Conceptual Model Update for the Hill Country Portion of the Trinity Aquifer

TWDB Contract No. 1648302061

SOUTHWEST RESEARCH INSTITUTE®

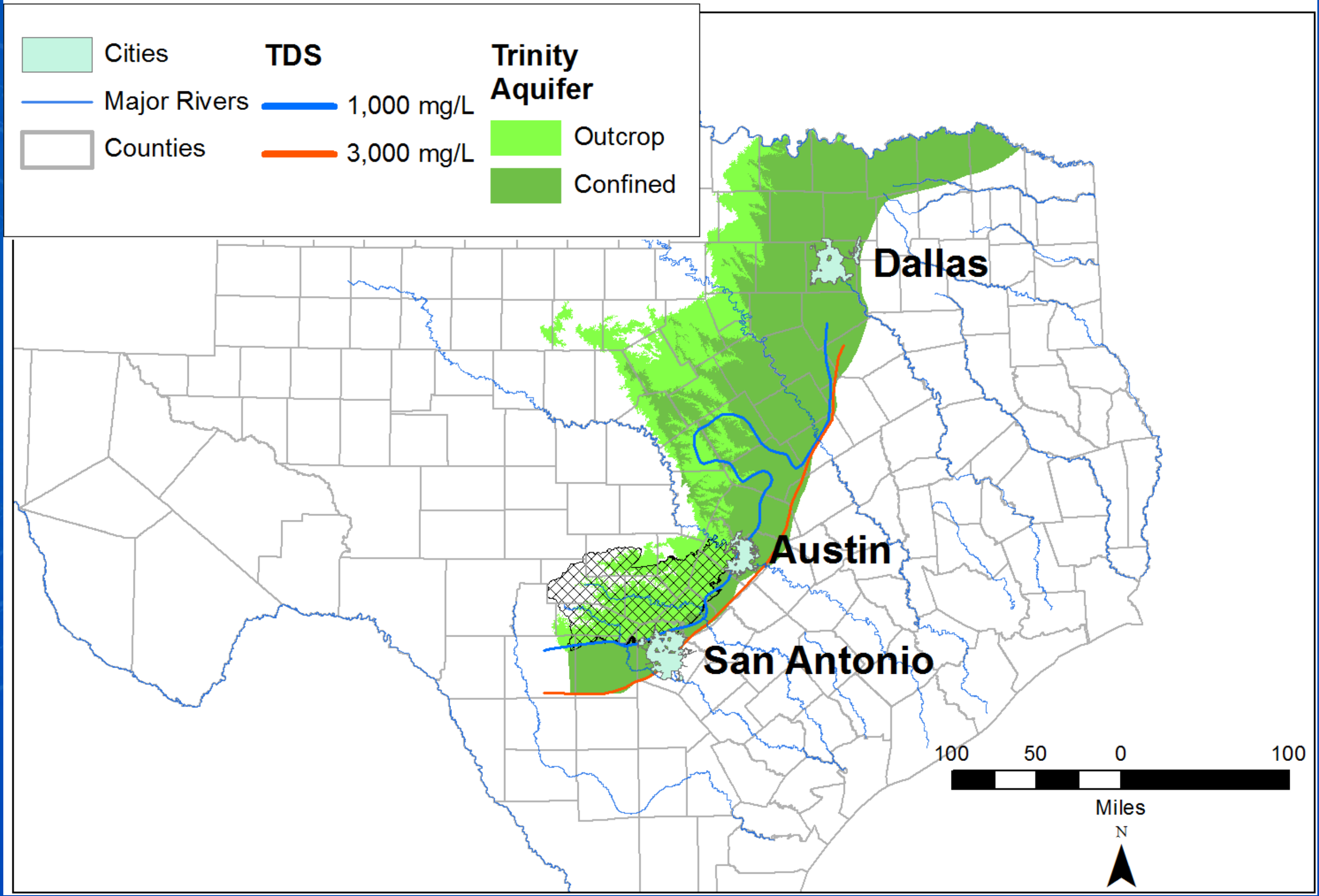
INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

July 13th, 2017
San Antonio, Texas

Project Team

- Ron Green, PhD, PG: Southwest Research Institute (SwRI) Project Manager
  - Nate Toll: Technical Lead, Hydrogeologist
  - Ron McGinnis: Structural Geologist, Geologic Modeler
  - Gary Walter, PhD: Hydrogeologist, Aqueous Geochemist
  - Leanne Stepchinski: Geologist
  - Beth Fratesi, PhD: Hydrogeologist
  - Rebecca Nunu: Hydrologist
  - Kirk Gulliver: Geoscientist
- Neil Deeds, PhD, PG, PE: (Intera) Project Manager and Technical Lead
  - Jevon Harding , PG: Geologist

Background



Cities
Major Rivers
Counties
TDS
1,000 mg/L
3,000 mg/L
Trinity Aquifer
Outcrop
Confined
Dallas
Austin
San Antonio
100
50
0
100
Miles
N

Background

- Increasing demand on the Trinity Aquifer as a resource
- “The fastest-**growing** region in the country is a 74-mile **corridor (I-35)** anchored at either end by **San Antonio and Austin** that is coalescing”

  (Oct. 2016, Forbes Magazine)
- Materials Industry (Limestone Quarries)

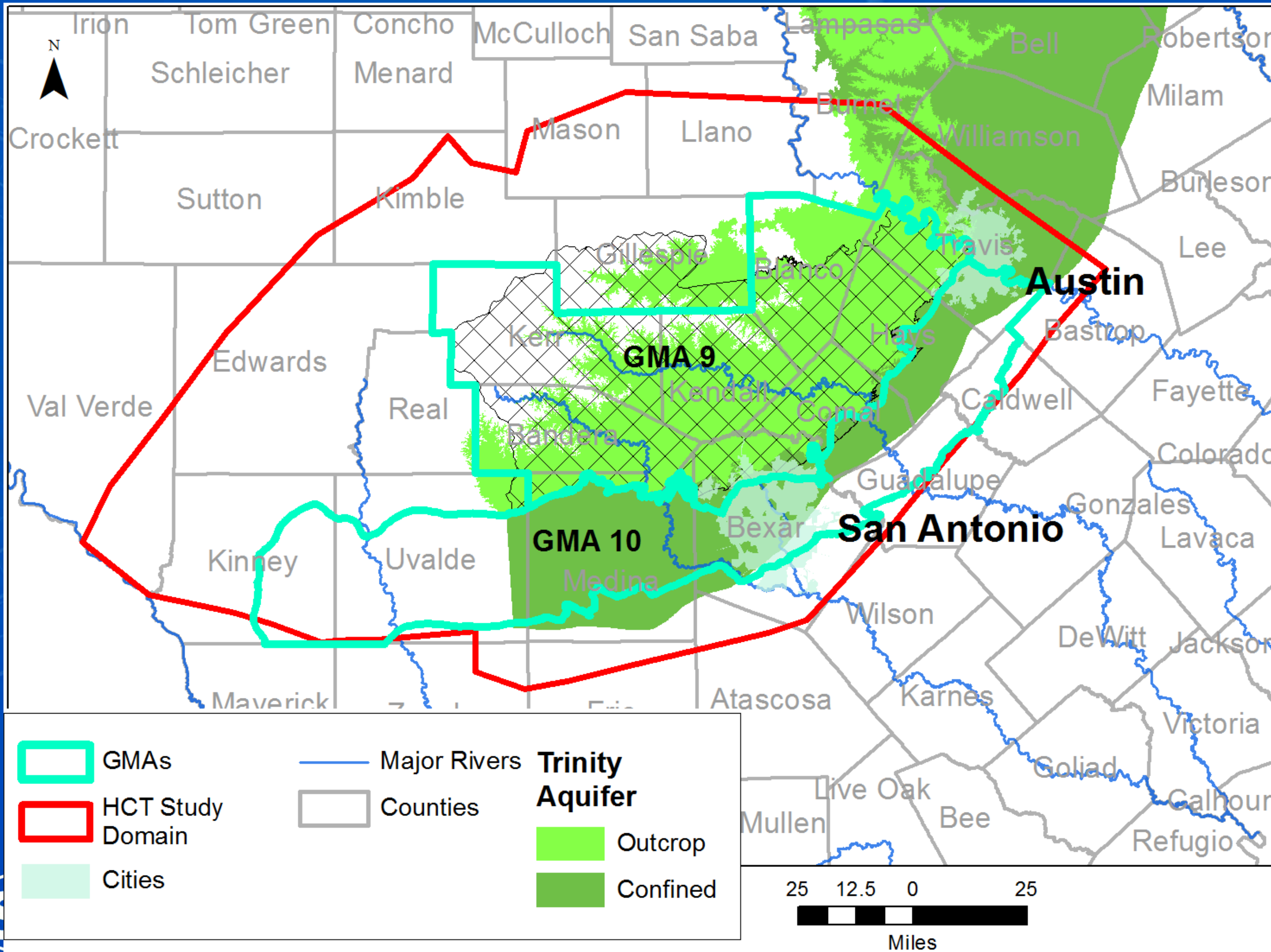
History of GAMs for the Hill Country Portion of the Trinity Aquifer

- Texas Water Development Board completed a **GAM in 2000** in cooperation with the Trinity Aquifer Advisory Committee
- In 2011, TWDB completed an **update** to the model to include the lower Trinity
- 2017, the TWDB contracted Southwest Research Institute (SwRI) to **update the conceptual model** for the Hill Country Portion of the Trinity Aquifer

Approach

- Objectives of this study include:
  - <u>Expansion</u> of the model region
  - Develop an understanding of the **<u>inter-formational flow between the Trinity Aquifer and the Edwards Balcones</u>** Fault Zone (BFZ) Aquifer
  - **<u>Extend the datasets</u>** for water levels, water chemistry, recharge, discharge, and hydraulic parameters both temporally and spatially

Conceptual Model Study Domain



Expanded Domain

- A key objective of this study was to expand the model domain.
  - Include downdip/confined portions of the Trinity Aquifer
    - Address inter-formational flow to the Edwards Aquifer
    - These portions are being utilized for water resources
  - Expand the model to the west to include portions of the Trinity Aquifer similar to the Northeastern portion.
    - Model will be coincident with the current Edwards Aquifer Authority numerical model domain.
  - Include all of GMA 9
- This is Not the domain for the future numerical model

Approach

- Project had **seven** main tasks

1. Project Management
2. Stakeholder Communication
3. Data Acquisition and Data Management
4. Geologic and Hydrostratigraphic Modeling
5. Hydraulic Data Analysis
6. Conceptual Model Synthesis
7. Reporting

Geologic and Hydrostratigraphic Modeling

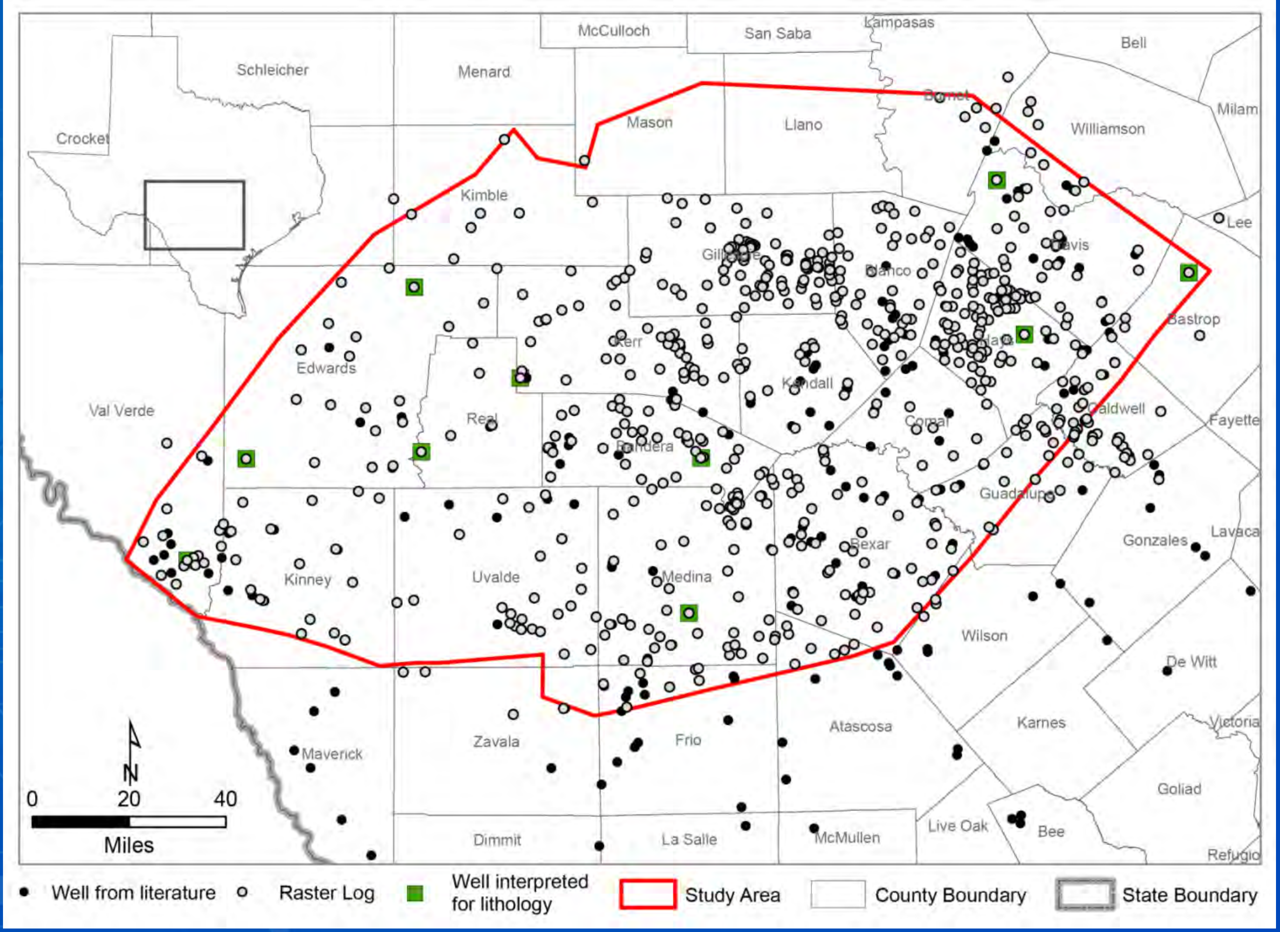
- Task 4 - Geologic Interpretation and Hydrostratigraphic Modeling
- Geophysical log interpretation will be central to providing information relating to the upper and lower Trinity Formation boundaries and fault locations for each hydrogeological framework model layer.
- The results of this work will enhance the Hill Country portion of the Trinity Aquifer conceptual model and will be incorporated into the GAM geodatabase.

Model Workflow

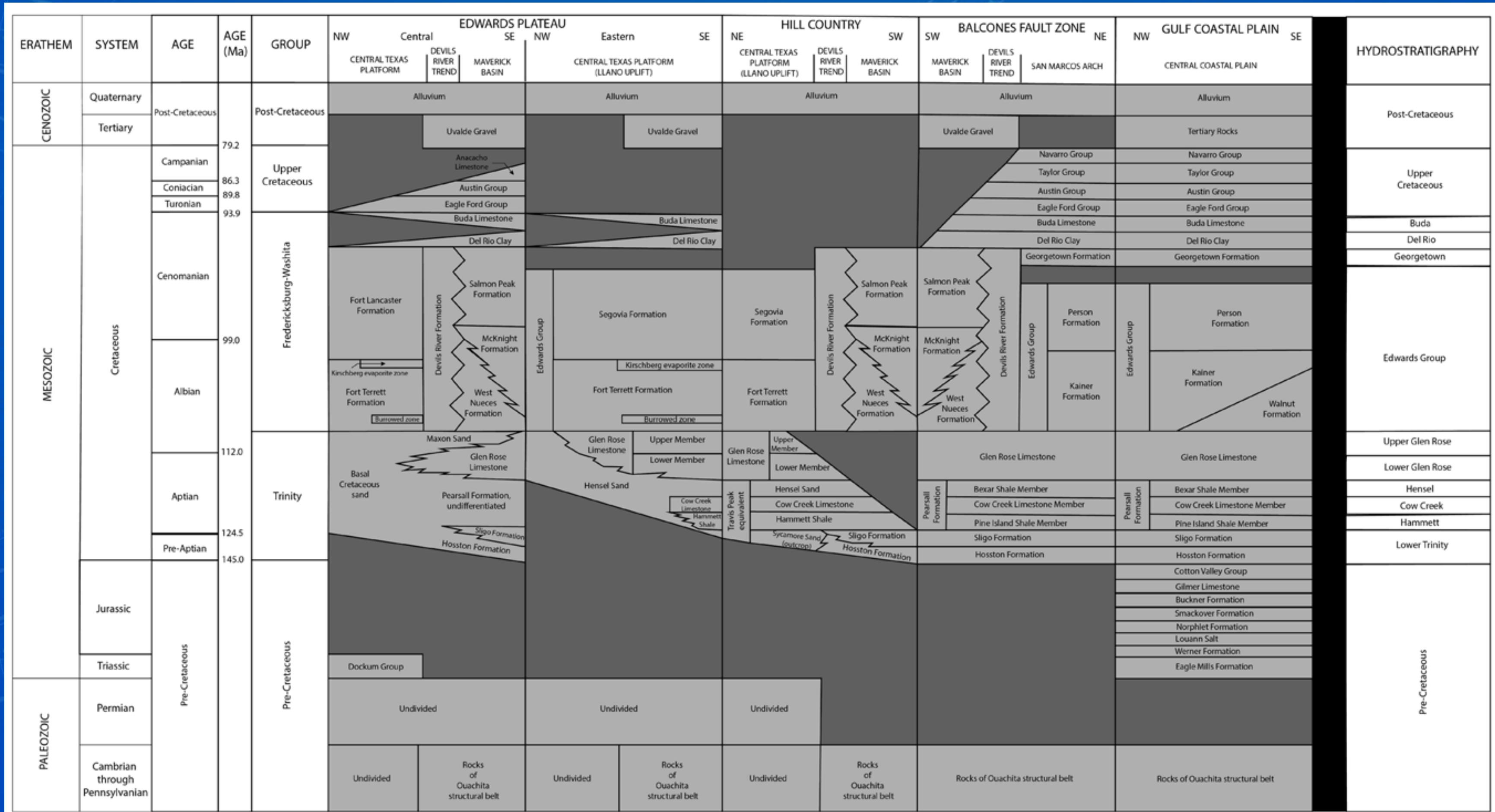
- 3 part workflow
  - Hydrostratigraphic horizon and fault input (Petrel)
  - Hydrostratigraphic framework modeling (Petrel)
  - Finalize hydrostratigraphic raster surfaces (ArcGIS)

Stratigraphic Characterization

- 877 wells
- 3,960 stratigraphic formation picks for 12 units
- Source:
  - Bracks database
  - IHS database
  - Literature
  - Stakeholders

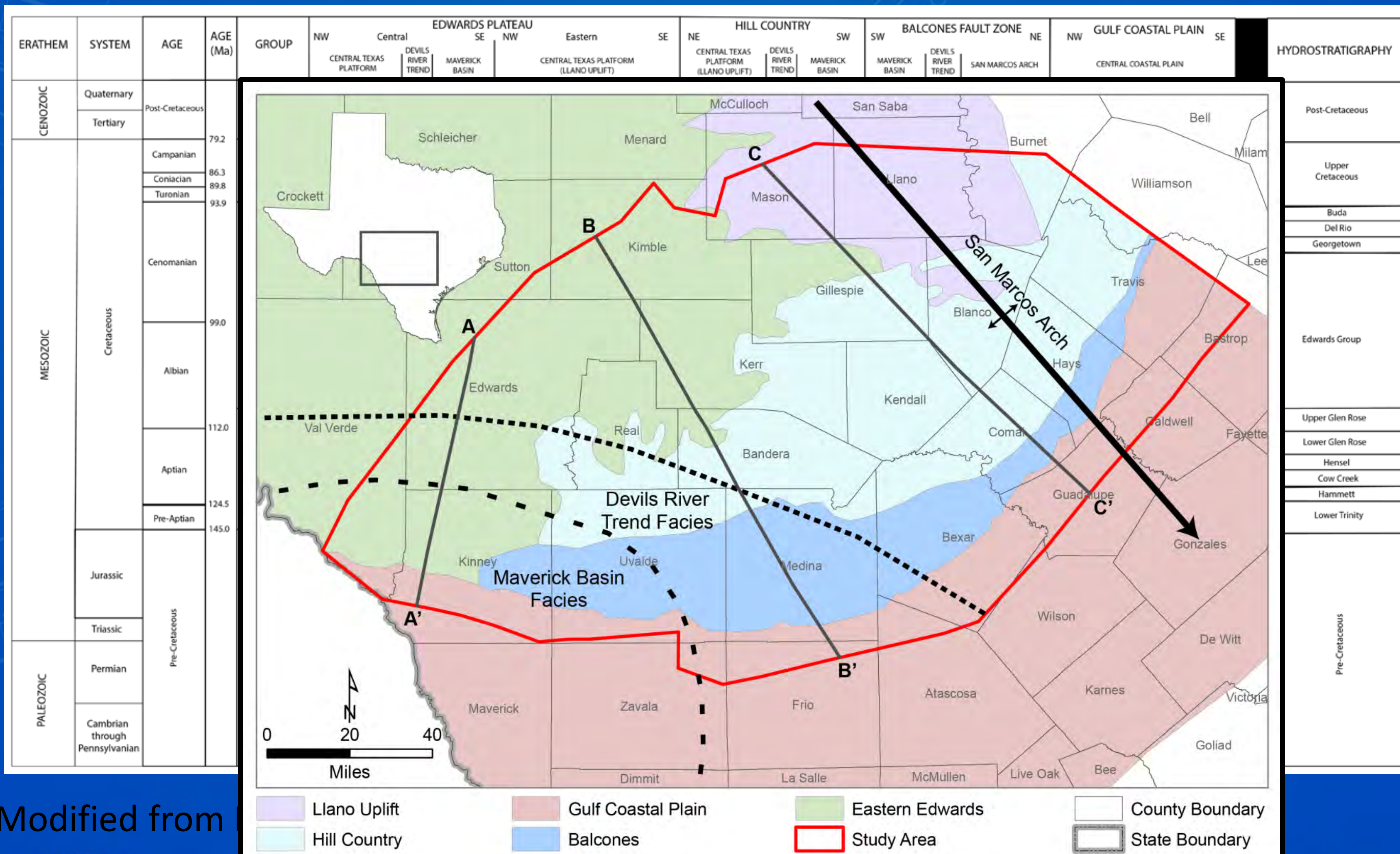


Stratigraphic and Hydrostratigraphic Domains



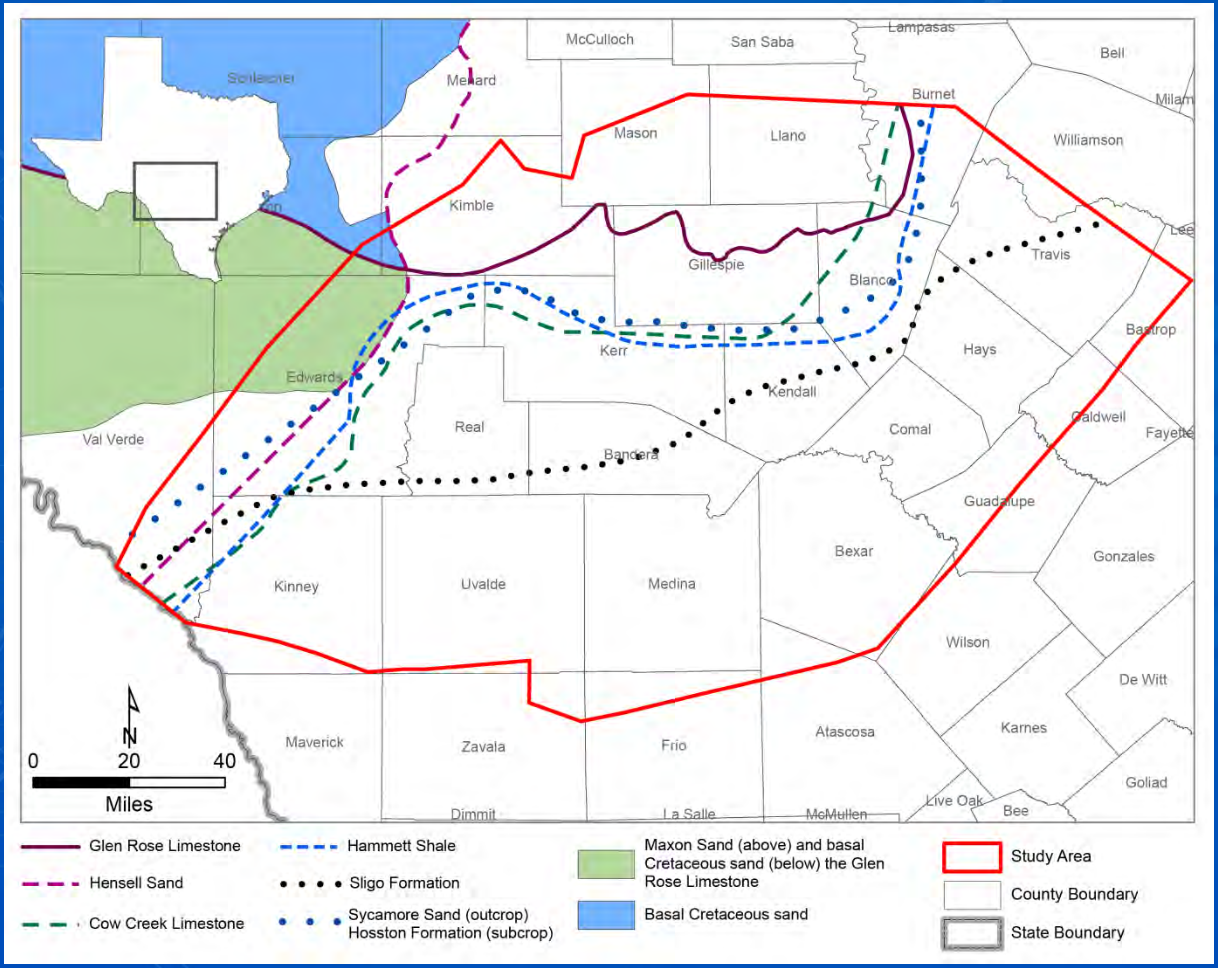
Modified from Barker and Ardis, 1996 and Rose, 2016

Stratigraphic and Hydrostratigraphic Domains



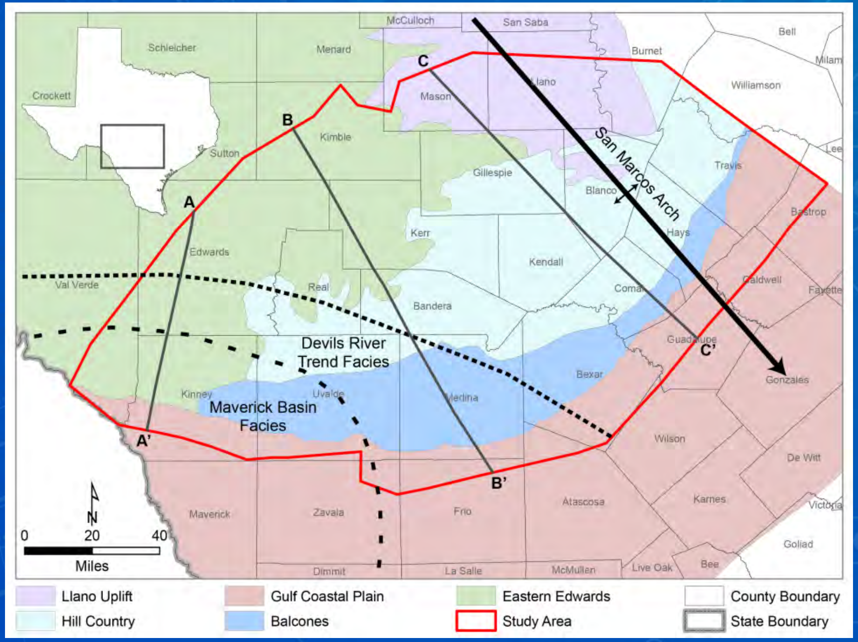
Modified from

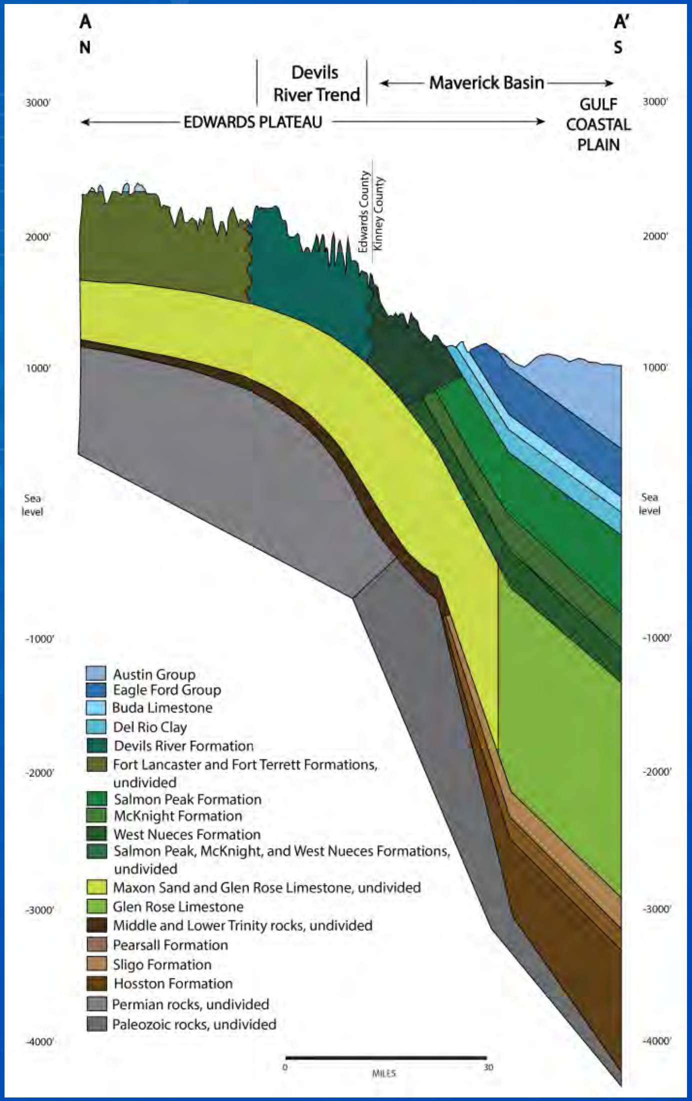
Updip Limits and Lateral Distribution of Trinity Units



Modified from Barker and Ardis, 1996

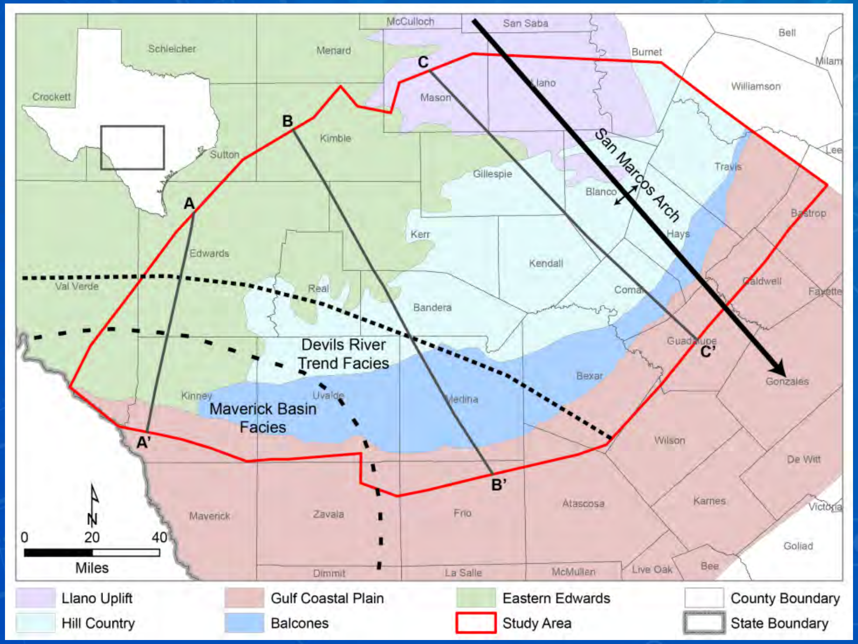
Generalized Geologic Cross-Section

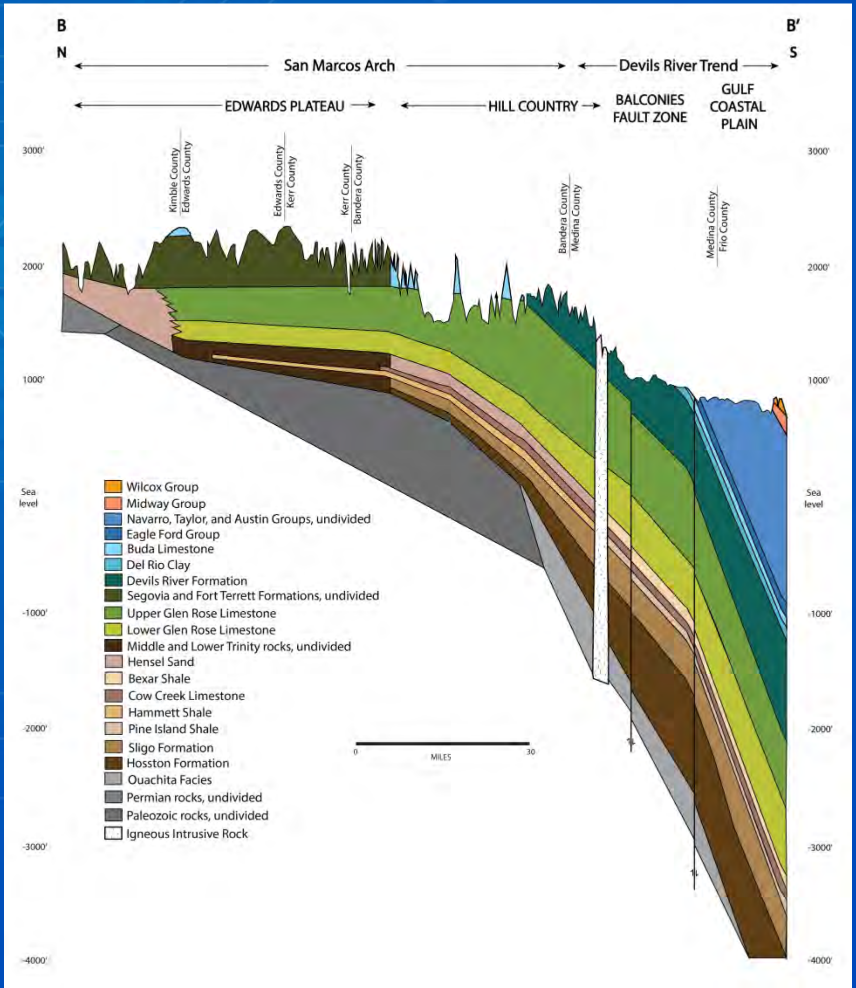




Modified from Barker and Ardis, 1996

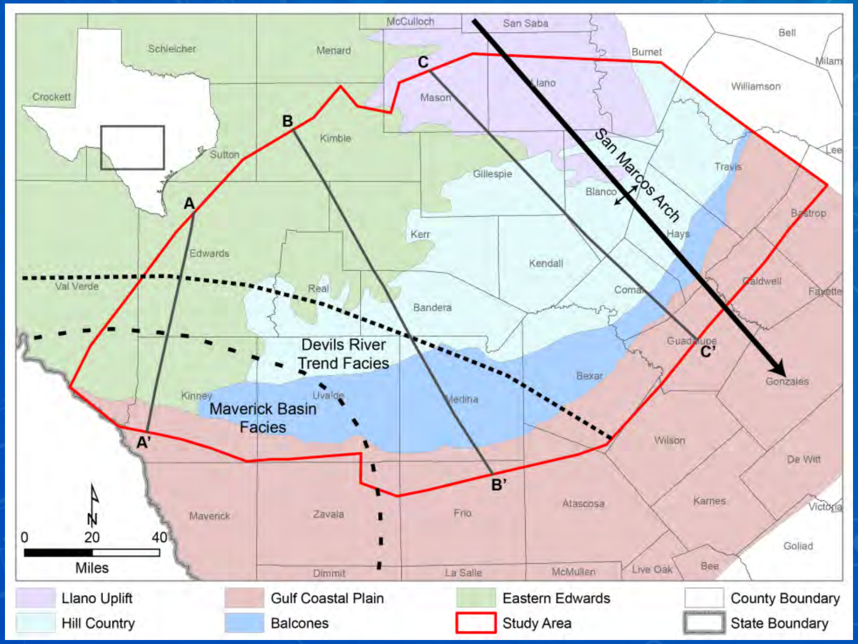
Generalized Geologic Cross-Section

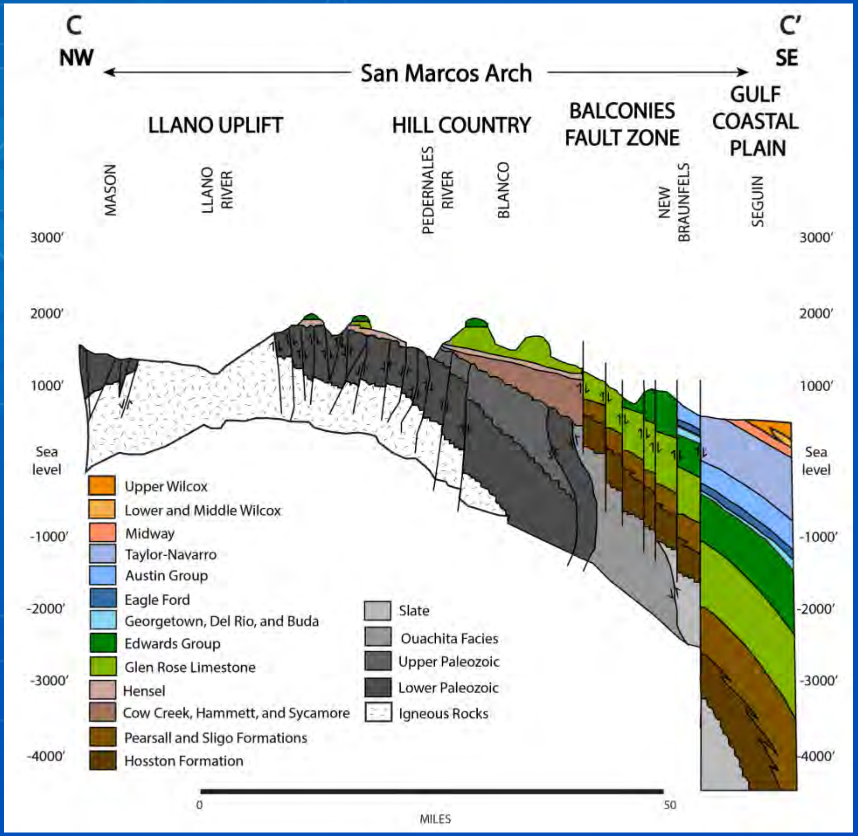




Modified from Barker and Ardis, 1996

Stratigraphy and Hydrostratigraphy

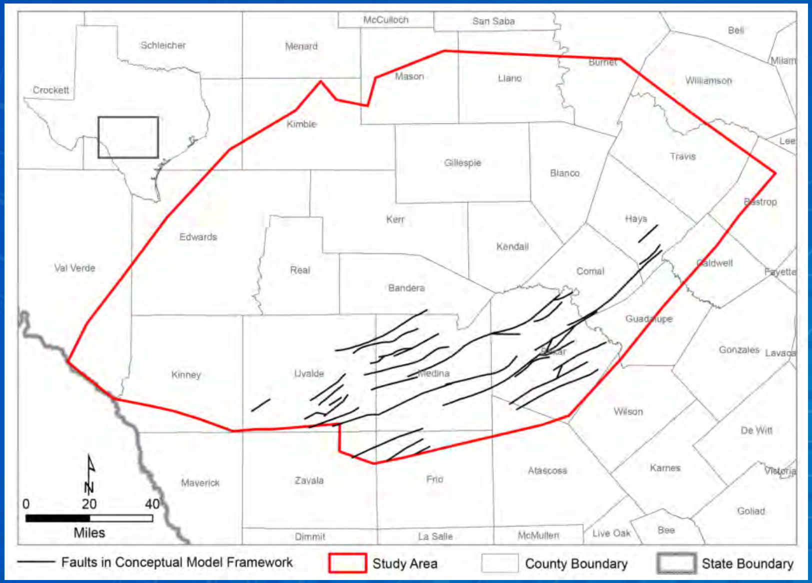


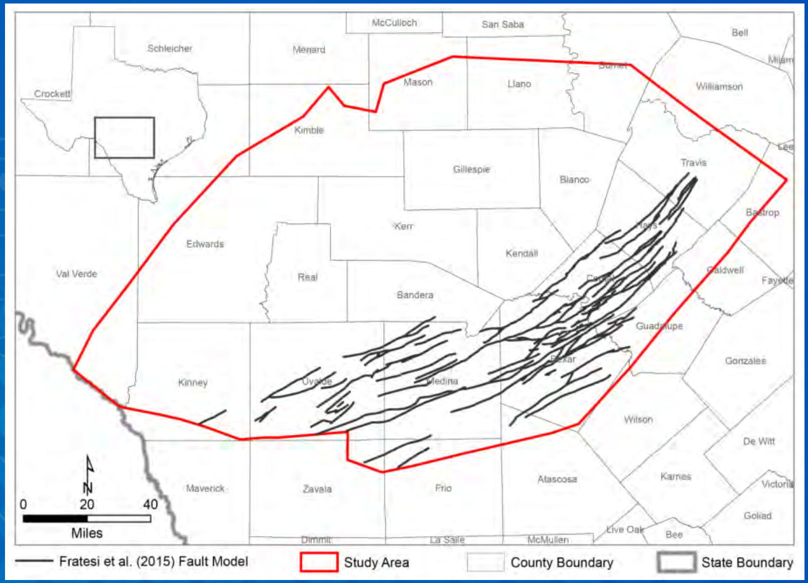


Modified from Rose, 2016

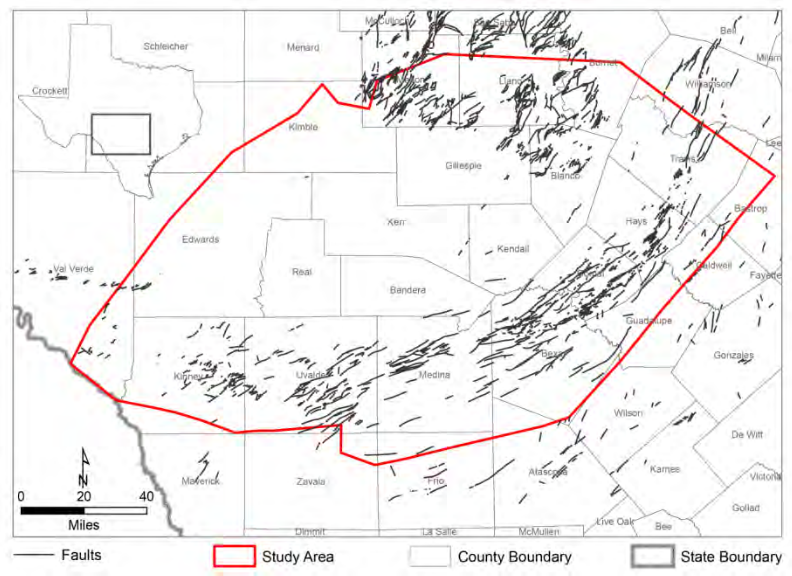
Fault Model

Fratesi et al. 2015



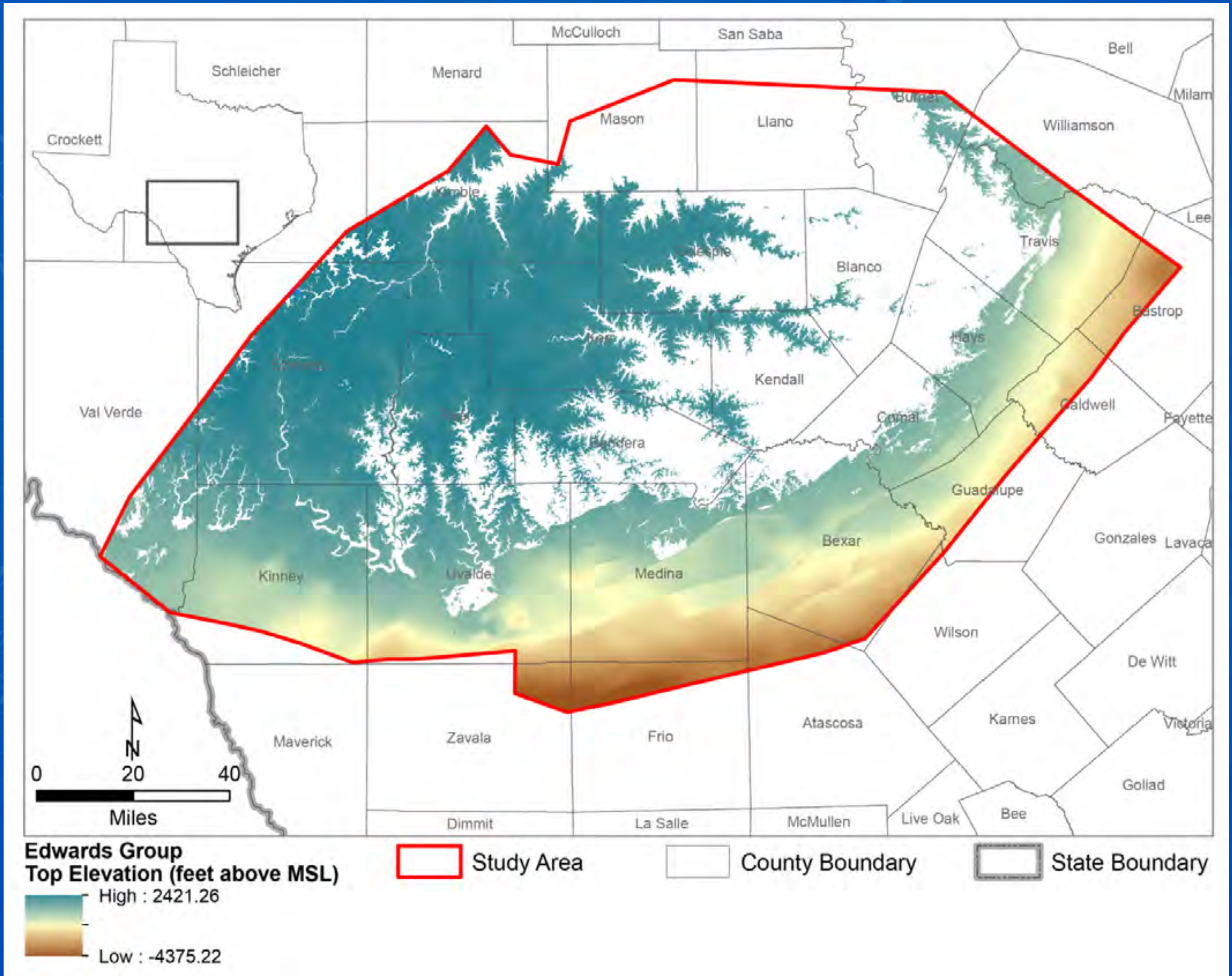


Hovorka et al., 1998

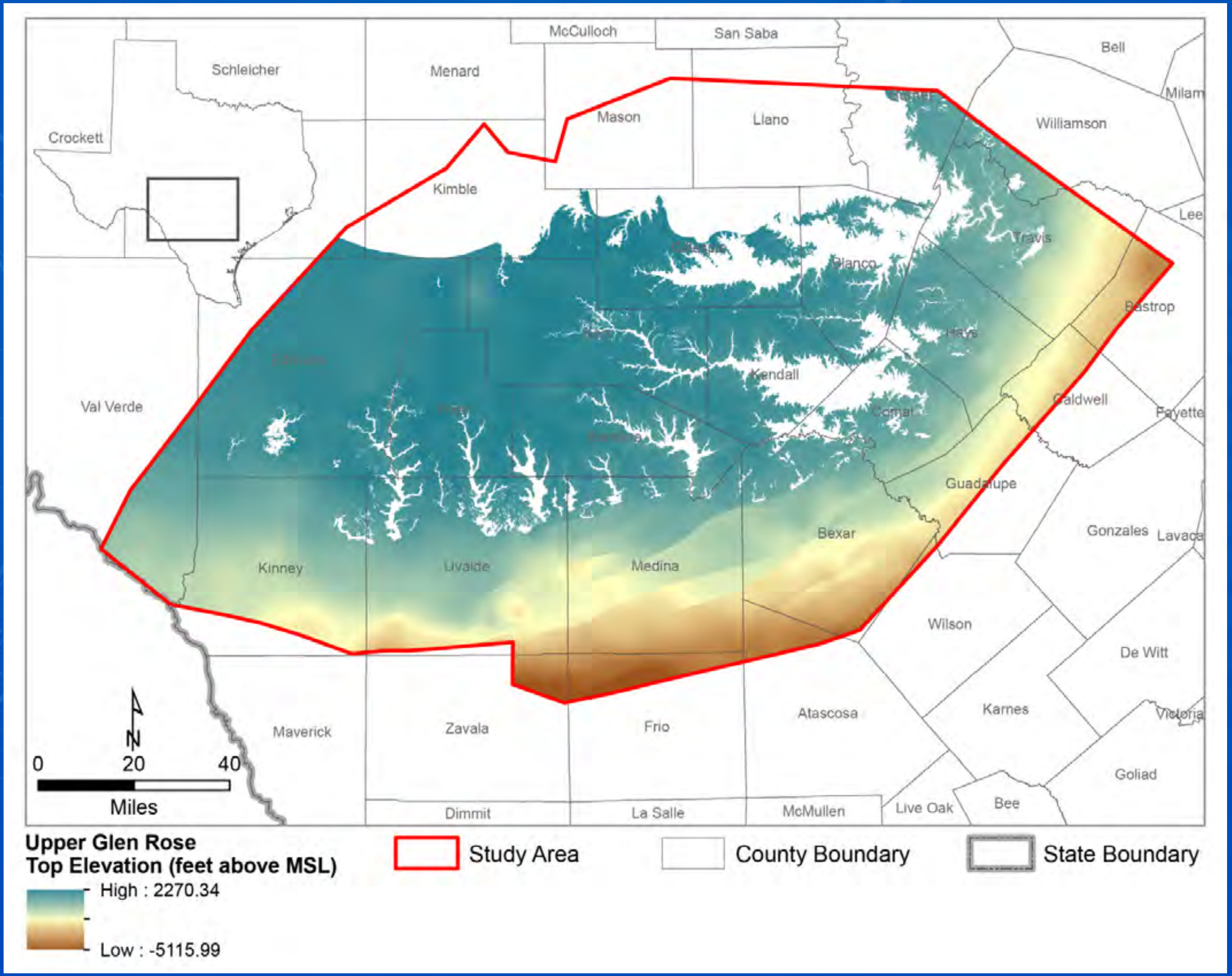


Collins and Hovorka, 1997; Barnes, 1977, 1983; Fisher, 1983; Ferrill and Morris, 2008; Ferrill et al., 2003, 2004, 2005, 2008, 2011; Fratesi et al., 2013

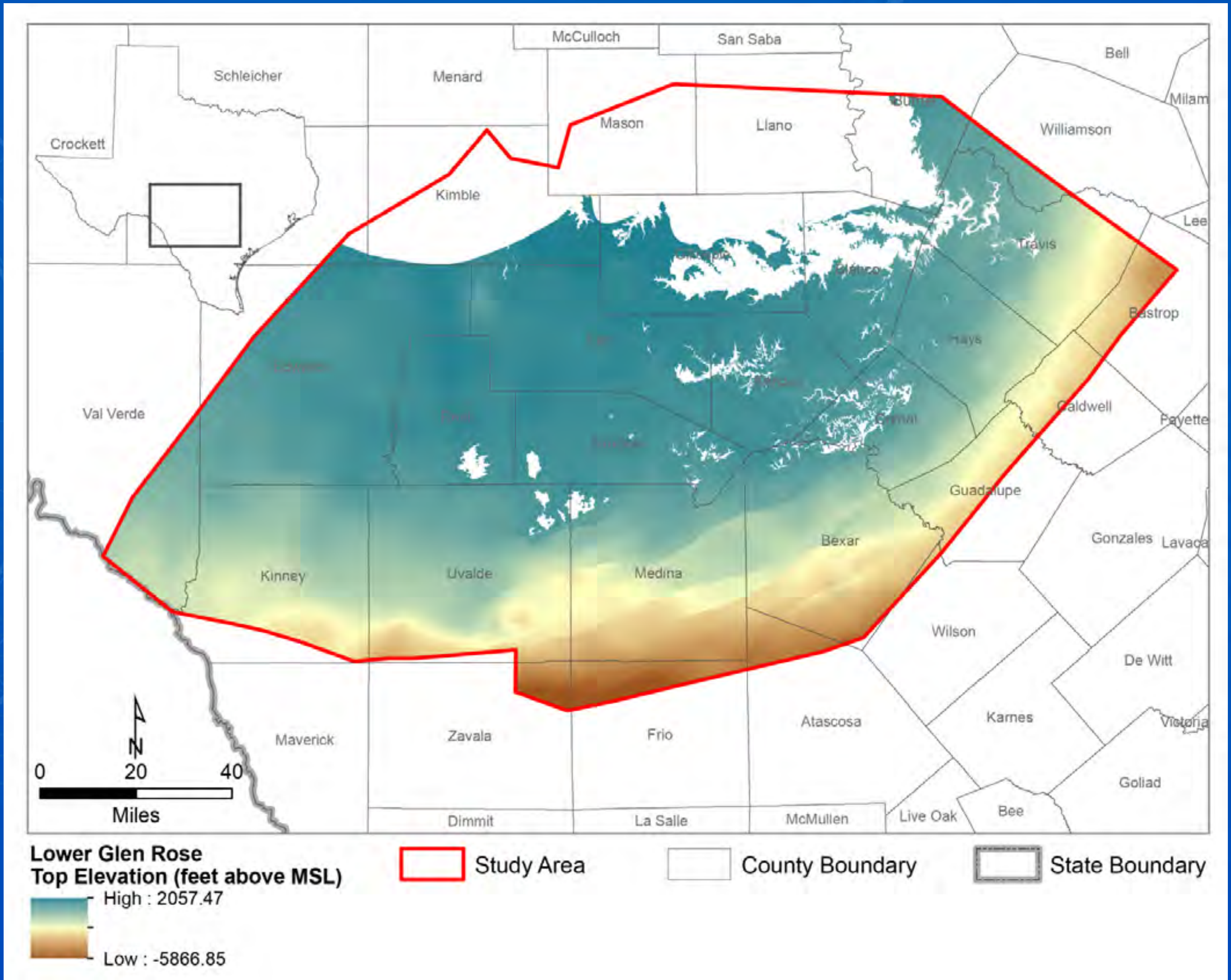
Edwards Top


McCulloch
San Saba
Bell
Schleicher
Menard
Milam
Burnet
Mason
Llano
Williamson
Crockett
Kimble
Lee
Travis
Blanco
Bastrop
Hays
Kendall
Val Verde
Caldwell
Comal
Fayette
Bandera
Guadalupe
Gonzales
Lavaca
Bexar
Kinney
Uvalde
Medina
Wilson
De Witt
Atascosa
Karnes
Victoria
Maverick
Zavala
Frio
Goliad
0
20
40
Miles
N
Dimmit
La Salle
McMullen
Live Oak
Bee
Edwards Group
Top Elevation (feet above MSL)
High : 2421.26
Low : -4375.22
Study Area
County Boundary
State Boundary

Upper Glen Rose Top



Lower Glen Rose Top

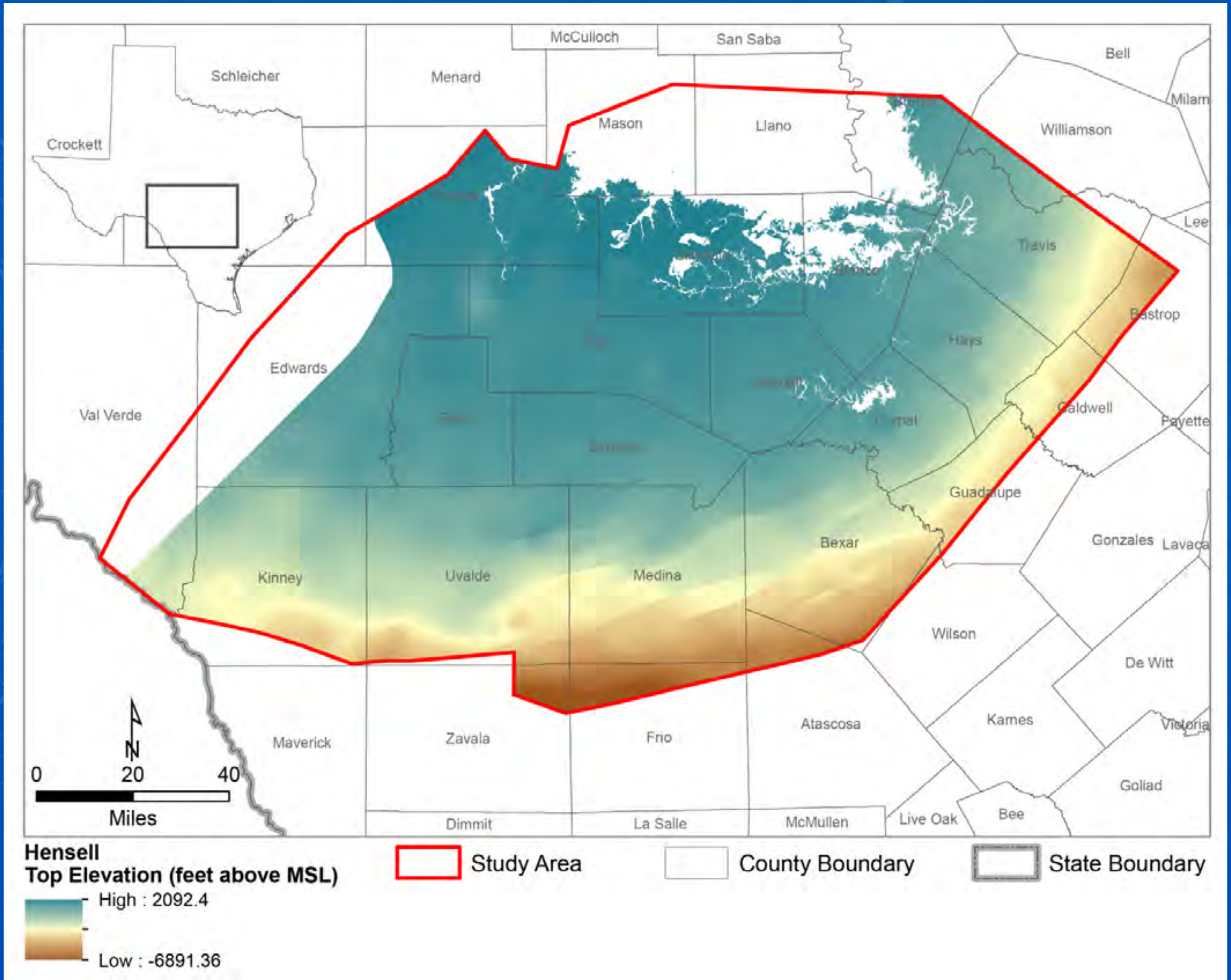


ADVANCED SCIENCE. APPLIED TECHNOLOGY.

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

swri.org

Hensel Top

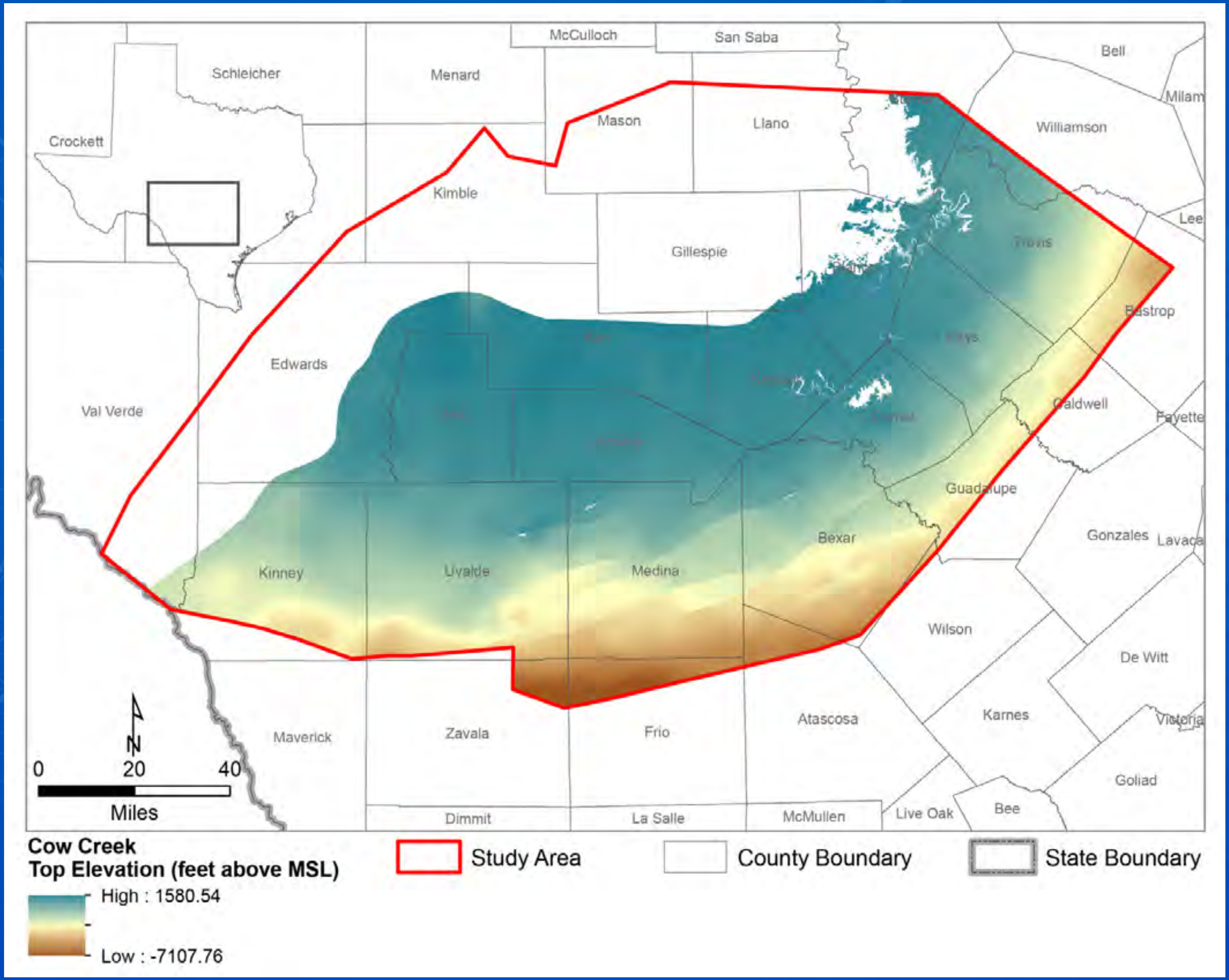


ADVANCED SCIENCE. APPLIED TECHNOLOGY.

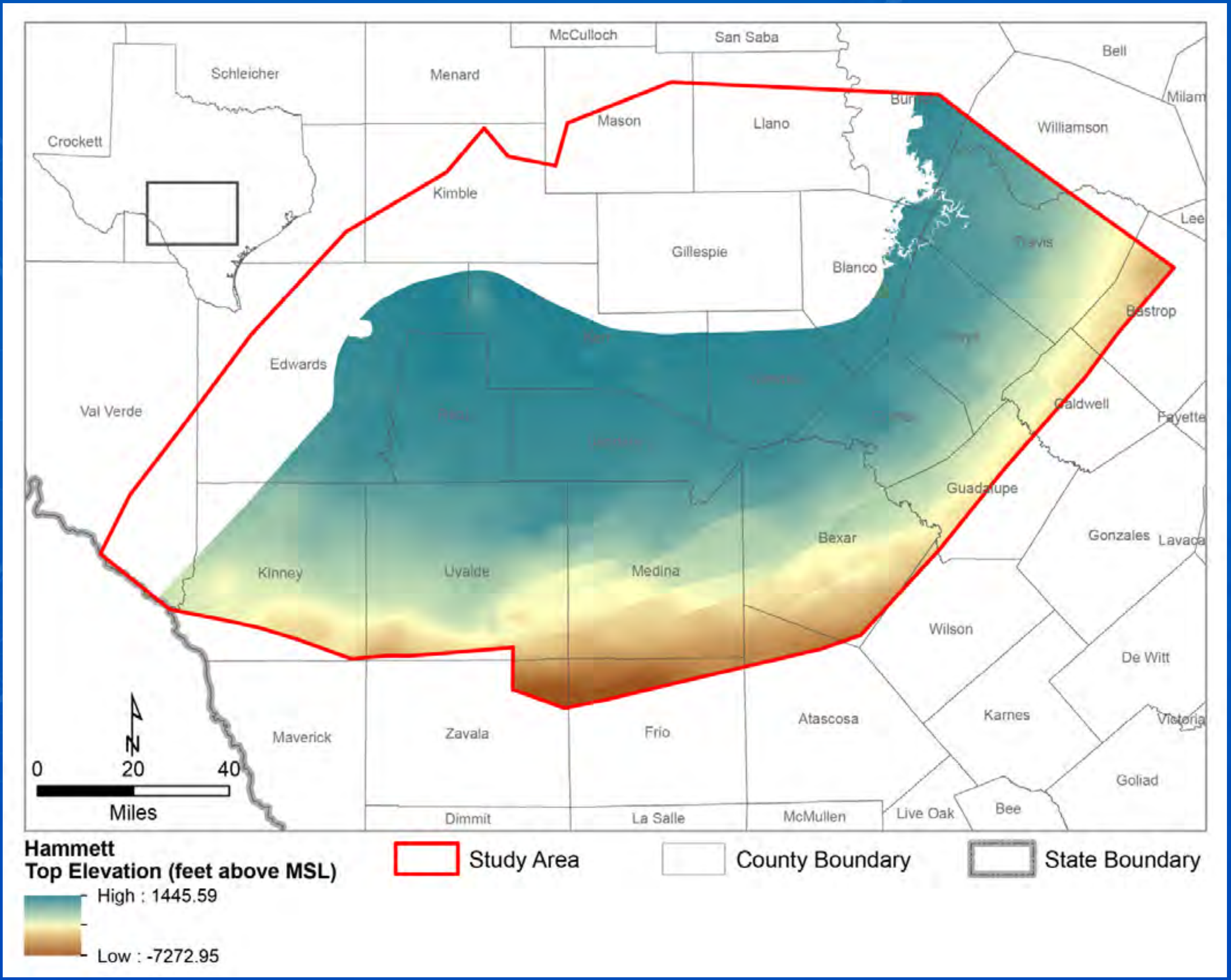
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

swri.org

Cow Creek Top



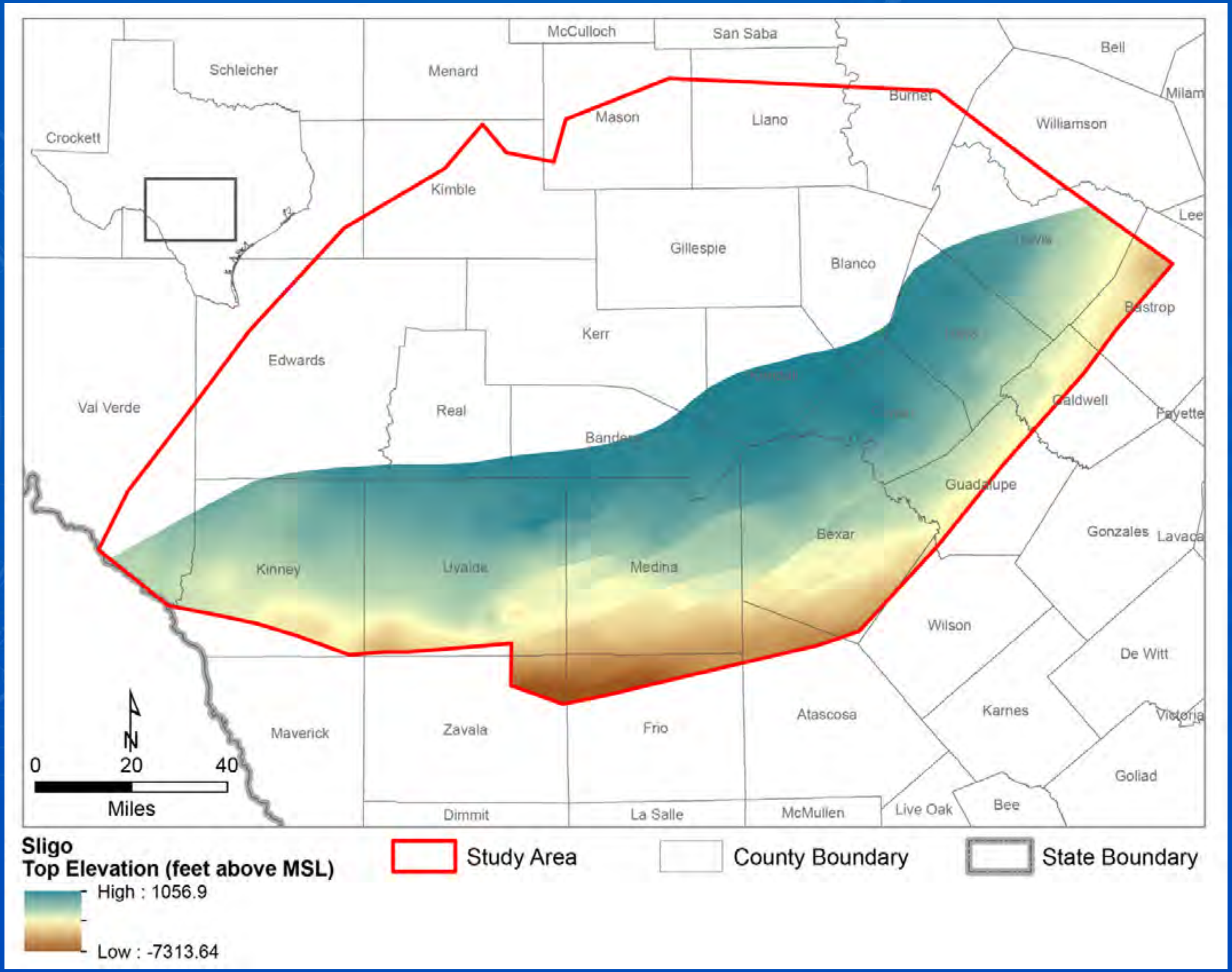
Hammett Top



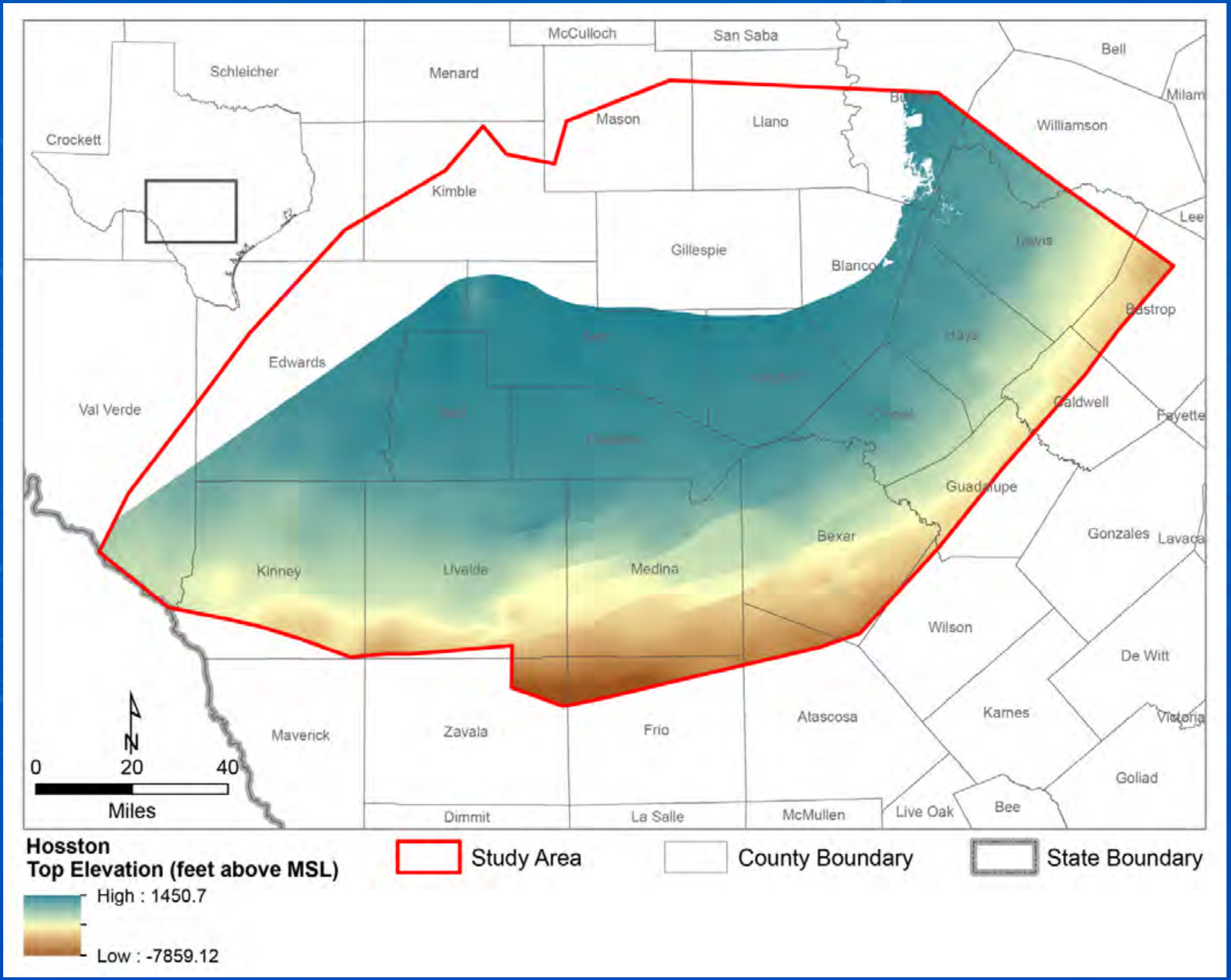
ADVANCED SCIENCE. APPLIED TECHNOLOGY.

swri.org

Sligo Top


McCulloch
San Saba
Bell
Schleicher
Menard
Milam
Mason
Llano
Burnet
Williamson
Crockett
Kimble
Lee
Gillespie
Blanco
Bastrop
Kerr
Edwards
Val Verde
Real
Caldwell
Fayette
Guadalupe
Gonzales
Lavaca
Bexar
Kinney
Uvalde
Medina
Wilson
De Witt
Karnes
Victoria
Atascosa
Maverick
Zavala
Frio
Goliad
Live Oak
Bee
Dimmit
La Salle
McMullen
0 20 40
Miles
Sligo
Top Elevation (feet above MSL)
High : 1056.9
Low : -7313.64
Study Area
County Boundary
State Boundary

Hosston Top



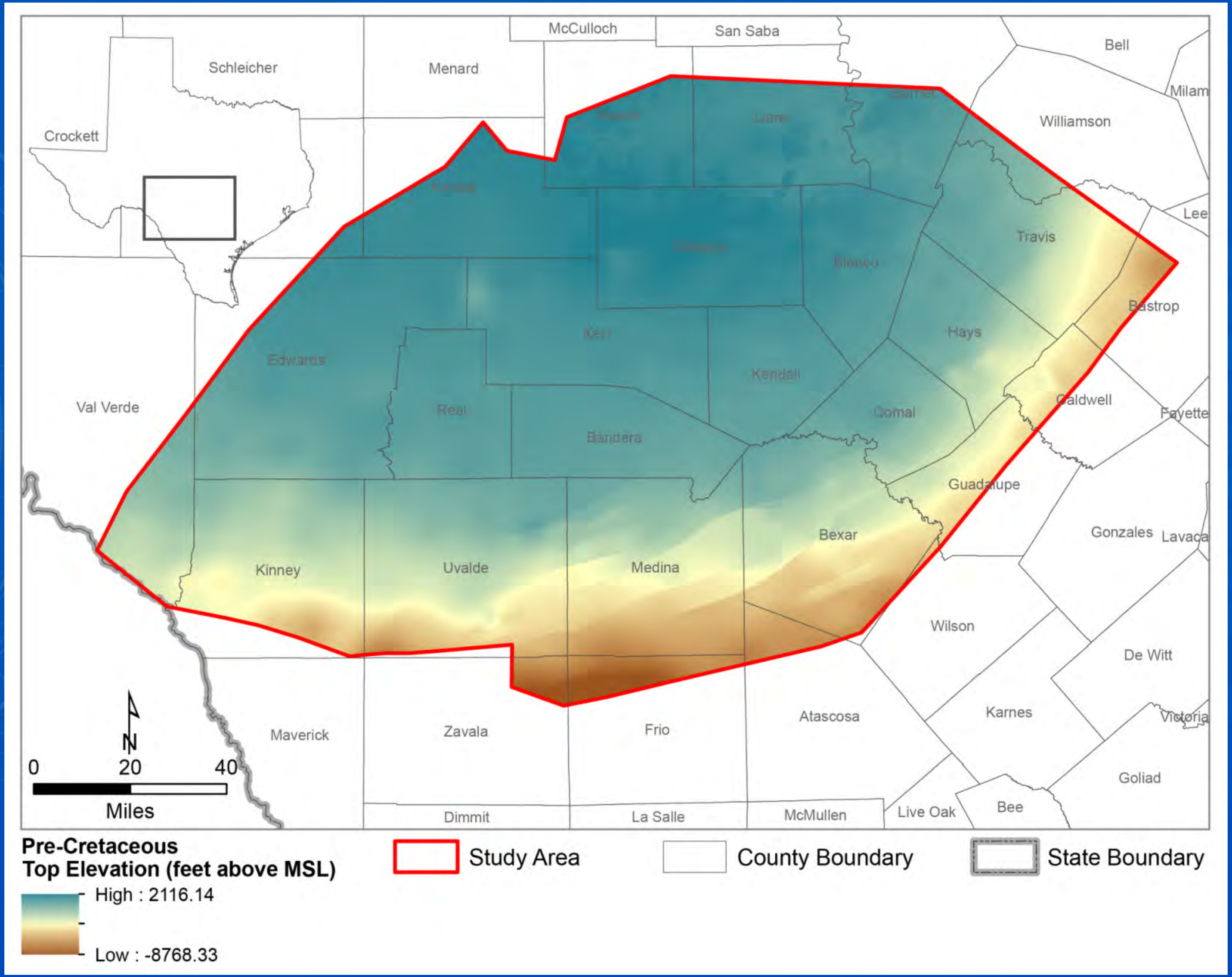
ADVANCED SCIENCE. APPLIED TECHNOLOGY.

SwRI

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

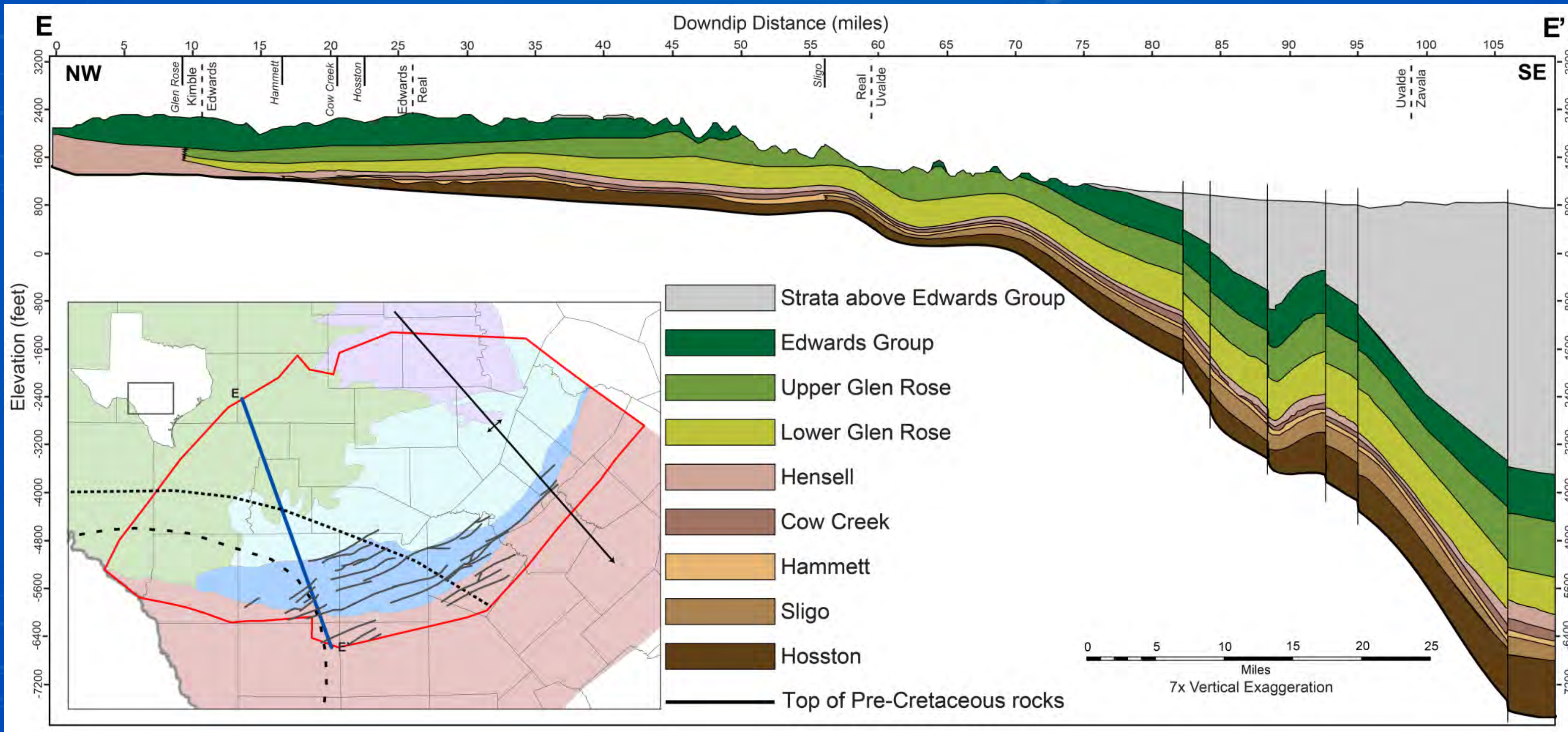
swri.org

Pre Cretaceous Top

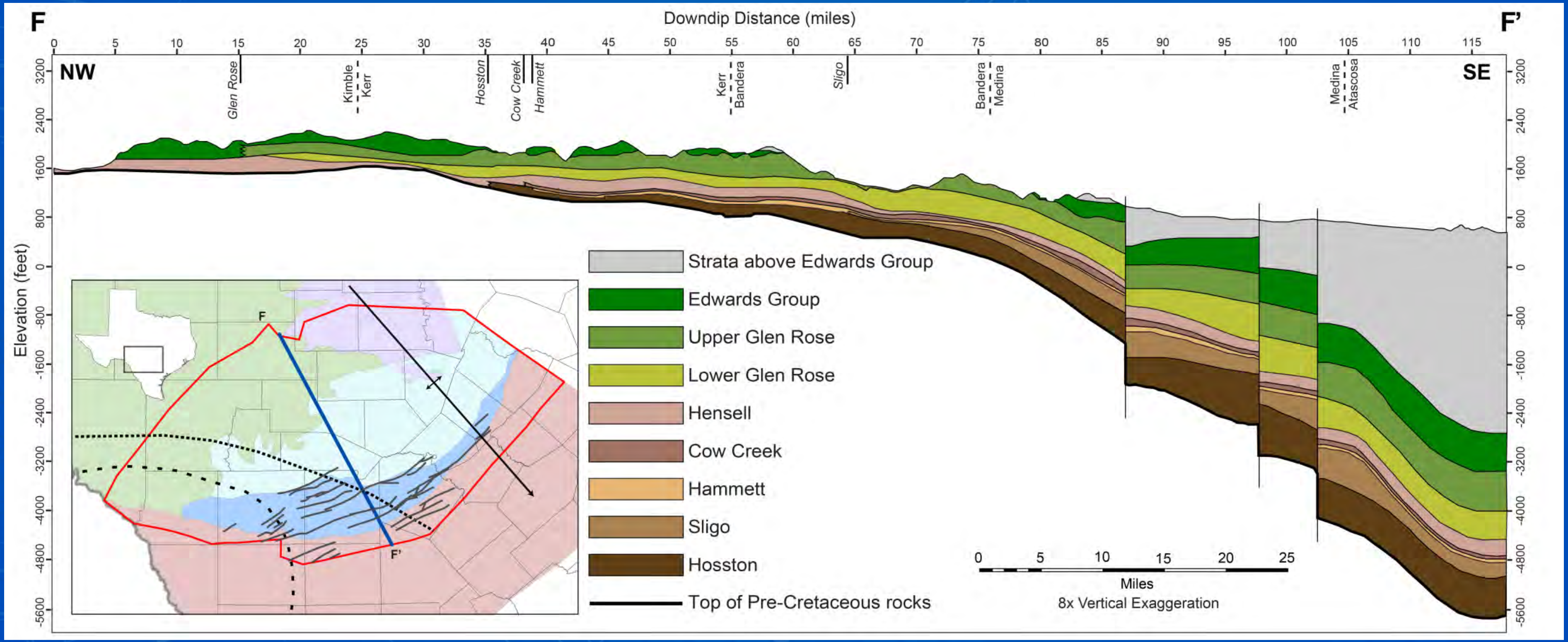


ADVANCED SCIENCE. APPLIED TECHNOLOGY.

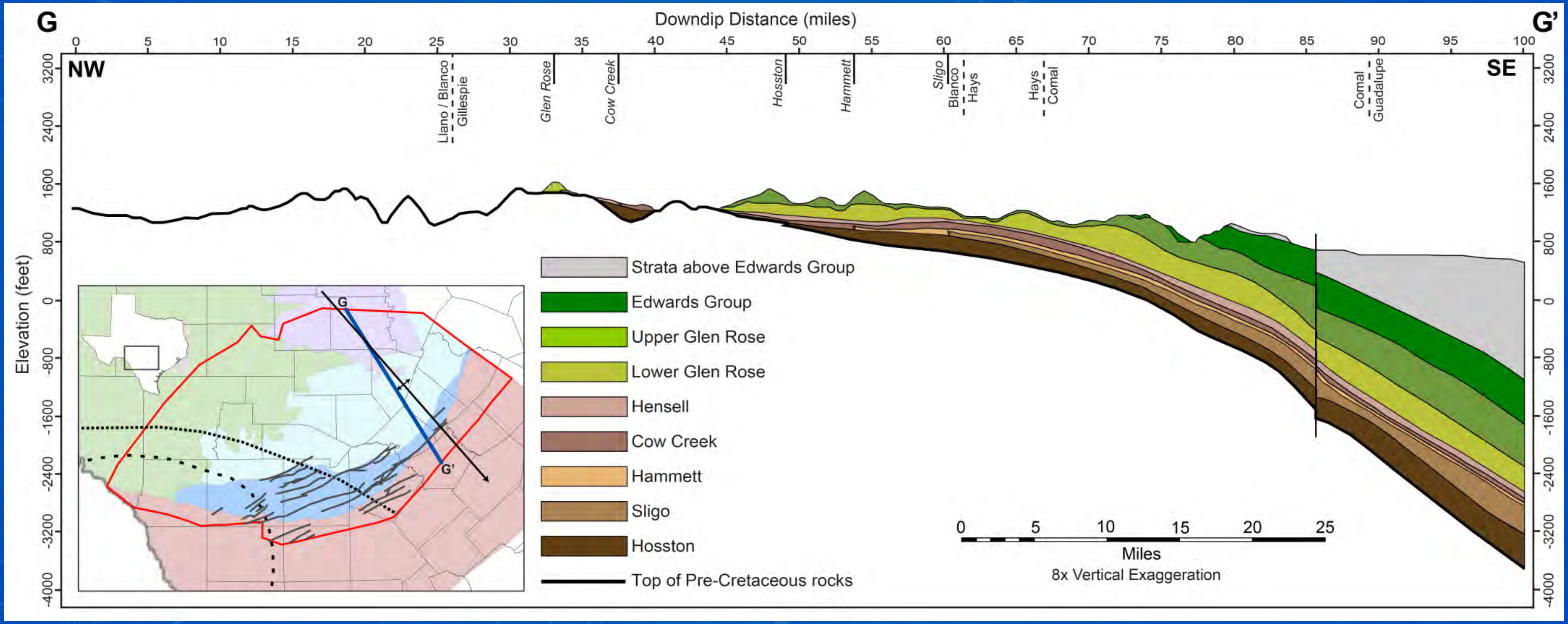
HCT Framework Model Cross-Section



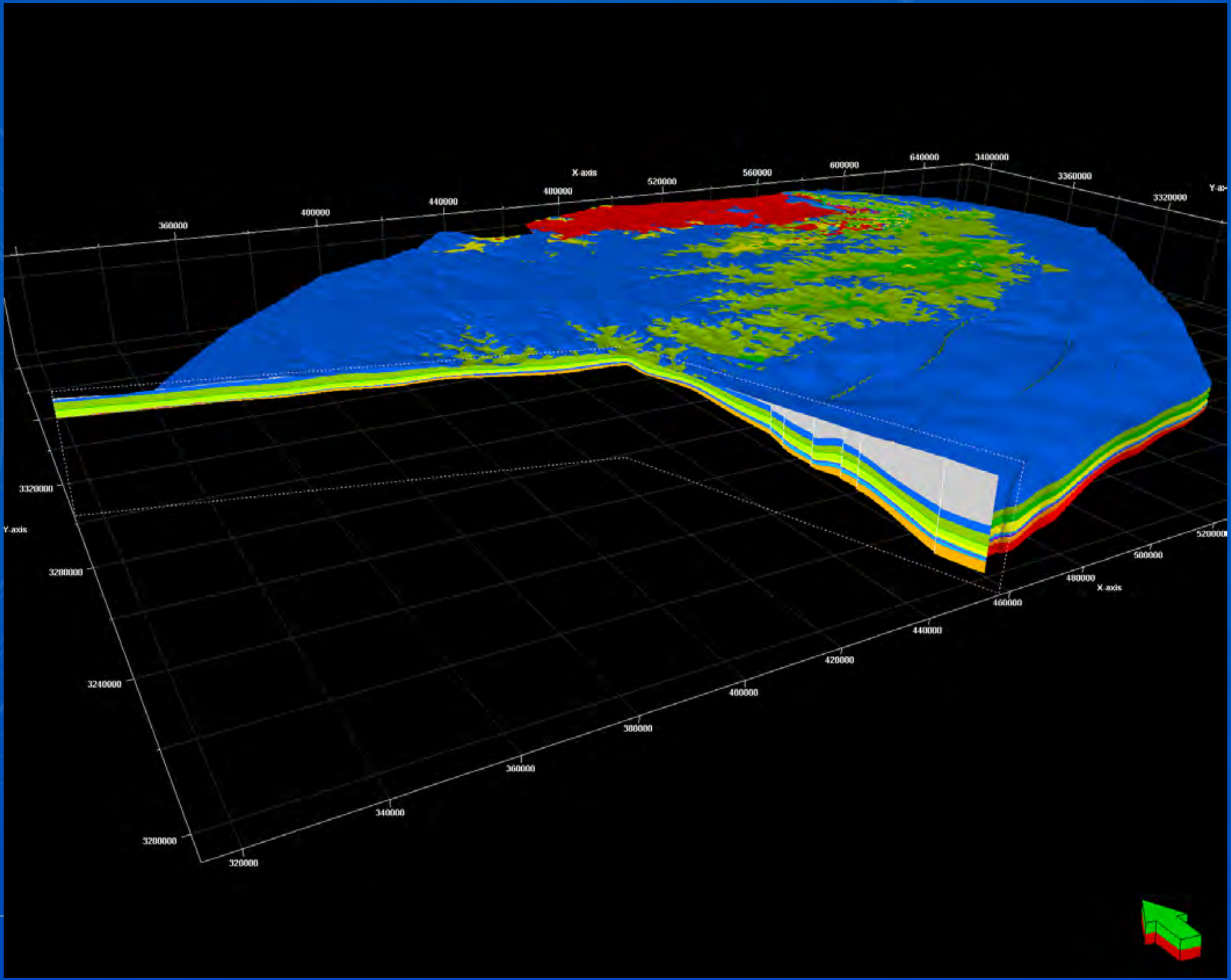
HCT Framework Model Cross-Section



HCT Framework Model Cross-Section



HCT Framework Model



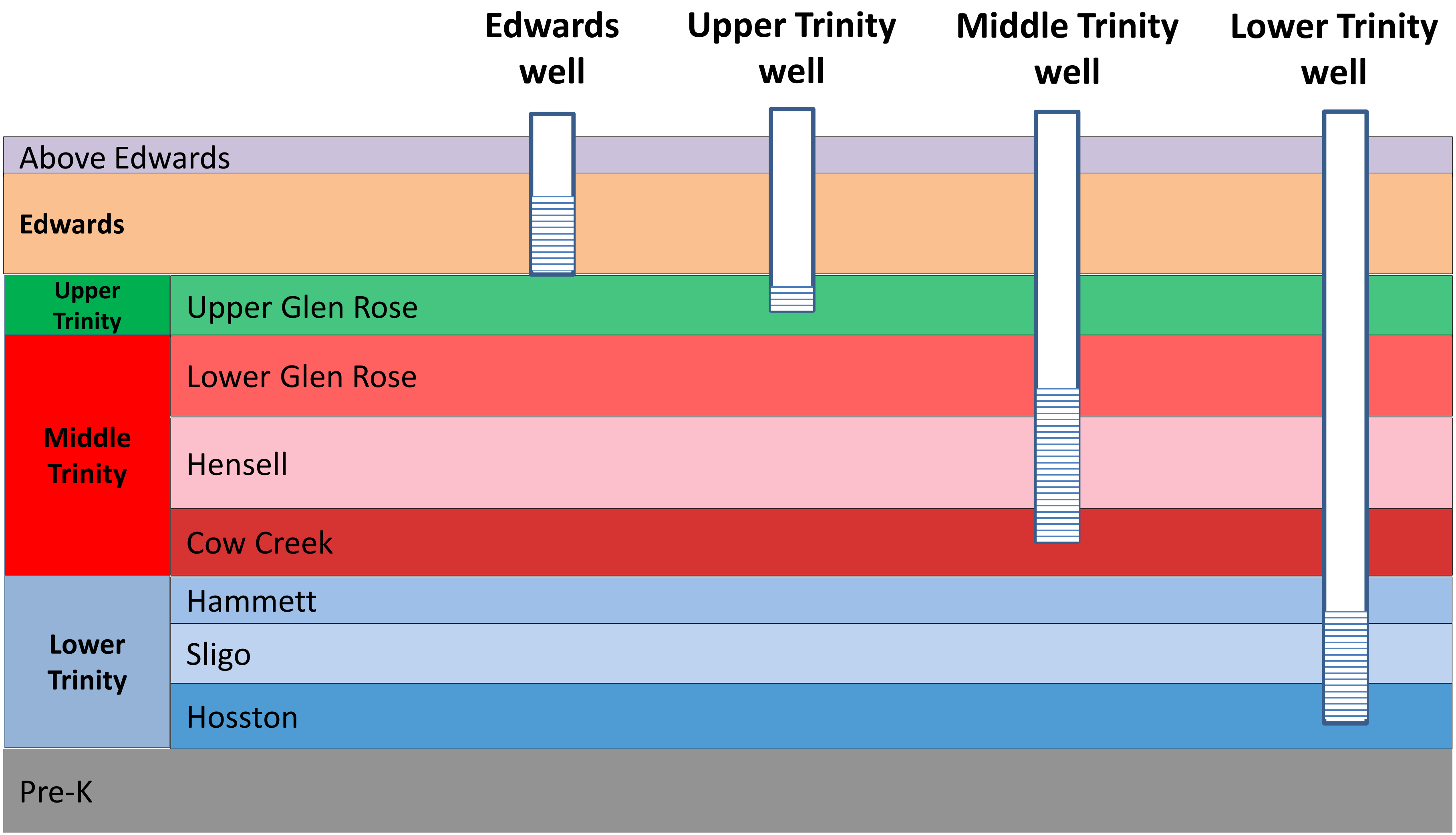
Data Acquisition and Data Management

- Mine all publically available digital datasets to acquire data relevant to stratigraphy, water levels, water chemistry, recharge, discharge, and hydraulic parameters.
- Search commercial data sources for geophysical logs and geologic interpretations.
- Conduct literature reviews for above data and geologic or hydrogeologic interpretations of the Trinity Aquifer.
- Evaluate submissions.
- **Compile GAM Geodatabase for use in future numerical model**

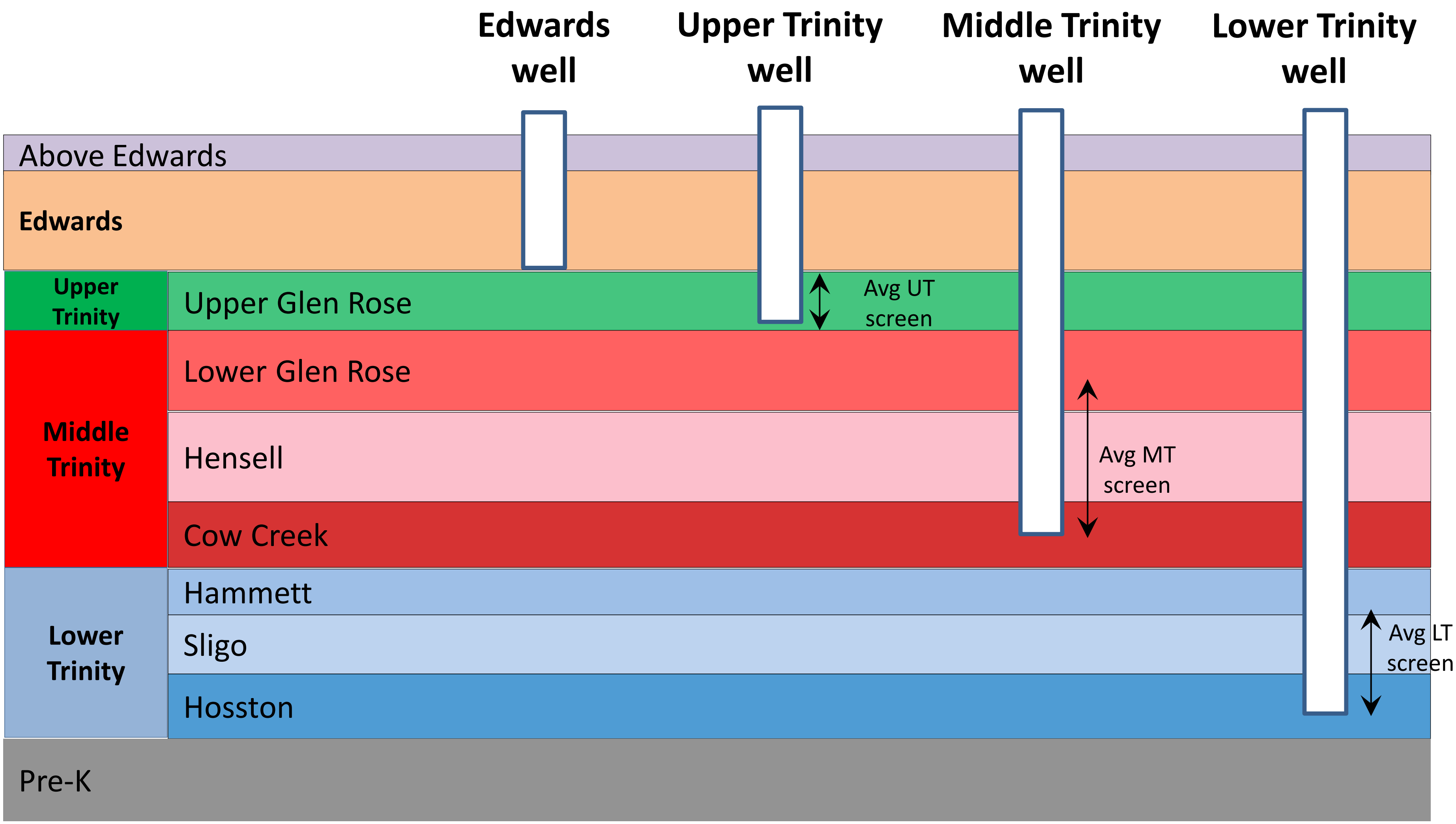
Hydraulic Data Analysis

- Water Levels were analyzed to identify wells in each formation to serve as calibration targets, establish initial conditions, and inform our understanding of groundwater flow
- Recharge and Discharge data were estimated for the study period
- Water Chemistry was analyzed to determine if spatial and temporal trends exist and if it can inform our understanding of interformational flow.
- Hydraulic parameters will be analyzed to improved the empirical basis for the numerical model parameters

Assignment to hydrostratigraphic units



Assignment to hydrostratigraphic units



Water Elevation

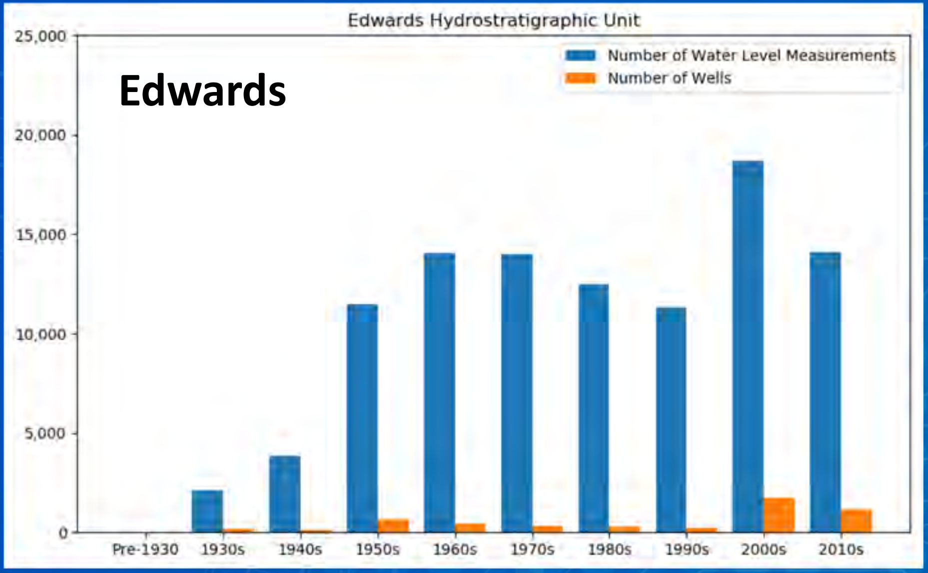
- Water level contours:

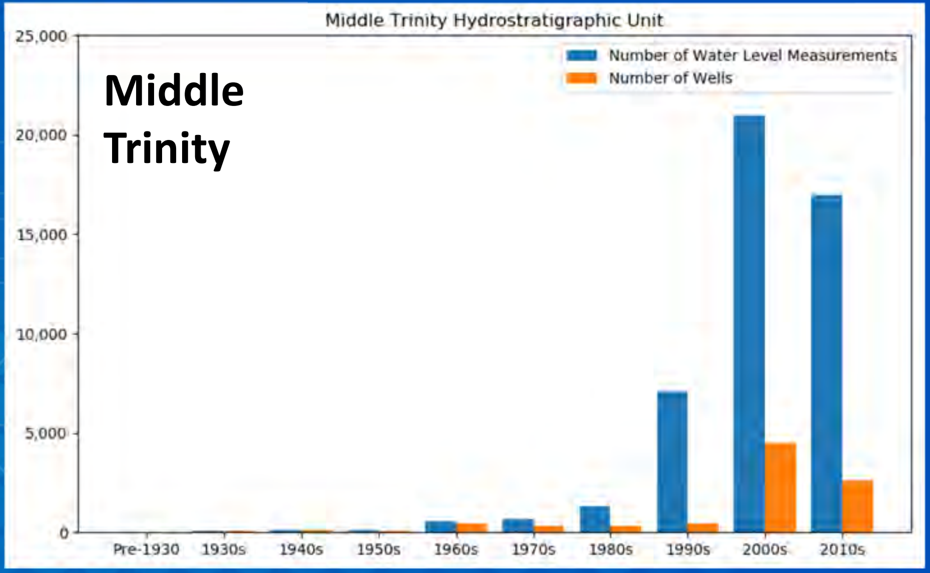
4 hydrostratigraphic units:
- Edwards
- Upper Trinity
- Middle Trinity
- Lower Trinity

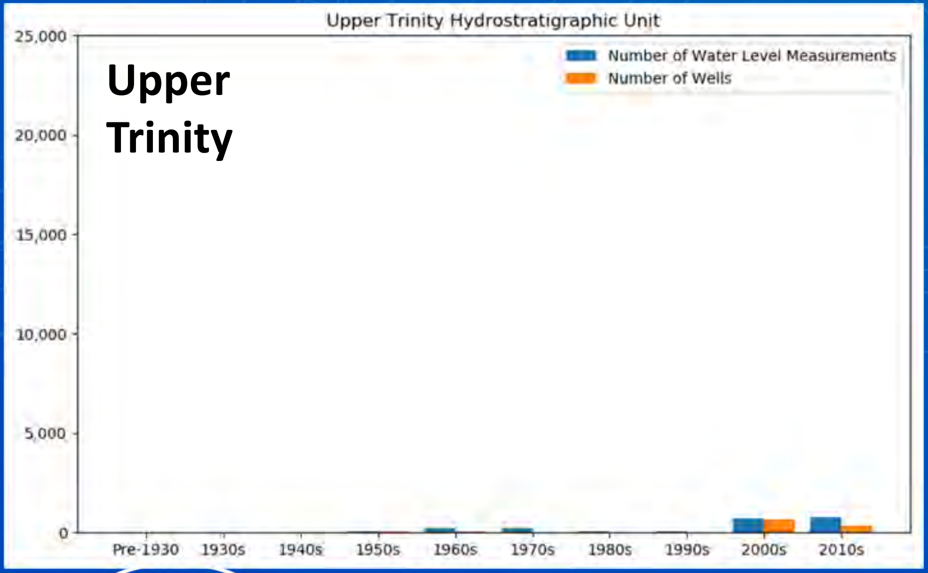
4 time periods:
- Pre-development
- 1990
- 2000
- 2010

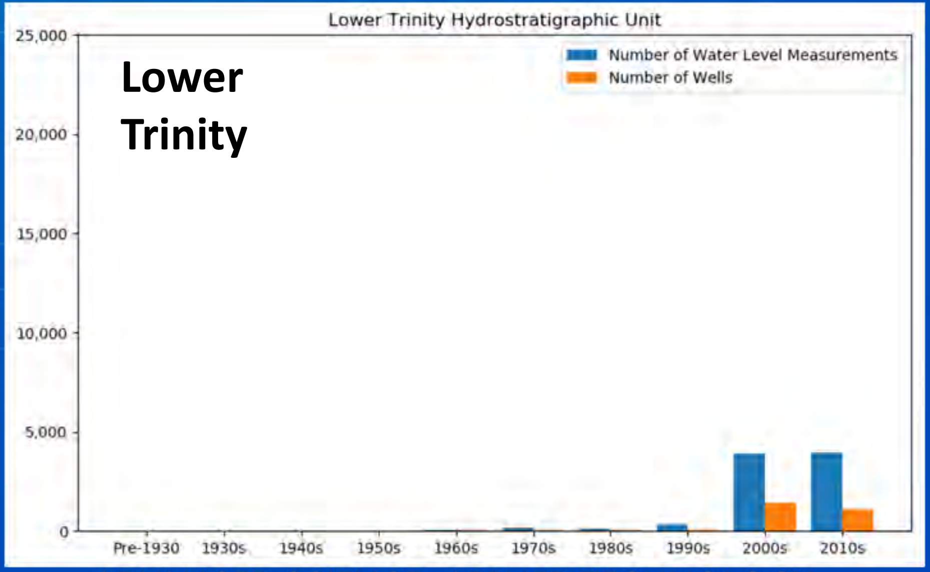
- Long-term Water Level records (calibration targets)

Water level elevation data



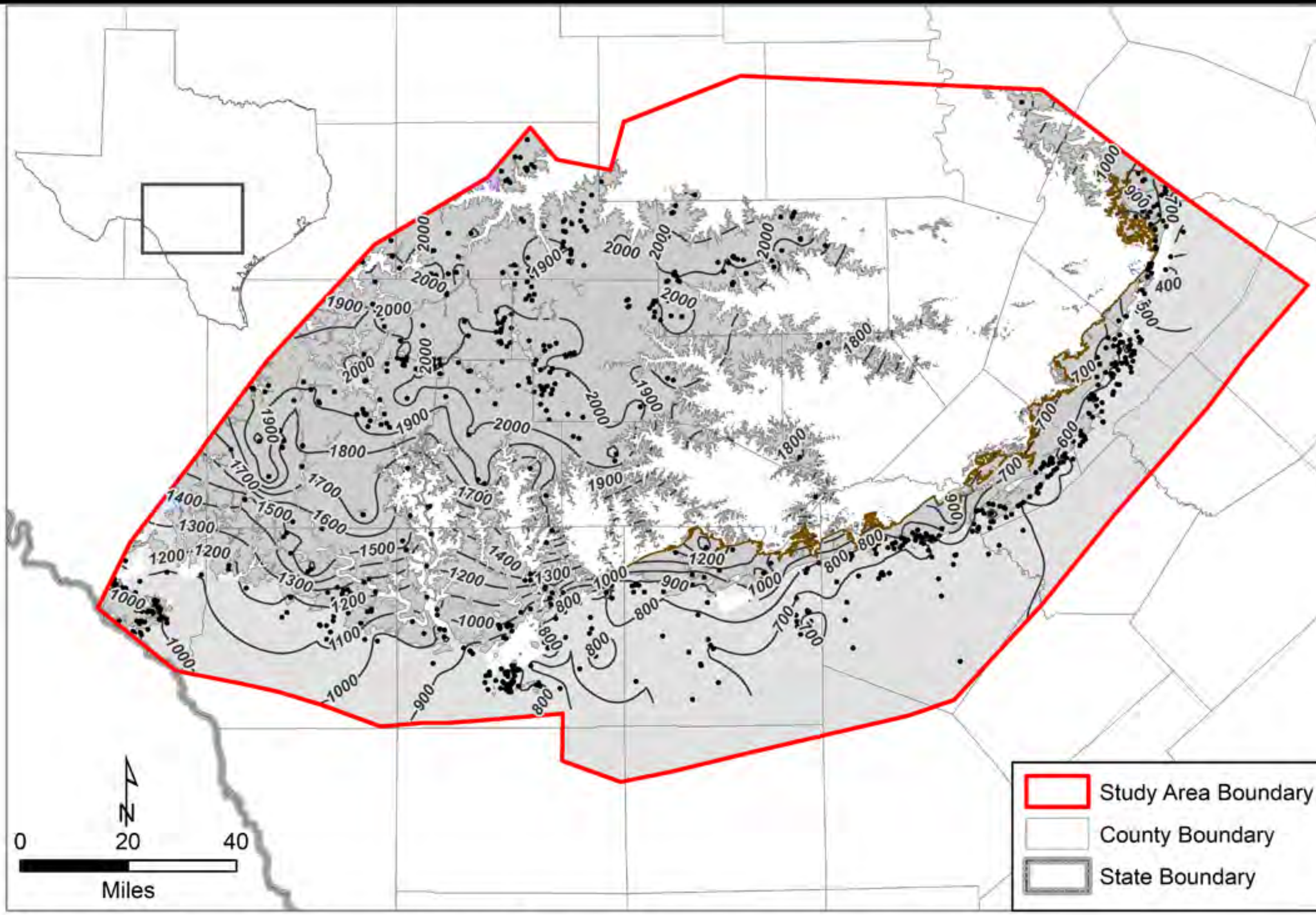






ADVANCED SCIENCE. APPLIED TECHNOLOGY.

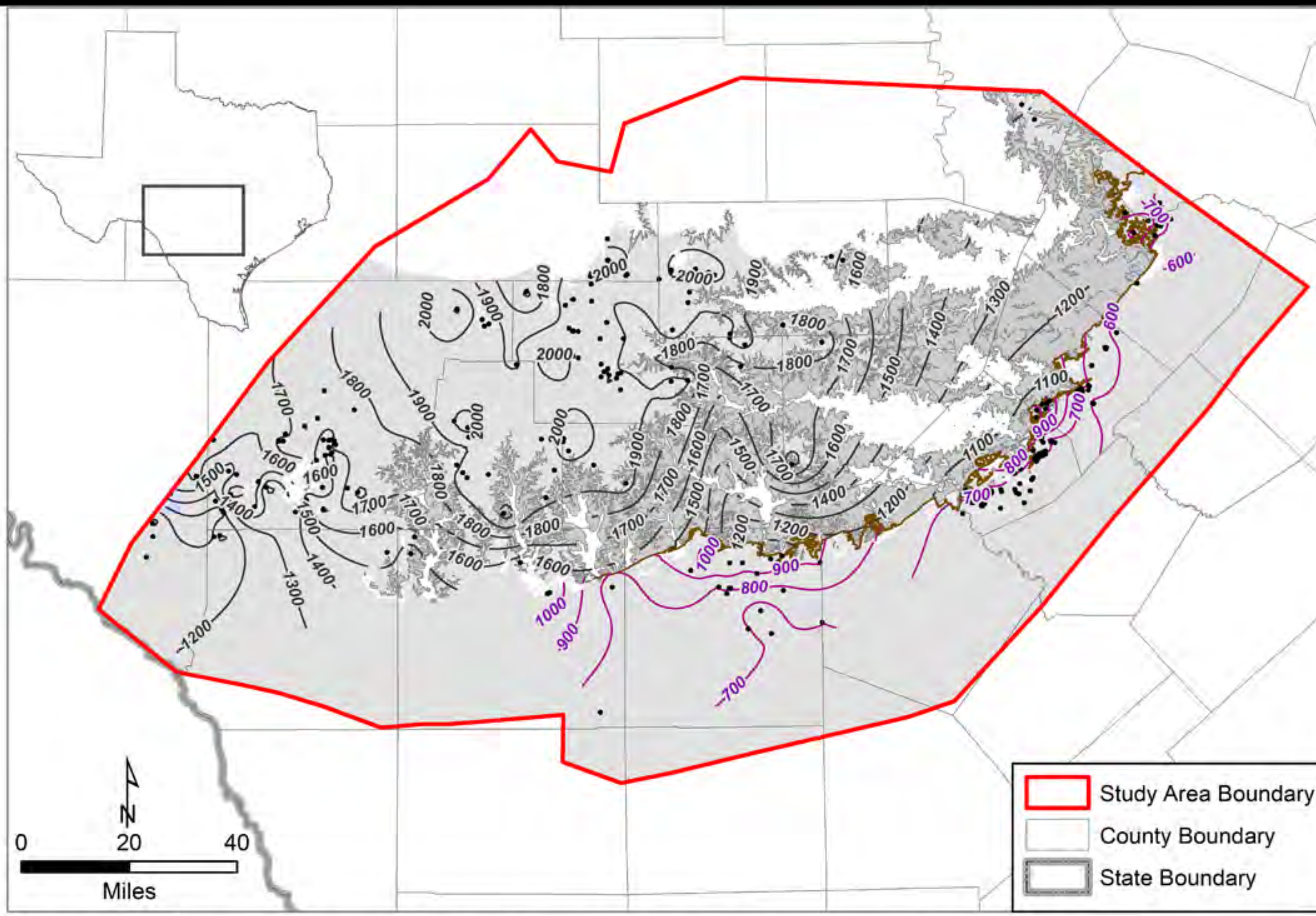
Example Water Level Contours (Edwards)



Water Level Elevation (ft amsl) in the Edwards Hydrostratigraphic Unit - 2010

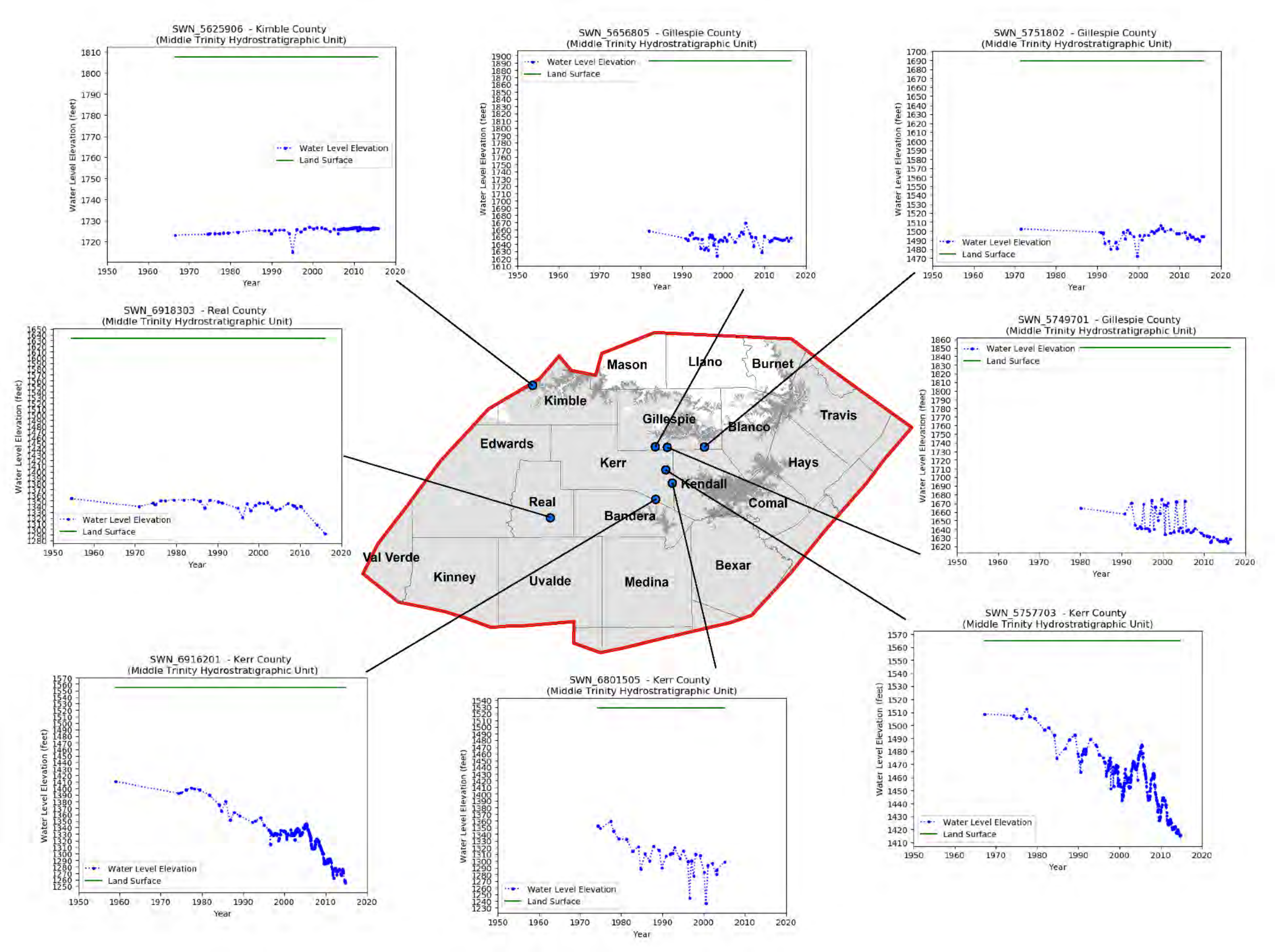
Example Water Level Contours (Trinity)

[redacted]



Water Level Elevation (ft amsl) in the Upper Trinity Hydrostratigraphic Unit - 2010

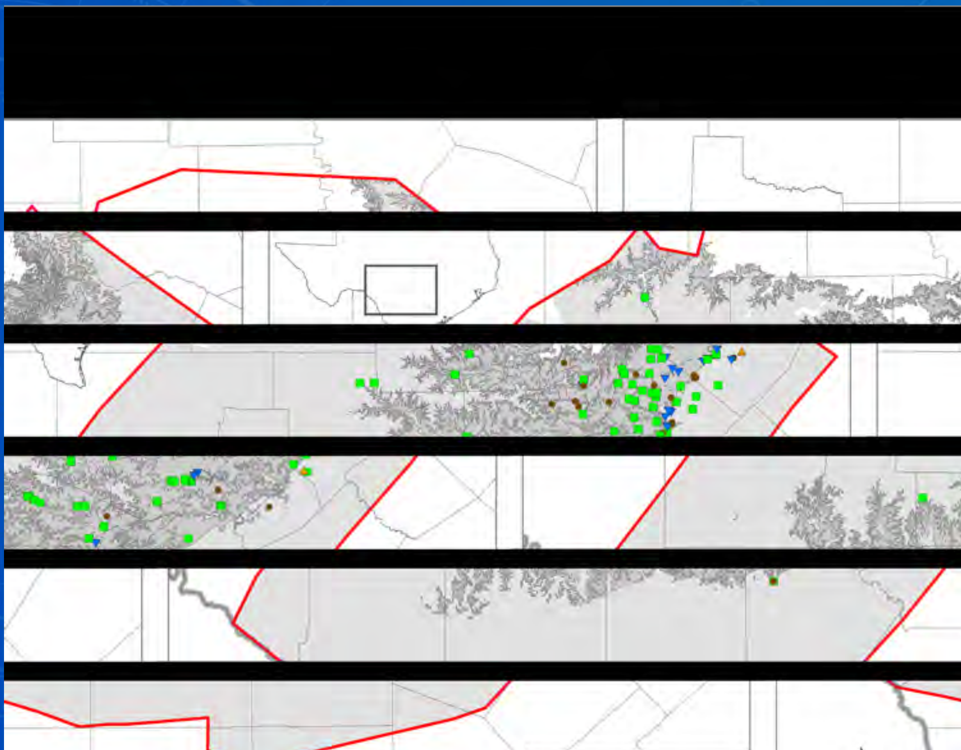
Example Hydrographs (Middle Trinity)



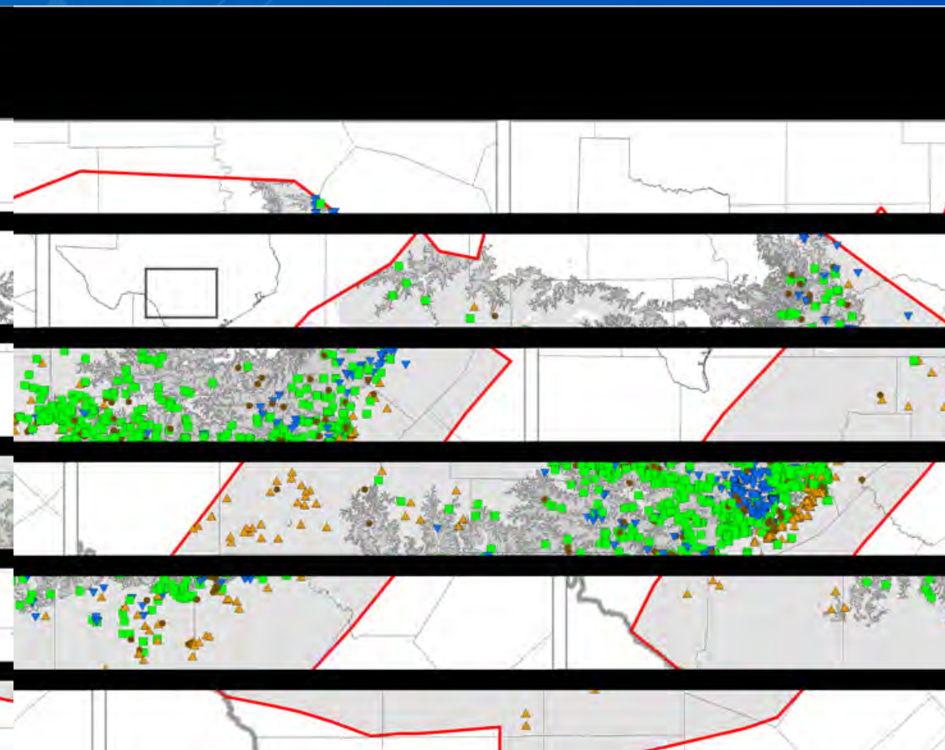
Hydraulic Parameters

- Transmissivity data from long-term aquifer pumping tests
- Specific capacity data
- Spatial distribution of Transmissivity, Hydraulic Conductivity & Storage
- Representative values of Transmissivity, Hydraulic Conductivity & Storage

Transmissivity data

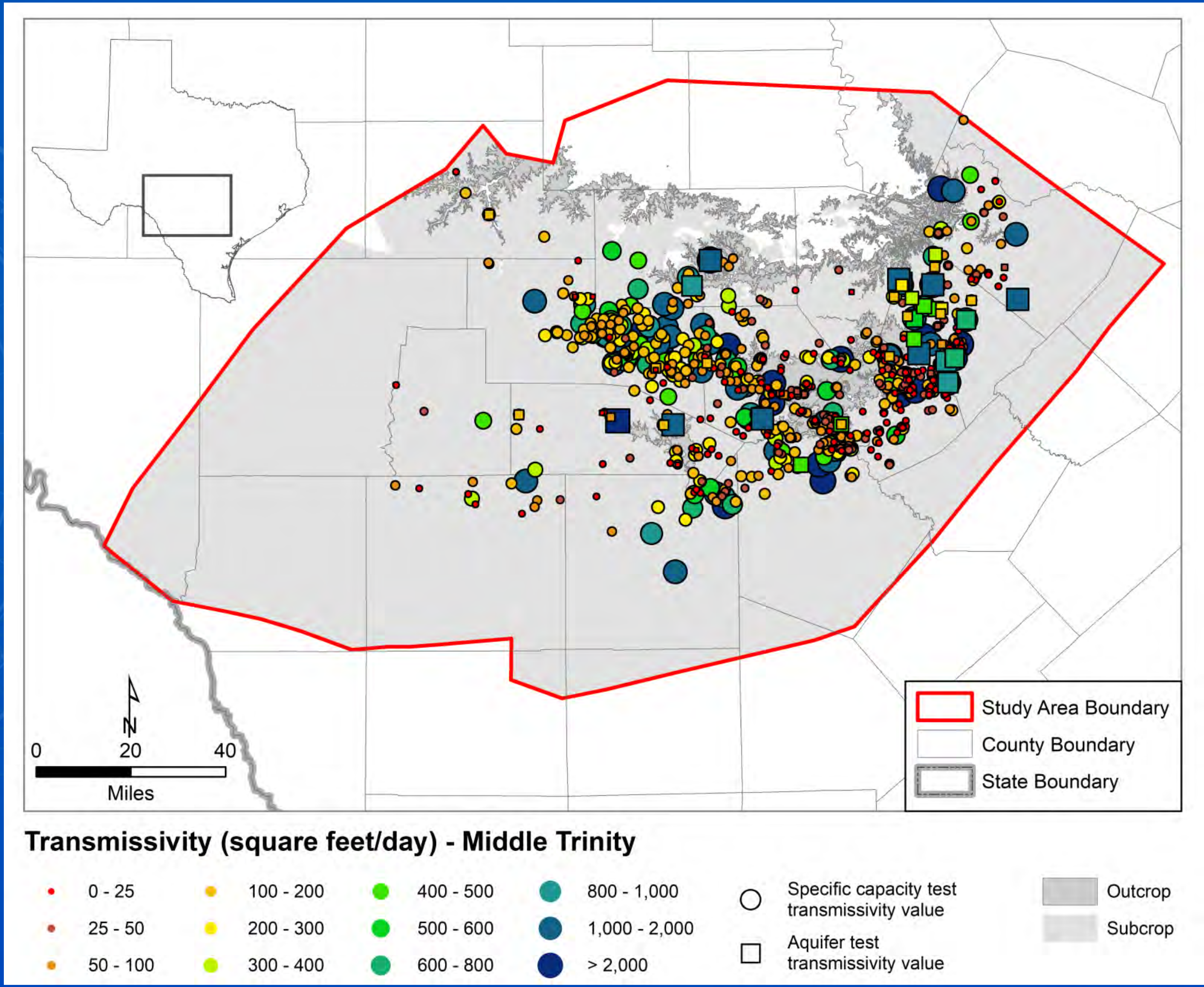


Data from
Long-term aquifer tests



Data from
Specific capacity tests

Example Transmissivity Spatial Distribution



Representative values by HSU

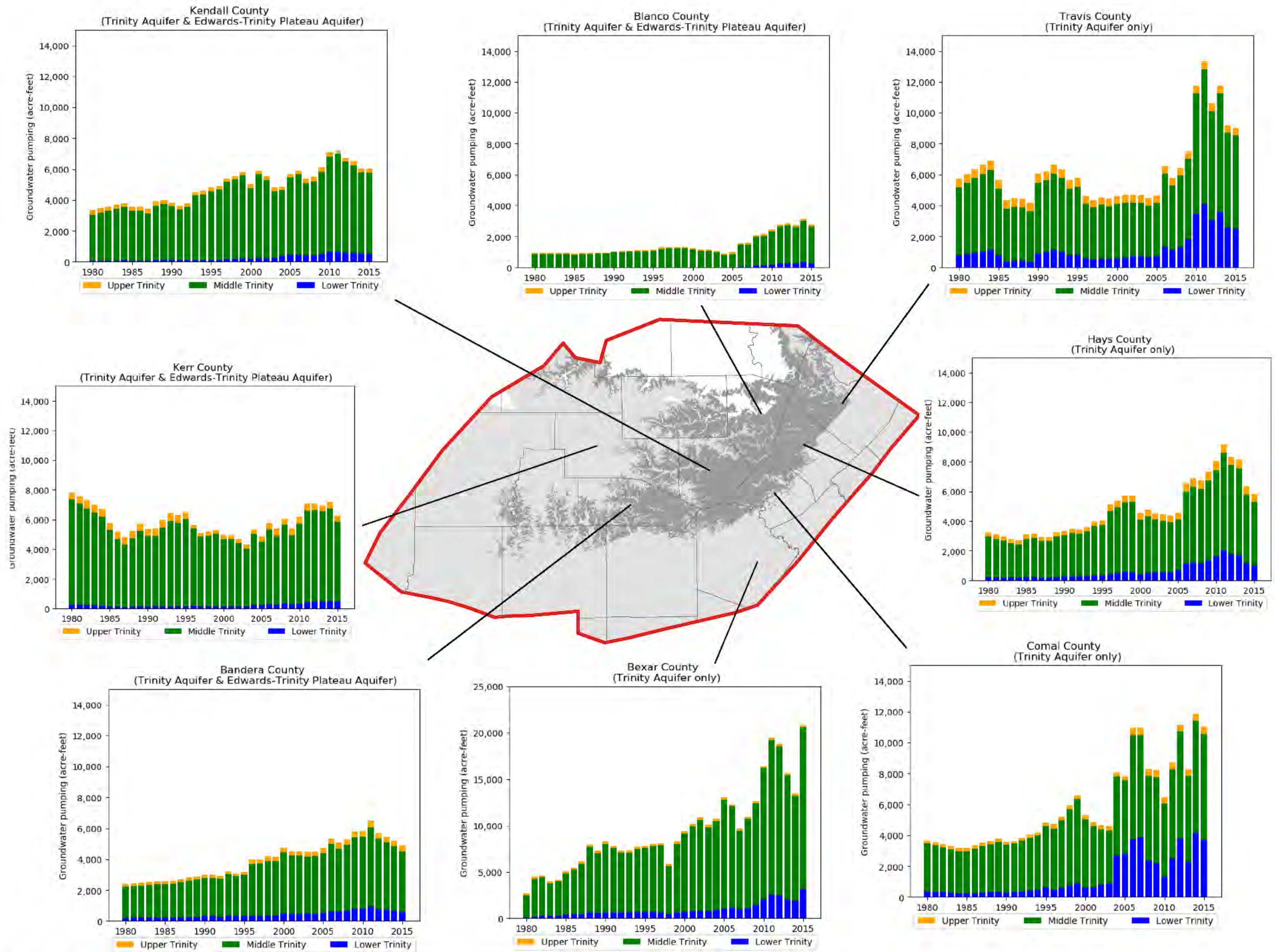
Hydrostratigraphic unit	Transmissivity values from Aquifer Pumping Tests (square feet/day)				Transmissivity values calculated from Specific Capacity (square feet/day)				All Transmissivity values from aquifer pumping tests and calculated from specific capacity (square feet/day)			
	Count	25th Percentile	Median	75th Percentile	Count	25th Percentile	Median	75th Percentile	Count	25th Percentile	Median	75th Percentile
Upper Trinity	1	--	199	--	217	7	28	70	218	8	28	70
Middle Trinity	58	41	159	521	821	26	70	185	879	28	73	200
Lower Trinity	17	142	214	317	385	35	54	127	402	35	57	147

Formation	Storativity	Storativity Value		
		Min	Median	Max
Upper Trinity	0	--	--	--
Middle Trinity	28	0.00001	0.0002	0.149
Lower Trinity	6	0.00001	0.00008	0.0045
mixed Trinity	13	0.00001	0.00009	0.0004
All Trinity	47	0.00001	0.0002	0.149

Discharge Estimates

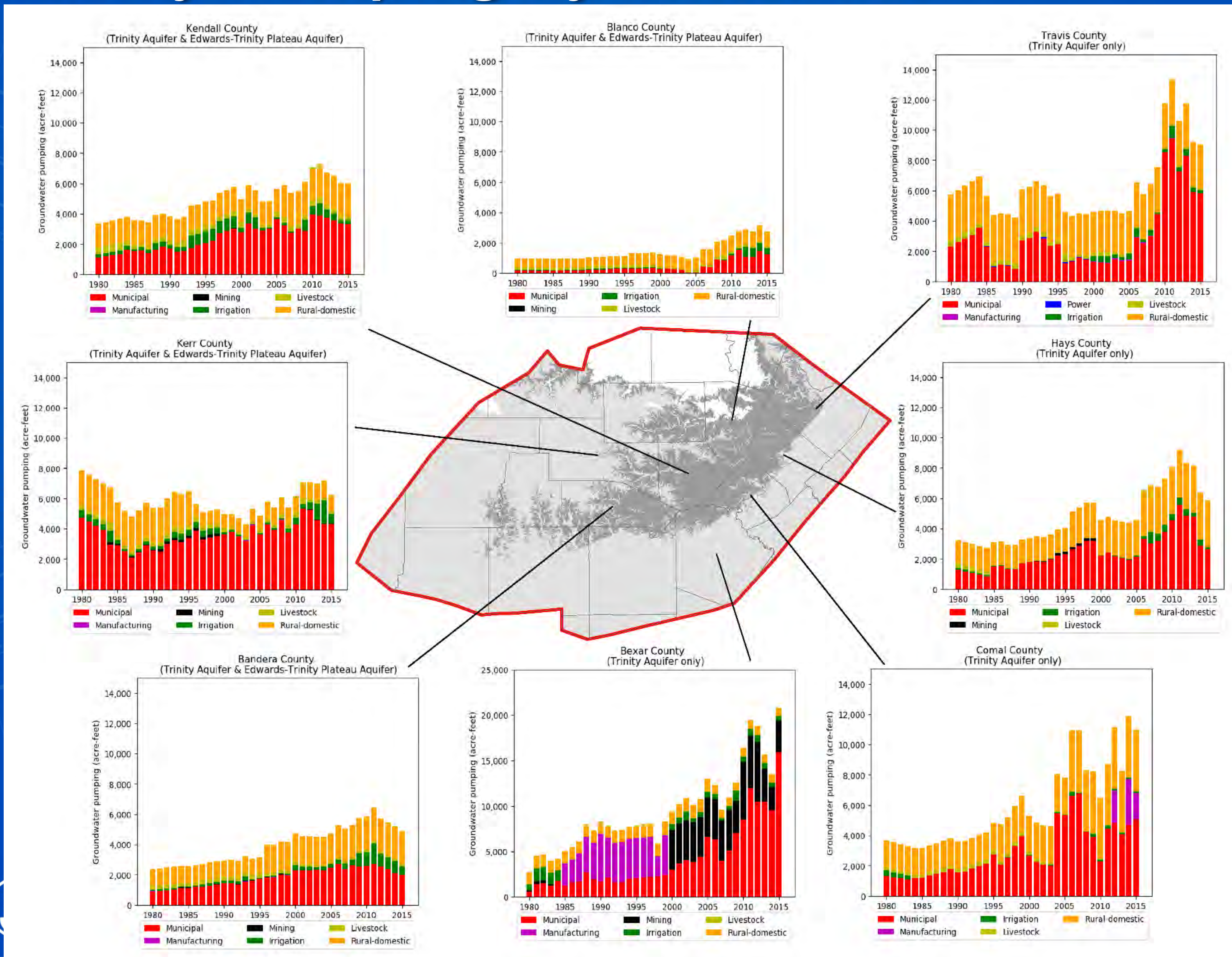
- TWDB Water Use Survey Data
- Rural Domestic Pumping based on Census data
- County Pumping by Hydrostratigraphic Unit
- County Pumping by Water Use

County Pumping by Hydrostratigraphic Unit



Document Path: S:\AUS\TWDB_Trinity_Hill_Country\GIS\mxd\Fig_4_6_x_County_PumpingGraphs_E_v2.mxd

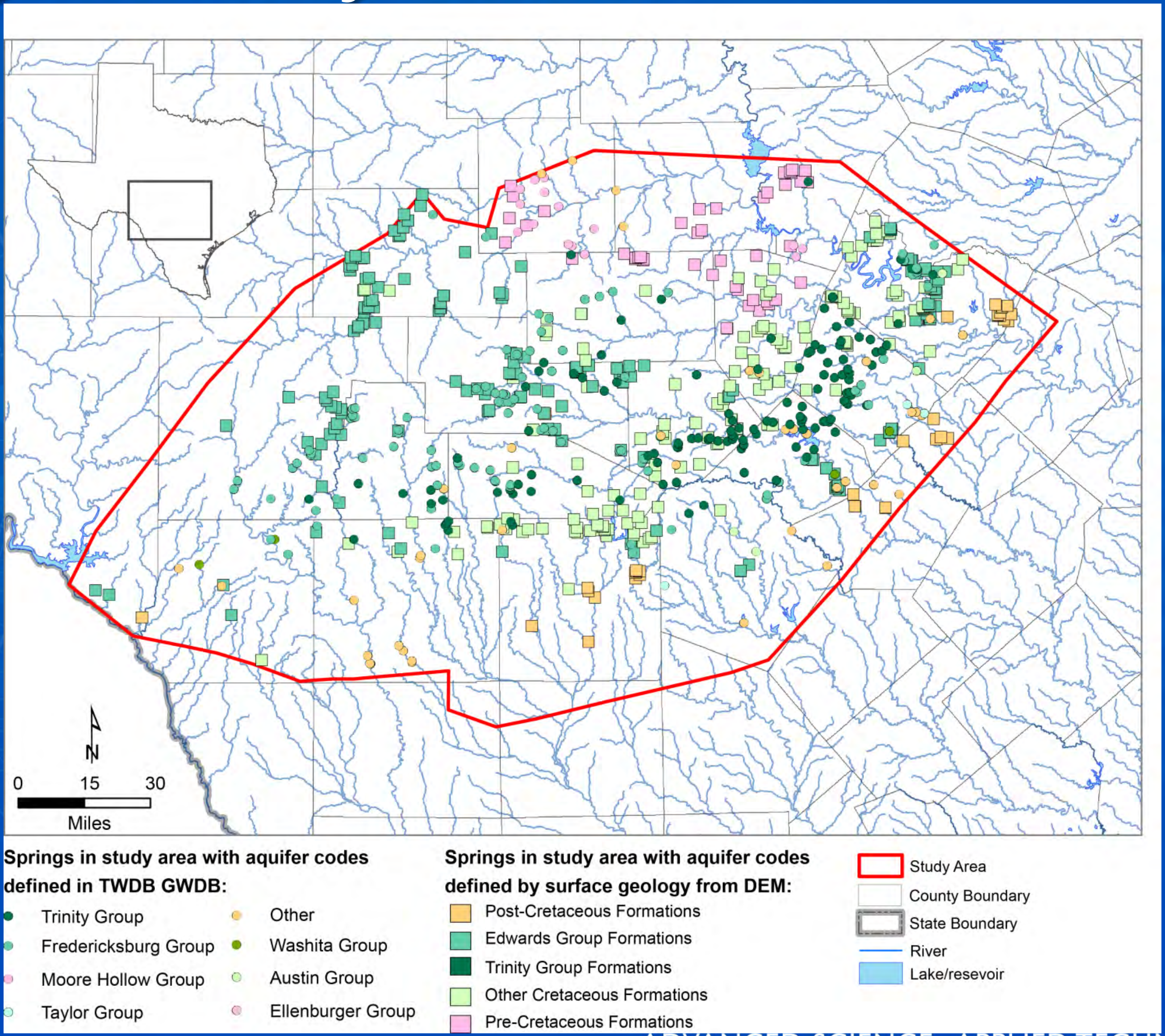
County Pumping by Water Use



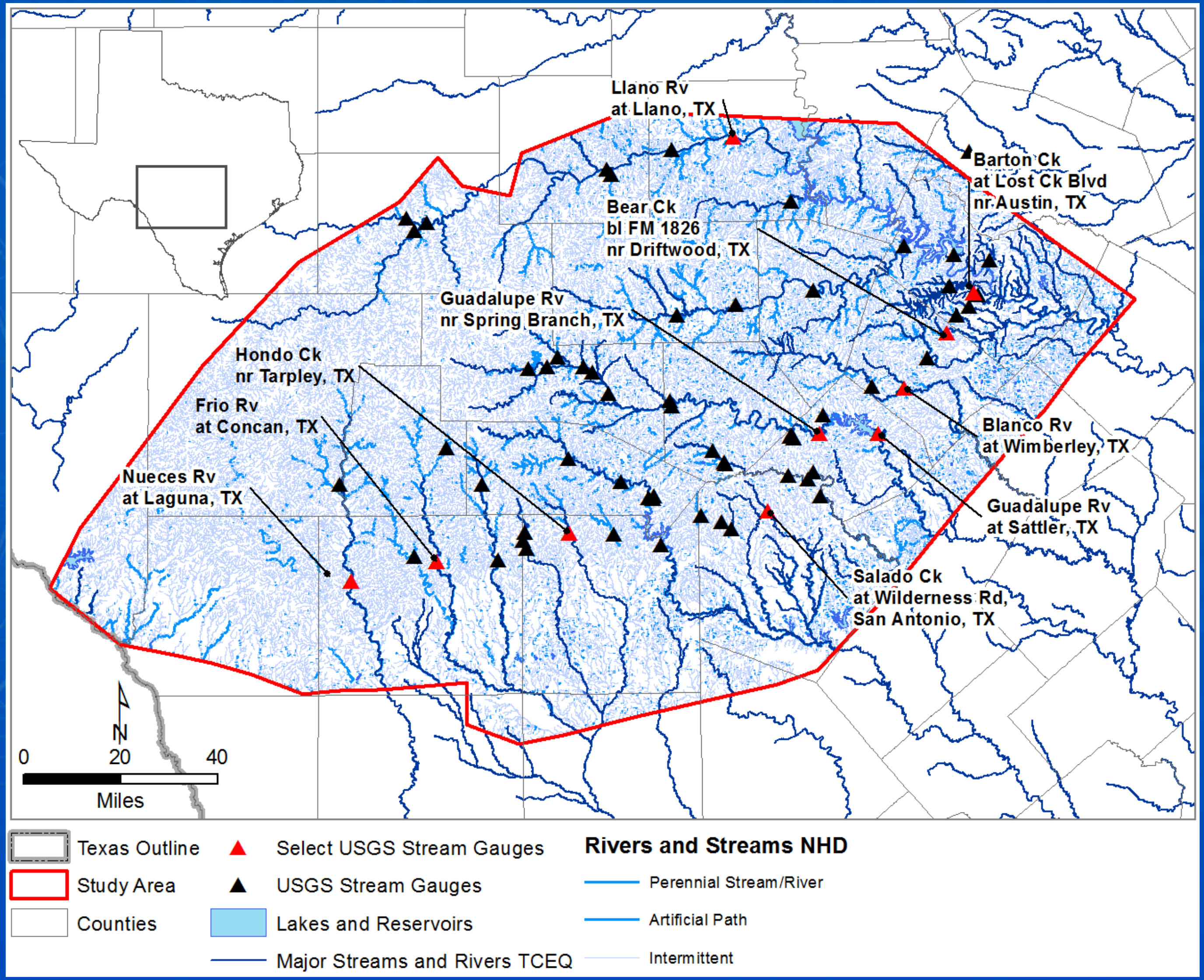
Discharge Estimates

- Natural Discharge to springs and streams is measured at USGS gauging stations throughout the HCT study domain
- Spring discharge is aggregated to streams and not directly measured with few exceptions

Springs in Study Domain

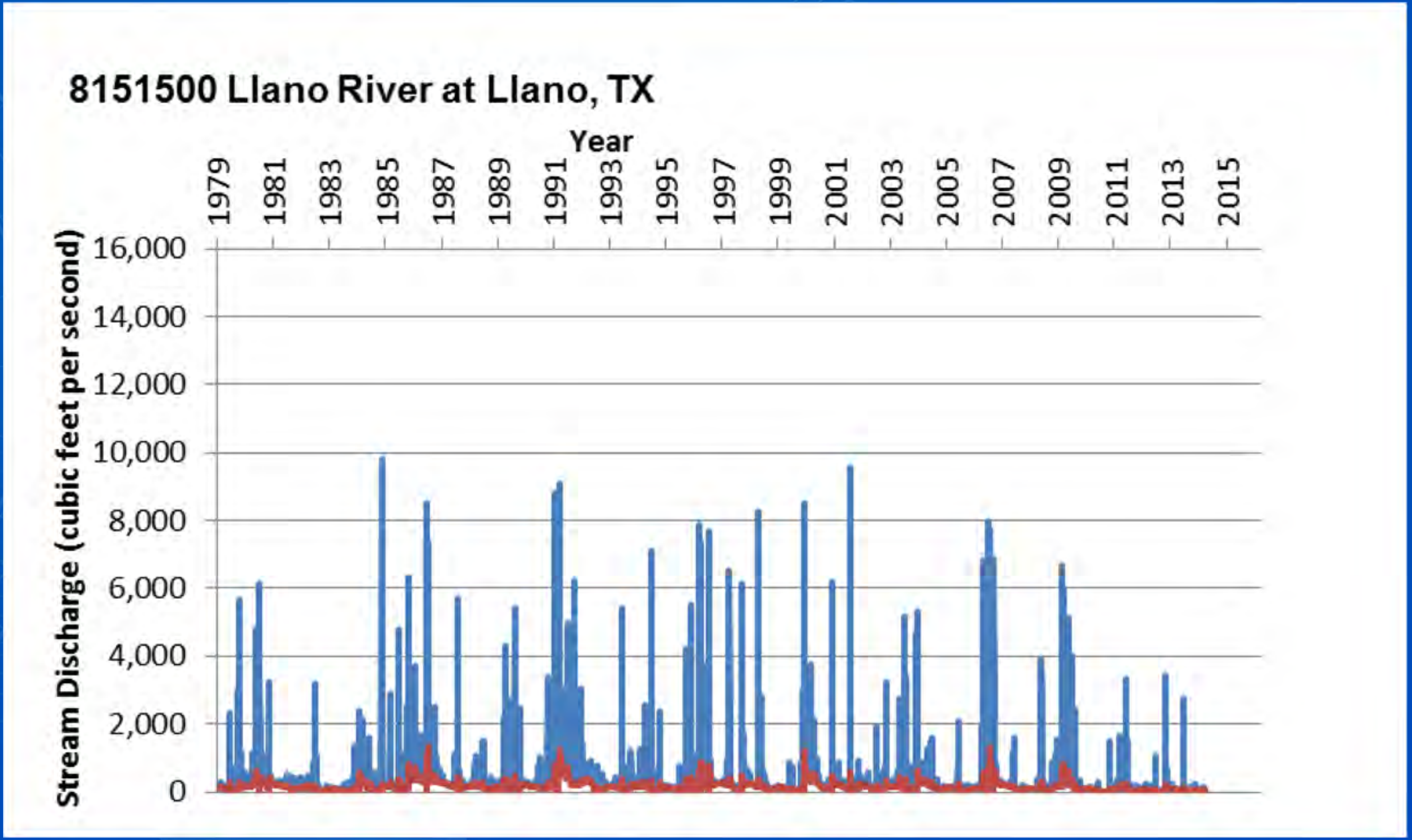


Stream Baseflow



ADVANCED SCIENCE. APPLIED TECHNOLOGY.

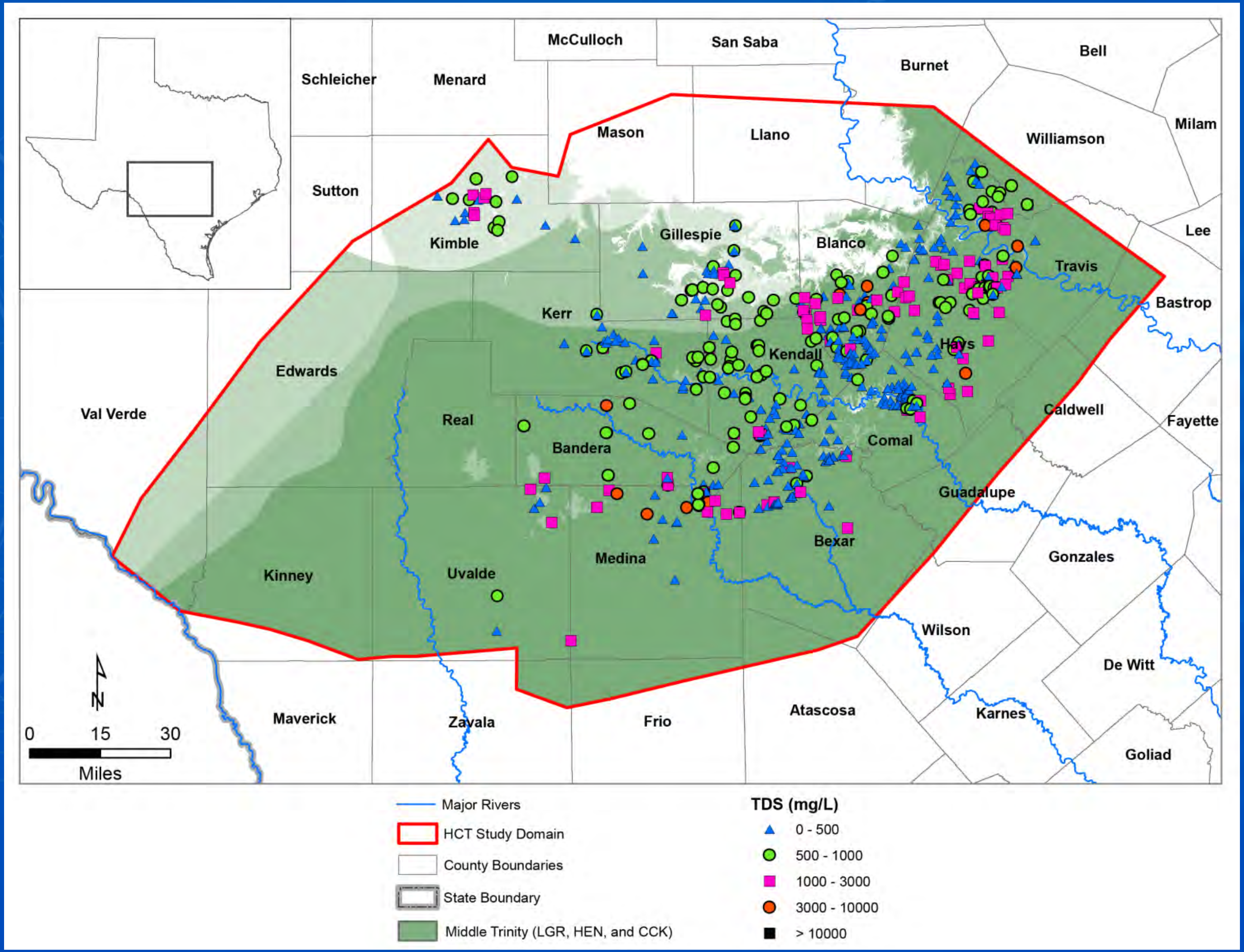
Stream Baseflow



Water Chemistry

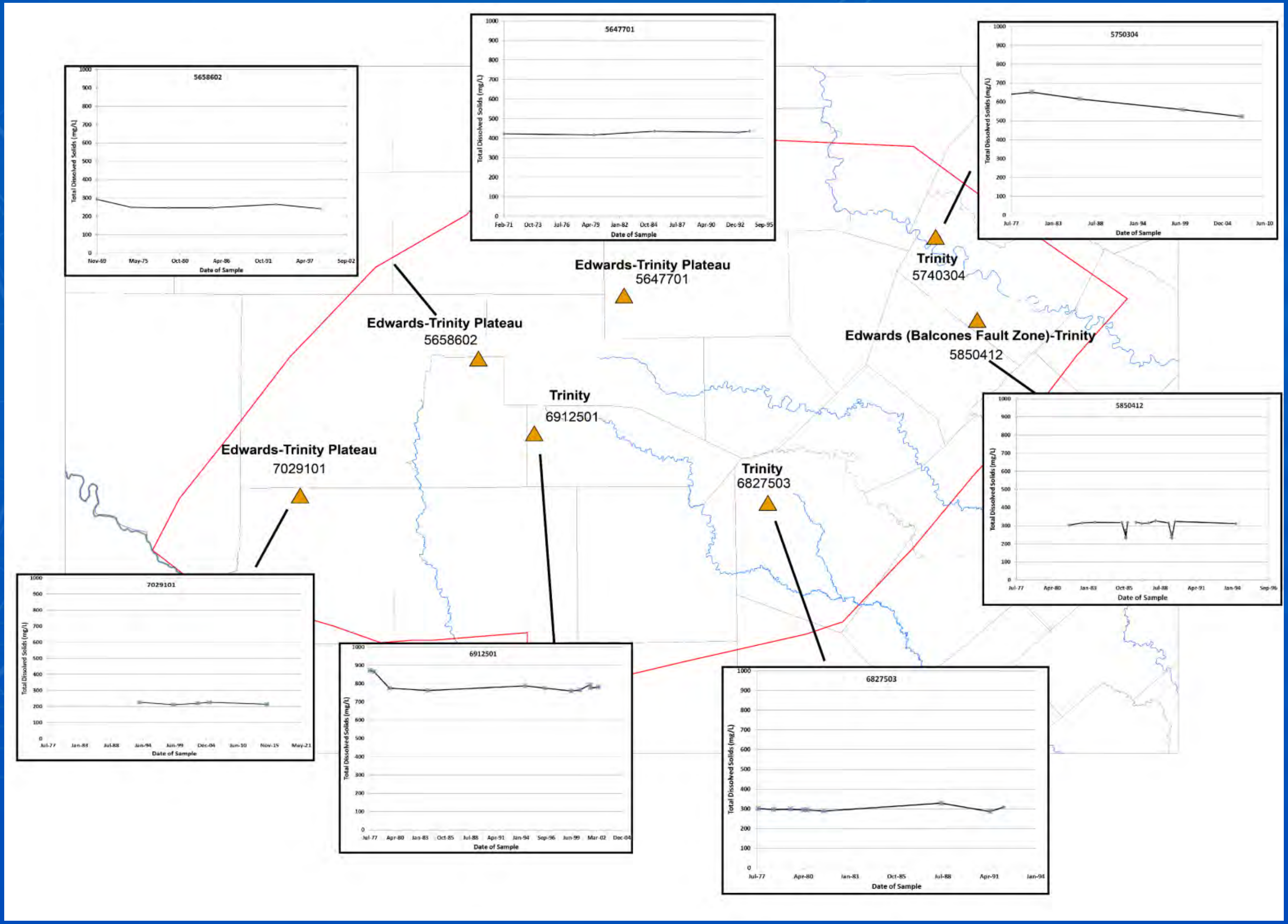
- Solute transport is not simulated in Groundwater Availability Models but water chemistry is still considered as it impacts water use and informs the conceptualization of the Aquifer
- Major ion chemistry reviewed for trends
  - No major changes identified in available databases
- Water chemistry research reviewed for indicators of interformational flow
  - Indications of interformational flow between the Trinity aquifer and the Edwards aquifer exist in the unconfined portions of the Edwards aquifer in the San Antonio pool

TDS Concentrations Example



INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

TDS Trends



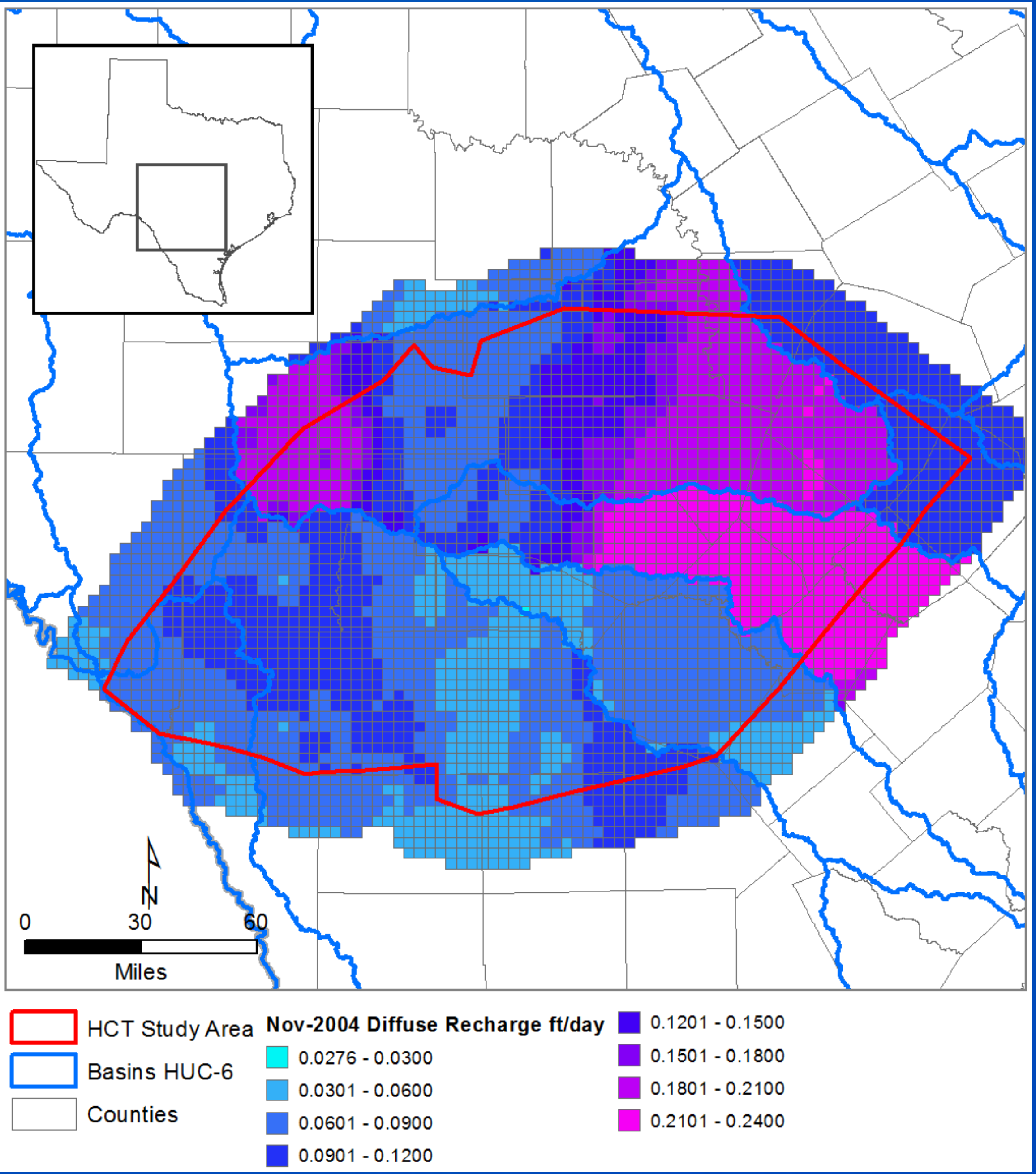
ADVANCED SCIENCE. APPLIED TECHNOLOGY.

swri.org

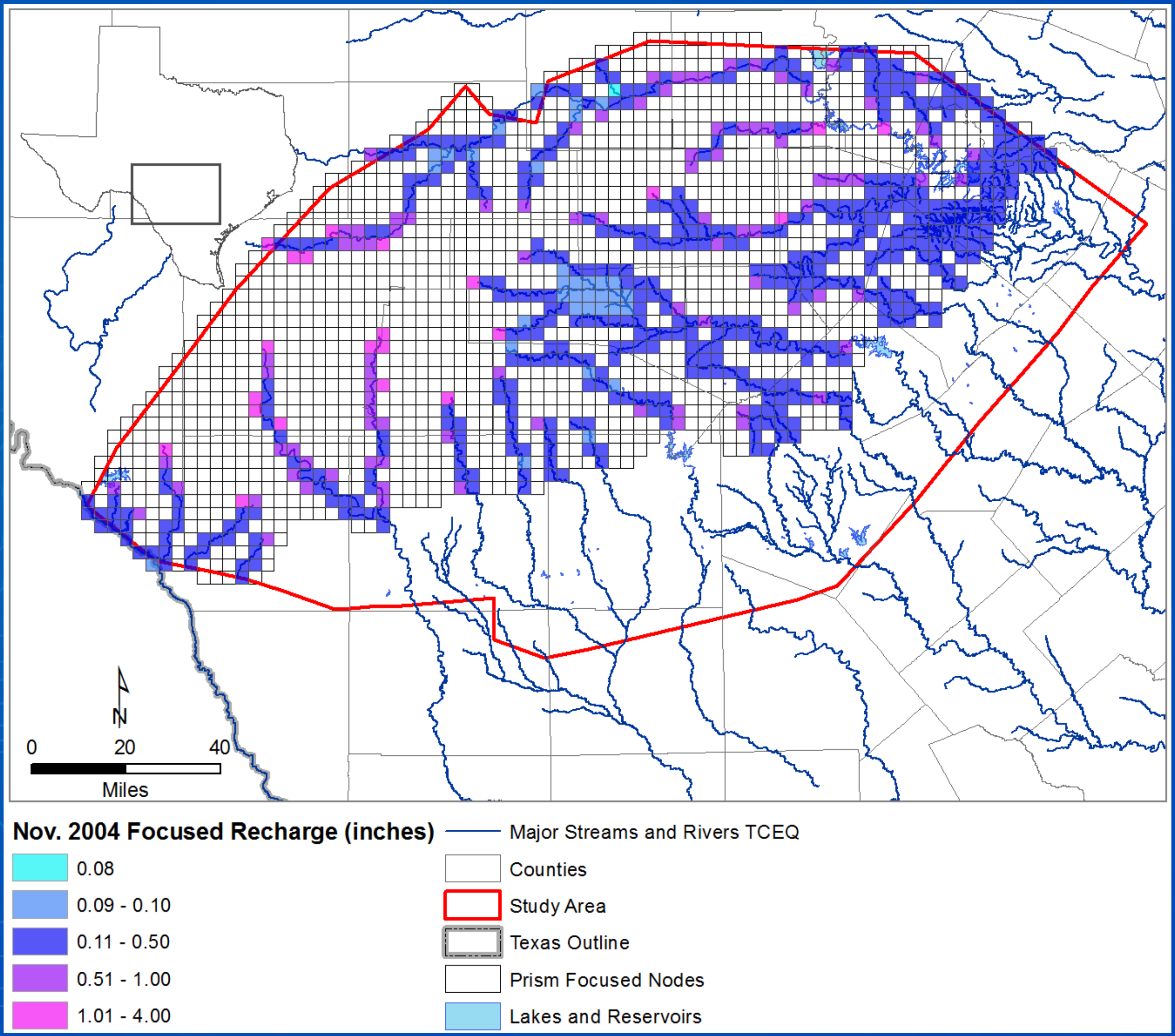
Recharge Estimates

- An empirical model was developed to estimate the spatial and temporal distribution of recharge
- Model for diffuse recharge developed
- Model for focused recharge developed

Diffuse Recharge Estimates



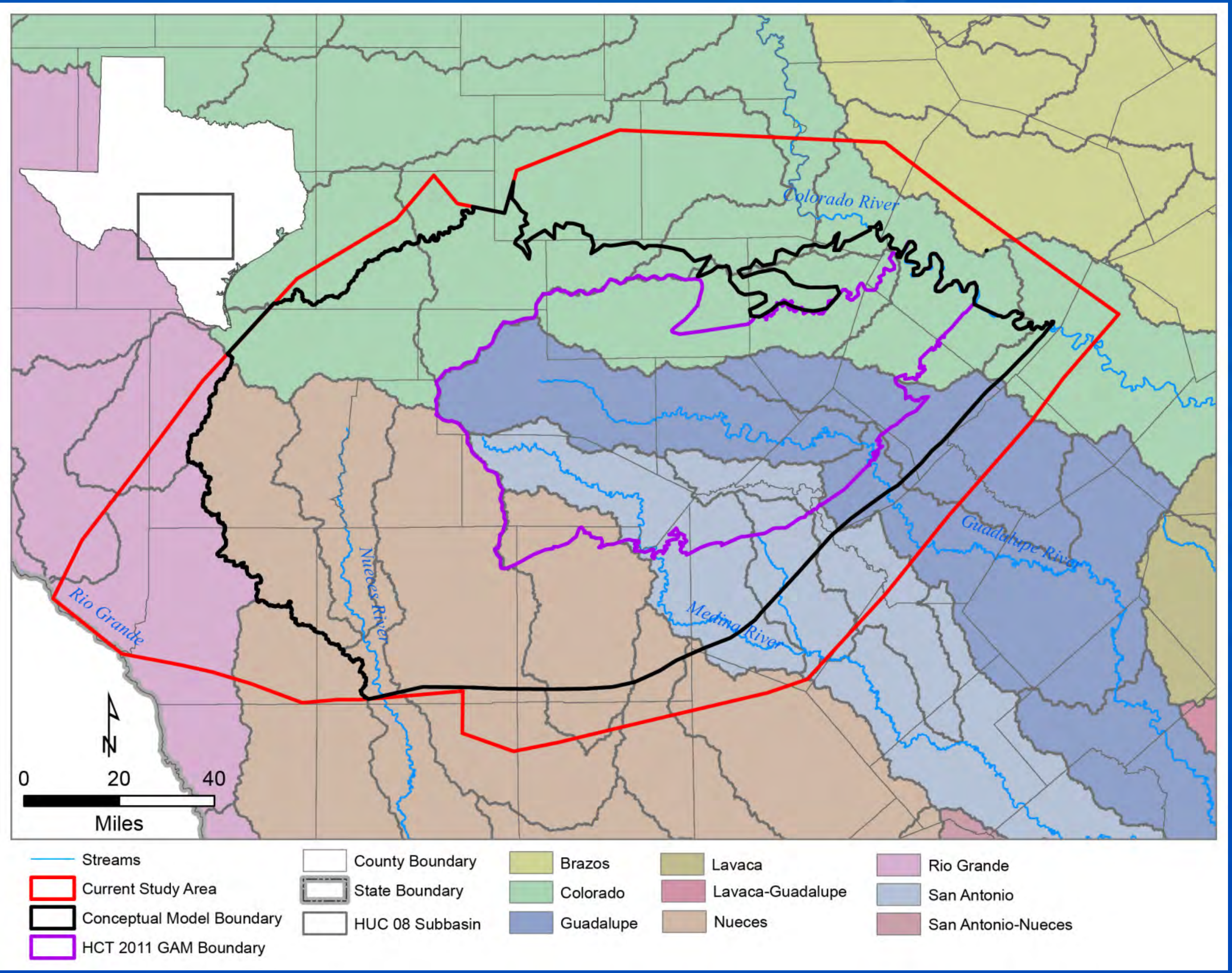
Focused Recharge Estimates



Conceptual Model Synthesis

- The collection of data in discrete parts of the aquifer does not constitute a conceptual model
- The SwRI team will developed a conceptual model that describes groundwater flow in the Hill Country portion of the Trinity Aquifer from recharge, through its path in the aquifer, to discharge at wells, springs, or rivers.
- Block models indicating flow in the aquifer were developed
- The Conceptual model and the data accumulated during the project is described in the draft report to be issued final in September 2018 and be used in an updated GAM numerical model. We have highlighted key features here.

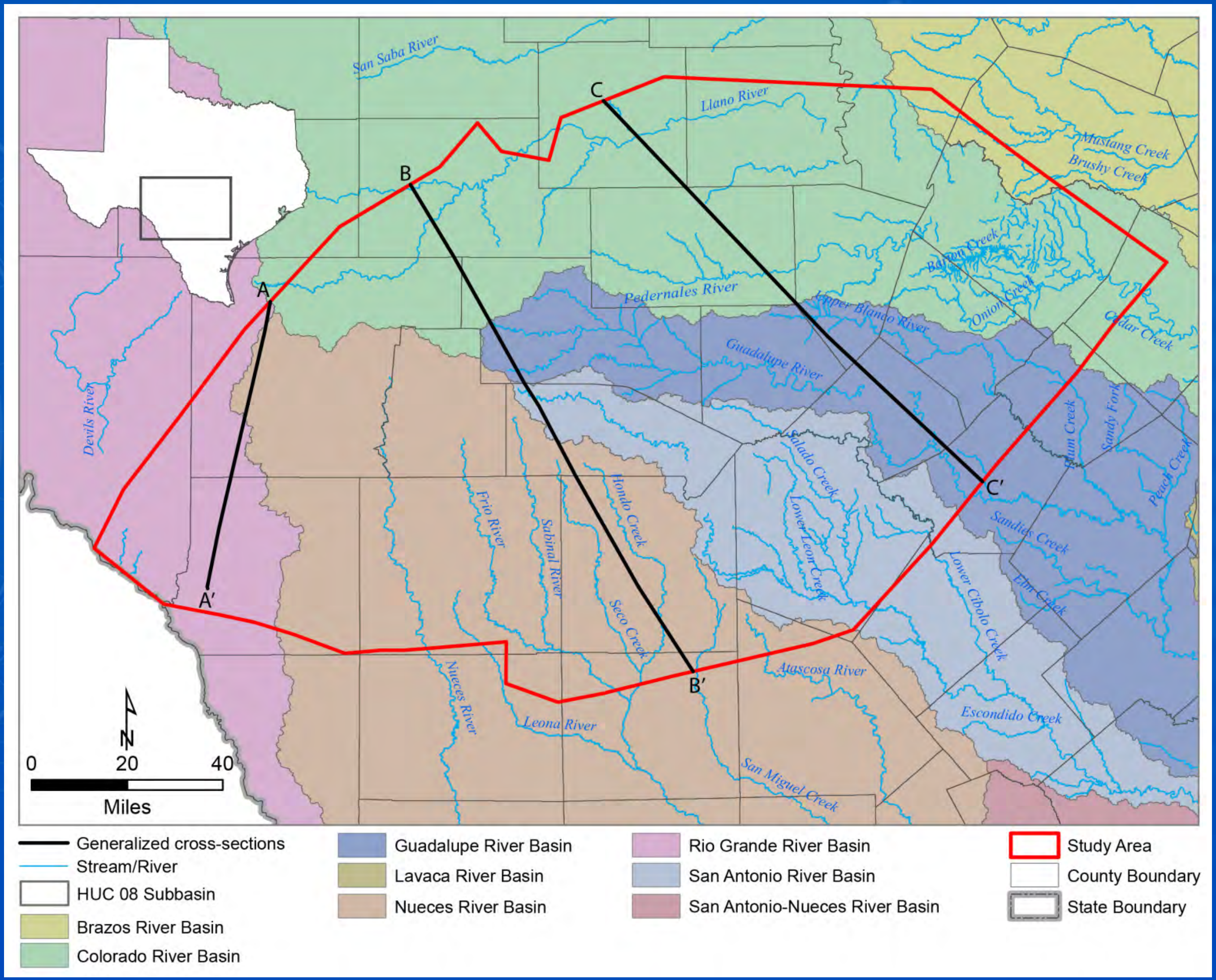
Conceptual Model Boundary



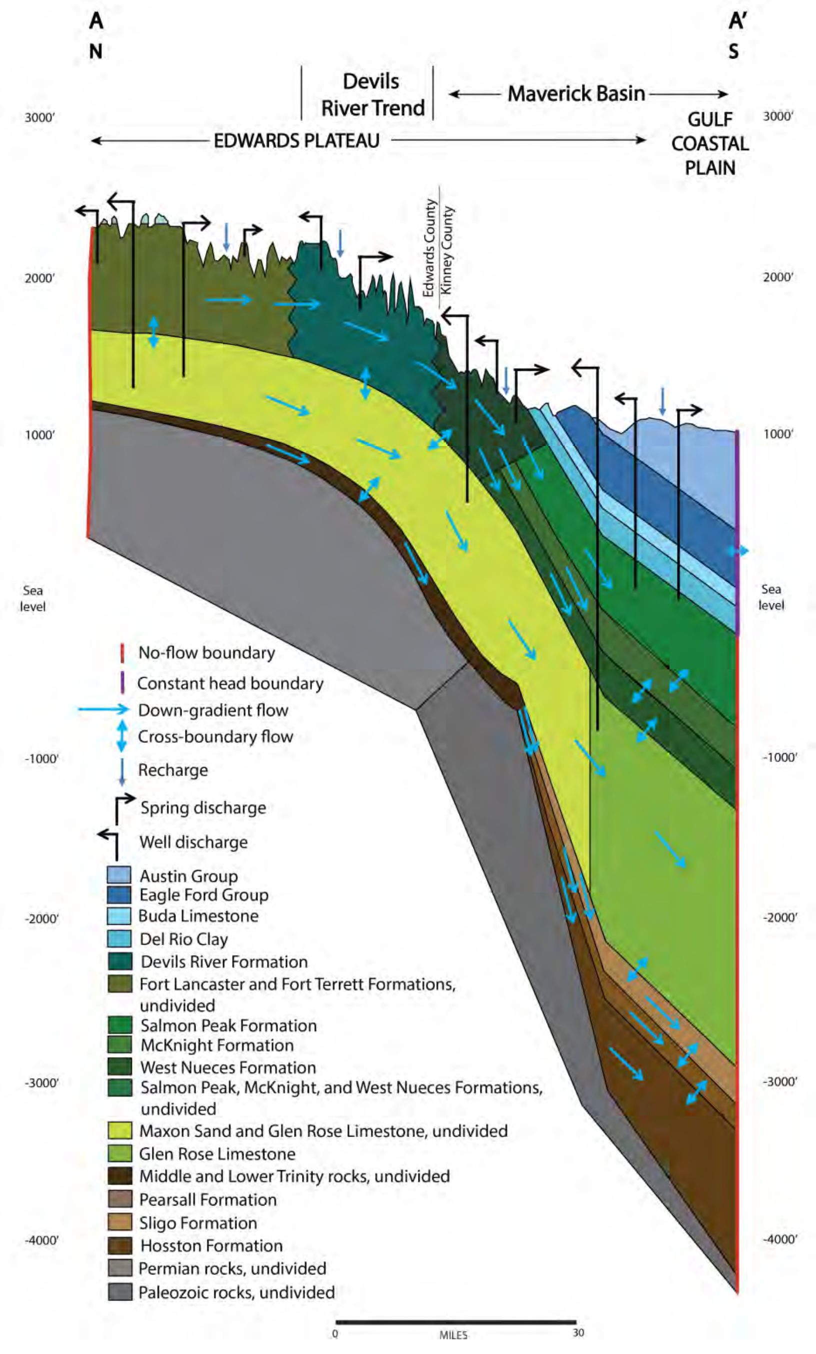
Conceptual Model Synthesis

- Lateral no flow boundaries
- Natural discharge to surface water dominates discharge followed by pumping and interformational flow
- Recharge is via diffuse and focused recharge, an empirical tool to estimate the temporal and spatial variability of recharge is provided
- Observed discharge to streams/springs should be included as a calibration parameter in addition to water elevations in the aquifer
- Interformational flow is still a challenge to estimate. Interformational flow will ultimately need to be determined during calibration of a numerical model

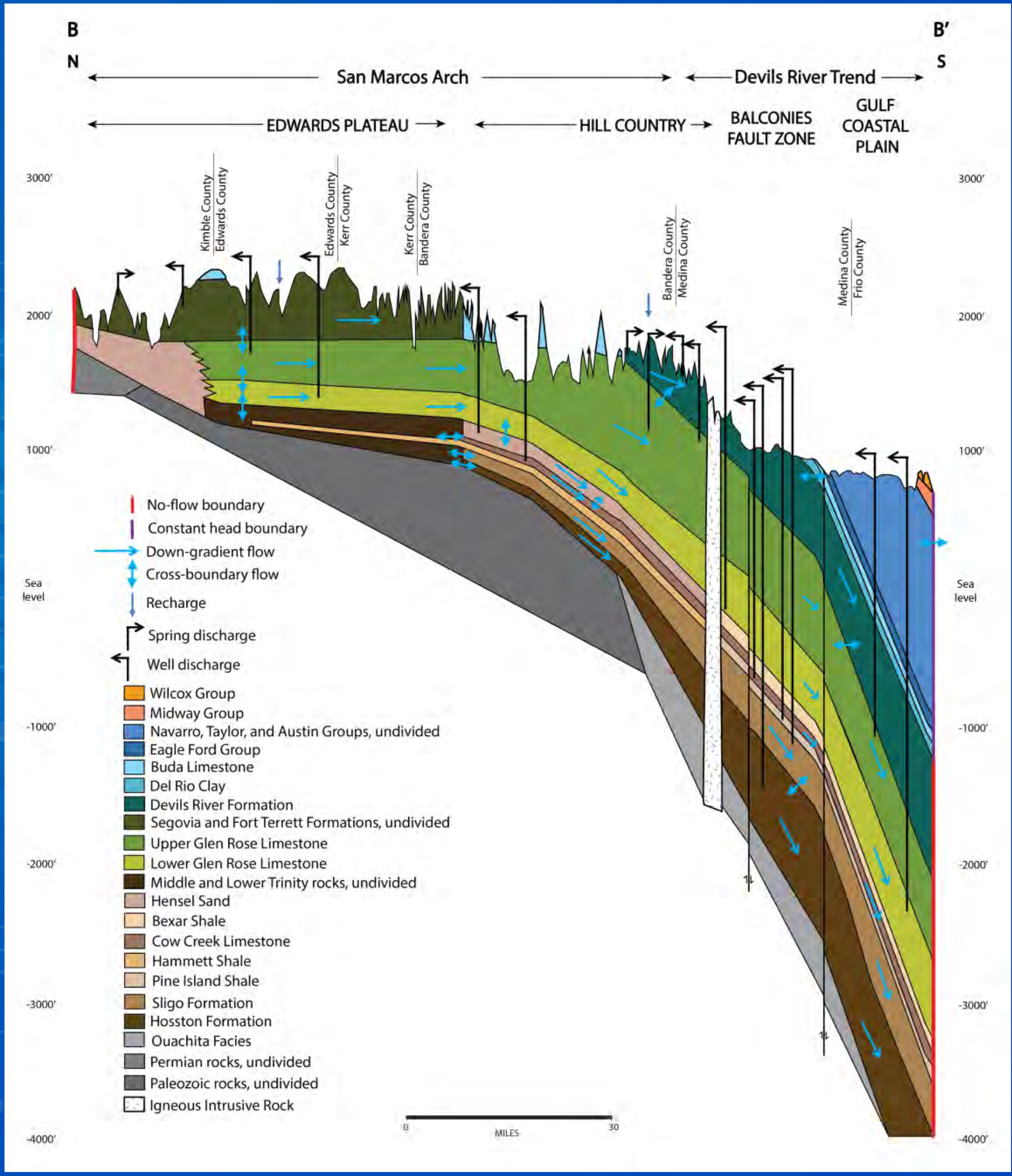
Conceptual Model Section Locations



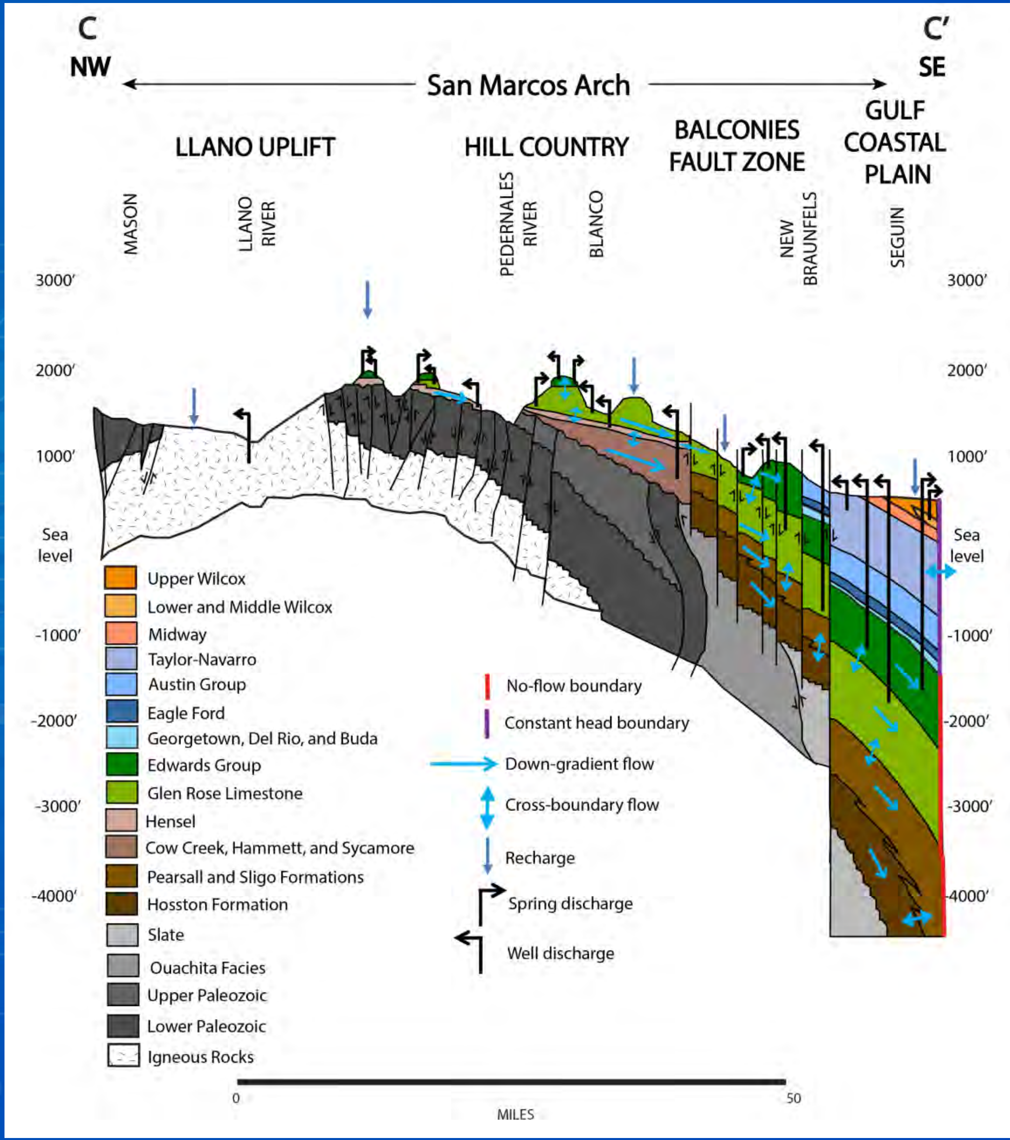
Conceptual Model Section A



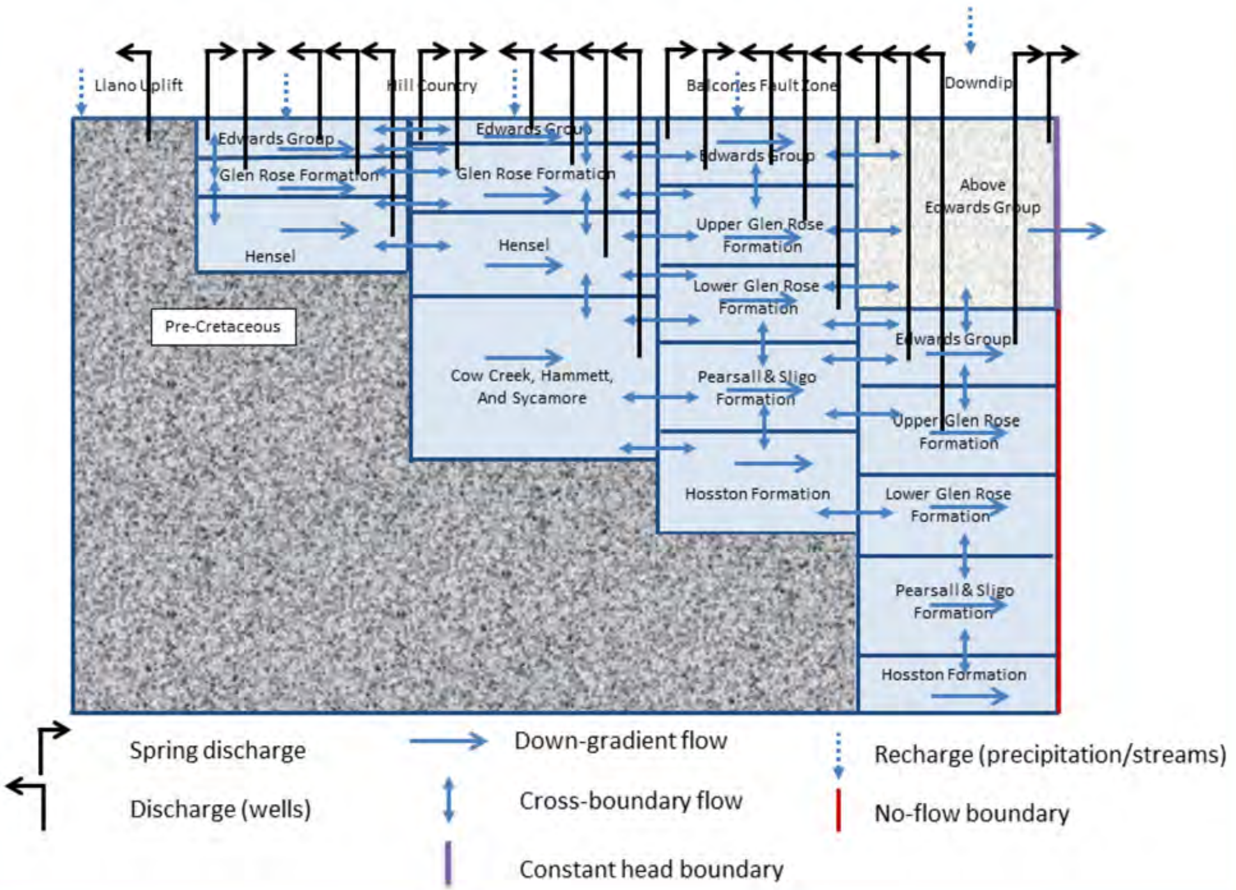
Conceptual Model Section B



Conceptual Model Section C



Conceptual Model Block Model



Schedule

- Comments from TWDB on draft report issued July 31st, 2018
- Final conceptual model report will be issued on September 28th, 2018
- No schedule is available for the development of a numerical groundwater flow model

Submission Contacts

Ian C. Jones, Ph.D., P.G.
TWDB Contract Manager
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711-3231

512-463-6641
ian.jones@twdb.texas.gov

Hill Country Trinity Aquifer Conceptual Model Stakeholder Meeting
July 13, 2018
Questions and Responses

Q: There's an interesting anticline in the model cross section. The Maverick basin is known to have inversion features.
A: This is an area of sparse data. This could be an effect of these different structure variations and complexities in the domain. It could also be the result of Laramide deformation similar to the Chittim anticline and Zavala Syncline that exist just to the southwest of the study domain.

Q: Were ramps able to reveal themselves in the data? At the regional scale are they not as obvious?
A: A previous EAA *[Edwards Aquifer Authority]* project focusing on Edwards and Trinity done by SwRI had a more complex fault model. Relay ramps are better delineated in that fault model. Even though the data and resolution are sparse for this project, we still see evidence for ramp geometry in the data.

Q: Regarding the potentiometric surfaces – why is there a separation between Trinity Aquifer contours within and outside of the Balcones Fault Zone? In Hays and Travis counties, we see very continuous surfaces/no separate systems in these counties.
A: When you contour together, weird values occur along the zone due to large offsets. Studies have shown that separate water systems occur as Trinity Aquifer groundwater enters the Edwards Aquifer along the Balcones Fault Zone.

Q: What did you use to contour the potentiometric surfaces of Trinity units? Have you tried to use faults as barriers in that interpolation tool to avoid compartmentalizing two different systems (north and south of the Balcones Fault Zone)?
A: The control points are wells. The ArcGIS Topo-to-Raster function was used to generate the potentiometric surfaces. And no, we do not have fault lines to define barriers to see how it differs. This can be tested, but on a regional scale, this compartmentalization of Trinity Aquifer north and south of the Balcones Fault Zone was easiest. However, this is a complicated system, so this leaves many good options to explore.

Q: Did you consider gaining and losing streams in these potentiometric surfaces?
A: Yes, they were considered as control points (ex: springs) in predevelopment conditions.

Q: Did you look at measurement gain-loss sections?
A: Yes, it was not included in presentation but can be found in the draft final report. This is something that can inform the focused recharge model.

Q: Did you take into account age dating of water into the conceptual model?

A: We looked at it in the water chemistry analyses to assess inter-formational flow. In terms of the ages we evaluated, *[they are]* generally all meteoric.

Q: Regarding the block diagram: there are many arrows, which is a reflection of the remaining uncertainty of this system. We need to be careful about understanding these connections and how they may differ in different sections (for example, in Hays County, the continuous potentiometric surfaces have stark differences in geochemistry). I think the effort to simplify this large expanse can't address certain things without more details. It does help to show that we are far away from understanding the whole system due to so many complexities. Not sure if any GAM-scale model will capture these complexities.
A: The Edwards Aquifer Authority inter-formational flow project will shed more light. The model will be relatively insensitive to some of these complexities. This is more constrained than it may appear but because of the effort to establish each of these arrows.

Q: Regarding the block diagram: there's no interaction with the Pre-Cretaceous and Trinity?
A: This is addressed and discussed in the report. Primary and secondary porosity is sufficiently lower in the Pre-Cretaceous rocks. This may need to be addressed in the numerical model. Arrows were previously there but removed due to scale of permeabilities. There may be communication but it is challenging to constrain this.

Q: Regarding the inter-formational flow figures in the draft final report: there is not much text associated with them? Is there more discussion of spatial variation of inter-formational flow between the Edwards and Trinity aquifers?
A: We did not feel we had sufficient information to address this further. We haven't had the information at our disposal. We expected Edwards Aquifer Authority inter-formational flow work to be further developed and anticipated this would be a great source of knowledge. I think we can do a better job of summarizing this in the report.

Participant	Organization
Daniel Meyer	Plum Creek Conservation District
Marcus Gary	Edwards Aquifer Authority
Paul Bertetti	Edwards Aquifer Authority
Kendall Bell-Enders	Barton Springs Edwards Aquifer Conservation District
Brian Hunt	Barton Springs Edwards Aquifer Conservation District
Ron Green	Southwest Research Institute
Larry Schmidlapp	Texas Water Supply
Ronald McGinnis	Southwest Research Institute
John Mikels	GEOS Consulting
Ian Jones	Texas Water Development Board
Larry French	Texas Water Development Board
Doug Wierman	Blue Creek Consulting
Nate Toll	Southwest Research Institute
Steve Young	
Jevon Harding	INTERA
Genell Hobbs	Kinney County Groundwater Conservation District
Joel Pigg	Real-Edwards Conservation and Reclamation District
Paul Tybor	Hill County Underground Water Conservation District
Ron Fieseler	Blanco-Pedernales Groundwater Conservation District
Neil Deeds	INTERA