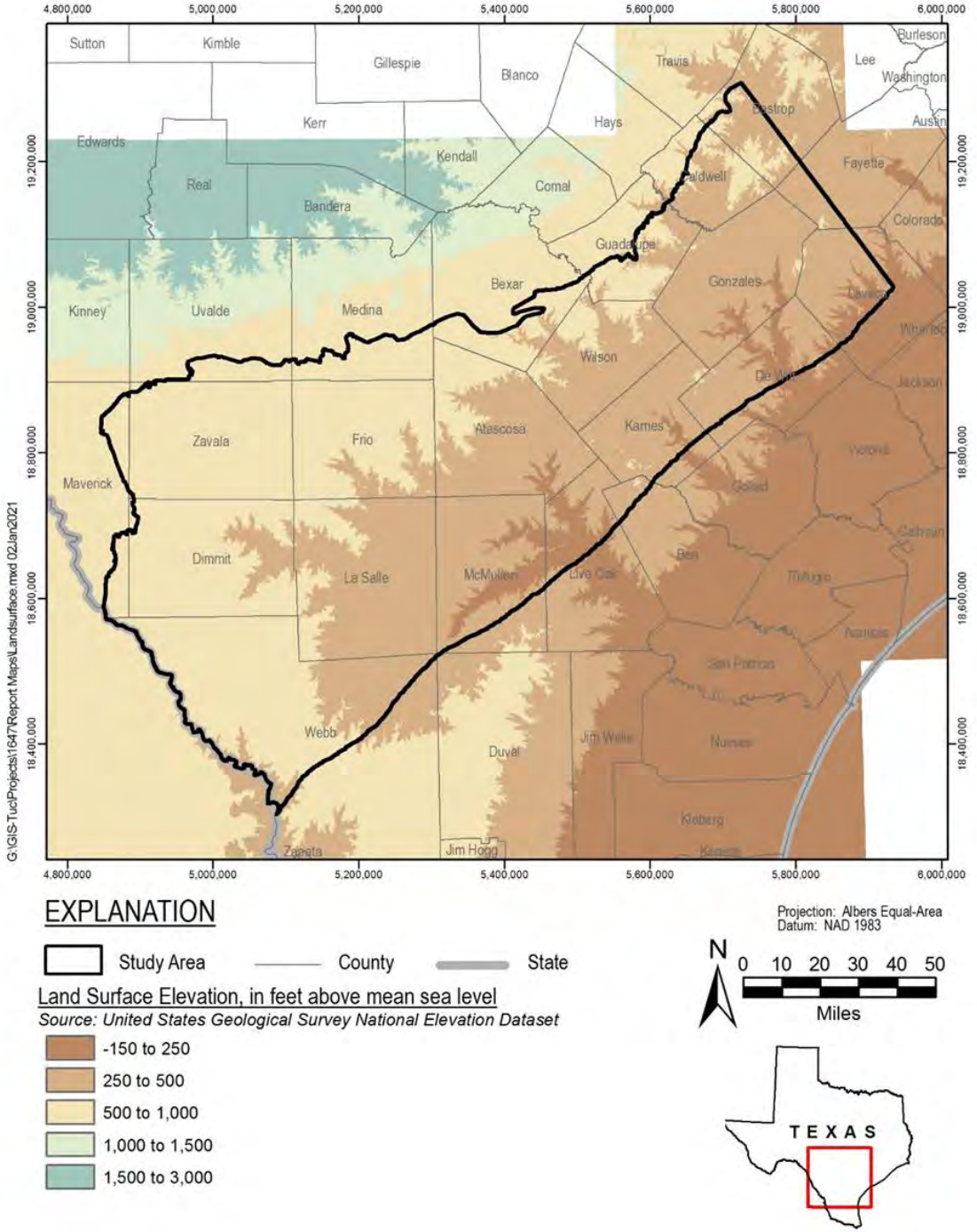
- Study Area


Austin
San Antonio
Gonzales
Victoria
Corpus Christi
Laredo
Uvalde
Medina
Bexar
Wilson
Floresville
De Witt
Guadalupe
Gonzales
Lavaca
Bastrop
Caldwell
Fayette
Pleasanton
Atascosa
Karnes
Bee
Live Oak
McMullen
La Salle
Dimmit
Zavala
Frio
Maverick
Crystal City
Carrizo Springs
Webb
Nueces River
Rio Grande
Frio River
Atascosa River
San Antonio River
Colorado River
Guadalupe River
Lavaca River
EXPLANATION
Study Area
Urban Areas
County
State
Major Rivers
Highway
N
0 200 400 600 800
Miles
Projection: Albers Equal-Area
Datum: NAD 1983
TEXAS
G:\GIS-Tuc\Projects\11647\Report Maps\StudyAreaLocationMap_Resized.mxd 28Dec2020

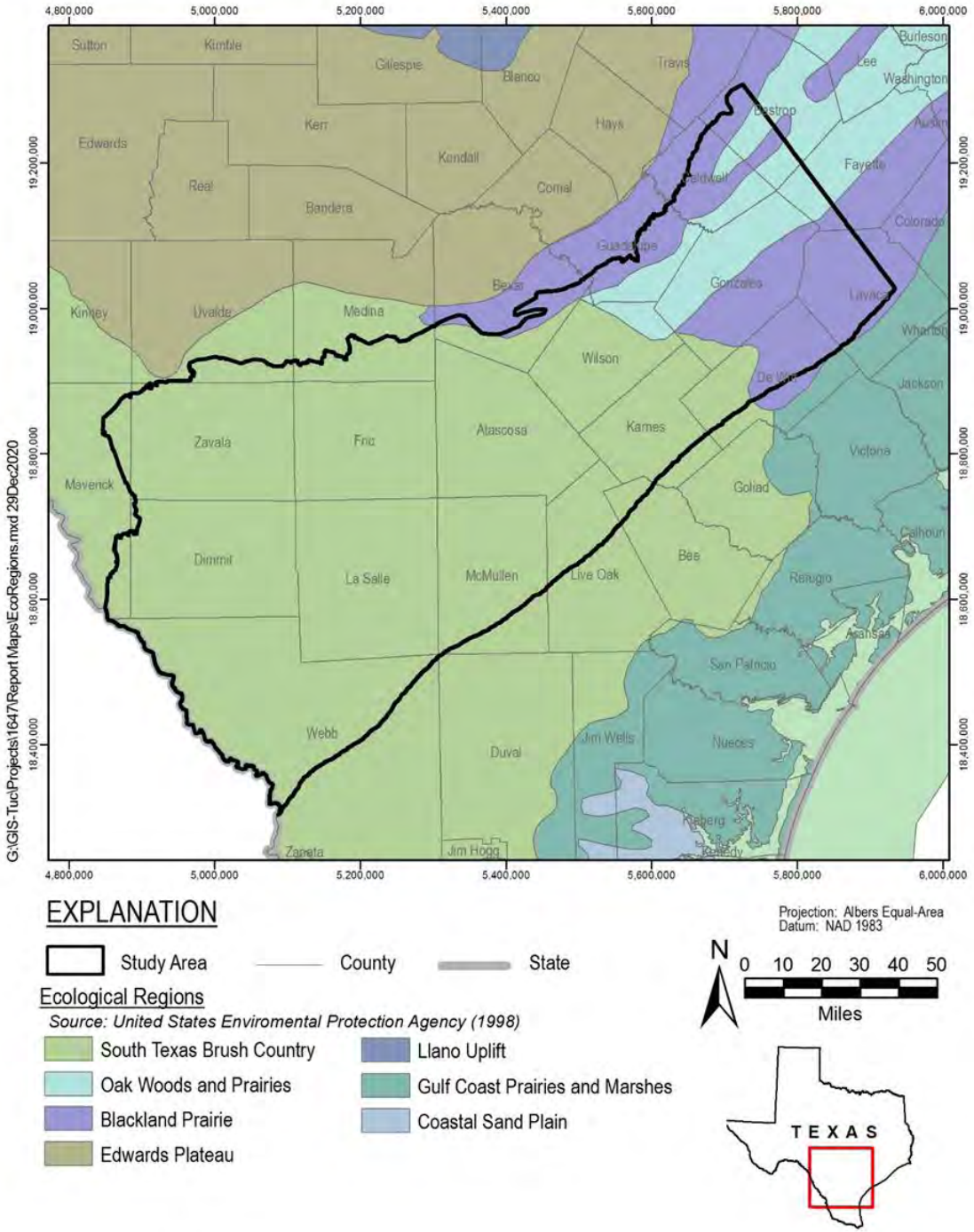
- River Basins



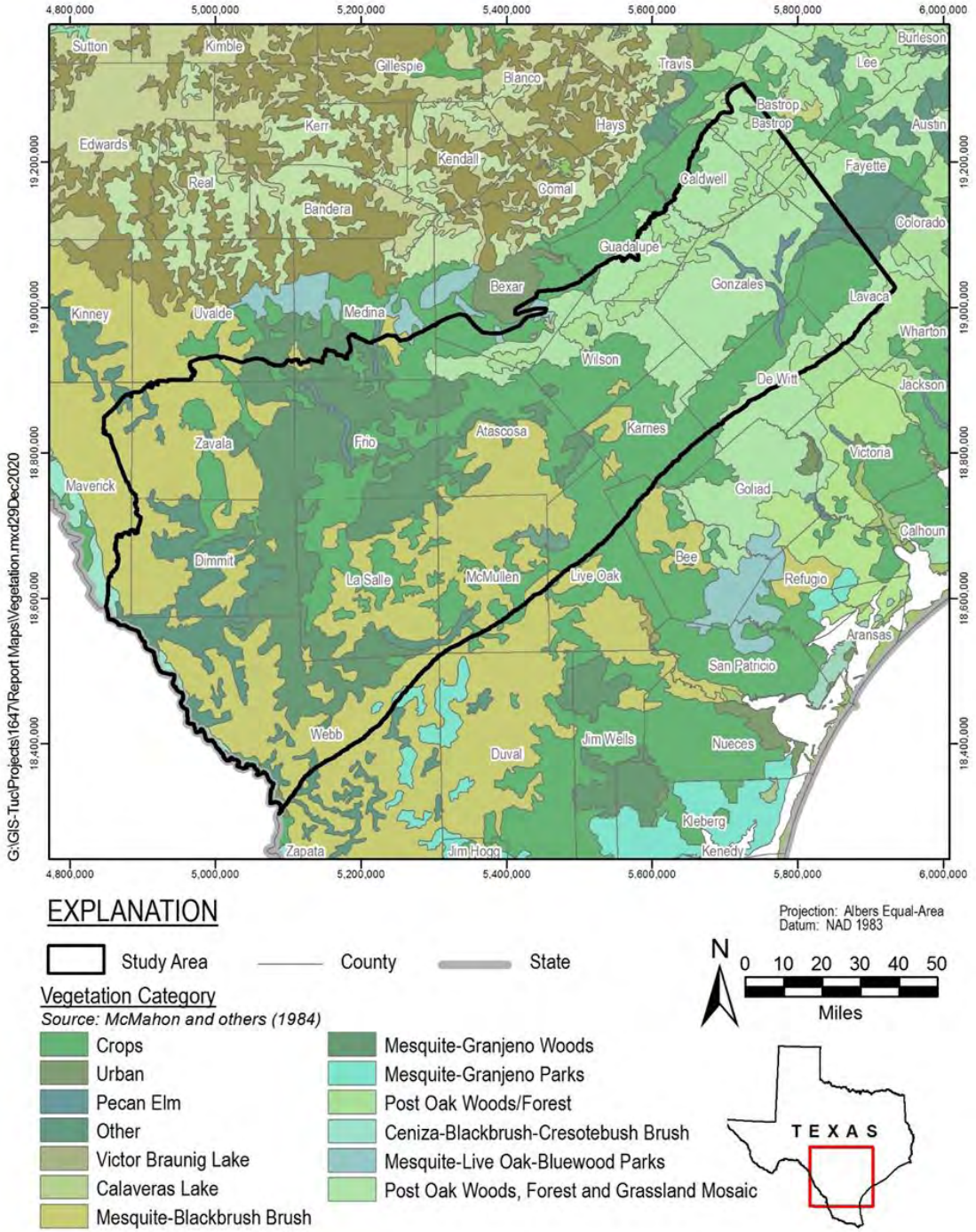
- Land Surface Elevation



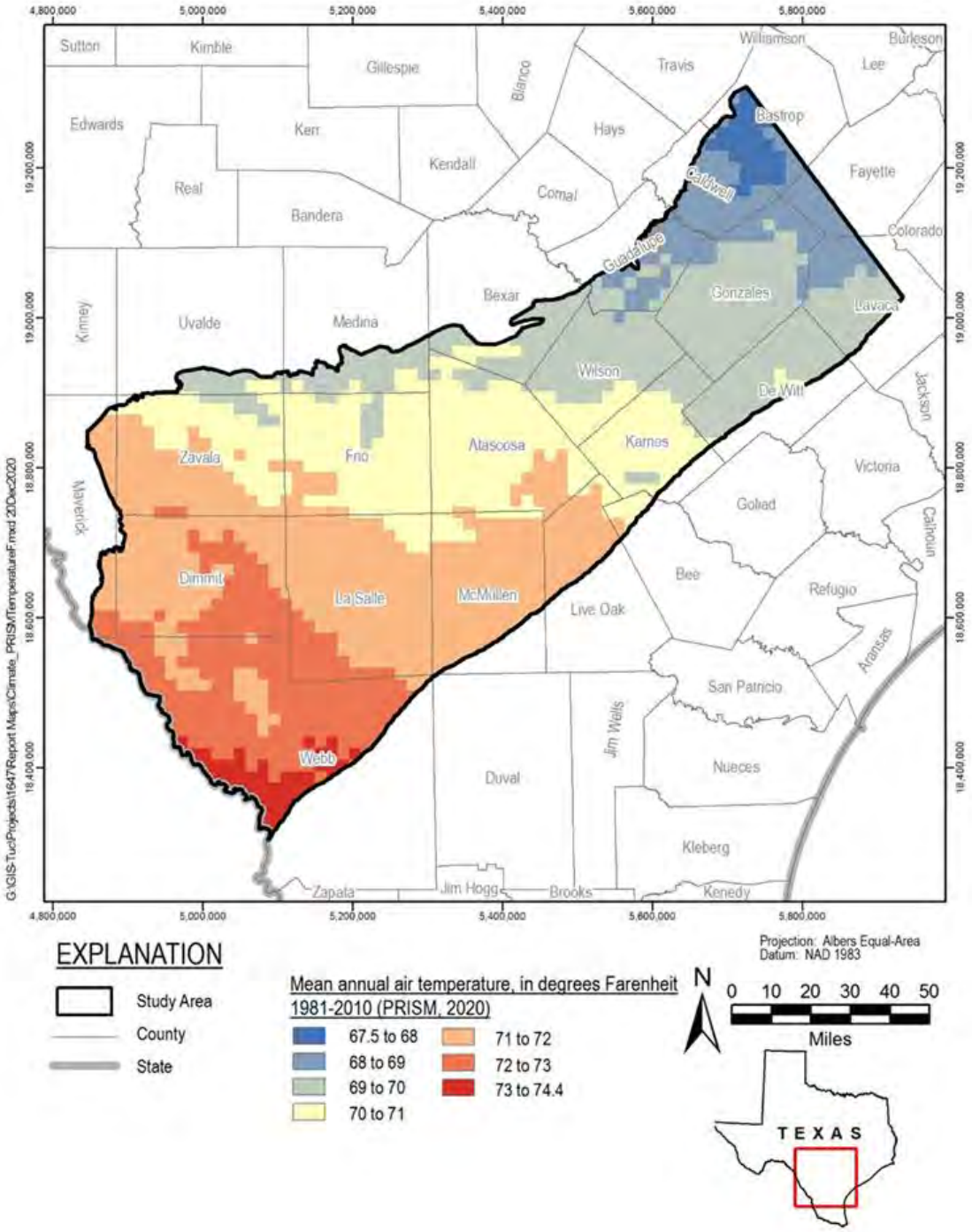
- Ecological Regions



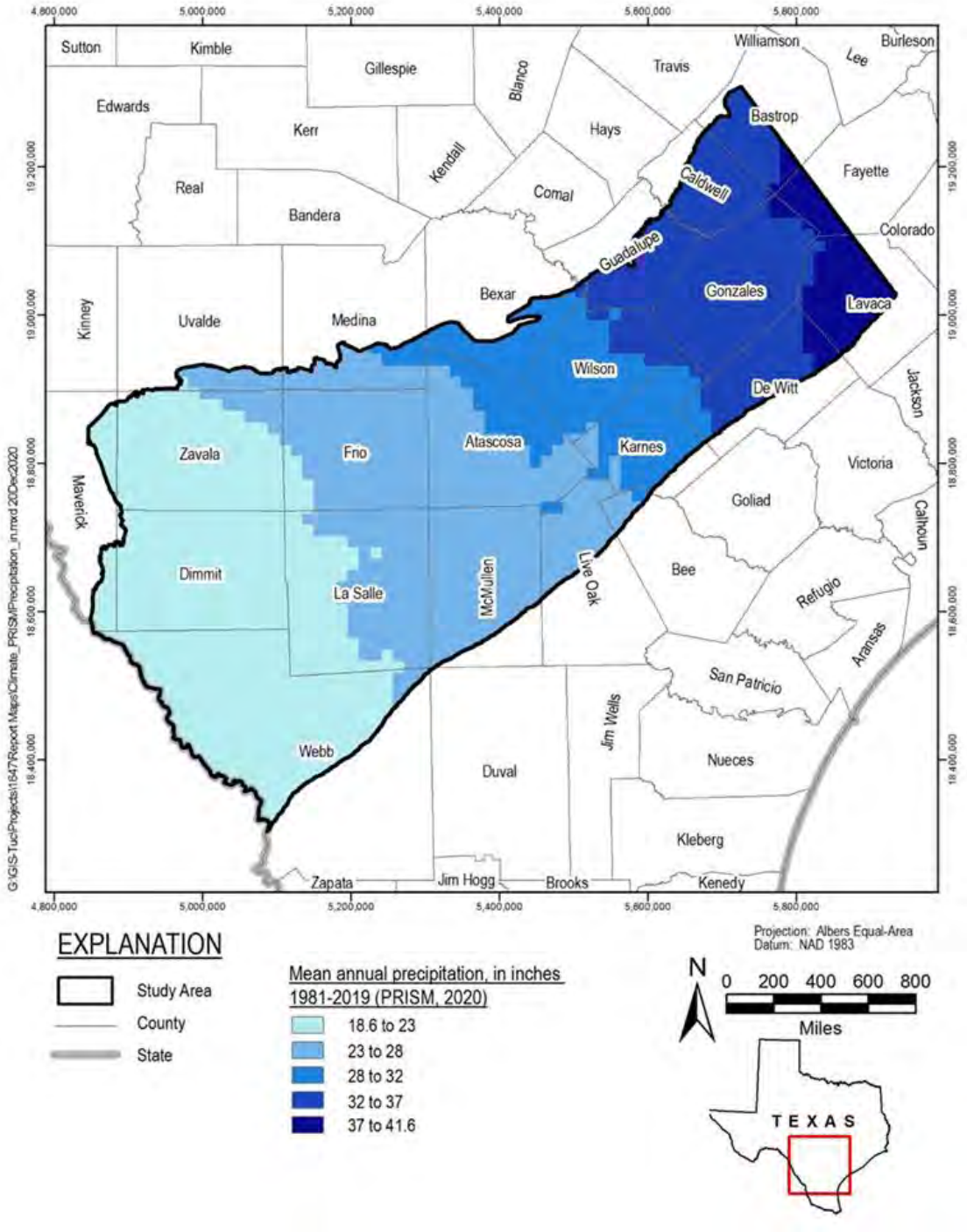
- Vegetation Type



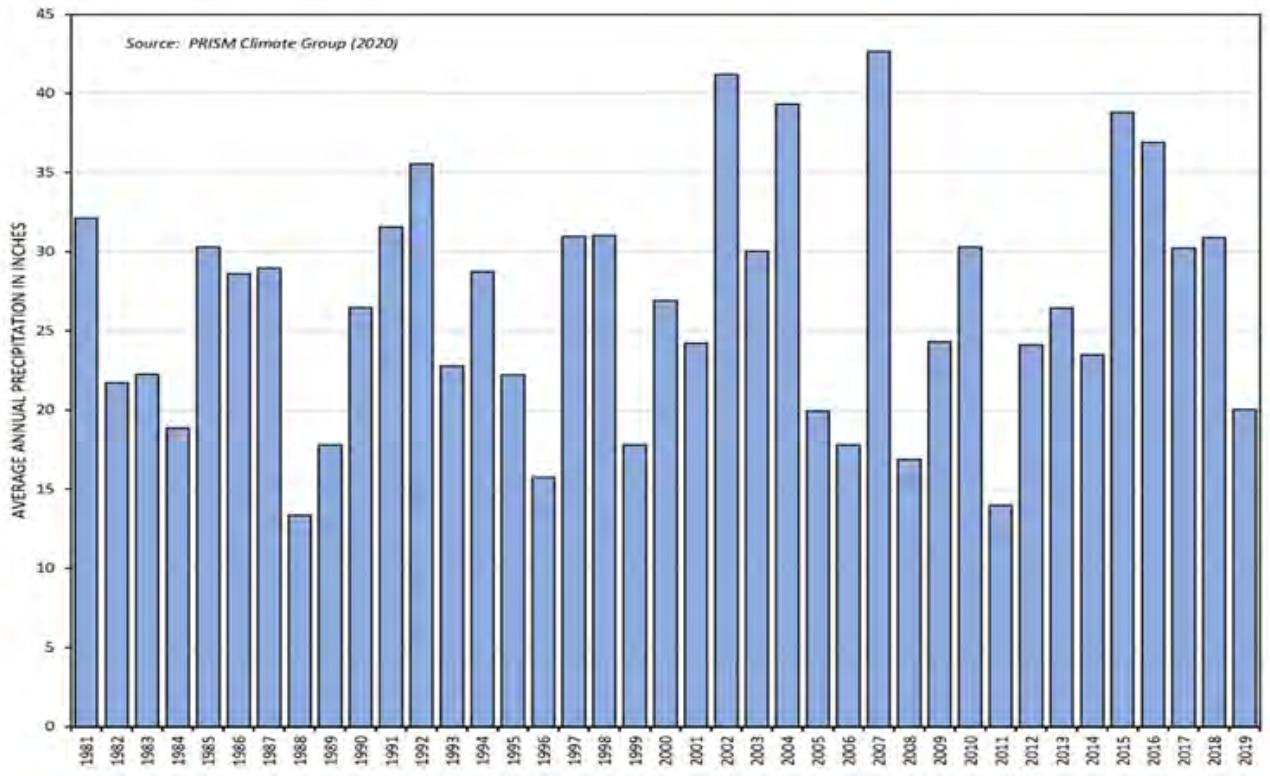
- Average Temperature



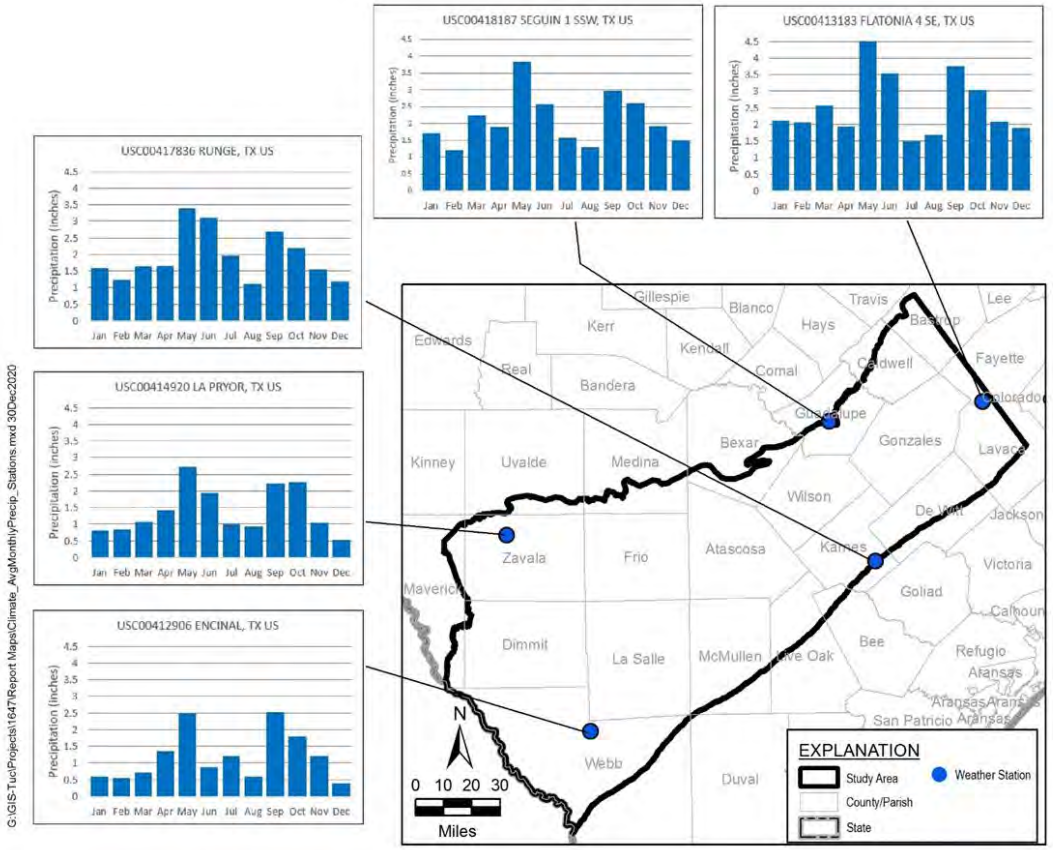
- Average Precipitation



- Annual Precipitation

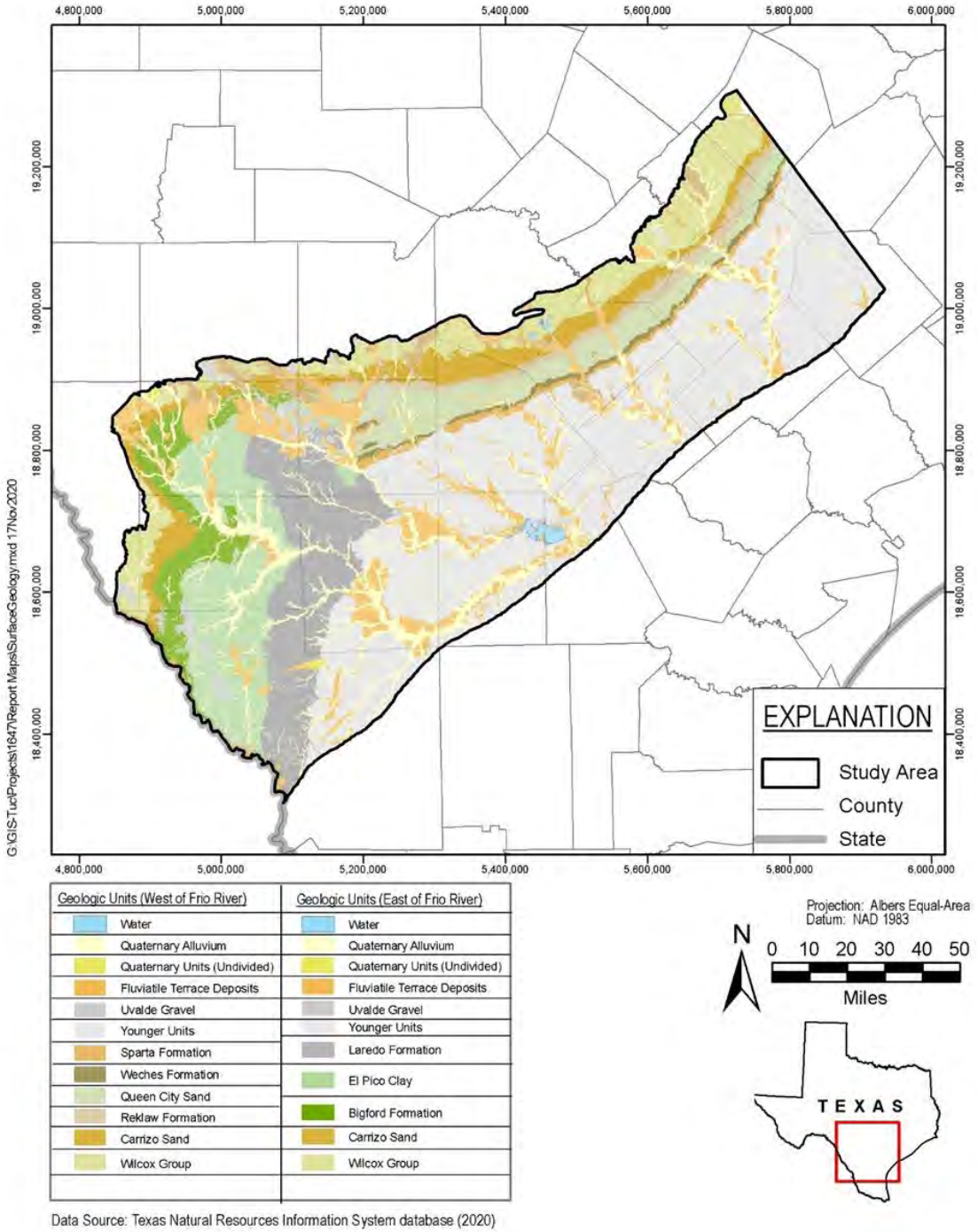


- Precipitation at selected stations
- Seasonal trends

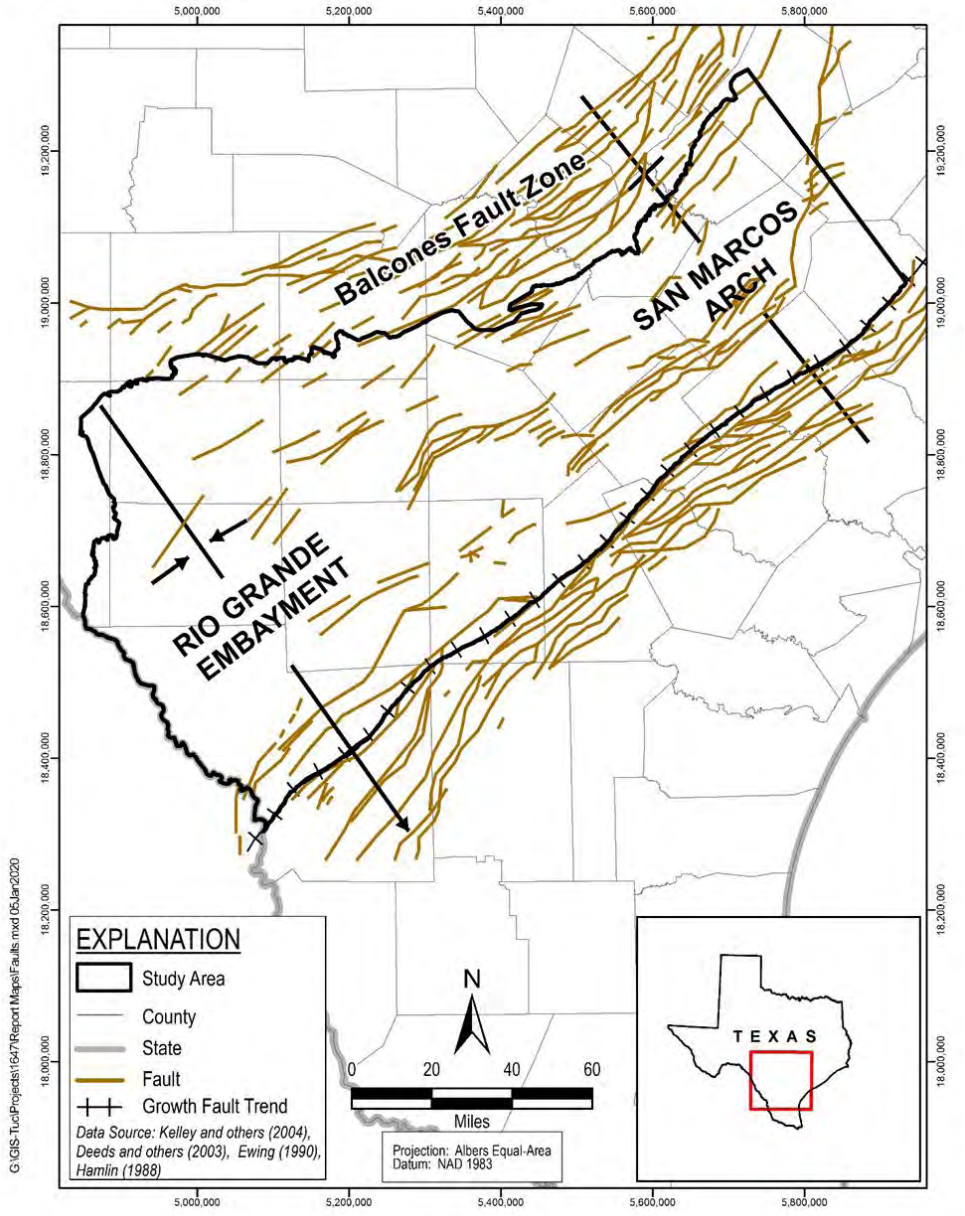


GEOLOGY

- Surface Geology
  - Change in classification east/west of Frio River



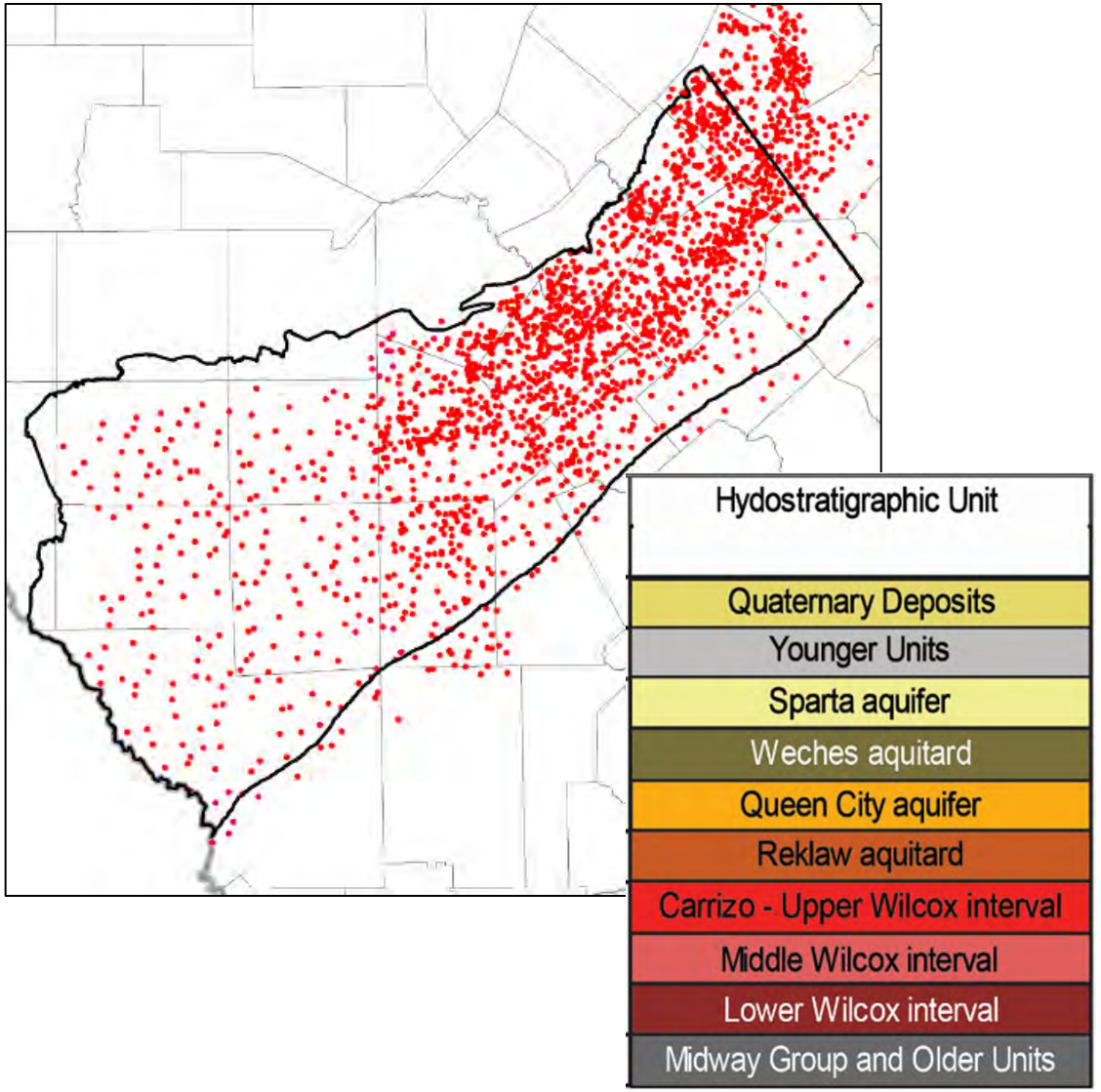
- Faults and Structural Features



HYDROSTRATIGRAPHY AND AQUIFER FRAMEWORK

AQUIFER FRAMEWORK

- Based on geophysical methods used in recent studies by BRACS group and BEG
- Incorporated geophysical data provided by GCDs in Fall 2019
- Completed in January 2020, approved by TWDB
- 8-layer aquifer system, including river alluvium
- “Younger Units” overlay this GAM



HYDROSTRATIGRAPHY

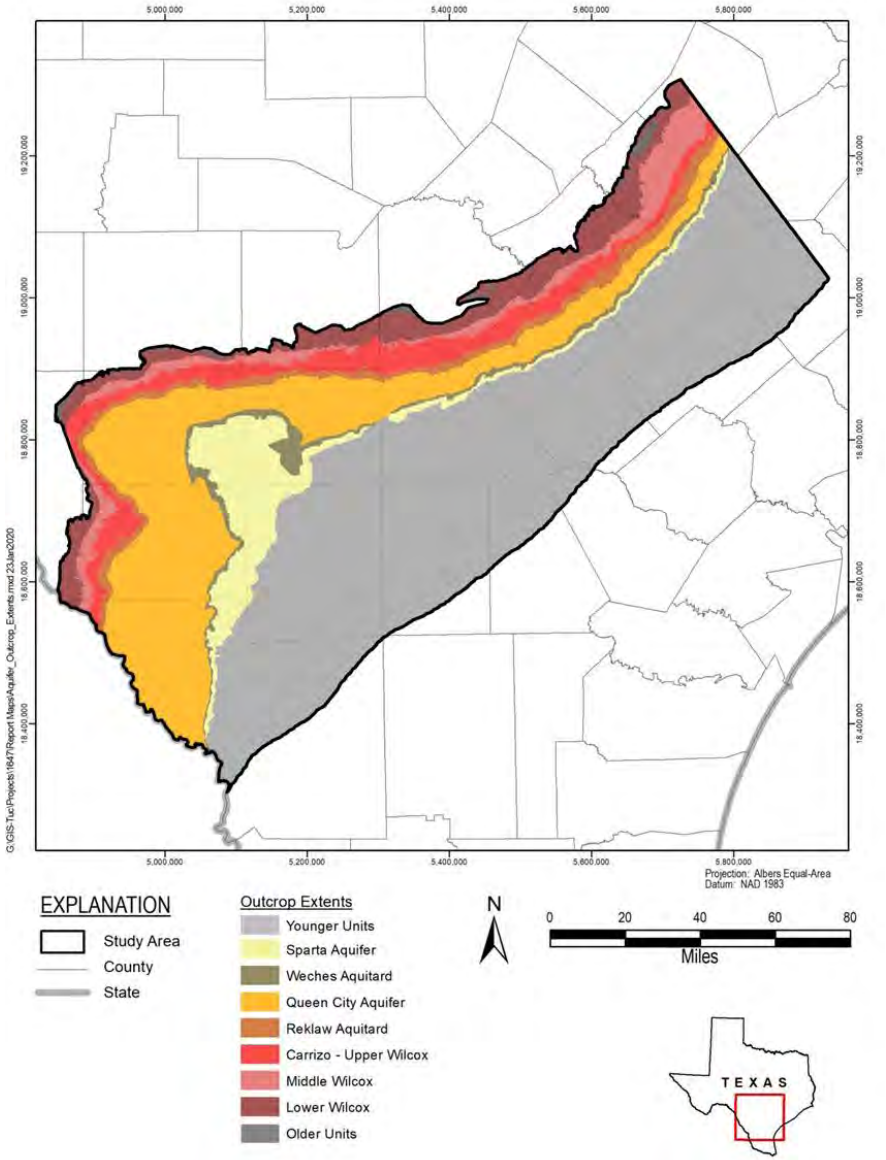
Previous GAM: 9 Layers

PERIOD	EPOCH	HYDROSTRATIGRAPHIC UNITS
Quaternary	Post-Eocene	Quaternary Alluvium
		Younger Units
Tertiary	Eocene	Sparta Sand
		Weches Formation
		Queen City Sand
		Reklaw Formation
		Carrizo Sand
		Upper Wilcox
		Middle Wilcox
	Paleocene	Lower Wilcox
	Post-Paleocene	Midway Group and Older Units

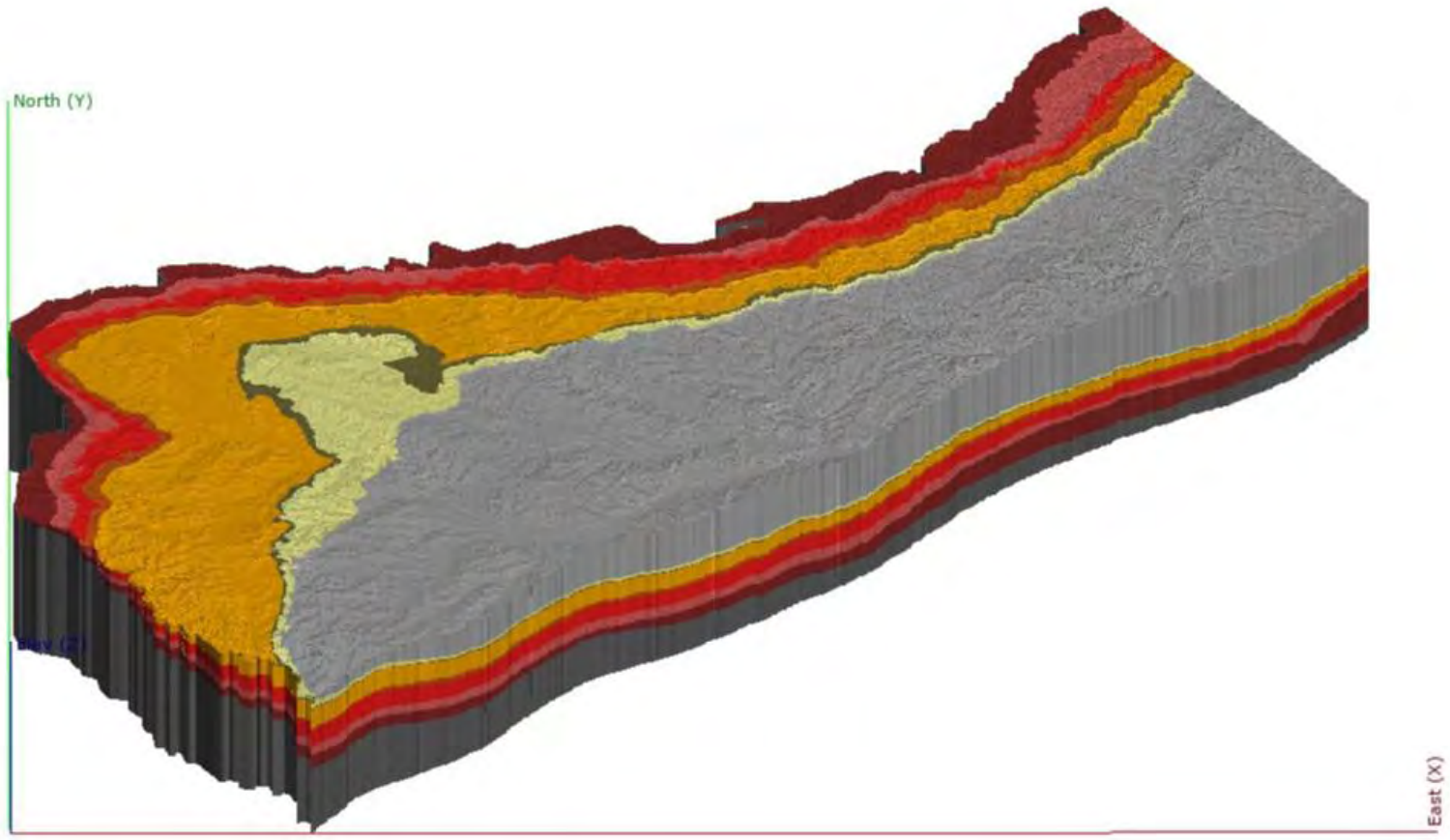
Updated GAM: 8 Layers

PERIOD	EPOCH	HYDROSTRATIGRAPHIC UNITS
Quaternary	Post-Eocene	Quaternary Alluvium
		Younger Units
Tertiary	Eocene	Sparta Sand
		Weches Formation
		Queen City Sand
		Reklaw Formation
		Carrizo-Upper Wilcox (Combined)
		Middle Wilcox
	Paleocene	Lower Wilcox
	Post-Paleocene	Midway Group and Older Units

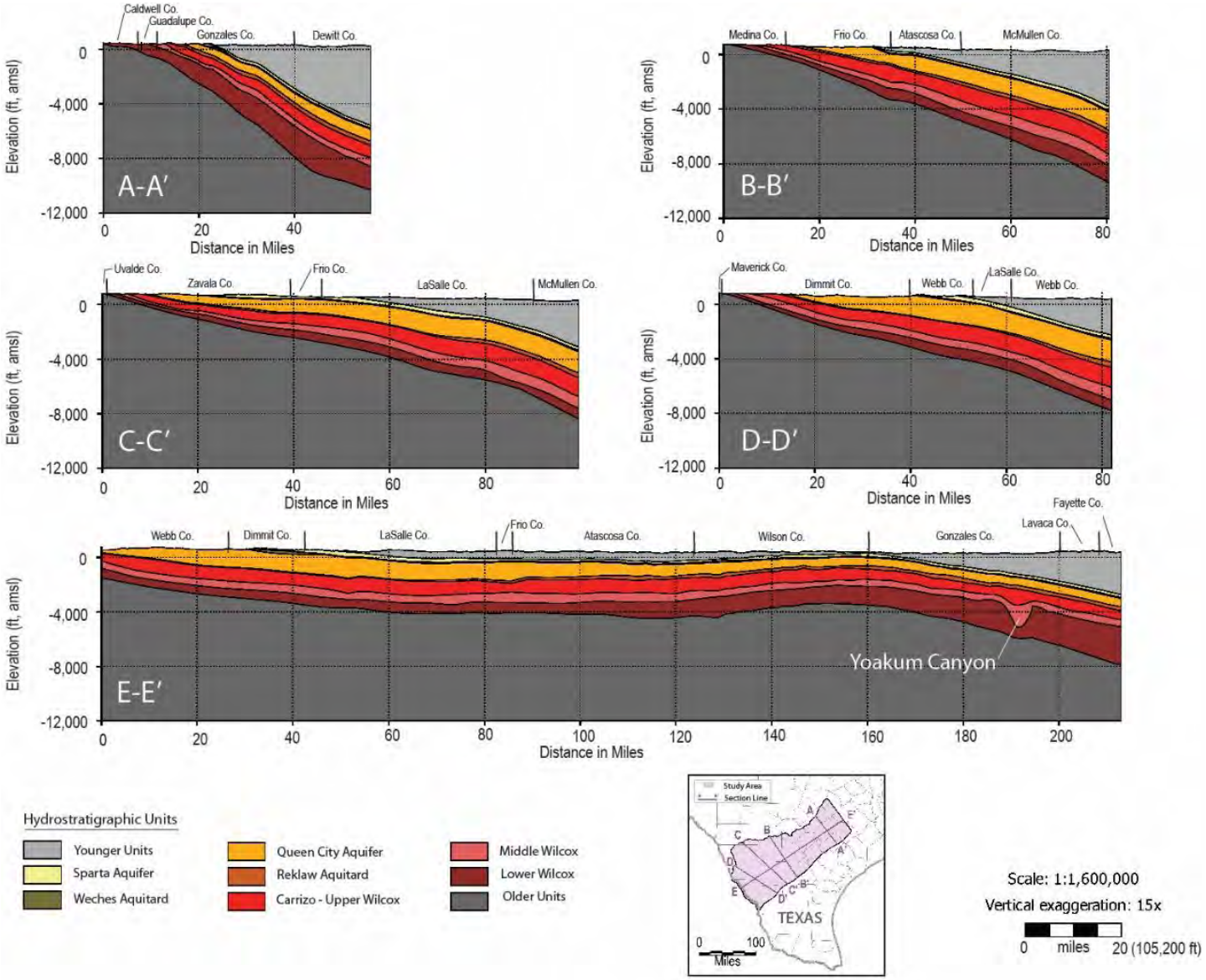
OUTCROPS OF LAYERS



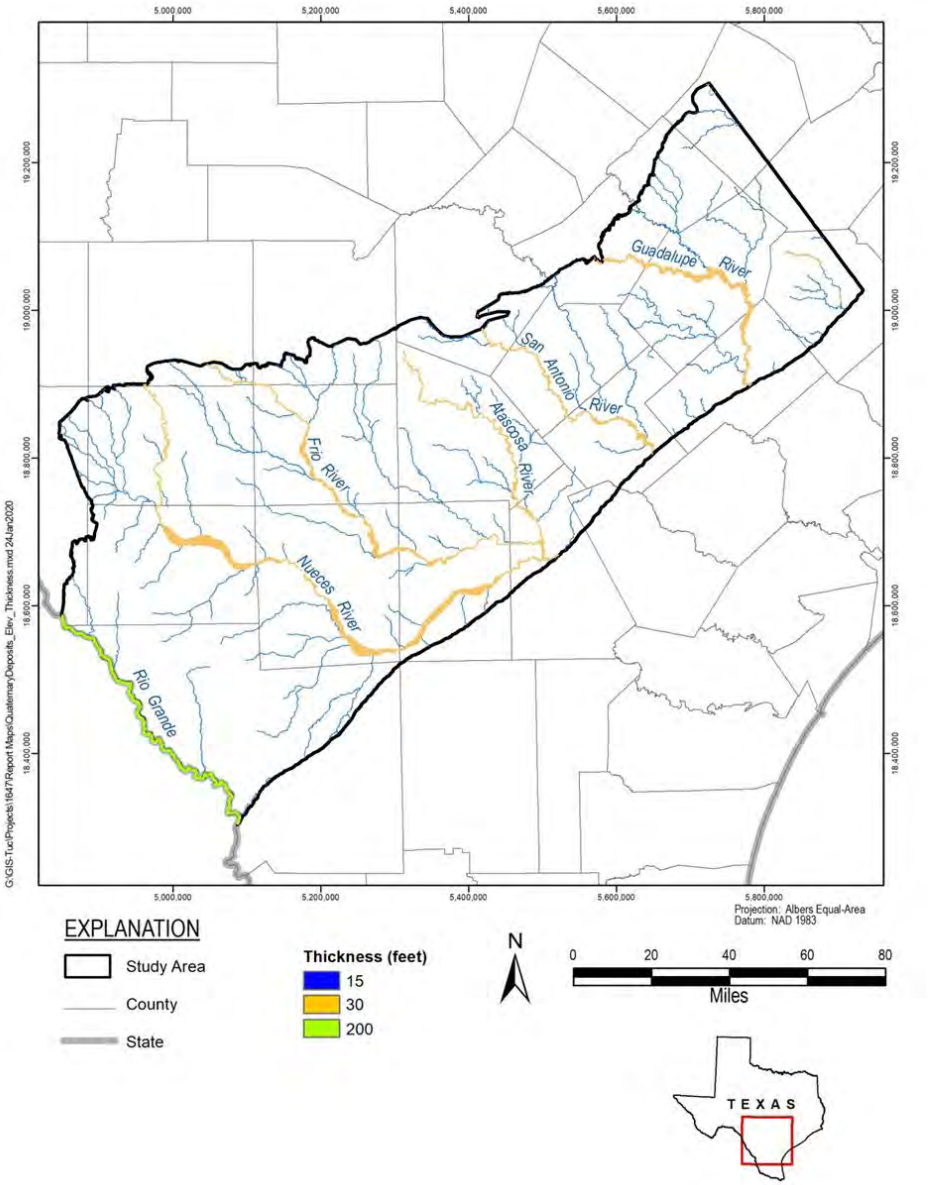
THREE-DIMENSIONAL GEOLOGIC MODEL



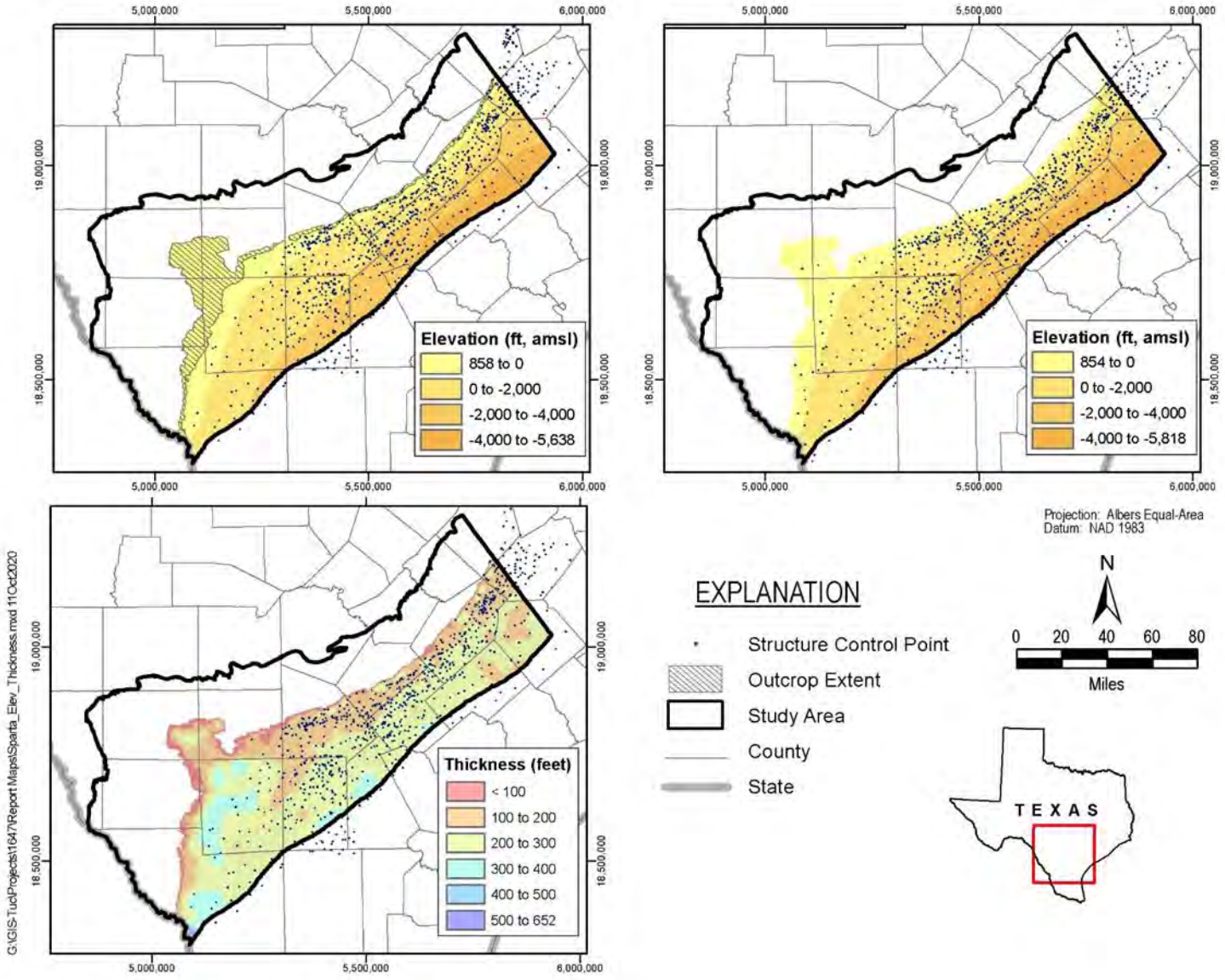
CROSS-SECTIONS



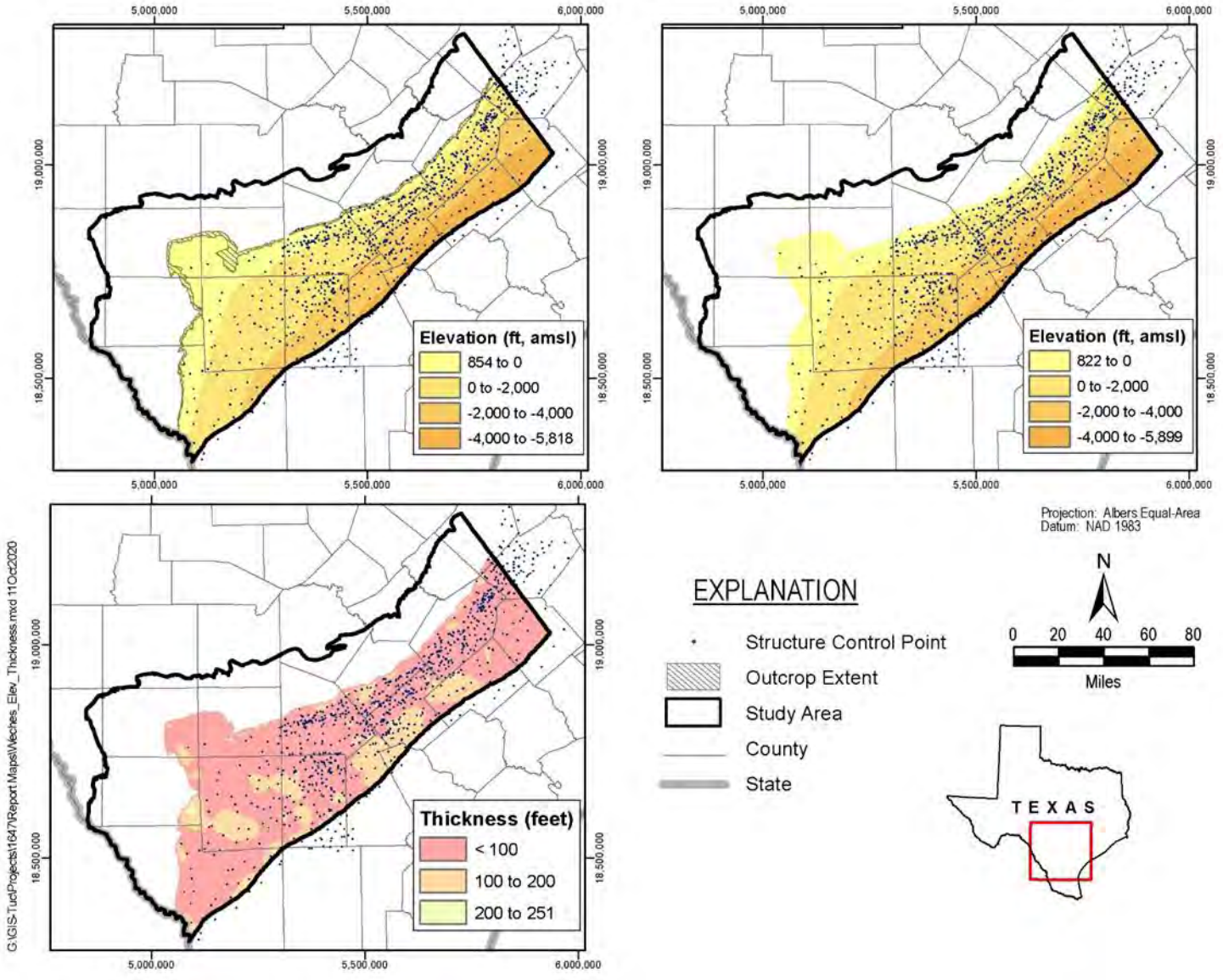
LAYER 1: RIVER ALLUVIUM



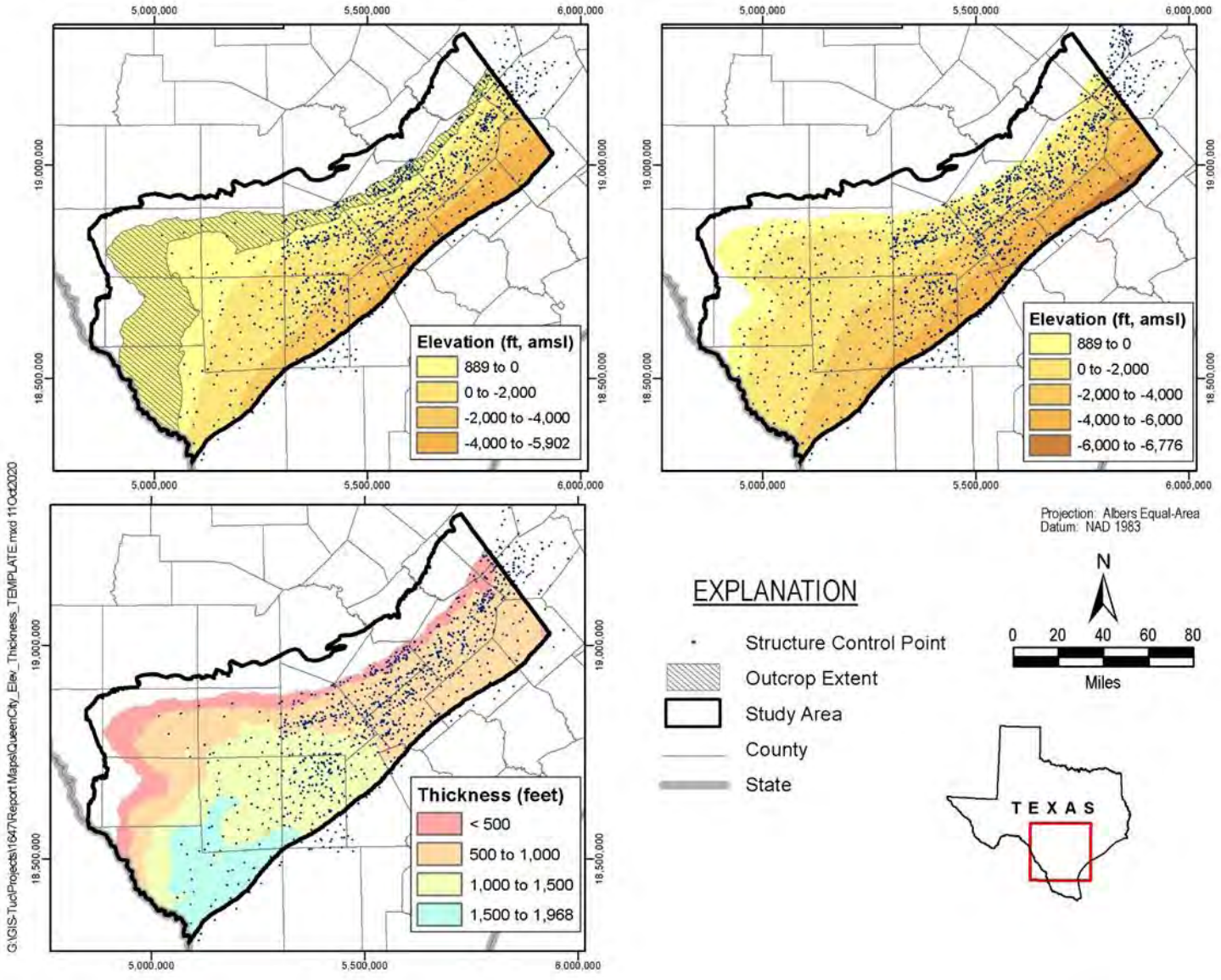
LAYER 2: SPARTA AQUIFER



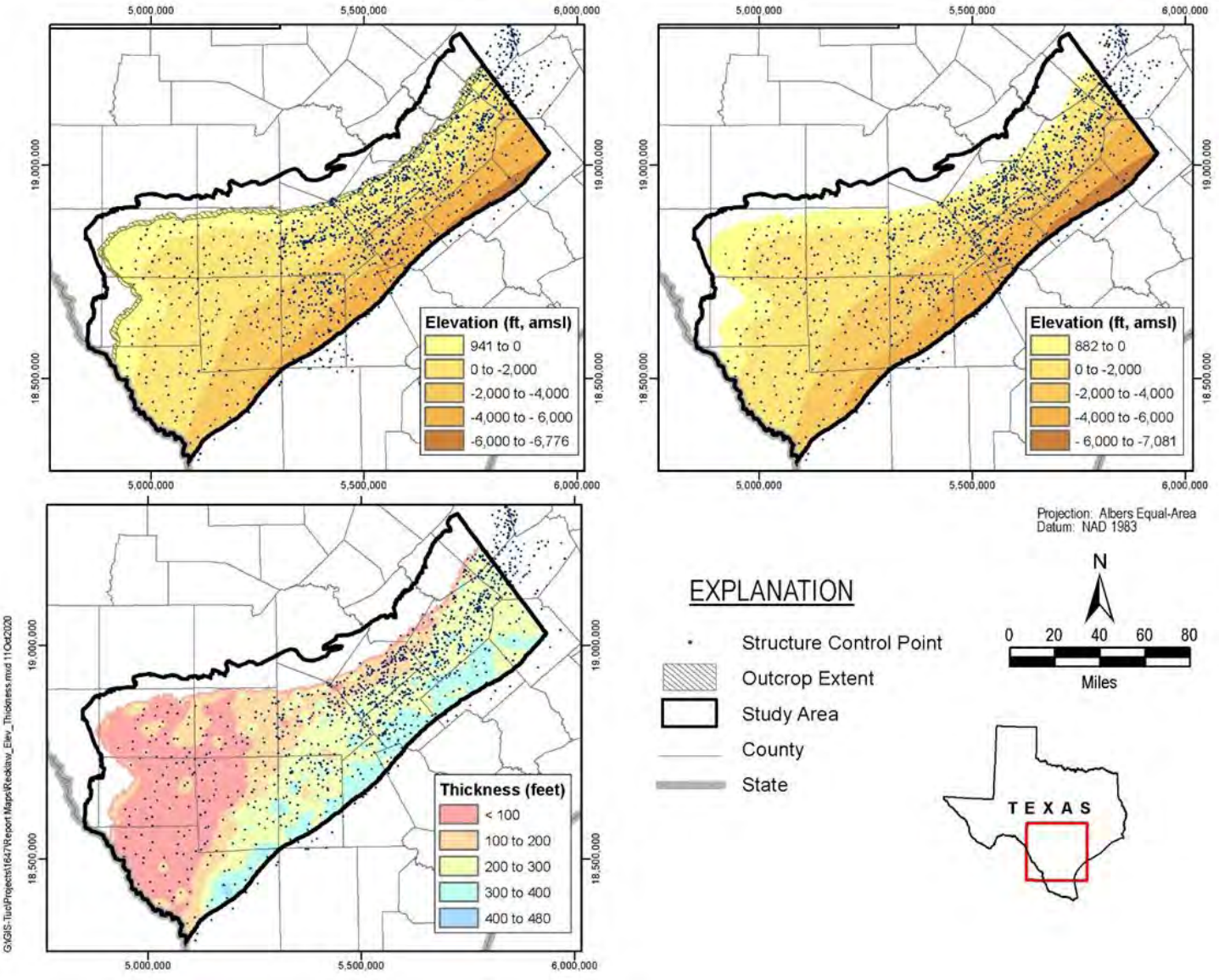
LAYER 3: WECHES AQUITARD



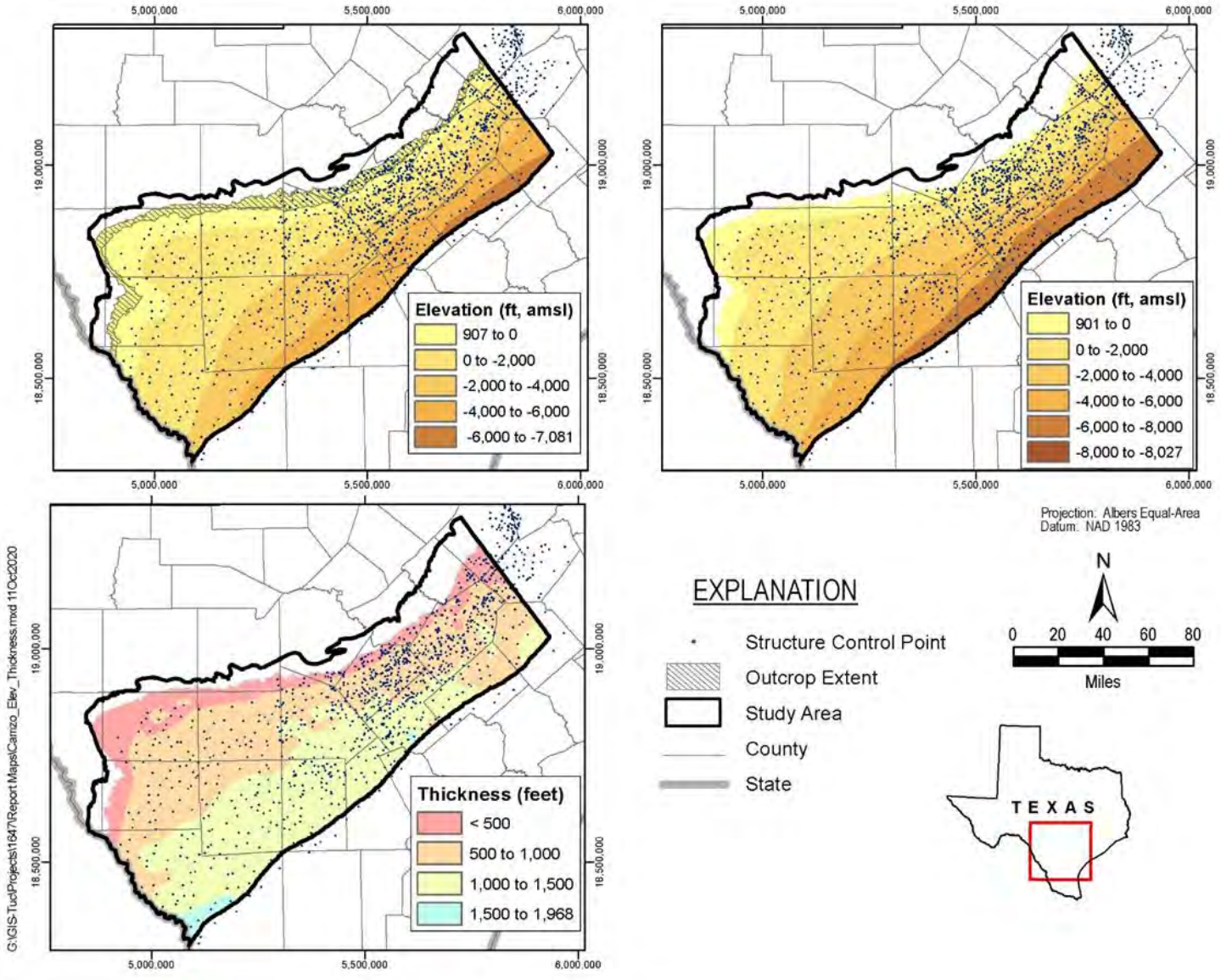
LAYER 4: QUEEN CITY AQUIFER



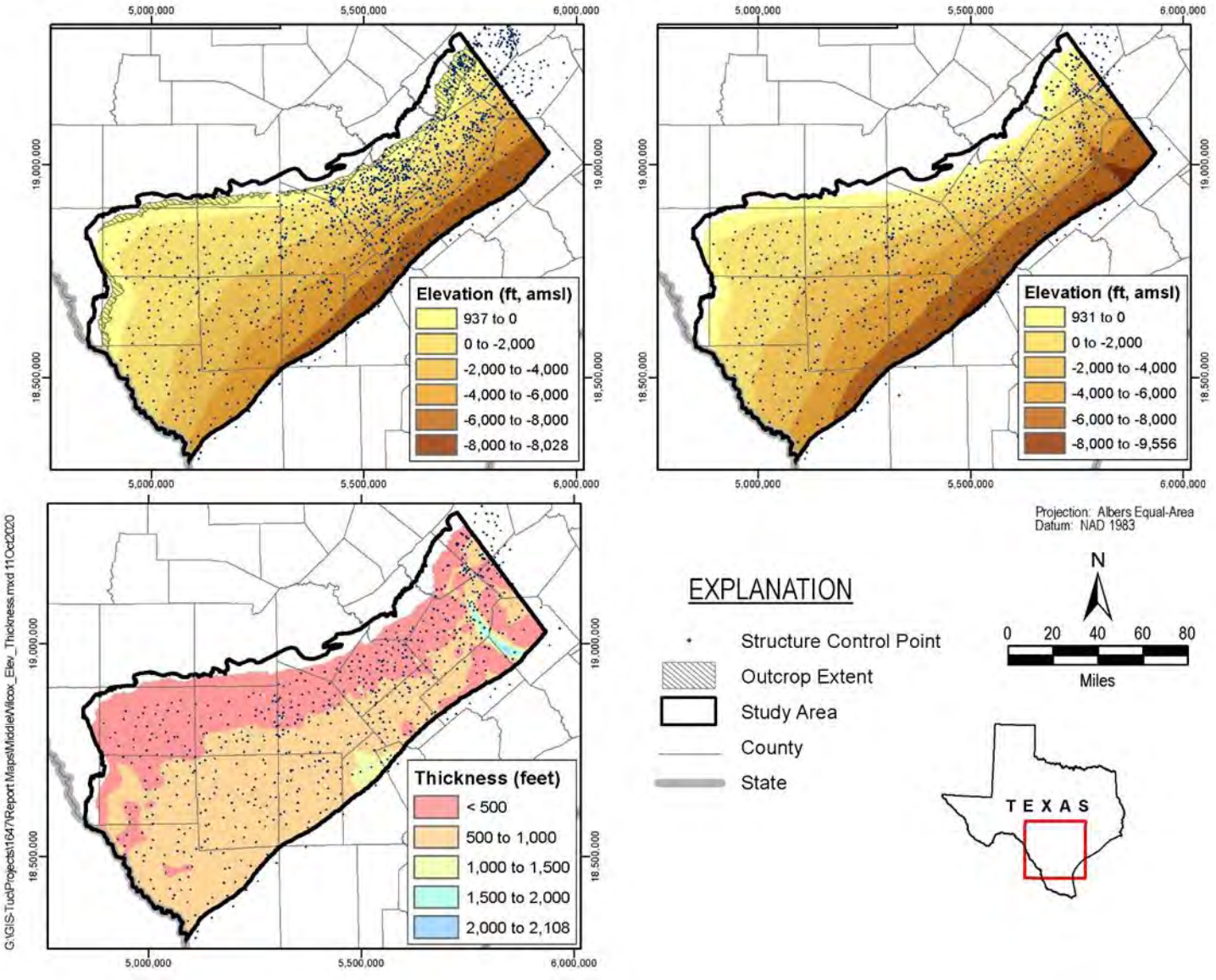
LAYER 5: REKLAW AQUITARD



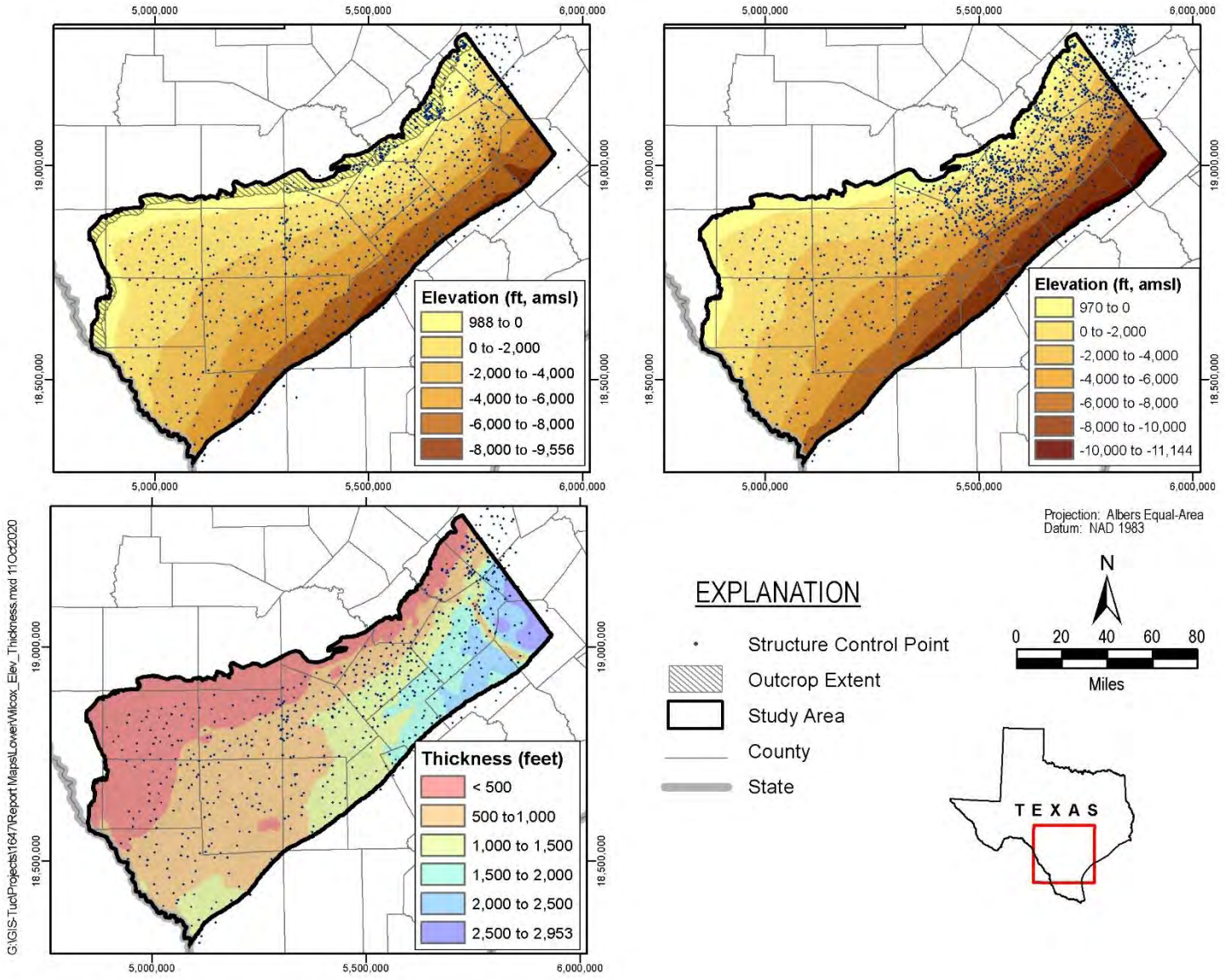
LAYER 6: CARRIZO-UPPER WILCOX



LAYER 7: MIDDLE WILCOX



LAYER 8: LOWER WILCOX

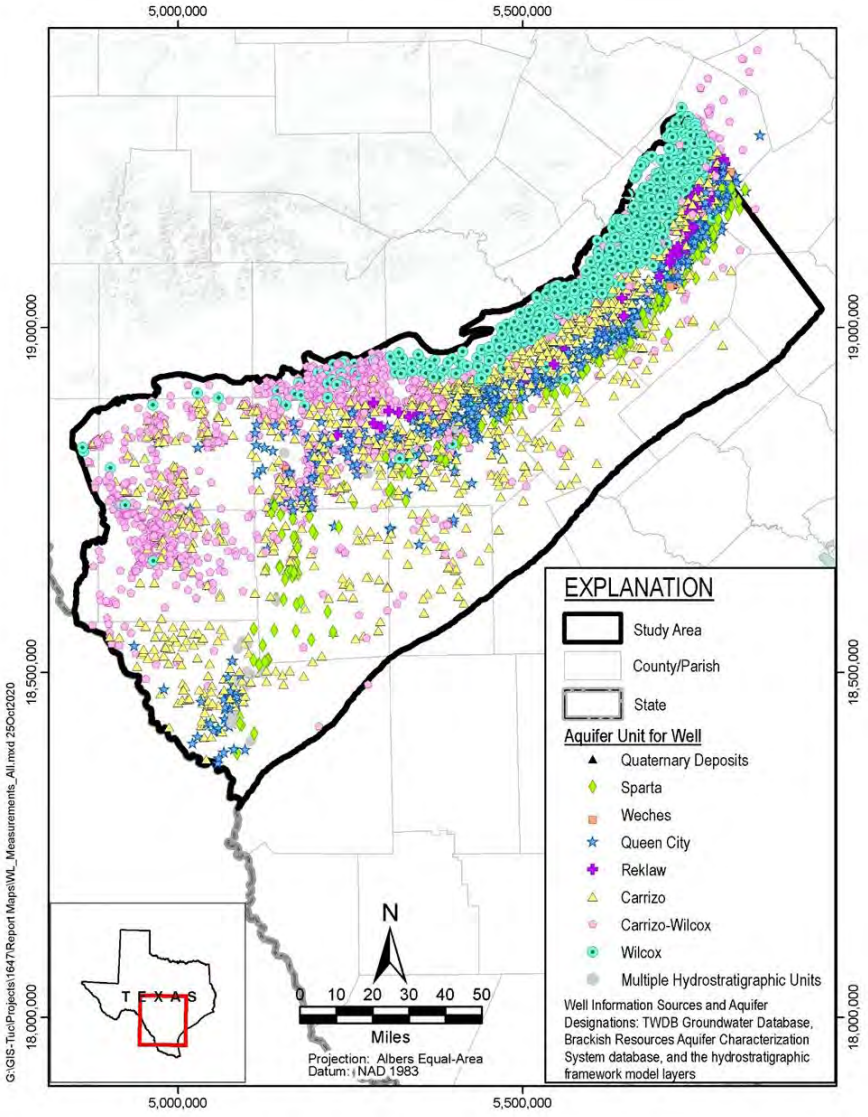


GROUNDWATER LEVELS AND REGIONAL GROUNDWATER FLOW

GROUNDWATER LEVELS

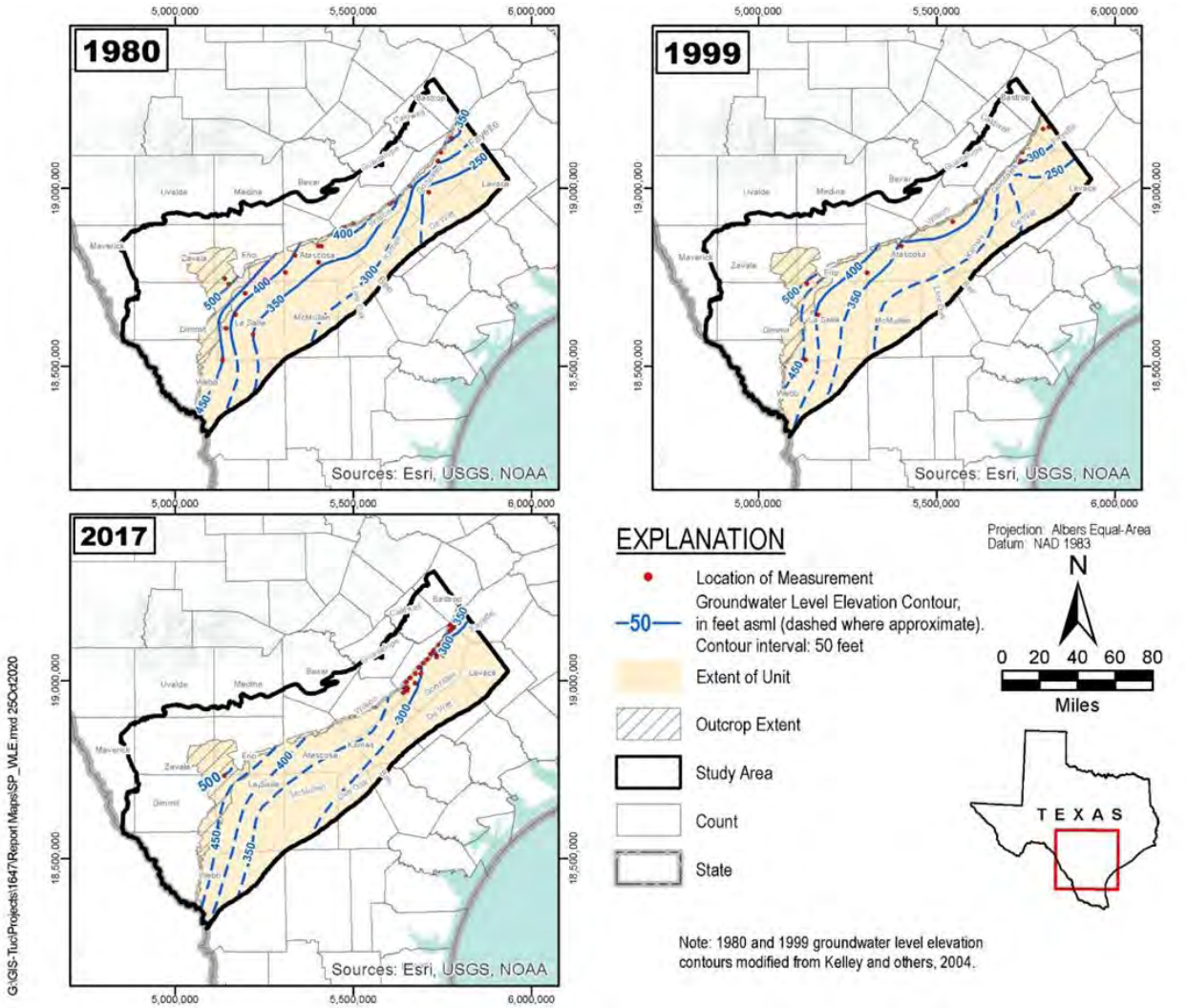
- Compiled data from TWDB Groundwater Database and Groundwater Conservation Districts
- Reviewed hydrographs to identify outliers and trends
- Contouring:
  - Using the predevelopment conditions established in previous GAM
  - Based on winter measurements
  - Verified contours from previous GAM for the beginning and middle of simulation (1980 and 1999); minor modifications were made (dashed lines, additional aquifer designations)
  - Prepared contours representing the end of the simulation period (2017)

GROUNDWATER LEVEL DATA

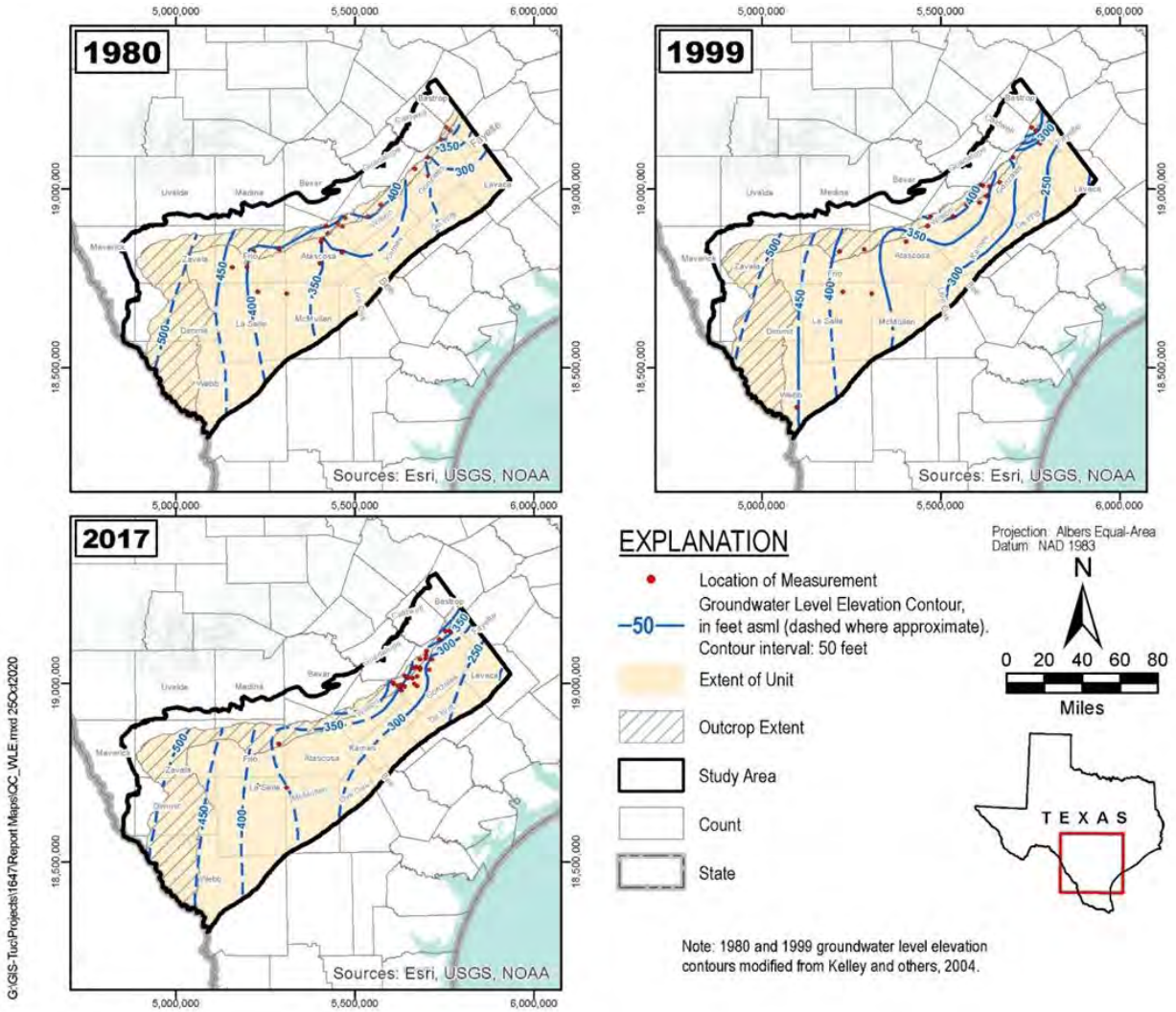


- Most data for northern portion of study area and outcrop areas

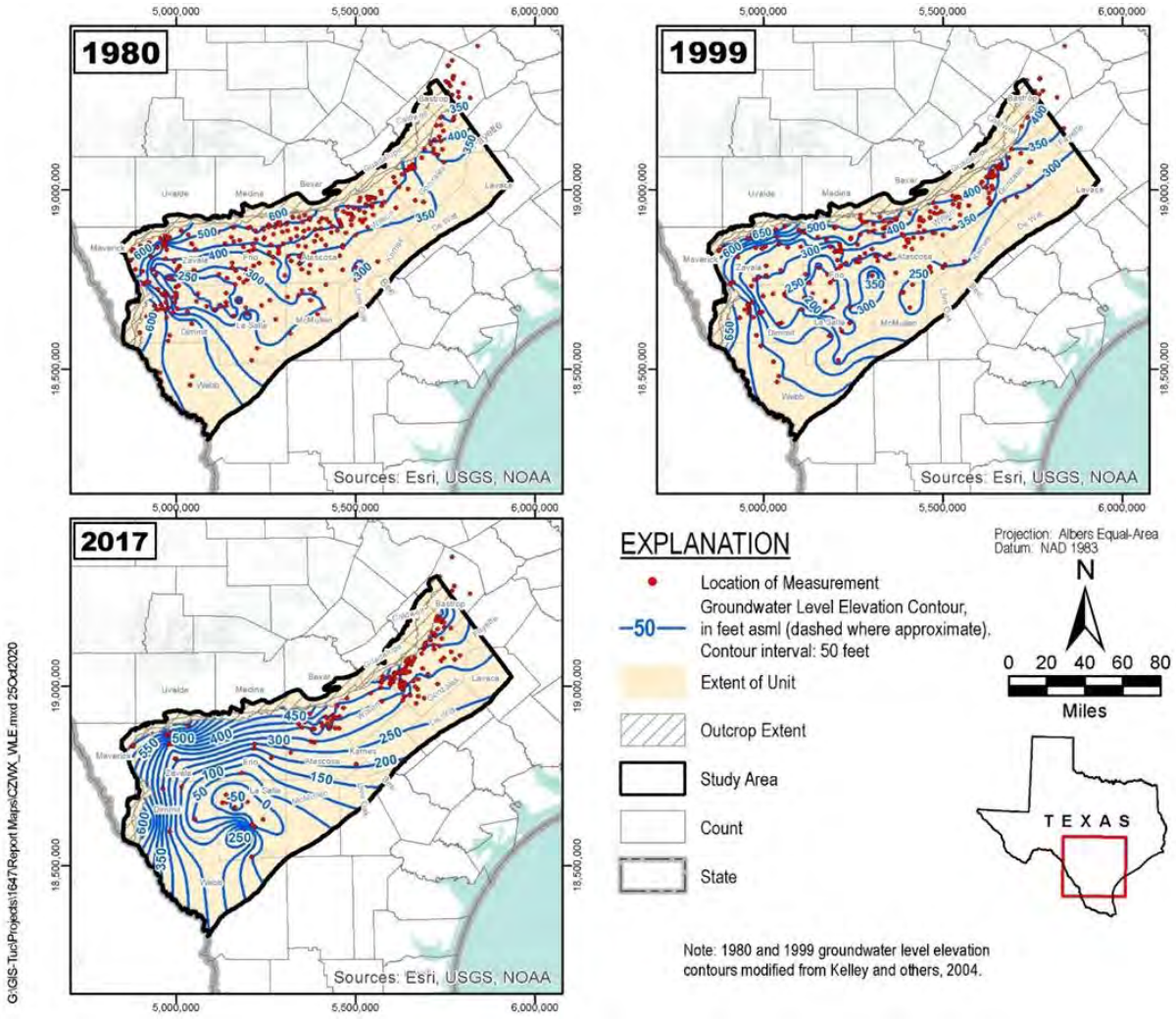
WATER LEVEL CONTOURS: SPARTA AQUIFER



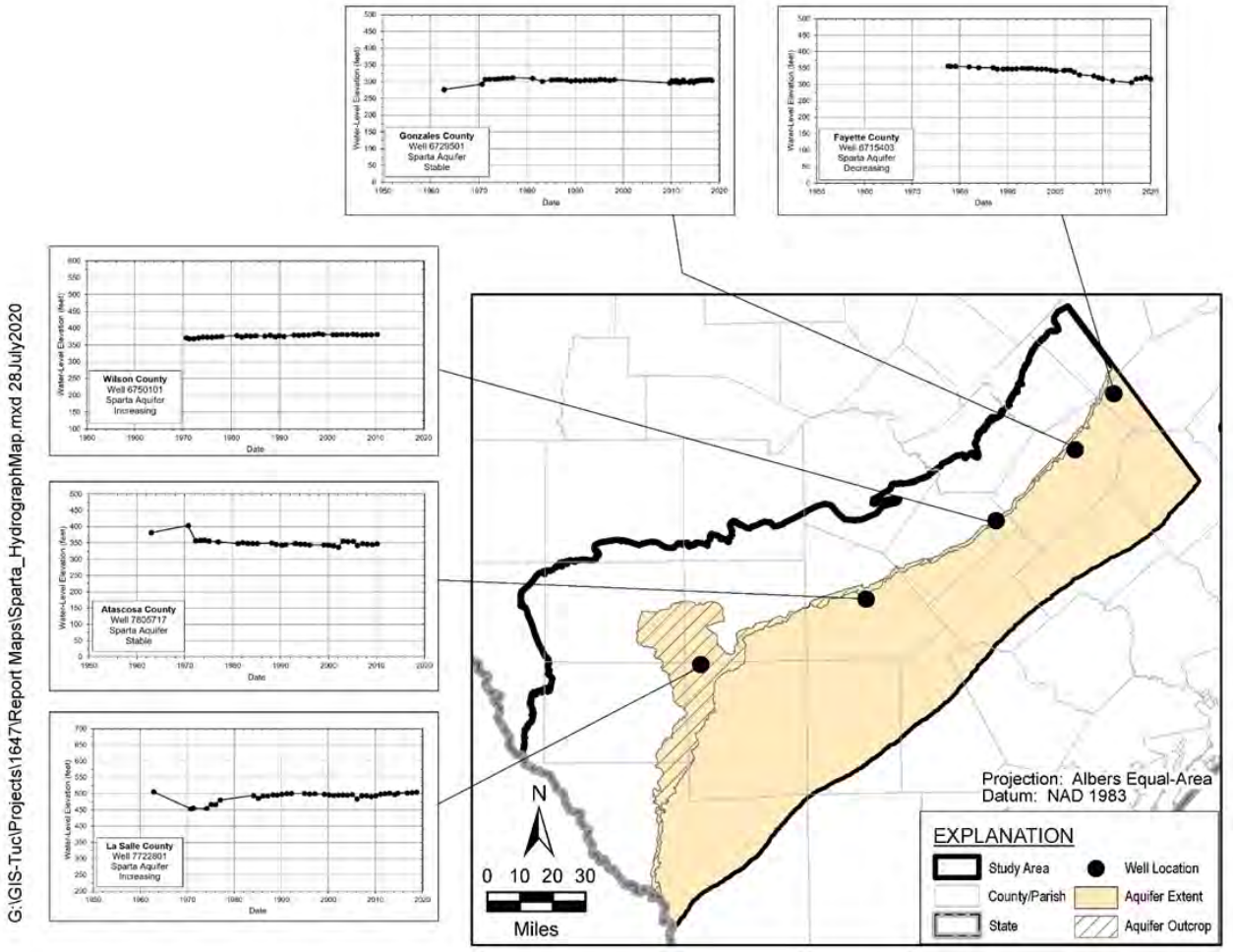
WATER LEVEL CONTOURS: QUEEN CITY AQUIFER



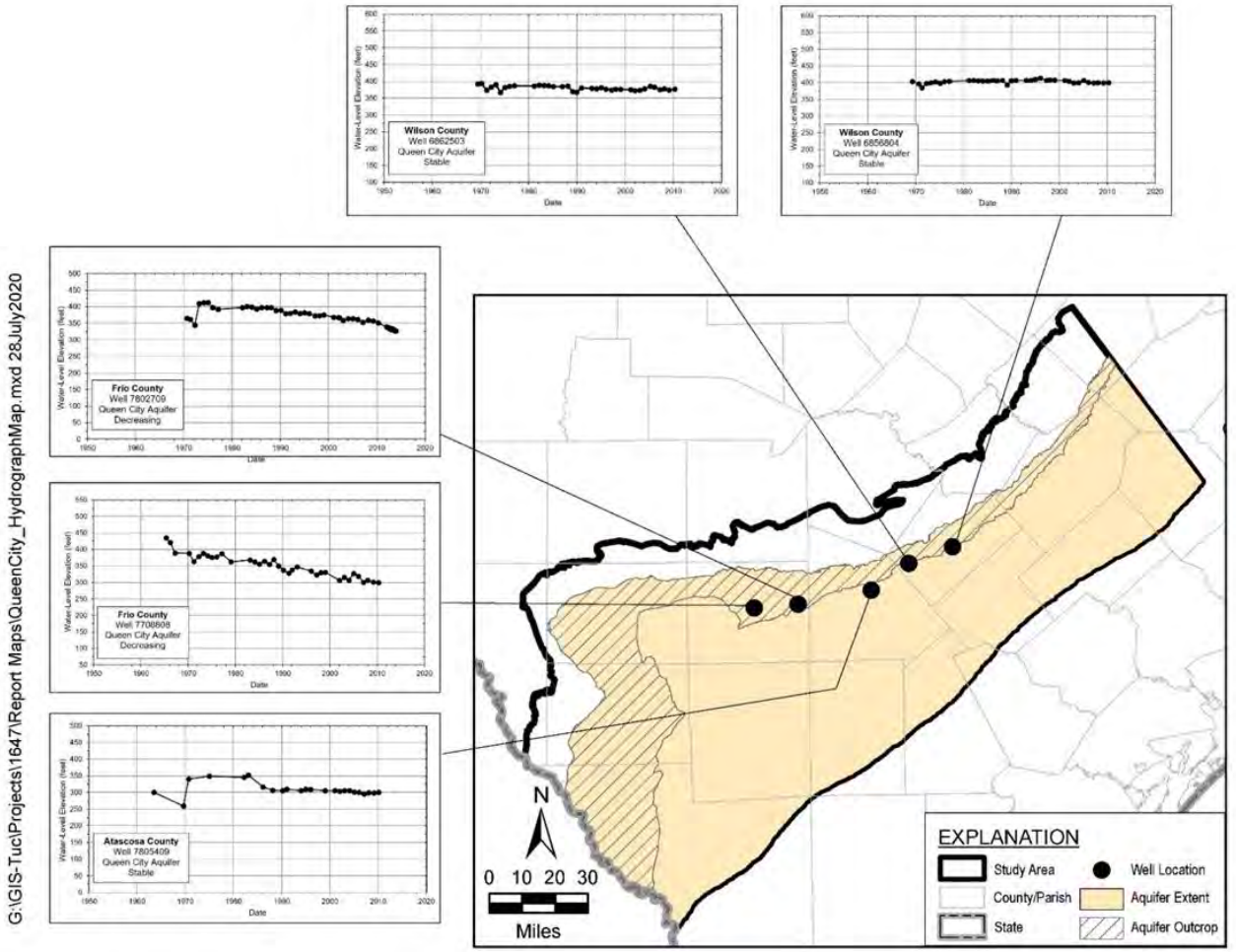
WATER LEVEL CONTOURS: CARRIZO-WILCOX AQUIFER



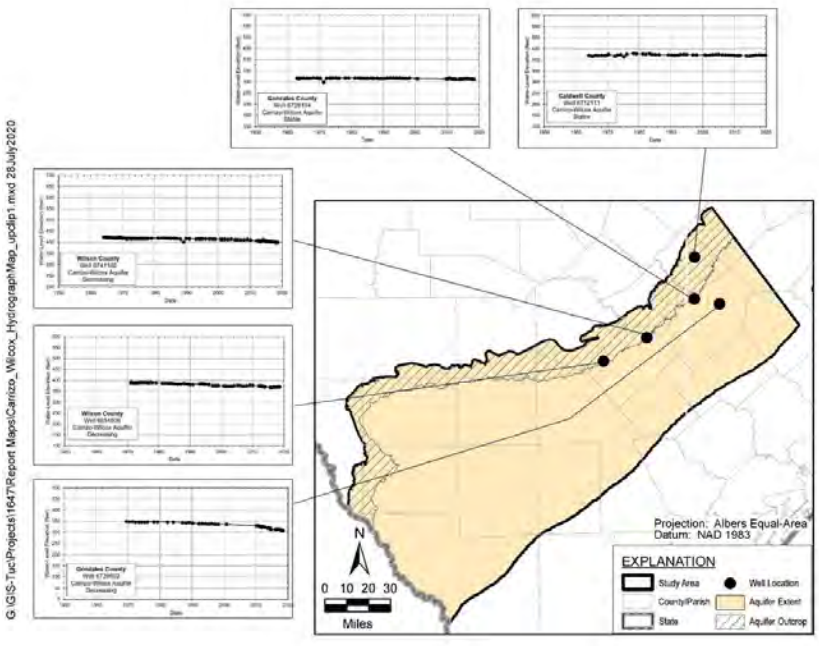
WATER LEVELS THROUGH TIME: SPARTA AQUIFER

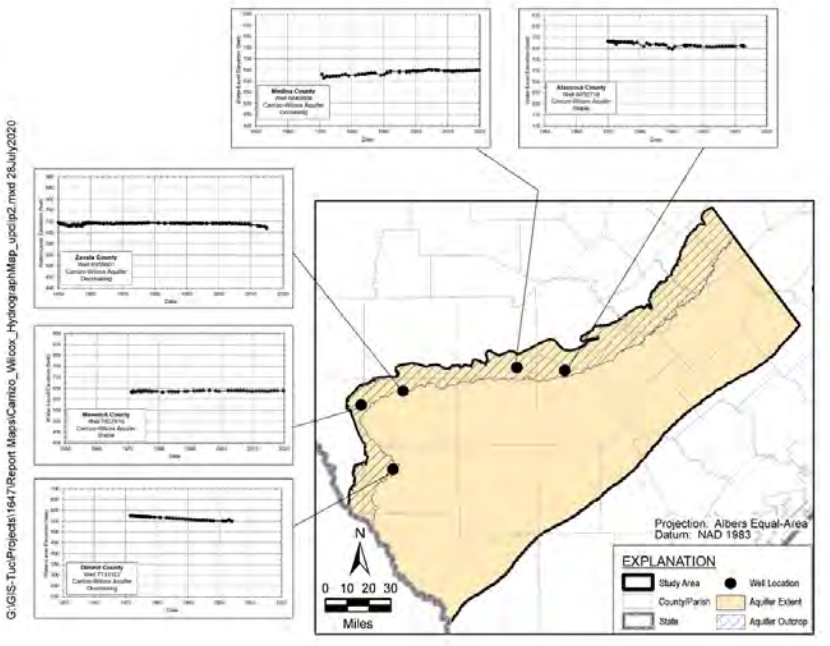


WATER LEVELS THROUGH TIME: QUEEN CITY AQUIFER

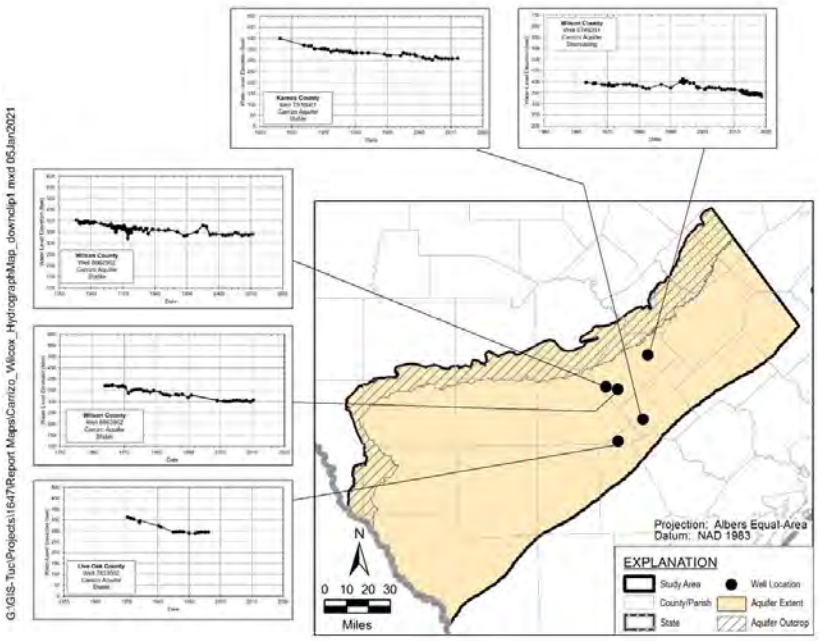


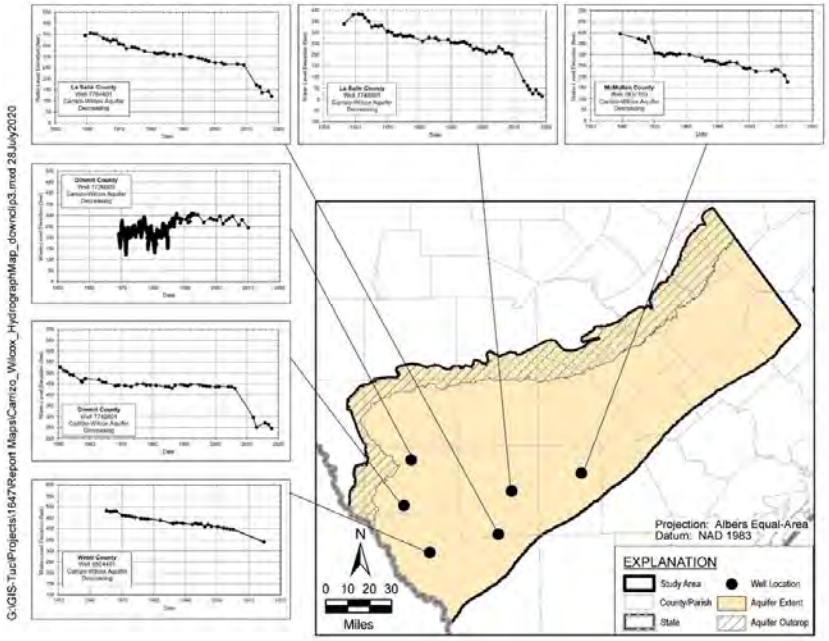
WATER LEVELS THROUGH TIME: CARRIZO-WILCOX AQUIFER - OUTCROP





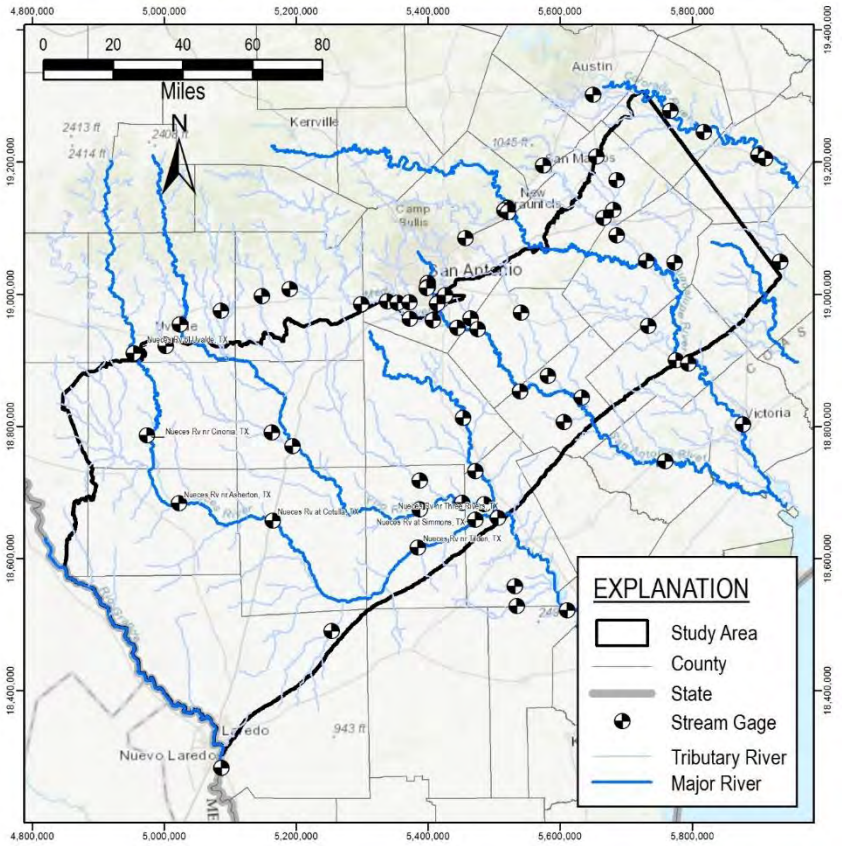
WATER LEVELS THROUGH TIME: CARRIZO-WILCOX AQUIFER – DOWN-DIP





SURFACE WATER

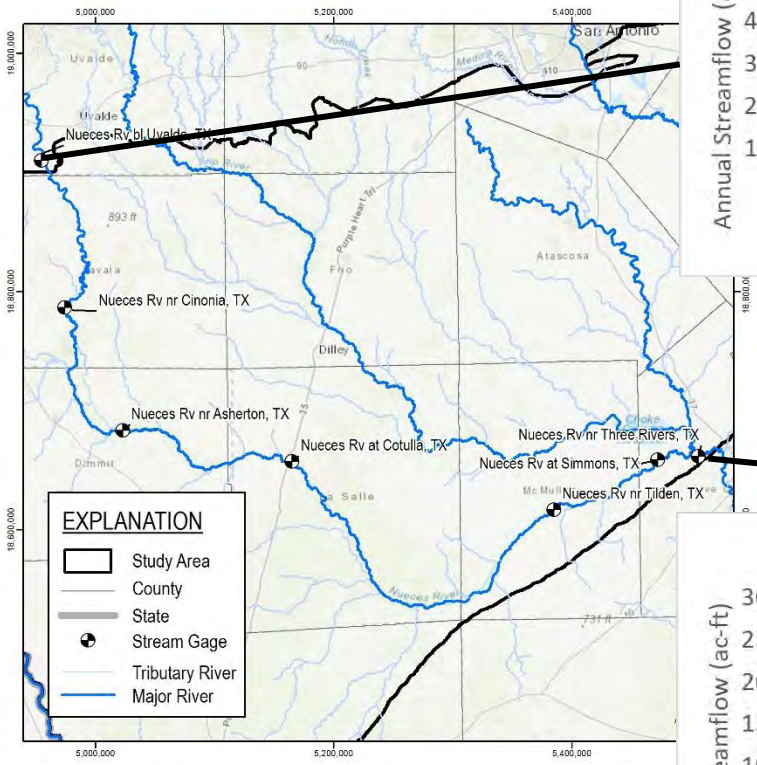
STREAMFLOW GAGE DATA

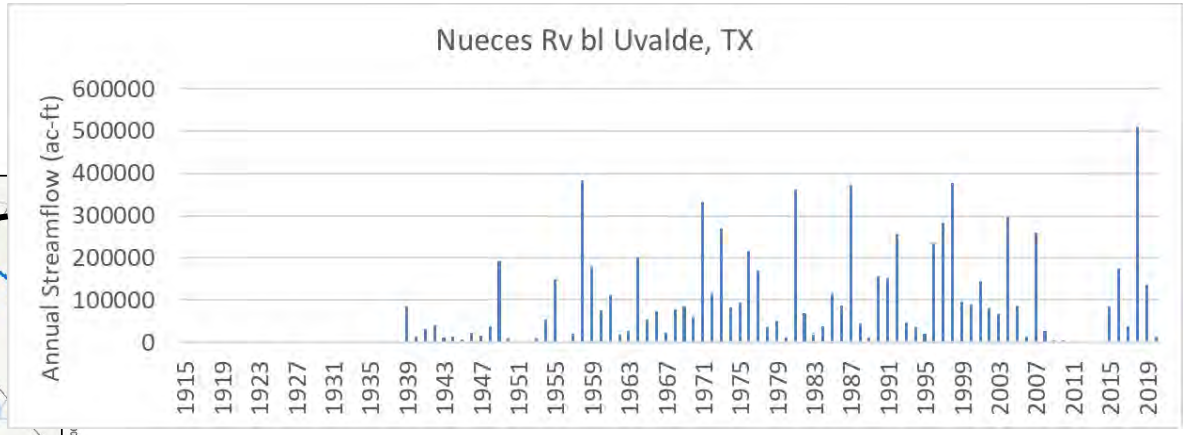


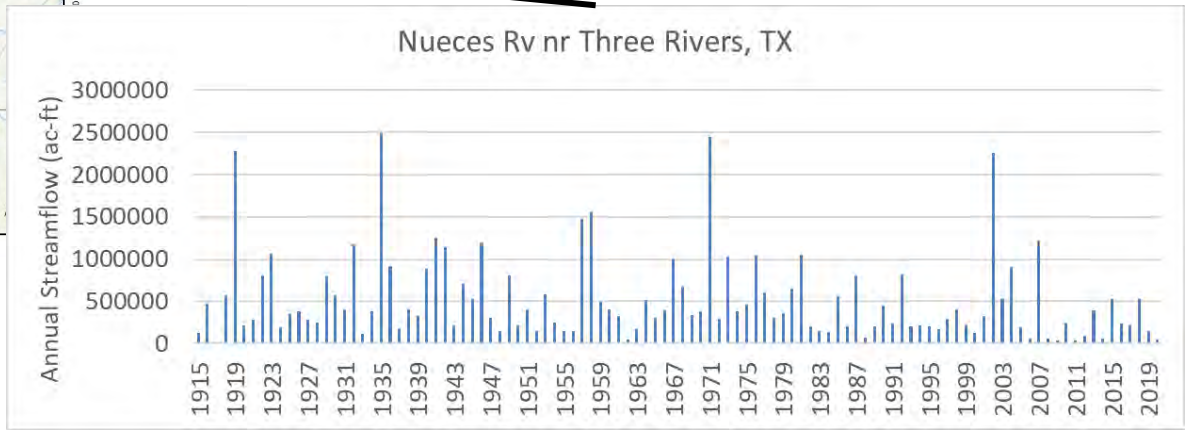
- Updated flow measurement data for USGS streamflow gages
- Computed change in flow along major rivers

STREAMFLOW HYDROGRAPHS FOR SELECTED GAGES

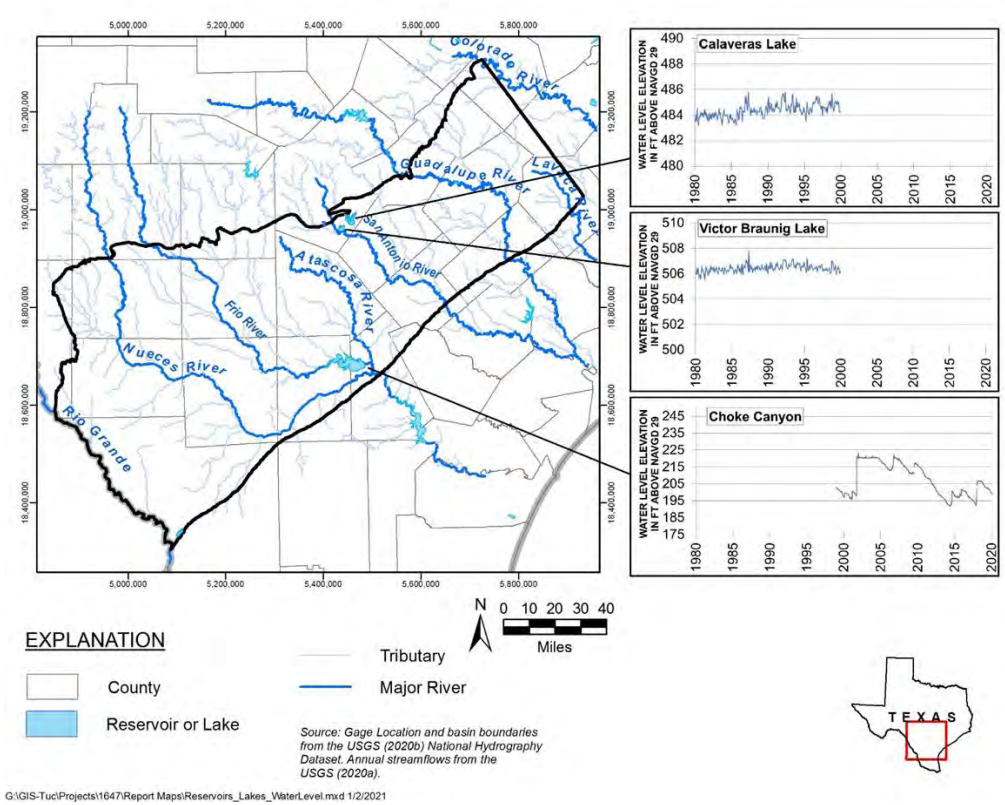
- Nueces River







RESERVOIRS

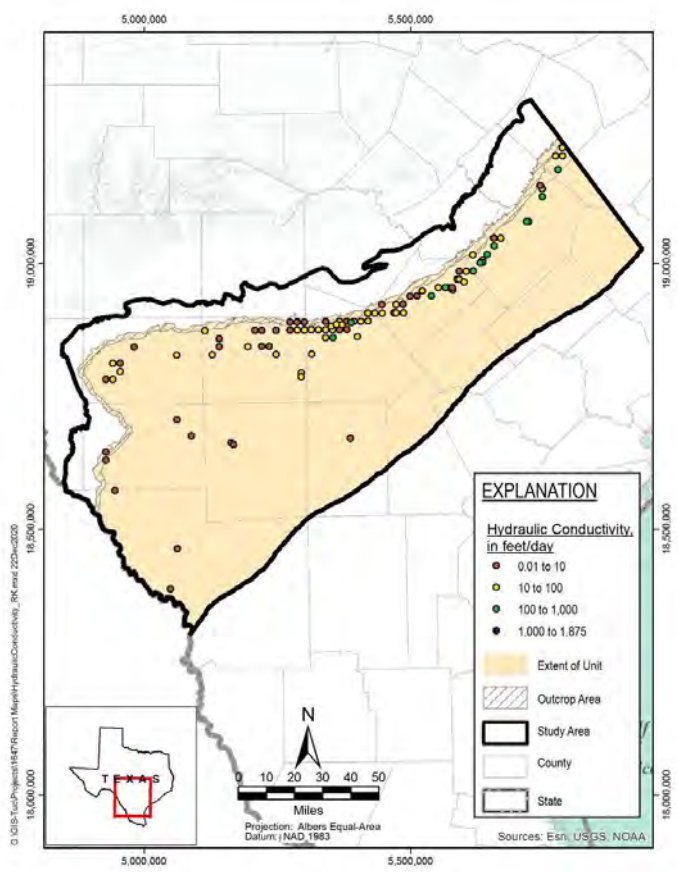


- Updated discharge and stage data for large reservoirs

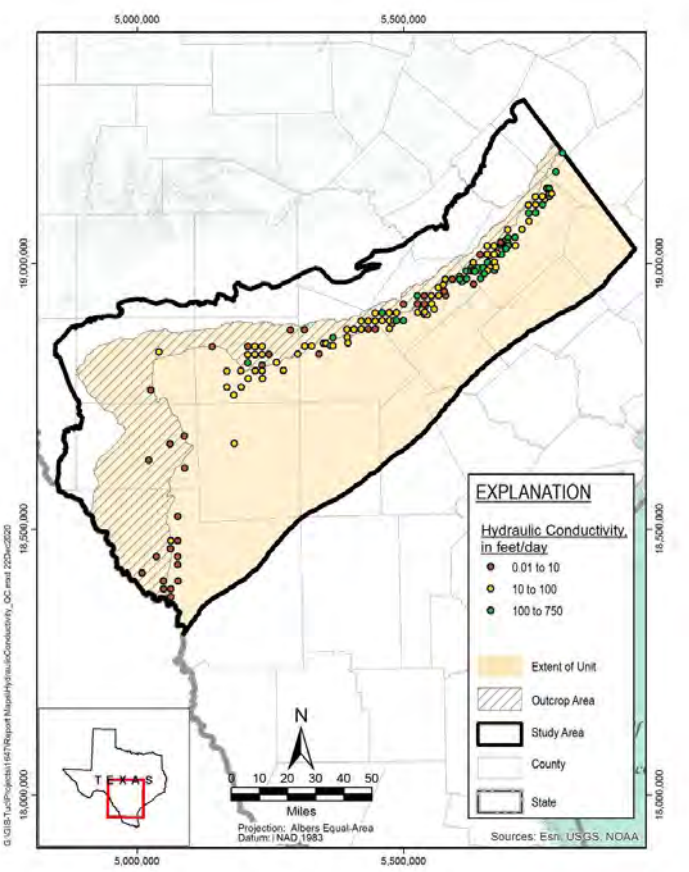
AQUIFER HYDRAULIC PROPERTIES

HYDRAULIC CONDUCTIVITY

Sparta Aquifer

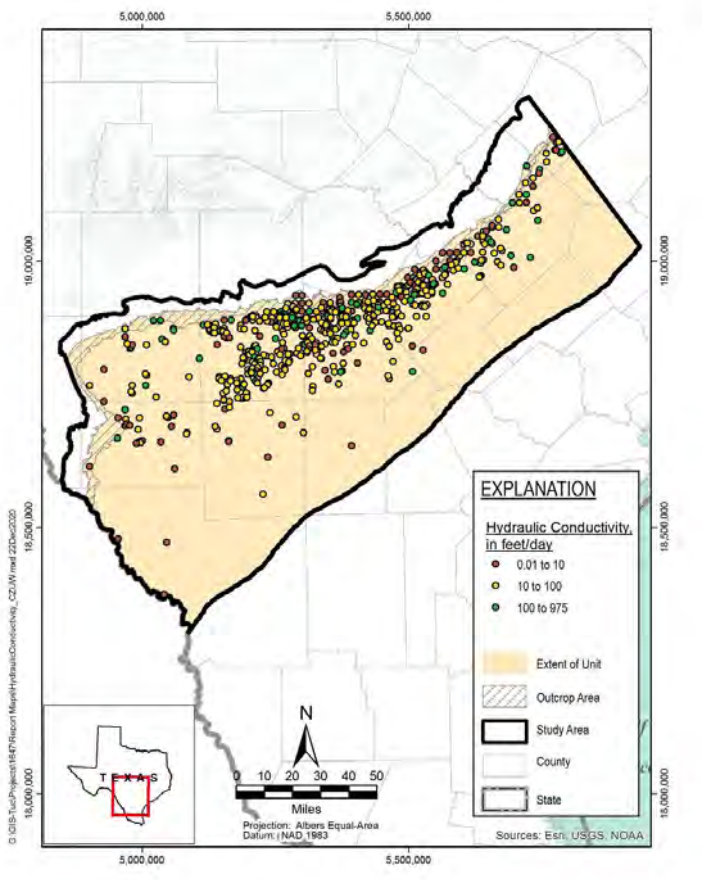


Queen City Aquifer



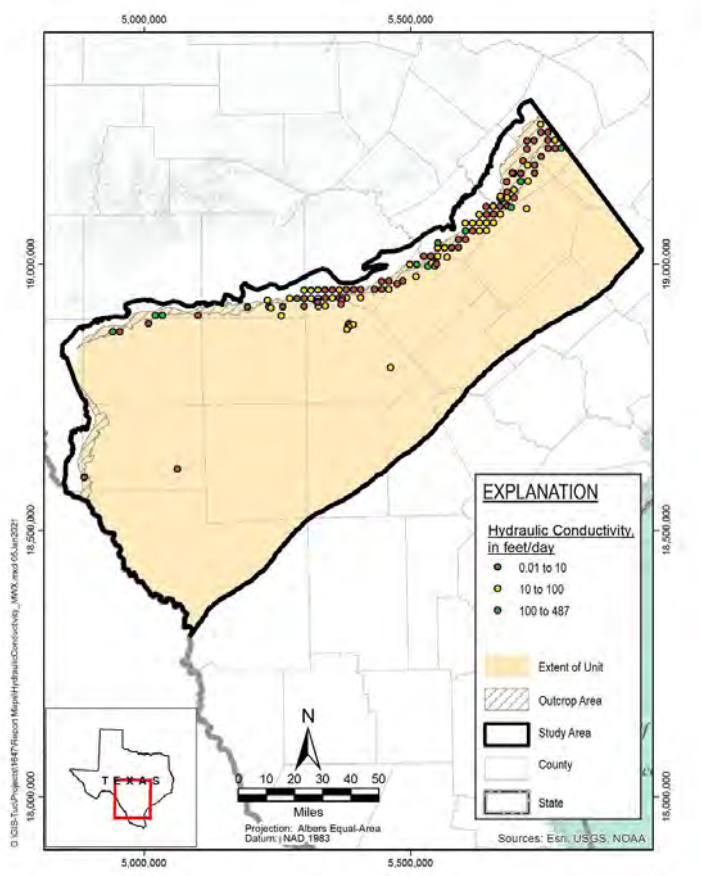
HYDRAULIC CONDUCTIVITY

Carrizo-Upper Wilcox

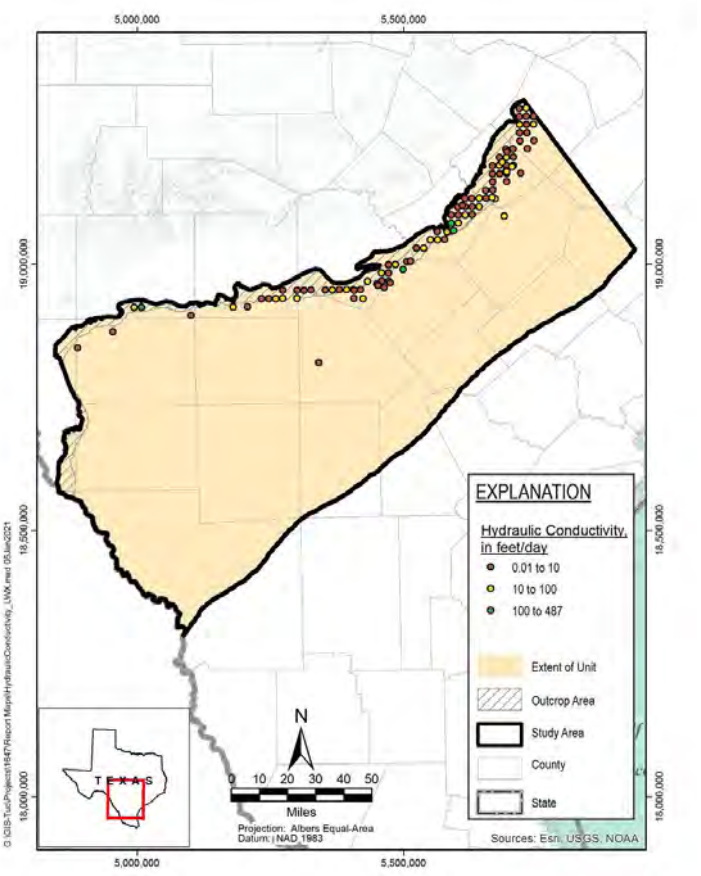


HYDRAULIC CONDUCTIVITY

Middle Wilcox



Lower Wilcox



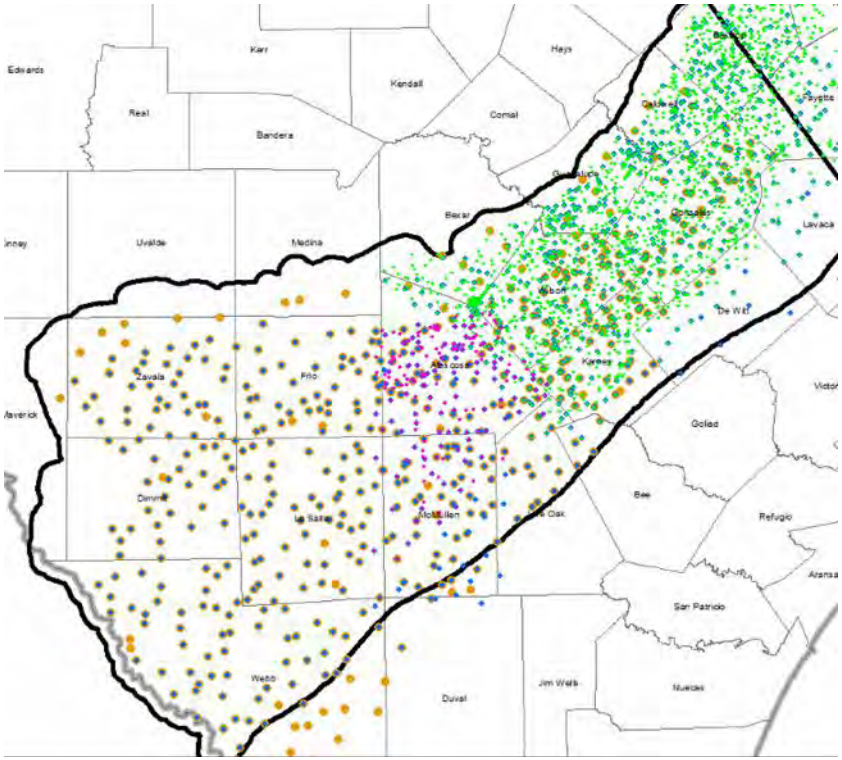
SUMMARY OF HYDRAULIC CONDUCTIVITY

Formation/ Model Layer	Number of Measurements	Min	Max	Average
Sparta Aquifer	2	20	100	45.6
Weches Aquitard	--	--	--	--
Queen City Aquifer	279	0.01	750	31.5
Reklaw Aquitard	130	0.01	575	18.5
Carrizo - Upper Wilcox	736	0.06	487	32.3
Middle Wilcox	215	0.08	332	8.4
Lower Wilcox	173	0.08	487	5.0

Units in feet per day

NET SAND ANALYSIS

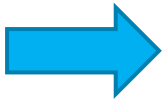
- Data Source: BRACS Database
  - Includes lithologic interval data from the following studies:
    1. 2019 GMA 13 BEG study
    2. 2019 Draft UCPC BRACS study
    3. 2014 QCSP (Atascosa & McMullen counties) by M. Wise
    4. Previous GAM
  - For aquifer assignment, lithologic interval data from a total of 3,469 location points were evaluated to the updated HSU framework layer depths



NET SAND ANALYSIS: CLASSIFICATION

- Two-tier System (Sand or Clay)
  - For consistency, lithologic interval data with four-tier classification were modified to a two-tier system
  - Net Sand calculated as sum of the sand intervals as classified by the two-tier system within model layer thicknesses
  - Percent sand calculated by dividing net sand value by the sum of all documented lithologic intervals within model layer thickness

Ex. Simplified Lithologic Name	Sand Percent
Clay with Sand	0.35
Sand and Silt	0.5
Gravel and Clay	0.5
Sand with Clay	0.65
Silty Sand	1



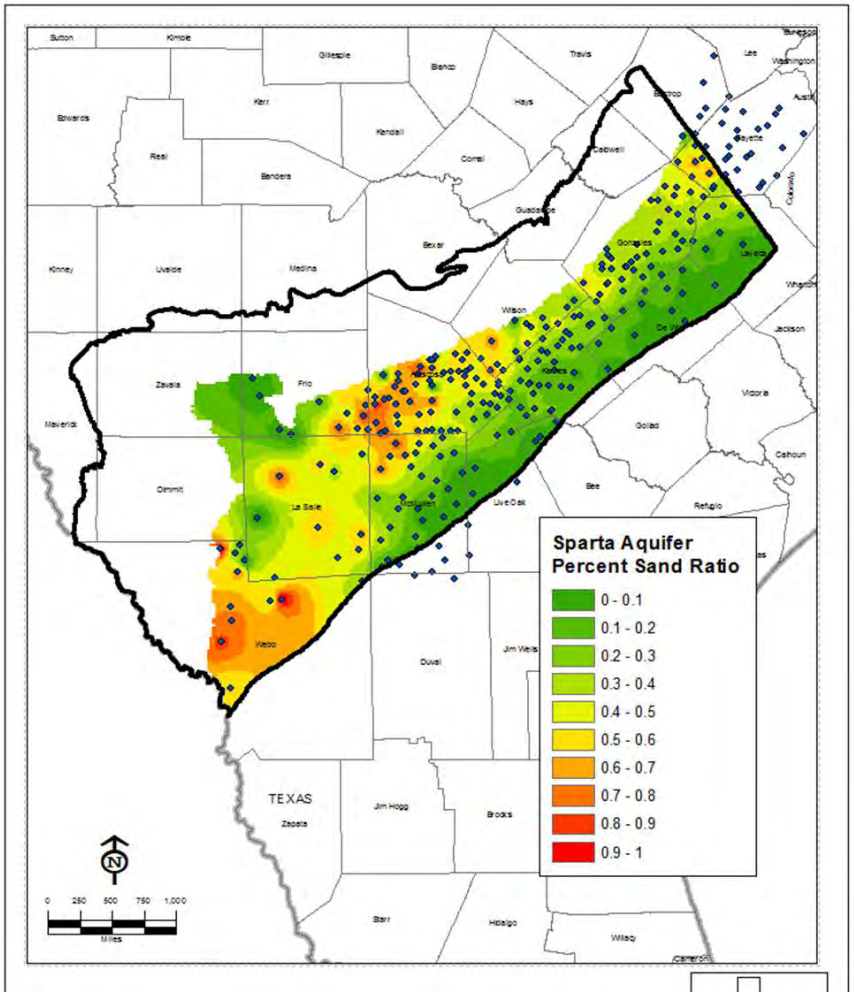
Simplified Lithologic Name	Sand Percent
Clay	0
Clay	0
Clay	0
Sand	1
Sand	1

NET SAND ANALYSIS:
CONTROL POINTS

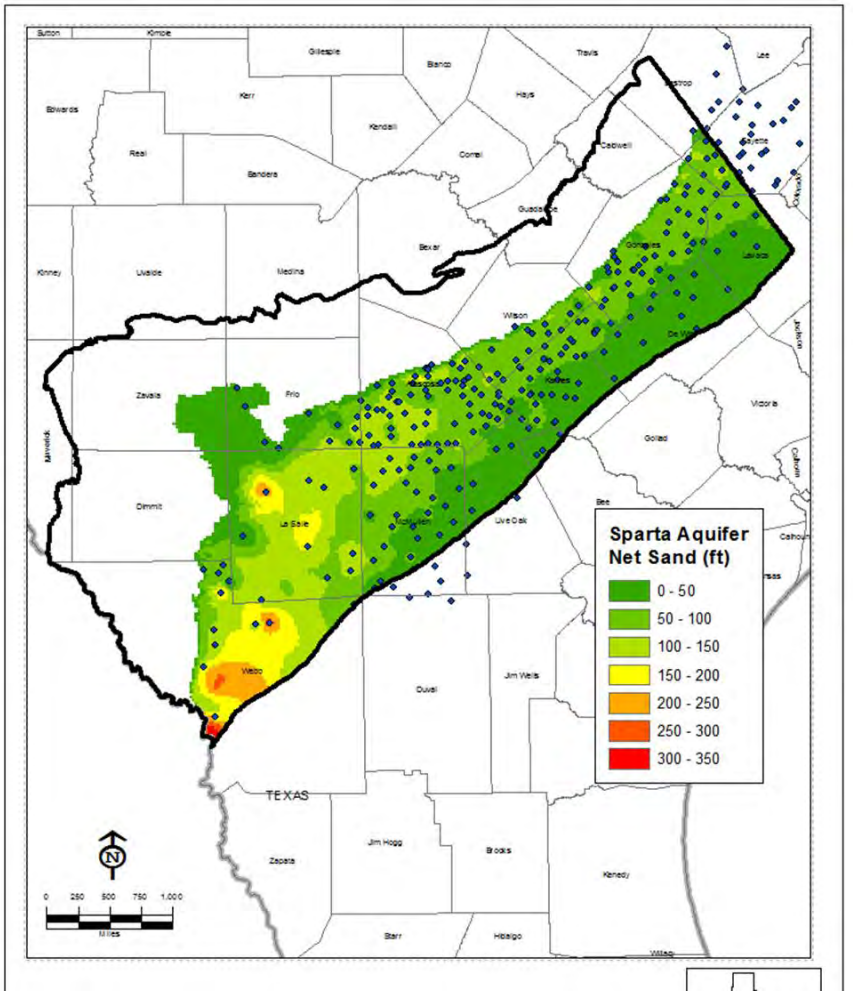
Formation/ Model Layer	Number of Utilized Control Points	Average Percent Sand
Sparta Aquifer	293	0.35
Weches Aquitard	421	0.08
Queen City Aquifer	460	0.39
Reklaw Aquitard	465	0.15
Carrizo - Upper Wilcox	527	0.65
Middle Wilcox	571	0.27
Lower Wilcox	535	0.45

NET SAND: SPARTA

- **Percent Sand**

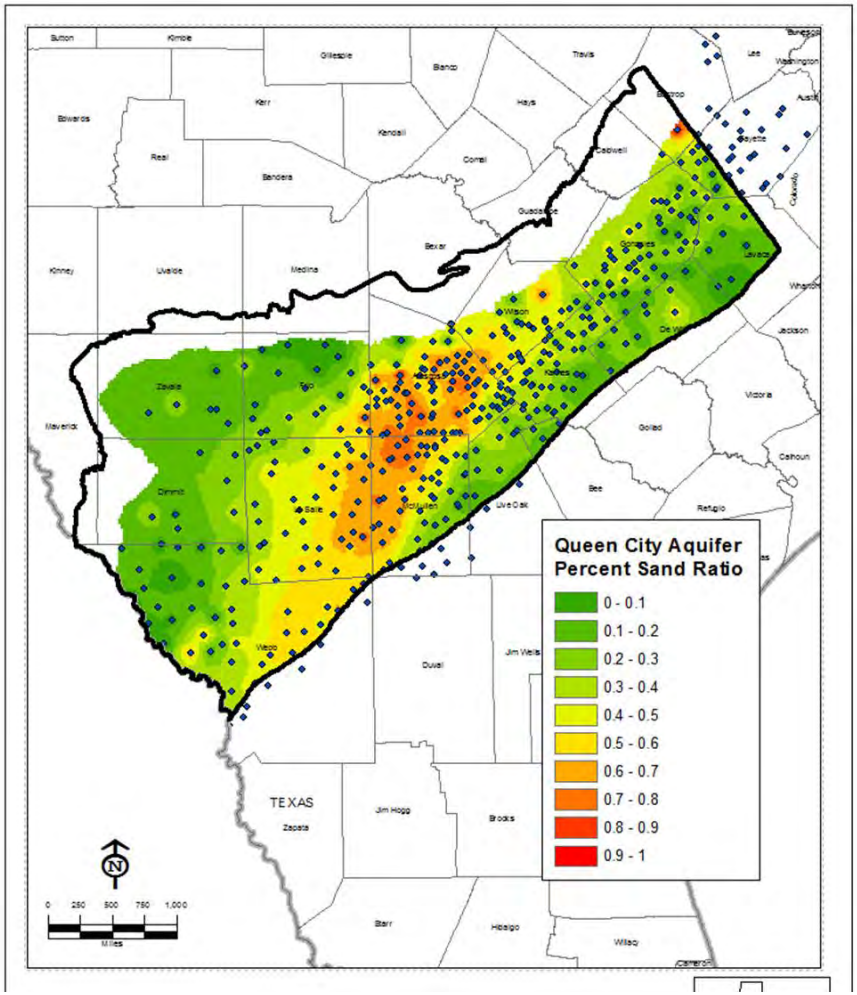


- **Net Sand Thickness**

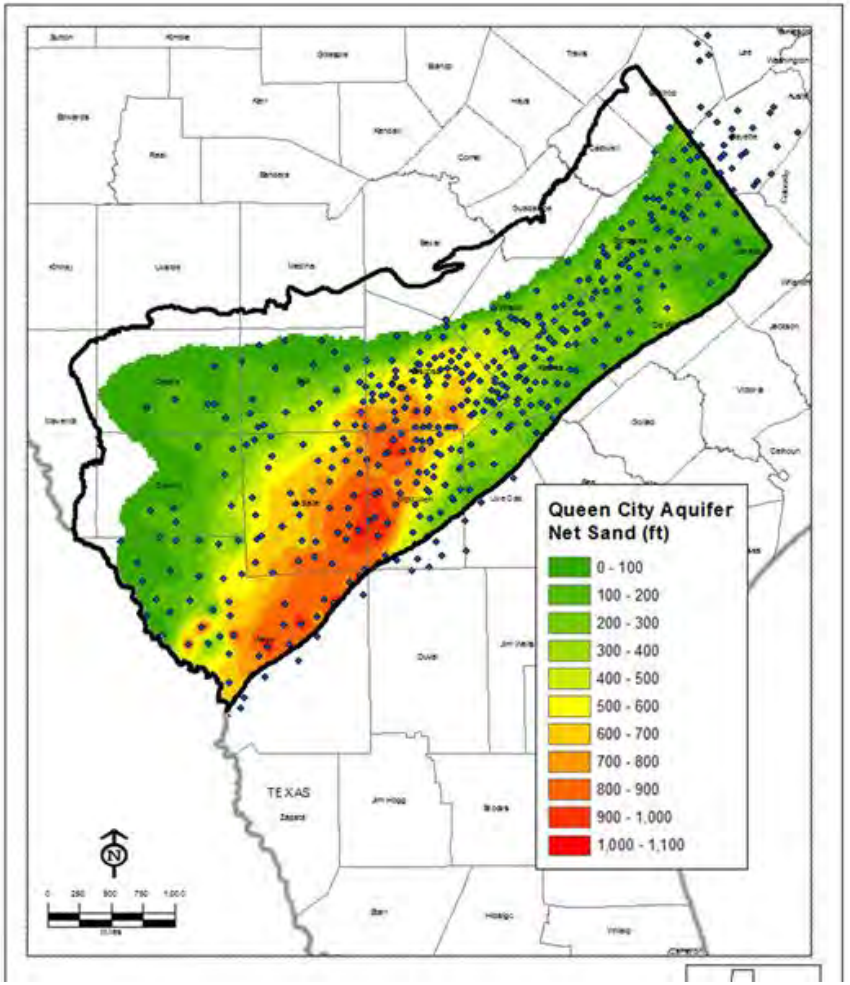


NET SAND: QUEEN CITY

- **Percent Sand**

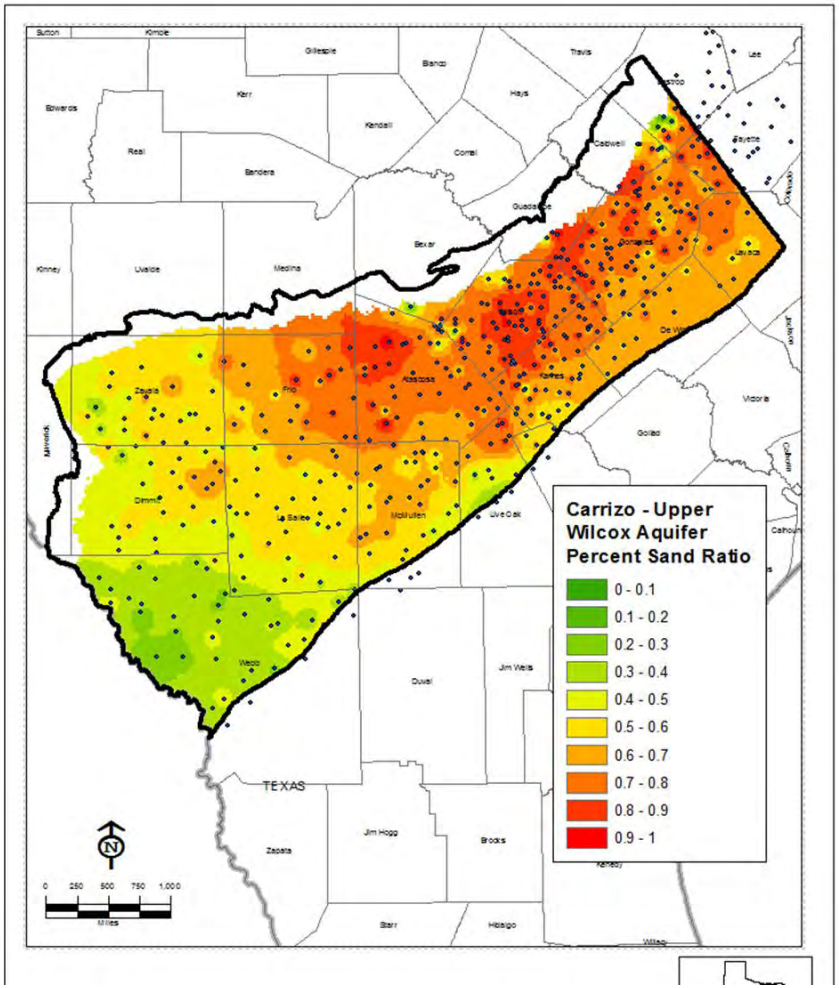


- **Net Sand Thickness**

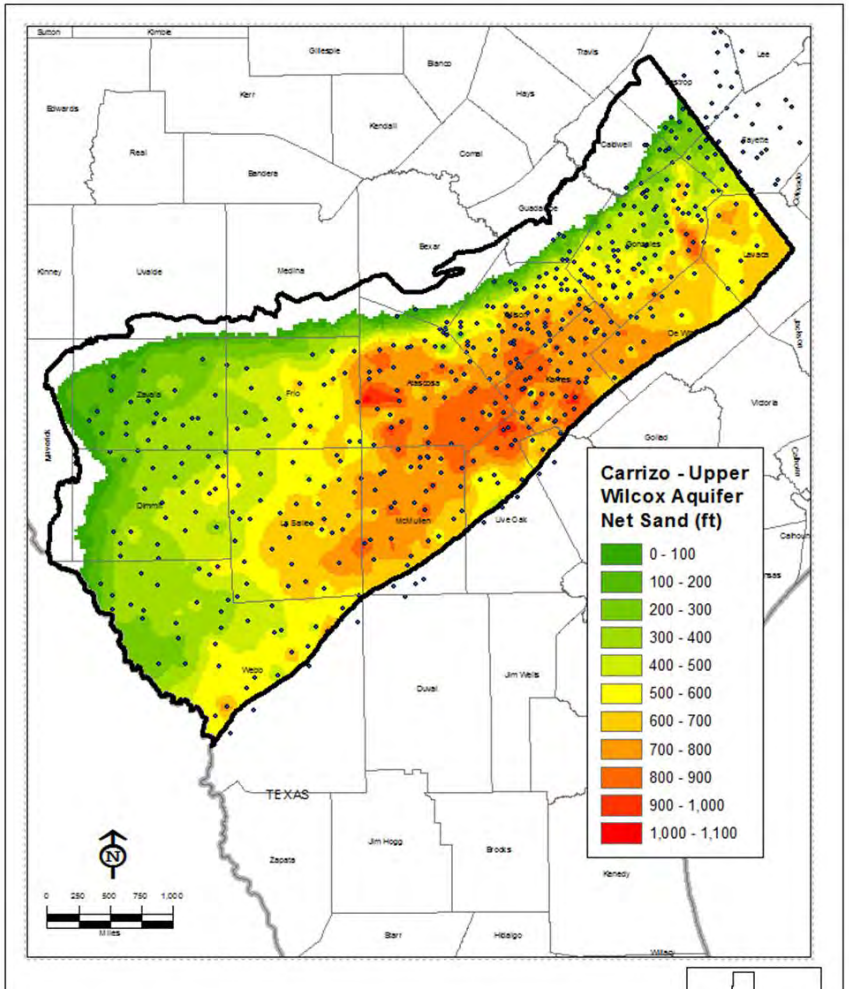


NET SAND: CARRIZO-UPPER WILCOX

- **Percent Sand**

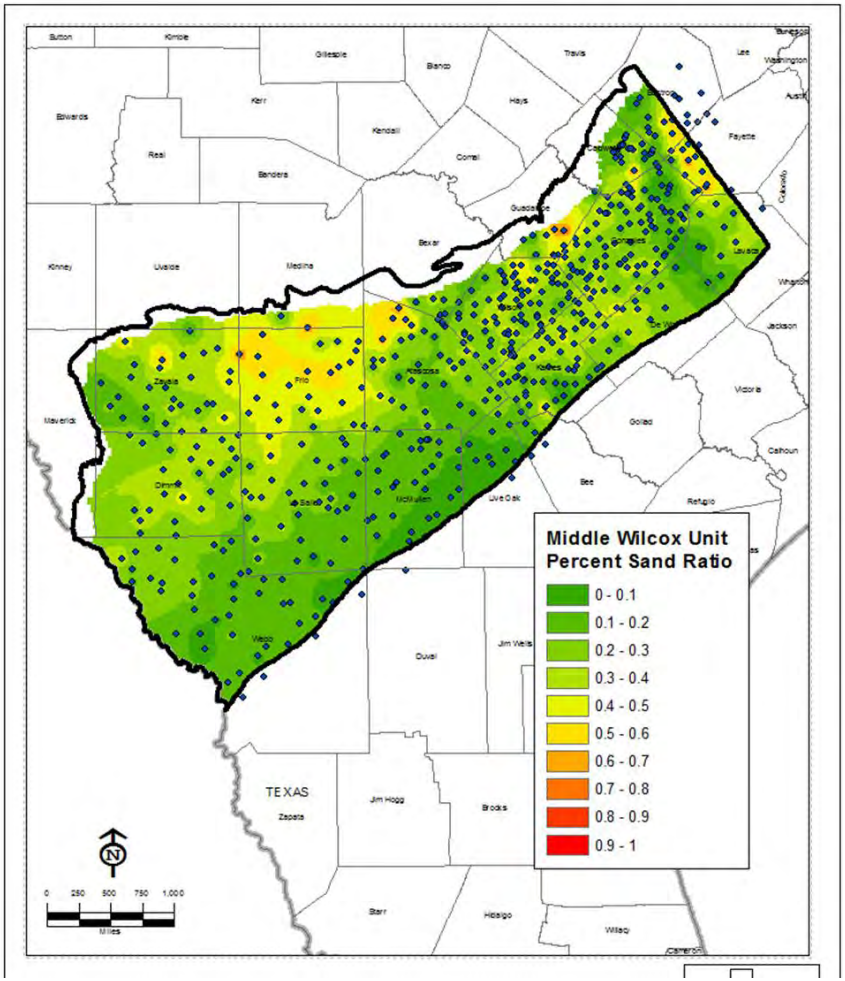


- **Net Sand Thickness**

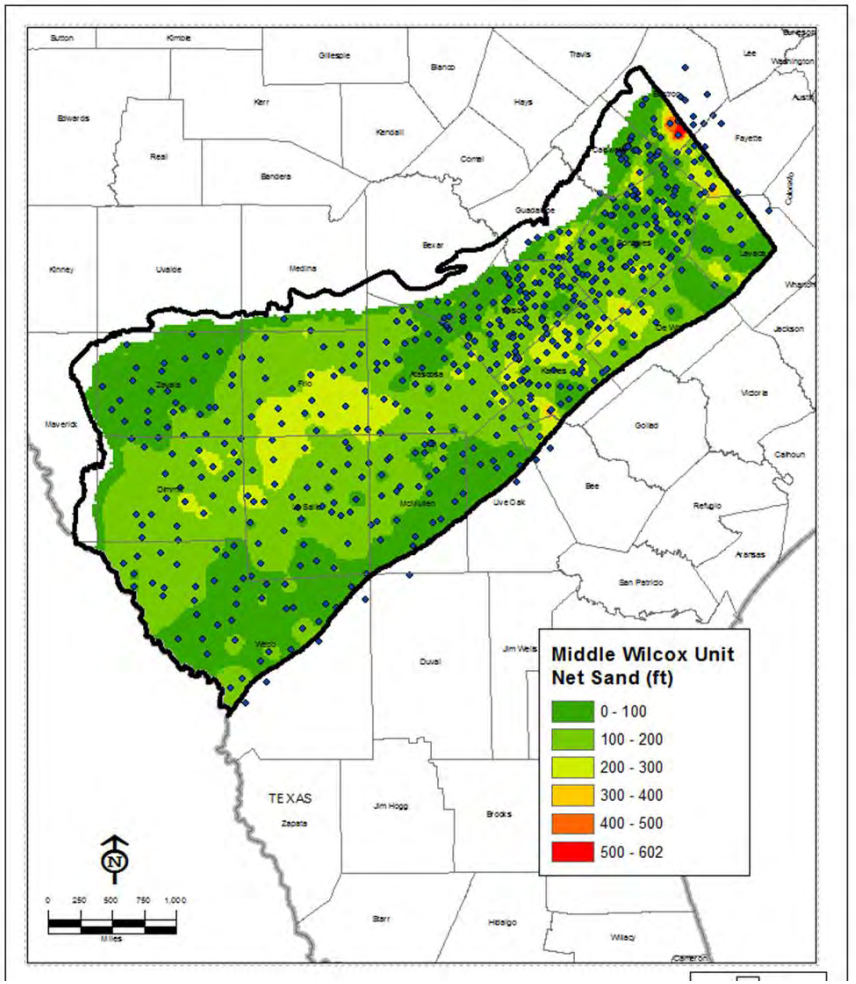


NET SAND: MIDDLE WILCOX

- **Percent Sand**

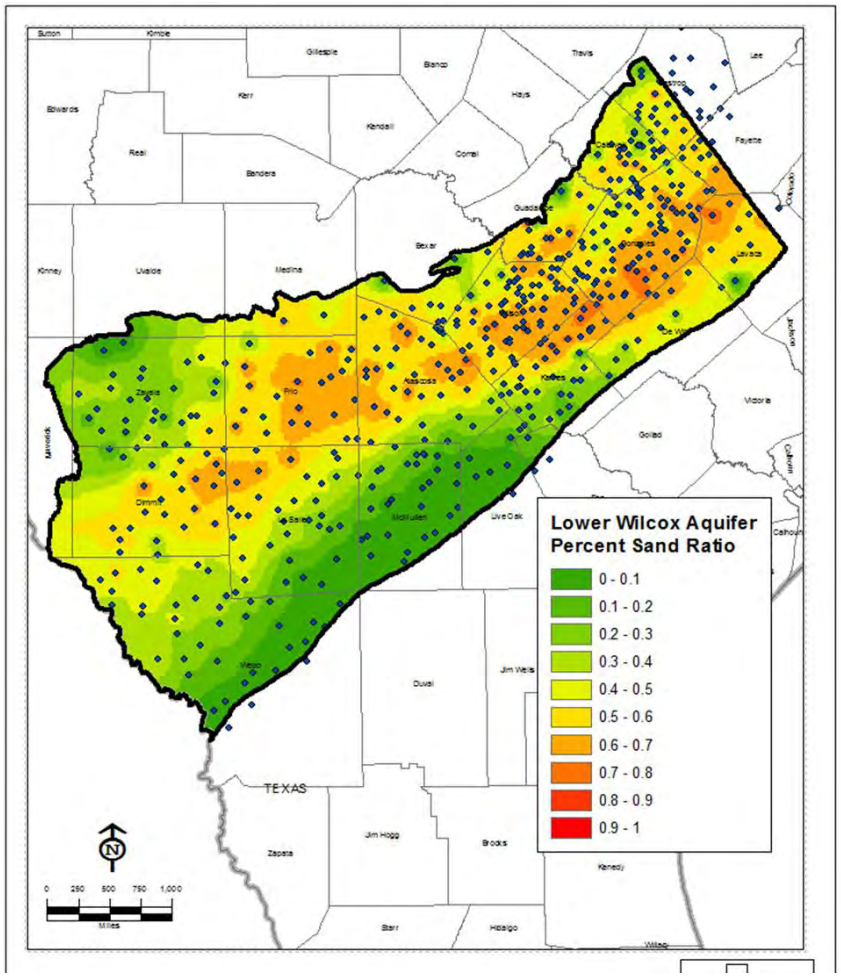


- **Net Sand Thickness**

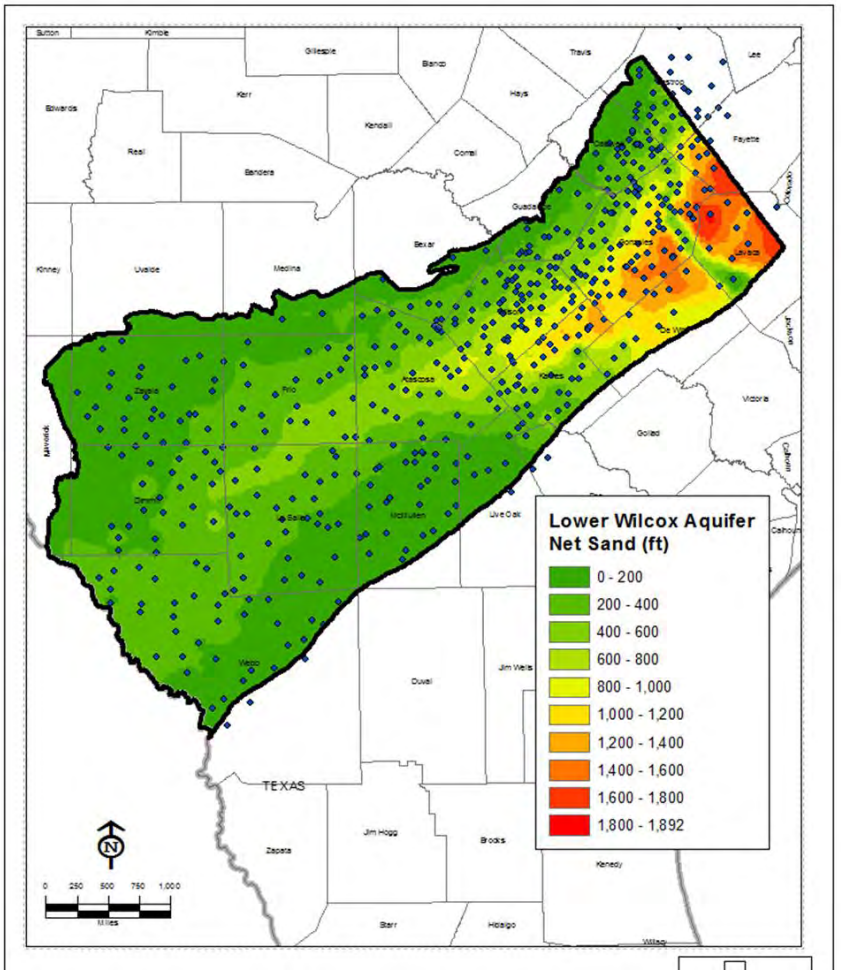


NET SAND: LOWER WILCOX

- **Percent Sand**



- **Net Sand Thickness**

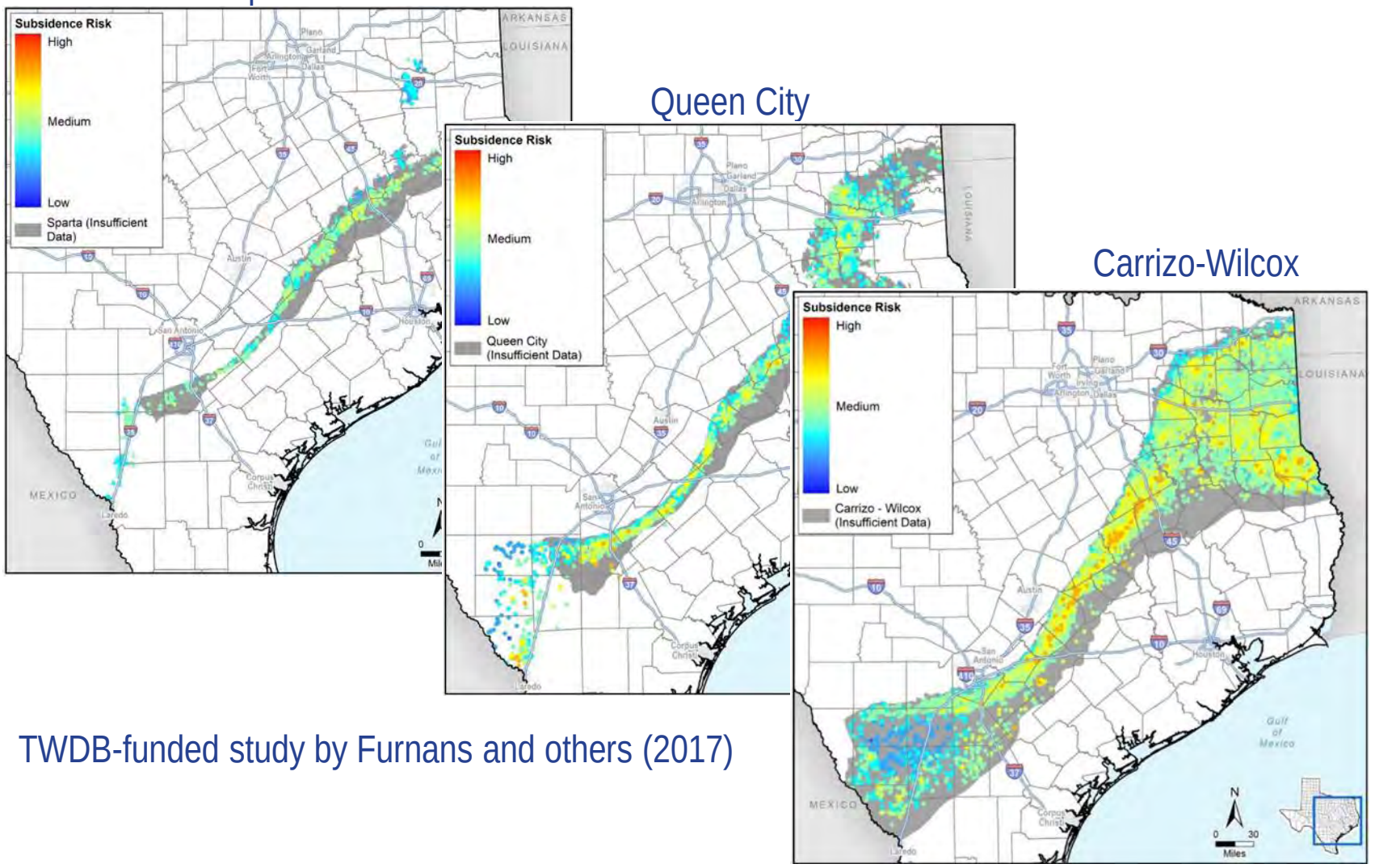


POTENTIAL FOR SUBSIDENCE

Sparta

Queen City

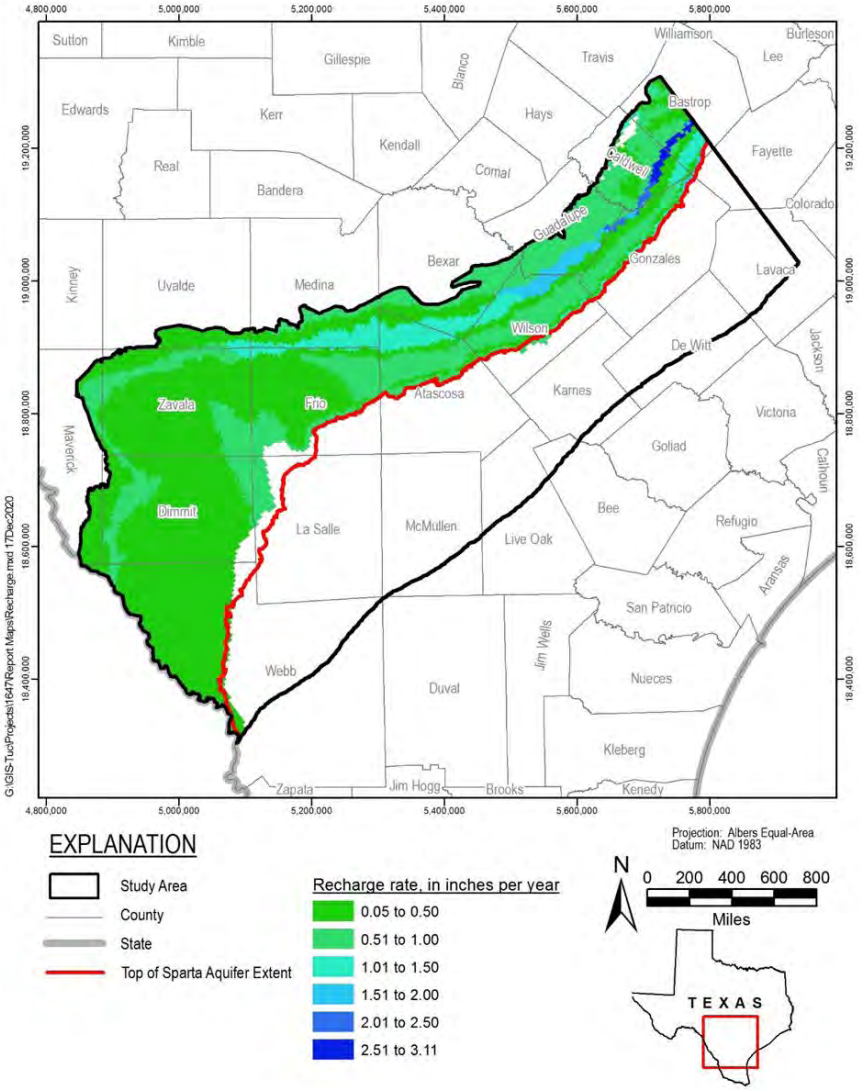
Carrizo-Wilcox



TWDB-funded study by Furnans and others (2017)

INFLOWS AND OUTFLOWS

GROUNDWATER INFLOW



- Recharge of precipitation
  - Outcrop areas
  - Based on analysis from previous GAM study

GROUNDWATER OUTFLOWS

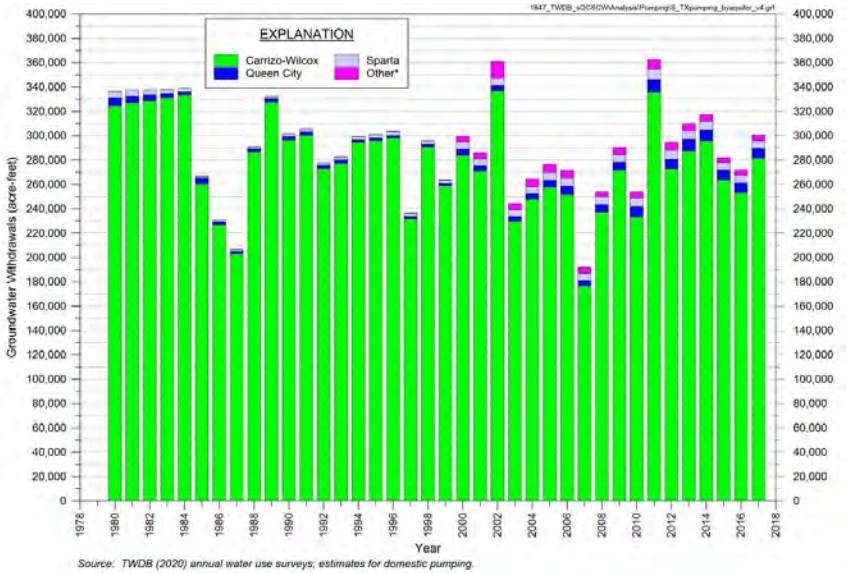
- Groundwater Pumping
- Evapotranspiration

GROUNDWATER PUMPING

- Compiled TWDB water use surveys for estimates of annual pumping through 2017
- Received pumping data from only one GCD (Plum Creek) in response to data requests
- Vast majority of pumping in study area occurs from the Carrizo-Wilcox Aquifer

ESTIMATED GROUNDWATER PUMPING

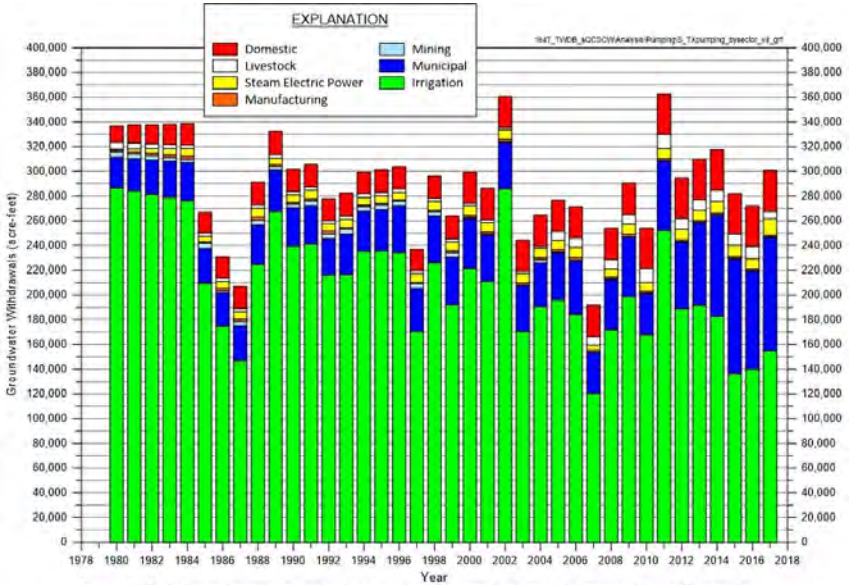
By Aquifer



Source: TWDB (2020) annual water use surveys; estimates for domestic pumping.

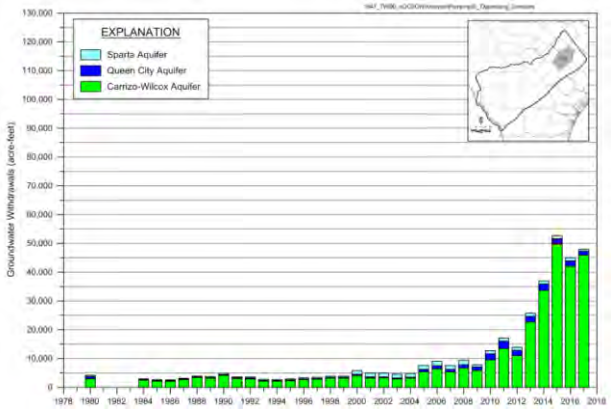
Note:
TWDB water use estimates do not include domestic pumping estimates.
**Other" aquifer data is compiled from counties west of Frio River where Queen City and Sparta are not classified.
The "Other" category may contain data from wells completed in alluvium and in any other units shallower than the Carrizo but deeper than theYegua-Jackson aquifer.

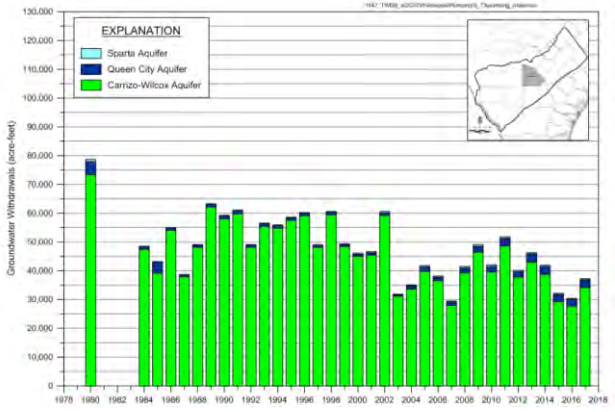
By Water Use

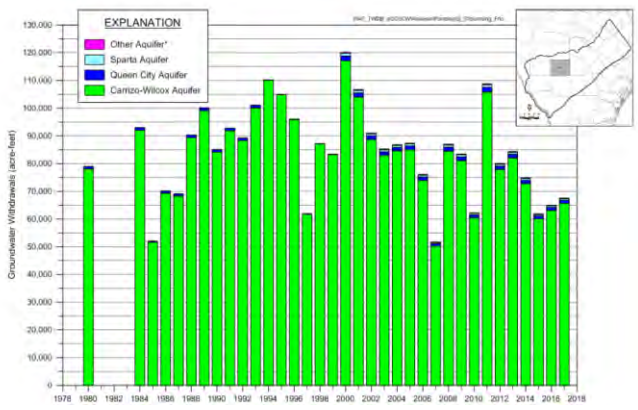


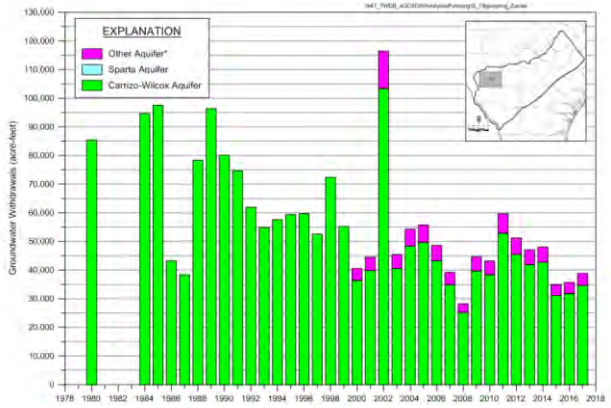
Source: TWDB (2020) annual water use surveys; totals include estimated pumpage from Queen City, Sparta, and Carrizo-Wilcox aquifers
Totals also include estimated pumpage from the "Other Aquifer" classification for counties west of the Frio River

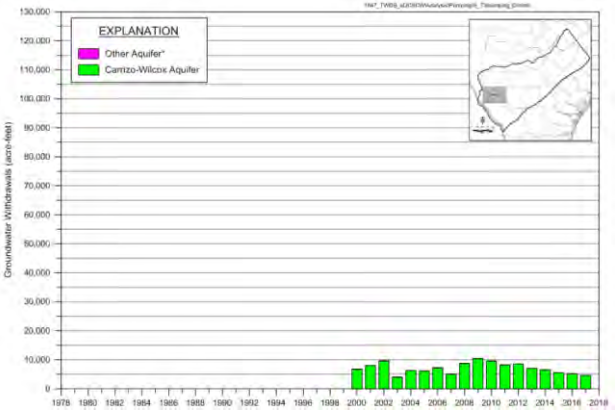
GROUNDWATER PUMPING ESTIMATES FOR SELECTED COUNTIES

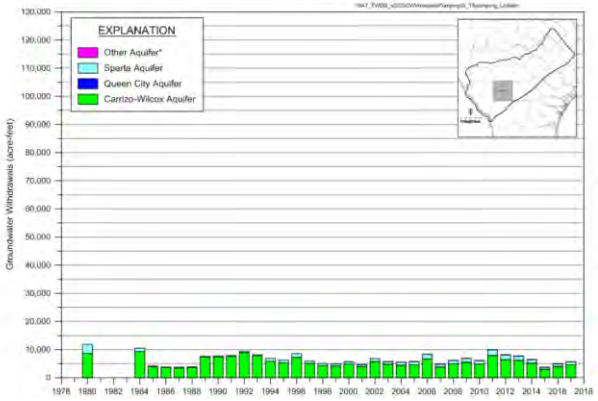




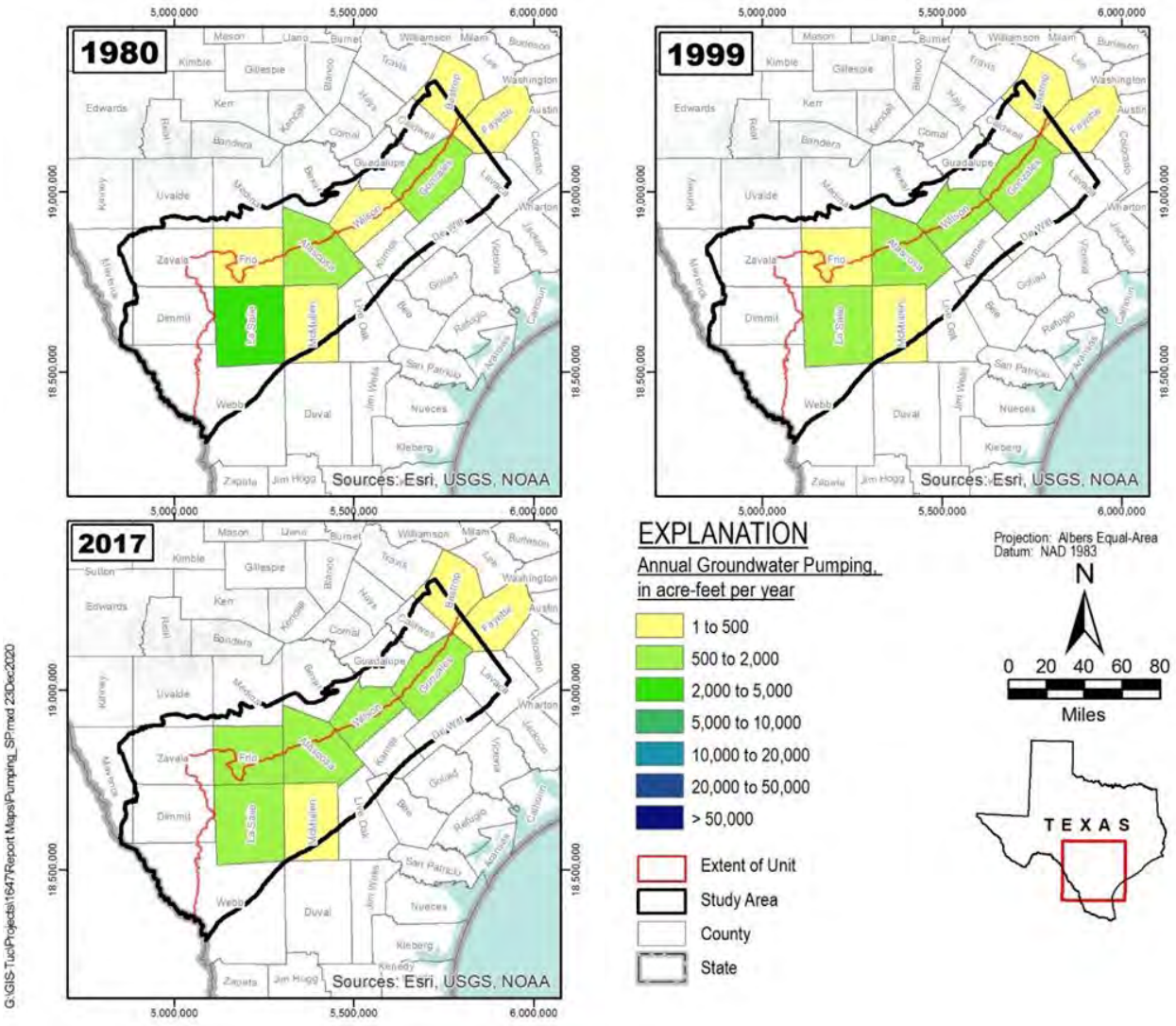




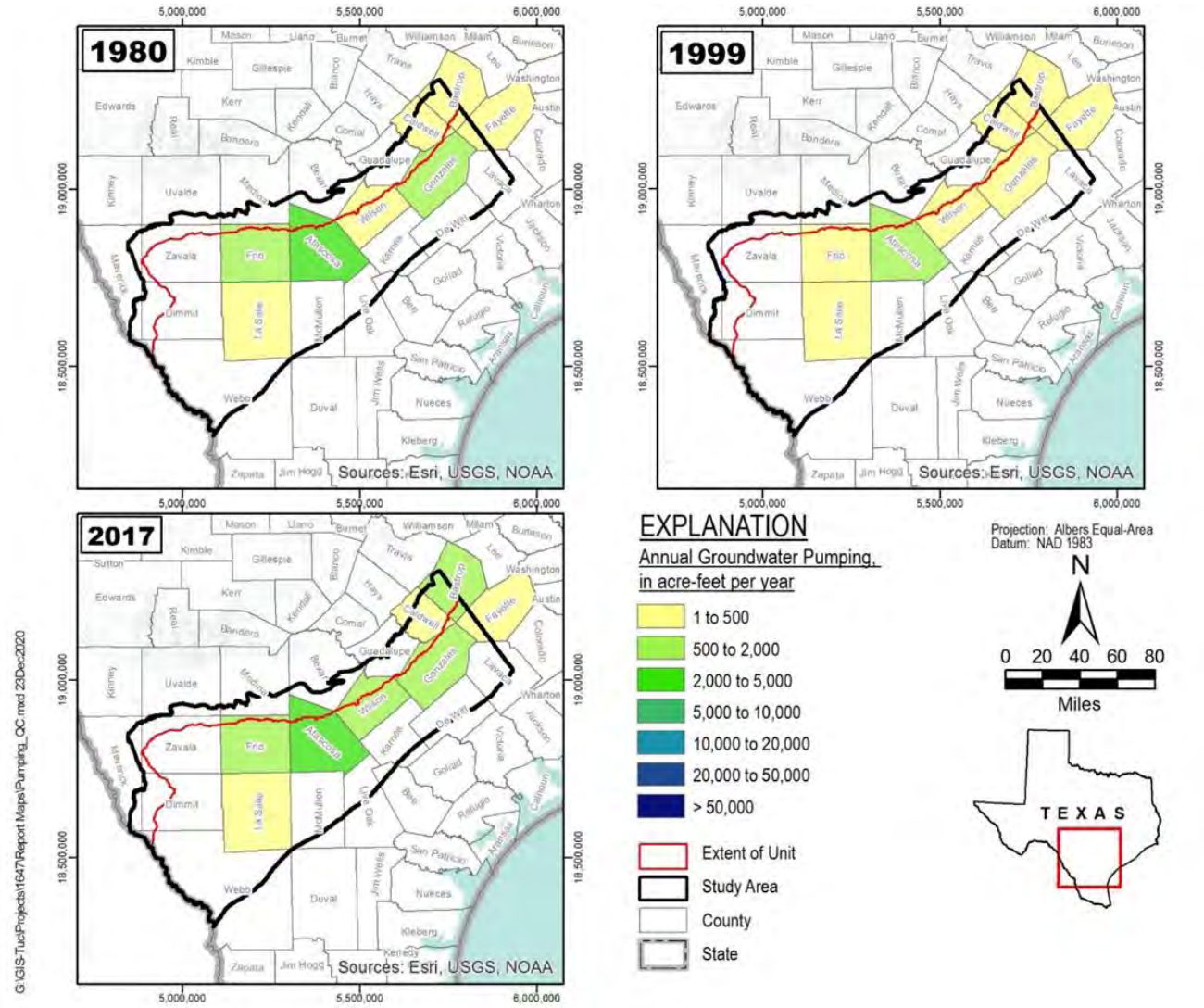




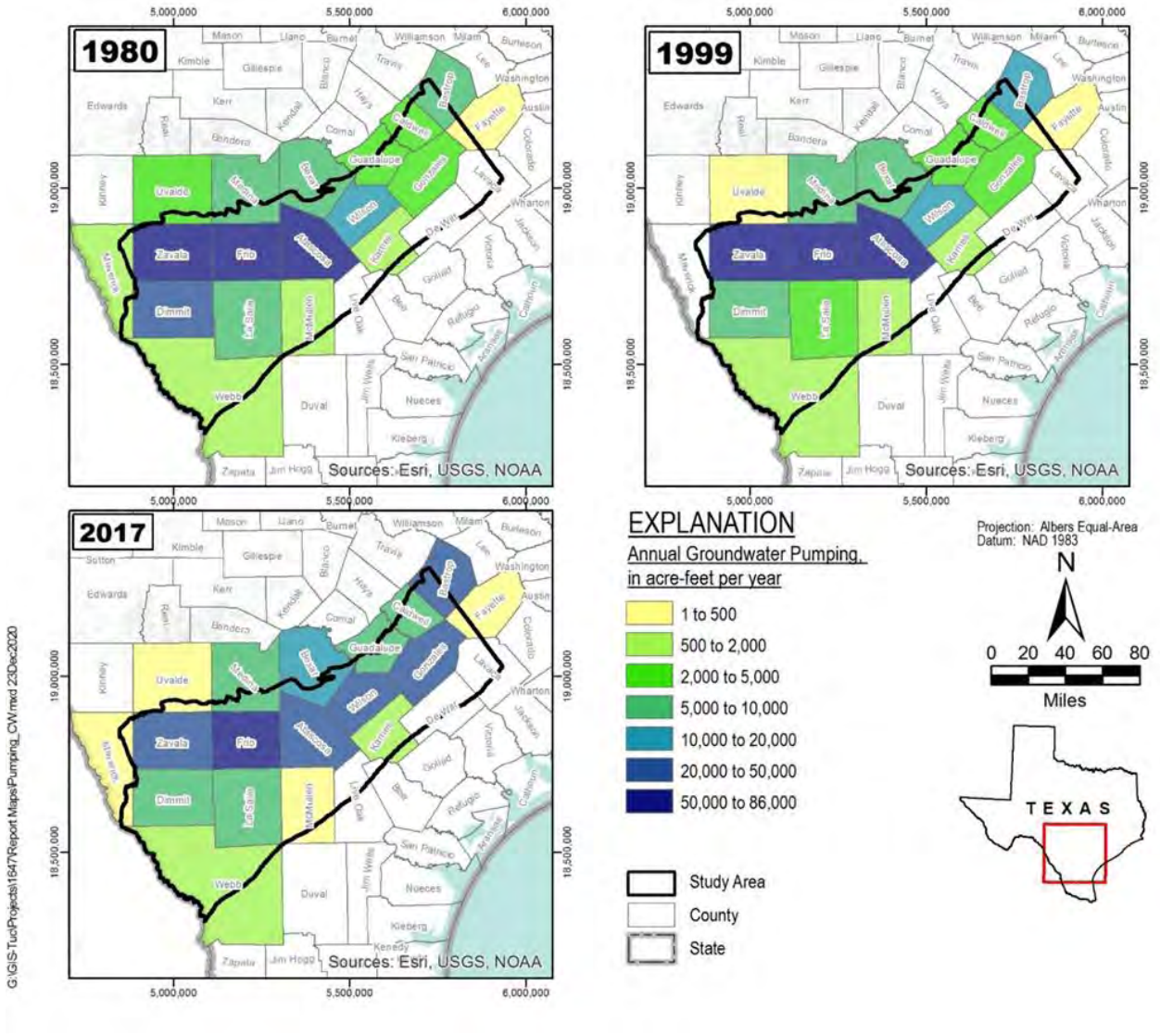
GROUNDWATER PUMPING: SPARTA AQUIFER



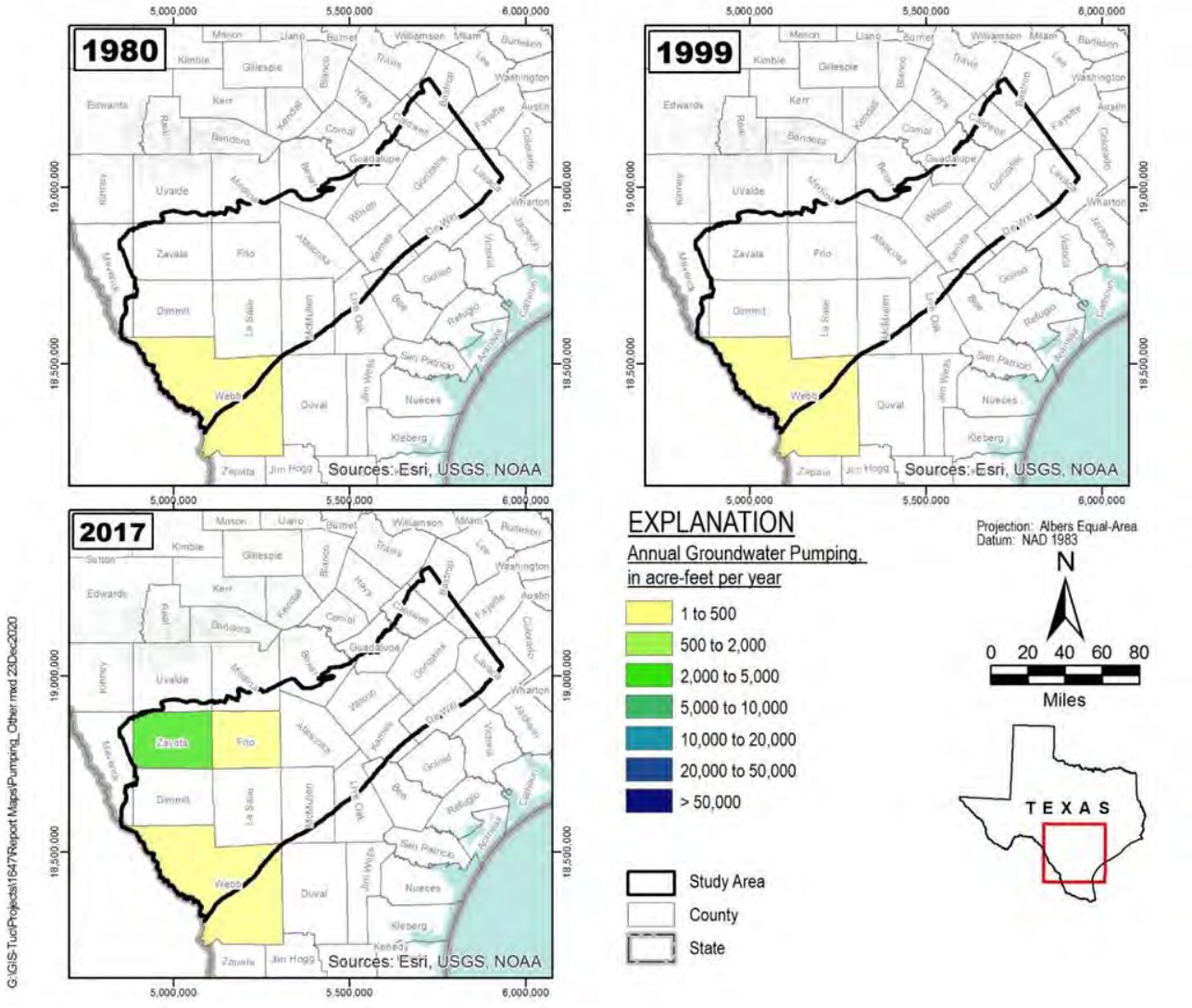
GROUNDWATER PUMPING: QUEEN CITY AQUIFER



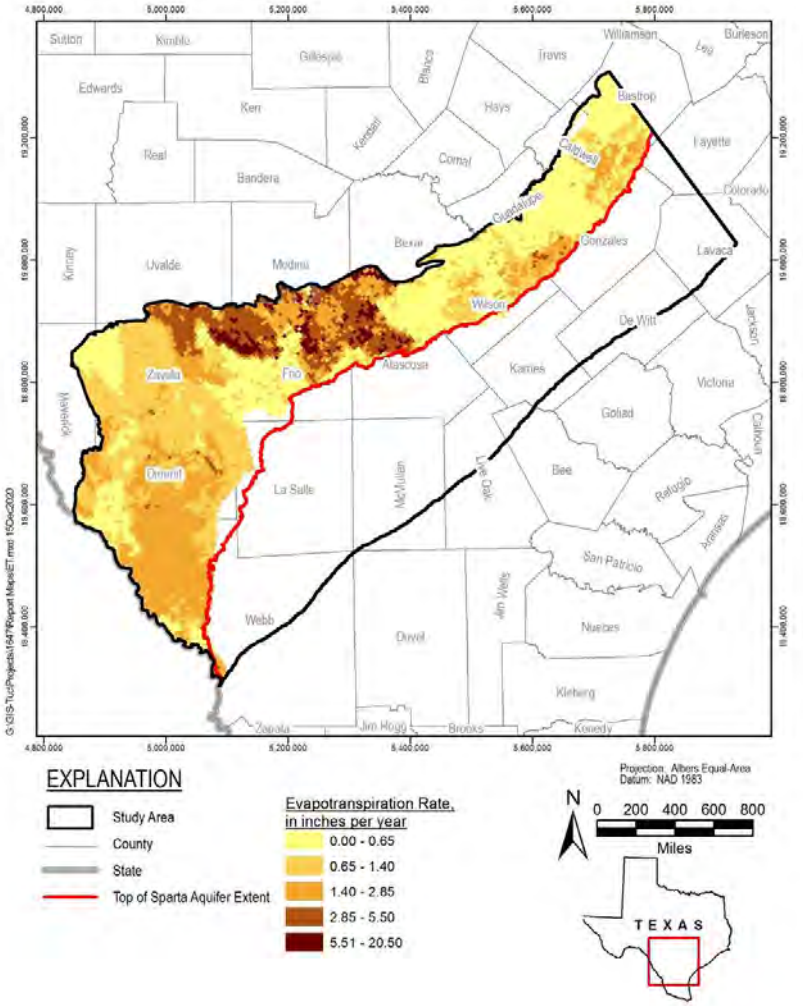
GROUNDWATER PUMPING: CARRIZO-WILCOX AQUIFER



GROUNDWATER PUMPING:
“OTHER” AQUIFER



EVAPOTRANSPIRATION



- Outcrop areas
- Based on analysis from previous GAM study

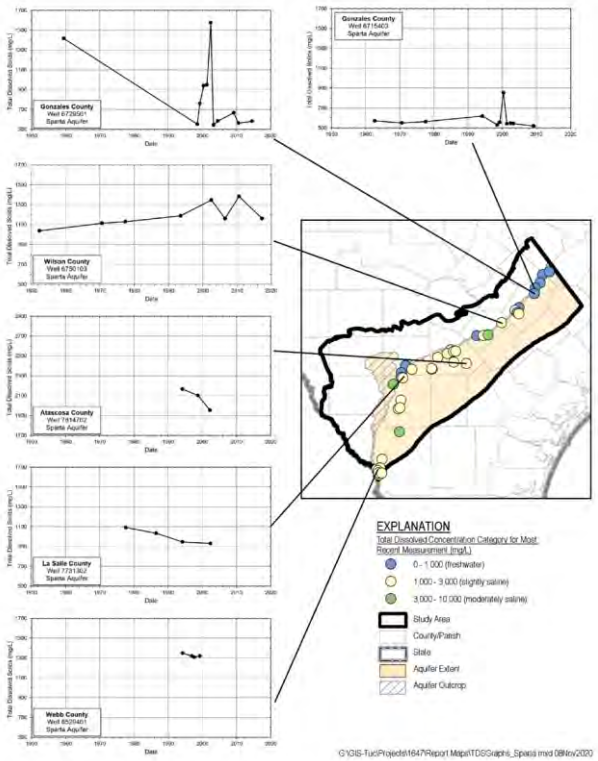
GROUNDWATER QUALITY

GROUNDWATER QUALITY

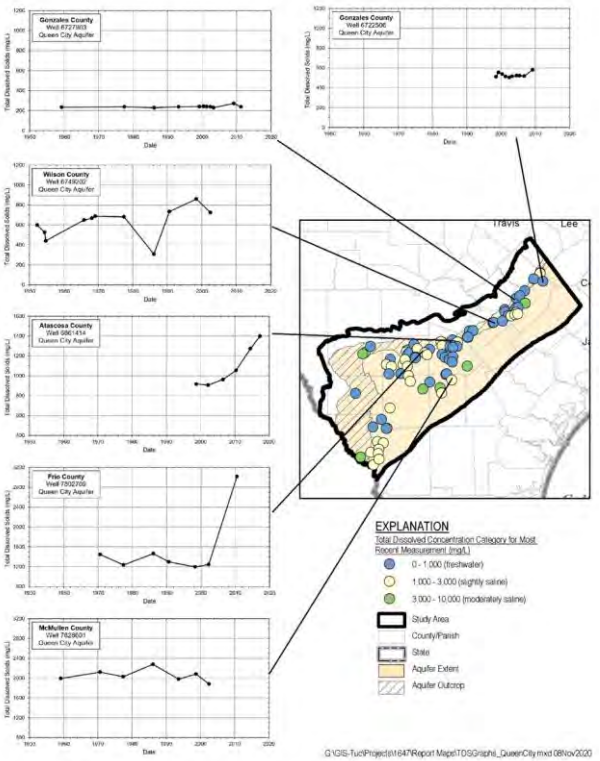
- Groundwater quality data compiled from the TWDB Groundwater Database and USGS Produced Waters Database
- Evaluated data collected since 2010 to find exceedances for drinking water, irrigation, and industrial purposes
- Also evaluated TDS data for changes in time, and for zones of saline and freshwater

TOTAL DISSOLVED SOLIDS TIME-SERIES

Sparta

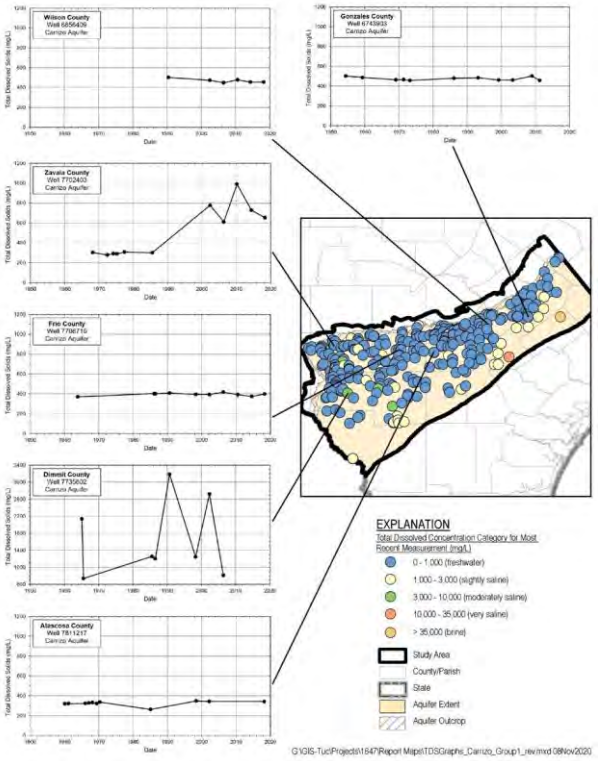


Queen City

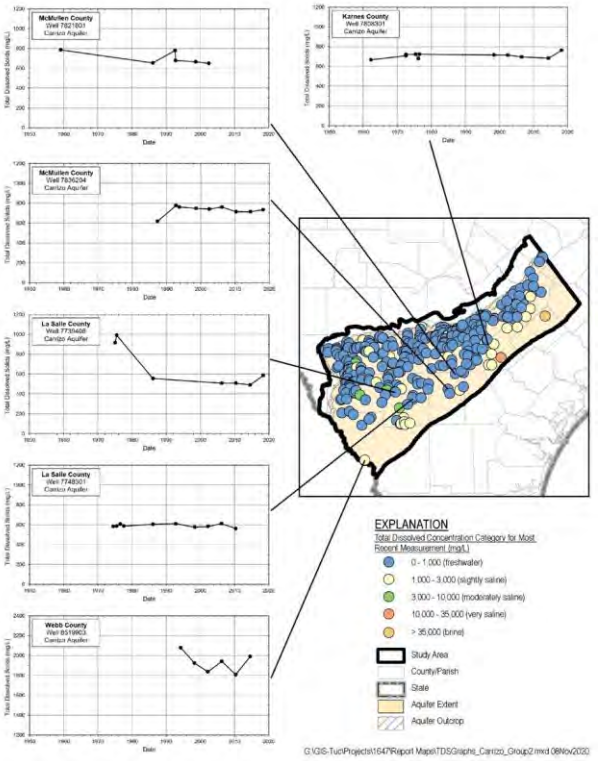


TOTAL DISSOLVED SOLIDS TIME-SERIES

Carrizo

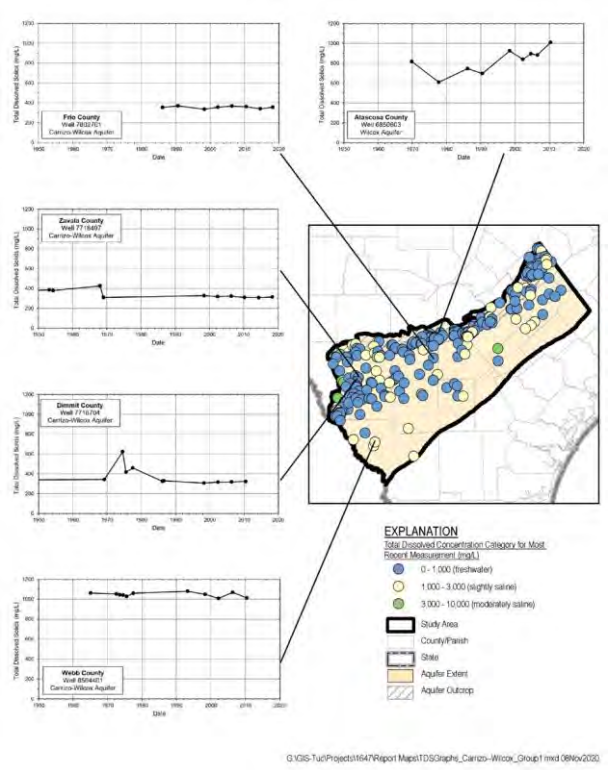


Carrizo

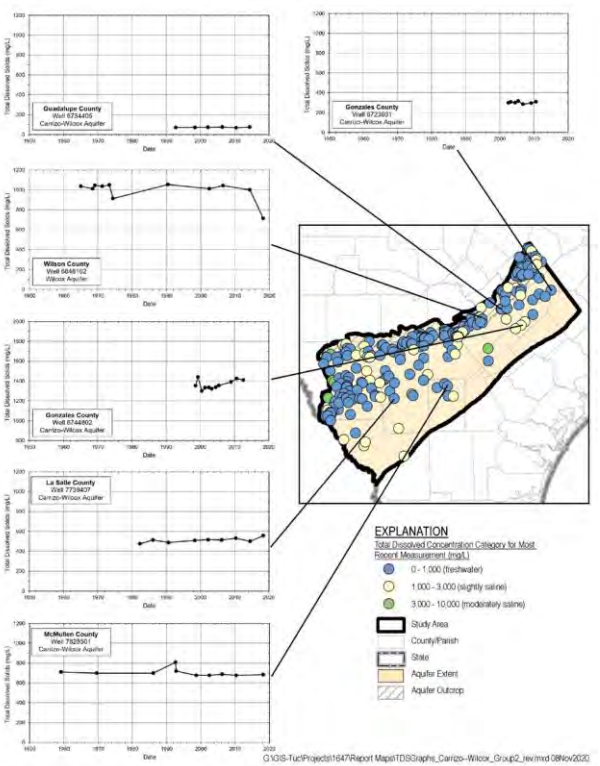


TOTAL DISSOLVED SOLIDS TIME-SERIES

Carrizo-Wilcox

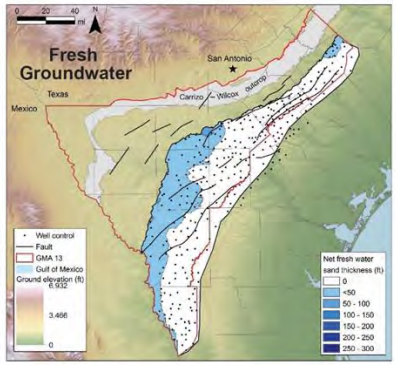


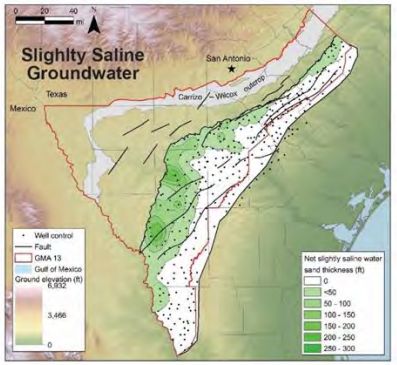
Carrizo-Wilcox

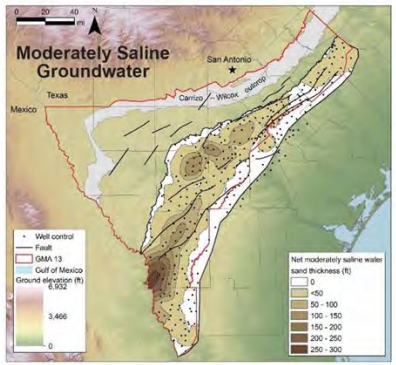


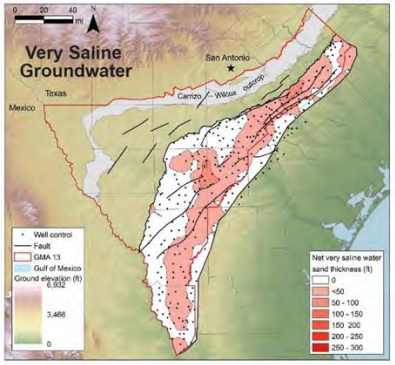
SALINITY ZONES: BRACS STUDY RESULTS

Sparta









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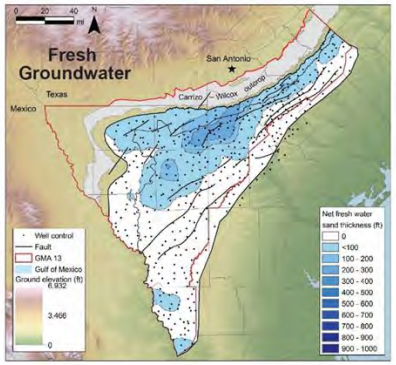
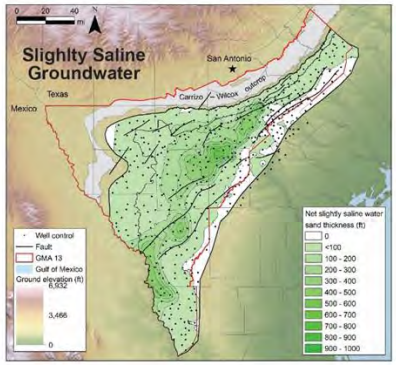
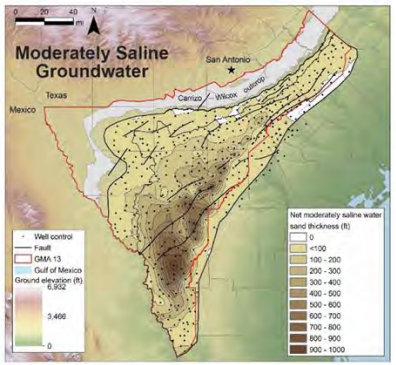
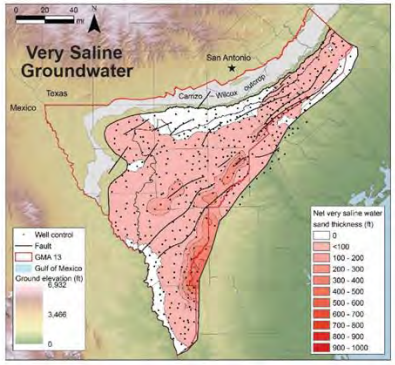
Queen City









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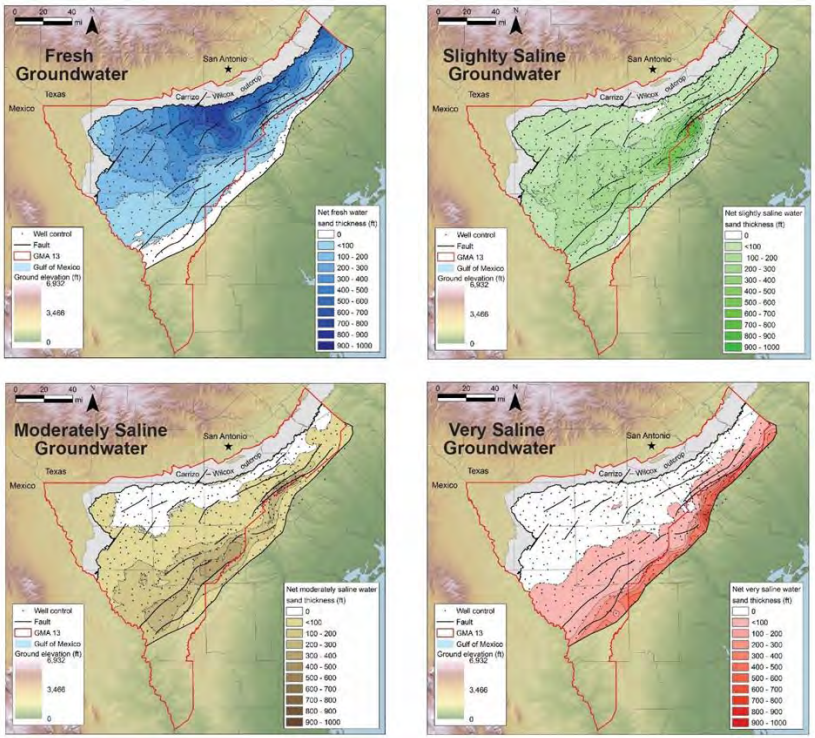
SALINITY ZONES: BRACS STUDY RESULTS

Carrizo-Upper Wilcox



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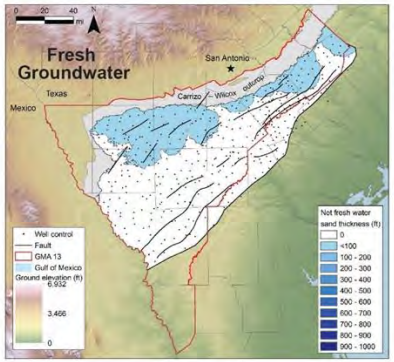
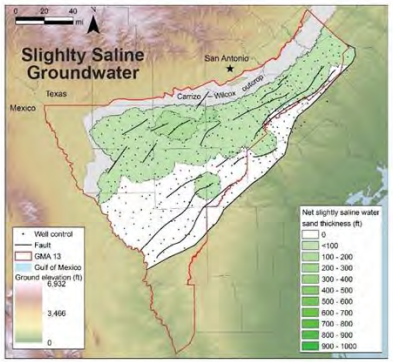
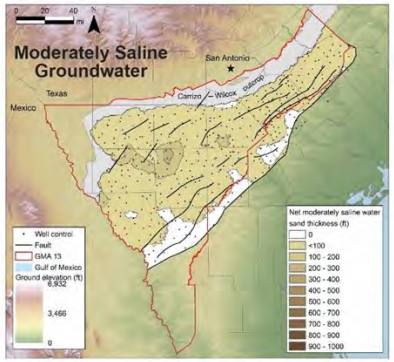
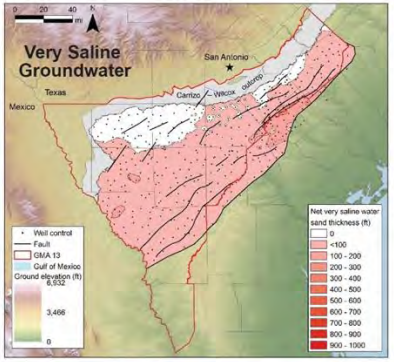
SALINITY ZONES: BRACS STUDY RESULTS

Middle Wilcox

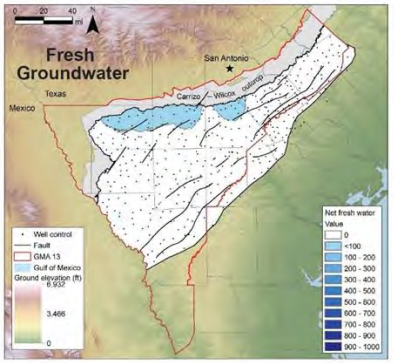


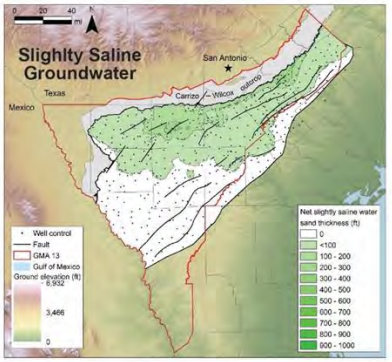


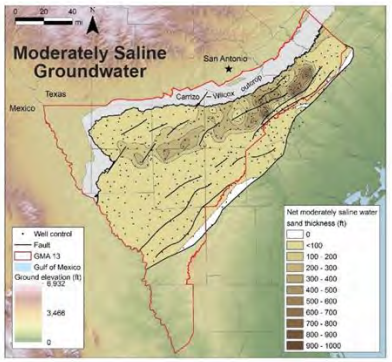


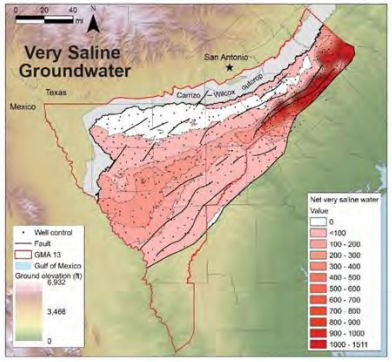


Lower Wilcox









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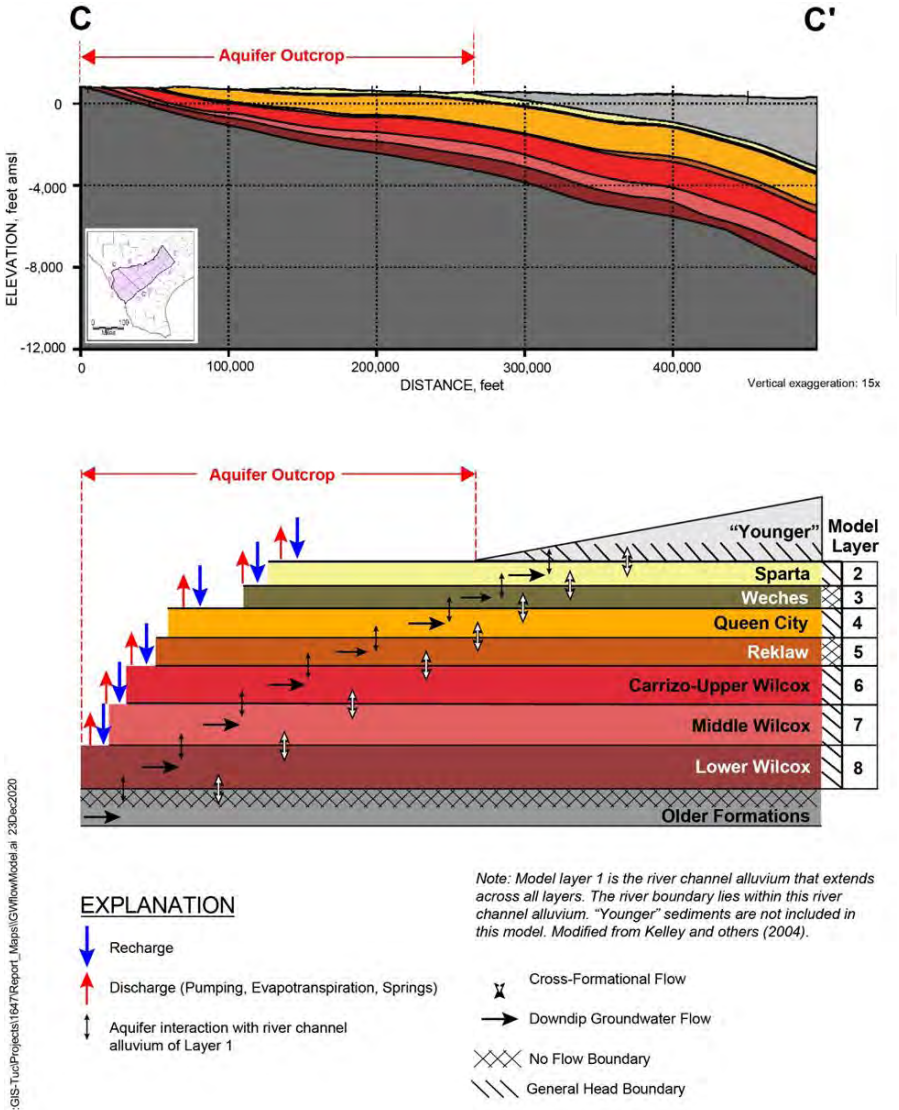
INCORPORATING CONCEPTUAL MODEL INTO NUMERICAL MODEL

SUMMARY OF CONCEPTUAL MODEL



- 8-layer aquifer system
- Inflows, outflows, interactions between layers
- Provides input for GAM construction and calibration

FUTURE IMPROVEMENTS

- Pumping estimates would improve by
  - Incorporating additional data from GCDs
  - Establishing a standard approach for addressing changes in methods used in the TWDB water use estimates
  - A better understanding of pumping from the “Other” Aquifer category
- Additional information for deep, down-dip portions of the aquifer layers would improve conceptual understanding of that part of the aquifer system
  - E-logs, water levels, aquifer properties

DRAFT CONCEPTUAL MODEL REPORT

- TWDB posted the Draft Conceptual Model Report for public review through March 18, 2021: http://www.twdb.texas.gov/groundwater/models/gam/czwx_s/czwx_s.asp

- Submit comments to Jean Perez at TWDB

  jean.perez@twdb.texas.gov

NEXT STEPS

PROJECT SCHEDULE

- ✓ Contract Signed by TWDB
  - May 17, 2019
- ✓ Interim Framework Completed
  - January 31, 2020
- ✓ Interim Draft Conceptual Model Completed
  - January 15, 2021
- Interim Draft Model Design Deadline
  - June 30, 2021
- Calibrated Model Deadline
  - January 31, 2022
- Final Report Deadline
  - June 30, 2022

QUESTIONS AND DISCUSSION

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