

Brackish Resources Aquifer Characterization System

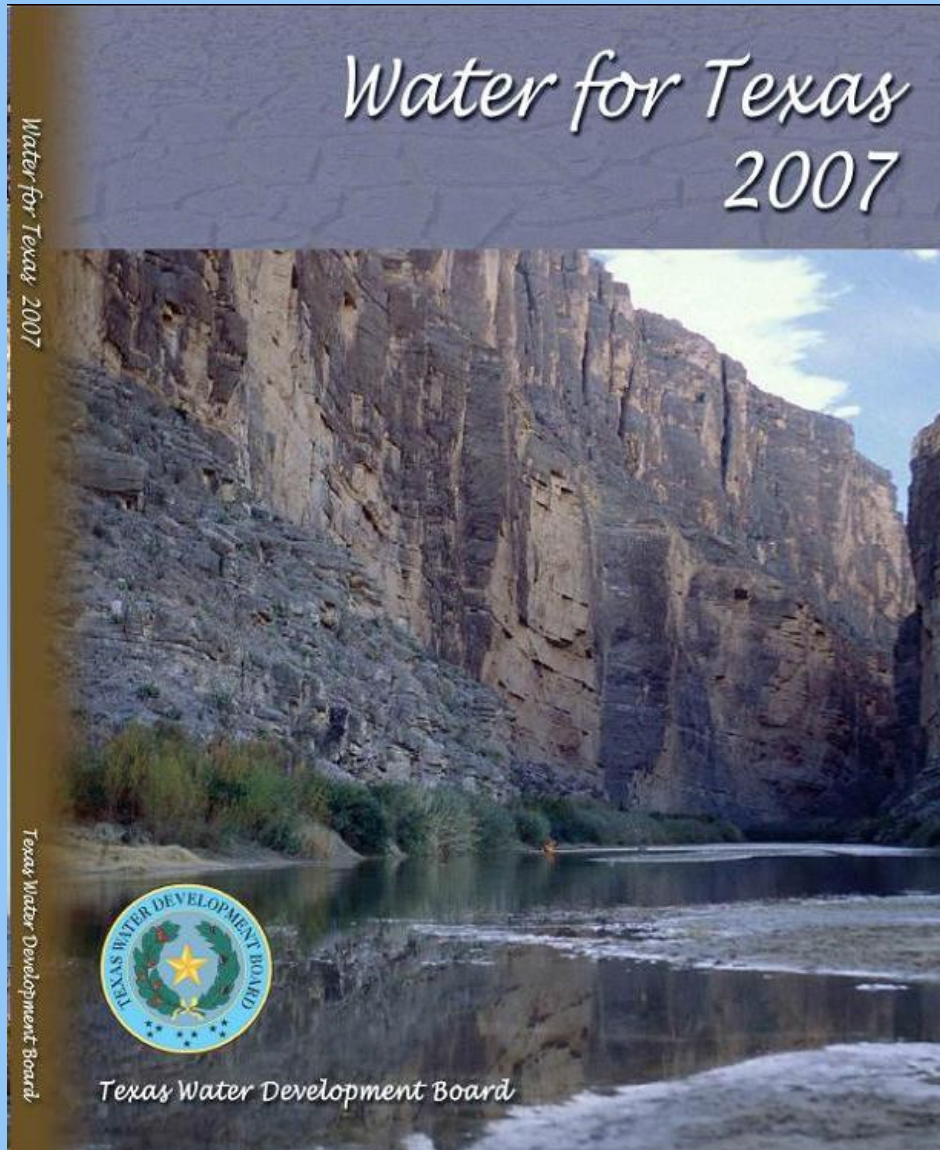
April 4, 2011



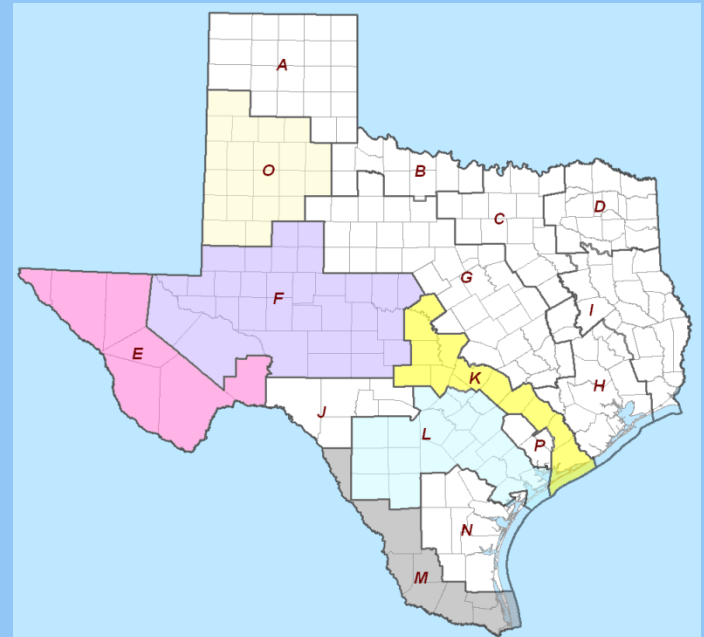
John E. Meyer P.G.
Matthew R. Wise, P.G.

Texas Water Development Board
Water Science and Conservation
Innovative Water Technologies

State and regional water planning



- Consider and evaluate all potentially feasible water management strategies
- Brackish groundwater desalination
 - Develop 175,000 acre-feet/year by 2060
 - 6 regions recommended strategy



Brackish groundwater in Texas

- 1956: USGS Water Supply Paper 1365, Saline-Water Resources in Texas
- 1959: Texas Legislature appropriated \$20,000 to study scaling problems in desalination
- 1965: The potential contribution of desalting to future water supply in Texas (TWDB and USDOJ Office of Saline Studies)
- 1972: TWDB Report 157, A survey of the subsurface saline waters of Texas
- 1973: H. P. Burleigh, TWDB Executive Director, testimony before Congress : “Continued Federal Support of Desalination Research and Development”
- 2003: Brackish Groundwater Manual for Regional Water Planning Groups
- 2005, 2007, 2009: Texas Legislature appropriates funds for brackish groundwater desalination demonstration projects

BRACS Goals

- Extend the 2003 TWDB study:
 - map aquifers to 10,000 mg/L Total Dissolved Solids
 - map key desalination parameters (for example: silica, iron, ...)
 - estimate aquifer properties
 - estimate volumes of water
 - build replicable numerical groundwater flow models
 - collect well logs (water, oil/gas) for interpretation
 - build datasets (database, GIS) of project information
- Assist regional water planning groups
- Collect and disseminate information to be used for site-specific brackish groundwater projects

Tasks

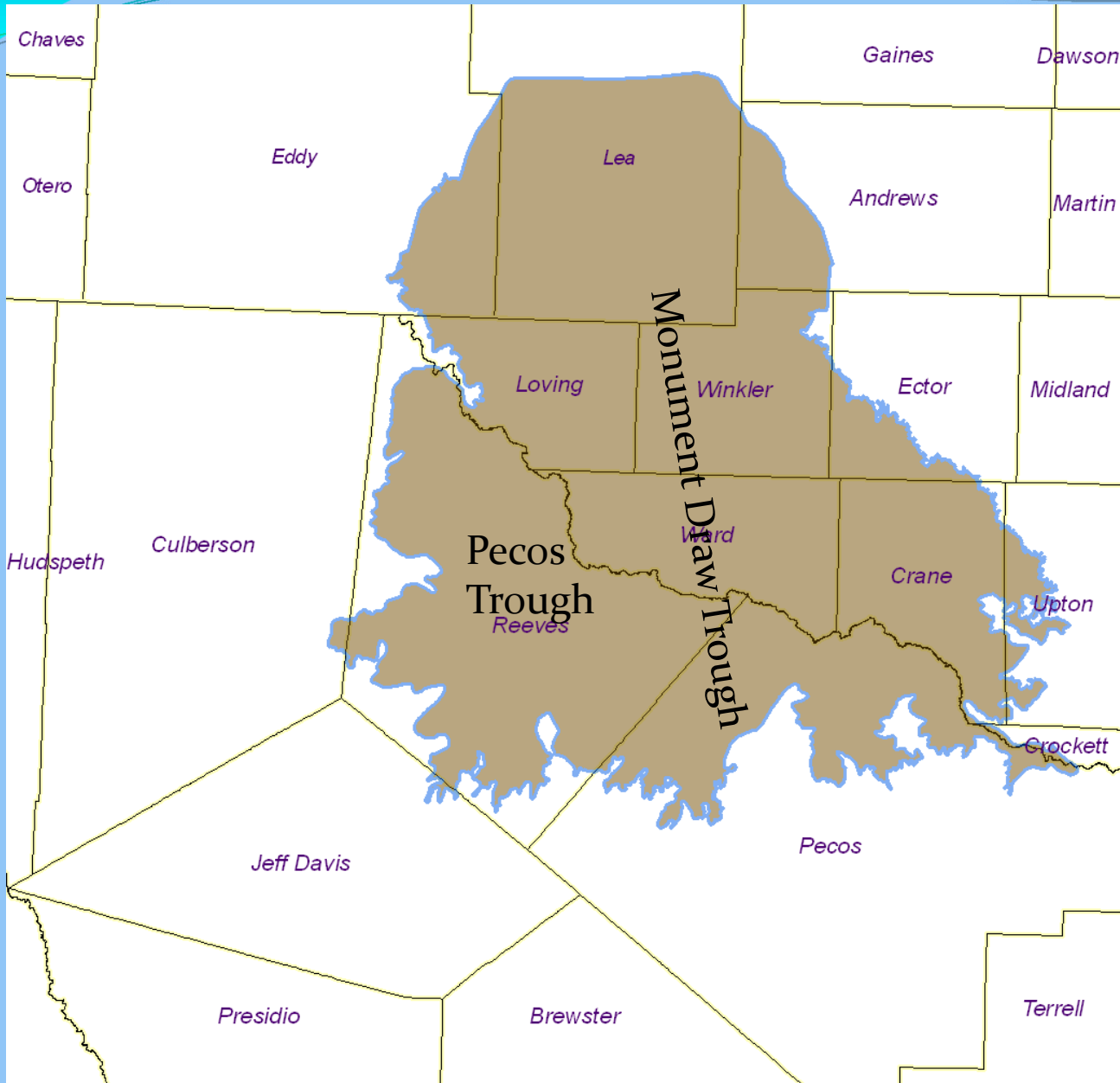
- Convene a Technical Resource Panel
- Brackish Groundwater Pilot Study: Pecos Valley Aquifer, West Texas
- Contracts to support brackish groundwater analysis include:
 - Digital Geological Bibliography of Texas to focus on articles on brackish portions of aquifers in Texas
 - Compile digital geophysical well logs across Texas for resistivity / stratigraphic analysis (goal: 1 log per 2.5 minute grid cell)
 - Assessment of Groundwater Modeling Approaches to Brackish Aquifers, using Variable Density Modeling

Technical Resource Panel

- Assist TWDB staff with developing a firm technical foundation for the Brackish Resource Aquifer Characterization System
- Consists of State, Federal, Private representatives interested in Brackish Resources of Texas
- First meeting held in February, 2010 ... lots of valuable feedback.

Pilot study tasks

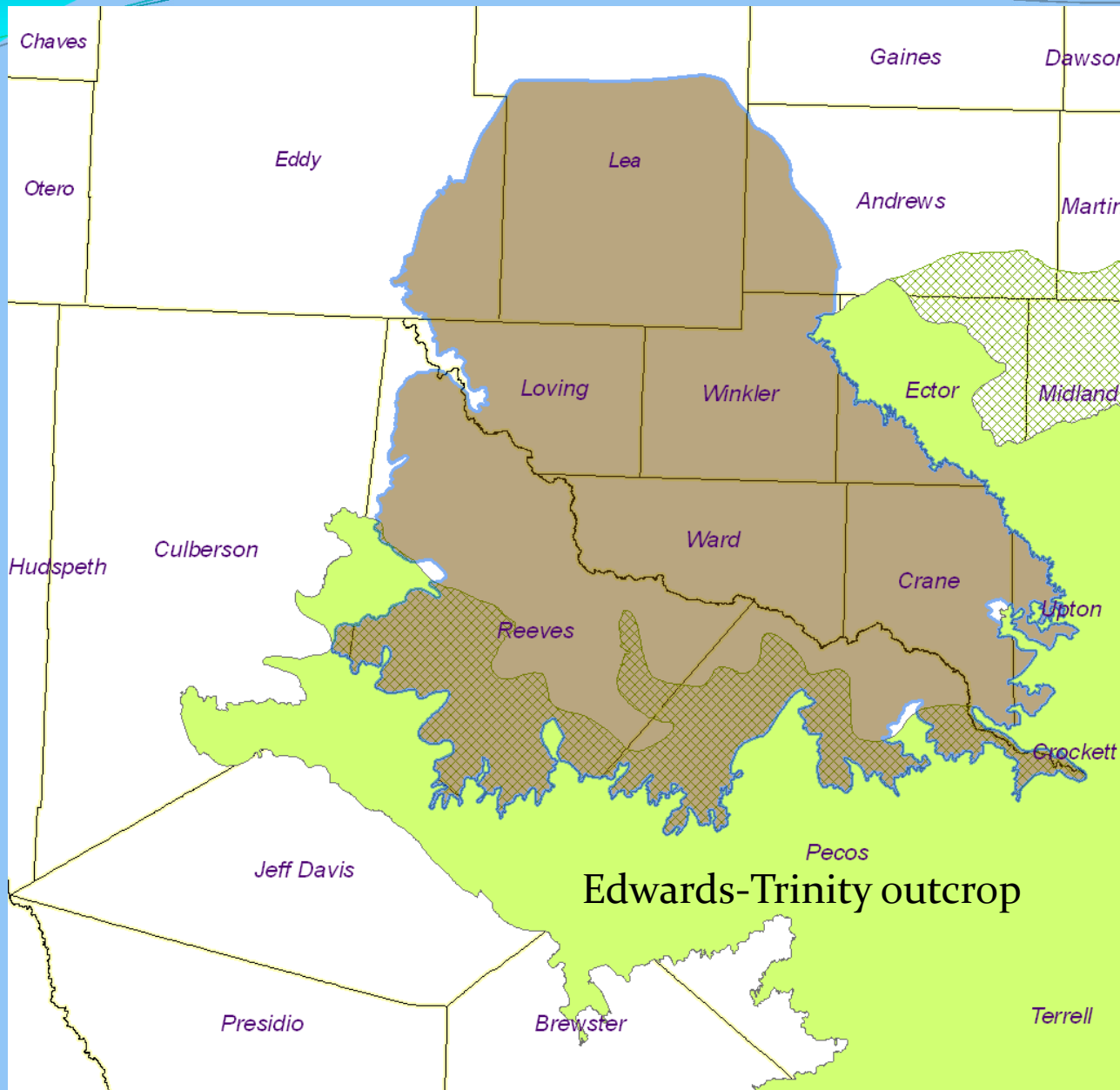
- Develop a project database to contain and analyze information
- Collect information: water well reports, geophysical well logs, ...
- Literature review
- Process this information into database and GIS records
- Create GIS files showing aquifer architecture
- Test techniques to interpret TDS from geophysical well logs
- Create GIS files of water quality data per aquifer
- Create GIS files of aquifer characteristics
- Quantify brackish resource in area
- Provide information: Report, raw data, database and GIS files



Pecos Valley Aquifer

Age: Cenozoic





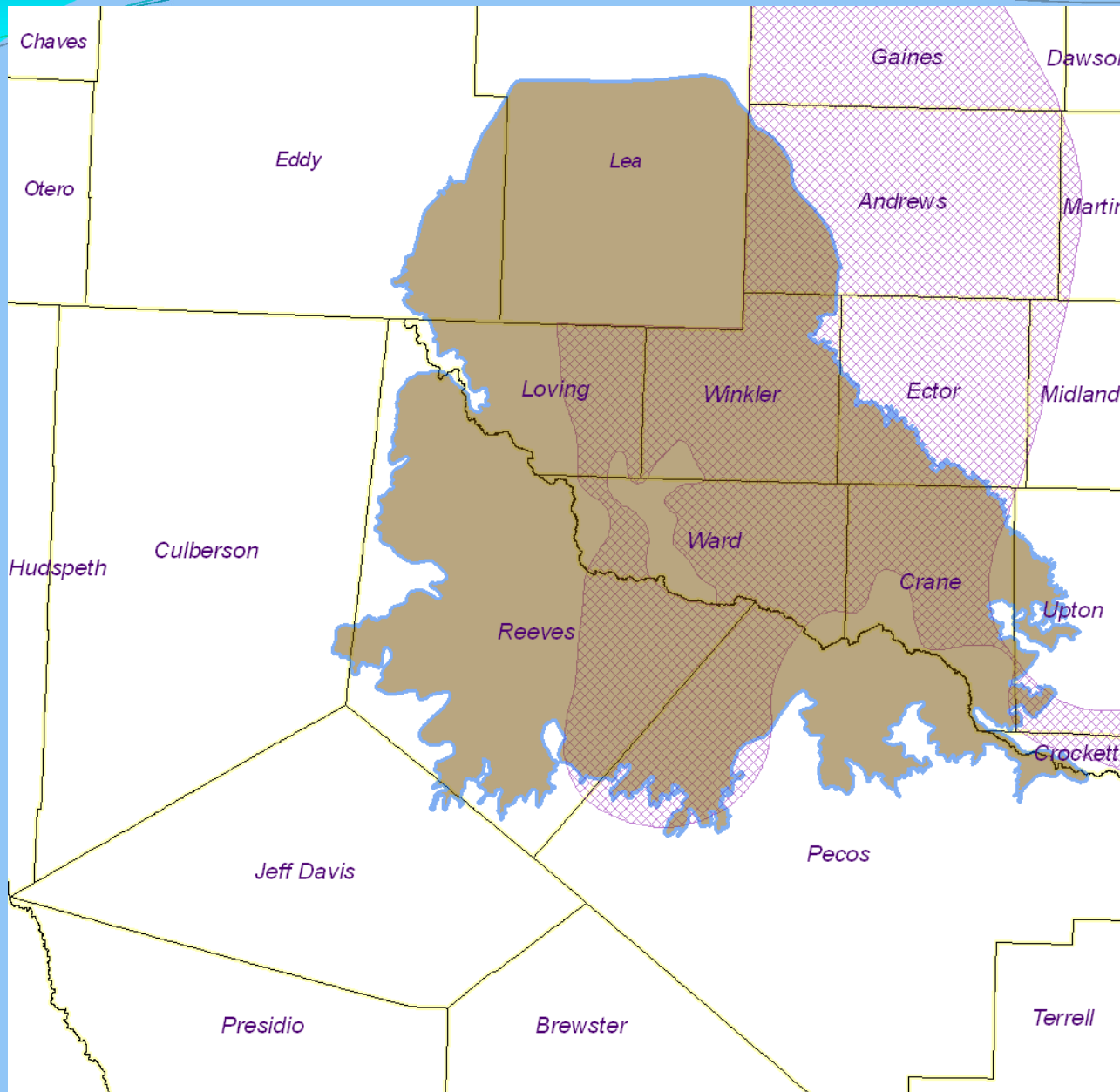
Pecos Valley Aquifer

overlying

Edwards –Trinity Plateau Aquifer

Age: Cretaceous





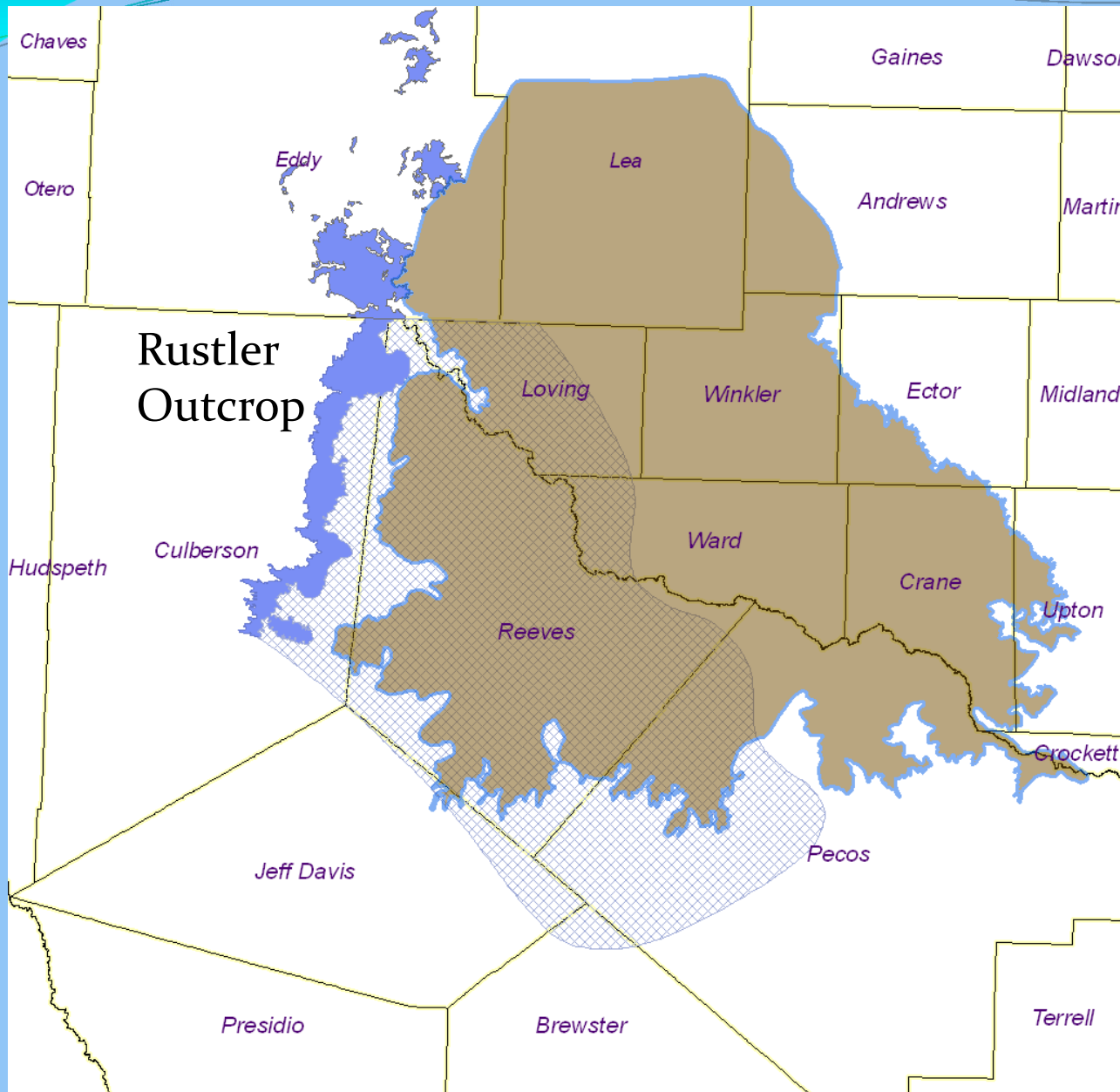
Pecos Valley Aquifer

overlying

Dockum Aquifer

Age: Triassic





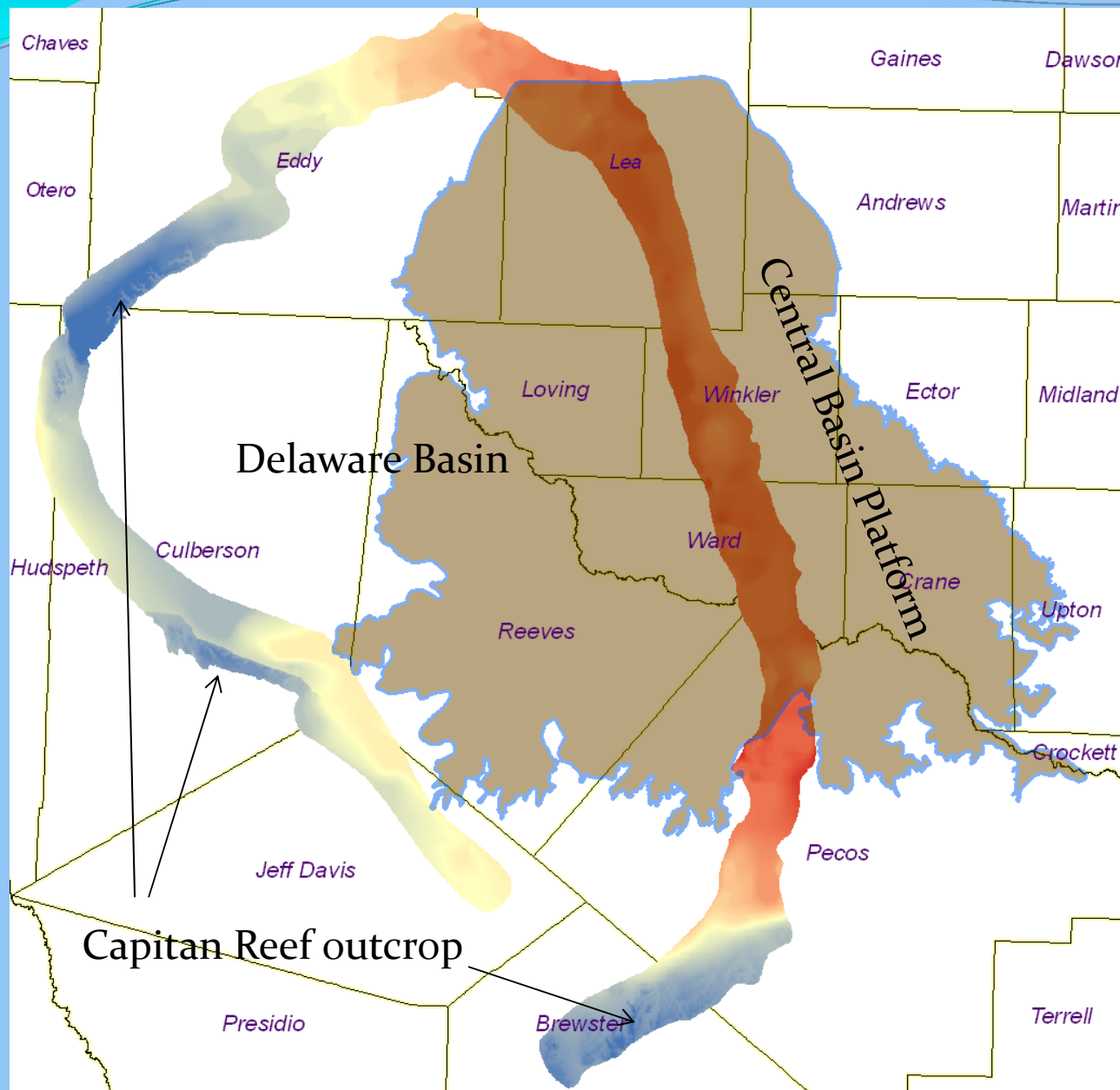
Pecos Valley
Aquifer

overlying

Rustler Aquifer

Age: Permian





Pecos Valley Aquifer

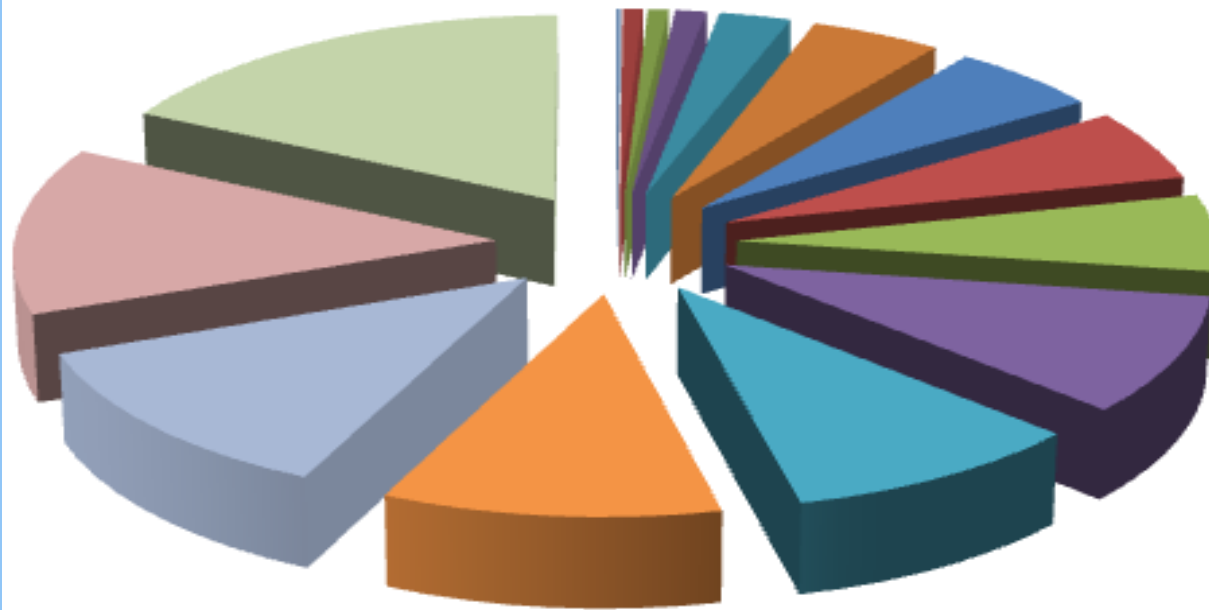
overlying

Capitan Reef Complex

Age: Permian



Sources of Data for the Pecos Valley Study



- NM OSE Aquifer Test Information
- NM OSE Digital Water Well Reports
- TCEQ PWS Water Wells
- TWDB Geophysical Logs
- NM OSE Paper Water Well Reports
- DBSA Capitan Reef Study
- NM EMNRD Geophysical Logs
- ULUTS Digital Geophysical Logs
- TCEQ SC Q Paper/Digital Geophysical Logs
- RRC Digital Geophysical Logs
- TWDB Groundwater Database
- TCEQ Water Well Images
- TDLR Digital Water Well Reports
- BEG Paper/Digital Geophysical Logs
- TWDB Published Reports

3,354 wells in project

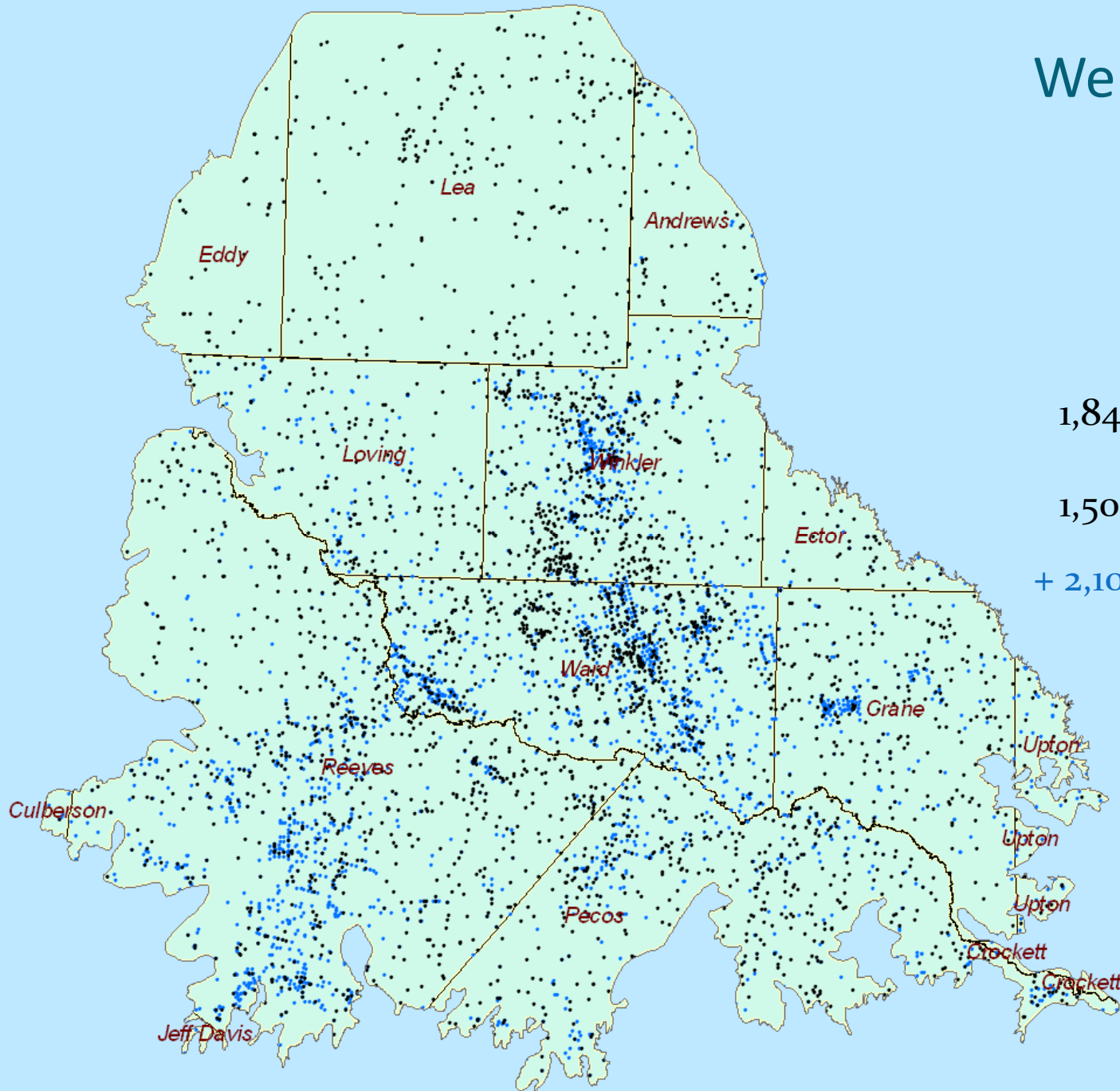
85% new data to TWDB

Well control

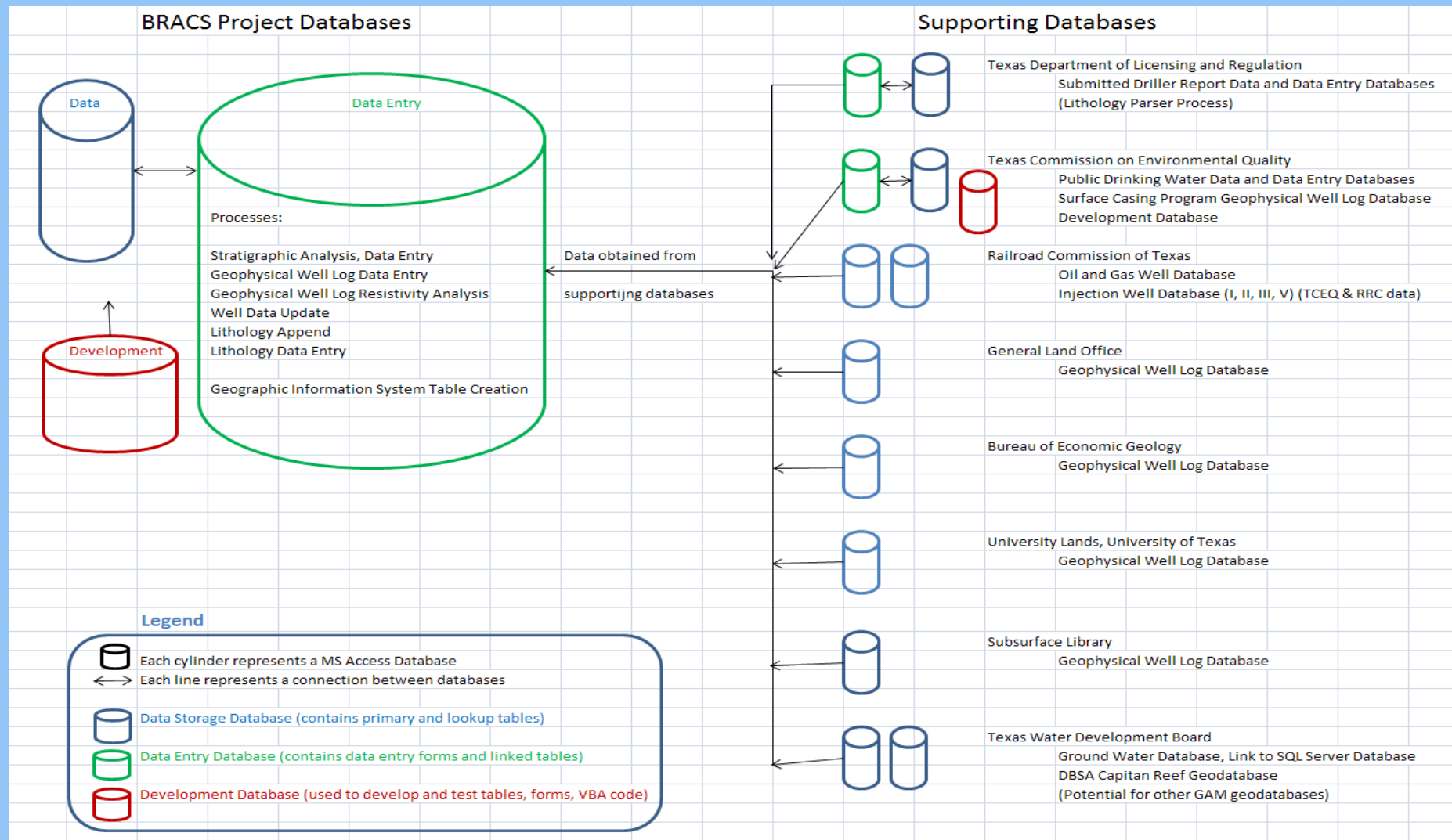
1,849 water wells

1,505 oil/gas wells

+ 2,100 TWDB wells



Relational databases were developed to manage information



Well Attributes: location, source, log types, ...

TWDB WSC IWT BRACS Geophysical Log Search Task

484 API NUMBER 42-389-32310 TRACK NUMBER 0 Source of Well Data RRC Digital Geophysical Logs Close Form

STATE WELL NUMBER 0 WATER SOURCE Q Number Q-229b Initials JEM

Load Attributes Load Digital File Name Load GL Hyperlink

County Name REEVES Owner Chisos Operating Inc

Depth Total 5544 Latitude 31.3589051148 Elevation 2702 Well Number Caldwell No. 1

Depth Well 0 Longitude -103.61620577 Horizontal Datum 83 Vertical Datum 29 Remarks N/A

Drill Date 11/22/2004 Location Method Unknown Elevation Method D

Kelly Bushing Height 7 Agency RRC Elevation Agency TWDB

Well Type Oil or Gas Location Date 2/23/2010 Elevation Date 2/23/2010

2.5' Grid Cell 46-44-1

264 Log File Type Tif Image Bracs Project Yes

File Name 4238932310

JEM: GL Hyperlink <G:\BRACS\GeophysicalLogs\4238932310.tif> MRW: GL Hyperlink <F:\BRACS\GeophysicalLogs\4238932310.tif>

Geophysical Log	GL Code	Top Depth	Bottom Depth	Remarks
CALIPER	CAL	2440	5440	N/A
DENSITY	DEN	2440	5440	N/A
GAMMA RAY OR GAMMA	GR	200	5440	N/A
NEUTRON	NEU	200	5440	N/A
TENSION	TEN	200	5440	N/A
*		0	0	N/A

Record: 1 of 1 No Filter Search

Record: 464 of 2876 No Filter Search

Geophysical Well Logs and Water Well Reports Provided:

frmWell_Lithology_DE

2509 API Number: 4249532576 State Well Number: 0 Owner: ENERGEN RESOURCES CORPORATION Drill Date: 10/20/1996
 Track Number: 0 Water Source: Well Number: UNIVERSITY 47-21 3 Depth Total: 7300
 Q Number: Source of Well Data: ULUTS Digital Geophysical Logs

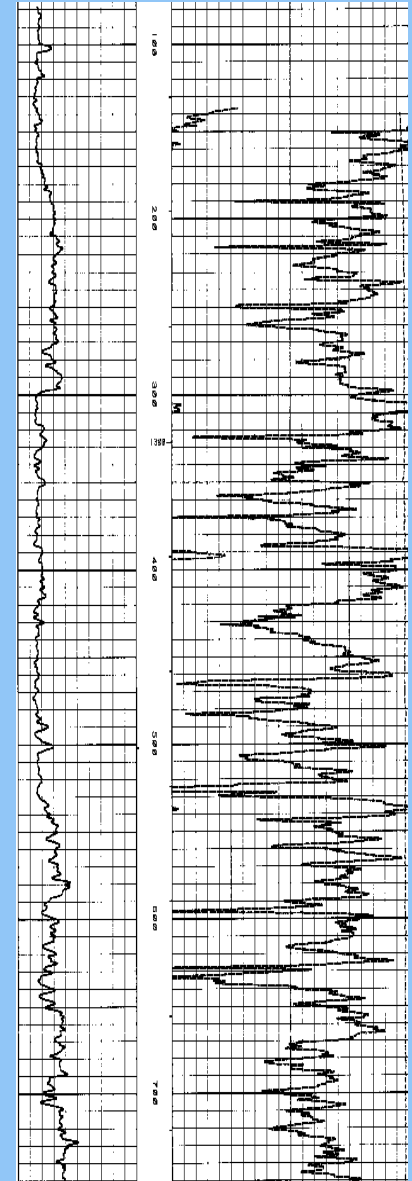
Lithologic Description				Stratigraphic Description			
Record Number	Geologic Pick	Top Depth Bottom Depth Thickness	Lithologic Description Source of Data Initials Last Change	Record Number	Geologic Pick	Top Depth Bottom Depth Thickness	Stratigraphic Description Source of Data Initials Last Change
5	Lithologic	0 80 80	No Record GEOPHYSICAL WELL LOG JEM 3/7/2011	1	Stratigraphic	0 1330 1330	Pecos Valley Alluvium GEOPHYSICAL WELL LOG JEM 3/7/2011
6	Lithologic	80 170 90	Sand GEOPHYSICAL WELL LOG JEM 3/7/2011	2	Stratigraphic	1330	Dockum Group GEOPHYSICAL WELL LOG JEM 3/7/2011
7	Lithologic	170 297 127	Clay GEOPHYSICAL WELL LOG JEM 3/7/2011	3	Stratigraphic	1792	Dewey Lake Redbeds GEOPHYSICAL WELL LOG JEM 10/22/2010
8	Lithologic	297 532 235	Sand GEOPHYSICAL WELL LOG JEM 3/7/2011	4	Stratigraphic	1792	Rustler Formation GEOPHYSICAL WELL LOG JEM 8/30/2010
9	Lithologic	532 752 220	Sand and Clay GEOPHYSICAL WELL LOG JEM 3/7/2011	*			
10	Lithologic	752 810 58	SAND GEOPHYSICAL WELL LOG JEM 3/7/2011				
11	Lithologic	810					

NMOSE POD HYP

Geophysical Well Log Hyperlinks

JEM: <G:\BRACS\GeophysicalLogs\4249532576.tif>
 MRW: <F:\BRACS\GeophysicalLogs\4249532576.tif>

Record: 1 of 1 No Filter Search

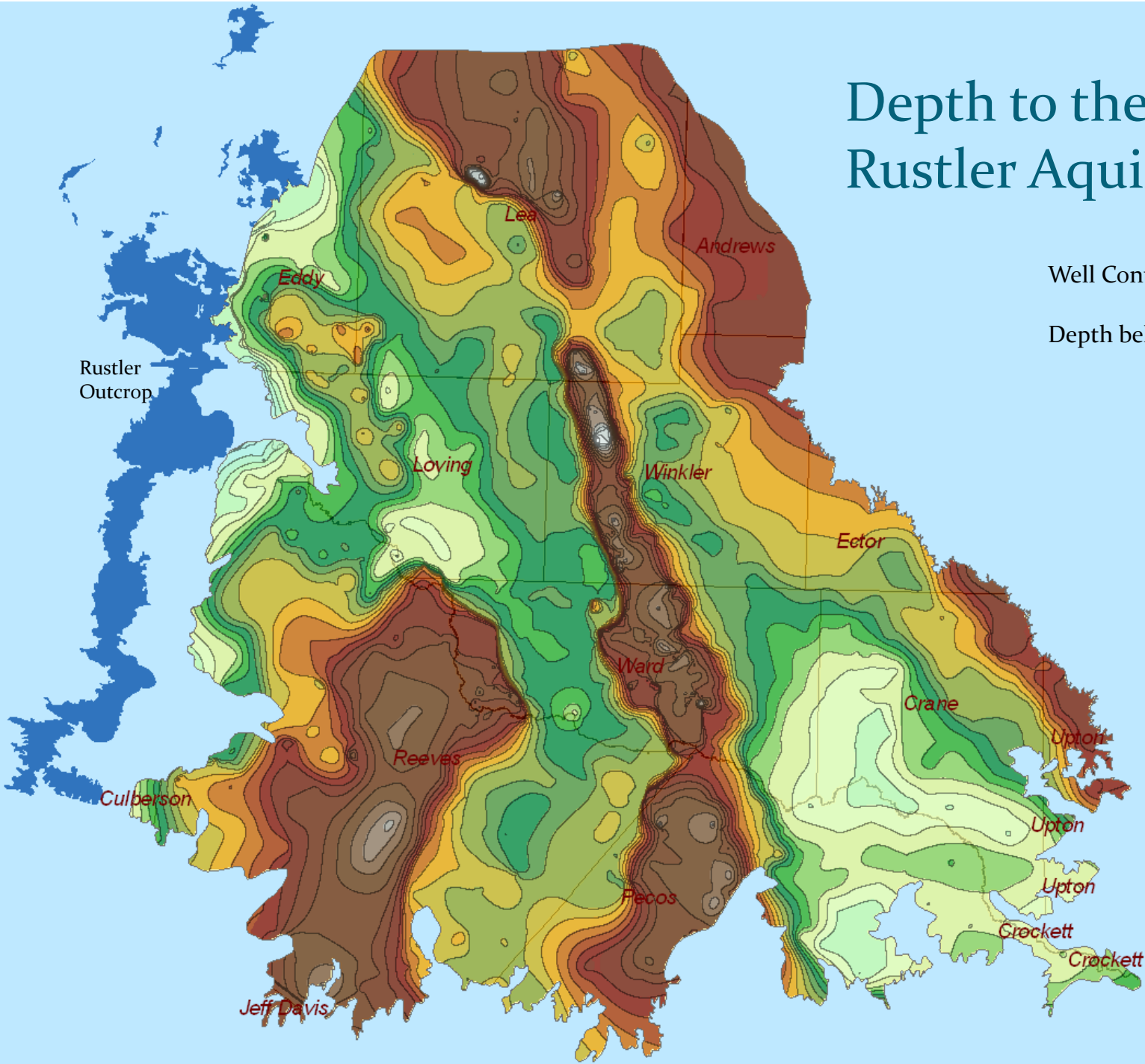
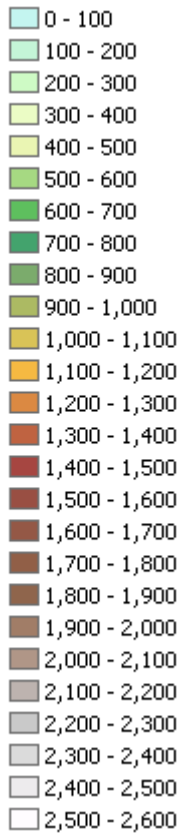


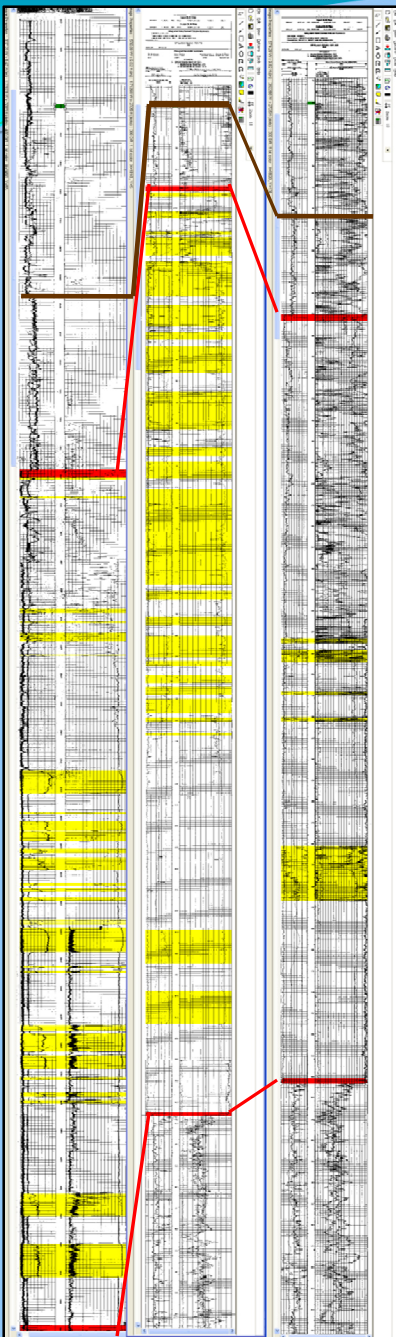
Depth to the Rustler Aquifer Top

Well Control: 1,479 wells

Depth below ground surface

Units = feet





Pecos Valley Aquifer

Dockum Group and Dewey Lake

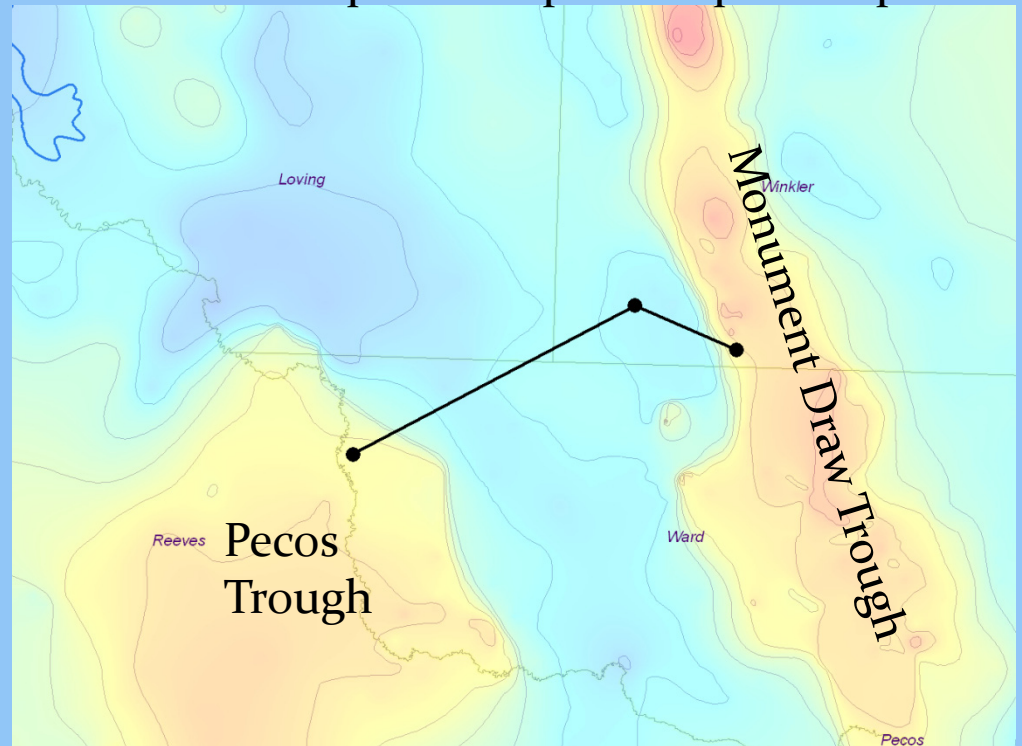
Rustler Aquifer

Salado Fm.
(halite = yellow)

Castile Fm.

Cross-section showing
the Salado Formation
halite ridge

Rustler Aquifer: depth to aquifer top



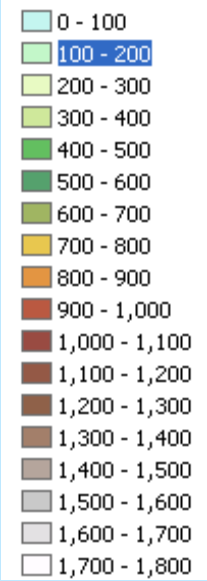
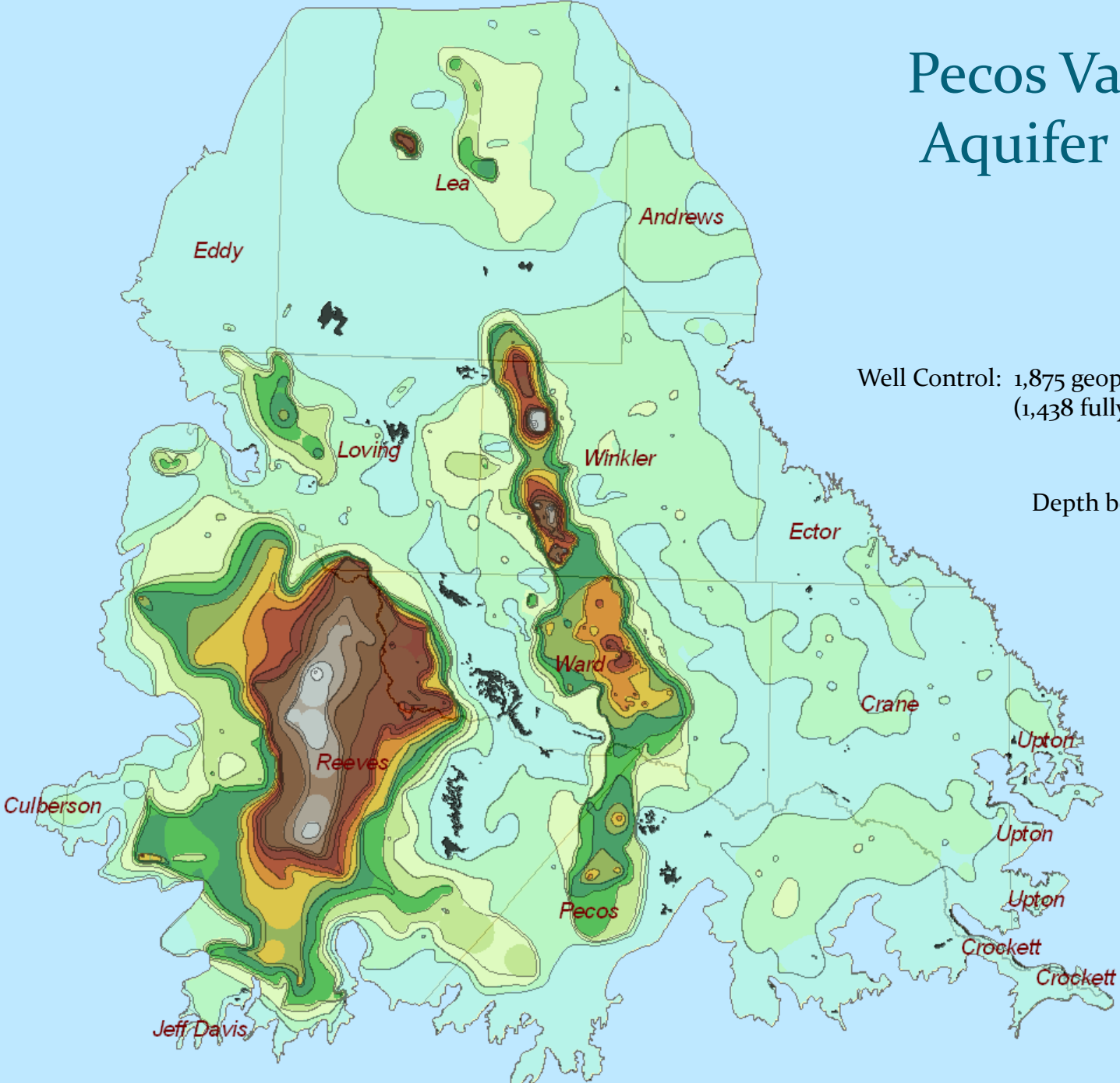
Shallow Deep

Pecos Valley Aquifer Thickness

Well Control: 1,875 geophysical logs and water wells
(1,438 fully penetrate aquifer)

Depth below ground surface

Units = feet

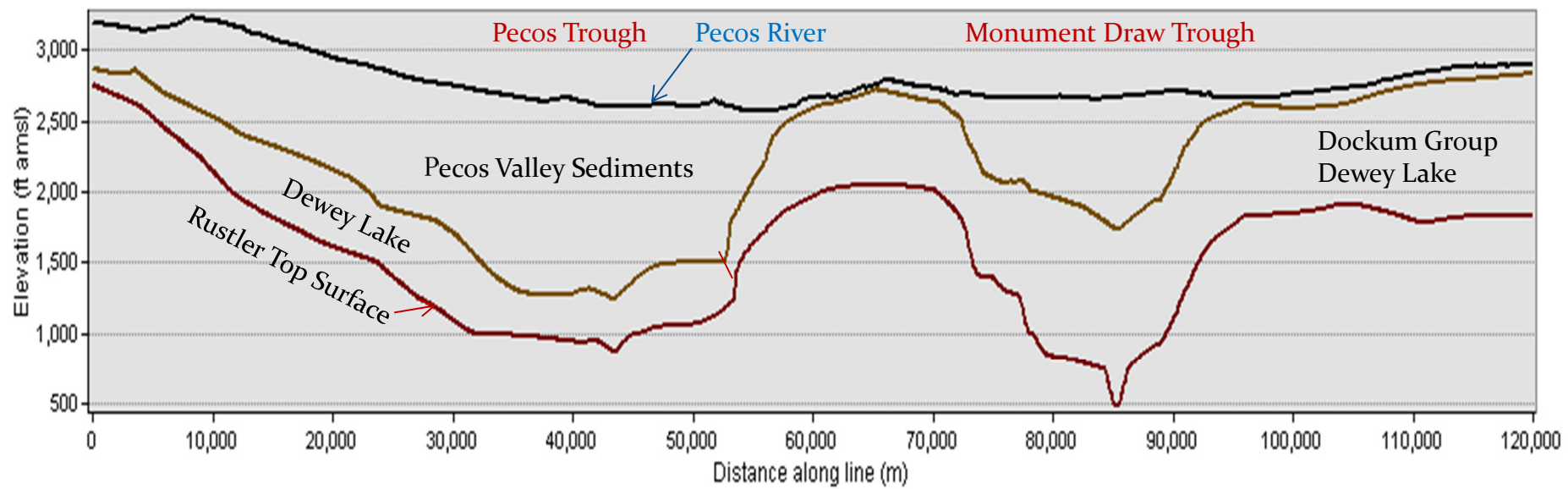


West to East Cross-Section

Pecos Valley Pilot Project

West

East

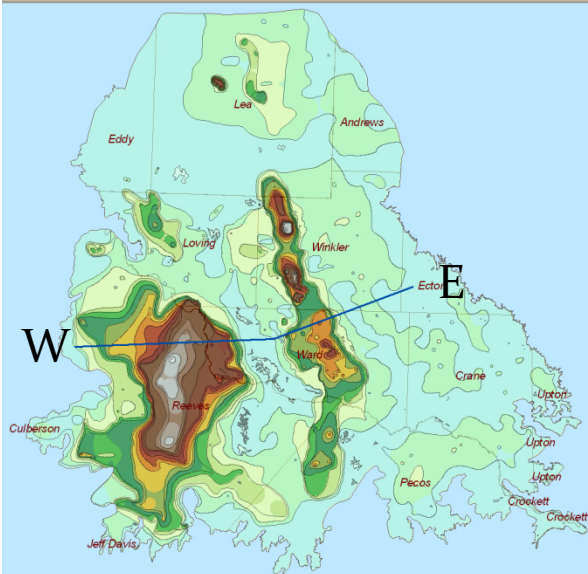


BRACS: Pecos Valley Pilot Project

April 4, 2011

(Vertical Exaggeration x 25)

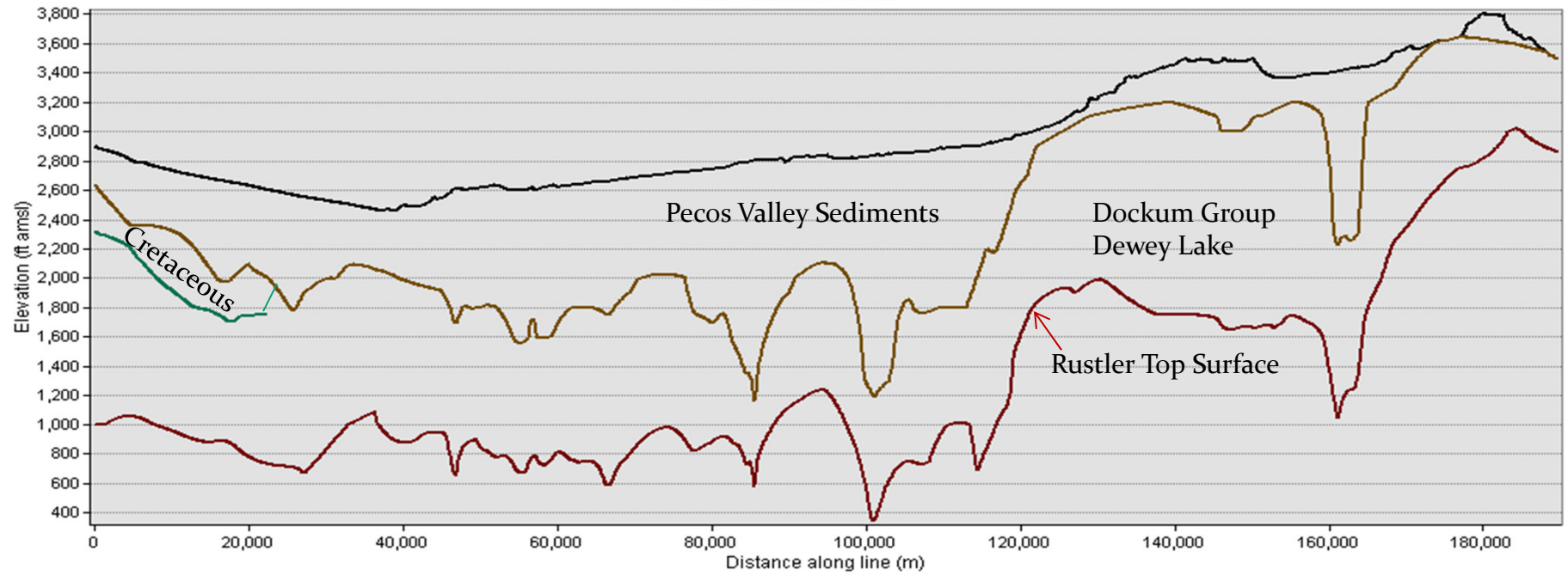
Cross-section across both troughs



South

South to North Cross-Section
Pecos Valley Pilot Project

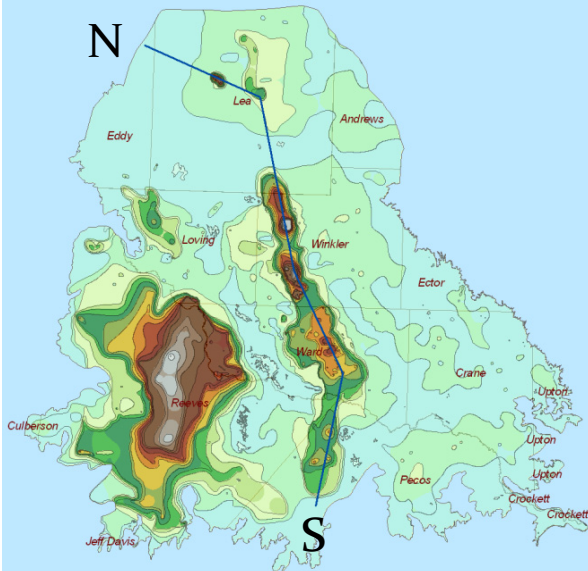
North

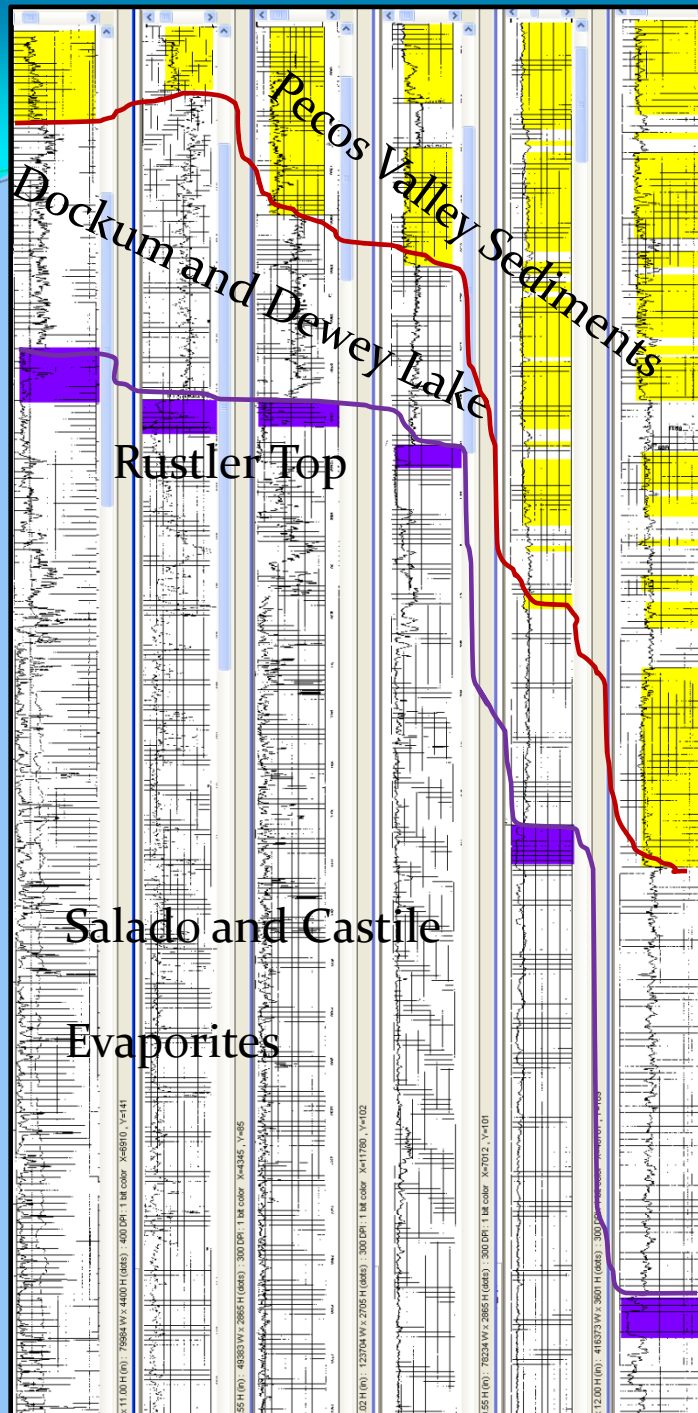


BRACS: Pecos Valley Pilot Project
April 4, 2011

(Vertical Exaggeration x 50)

Cross-section along length of Monument Draw Trough





Cross-section through west side solution trough, southern Winkler County

The solution troughs filled in with a complicated sequence of sediment packages.

Erosion of underlying formations occurred.

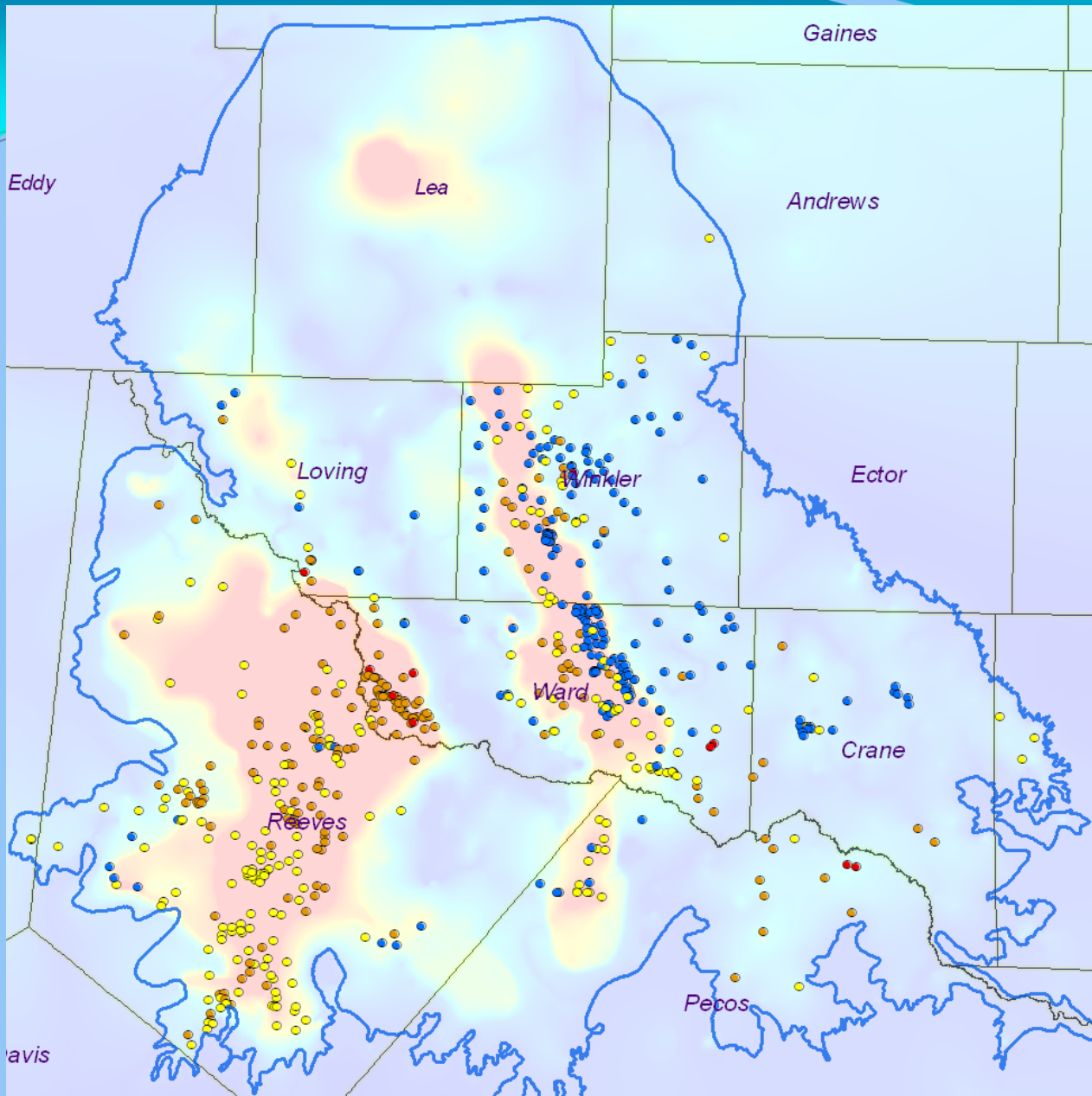
Timing of solution collapse is uncertain.

Discerning Pecos Valley from underlying Dockum sediments can be extremely complicated.



Desalination parameters of interest

Physical Parameters	Chemical Parameters		
	Cations (mg/L)	Anions (mg/L)	Other Chemical Parameters
Conductivity (mS/cm)	As ³⁺	Cl ⁻	Alkalinity (mg/L as CaCO ₃)
pH	As ⁵⁺	F ⁻	Boron (mg/L)
Silt density index	Ba ²⁺	HCO ₃ ⁻	Dissolved oxygen concentration (mg/L)
Temperature (°C)	Ca ²⁺	NO ₂ ⁻ -N	H ₂ S (mg/L)
Turbidity (NTU)	Cu ²⁺	NO ₃ ⁻ -N	Hardness (mg/L as CaCO ₃)
	Fe ₃ ⁺	SO ₄ ²⁻	Pesticides(mg/L)
	K ⁺		Radionuclides (pCi/L) Uranium (µg/L)
	Mg ²⁺		Silica (mg/L)
	Mn ²⁺		TDS (mg/L)
	Na ⁺		
	NH ₄ ⁺ -N		
	Ni ²⁺		
	Zn ²⁺		



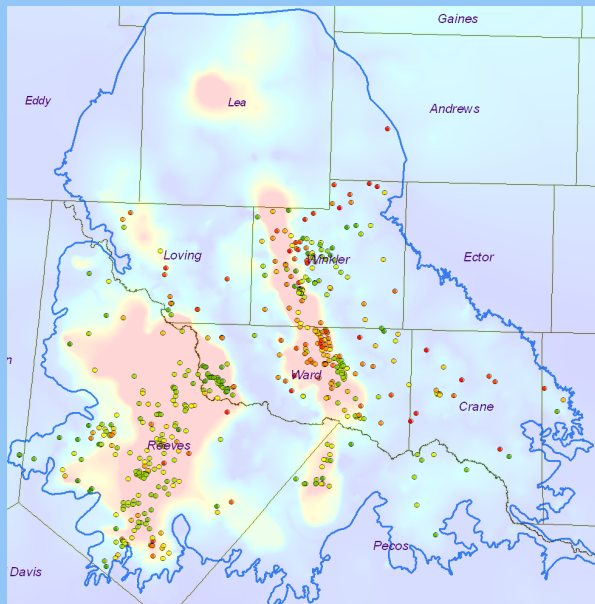
Pecos Valley Aquifer Total Dissolved Solids (mg/L)

Blue	0 - 1,000
Yellow	1,000 - 3,000
Orange	3,000 - 10,000
Red	> 10,000

Range: 116 to 312,487 mg/L
628 wells

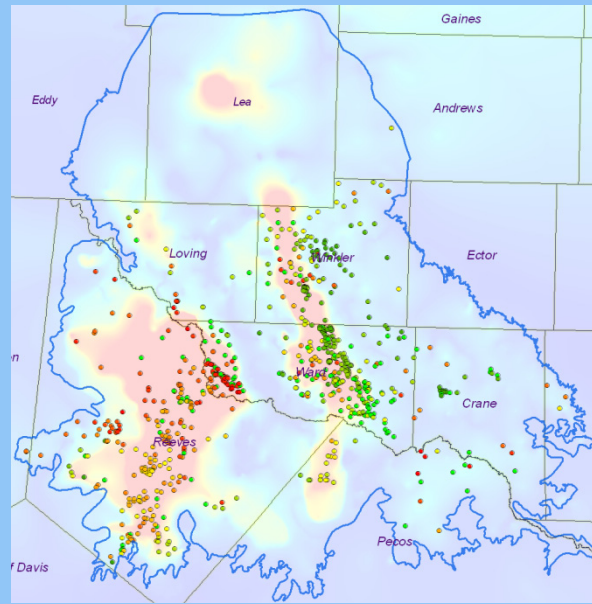
Base map: Pecos Valley Aquifer Depth Below Ground Surface Shallow  Deep

Pecos Valley Aquifer Geochemistry



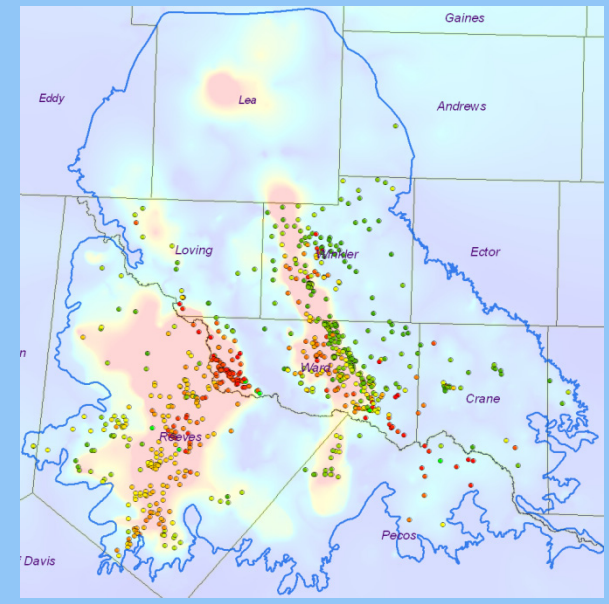
Silica

Range: 1 to 83 mg/L
493 wells



Sulfate

Range: 3 to 3,260 mg/L
717 wells



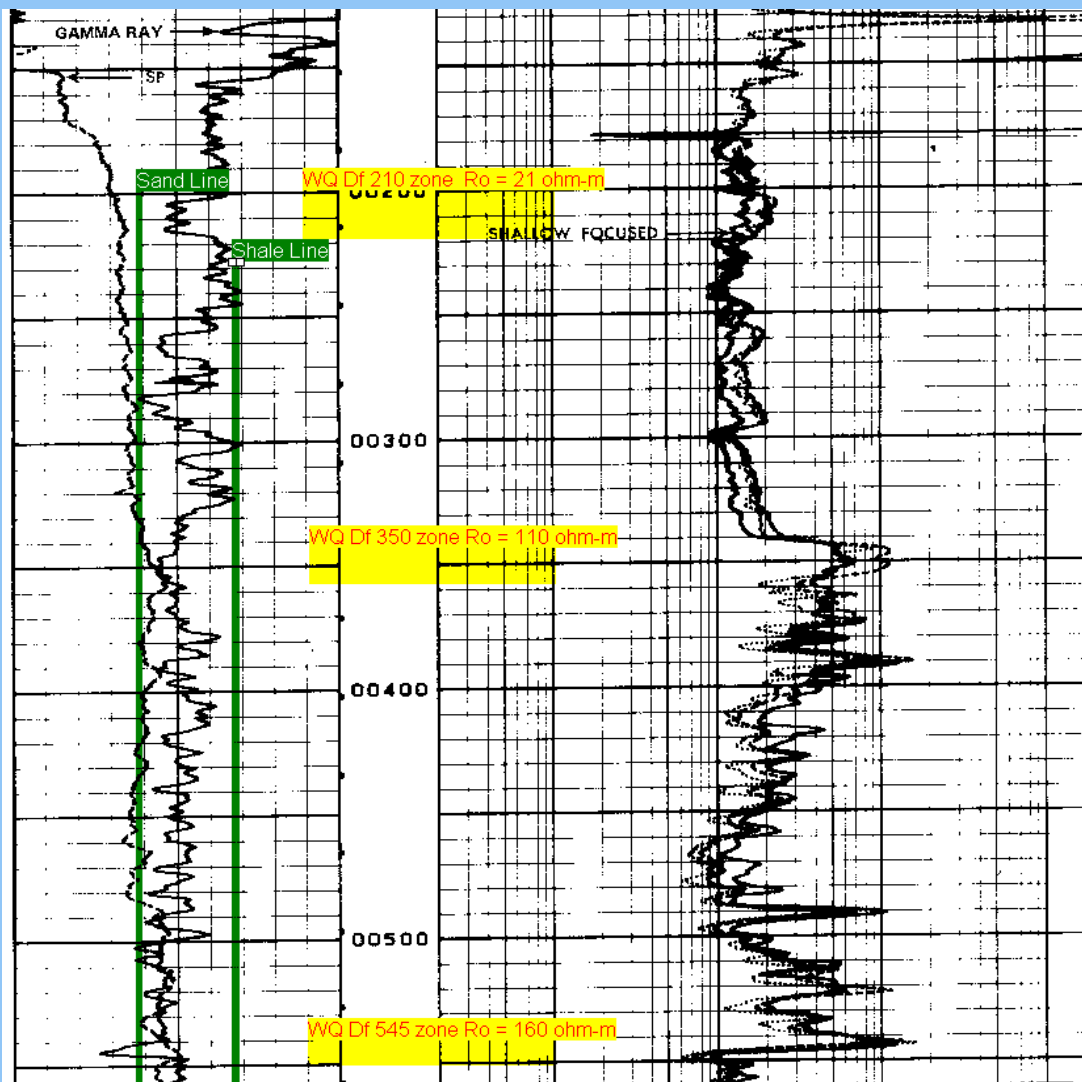
Chloride

Range: 3 to 86,200 mg/L
739 wells

Chemical Content: Low  High

Base map: Pecos Valley Aquifer Depth Below Ground Surface  Shallow Deep

Determining resistivity values for calculating TDS



Can use:

SP Log
(Spontaneous Potential)

Resistivity Tools

- Induction
- Laterolog
- Resistivity
- Electric
- Lateral

Calculation of TDS from geophysical well logs

Load method-specific log values and correction factors; automate the analysis

TWDB Water Science and Conservation Innovative Water Technologies Brackish Resources Aquifer Characterization System

Well Id: 1376 BRACS Geophysical Log Analysis for TDS Calculations White Field: fill in
GL Number: 844 Blue Field: Auto Loaded Load The New Data
Depth Formation (Df): 530 Gray Field: Calculated by CPU Close Form
Thickness Lithologic Unit: 30
TDS Interpreted: 3428 Ts: 63 Dt: 1015 SP Method Mean Ro
Consensus TDS Method: SP Method TF: 69.2660 Rmf: 1.7 Alger - Harrison Rwa Method
Tbh: 75 Rmf Tf: 1.546213 Estepp
Remarks: High sulfate water in the Pecos Valley Aquifer, Reeves County, Tx

TDS Method: SP Method Rwe: 2.010062 Rw: 2.211068 Rw75: 2.042024 Cw: 4897.101 TDS: 3428 Initials: JEM
Geophysical Log Used: SPONTANEOUS POTENTIAL

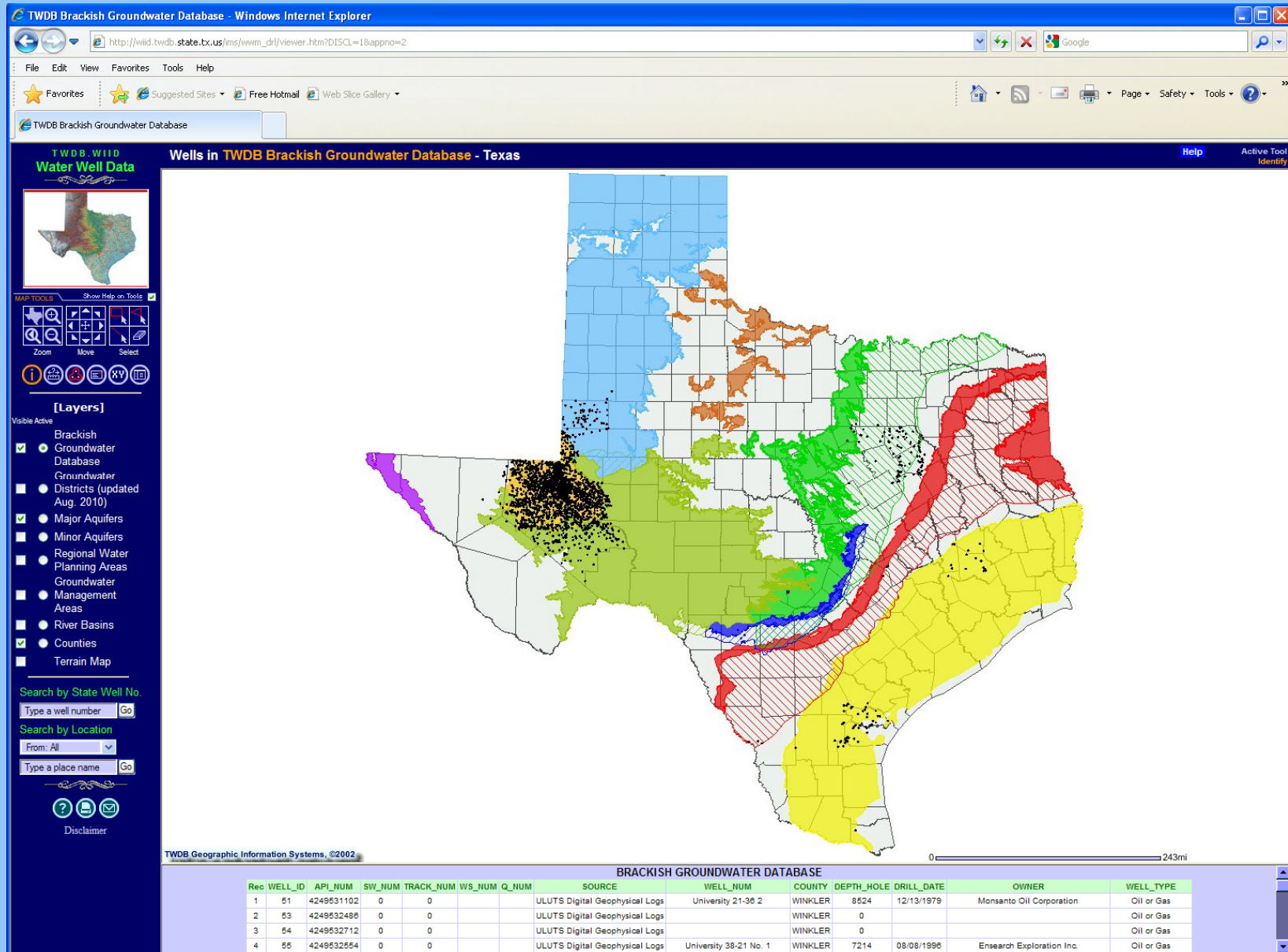
Correction Factors

SP	8	70.21238	K (Temperature): SP Method
Rxo	0	1.1	Rwe Rw: Sp, Alger Harrison, and Rwa Minimum Methods
Ro	0	1	Rmf: SP and Alger Harrison Methods
Rxo / Ro		0.7	ct: Many Methods
m	0	99	Invasion Zone: Alger Harrison Method
Source m	N/A	1	m correction factor: Estepp Method high anion waters
Porosity:	.0	1	Ro: Mean Ro Method
Source Porosity:	N/A		Mean Ro Nomograph

Chart: N/A
Remarks: N/A

Record: 1 of 1

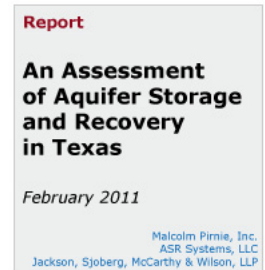
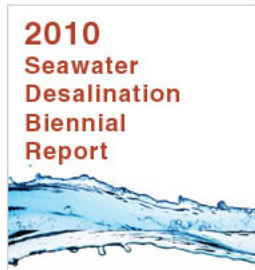
Brackish Groundwater Database well locations in WIID



WIID: Water Information Integration & Dissemination

Summary

- The 2003 Brackish Groundwater Manual indicated the estimated total volume of brackish groundwater in: Texas : > 2.7 billion acre-feet.
Pecos Valley Aquifer: > 116 million acre-feet.
- 44 water treatment plants in Texas use Reverse Osmosis to treat brackish water.
- The Texas Innovative Water 2010 Seminar held in San Antonio in October, 2010, showed a tremendous interest in brackish groundwater resources.
- The TWDB, through the BRACS project and external contracts, is well-poised to provide the information Texas needs to continue development of this resource.
- Each aquifer is different and techniques of analysis will need to fit data available.
- August 31, 2011 is the deadline for the Pecos Valley aquifer pilot study.
- August 31, 2011 is the deadline for the three contracts: Geophysical well logs, Geological Bibliography, and Groundwater Modeling and Variable Density applicability.



- 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.

Questions?

TWDB: (512) 463-7847

<http://www.twdb.state.tx.us>

Contact: john.meyer@twdb.state.tx.us