Brackish Groundwater Resources of the Northern Trinity Aquifer, Texas

Mark C. Robinson[1] and Daniel M. Lupton[2]

[1]Texas Water Development Board, 1700 N. Congress Ave., Austin, Texas 78711

[2]INTERA Incorporated, 9600 Great Hills Trail, Ste. 300W, Austin, Texas 78759

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ABSTRACT

The Trinity Aquifer is a Texas Water Development Board (TWDB) designated major aquifer and underlies all or parts of 70 counties in Texas as well as extending into portions of Oklahoma and Arkansas. In Texas, the aquifer extends uninterrupted from the Oklahoma border to south-central Texas. We define the Northern Trinity Aquifer as that portion of the Trinity Group in Texas which lies north of the Colorado River. We utilized the hydrostratigraphic zonation from the groundwater availability model (GAM) developed for the TWDB (Kelly et al., 2014) which subdivided the Trinity Group into five distinct hydrostratigraphic units; Hosston, Pearsall, Hensell, Glen Rose, and Paluxy. These Lower Cretaceous units are predominantly composed of interbedded sands, shales, and carbonates with minor evaporate beds present. The combined saturated thickness of the Northern Trinity Aquifer averages between 600 and 1900 feet.

In 2009, the 81st Texas Legislature provided funding to the TWDB to establish the Brackish Resources Aquifer Characterization System (BRACS). The goal of the program is to map and characterize the brackish portions of the aquifers in Texas in sufficient detail to provide useful information and data to regional water planning groups and other entities interested in using brackish groundwater as a water supply. House Bill 30, passed by the 84th Texas Legislative Session in 2015, requires the TWDB to identify and designate brackish groundwater production zones in the aquifers within the state. The Trinity Aquifer was one of the aquifers selected for study in House Bill 30.

In this study we combined the hydrostratigraphic units of the Northern Trinity Aquifer GAM with groundwater salinity values measured from groundwater samples and calculated from geophysical well logs. The geophysical well log measurements used in calculating groundwater salinity were mainly induction resistivity run primarily in oil and gas wells. Salinity zones were then mapped based upon the combined sampled and calculated total dissolved solids concentrations of the groundwater for each of the five hydrostratigraphic units. The four salinity zones mapped for each hydrostratigraphic unit are based upon total dissolved solids concentrations: these are (1) fresh (0 to 1000 milligrams per liter); (2) slightly saline (1000 to 3000 milligrams per liter); (3) moderate-

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ly saline (3000 to 10,000 milligrams per liter); and (4) very saline (10,000 to 35,000 milligrams per liter). Groundwater volumes were calculated for each mapped salinity zone for each of the five hydrostratigraphic units. All data and analysis techniques were documented and will be made publicly available.

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GCAGS

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Shreveport, Louisiana

Mark Robinson, P.G.
Innovative Water Technologies
Texas water Development Board
Mark.Robinson@twdb.Texas.gov

Daniel Lupton, P.G.
INTERA
dlupton@intera.com

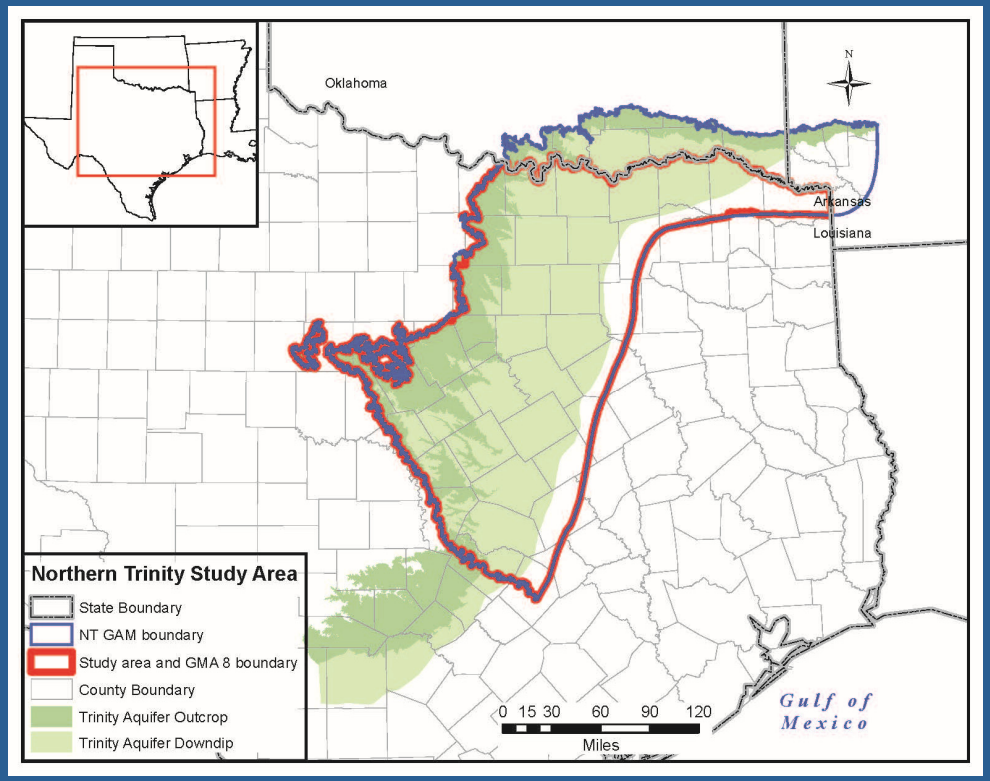
Unless specifically noted, this presentation does not necessarily reflect official Board positions or decisions.

Project Objectives

Evaluate the fresh, brackish, and saline groundwater resources of the Trinity Aquifer

- Evaluate groundwater, water chemistry, and geophysical log data available in the study area
- Develop and employ a technical approach for estimating total dissolved solids (TDS) from geophysical logs
- Delineate fresh, brackish, and saline groundwater both horizontally and vertically in the aquifers of the project area
- Calculate brackish groundwater volumes

Geology of the Trinity Aquifer



Northern Trinity Hydrostratigraphic Units

Age m.y	Period	Group	Formations					Hydrostratigraphic Units
			North and West	Central		South		
65	Upper Cretaceous	Eagle Ford	not present	undifferentiated		undifferentiated		
		Woodbine	not present	undifferentiated		undifferentiated		
		Washita	Grayson Mainstreet Pawpaw Weno Denton Fort Worth Duck Creek	Buda Del Rio Georgetown		Buda Del Rio Georgetown		
100	Lower Cretaceous	Fredericksburg	Kiamichi Goodland Walnut	Kiamichi Edwards Comanche Peak Walnut		Kiamichi Edwards Comanche Peak Walnut		
		Trinity	Antlers	Paluxy Glen Rose		Paluxy Glen Rose		Paluxy Glen Rose
				Twin Mountains	Hensell Pearsall Hosston	Travis Peak	Hensell Pearsall Cow Creek Hammett Sligo Hosston	Hensell Pearsall Hosston
Pre-Cretaceous								

Trinity Geologic Framework:
GAM Hydrostratigraphy Work Flow (Kelley and others, 2014)

Build Well Log Database
- BRACS, BEG, TCEQ PWS, Q-logs, commercial sources

Correlate Stratigraphic Surfaces
- Original work but built off of previous studies

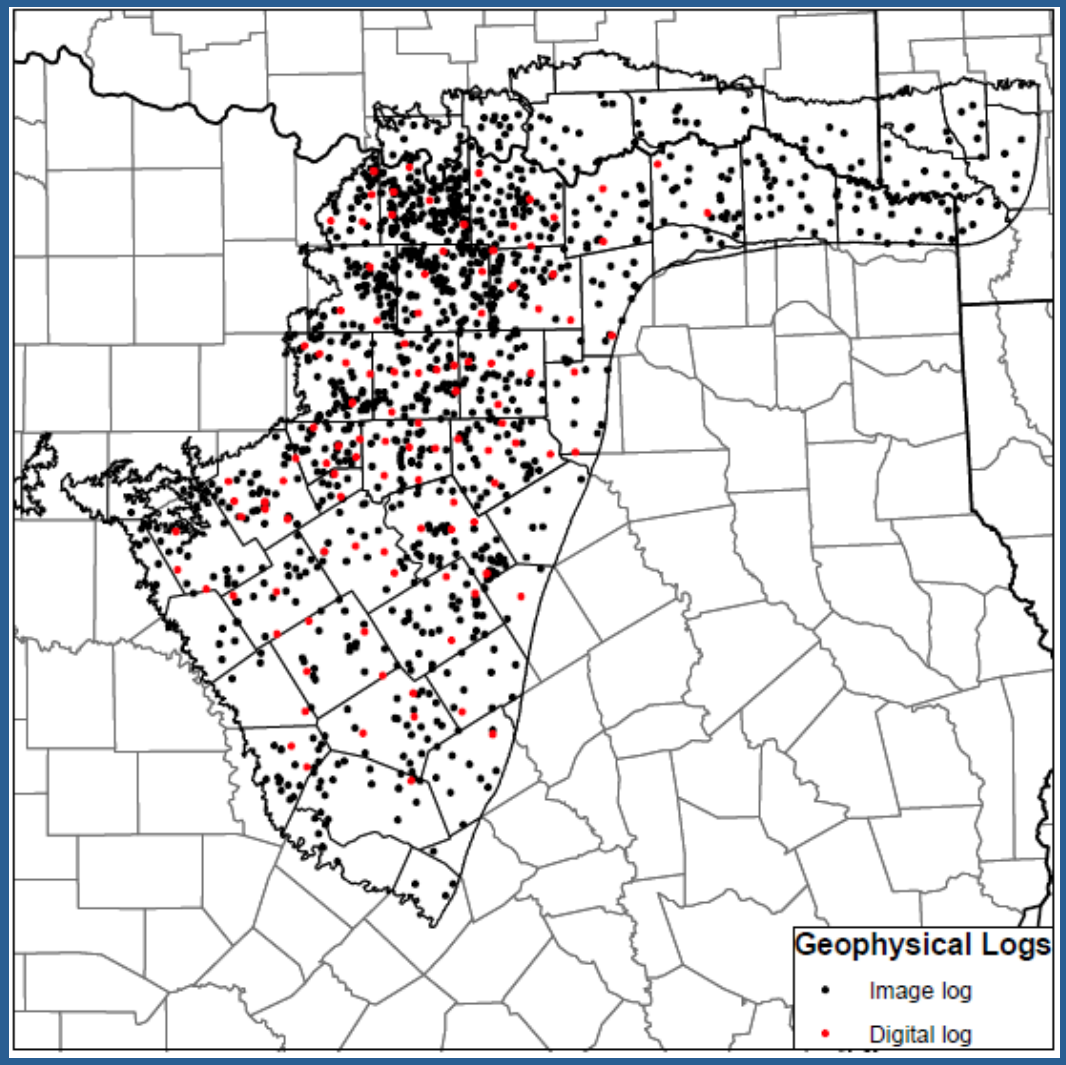
Interpret Lithologies from Well Logs
- Vertical record of interbedded lithologies – 5 to 10 foot scale

Map Layer Thicknesses and Compositions
- Structure, isopach, net sandstone maps

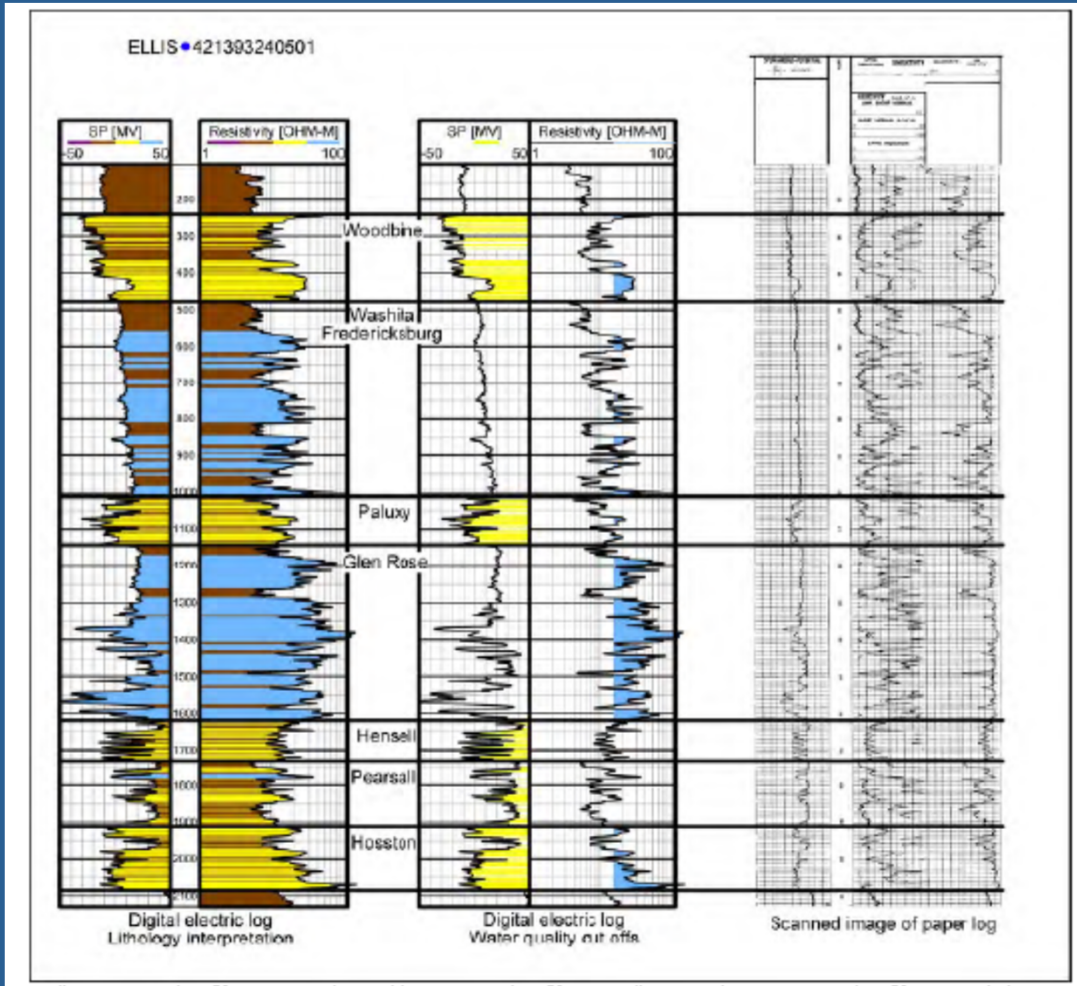
Interpret Depositional Environments
- Enhance predictability between wells – defines properties

Well Log Database (Kelley and others, 2014)

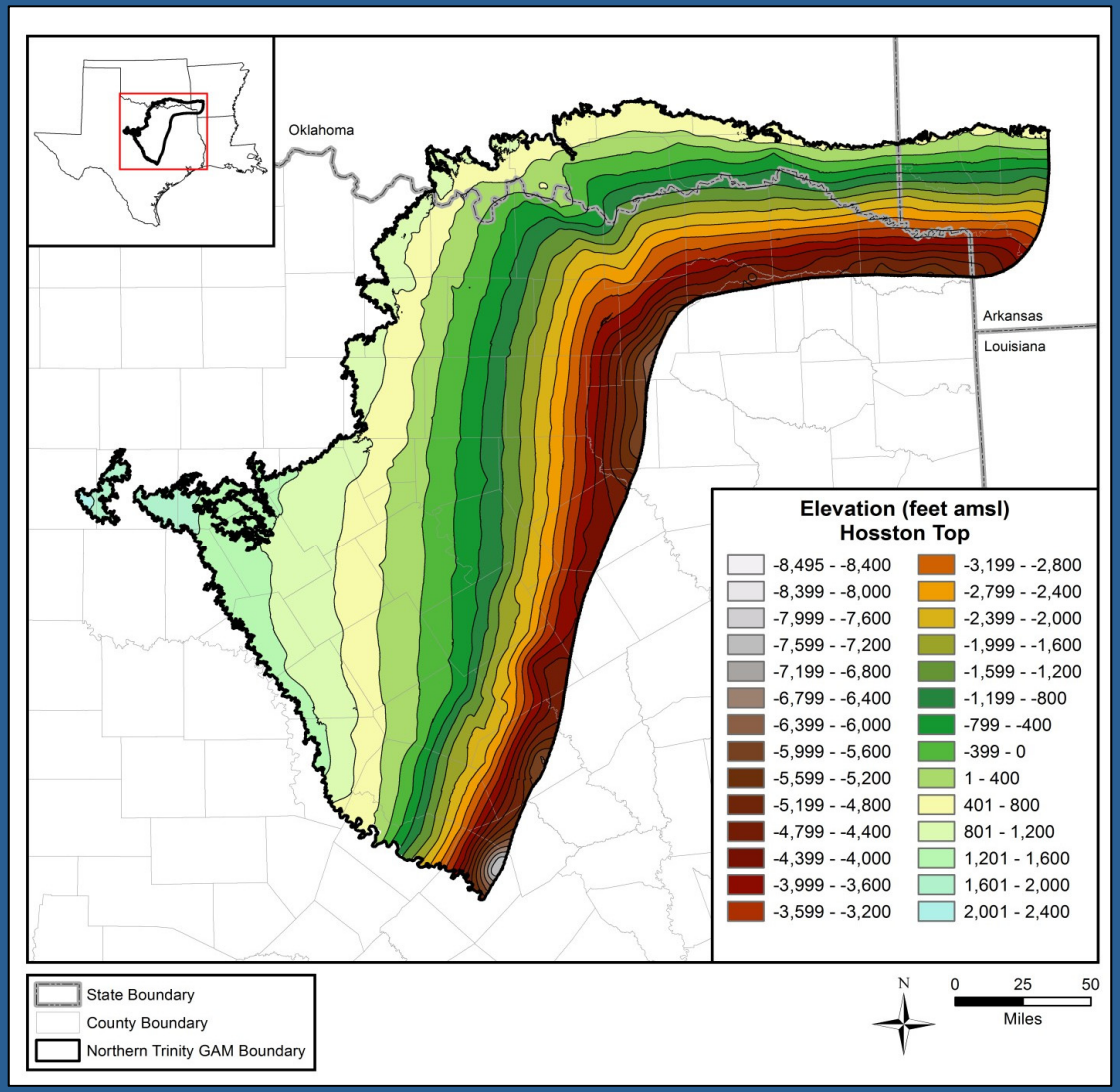
- 1193 wells with depth registered image logs
- 109 wells with digitized logs



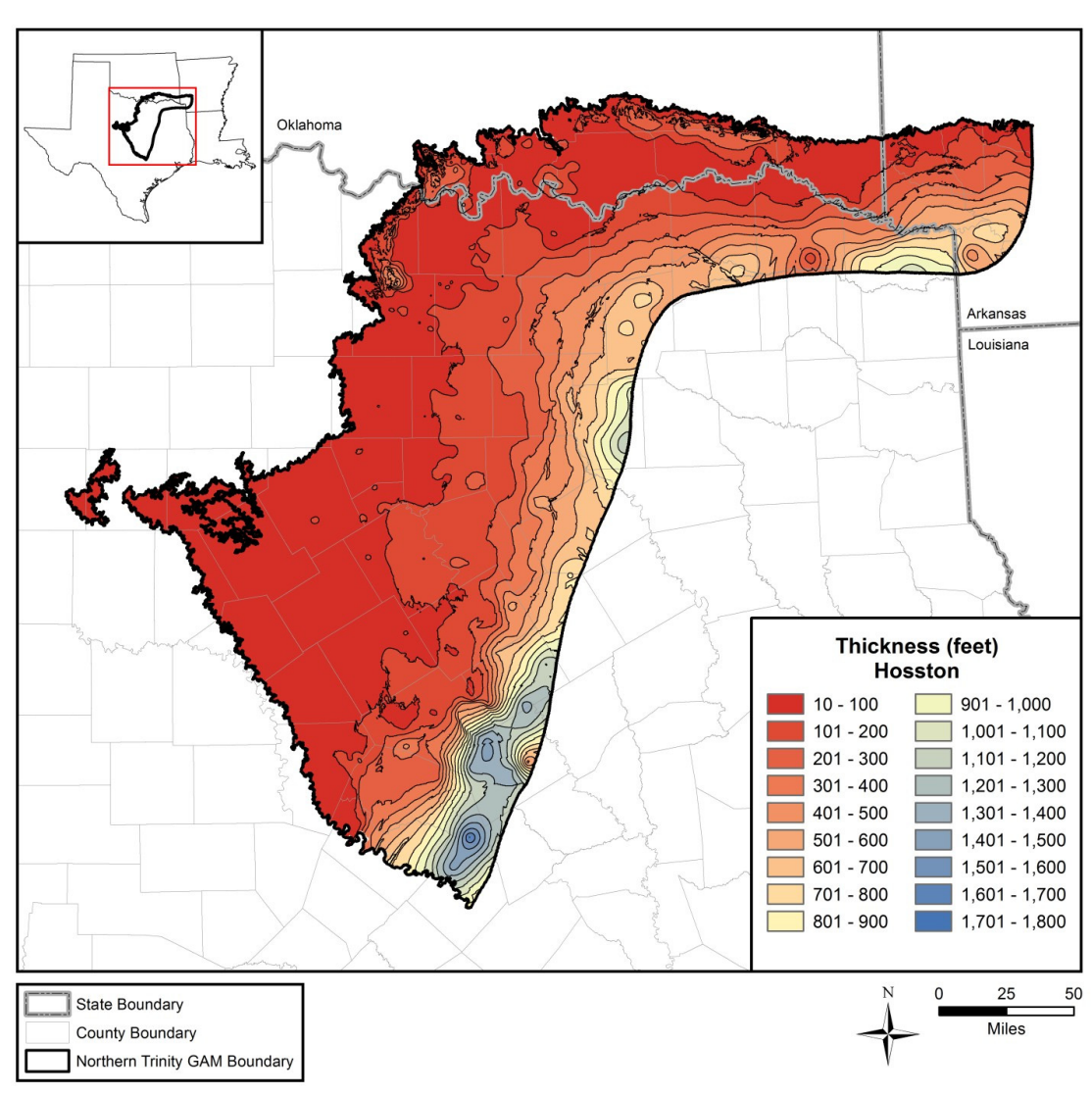
Well Log Correlations/Lithologies (Kelley and others, 2014)



Hydrostratigaphic Surfaces (Kelley and others, 2014)



Isopach Hydrostratigaphic Units (Kelley and others, 2014)

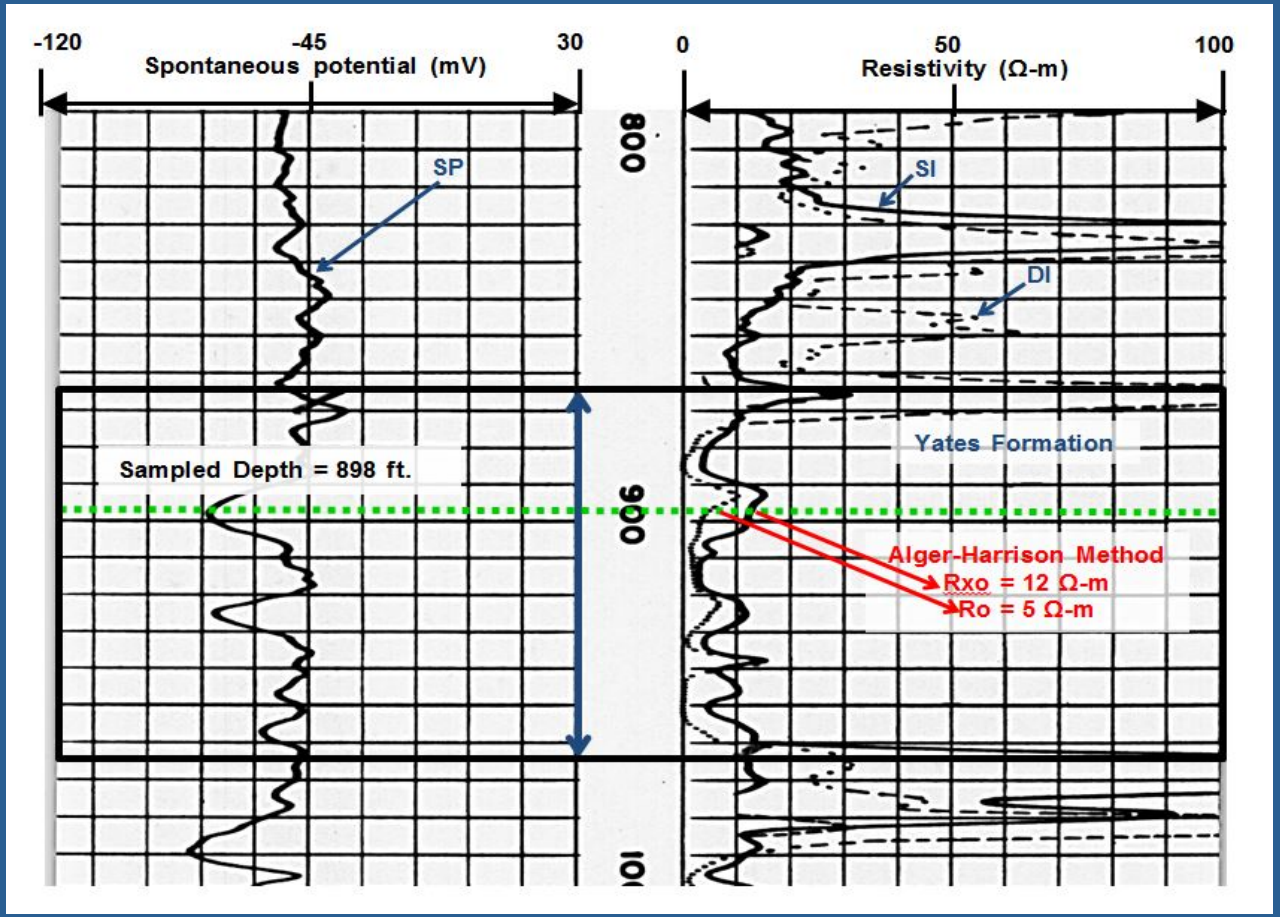


Salinity Zone Determination

- Use hydrostratigraphic framework to designate which water wells are completed exclusively in unique units.
- Use TDS values derived from groundwater samples taken in these wells to provide control in “up-dip” areas dominated by fresh and slightly saline groundwater production.
- Calculate TDS values from geophysical well logs to provide control in “down-dip” areas typified by higher salinity groundwater.

Resistivity Ratio Method (Alger, 1966; Estepp, 1998)

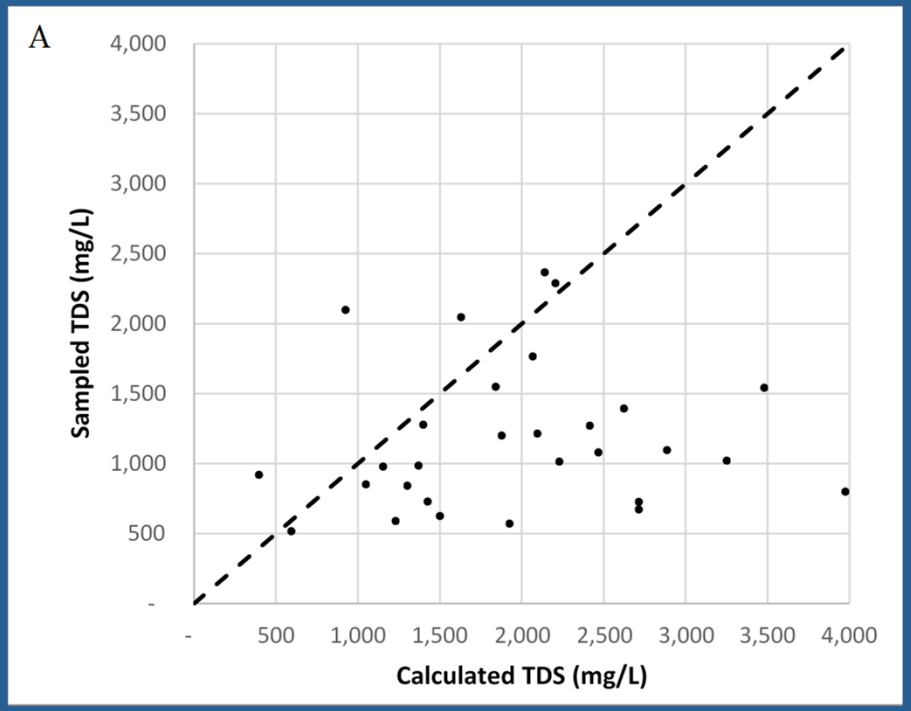
- BRACS well ID 35809 example log
  - Deep formation resistivity 5 Ω-m (ohm-meter)
  - Shallow formation resistivity 12 Ω-m (ohm-meter)
  - Other required information (temperature, depths, etc.) on log header (not shown)

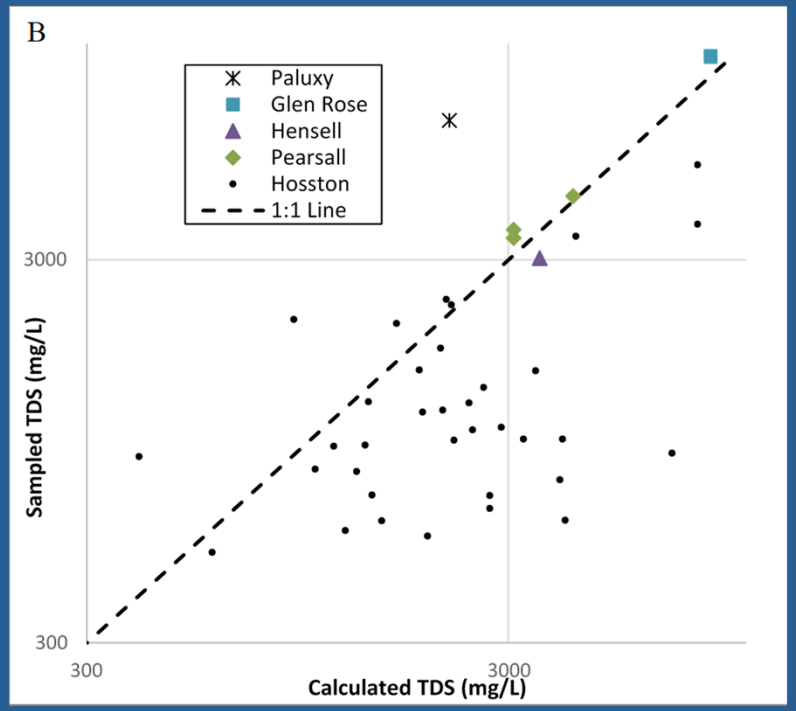


Calculated total dissolved solids (TDS) using the resistivity ratio method for Hosston water wells that have a sampled water quality

State Well Number	Depth (ft)		Resistivity (ohm-m)				F	TDSNaCl	TDSNaCl to TDS Multiplier	Calculated TDS		Measured TDS
	TOP	BOTTOM	Ro	Rs	Rmfz	Rw				Sand Interval	Average Over Screen Interval	
4055701	2,494	2,611	33	34	4	4	0.12	869	1.2	1,045	1,045	852
4061501	1,136	1,208	28	27	3	3	0.11	1,258	1.14	1,432	1,628	2,047
	1,212	1,226	43	52	3	2	0.06	1,604	1.14	1,826		
	1,237	1,252	40	44	3	3	0.07	1,428	1.14	1,626		
4062801	2,209	2,307	33	27	1	1	0.03	3,454	1.16	3,999	4,034	1,021
	2,326	2,358	39	33	1	1	0.03	3,513	1.16	4,068		
5805902	2,191	2,287	26	24	2	2	0.07	1,914	1.17	2,242	2,203	2,288
	2,293	2,310	24	23	2	2	0.08	1,964	1.17	2,301		
	2,321	2,418	30	26	2	2	0.07	1,764	1.17	2,066		
1850501	2,278	2,295	27	14	1	1	0.04	3,148	1.09	3,439	3,476	1,541
	2,298	2,321	27	14	1	1	0.04	3,084	1.09	3,370		
	2,350	2,392	34	17	1	1	0.04	2,999	1.09	3,276		
	2,404	2,466	24	13	1	1	0.05	3,166	1.09	3,459		
	2,479	2,493	20	12	1	1	0.05	3,509	1.09	3,834		
4026102	565	612	36	38	13	12	0.34	349	1.14	398	398	920
3224306	1,892	2,000	33	30	5	5	0.15	732	1.19	874	925	2,098
	2,009	2,043	40	39	5	5	0.11	818	1.19	977		
3301301	2,016	2,066	23	19	2	3	0.11	1,706	1.16	1,980	2,063	1,766
	2,068	2,076	17	16	2	2	0.14	1,840	1.16	2,136		
	2,088	2,172	24	20	2	3	0.11	1,681	1.16	1,951		
	2,186	2,268	26	24	2	2	0.09	1,882	1.16	2,184		

Total Dissolved Solids: Sampled vs Calculated



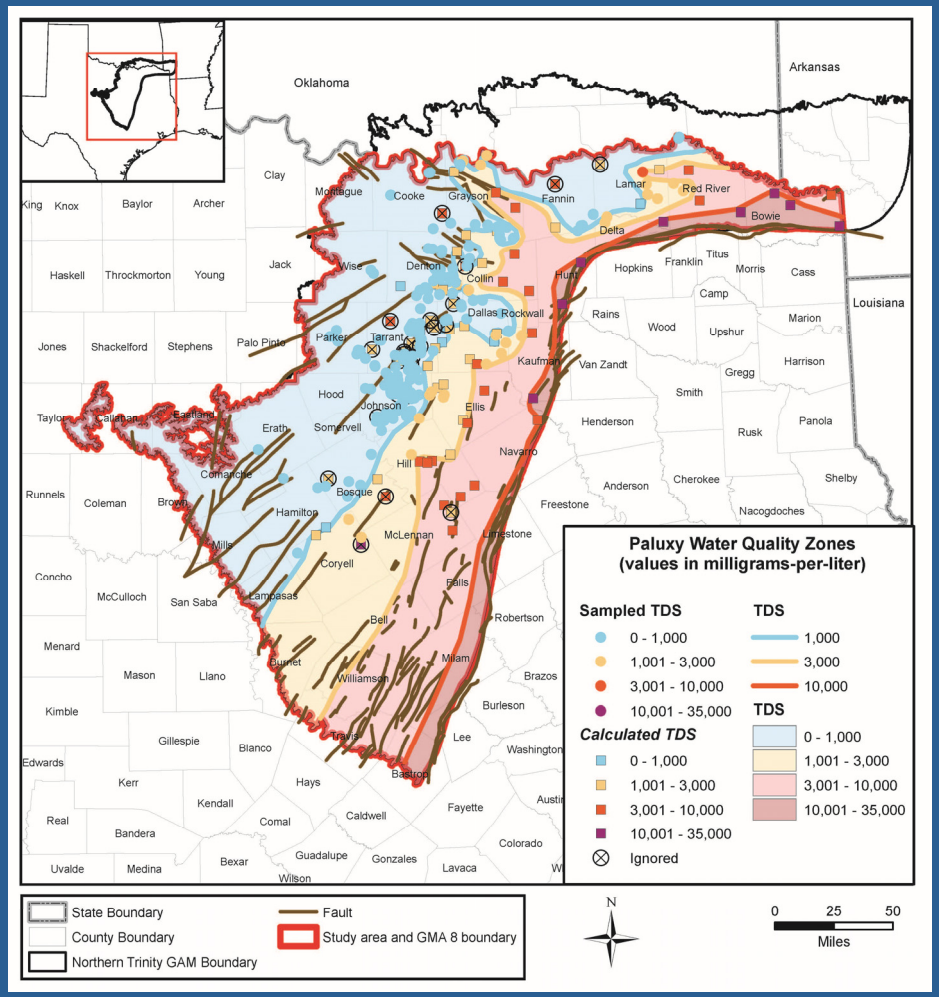


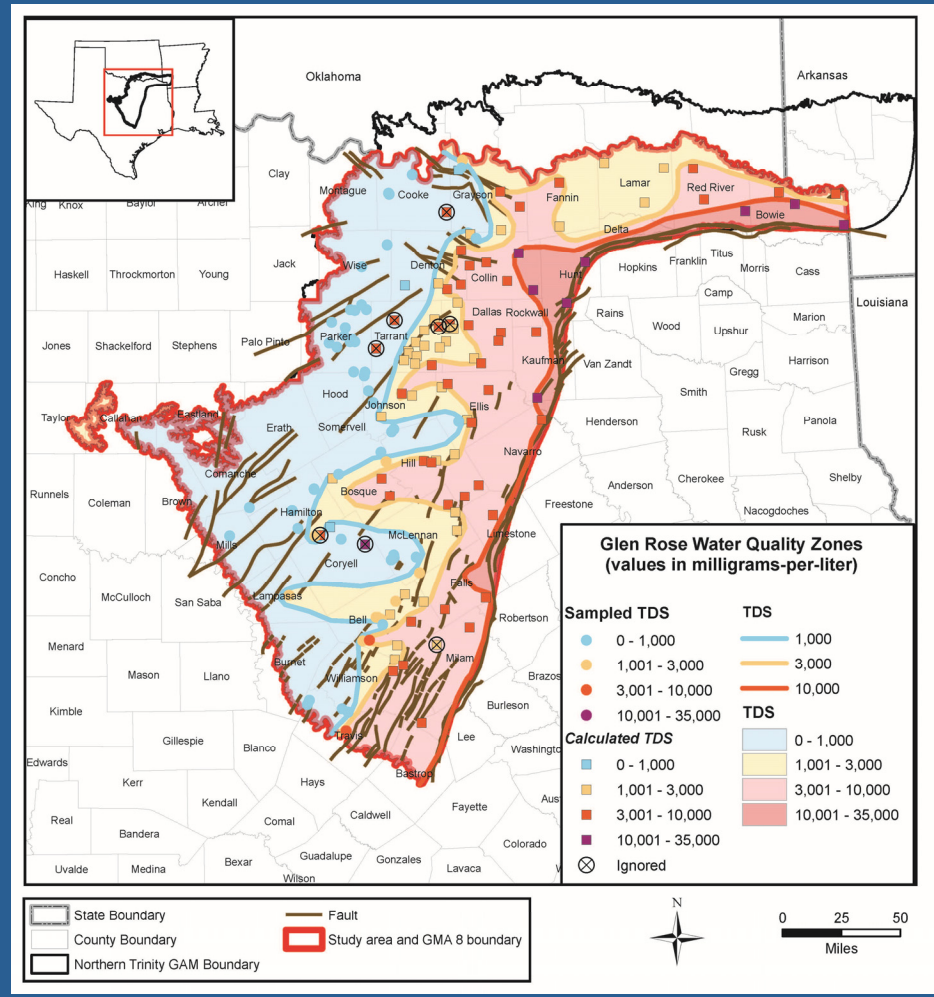
A) Sampled total dissolved solids plotted against calculated total dissolved solids using the resistivity ratio method.

B) Sampled total dissolved solids plotted against calculated total dissolved solids using the resistivity ratio method, with higher sampled concentration well pair results added.

Trinity Salinity Zones:

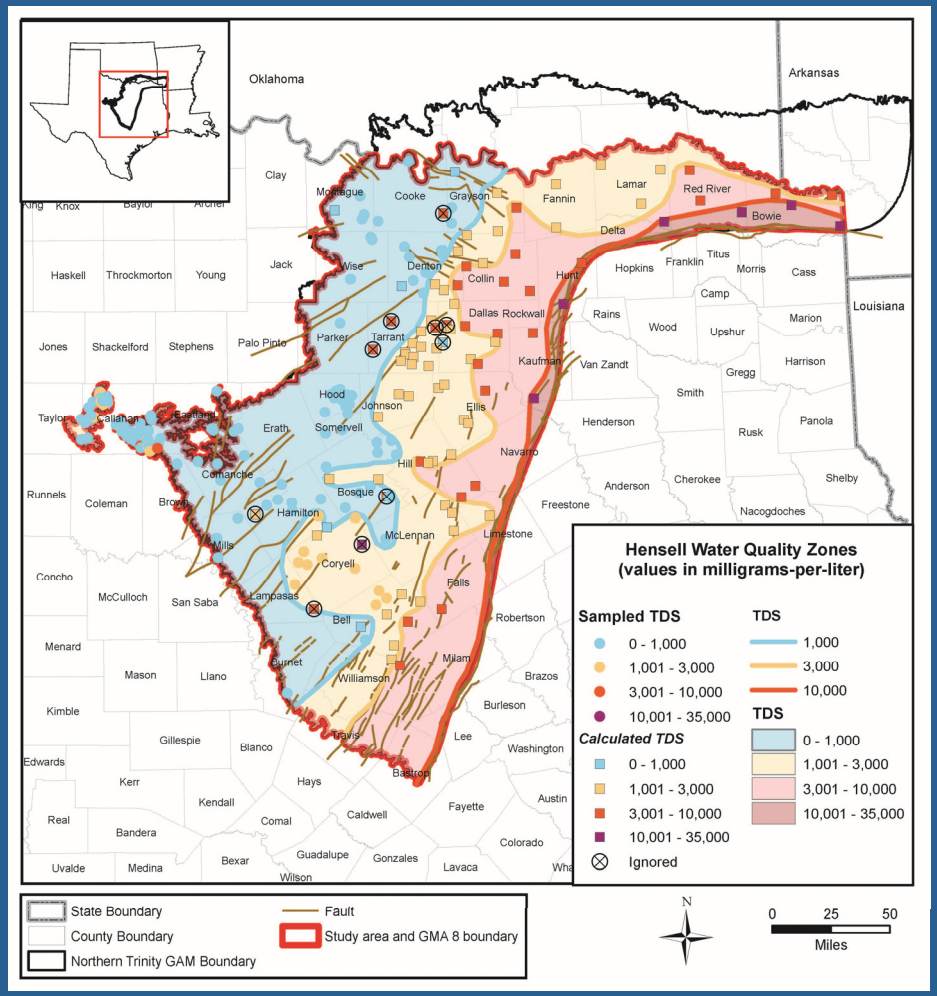
Measured and calculated water quality for Paluxy and Glen Rose units

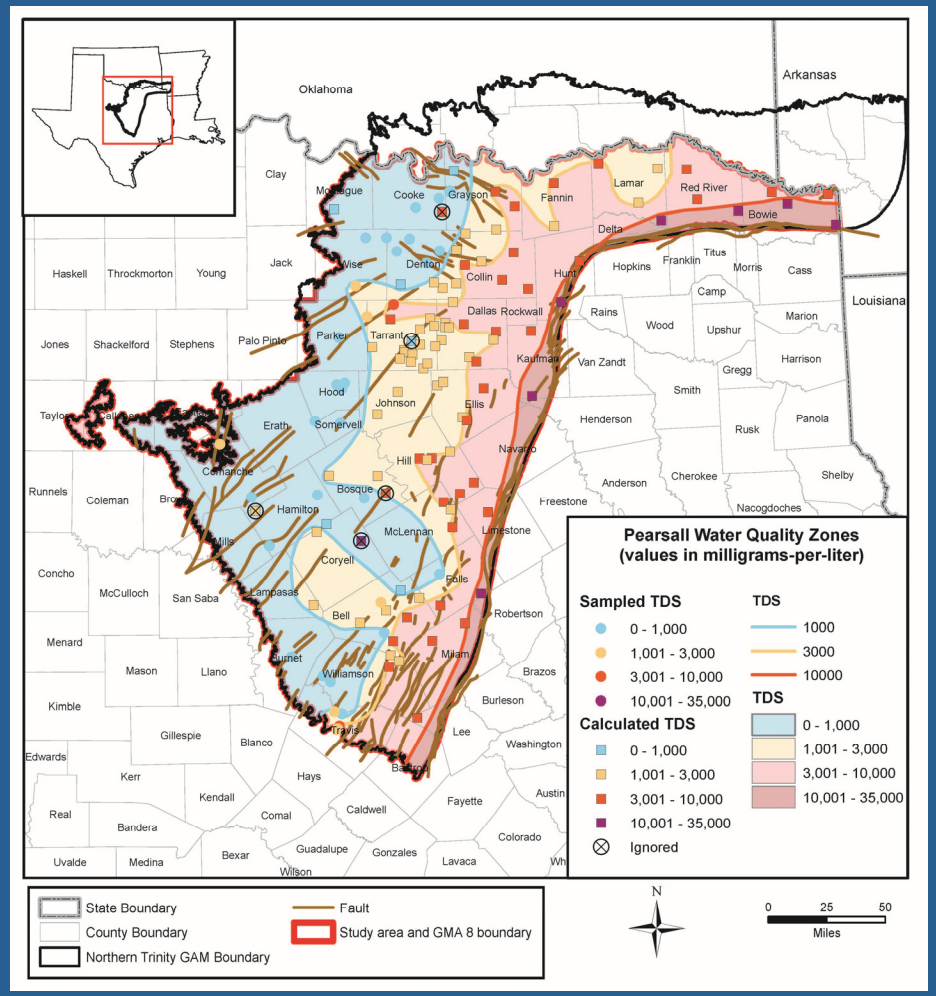




Trinity Salinity Zones:

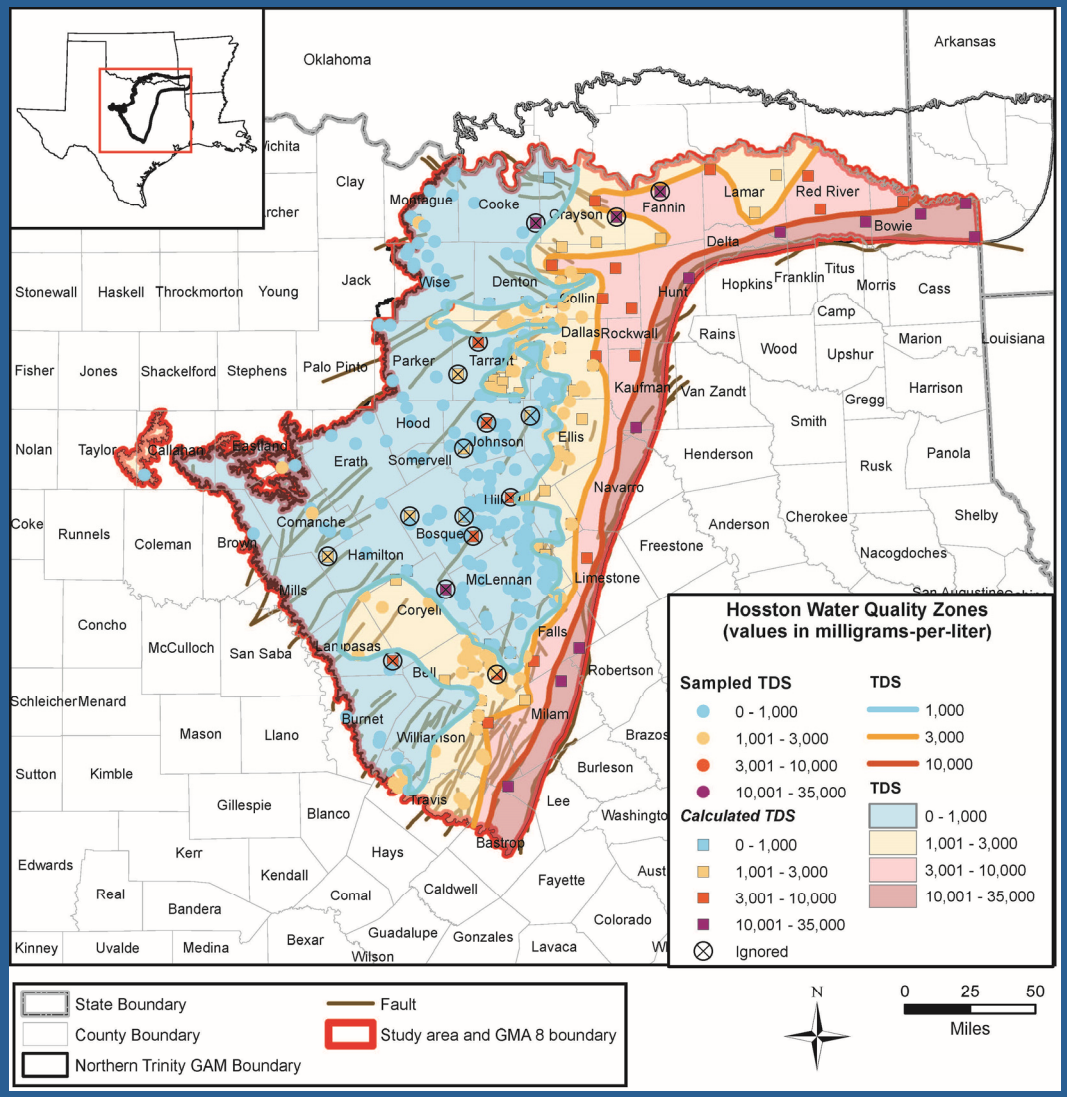
Measured and calculated water quality for Hensell and Pearsall units





Trinity Salinity Zones:

Measured and calculated water quality for Hosston Formation



Volumes of fresh, moderately saline, slightly saline, very saline, and total groundwater volumes

	Total Volume (Acre-feet)				
Aquifer Unit	Fresh	Slightly saline	Moderately saline	Very saline	Total
Paluxy	114,748,000	80,676,000	64,503,000	81,312,000	341,239,000
Glen Rose	107,622,000	137,657,000	114,292,000	79,875,000	439,446,000
Hensell	94,766,000	63,080,000	34,648,000	20,647,000	213,141,000
Pearsall	31,834,000	52,494,000	52,433,000	31,124,000	167,885,000
Hosston	171,110,000	246,770,000	232,964,000	256,357,000	907,201,000
Total	520,080,000	580,677,000	498,840,000	469,315,000	2,068,912,000

Next Steps

- House Bill 30, passed by the 84th Texas Legislative Session in 2015, requires the TWDB to identify and designate brackish groundwater production zones in the aquifers within the state.
- An expanded version of this study that includes groundwater production modeling (Robinson and others, 2019), will provide the data necessary for the TWDB to designate brackish groundwater production zones at a public board meeting in 2019.

References

- Alger, R. P., 1966, Interpretation of electric logs in fresh water wells in unconsolidated sediments: in Society of Professional Well Log Analysts, Tulsa, Oklahoma, 7th Annual Logging Symposium Transaction, 25 p.
- Estepp, J.D., 1998, Evaluation of ground-water quality using geophysical logs: Texas Natural Resource Conservation Commission, unpublished report, 516 p.
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