Stakeholder Advisory Forum 2
Conceptual Model for the Rustler Aquifer

May 19, 2011

Van Kelley, P.G.
Toya Jones, P.G.

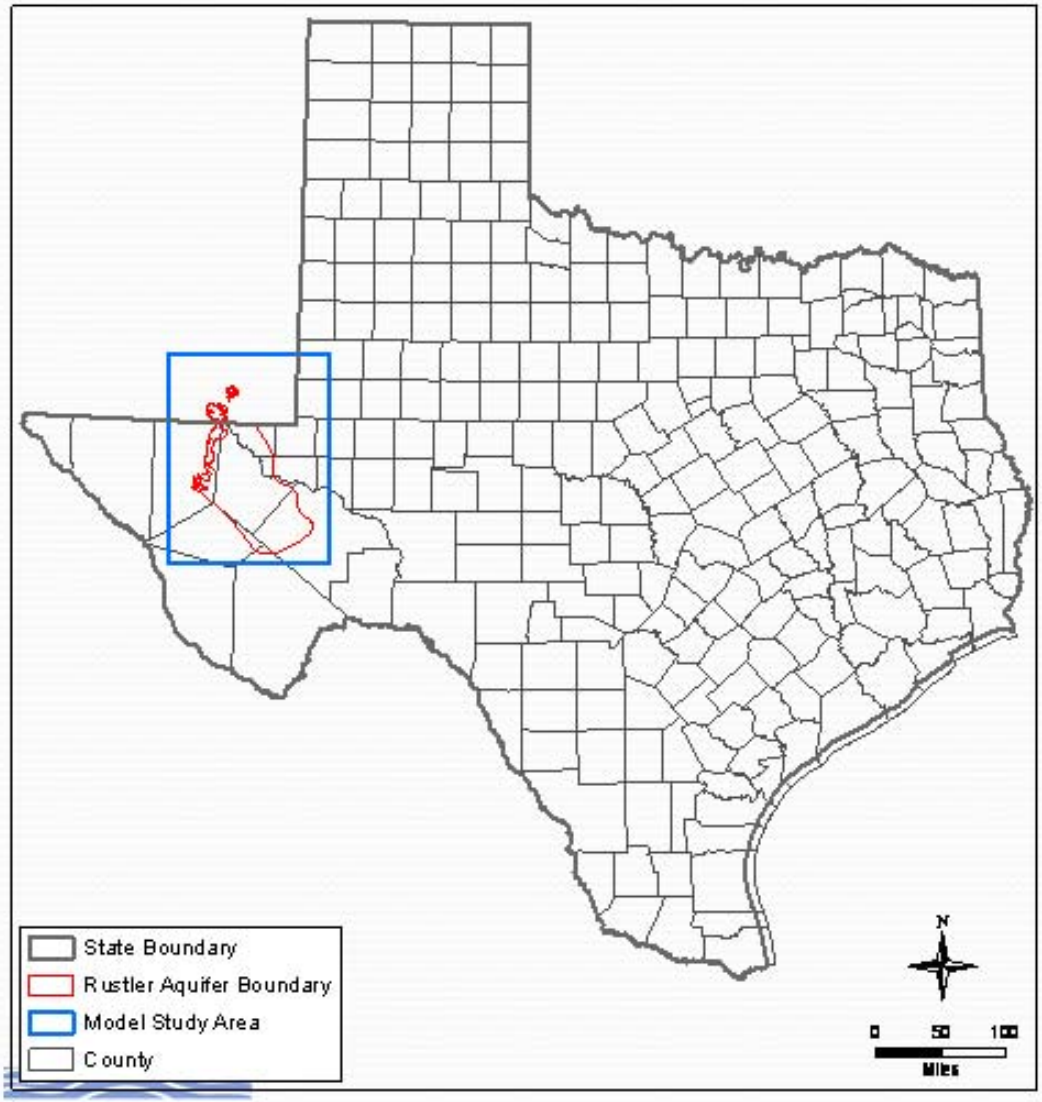
Dr. Dennis Powers, P.G.
Dr. Jack Sharp, P.G.
Dr. Bob Holt

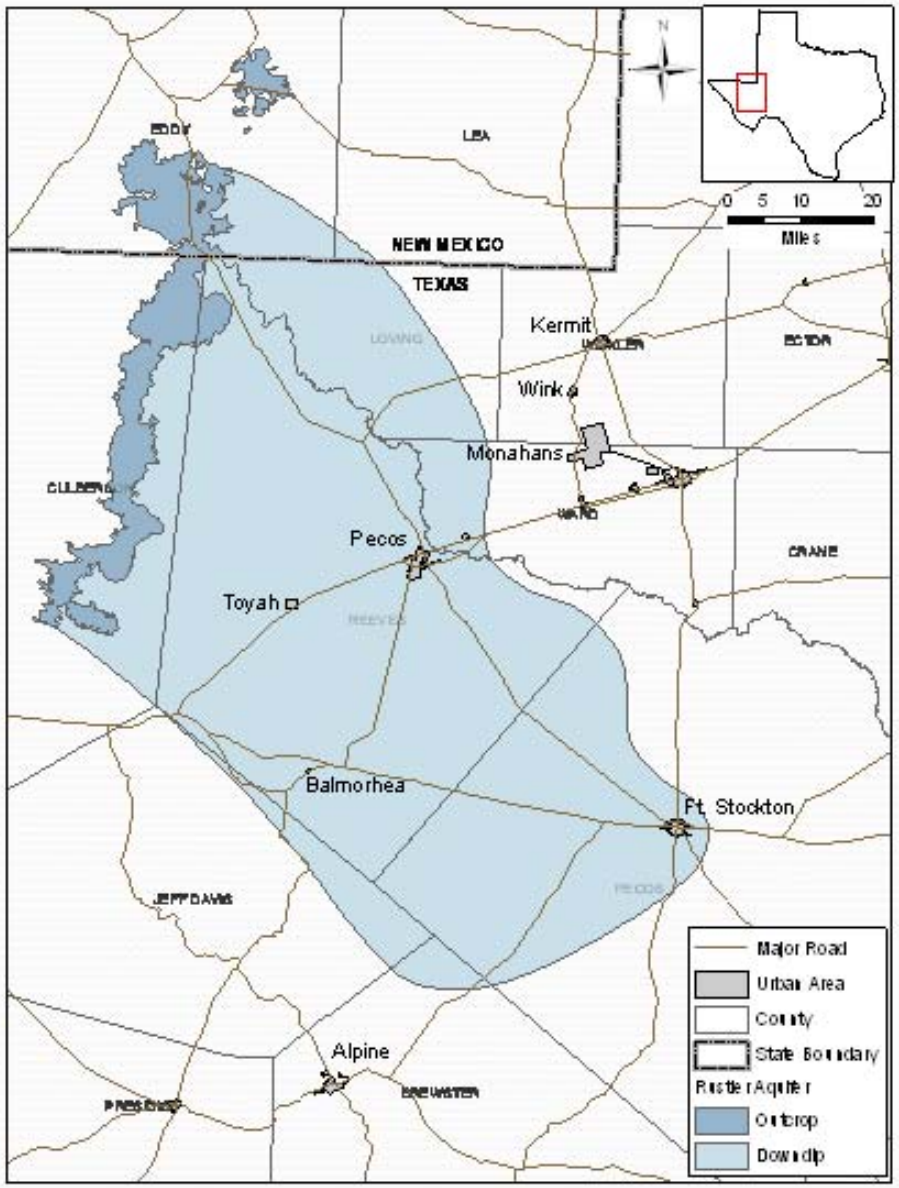
Outline

- Review of Study Area
- Rustler Aquifer Framework (Structure)
- Rustler Aquifer Hydrogeology
  - Properties
  - Heads
  - Recharge/Discharge
  - Pumping
- Conceptual Model
- Implementation Approach
- Project Schedule

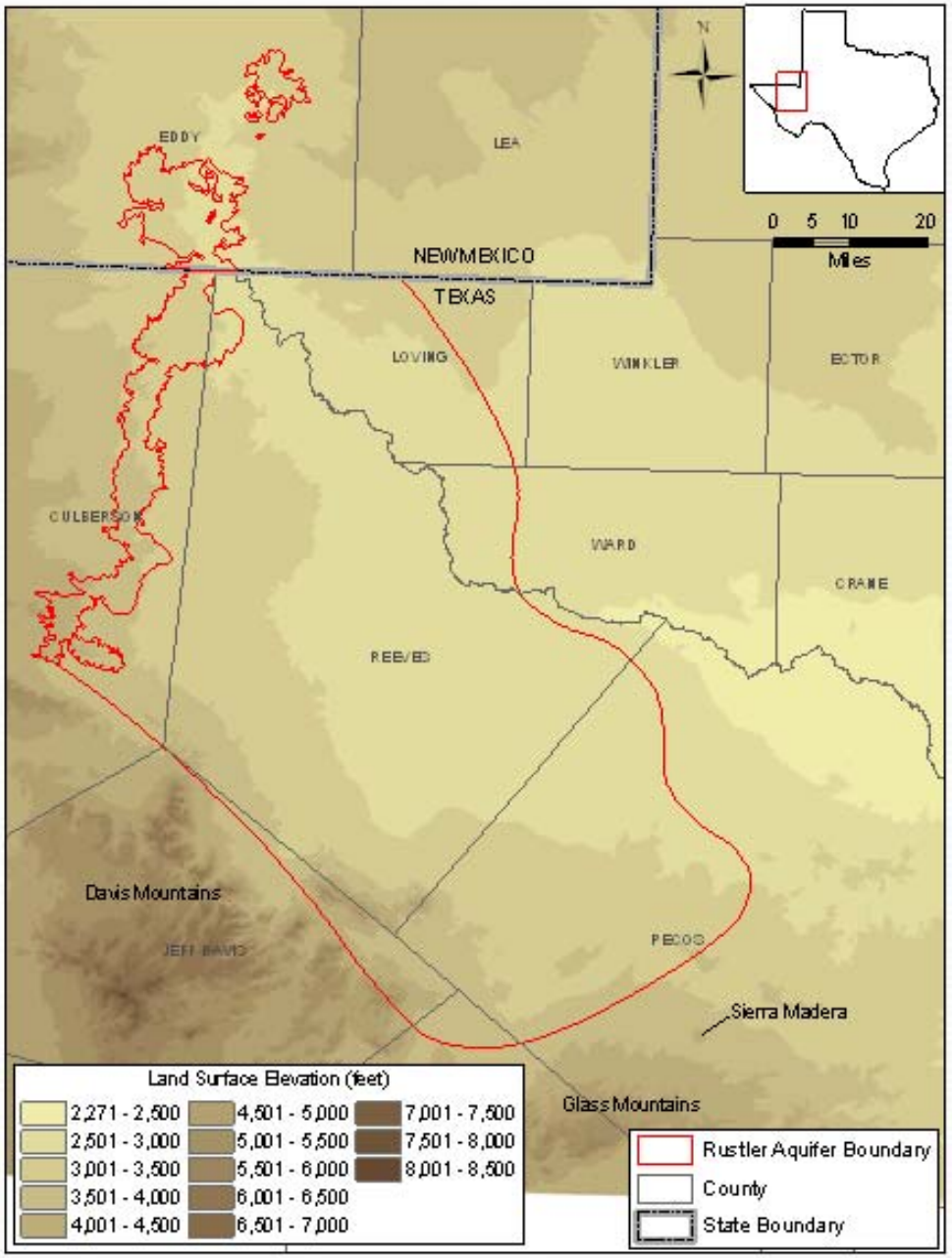
Project Team and Responsibilities

Aquifer Study Area





Topography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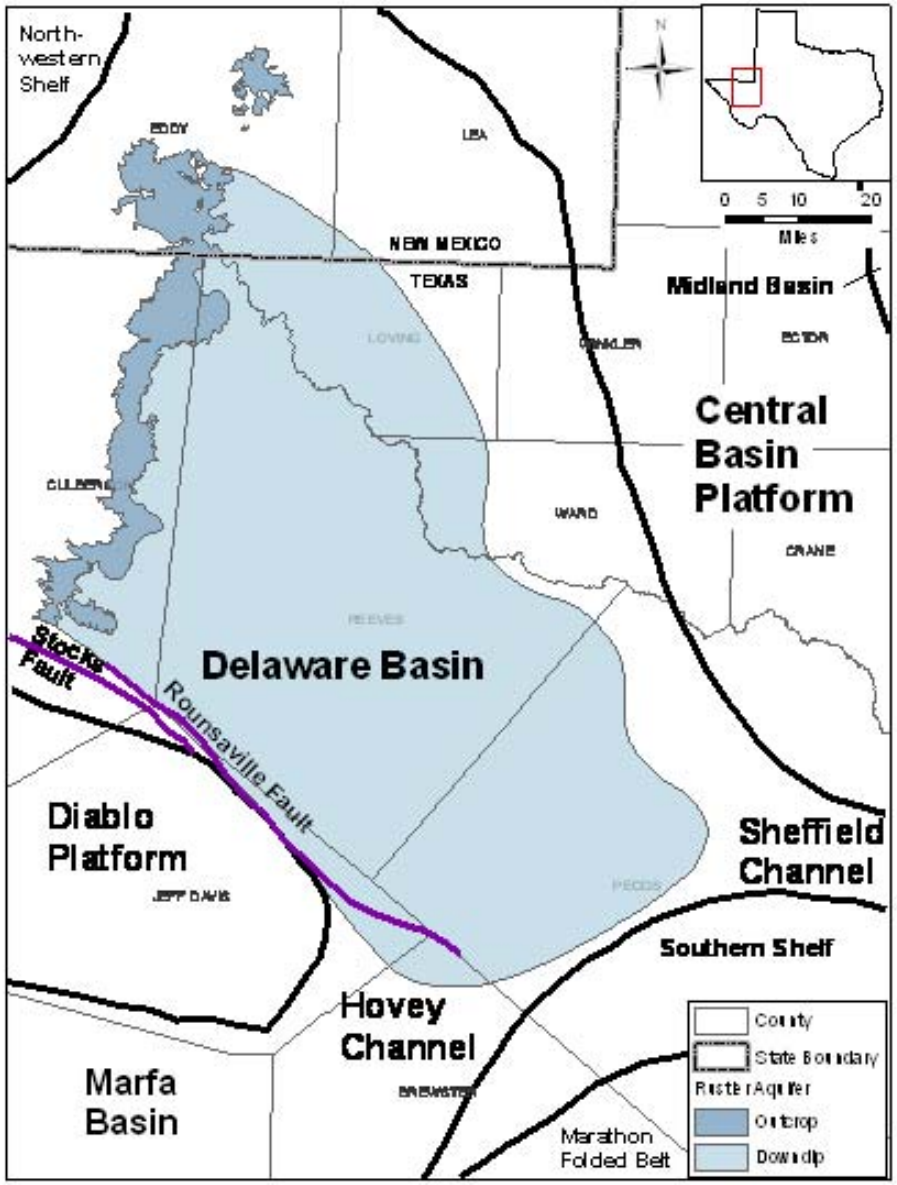
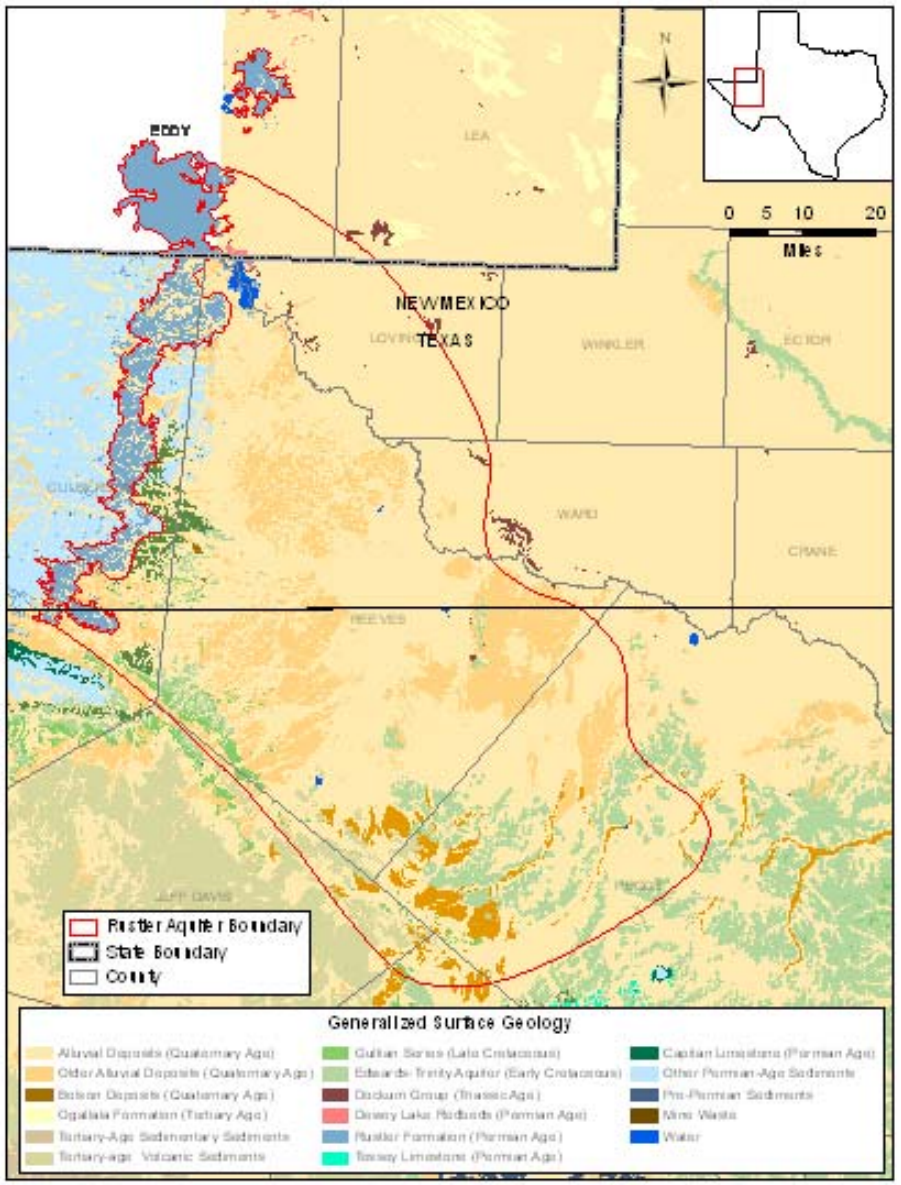
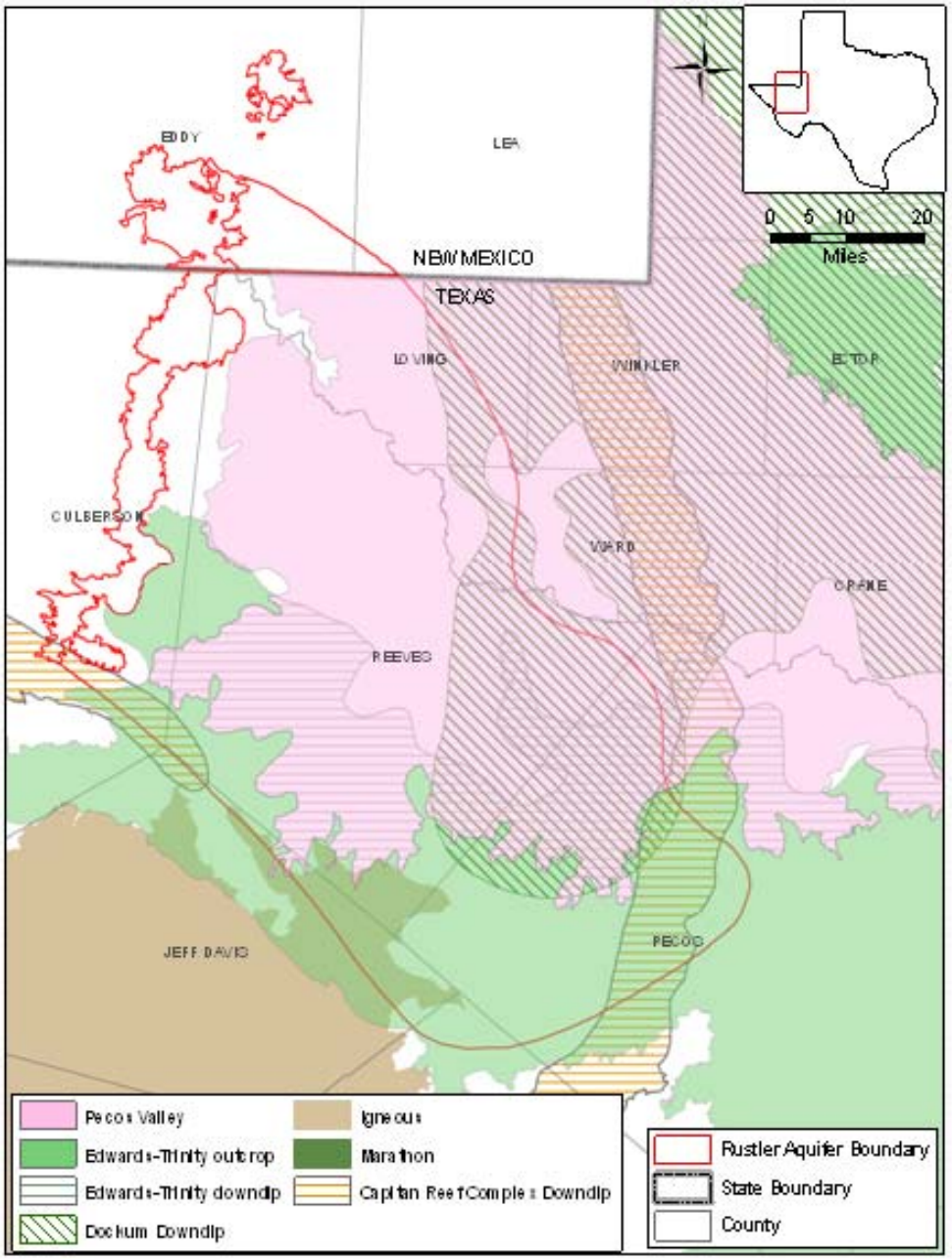
0 5 10 20
Miles
EDDY
LEA
NEW MEXICO
TEXAS
LOVING
WINKLER
ECTOR
CULBERSON
WARD
CRANE
REEVES
Davis Mountains
JEFF DAVIS
PECOS
Sierra Madera
Glass Mountains
Land Surface Elevation (feet)
2,271 - 2,500
2,501 - 3,000
3,001 - 3,500
3,501 - 4,000
4,001 - 4,500
4,501 - 5,000
5,001 - 5,500
5,501 - 6,000
6,001 - 6,500
6,501 - 7,000
7,001 - 7,500
7,501 - 8,000
8,001 - 8,500
Rustler Aquifer Boundary
County
State Boundary

Structure Features/Surface Geology

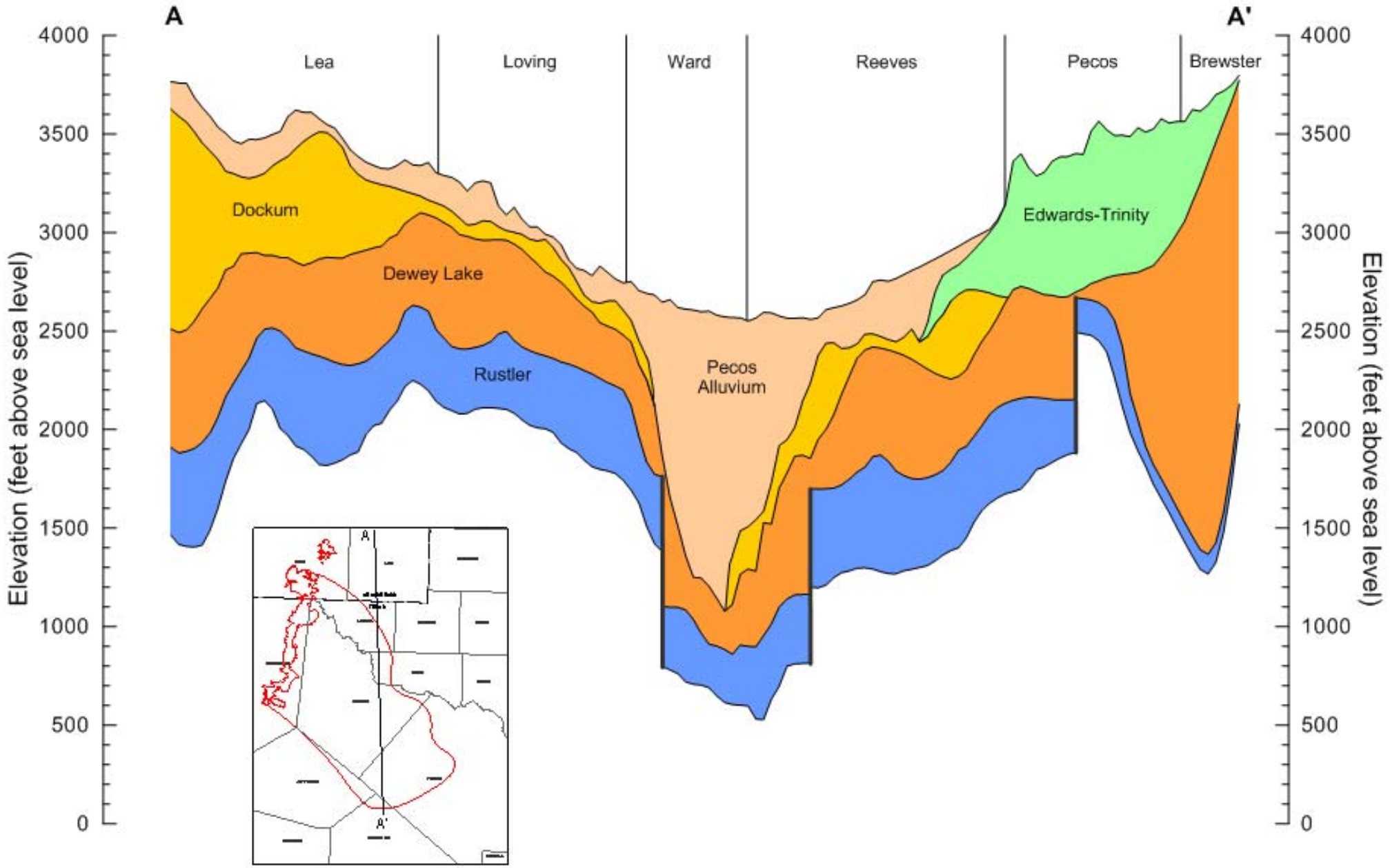




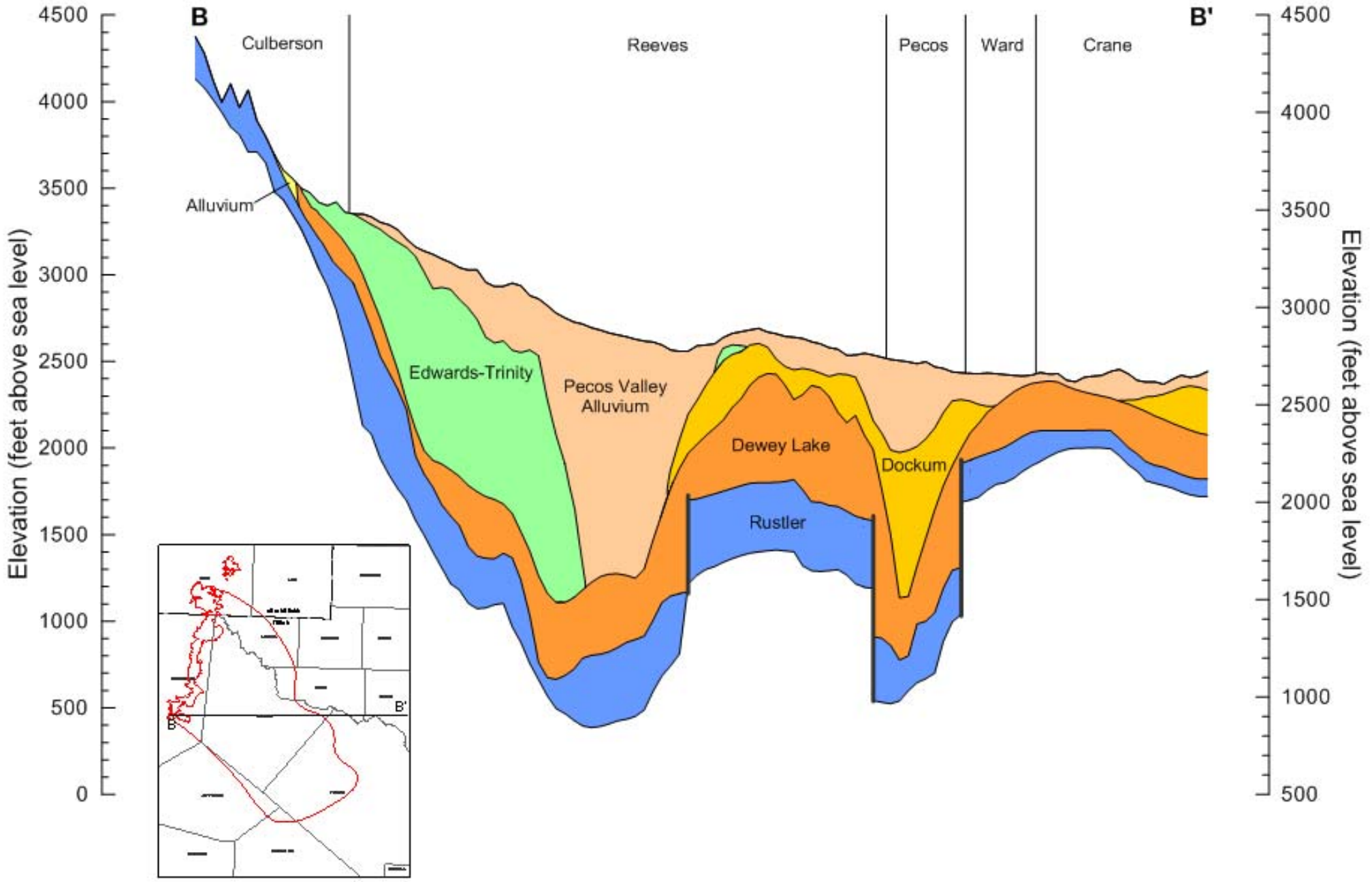
Other Aquifers in Vicinity



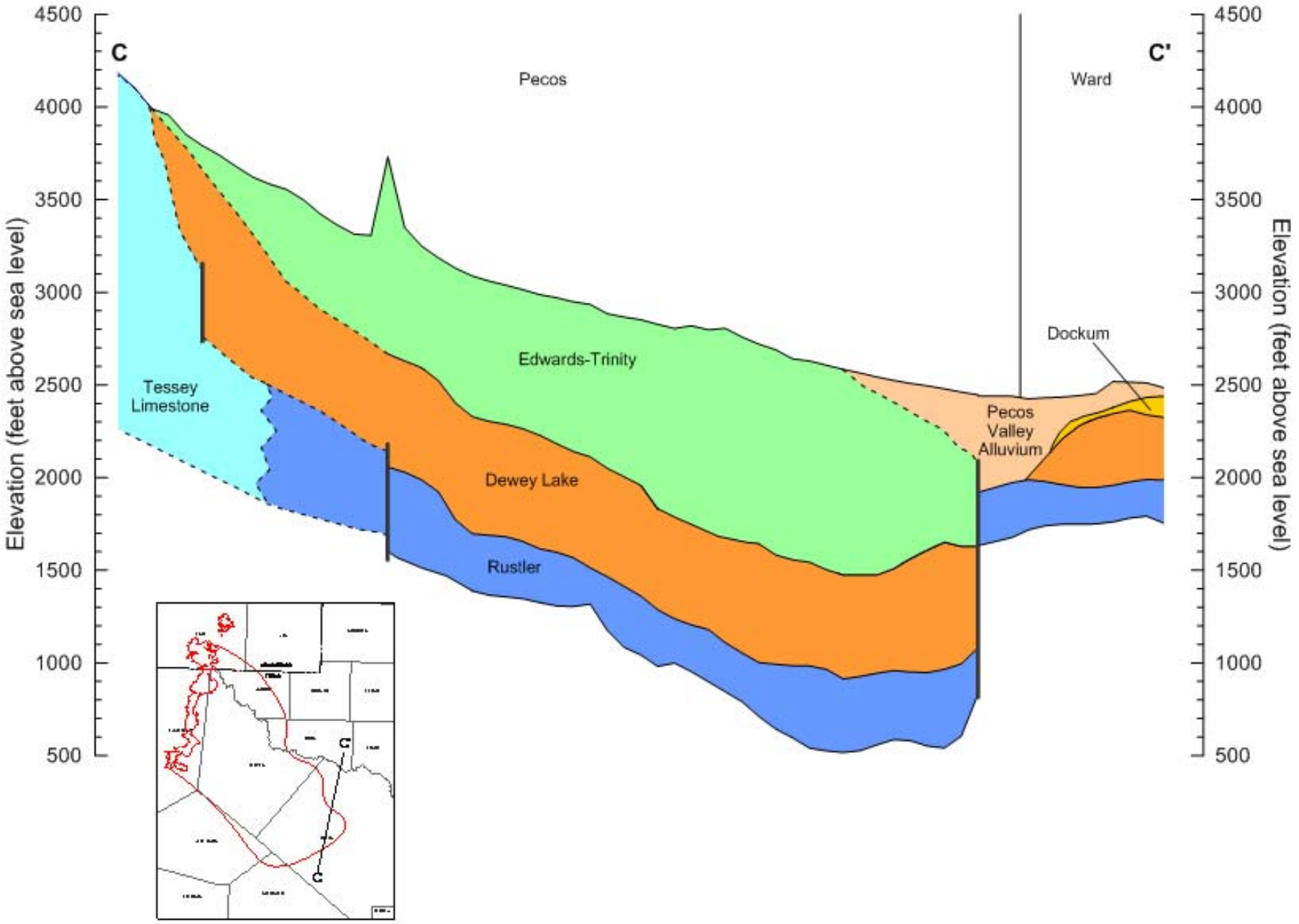
North-South Cross-Section



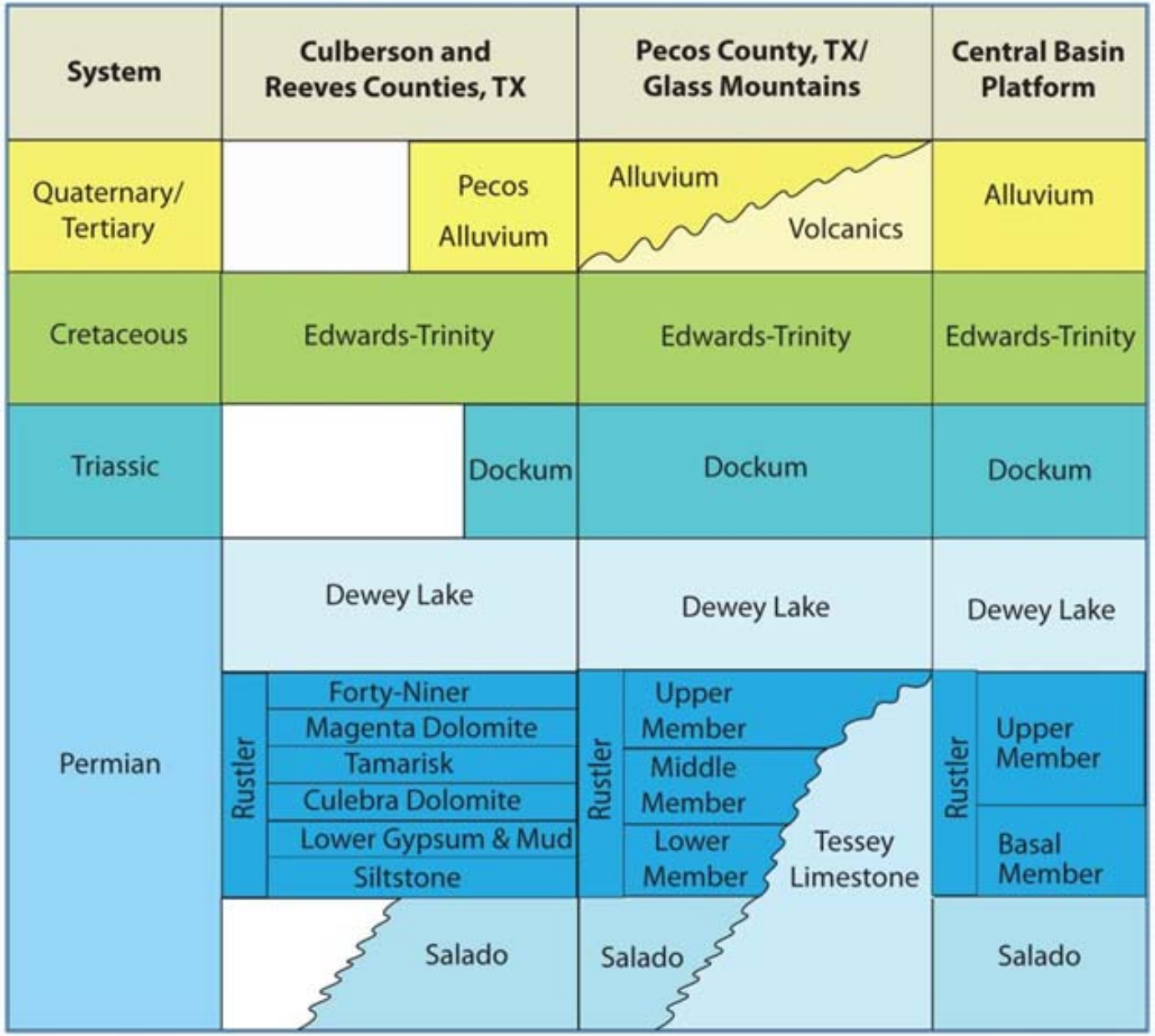
East-West Cross-Section



Southwest-Northeast Cross-Section



General Regional Stratigraphy



Rustler Stratigraphy

Culberson and Reeves County, Texas[1]		Pecos County, Texas[1]		Central Basin Platform[2]	
Member	Lithology	Member	Lithology	Division	Lithology
Forty-niner Member	two beds of massive and nodular anhydrite and gypsum separated by a thin gypsiferous mudstone or siltstone bed	Upper Member	locally calcareous and oolitic dolomite	Upper Member	anhydrite, salt, and sand with some dolomite
Magenta Member	interbedded dolomite and gypsiferous dolomite				
Tamarisk Member	two beds of massive and nodular anhydrite and gypsum spearated by a gypsiferous mustone bed	Middle Member	calcareous siltstone, sandstone, shale, with interspersed anhydrite, gypsum, and shale; locally massive anhydrite and gypsum, and		
Culebra Member	locally brecciated laminated dolomite				
Lower gypsum and mudstone member	mudstone and gypsum interspersed with thin gypsiferous dolomite beds	Lower Member	locally calcareous, argillaceous, oolitic, or sandy dolomite	Basal Member	sand, congomerate and variegated shale
Siltstone member	dolomitic silstone and mudstone in lower part with dolomite at top				

[1] after Boghici and Van Groekhoven (2001)
[2] Dockery (1989)

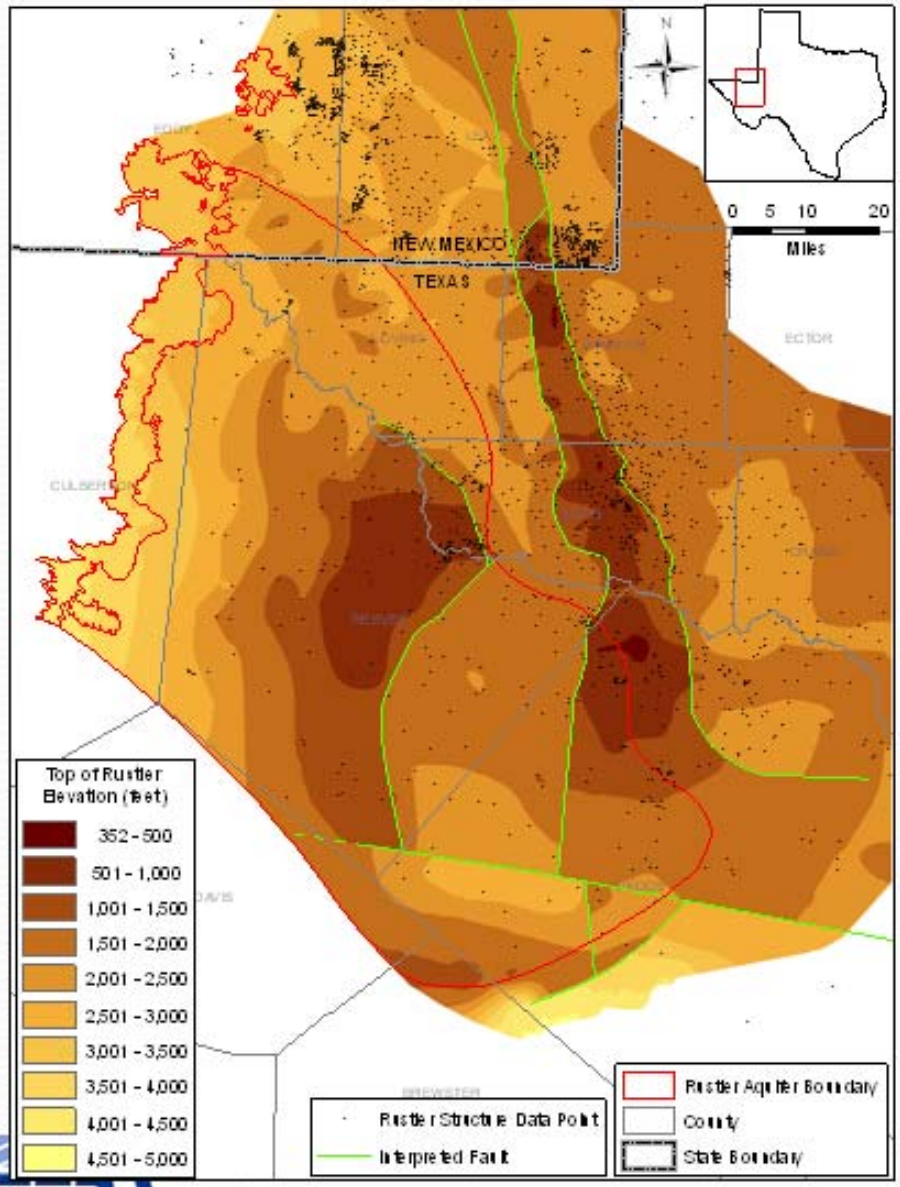
Rustler Structure

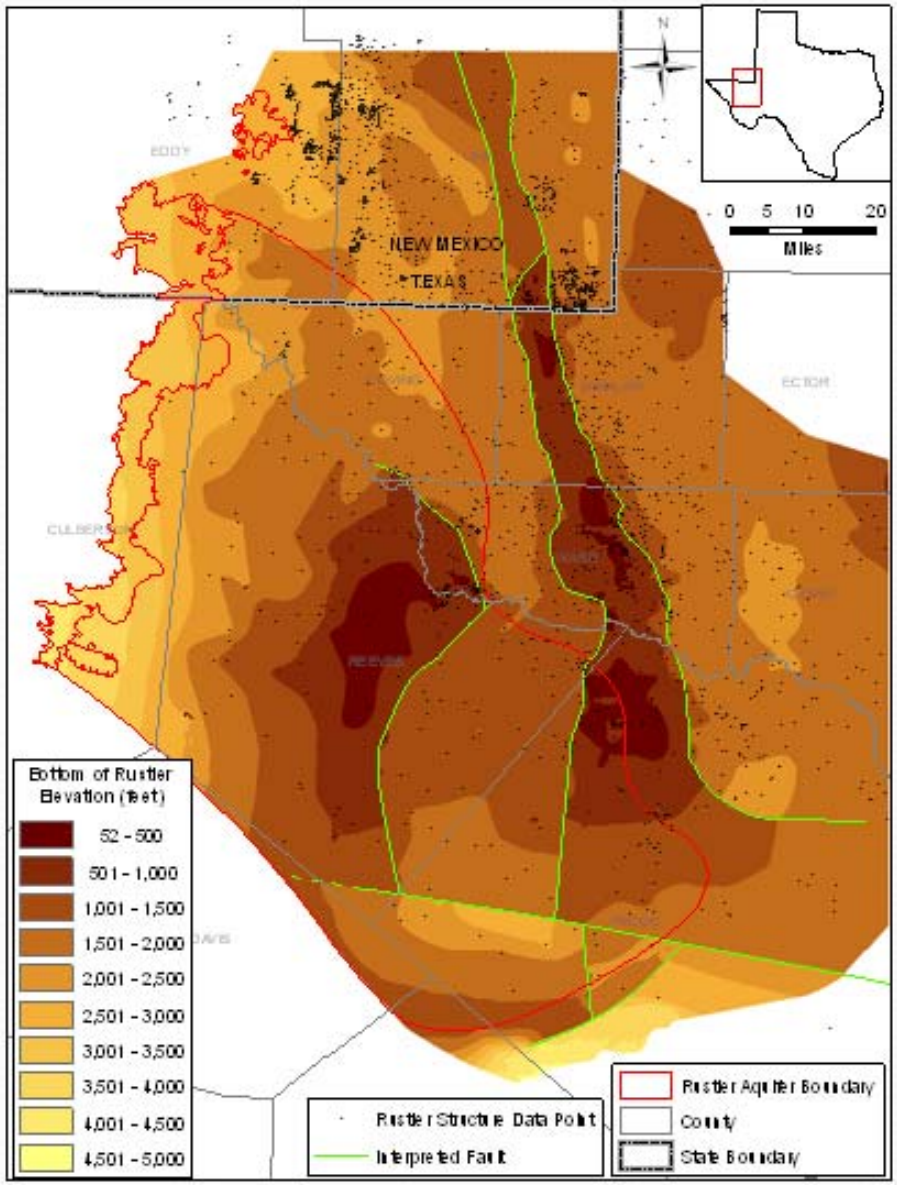
- Objectives
  - Develop the structure for the top and bottom of the Rustler Formation
  - Develop some insight into internal stratigraphy for a proxy for property definition
  - Also required Dewey Lake and Dockum for upper model layer

Rustler Structure Sources

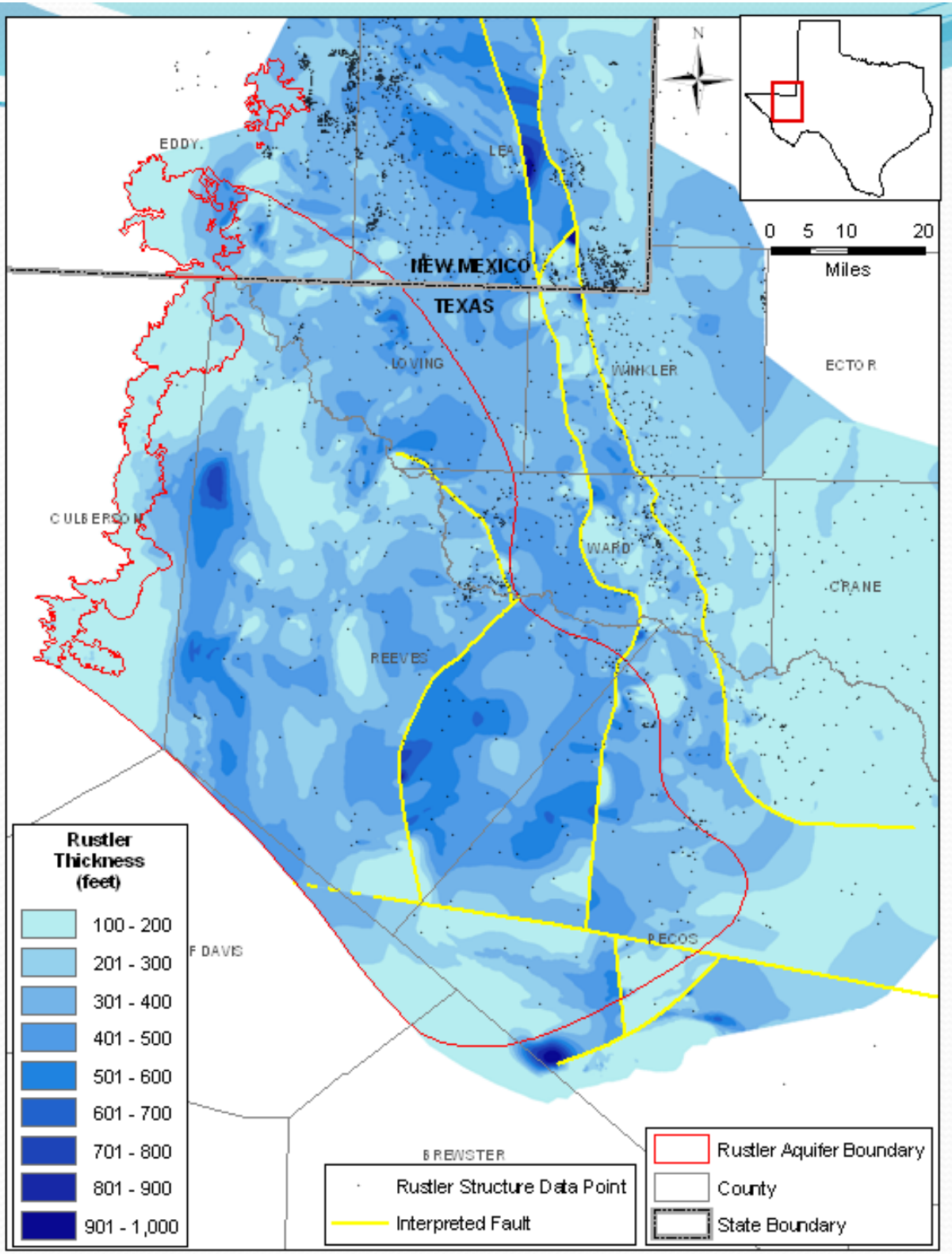
- Hiss (1976)
- 2,305 electric logs interpreted by Powers in this study
- 1,953 electric logs interpreted by BRACs (Myers)
  - Younger interval contacts from BRACs
  - Known collisions with current GAMs
- Hand contoured surfaces that were later digitized

Rustler Top & Bottom Elevations



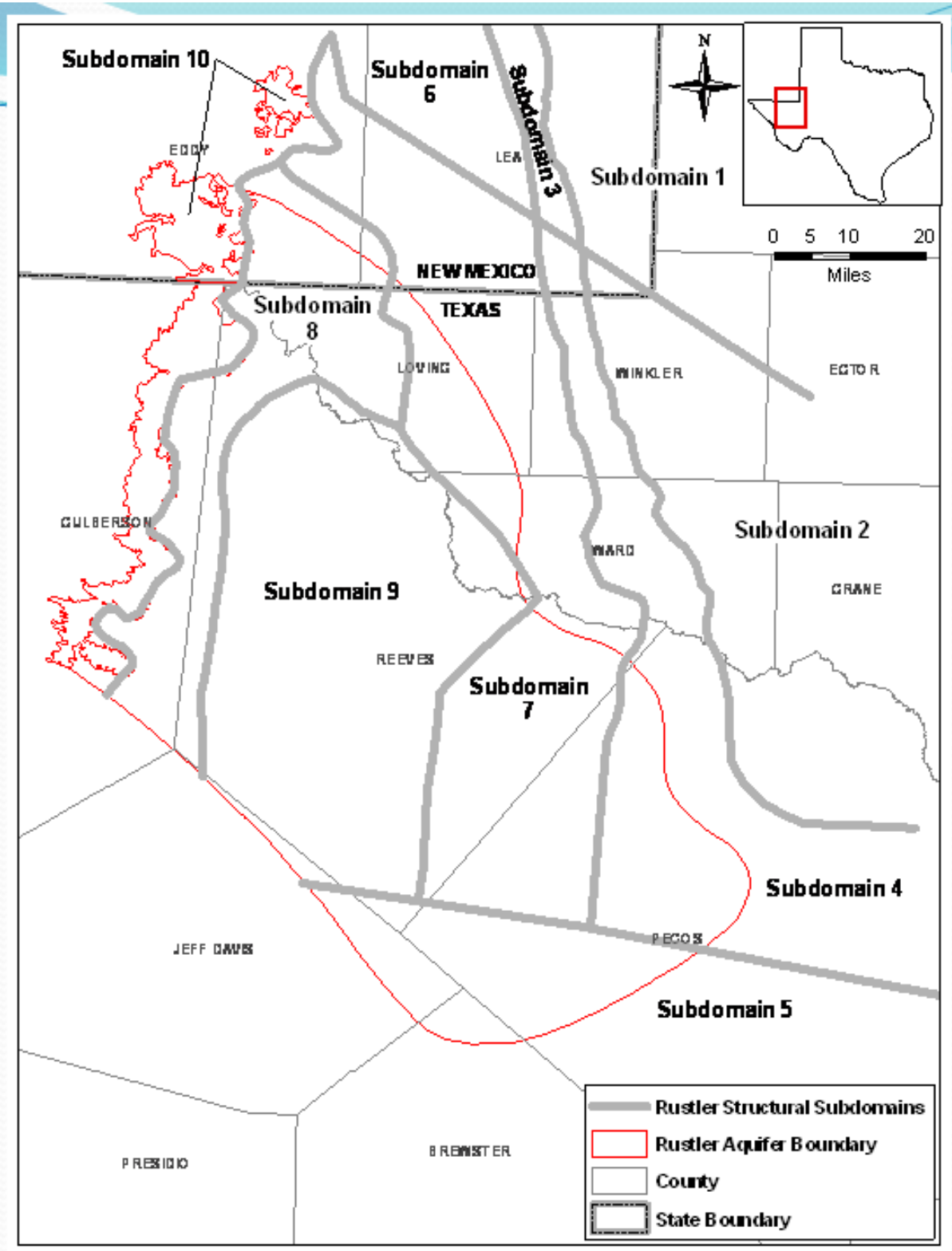


Rustler Thickness



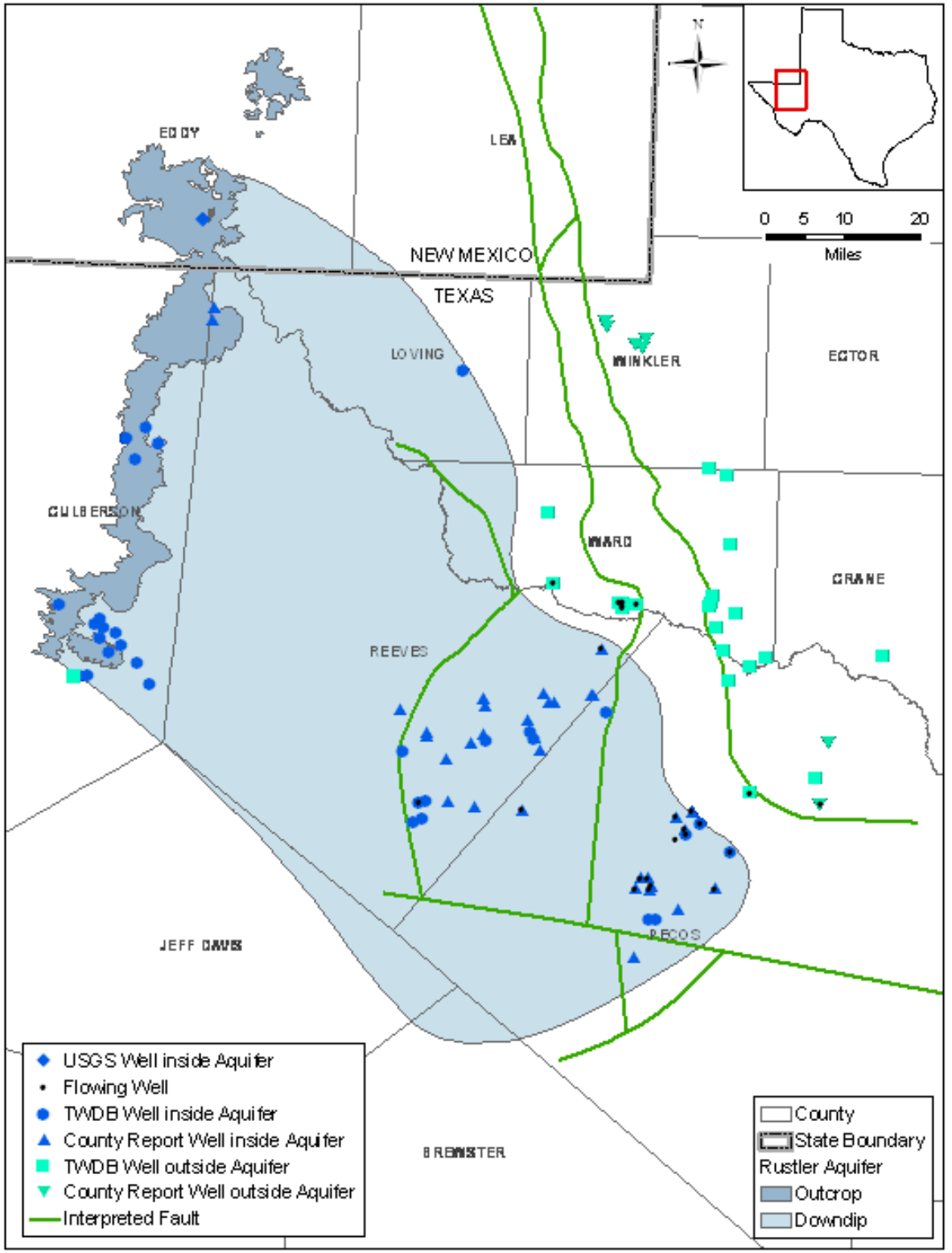
Structural Domains

- Zones defined as being structurally similar based upon
  - Outcrop/subcrop
  - Depth of burial
  - Aquifer stratigraphy/ mineralogy
  - Salado dissolution



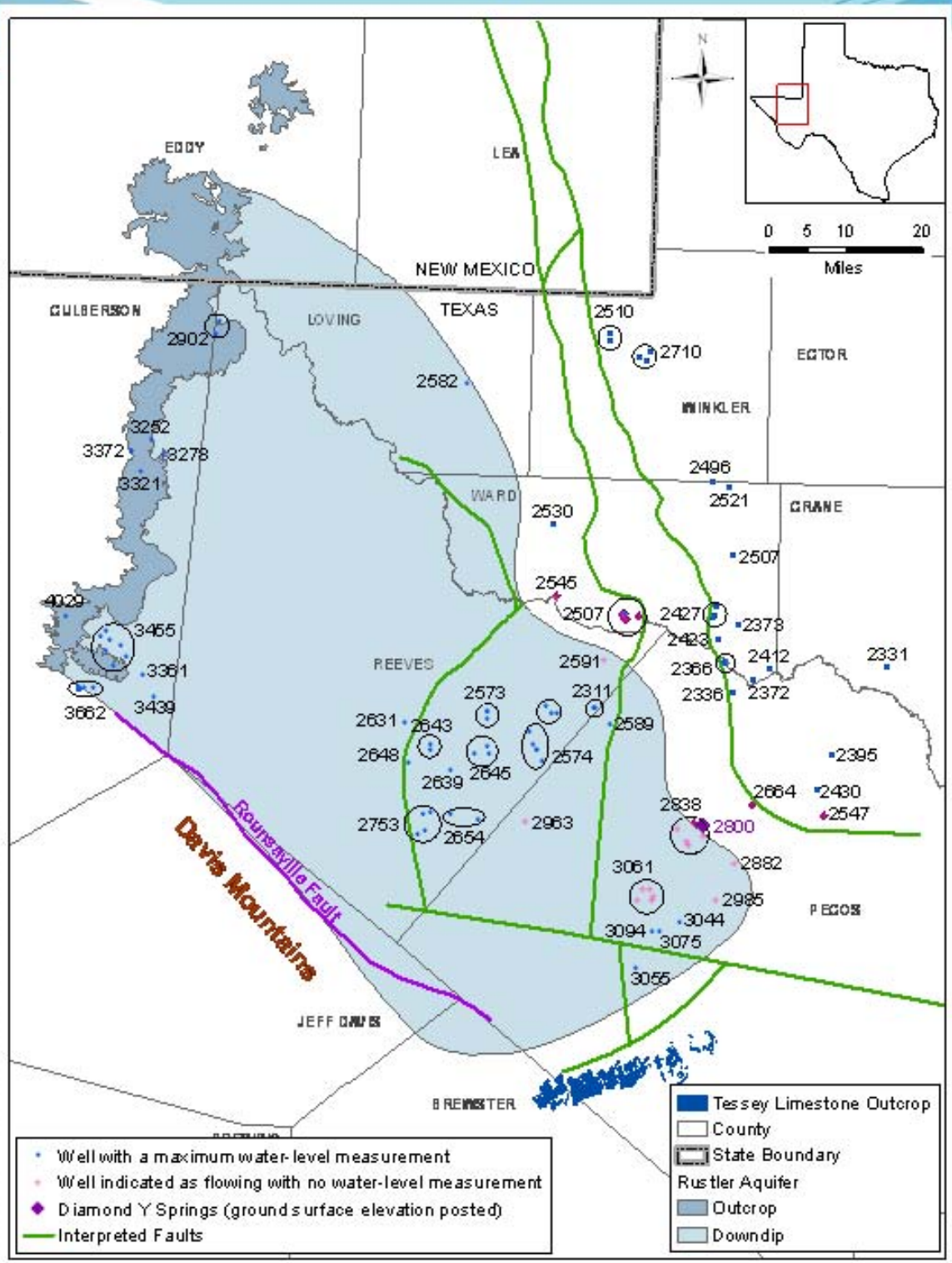
Rustler Groundwater Data

- Sources
  - TWDB gw database
  - County reports
  - USGS water-level data
- Amount
  - 100 wells with water level data
  - 326 water-level measurements

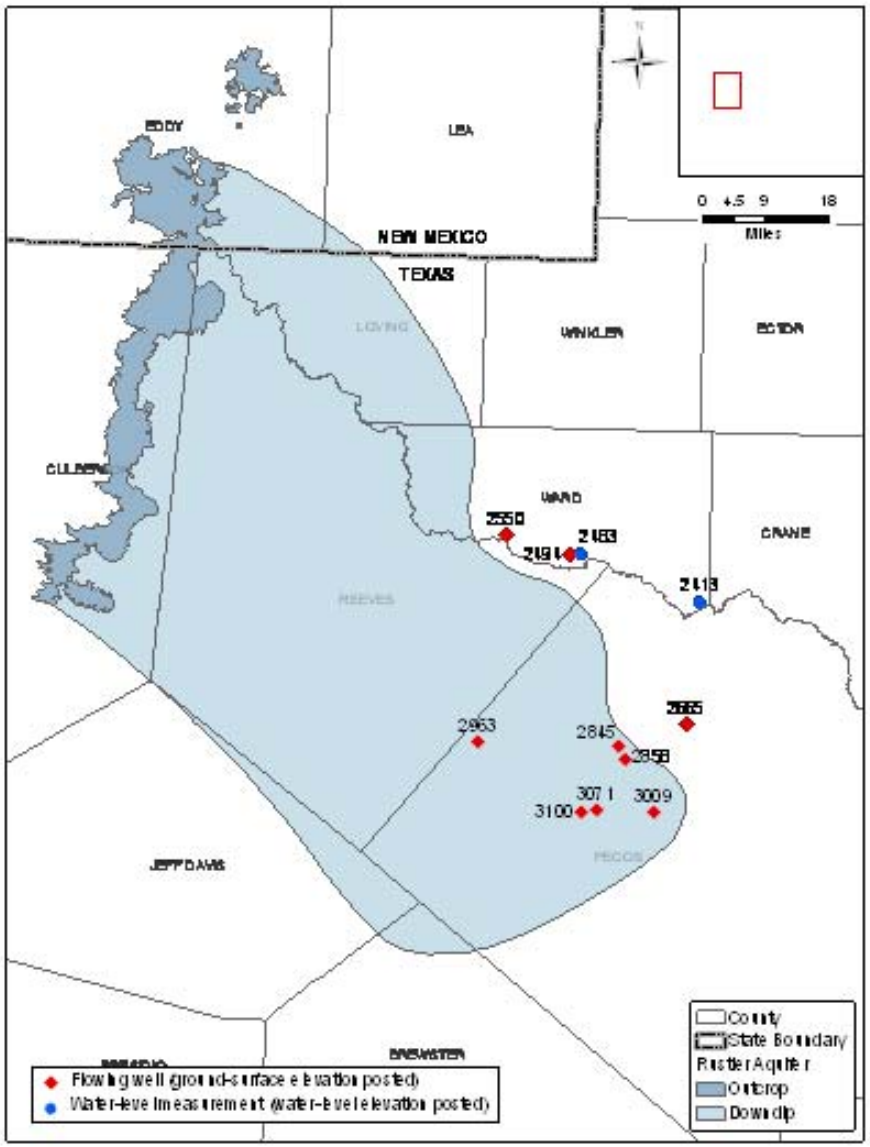


Groundwater Flow

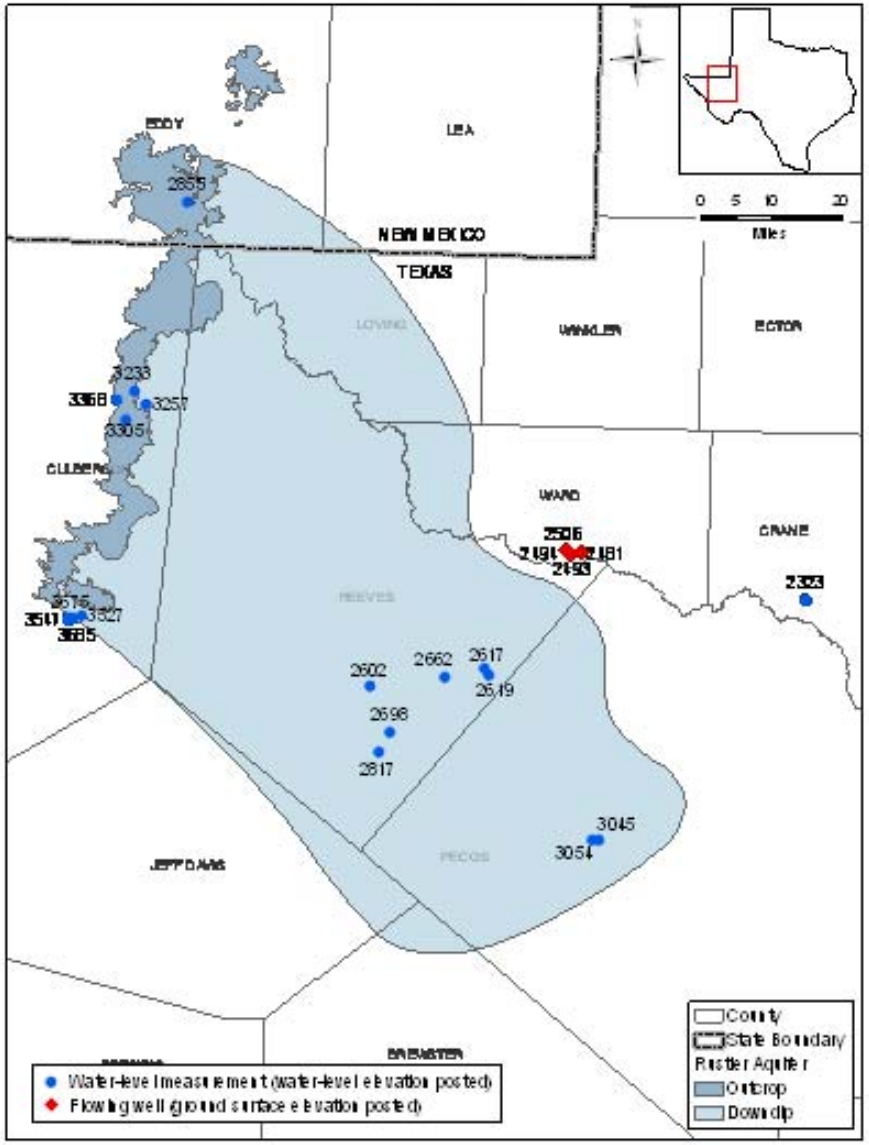
- Many originally flowing wells
- Many high capacity wells in southern portion of graben
- Some areas had dry holes before the practice of acidizing
- Groundwater flow directions
  - from outcrop to the east
  - from Glass Mountains to the north
  - southward from New Mexico and Panhandle
- Cross-formational flow
  - from Rustler into overlying Pecos Valley and Edward-Trinity aquifers
  - possibly from underlying Capitan to Rustler



Rustler Heads



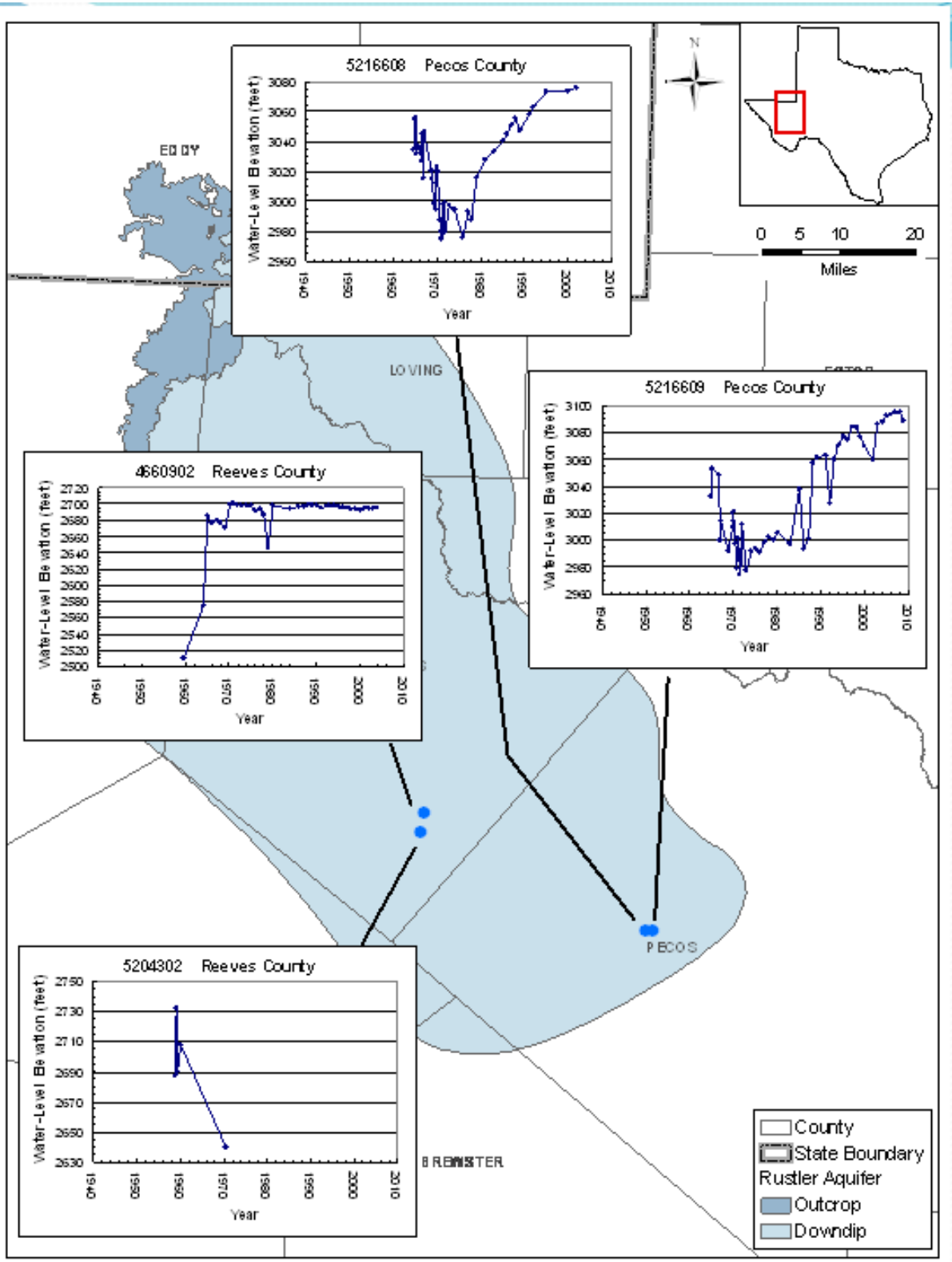
Predevelopment Data



1990 Average Data

INTERA

Hydrographs



Rustler Recharge/Discharge

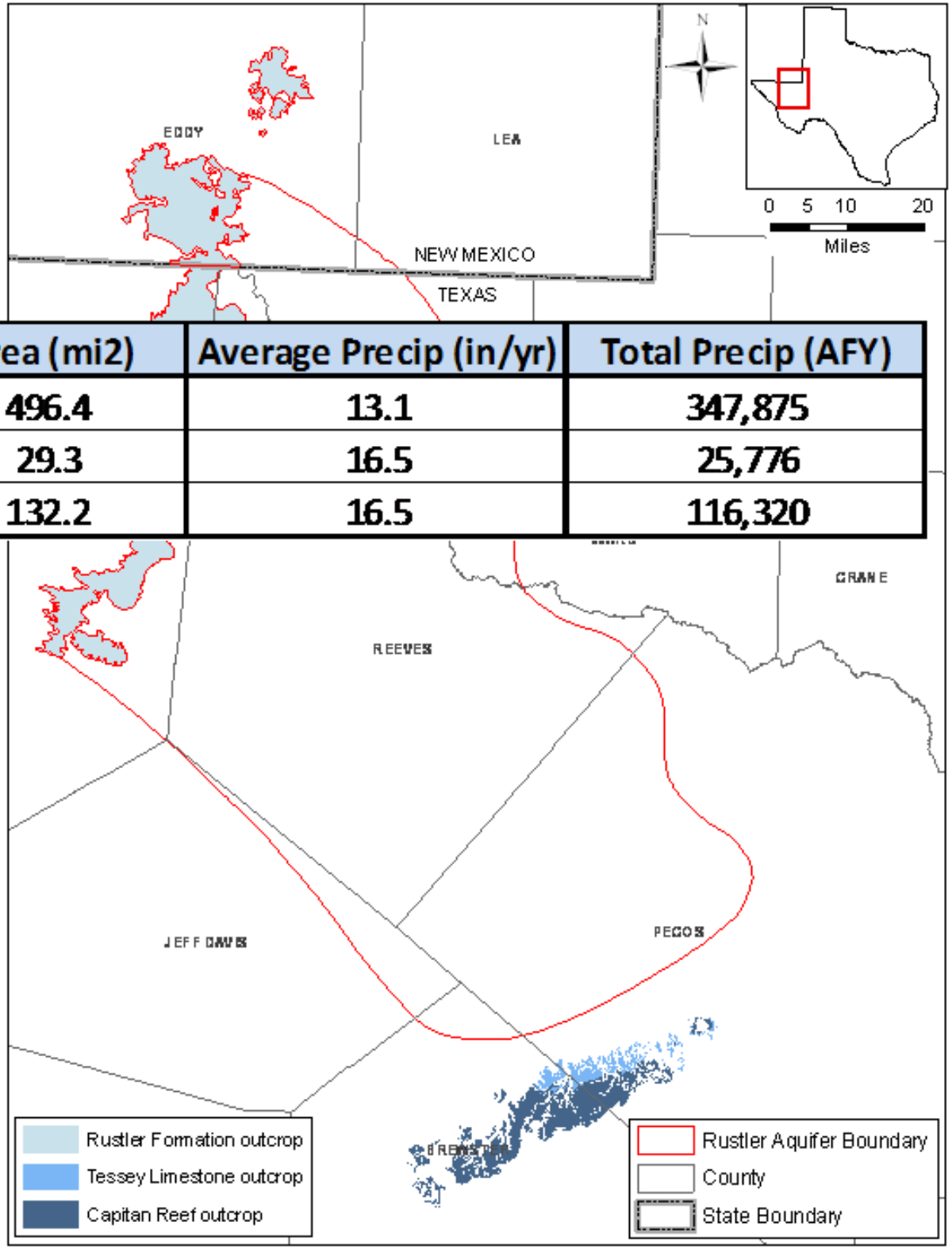
- Recharge potentially occurs through
  - Direct infiltration of precipitation
  - Cross-formational flow (documented to be important)
  - Runoff redistribution considered less important conceptually as compared to igneous bolson aquifers
- Information is incomplete to attempt to balance inflows/outflows in a traditional water balance approach

INTERA

Recharge Areas

Outcrop	Area (mi2)	Average Precip (in/yr)	Total Precip (AFY)
Rustler	496.4	13.1	347,875
Tessey Limestone	29.3	16.5	25,776
Capitan	132.2	16.5	116,320

- Tessey Limestone has karst/caverns
- Epikarst could expand the recharge area for Tessey with cross-formational flow and elevation drive



Bounding Calculations

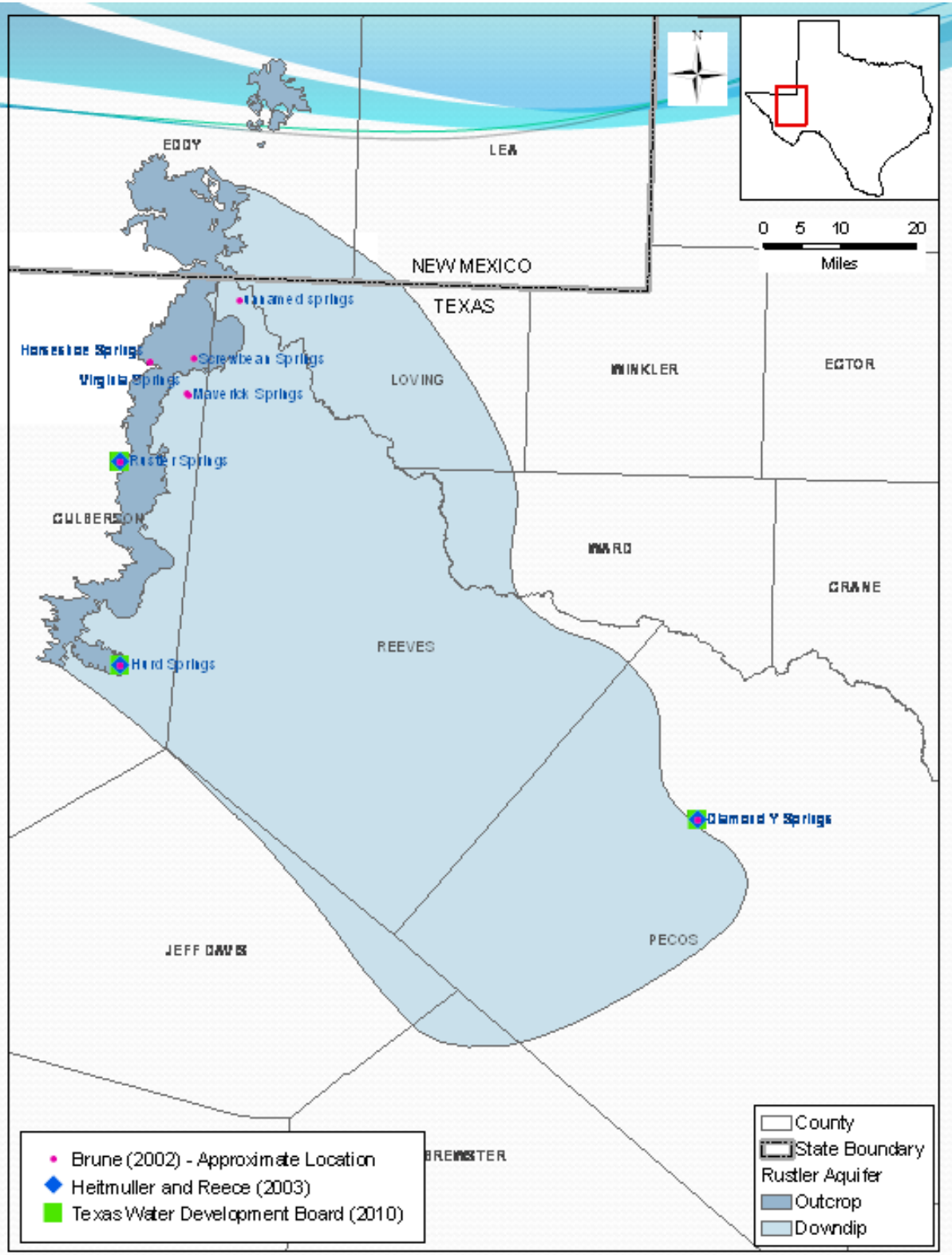
Characteristic	Units	Salt	Pecos	Rio Grande	Total
Total Precip	**AFY**	**2,111,077**	**1,512,759**	**1,798,709**	**5,422,545**
Total Precip	**in/yr**	**15.8**	**15.8**	**15.6**	
One percent rule	AFY	21,111	15,128	17,987	54,255
Runoff-Redistribution	AFY	25,389	28,741	13,810	67,940
Runoff-Redistribution	% of Precip	1.20%	1.90%	0.77%	1.25%

	Recharge Expressed as a Fraction of Avg. Annual Precipitation			
Outcrop	0.77 Percent	1 Percent	2 Percent	10 Percent
Rustler	**2,679**	**3,479**	**6,958**	**NA**
Tessey Limestone	**198**	**258**	**516**	**2,578**
Capitan	**896**	**1,163**	**2,326**	**11,632**

Natural Aquifer Discharge

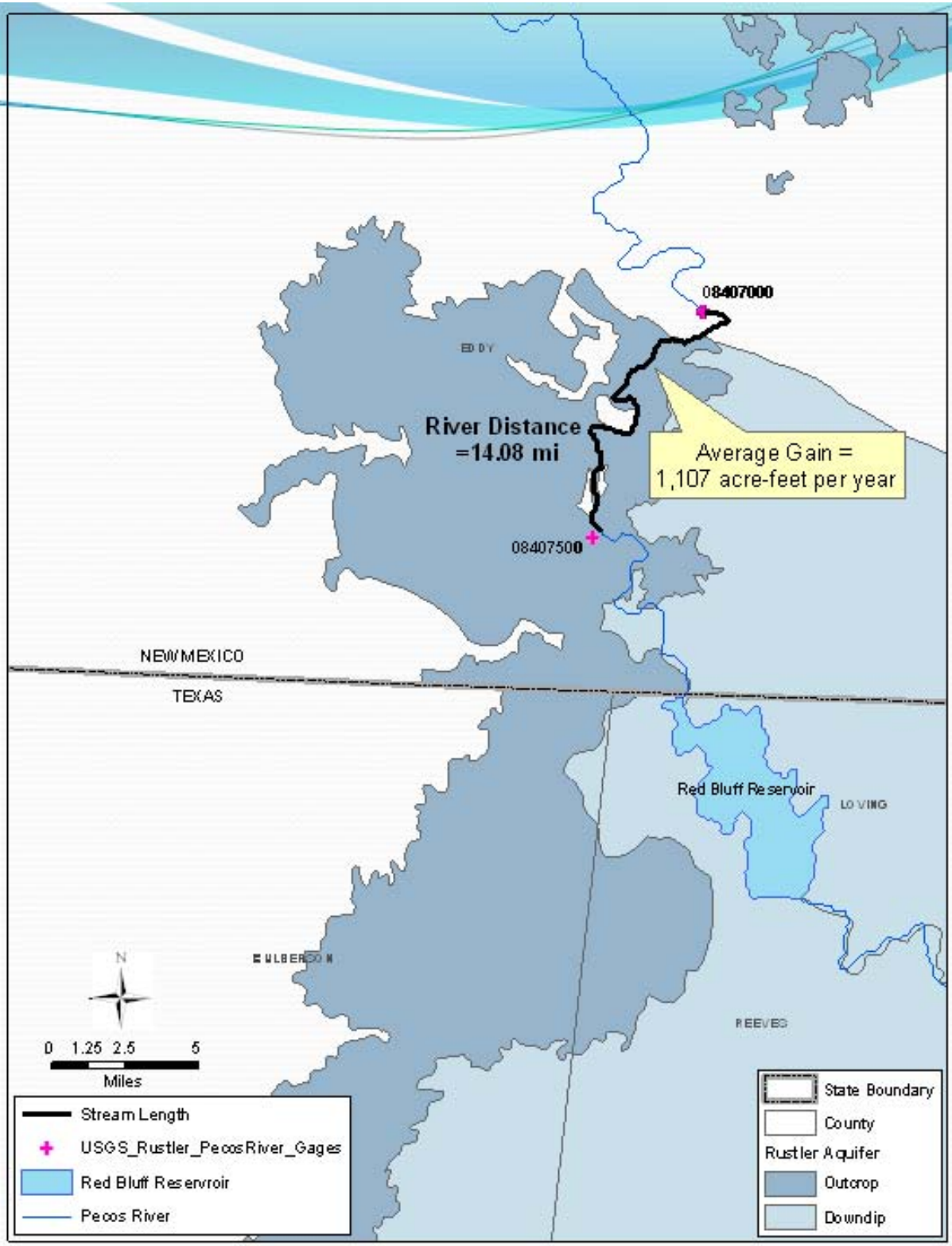
Discharge Mechanisms:

- Springs
- Baseflow
- Cross-formational flow
- ET in outcrop



Groundwater Discharge to Pecos in Outcrop

Equates to approximately 0.74 inches/year



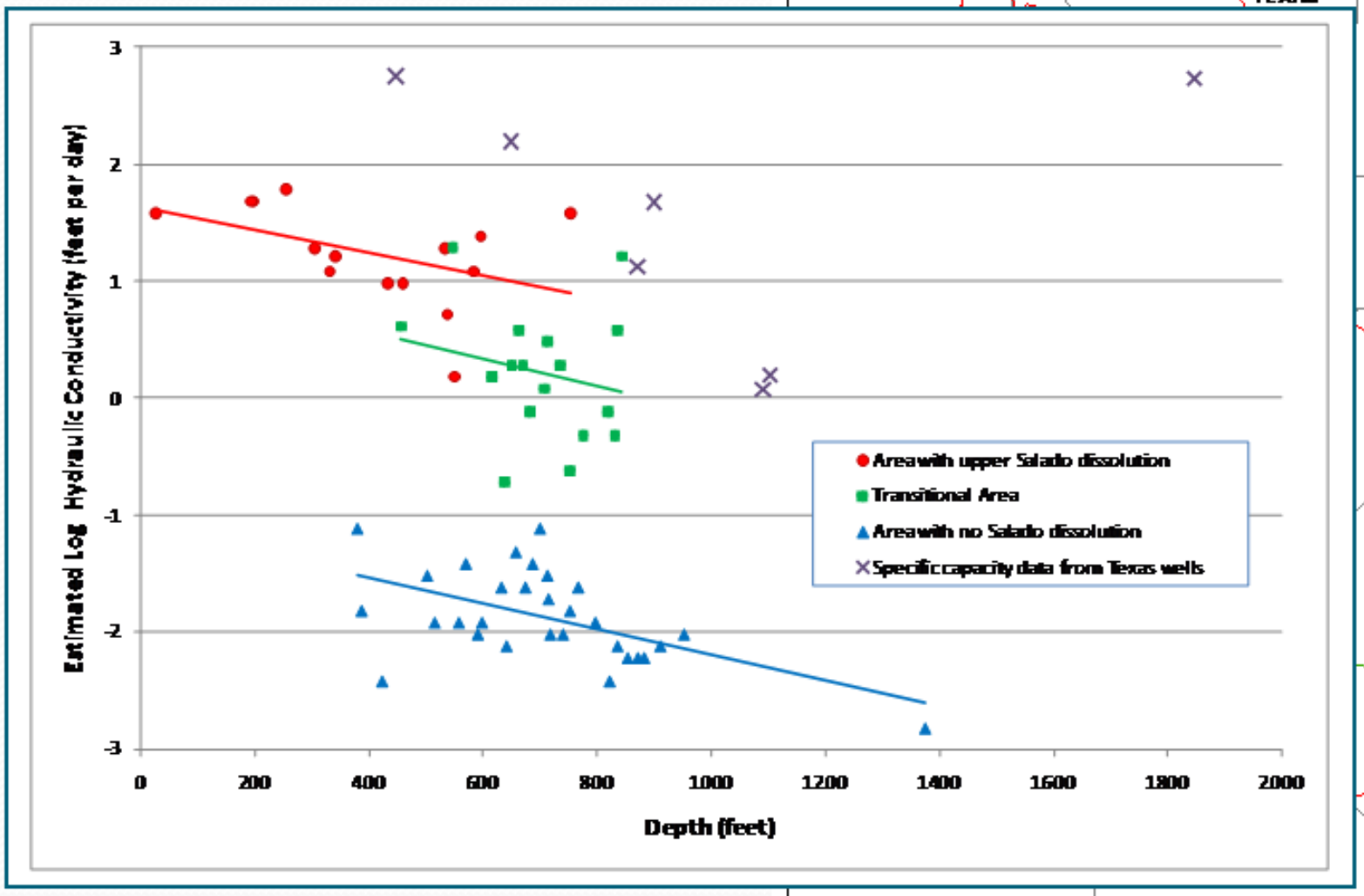
Natural Discharge ?

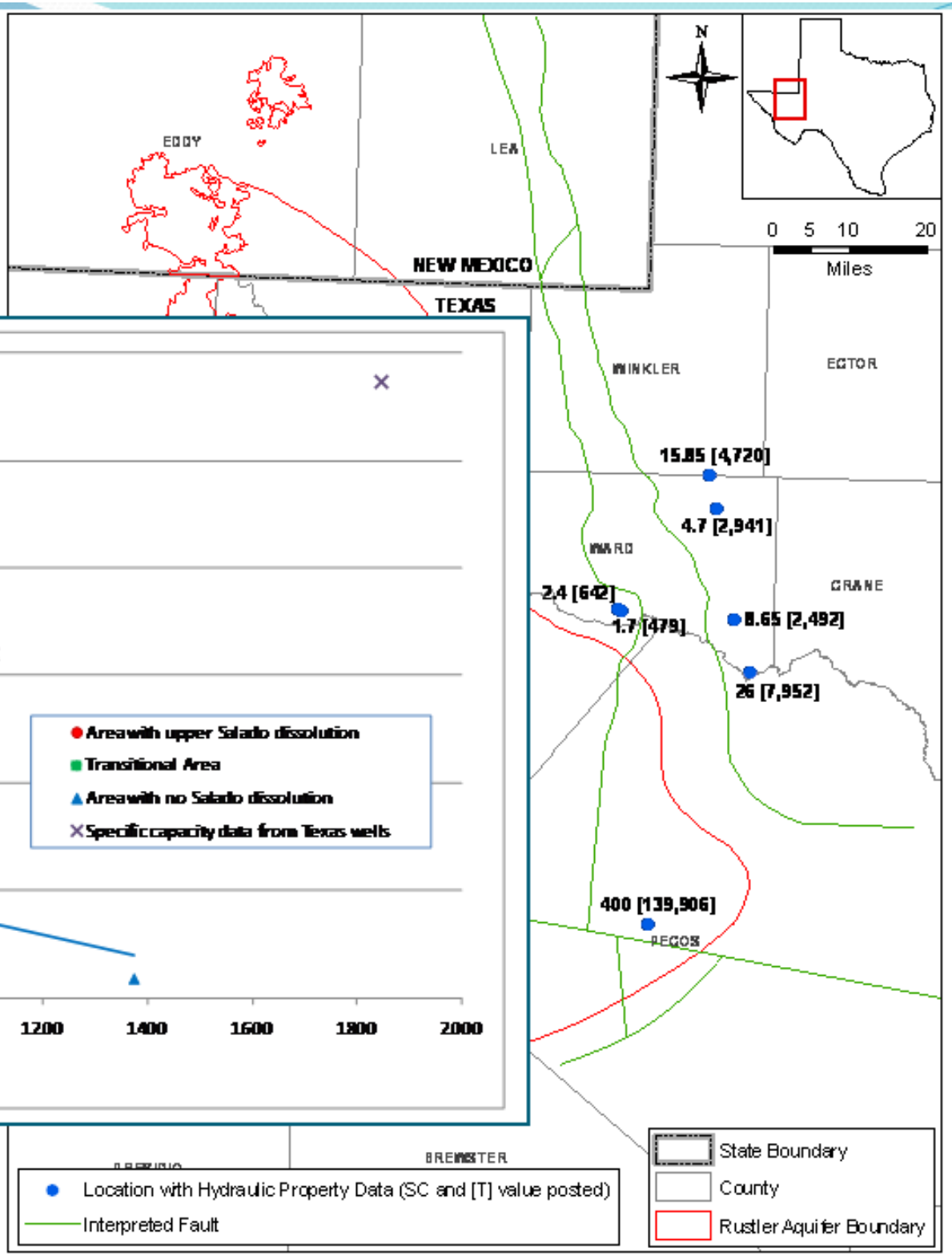
Rustler Properties

- Very little available data in Texas
  - 7 specific capacity measurements – WIID and Myers (1969)
  - TCEQ search yielded no data
- WIPP dataset focused upon Culebra
  - Properties found to be dependent upon 3 regional factors
    - Depth of burial (overburden thickness)
    - Presence of halite in the Rustler
    - Dissolution of the underlying Salado

INTERA

Property Data

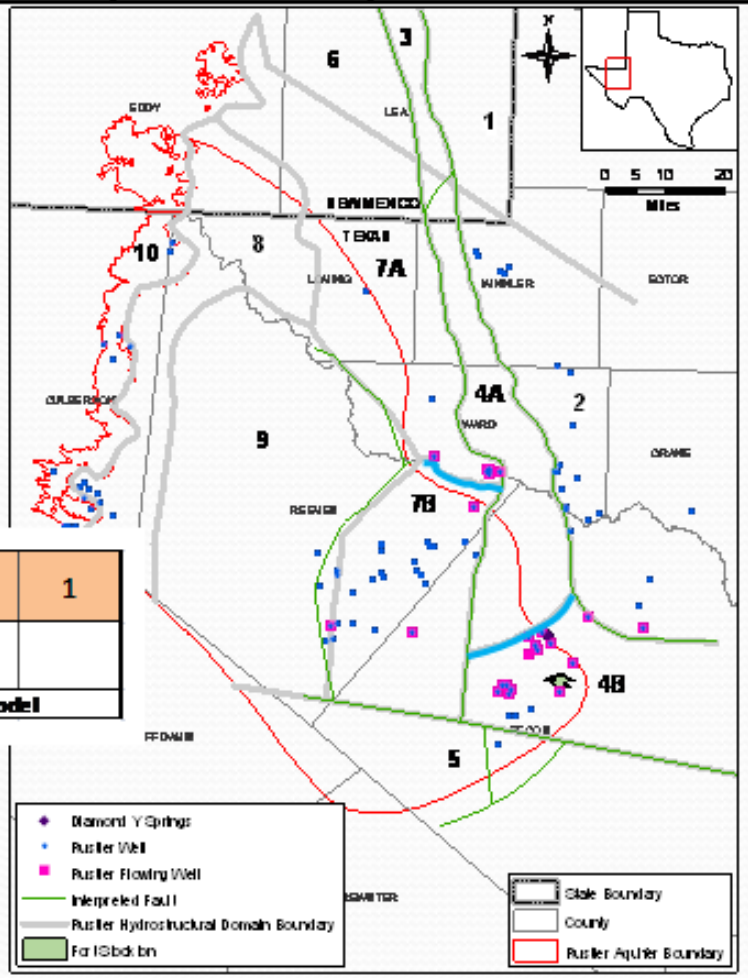




Subdomain	Upper Salado Dissolution	Presence of Rustler Halite	Thickness of Overburden	Observed Transmissivity Range (ft2/day)	Comments
1	None	Yes	Applicable	Non reported	Very tight and outside active model domain
2	Rare	Unknown	Applicable	2,941 to 7,952	Some productivity in Ward County, acidized?
3	Yes	Likely	Applicable	Non reported	Very tight and outside active model domain
4a	**Yes**	**None**	**Applicable**	**Non reported**	**Very deep, thick Dewey Lake, likely isolated**
4b	**Yes**	**None**	**Applicable**	**139,906**	**Very productive area, flowing wells and springs from Rustler**
5	**Not Applicable**	**Not Applicable**	**Applicable**	**Non reported**	**Tessy outcrop, Kartsic limestone**
6	None	Yes	Applicable	0.04 to 1.9	Very tight and outside active model domain
7a	**None**	**None**	**Applicable**	**4.4 to 1,474**	**May have to impose a decreasing trend west to east and to south**
7b	**Likely**	**None**	**Applicable**	**Non reported**	**Higher transmissivity due to increase dolomite and basal sand**
8	**Yes**	**None**	**Applicable**	**Non Reported**	**Thin to absent Dewey Lake**
9	**Yes**	**None**	**Applicable**	**Non reported**	**Western edge has Upper Salado dissolution – other unknown**
10	**Yes**	**None**	**Not Applicable**	**Non reported**	**Rustler outcrop – Karst features in places**

Use these hydrostructural domains and the controls on transmissivity to inform and constrain calibration

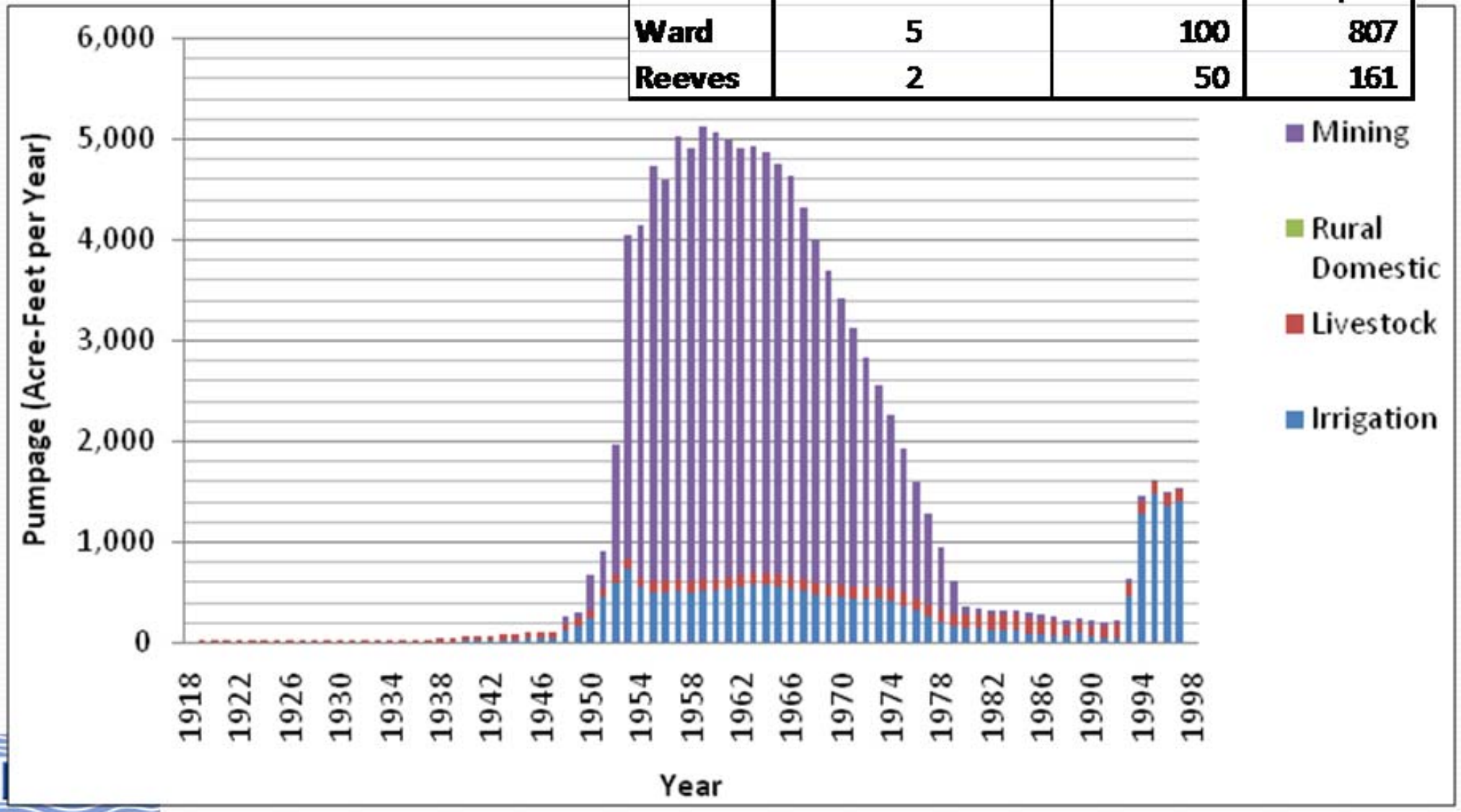
Hydrostructural Subdomain	5	4B	10	8	2	7B	7A	9	4A	6	3	1
Transmissivity (ft^2/day)	100,000		10,000						10	0.01		
Classification	Aquifer		Aquifer						Unknown	Outside Model		



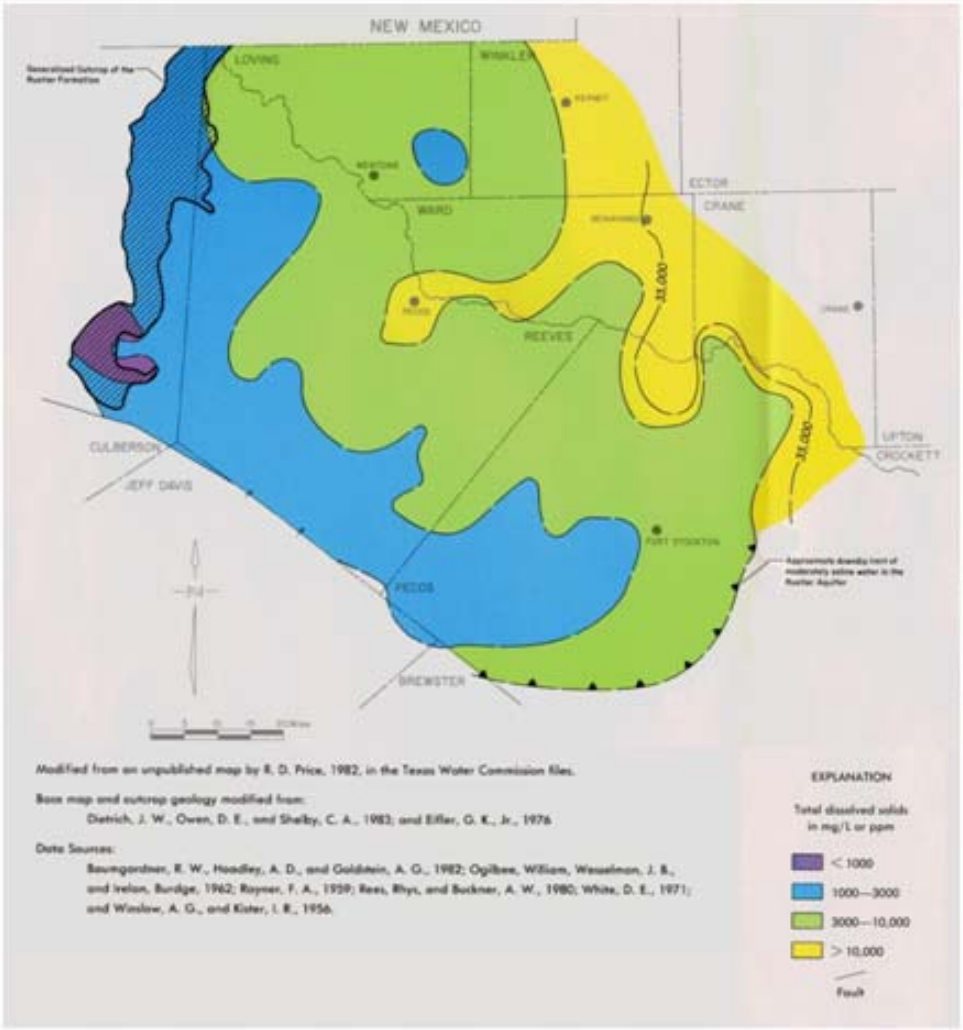
Pumping

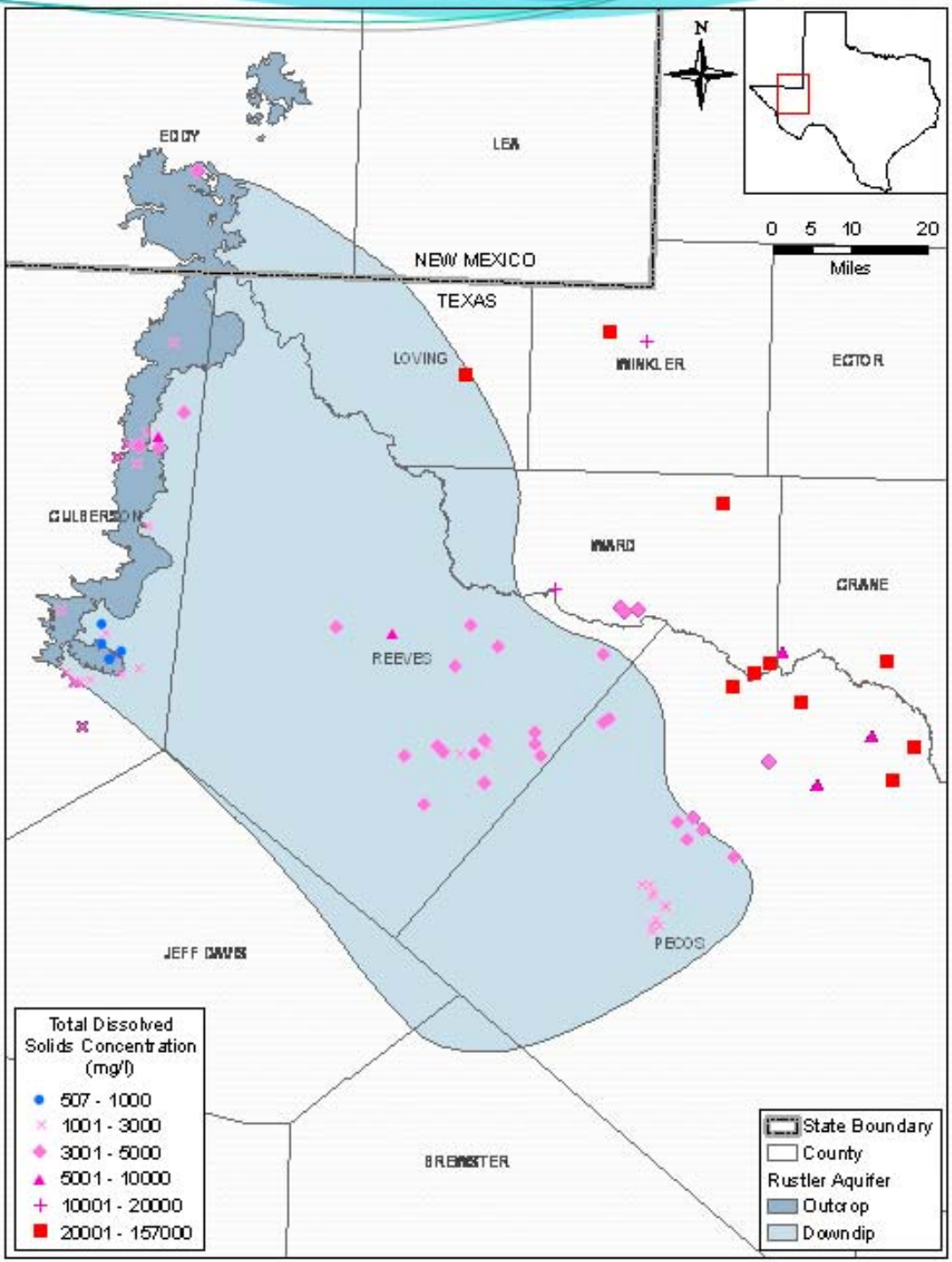
Flowing Wells and their impact

County	No. Flowing Wells	gpm/well	AFY
Pecos	15	500	12,107
Ward	5	100	807
Reeves	2	50	161

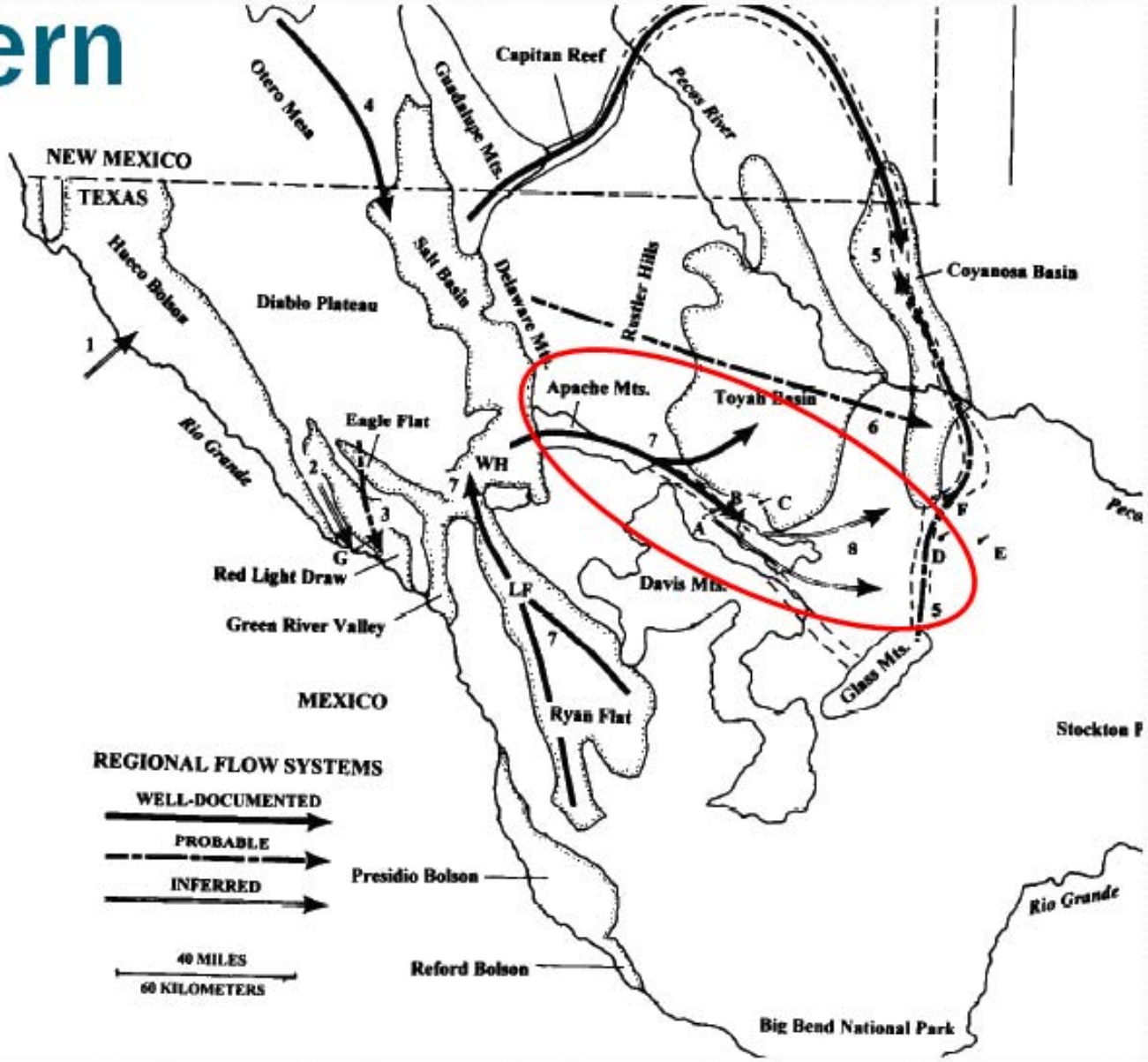


Water Quality



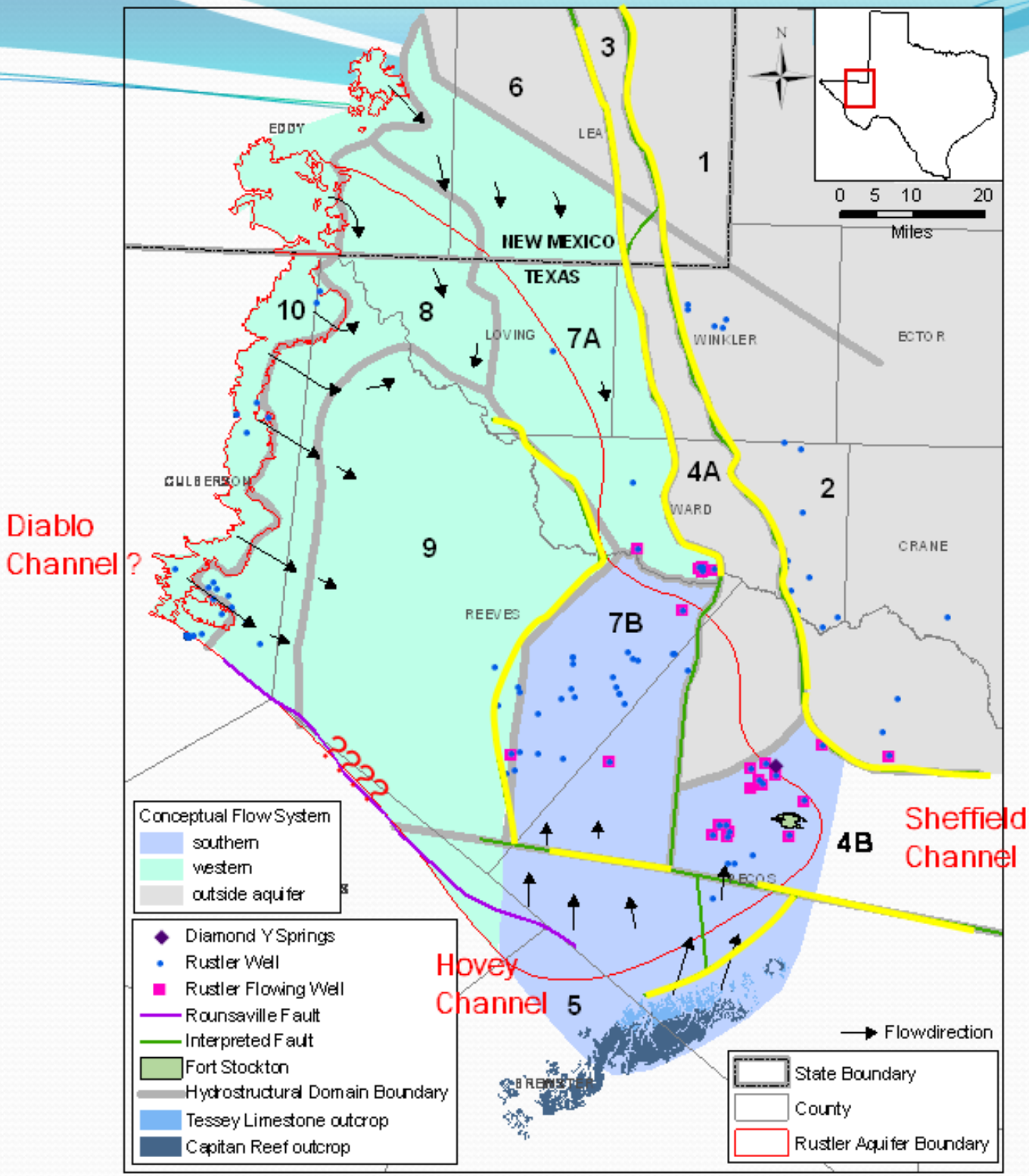


Southwestern Boundary

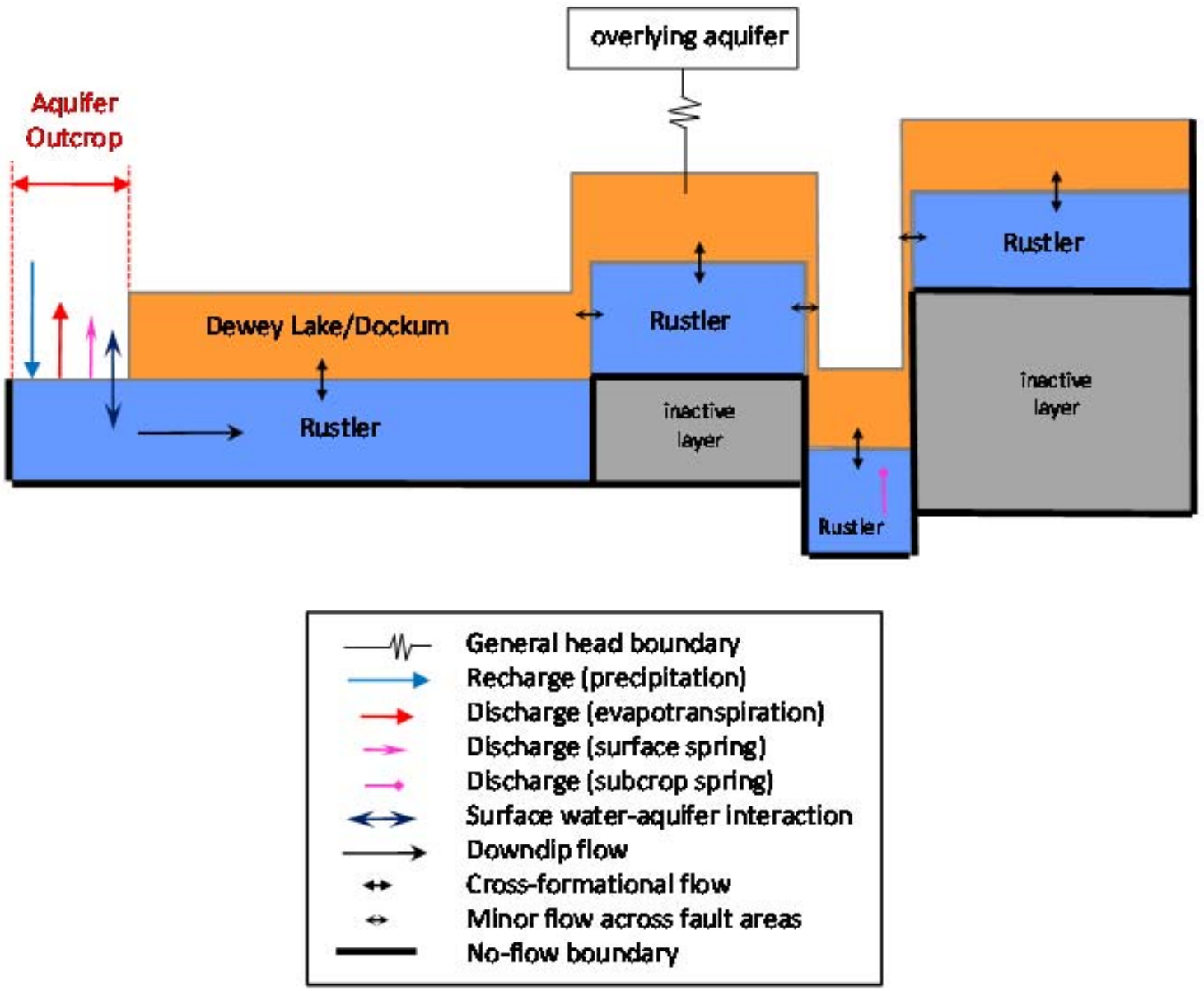


Sharp, 2001 – TWDB Report 356

Conceptual Flow Systems



Conceptual Flow Cross-Section



Implementation into Numerical Model

- Probably divide Layer 1 into multiple layers
- Properties - Use a zonal approach –function:
  - Depth of burial
  - Presence of halite in Rustler
  - Dissolution of Salado
  - Character of well productivity
- High level of uncertainty in
  - Effective properties
  - Boundaries (including cross-formational flow)
  - Pumping

INTERA

Still Time to Comment

- Draft report on the GAM website (http://www.twdb.state.tx.us/gam/rslr/Rustler_GAM_Conceptual_Model_Draft.pdf).
- Accept comments through May 26th
- Forward comments to:
  - Wade Oliver
  - wade.oliver@twdb.state.tx.us

Schedule

- Study Completion – October 31, 2011
- Final SAF and Training
- Final Report – January 31, 2012

Questions - Comments

Meeting Minutes for the

Second Rustler Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF) Meeting

May 19th, 2011

Pecos County Courthouse, Ft. Stockton, Texas

The second Stakeholder Advisory Forum (SAF) Meeting for the Rustler Groundwater Availability Model (GAM) was held on Thursday, May 19th, 2011 at 1:00 PM at the Pecos County Courthouse located at 103 West Callaghan in Ft Stockton, 79735. A list of meeting participants is provided at the end of these meeting notes.

The primary purpose of the second SAF meeting is to review the Conceptual Model developed for the Rustler Aquifer GAM and to solicit input from stakeholders regarding the aquifer conceptualization and proposed model implementation. The draft Conceptual Model Report was posted on the TWDB website on April 1st, 2011 for public comment.

SAF Presentation: Van Kelley, INTERA Inc

Van Kelley (INTERA) presented a prepared presentation structured according to the following outline:

(1) Review of the Study Area;
(2) Rustler Aquifer Framework;
(3) Rustler Aquifer Hydrogeology;
(4) Rustler Aquifer Conceptual Model for Groundwater Flow;
(5) Path Forward and Project Schedule.

The presentation has been submitted to the TWDB and will be available at the following website in the near future: http://www.twdb.state.tx.us/GAM/rslr/rslr.htm.

If you would like it before it gets posted, please contact vkelley@intera.com.

Questions and Answers:

Question: When looking at drawdown in the Pecos Alluvium, are you saying that it is connected to the Rustler?

Answer: Based upon water quality data, several investigators have proposed that there may be vertical flow from the Rustler to overlying formations including the Pecos Valley Alluvium. We will handle this potential for vertical flow using time-varying boundary conditions for aquifers younger than the Dockum.

Follow-up Question: But that would only affect it if it is hydraulically connected, correct?

Follow-up Answer: The Dewey Lake is a fairly tight formation (i.e., low permeability), but the possibility exists that there would be diffuse flow in the subcrop and perhaps focused flow in areas where there are faults enhancing vertical permeability.

Question: What kind of displacement is there at the faults?
Answer: We have mapped faults within the Rustler with upwards of 1000 feet of throw. In many areas the throw exceeds the Rustler thickness which puts the Rustler completely in contact with another formation in these areas. We expect that the faults are hydraulically significant.

Comment: (*In reference to a map showing that we have no well control in central Reeves County in the deeper portions of the Toyah Basin*) It may not be right that nobody uses the Rustler in the deeper portions of the Toyah Basin. A number of wells were drilled in the 1950s about 20 miles south of the city of Pecos there is a cluster of Rustler wells. Historically the Rustler was under a lot of pressure and water would come within 100 feet of land surface in portions of Reeves County. I recall the TDS in these wells was about 3000 ppm. There are also some Rustler wells near Imperial that were accidentally drilled during oil exploration. Comer Tuck may know more about the Imperial wells.

Question: Have you looked at possible increased hydraulic conductivity from the Sierra Madera impact?
Answer: No

Comment: The pumping estimate for the whole area includes Belding, correct? Did they provide estimates of pumping? Glenn Honaker, the president of Middle Pecos GCD, has two Rustler wells permitted at about 4,000 to 5,000 acre-feet per year.

Question: (*In reference to a specific water quality map shown in the presentation*) What report did the water quality information come from?
A: An unpublished report by R.D. Price in 1982, which was reproduced in TWC Report 89-01

Comment: I recommend adding more reference points such as roads and cities to the figures in the report.

Comment: In Culberson County south of Rustler Springs there is a major sulfur mine. For the sulfur mine, they found deep wells possibly in the Rustler with relatively good water quality about 25 miles south of Toyah.

Comment: Back in the 1930s there was a community out near Lake Leon with flowing wells, possibly from the Rustler.

Comment: It appears that the pumping estimates in the conceptual model report are too low due to under-reporting of historical pumping.

Comment: There is a groundwater model for western Pecos County that should be publically available.

Comment: It is possible that flow between aquifers has been enhanced due to the loss of well integrity in older Rustler boreholes.

Rustler Aquifer GAM Stakeholder Advisory Forum 2
May 19, 2011

Attendance

Name	Affiliation
Gary Bryant	Texas AgriLife
Darrell Peckham	Thornhill Group, Inc.
Mark Dobson	DNA Geosciences, Inc.
Bob Varmette	The Fort Stockton Pioneer
Alan R. Zerman	Reeves County
Wade Oliver	TWDB
Van Kelley	INTERA