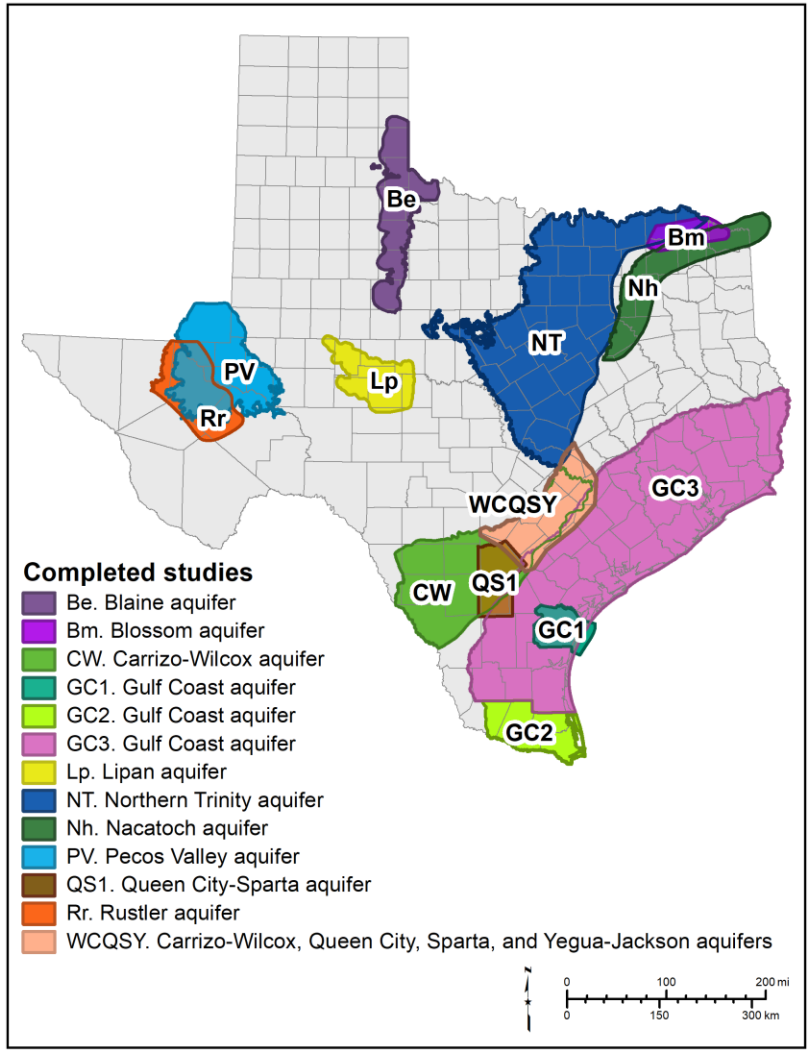
Brackish groundwater in the Hill Country Trinity Aquifer, Texas

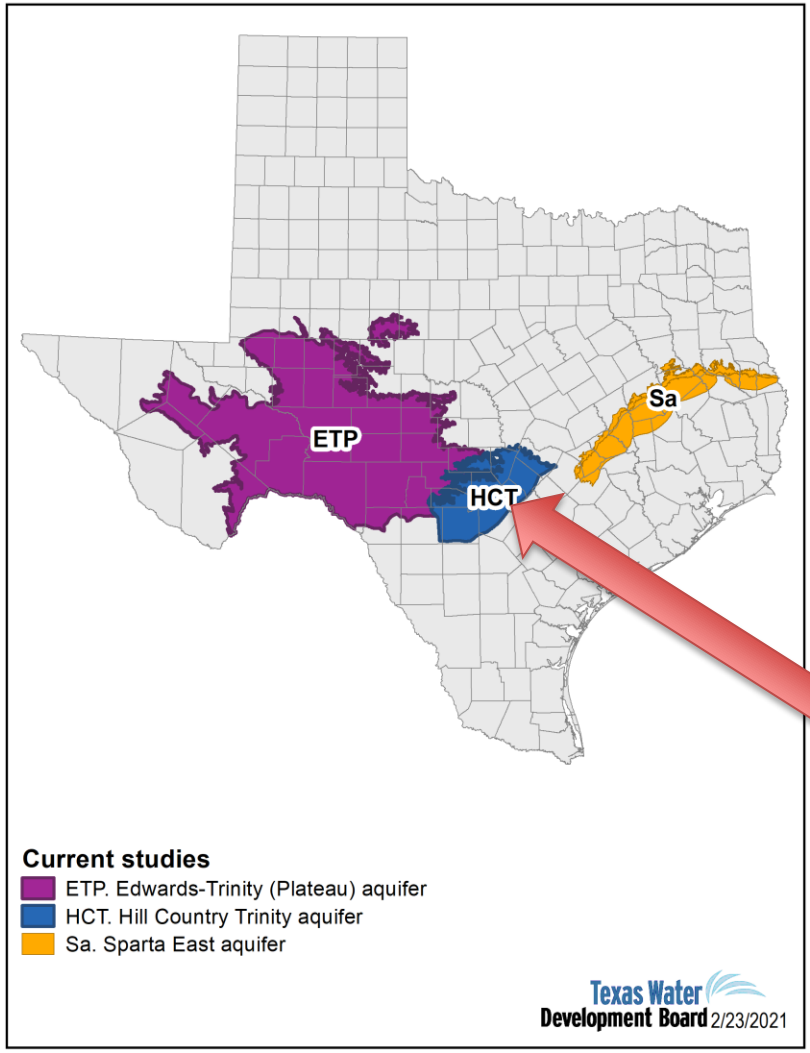
Theme 2, Session 8
Friday October 29, 2021
2021 GeoGulf Meeting

Mark C. Robinson*, Alysa K. Suydam, Evan D. Strickland, and Azzah AlKurdi

Unless specifically noted, this presentation does not necessarily reflect official Board positions or decisions

Brackish Resources Aquifer Characterization System (BRACS) Program - Study Status





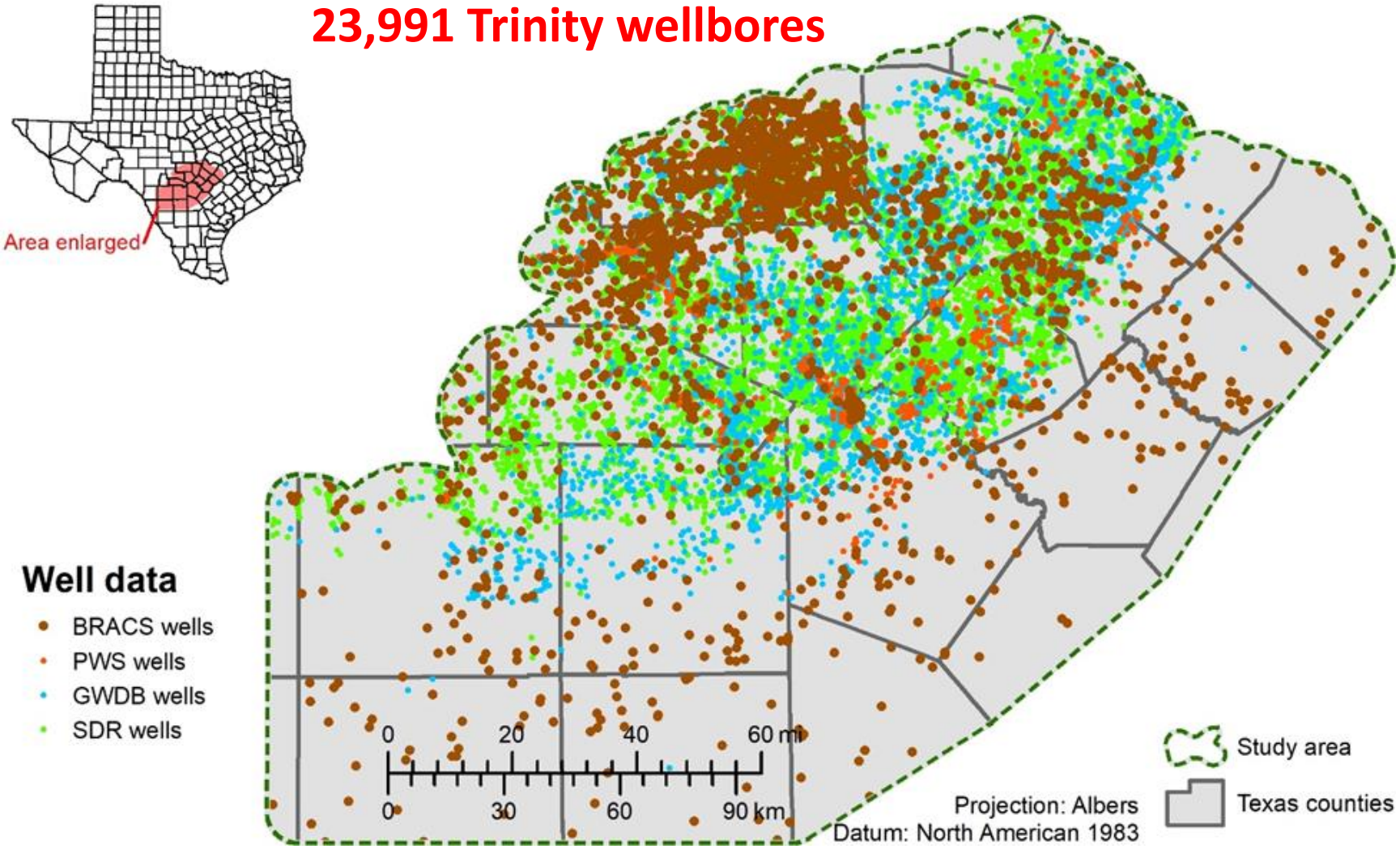
This report

BRACS Process

- Data
- Stratigraphy
- Aquifer assignment
- Salinity class mapping
- Volume calculations
- BGPZ designation – future work

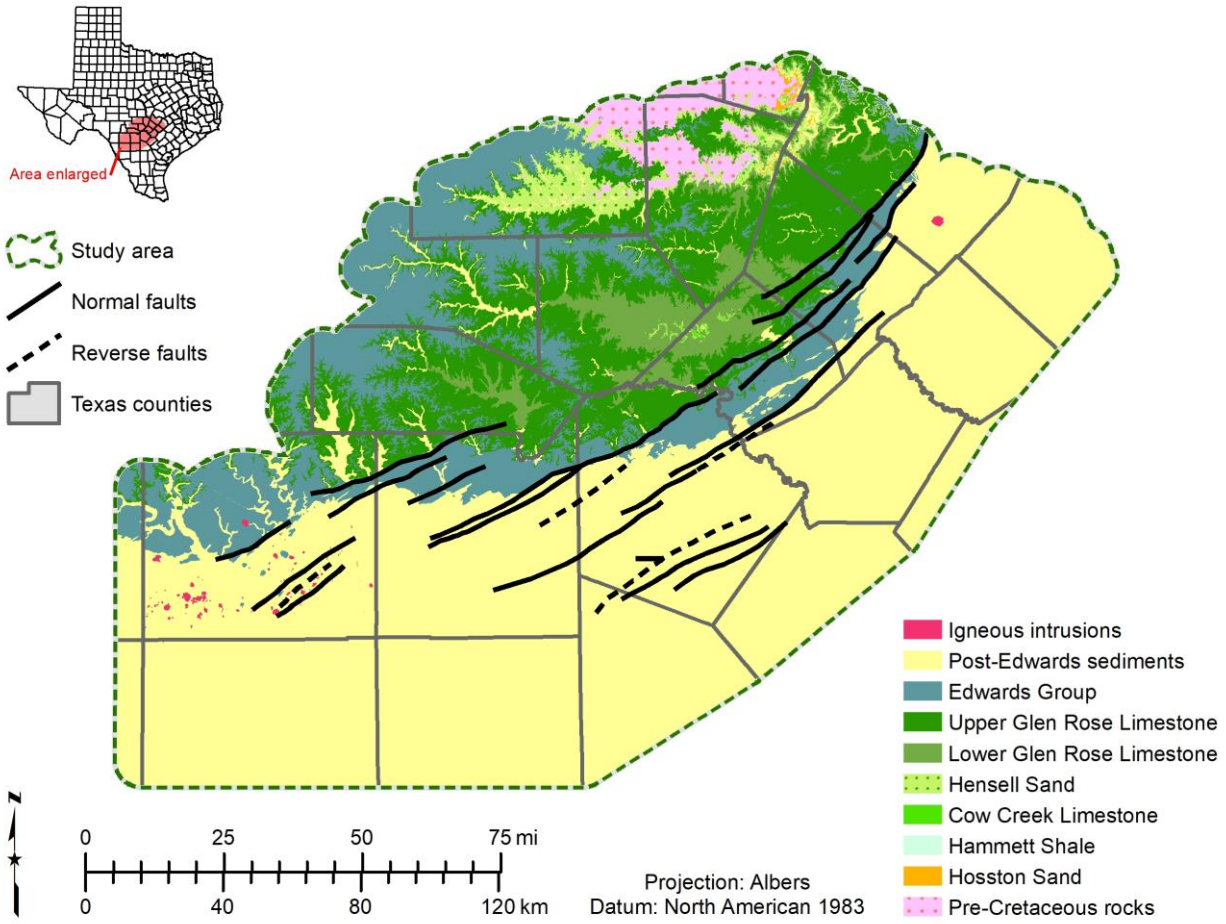
Well data coverage

23,991 Trinity wellbores



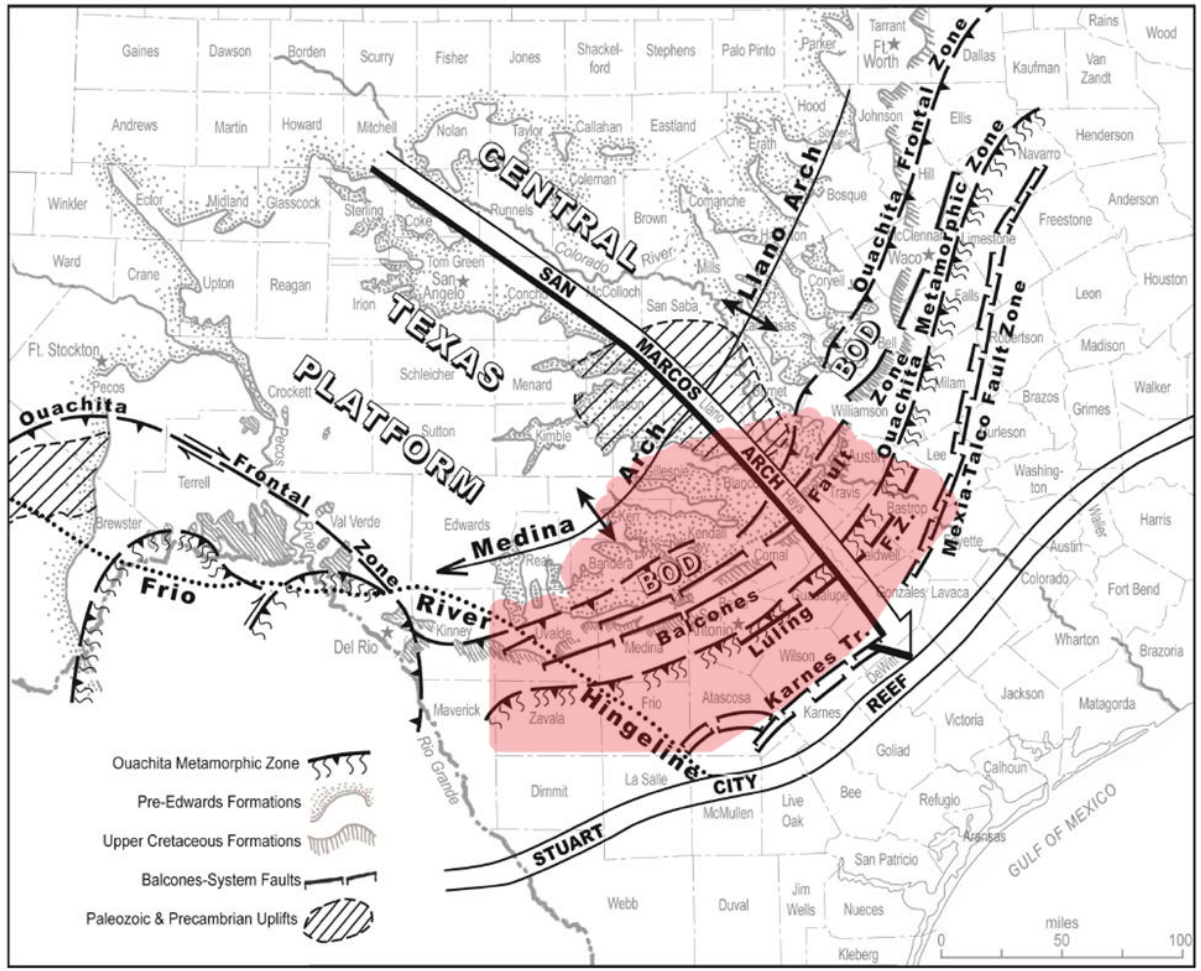
Stratigraphic framework

Age m.y.	Period	Epoch	Group	Formation		Hydrostratigraphic unit	Hydrologic unit
				Northern	Hill Country		
Undifferentiated post Buda formations and sediments							
95	Upper Cretaceous	Cenomanian	Washita	Grayson	Buda / Del Rio		
100		Upper Albian		Mainstreet / Papaw / Weno / Denton / Fort Worth / Duck Creek	Georgetown		
110	Lower Cretaceous	Lower Albian	Fredericksburg	Kiamichi	Kiamichi	Edwards	
				Edwards	Edwards		
				Comanche Peak	Comanche Peak		
				Walnut	Walnut		
			Trinity	Paluxy		Upper Glen Rose	Upper Trinity
113		Upper Aptian		Glen Rose	Glen Rose	Lower Glen Rose	Middle Trinity
				Twin Mountains	Hensell / Pearsall	Travis Peak	Hensell (Bexar Shale)	Hensell	
							Cow Creek	Cow Creek	
							Hammett (Pine Island)	Hammett	
125		Lower Aptian					Sligo	Sligo	Lower Trinity
129		Hauterivian-Valanginian			Hosston		Hosston	Hosston	
Pre-Cretaceous									

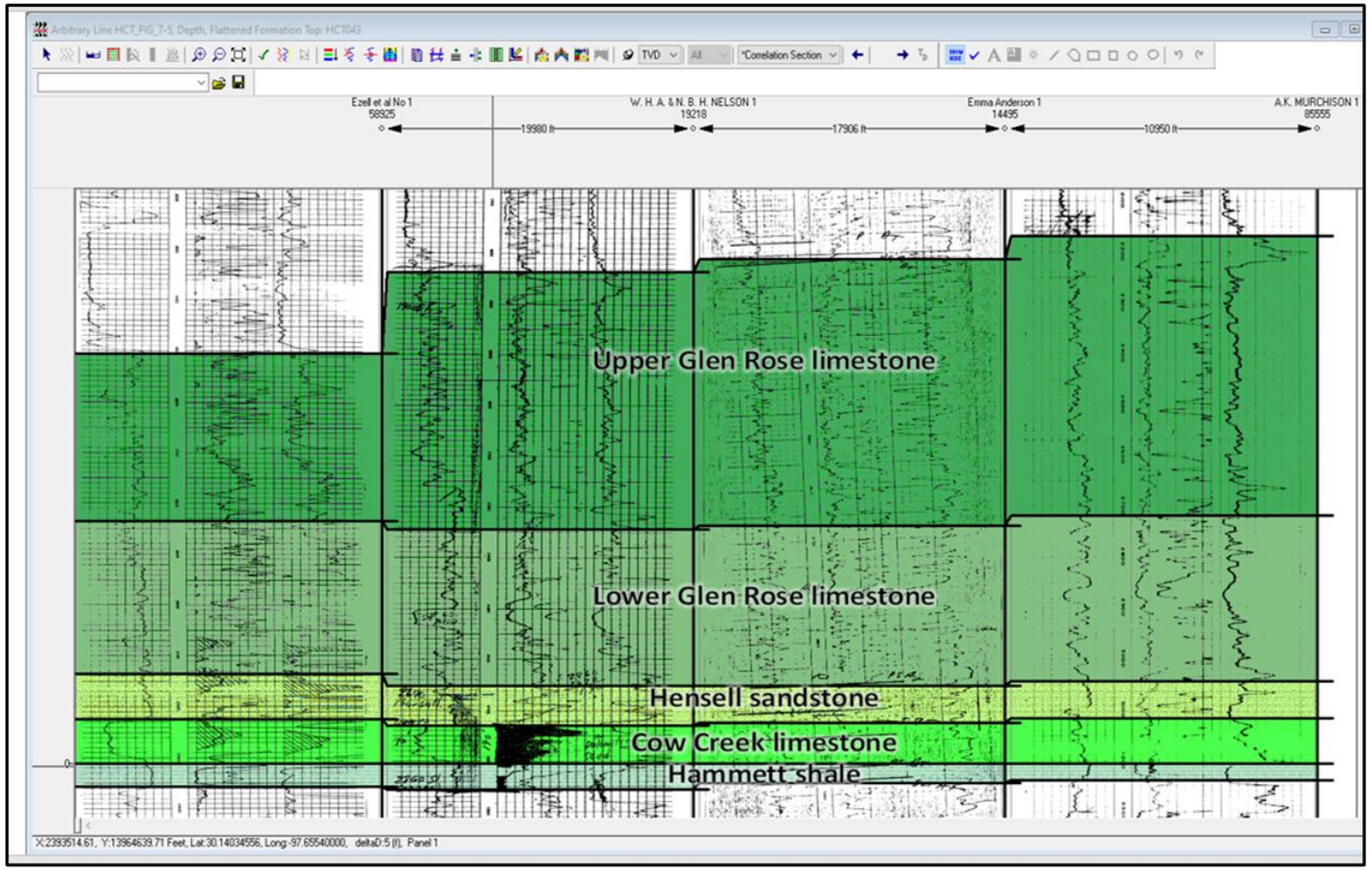


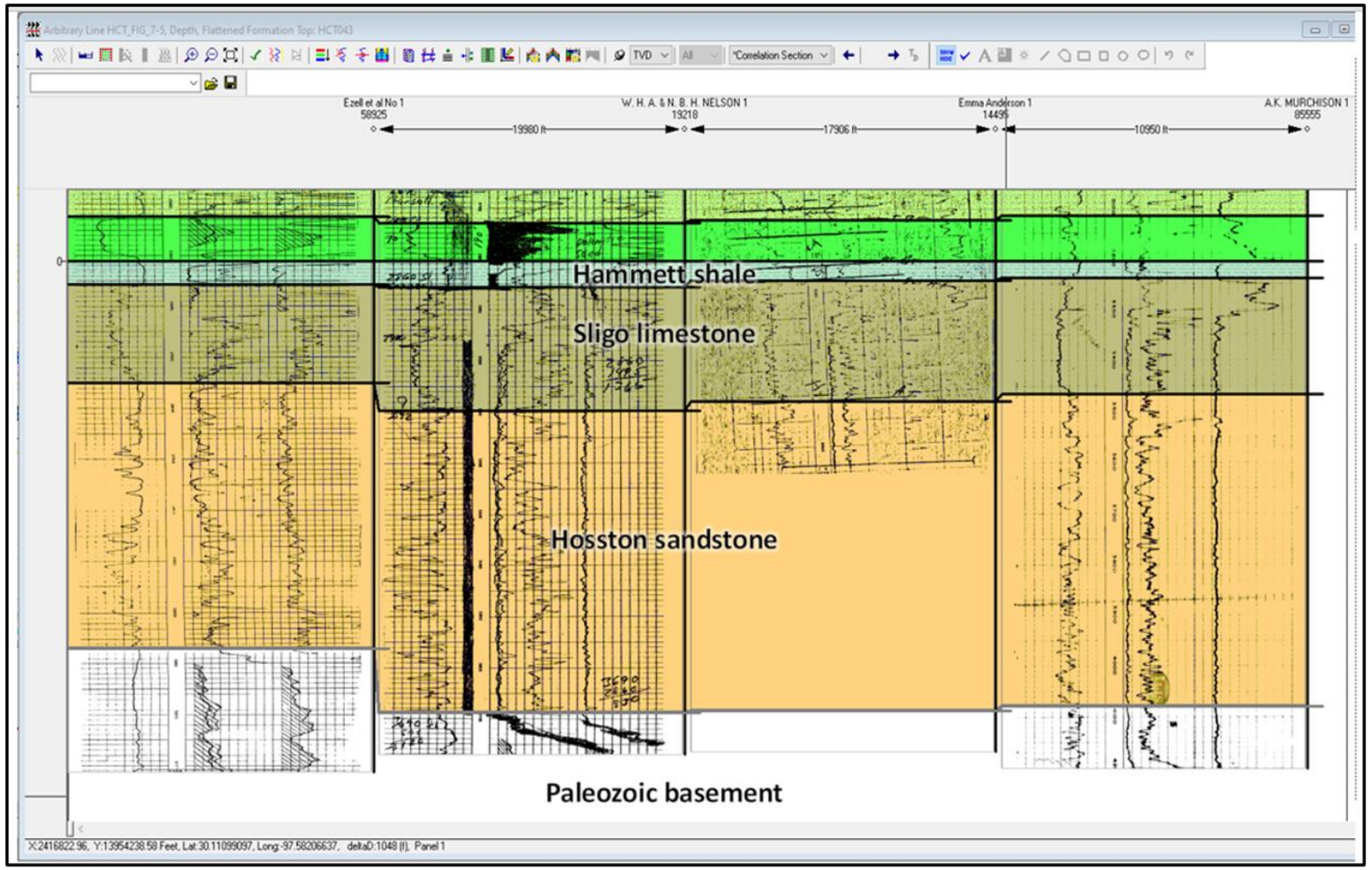
Structural and depositional setting

- Balcones Fault Zone
- Luling Fault Zone
- Cretaceous shelf
- Stuart City reef trend
- San Marcos Arch
- Llano Uplift



Modified from Rose (2016)


Ezell et al No 1
58925
W. H. A. & N. B. H. NELSON 1
19218
Emma Anderson 1
14495
A.K. MURCHISON 1
85555
19980 ft
17906 ft
10950 ft
Upper Glen Rose limestone
Lower Glen Rose limestone
Hensell sandstone
Cow Creek limestone
Hammett shale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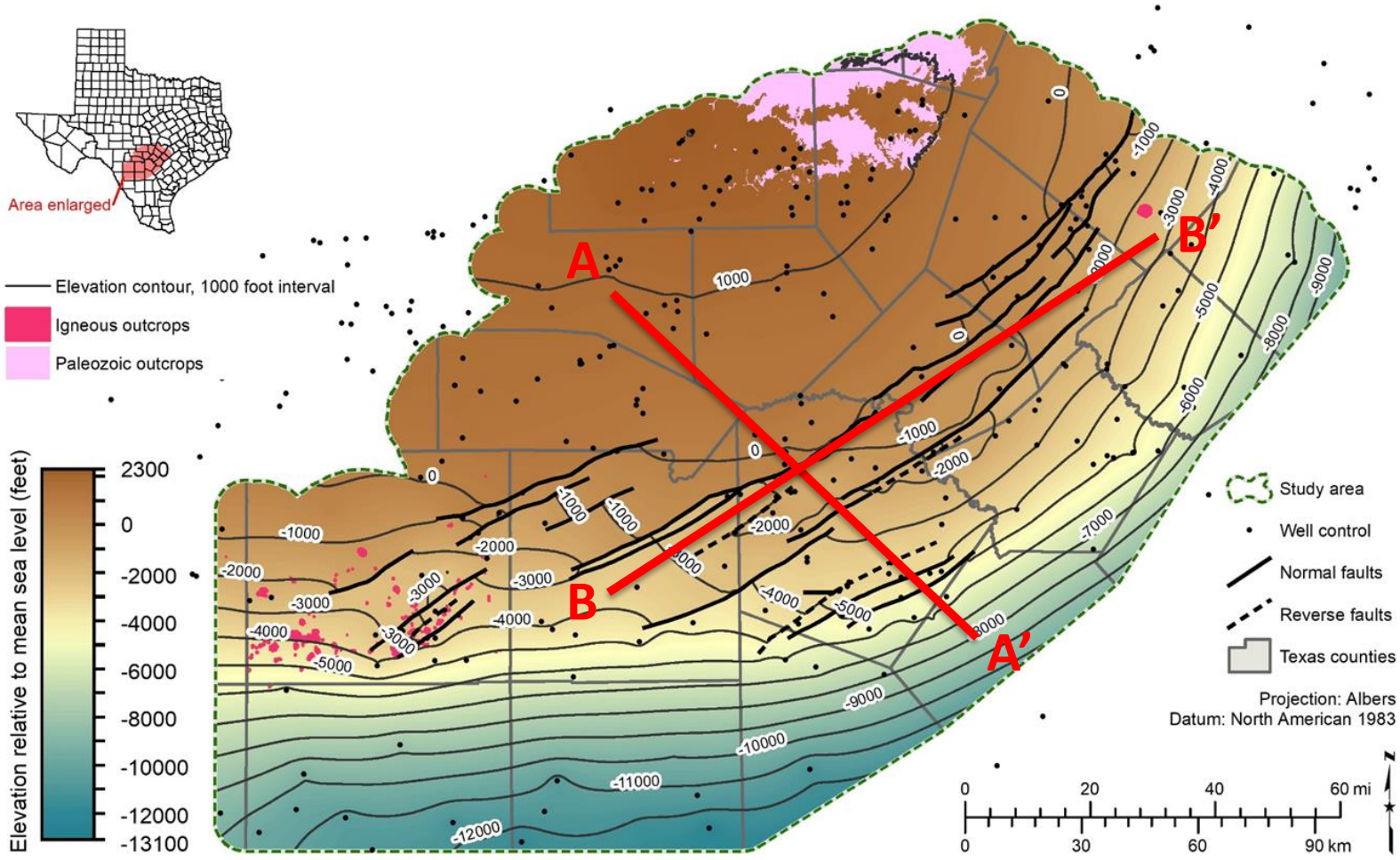
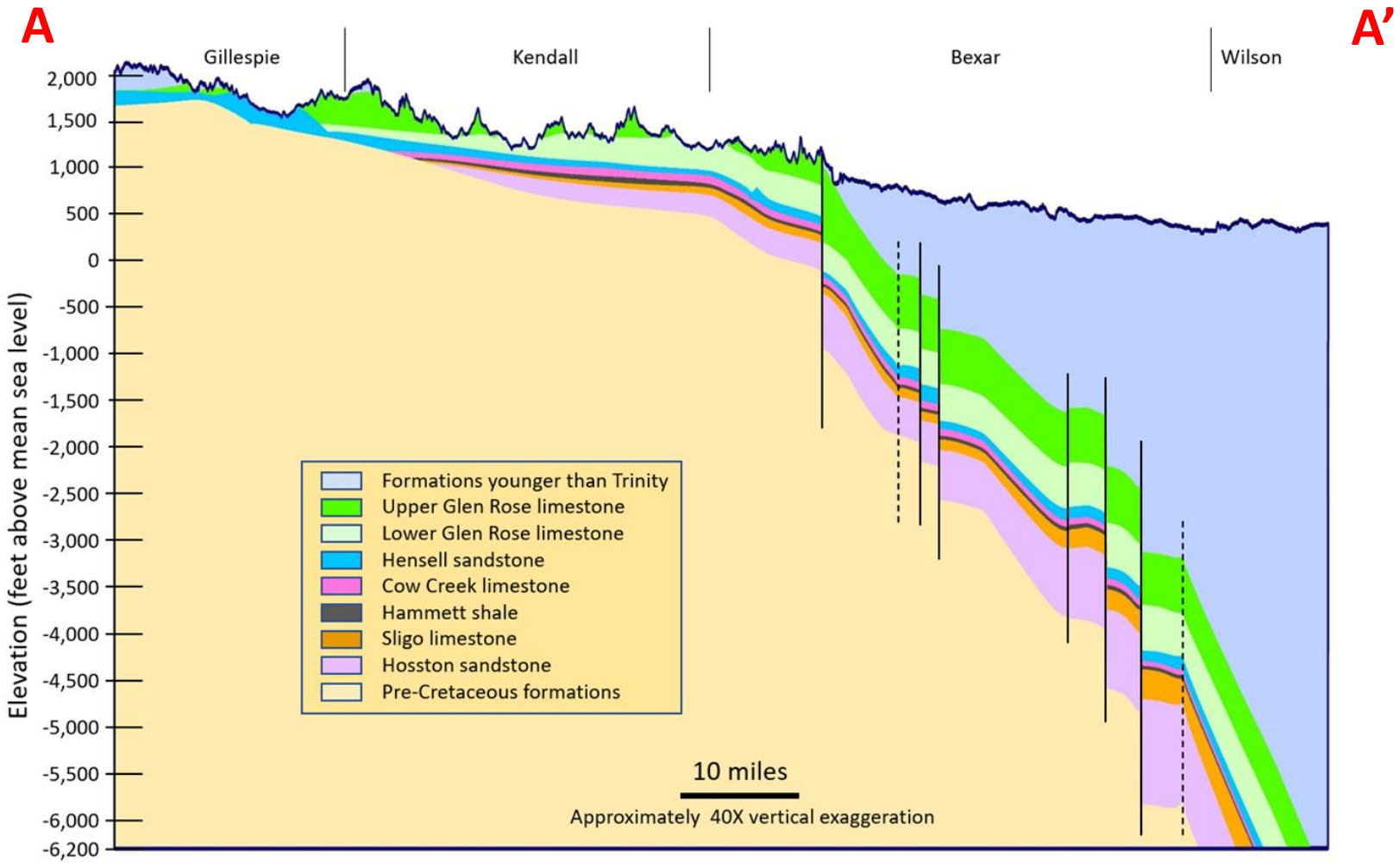
Hammett shale
Sligo limestone
Hosston sandstone
Paleozoic basement

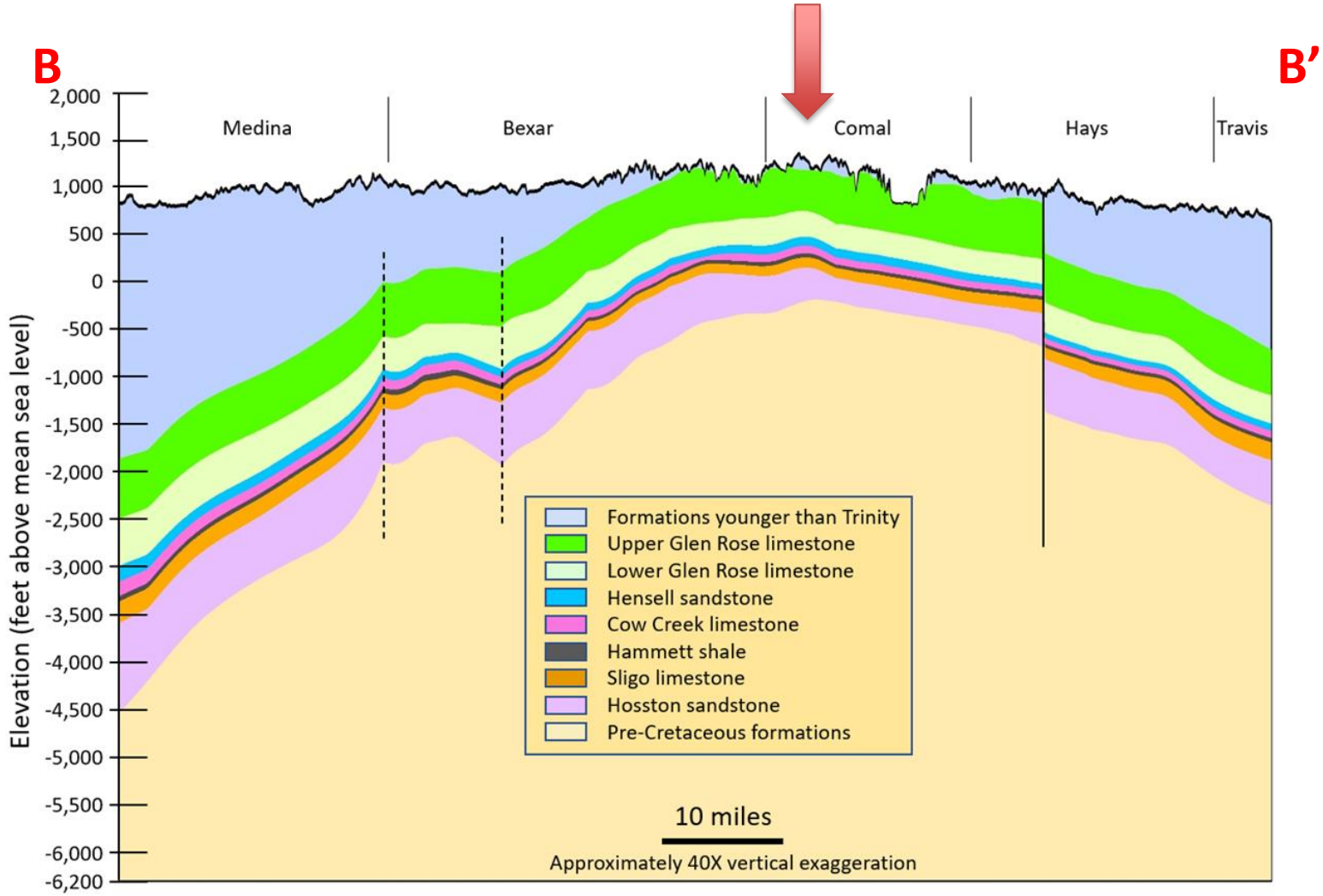
Base of Cretaceous structure



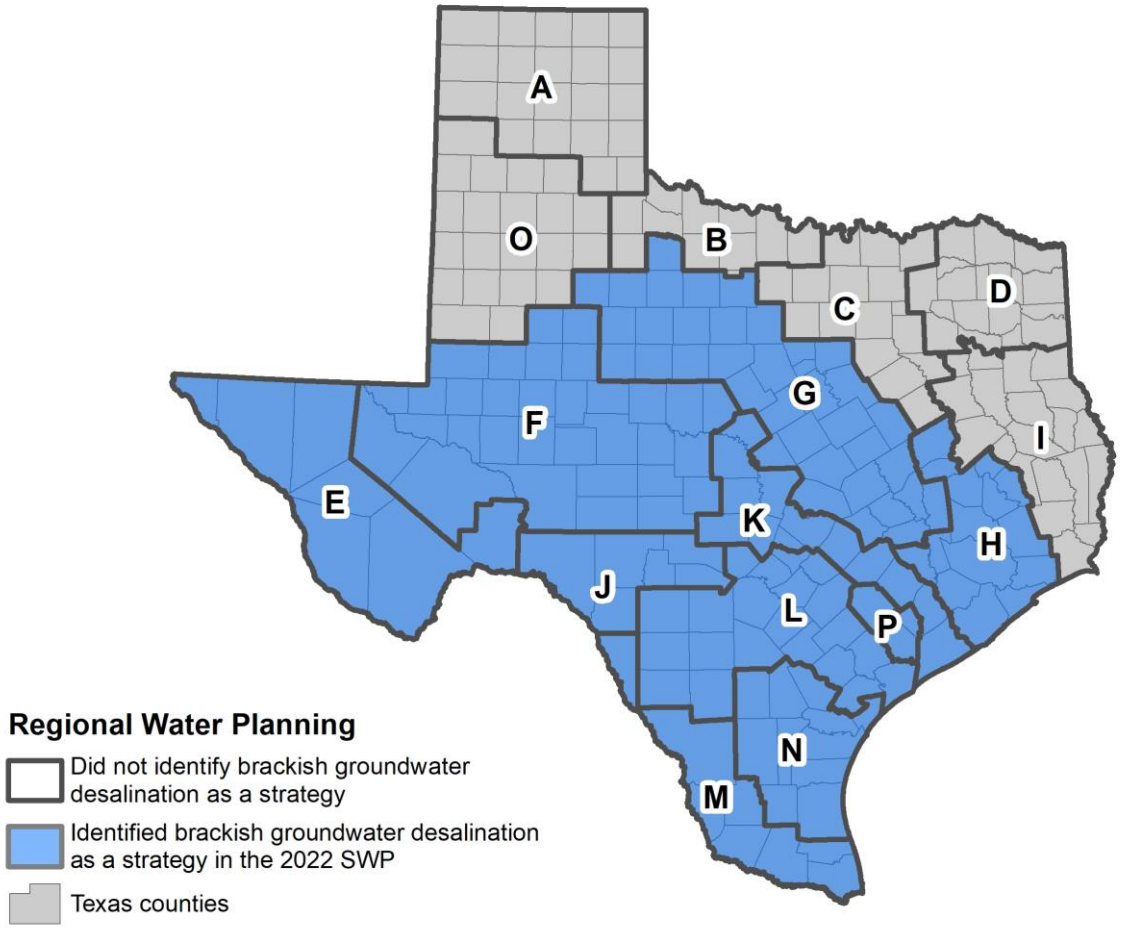
Dip cross section

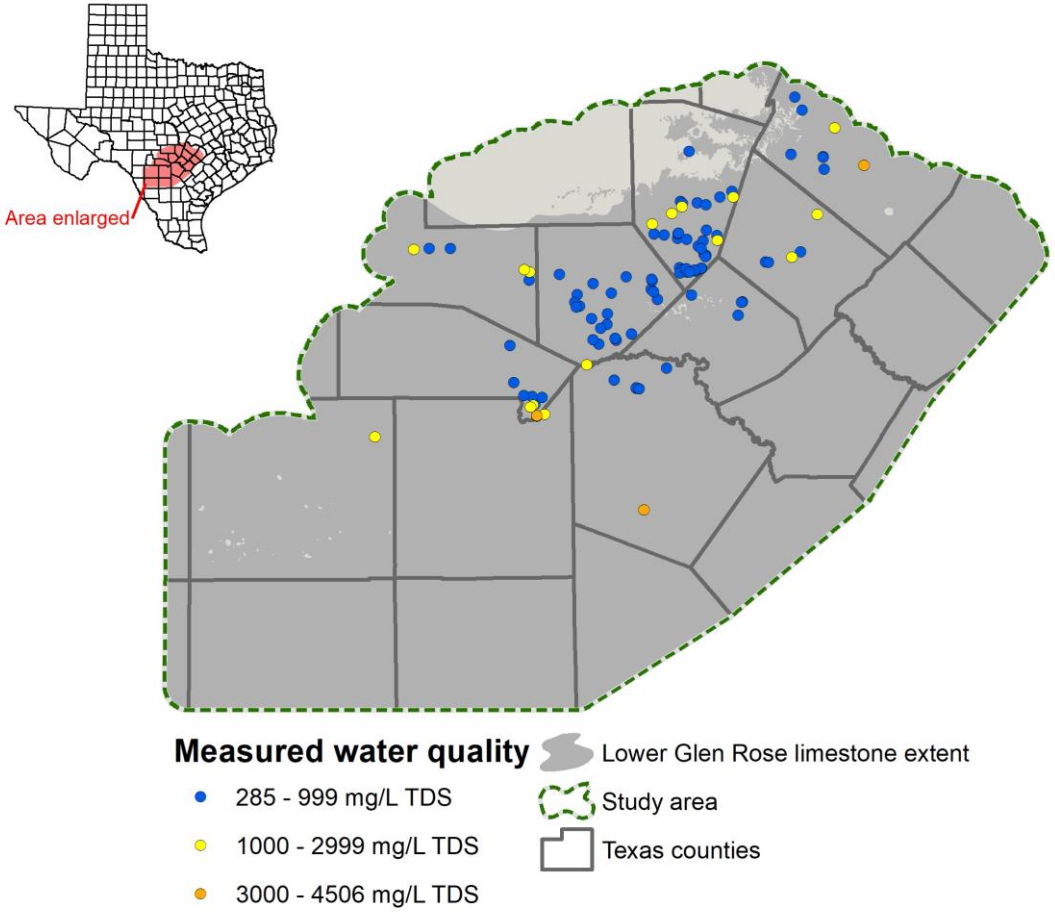


Strike cross section



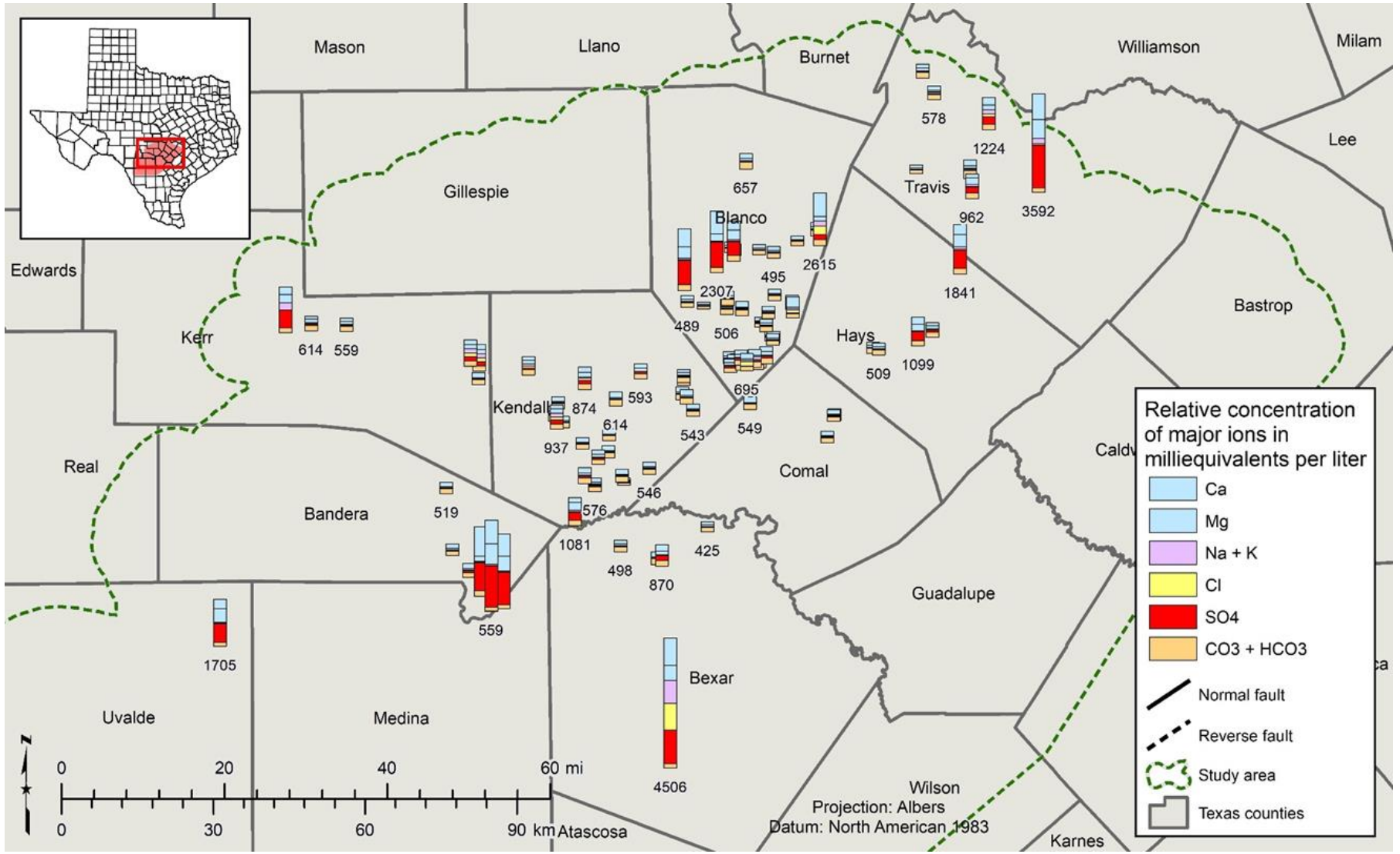
Why map aquifer salinity?



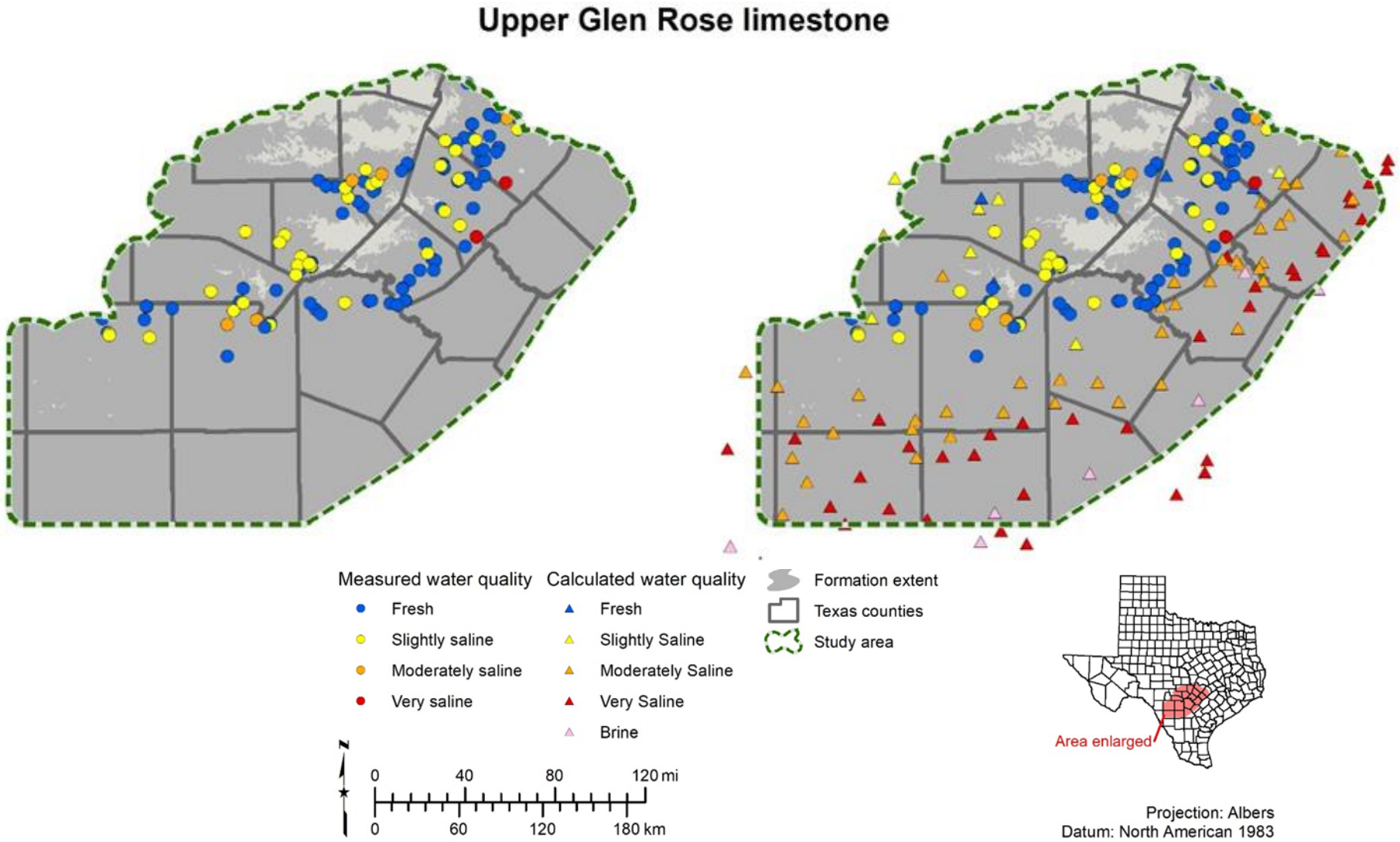


- by 2070 groundwater desalination is projected to provide 156,897 acre-feet/year (2% of total supply)

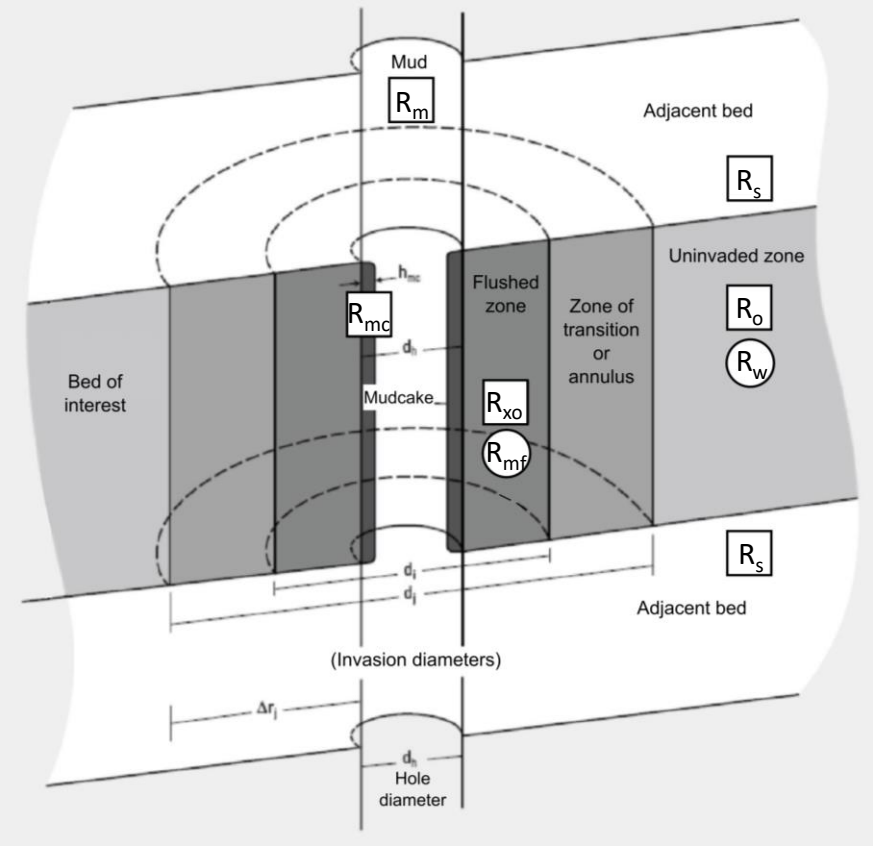
Water chemistry



Calculated salinity necessary



How did we estimate salinity?



- Resistivity ratio method (Alger and Harrison, 1989)
- Archie's Equation applied to both deep and shallow resistivity leads to ratio of known resistivity values as a solution for formation water resistivity.
- requires shallow and deep resistivity tool
- requires R_{mf} measurement
- calculate Rw, convert to Cw, then use TDS-Cw relationship to convert to TDS (mg/L)

Basic derivation of the Alger-Harrison method

1 $$R_o = R_w \cdot \frac{a}{\phi^m} \quad \& \quad R_{xo} = R_{mf} \cdot \frac{a}{\phi^m}$$

2 $$\frac{R_o}{R_w} = \frac{a}{\phi^m} \quad \& \quad \frac{R_{xo}}{R_{mf}} = \frac{a}{\phi^m}$$

3 $$\frac{R_o}{R_w} = \frac{R_{xo}}{R_{mf}}$$

4 $$R_w = \frac{R_o \cdot R_{mf}}{R_{xo}}$$

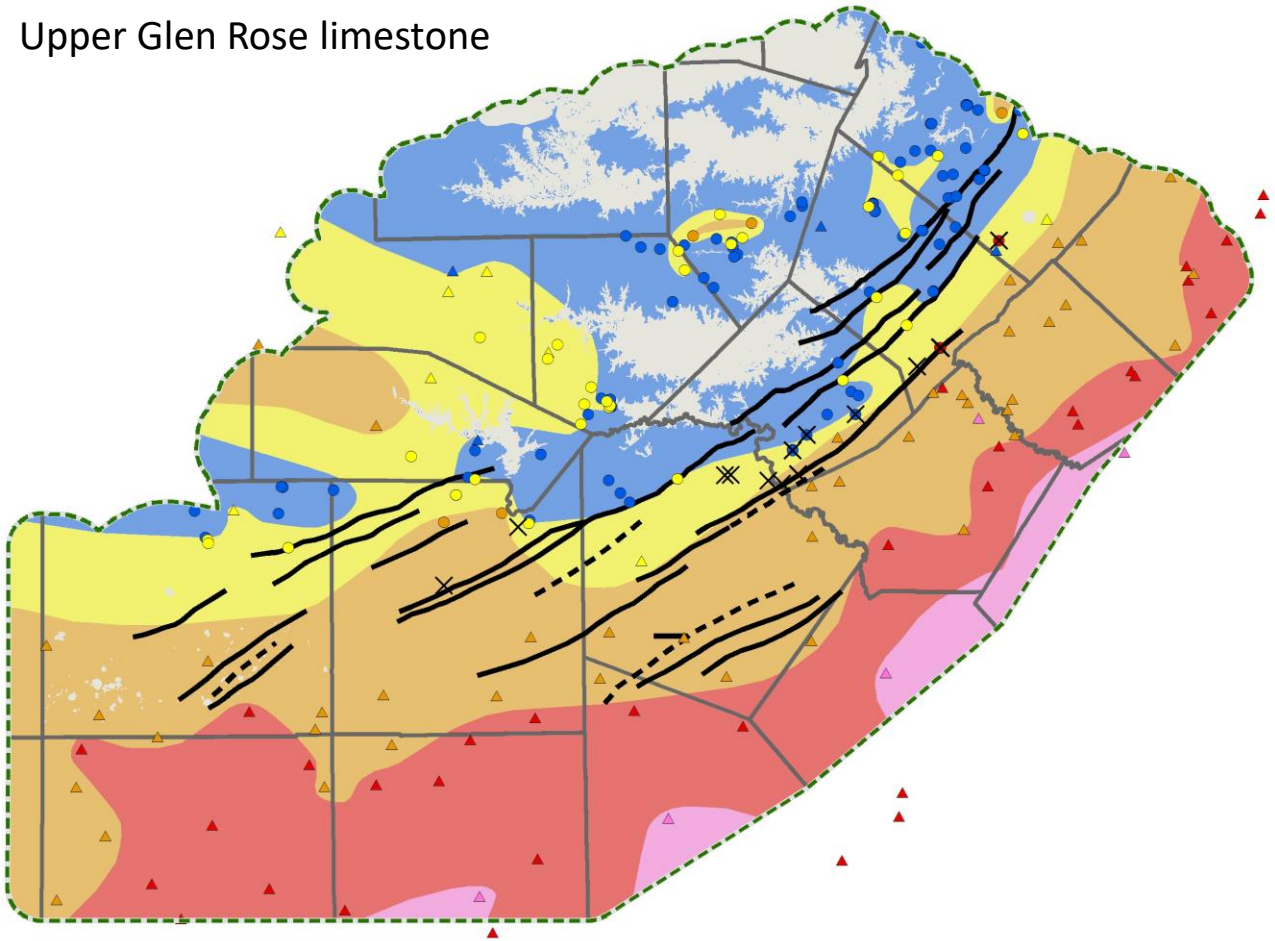
Salinity classes

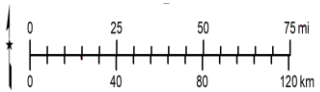
Salinity class	Total dissolved solids concentration (mg/L)
Fresh	0 < TDS < 1,000
Slightly saline	1,000 ≤ TDS < 3,000
Moderately saline	3,000 ≤ TDS < 10,000
Very saline	10,000 ≤ TDS < 35,000
Brine	35,000 ≤ TDS

Winslow and Kister (1956)

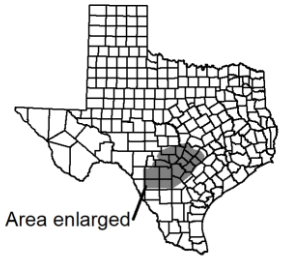
Upper Trinity salinity map

Upper Glen Rose limestone





Projection: Albers
Datum: North American 1983



Measured TDS
- Fresh
- Slightly saline
- Moderately saline
- Very saline

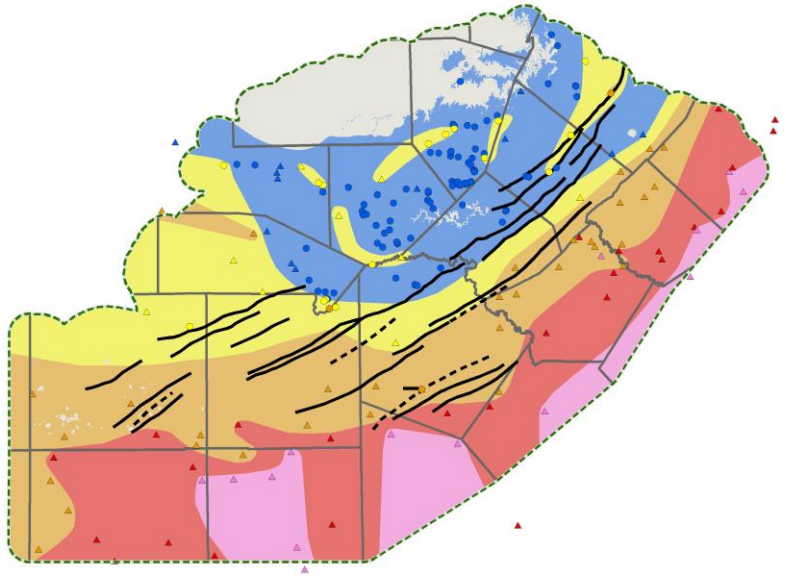
Calculated TDS
- Fresh
- Slightly Saline
- Moderately Saline
- Very Saline
- Brine

- Ignore

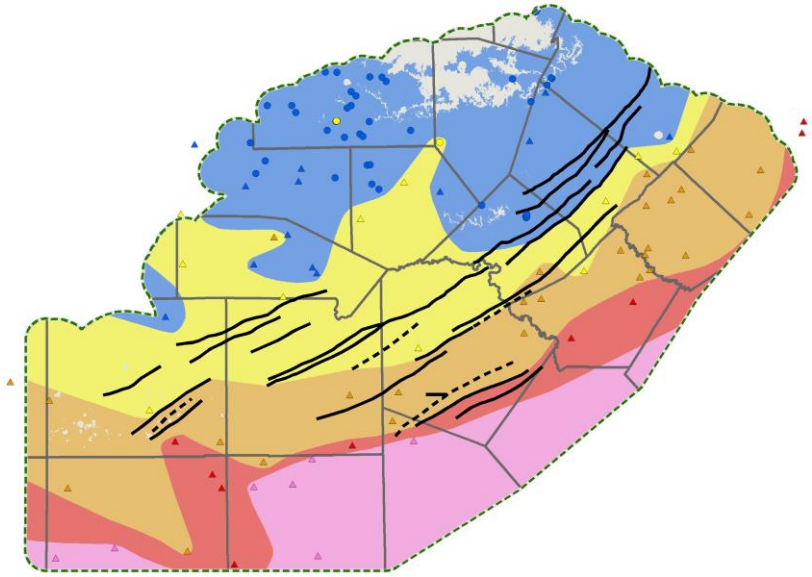
Salinity class
- Fresh
- Slightly saline
- Moderately saline
- Very saline
- Brine
- Study area
- Normal fault
- Reverse fault
- Texas counties

Middle Trinity salinity maps

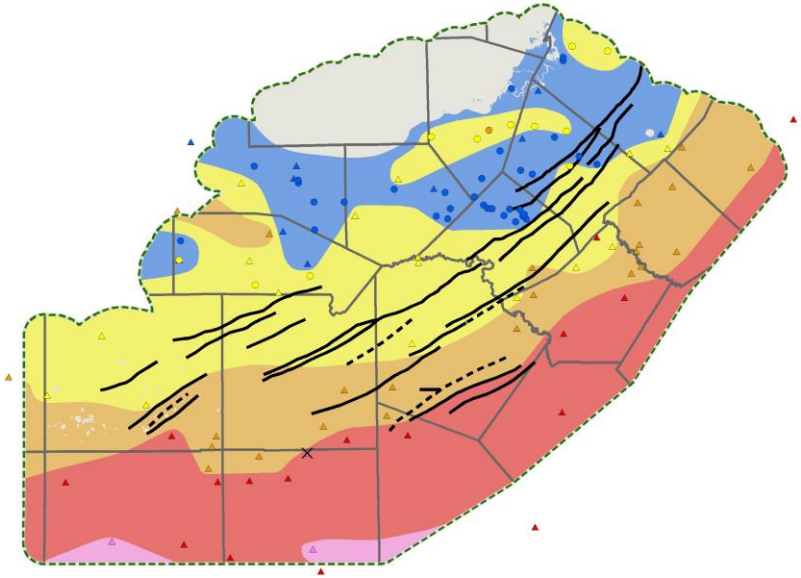
Lower Glen Rose limestone

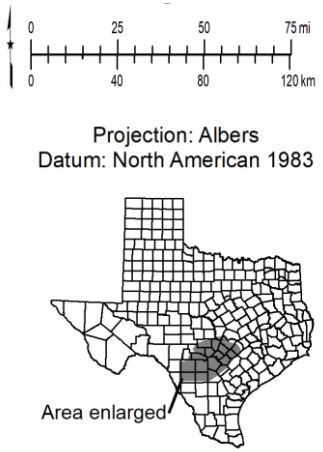


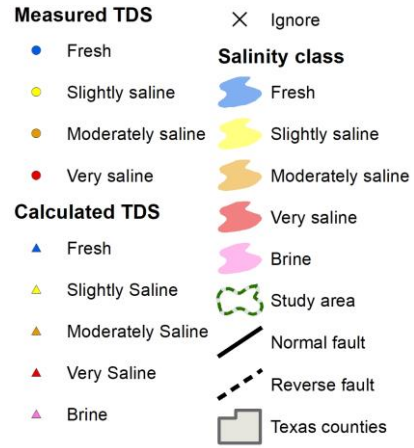
Hensell sandstone



Cow Creek limestone

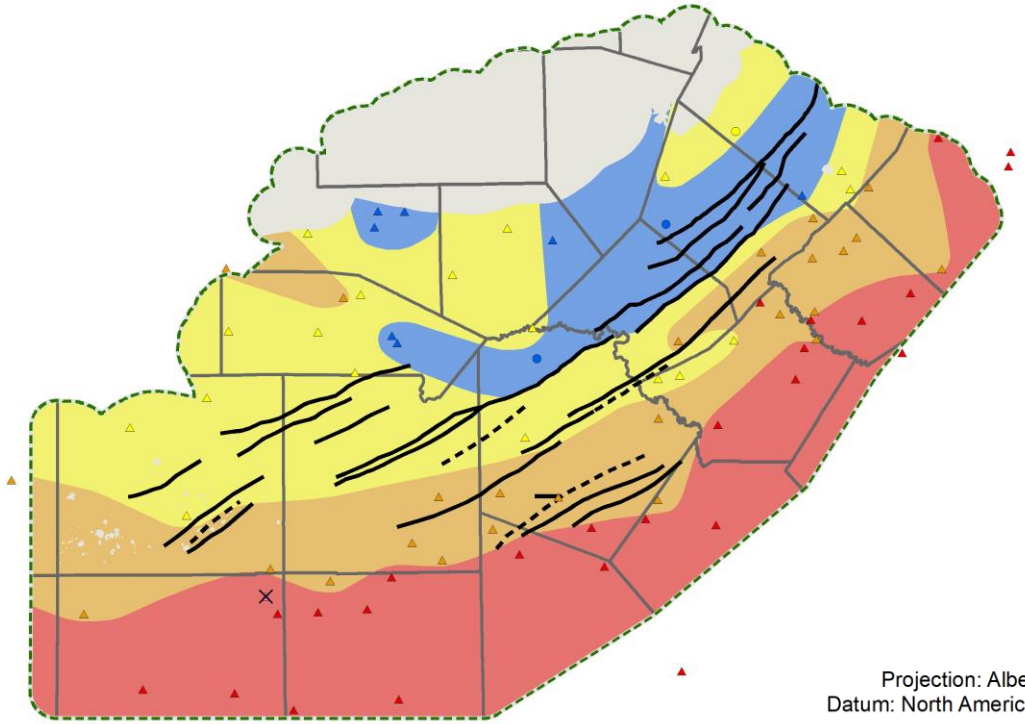




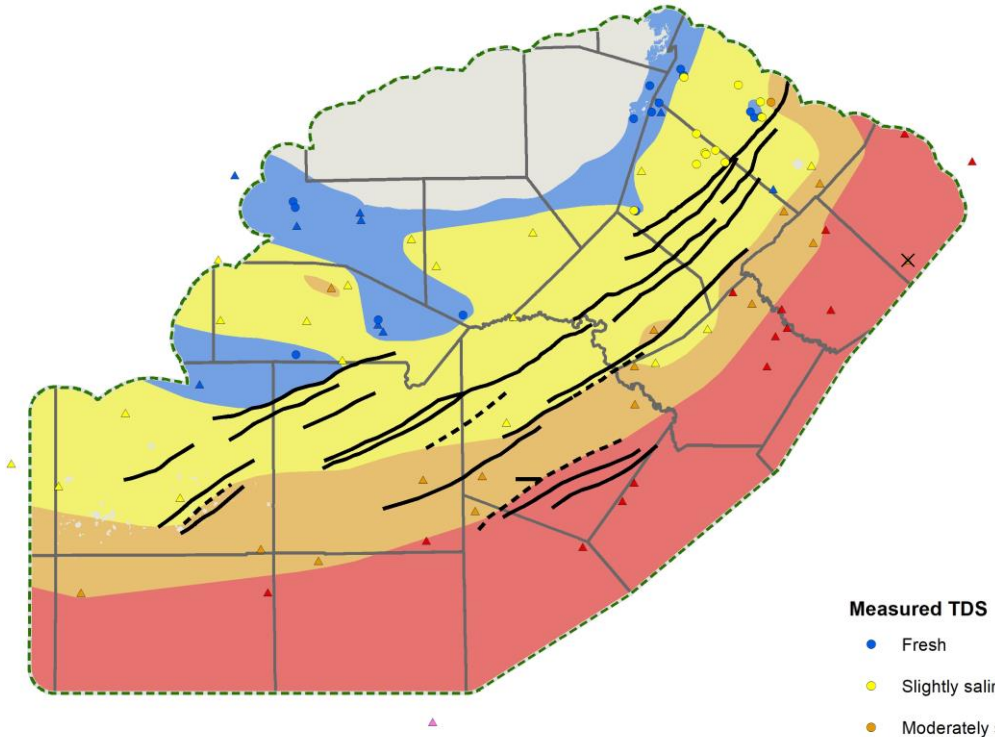


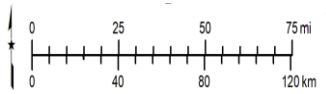
Lower Trinity salinity maps

Sligo limestone



Hosston sandstone





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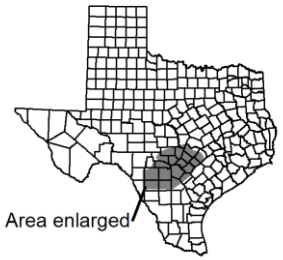

Measured TDS
- Fresh
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- Very saline

Calculated TDS
- Fresh
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- Very Saline
- Brine

- Ignore

Salinity class
- Fresh
- Slightly saline
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- Study area
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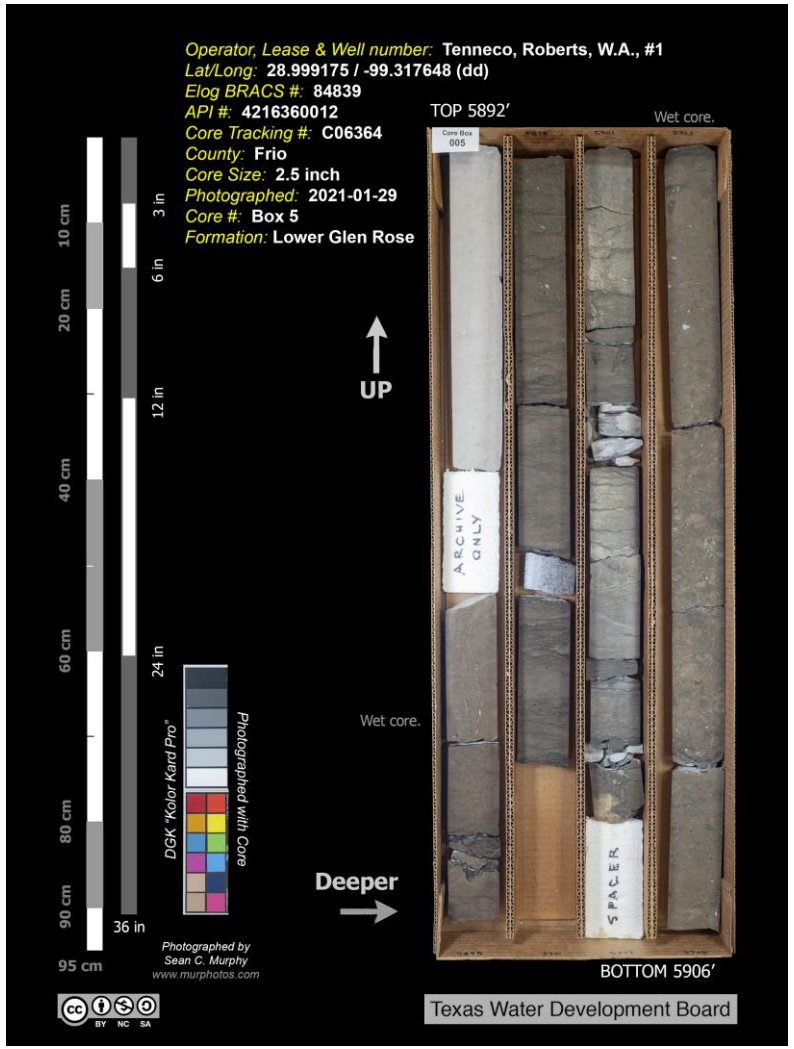
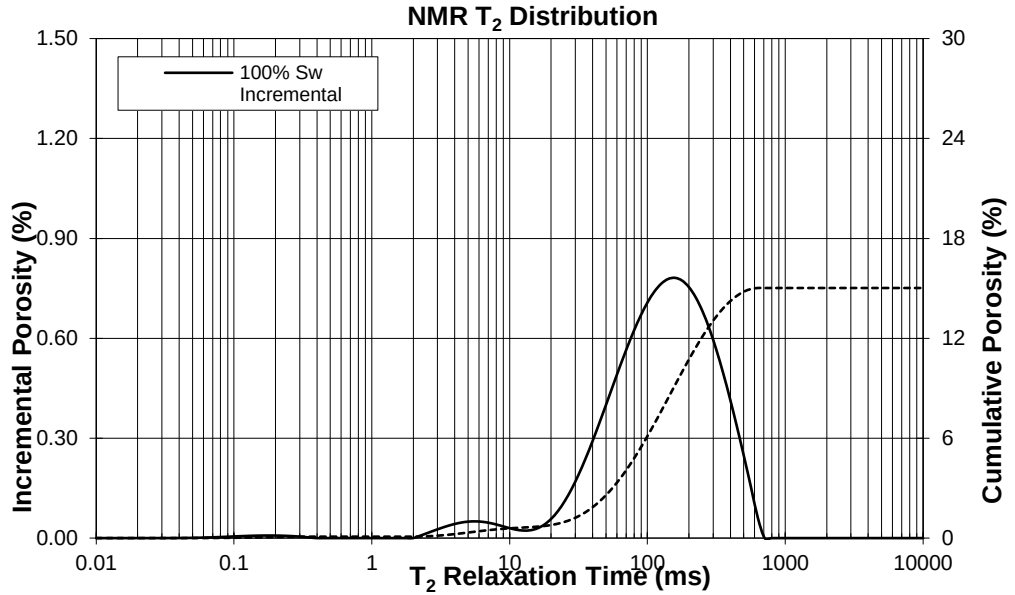
Aquifer properties





NMR T2 Measurement

Incremental and Cumulative Distribution

Sample ID	Box 4
Company:	Allan R. Standen, LLC
Well Name:	Roberts W. A #1
Location:	Frio County, Texas
Depth (ft):	5887.50
Core Lab File No.:	202100628

Core Analysis Data	
Permeability (md):	.521
Porosity (pu):	14.7
Pore Volume (cm^3):	1.741
Bulk Volume (cm^3):	11.89
Grain Density (g/cm^3):	2.71
Bulk Density (g/cm^3):	2.46

NMR Parameters	
Hydrogen Index:	1
Echo Spacing (ms):	0.20
Signal/Noise (Sat):	100
Gradient:	None
Temperature (degC):	28.0

NMR Data	
Log Mean T2 @ Sw=100% (msec):	112.5
NMR Porosity @ Sw=100% (pu):	15.0
Effective Porosity, T2min=2.8ms (pu):	14.9
Clay Bound Water, T2max=2.8ms (pu):	0.1

Volumes

Hydrostratigraphic unit	Volume (acre-feet)				
	Fresh	Slightly Saline	Moderately Saline	Very Saline	Total
Upper Glen Rose limestone	9,530,362	22,344,252	53,212,654	49,388,081	134,475,350
Lower Glen Rose limestone	34,573,100	35,608,649	61,689,916	67,289,482	199,161,147
Hensell sandstone	9,300,826	12,906,665	23,325,590	15,825,480	61,358,561
Cow Creek limestone	24,131,596	12,907,039	10,275,586	18,581,271	65,895,492
Sligo limestone	4,859,227	30,809,060	16,976,735	74,641,576	127,286,598
Hosston sandstone	8,769,583	86,970,453	77,588,464	217,030,438	390,358,937
Total	91,164,693	201,546,118	243,068,946	442,756,328	978,536,086

Conclusions

- Slightly brackish groundwater (<3,000 mg/l TDS) at depths exceeding 3,000 feet in the Middle and Lower Trinity.
- Moderately brackish groundwater (3,000 to 10,000 mg/l TDS) at depths exceeding 7,000 feet in all Trinity hydrologic units.
- Almost 900,000,000 acre-feet of brackish groundwater “in-place” (only a percentage is economically/technically producible).
- “Real” data can have a 10X impact on a study.

Depths of saline groundwater

Hydrostratigraphic unit	Fresh		Slightly saline		Moderately saline		Very saline	
	Average depth (feet)	Maximum depth (feet)	Average depth (feet)	Maximum depth (feet)	Average depth (feet)	Maximum depth (feet)	Average depth (feet)	Maximum depth (feet)
Upper Glen Rose limestone	45	1,758	297	1,819	2,257	7,018	5,732	8,904
Lower Glen Rose limestone	288	2,509	740	2,853	2,728	8,096	5,787	9,879
Hensell sandstone	423	3,168	1,193	3,057	3,935	9,742	6,290	10,153
Cow Creek limestone	559	3,409	1,238	3,187	3,620	7,608	7,260	10,849
Sligo limestone	702	2,261	1,415	3,554	3,645	7,165	7,669	11,328
Hosston sandstone	708	3,734	1,419	3,970	3,897	7,296	7,643	11,953

Questions?

Mark Robinson, P.G.
Mark.Robinson@twdb.texas.gov
512-463-7657

Alysa Suydam, P.G.
Alysa.Suydam@twdb.texas.gov
512-936-9488

Evan Strickland, P.G.
Evan.Strickland@twdb.texas.gov
512-463-6929

Photo courtesy of James Golab