

Spatial distribution of the quality and quantity of brackish groundwater in five aquifers in the central portion of the Upper Coastal Plains of Texas

Presentation 4-4

T23. Hydrogeology and Water Resources

Monday March 9, 2020

2020 GSA South-Central Section Meeting

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

Brackish Groundwater in Aquifers of the Upper Coastal Plains, Central Texas

- Full report with GIS data to be released this year
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Brackish Groundwater in Aquifers of the Upper Coastal Plains, Central Texas

by John E. Meyer, P.G., Andrea D. Croskrey, P.G., Alysa K. Suydam, GIT, Nathaniel Van Oort, and Erika Mancha, EIT

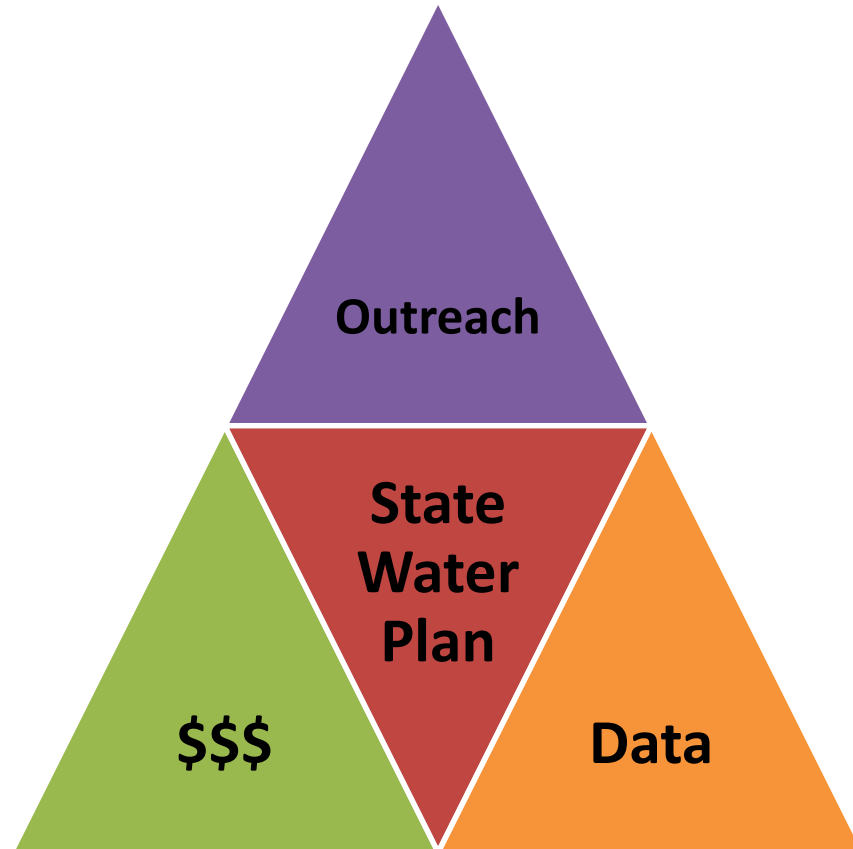
Report #

Month 2020





Texas Water Development Board (TWDB)



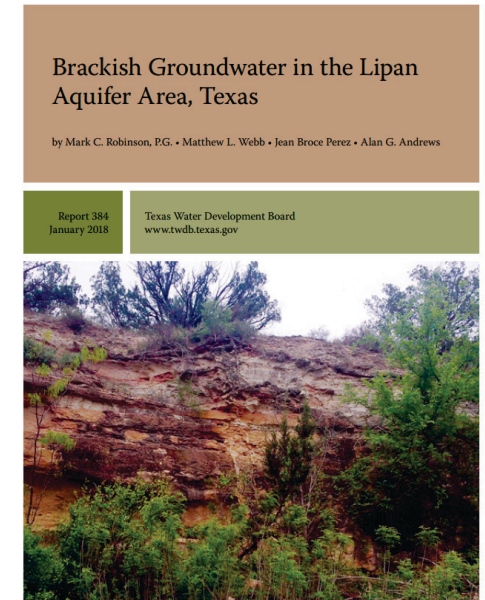
Create a 50-year State Water Plan every 5 years

Brackish Resource Aquifer Characterization System (BRACS)

<http://www.twdb.texas.gov/innovativewater/bracs/studies.asp>

Map brackish groundwater

1. Stratigraphy
2. Lithology
3. Water Quality

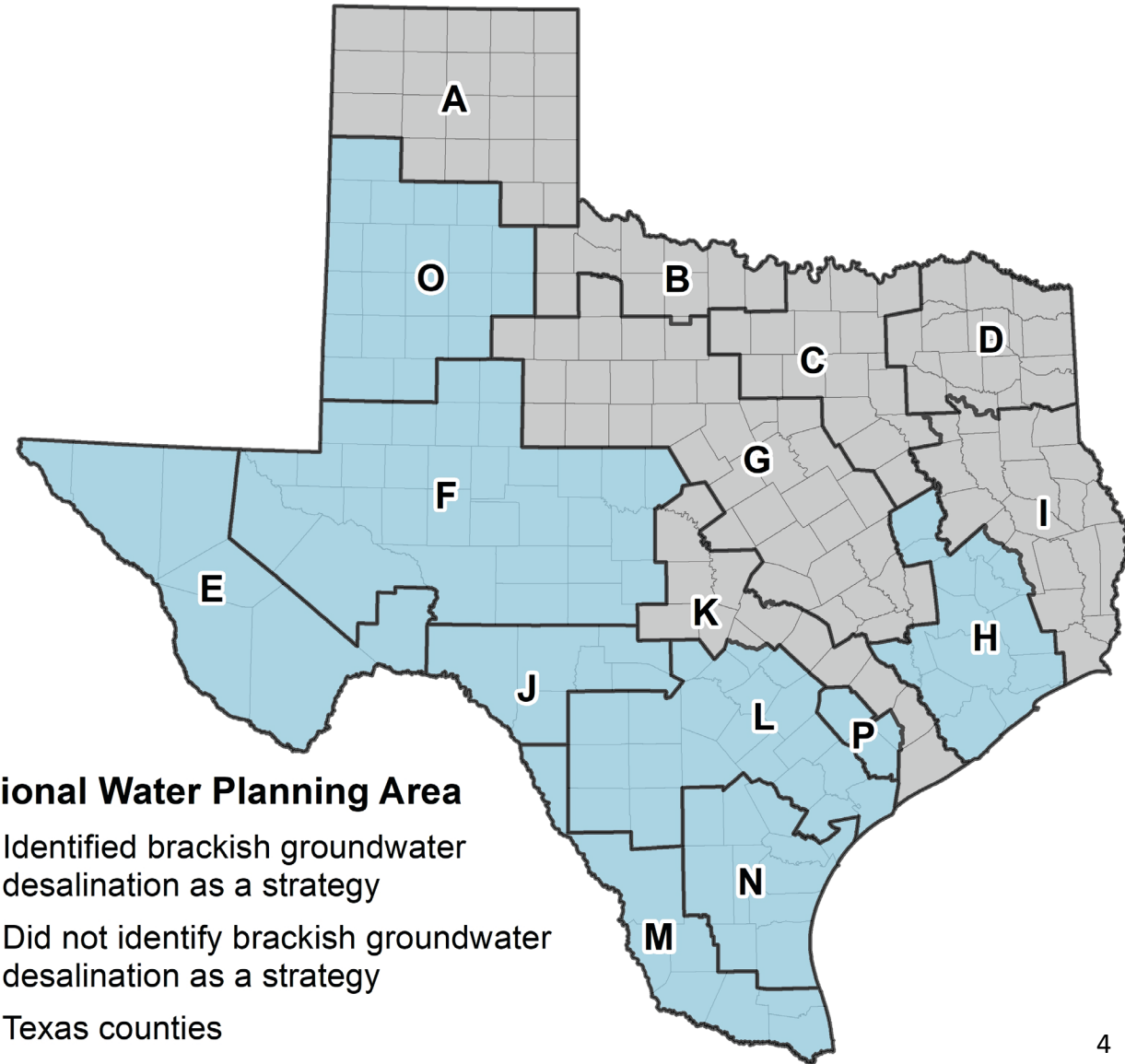
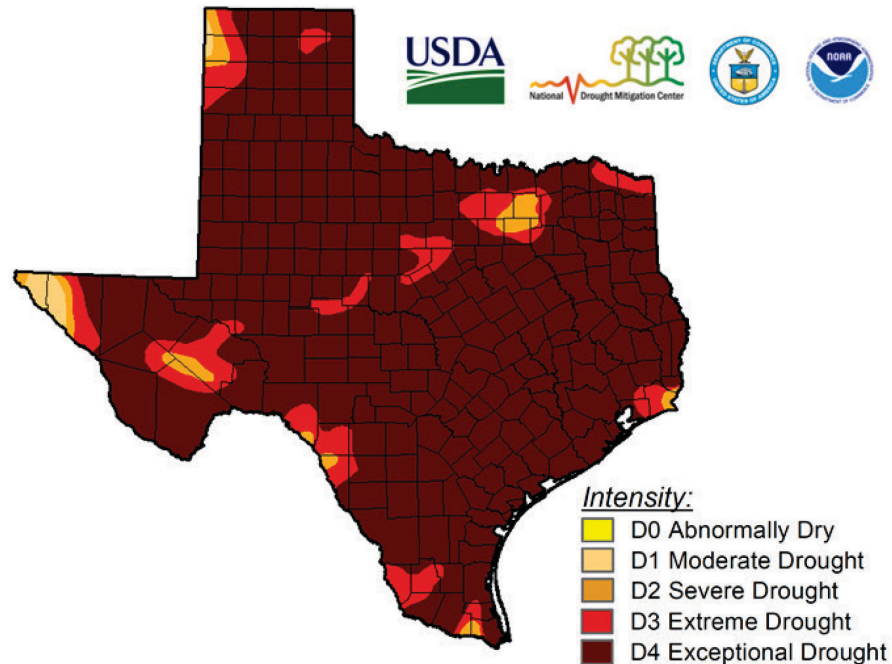


All this data is managed in an MS Access Database (available for download)









Why map brackish groundwater?

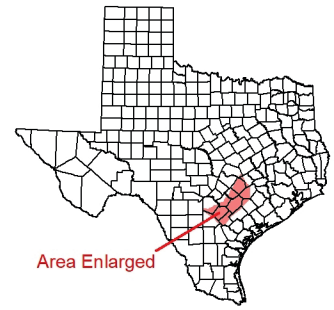
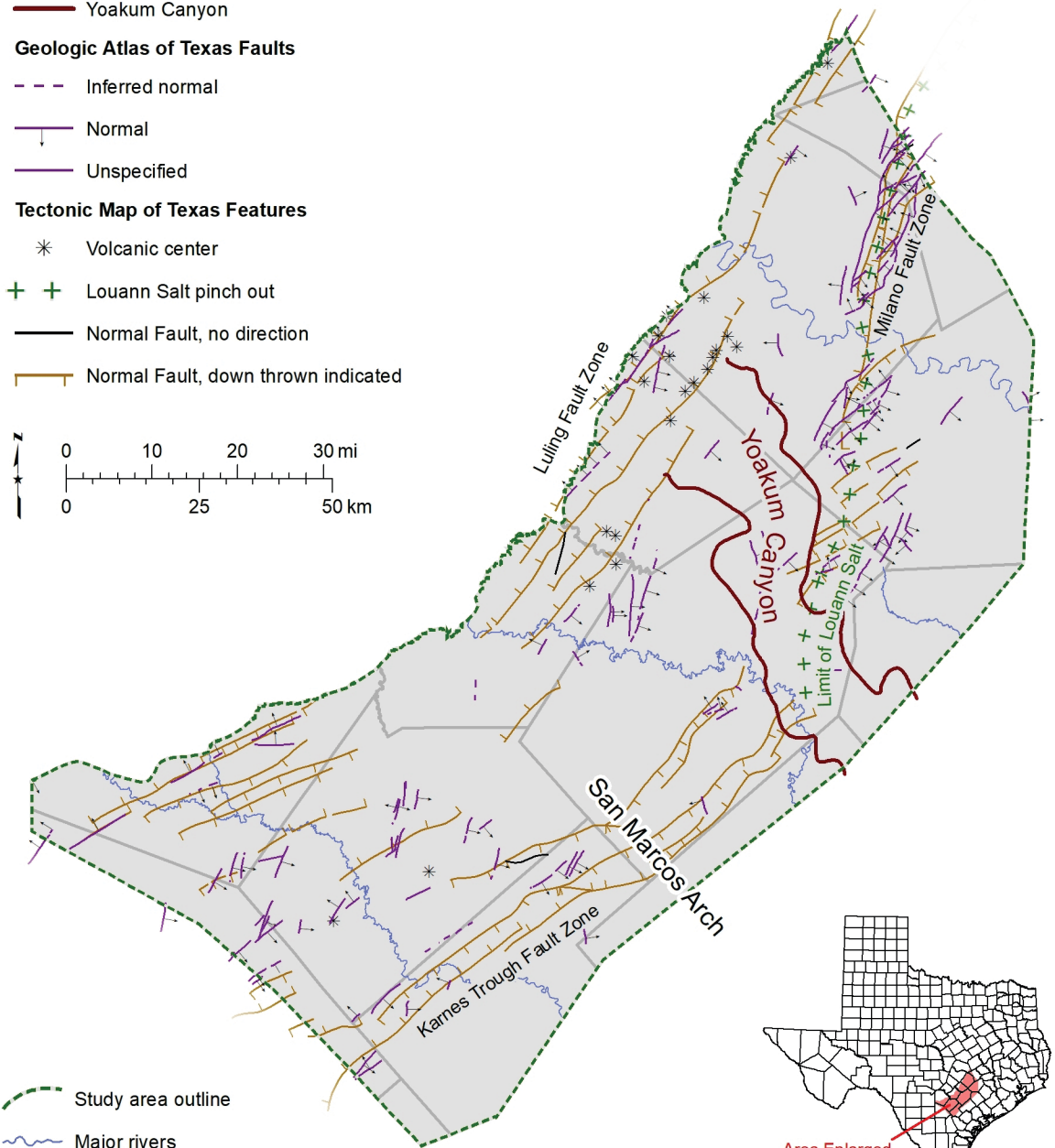
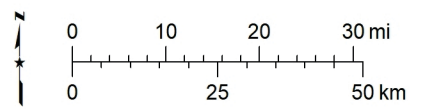
- 8 of 16 Regional Water Planning Areas identified brackish groundwater desalination as a strategy

October 4, 2011



Upper Coastal Plains Central

-  Yoakum Canyon
- Geologic Atlas of Texas Faults**
-  Inferred normal
-  Normal
-  Unspecified
- Tectonic Map of Texas Features**
-  Volcanic center
-  Louann Salt pinch out
-  Normal Fault, no direction
-  Normal Fault, down thrown indicated



Epoch	Group	Formation	USGS nomenclature	Texas Hydrogeologic unit
Eocene	Jackson	Caddell	Vicksburg-Jackson confining unit	Yegua-Jackson Aquifer
		Moodys Branch		
	Claiborne	Hiatus	Upper Claiborne Aquifer	Confining unit
		Yegua		
		Cook Mountain	Middle Claiborne Confining unit	Sparta Aquifer
		Hiatus		
		Sparta	Middle Claiborne Aquifer	Confining unit
		Weches		
		Hiatus	Queen City Aquifer	Queen City Aquifer
		Queen City		
		Reklaw	Lower Claiborne confining unit	Confining unit
		Hiatus		
Paleocene	Wilcox	Carrizo	Lower Claiborne – upper Wilcox Aquifer	Carrizo-Wilcox Aquifer
		Hiatus		
		Sabinetown		
		Rockdale	Middle Wilcox Aquifer	
		Seguin		
Midway	Wills Point	Midway confining unit	Confining unit	

Stratigraphic column showing the relationship between the epochs, formations, and hydrogeologic units. The United States Geological Survey (USGS) nomenclature is based on Ryder (1996). Texas hydrogeologic units are based on TWDB (2007) and George and others (2011). This table does not reflect the entire Jackson or Midway stratigraphy. This table is not scaled vertically in uniform units of time.



Salinity mapping

BRACKISH

	Groundwater Salinity Classification	Salinity Class Code	Total Dissolved Solids (milligrams per liter)	
	Fresh	Fr	0 to 1,000	
PWS →	Slightly Saline	Ss	1,000 to 3,000	← Most Texas Major/Minor Aquifer Mapped Limit
BUQ →				
	Moderately Saline	Ms	3,000 to 10,000	
USDW →	Very Saline	Vs	10,000 to 35,000	← Seawater
	Brine	Br	Greater than 35,000	

PWS: Public Water System threshold for fresh water, TX Commission on Environmental Quality
 BUQ: Base Useable Quality water, TX Railroad Commission
 USDW: Underground Source Drinking Water, US Environmental Protection Agency

modified from Winslow and Kister (1956) USGS WSP 1365

Measured and estimated water quality



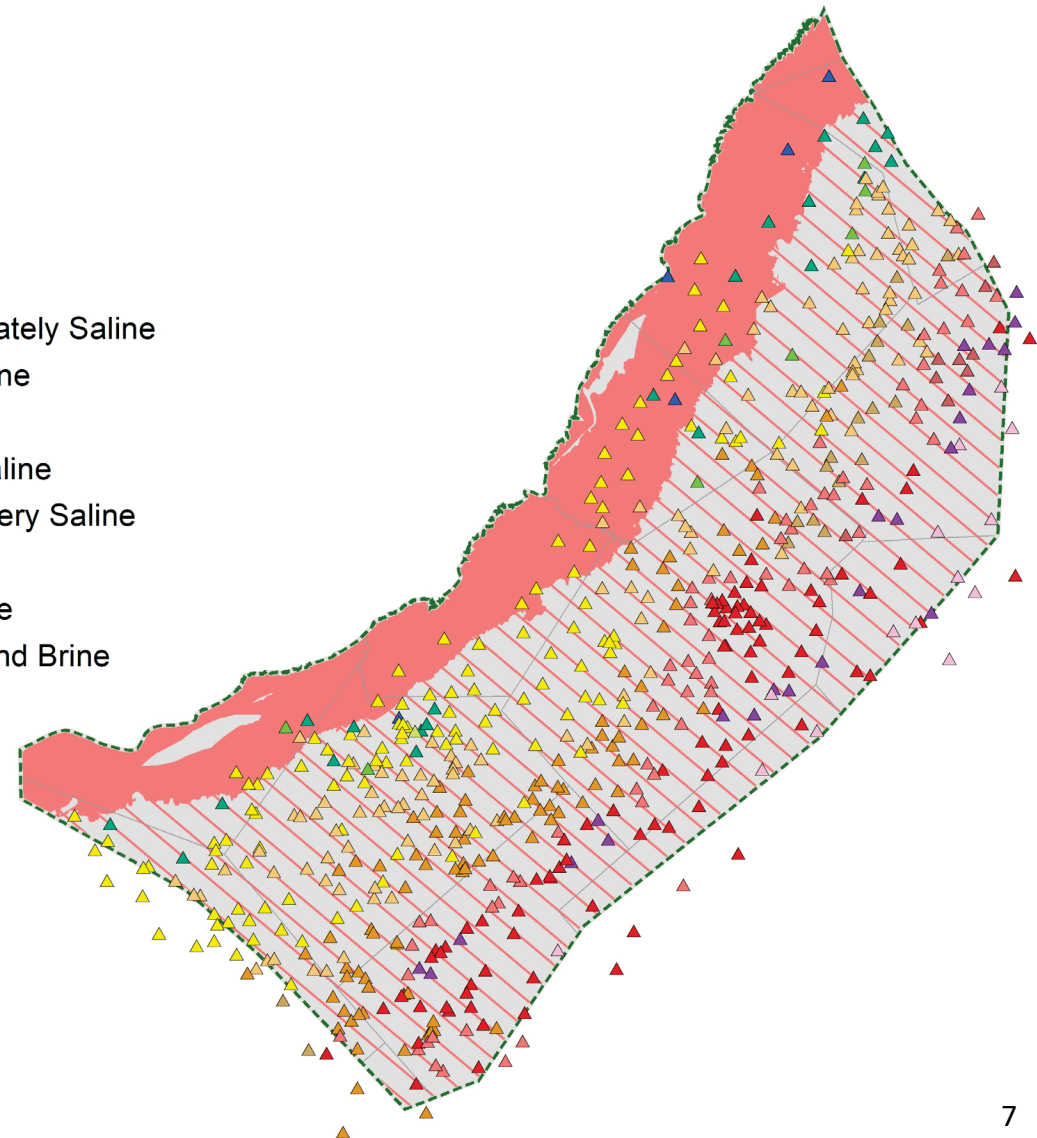
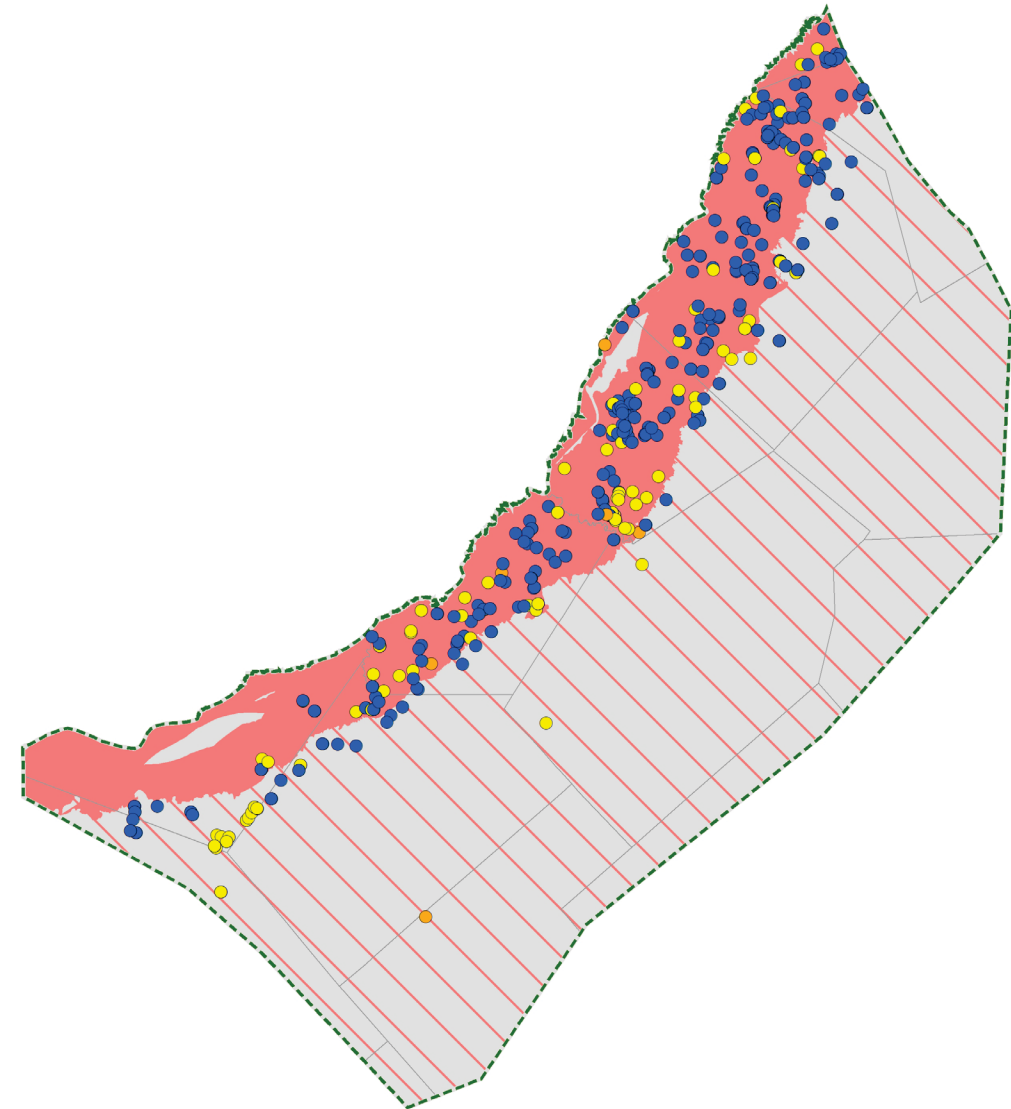
Measured water quality

- Fresh
- Slightly saline
- Moderately saline

Calculated water quality

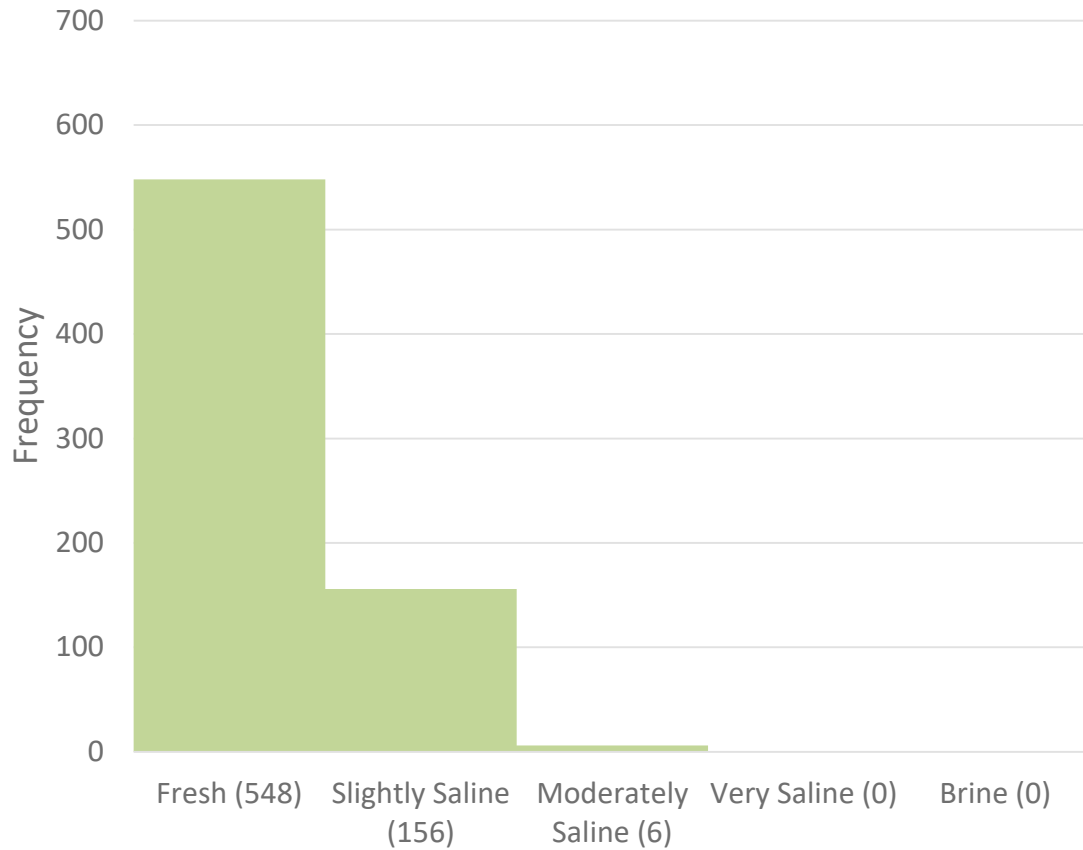
- ▲ Fresh
- ▲ Fresh and Slightly Saline
- ▲ Fresh, Slightly, and Moderately Saline
- ▲ Fresh and Moderately Saline
- ▲ Slightly Saline
- ▲ Slightly and Moderately Saline
- ▲ Slightly, Moderately, and Very Saline
- ▲ Moderately Saline
- ▲ Moderately and Very Saline
- ▲ Moderately, Very Saline, and Brine
- ▲ Very Saline
- ▲ Very Saline and Brine
- ▲ Brine

- Study area
- Texas counties
- Wilcox outcrop
- ▨ Wilcox subcrop

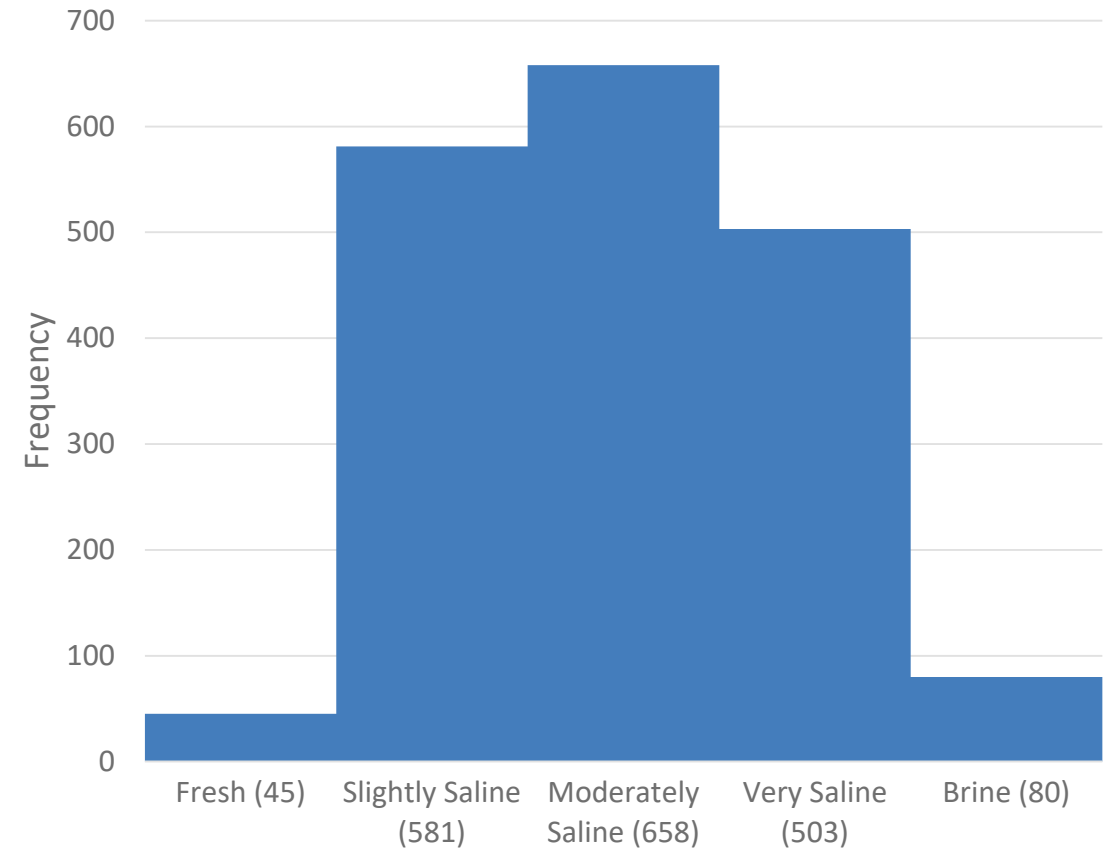


Measured and estimated water quality

Histogram of measured water quality values -
Wilcox Aquifer



Histogram of calculated water quality values -
Wilcox Aquifer



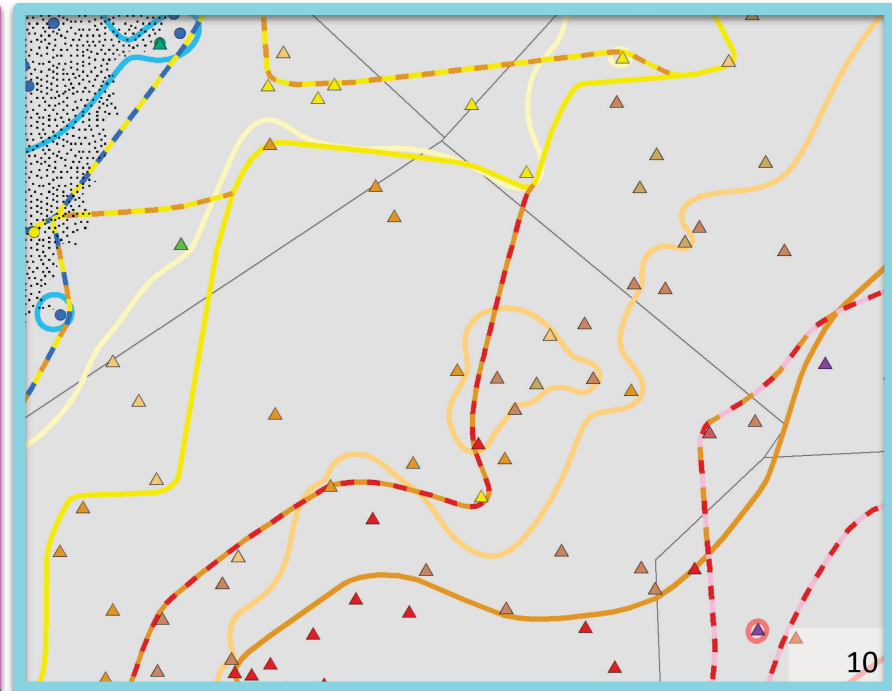
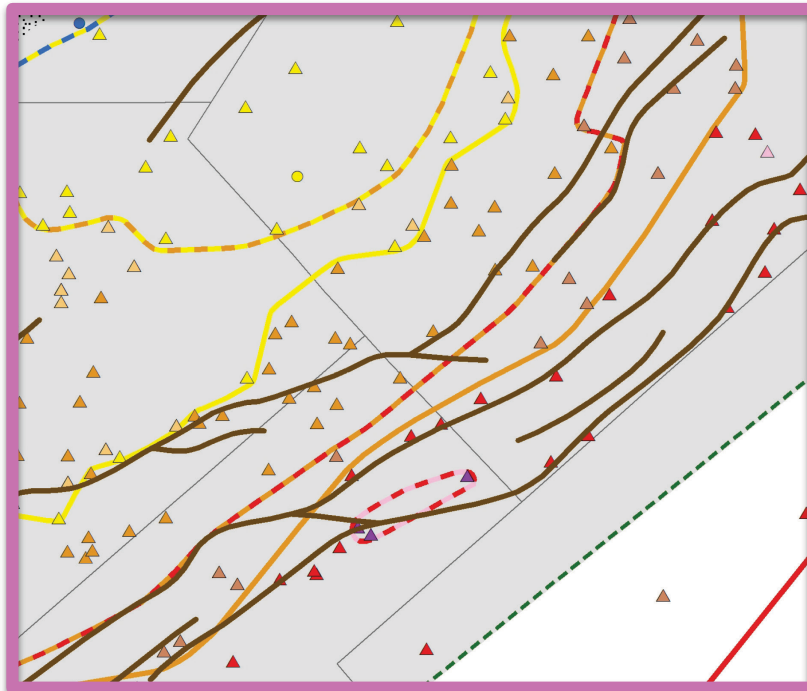
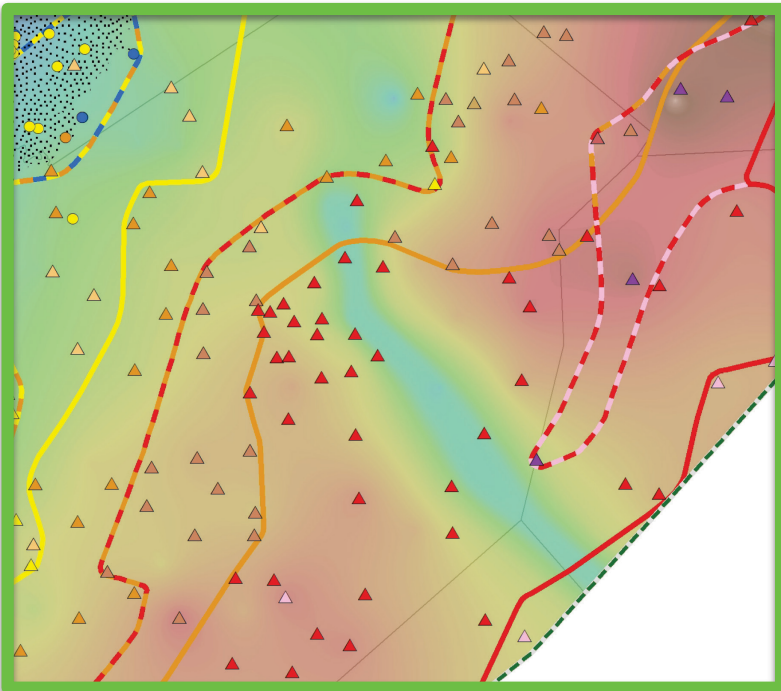
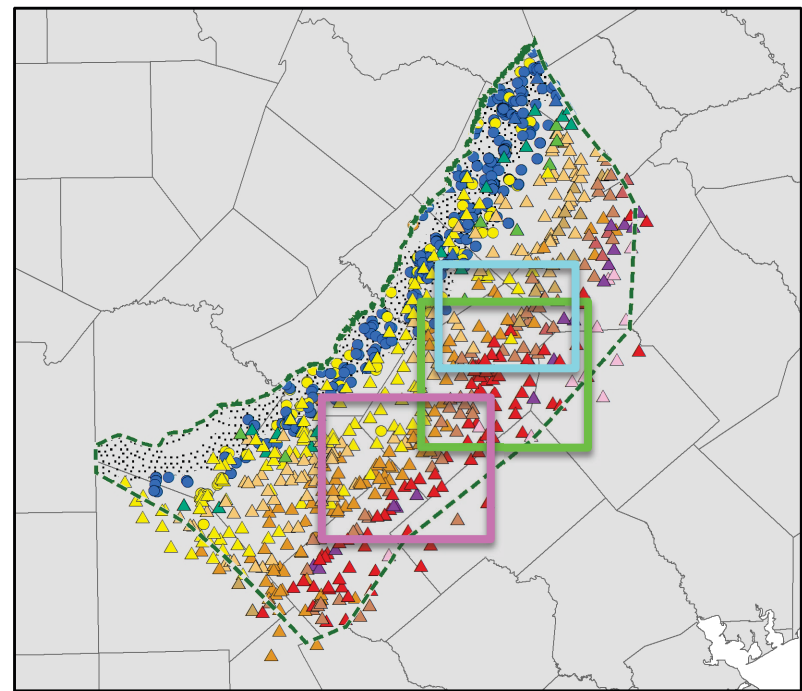
Salinity mapping – data points

- Not all measured water quality used
 - Need a known sample interval
- Calculated water quality
 - Rwa minimum method (modified from Estep, 1998), based on Archie's equation (1942)
 - $R_w = R_o \times \phi^m$

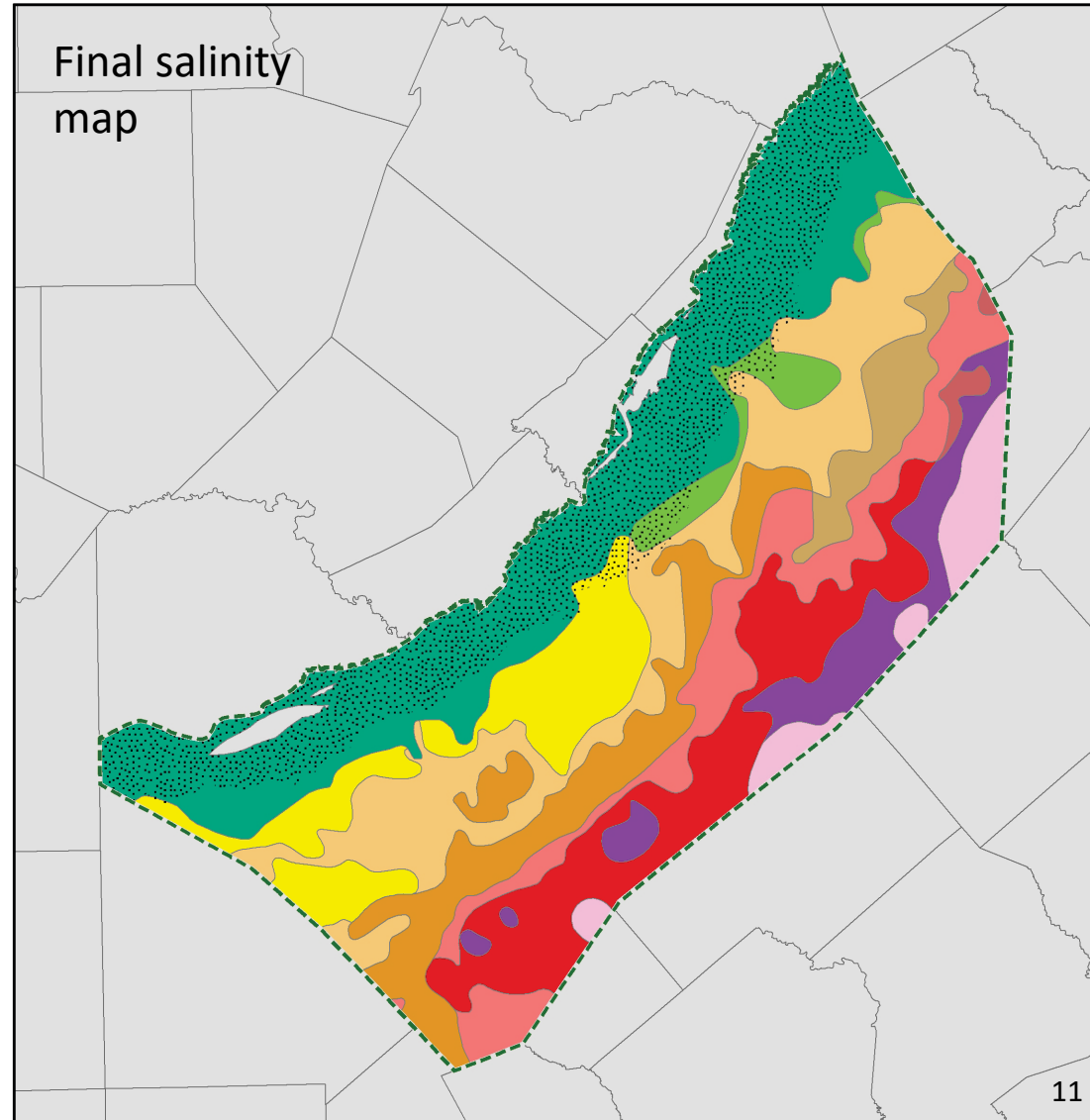
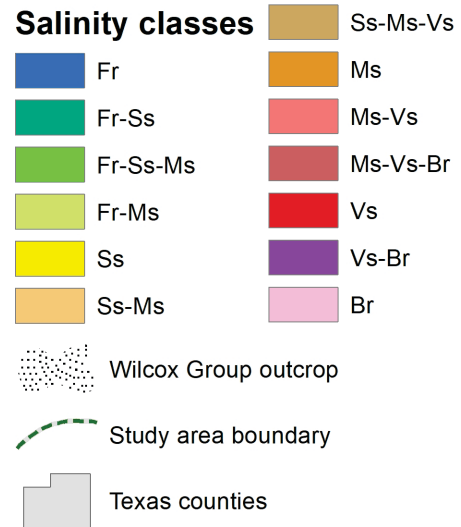
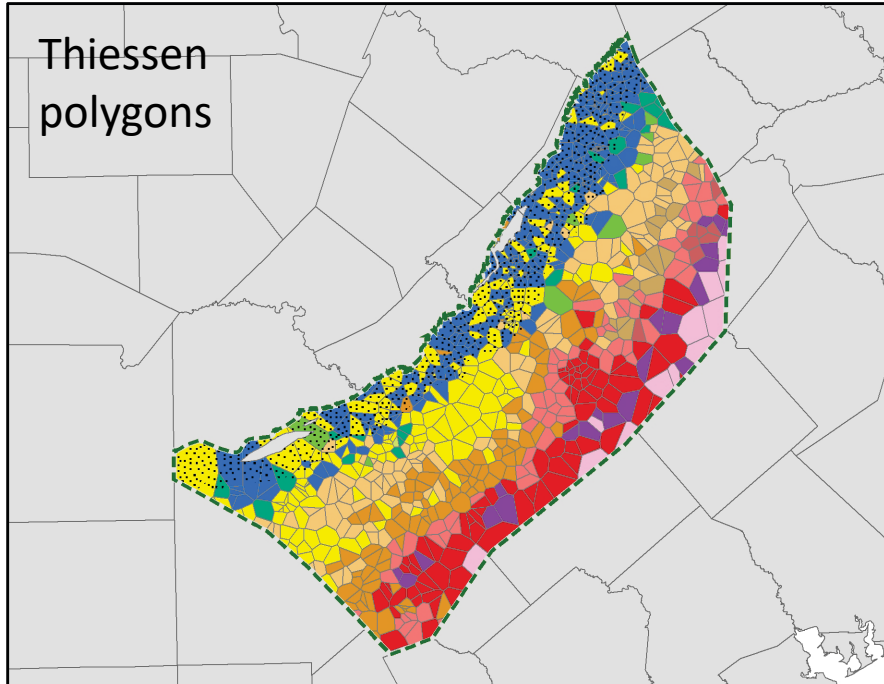
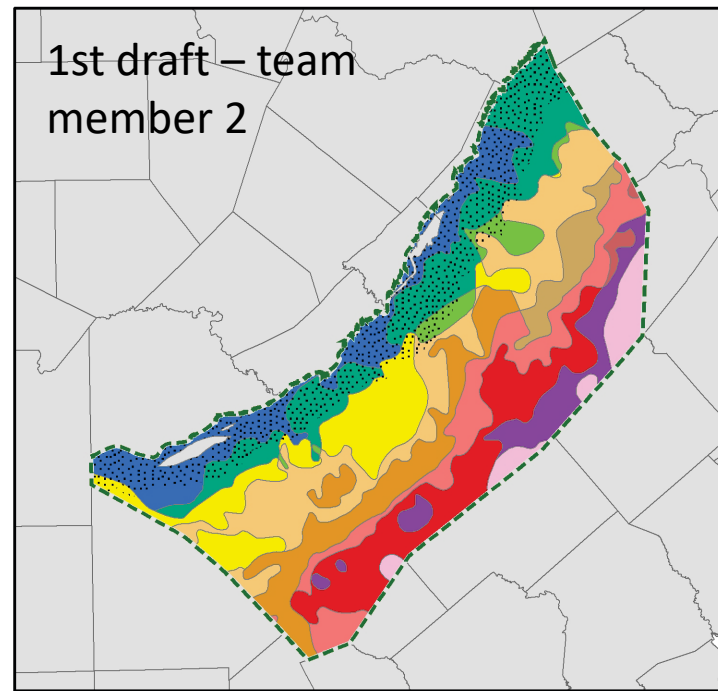
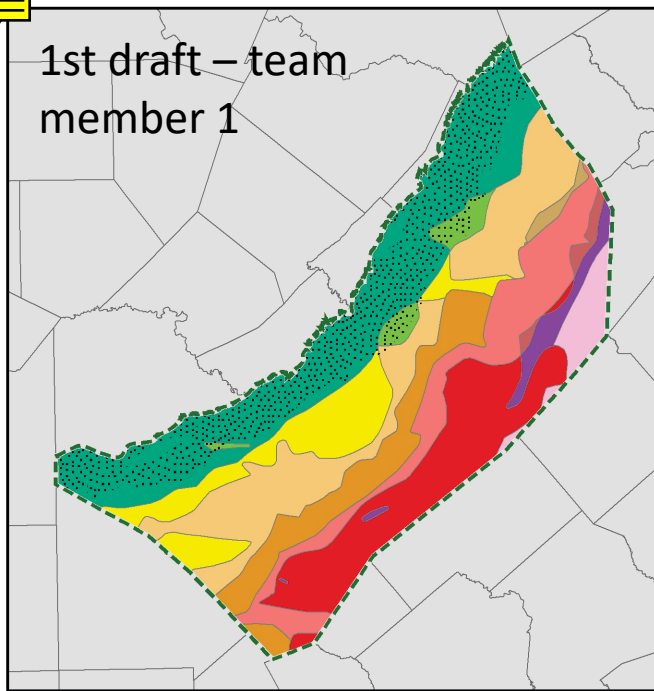
Aquifer	# of mapped measured water quality points	# of mapped TDS estimates from logs	# of salinity class points from calculations
Wilcox	710	1,867	605
Carrizo	676	1,283	854
Queen City	161	951	611
Sparta	34	436	421
Yegua	72	643	279
Total	1,653	5,180	2,770

Salinity mapping process

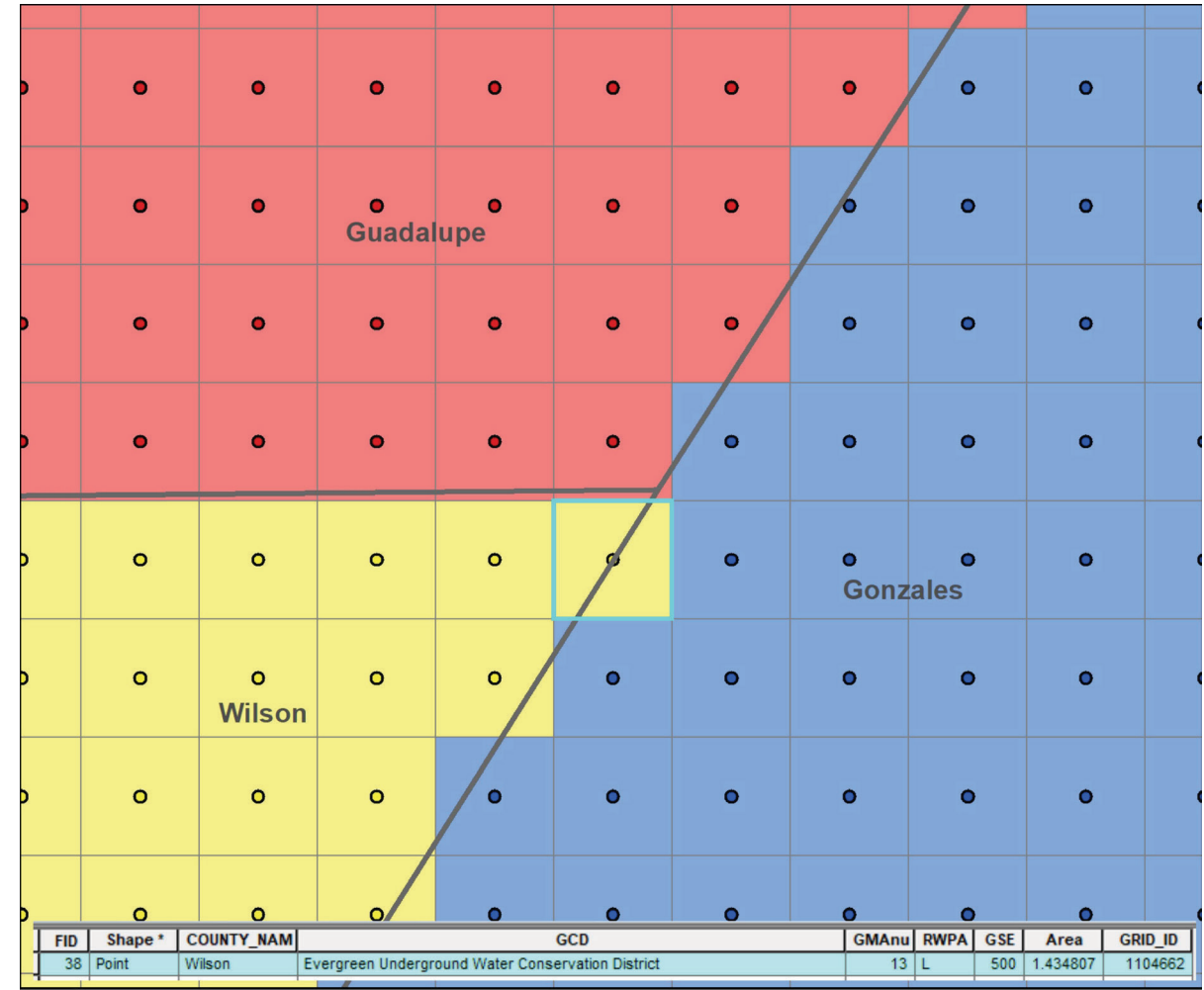
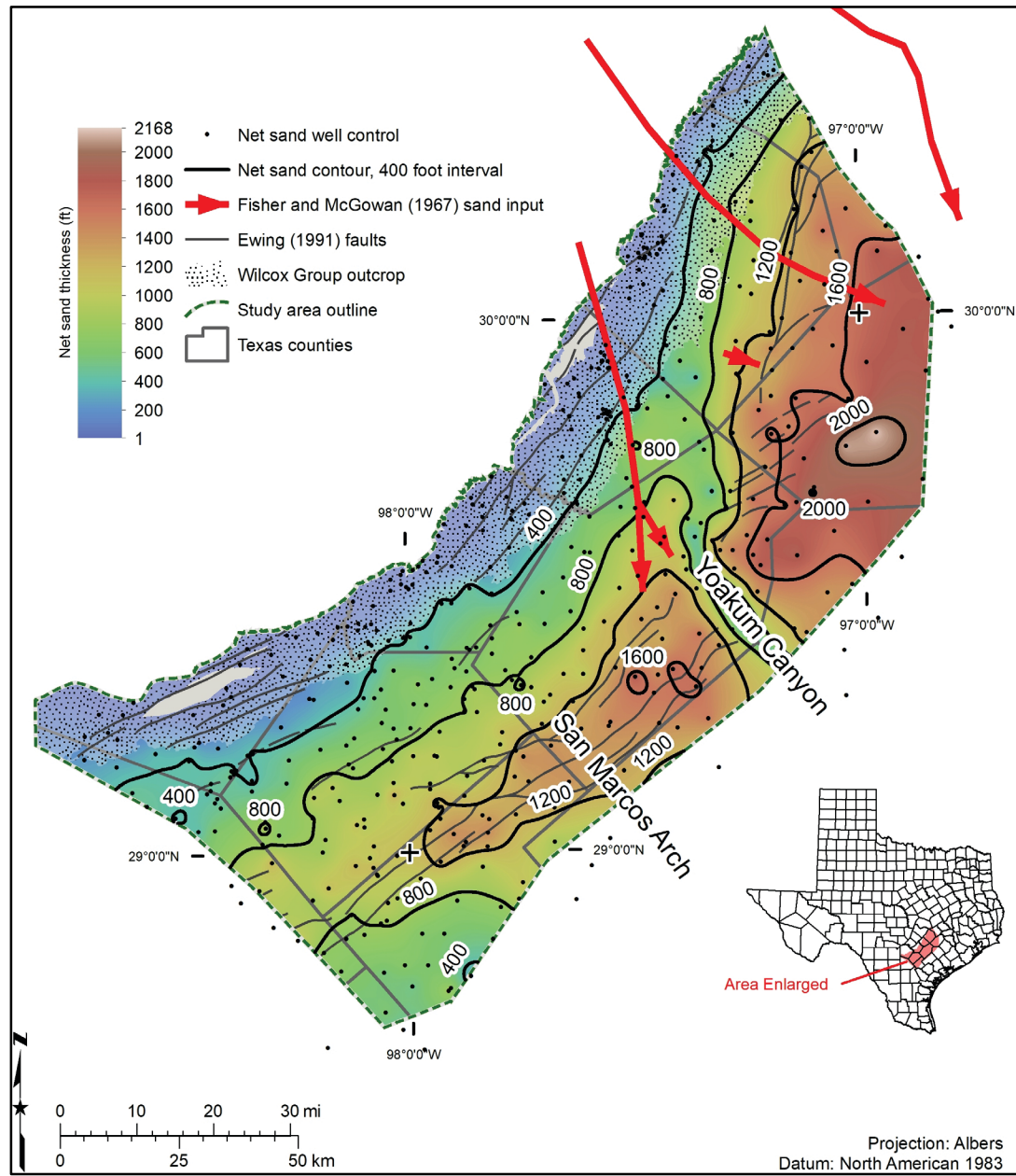
TDS points 1	Hand contours draft 1	Interpolated TDS 1	Wilcox net sand
● measured Fr	▲ calculated Ss	— Fr-Ss	■ Cumulative feet
● measured Fr-Ss	▲ calculated Ss-Ms	— Fr-Ss-Ms	■ 2168
● measured Ss	▲ calculated Ss-Ms-Vs	— Ss	■ 1
● measured Ms	▲ calculated Ms	— Ss-Ms	● Wilcox Group outcrop
▲ calculated Fr	▲ calculated Ms-Vs	— Ss-Ms-Vs	— Study area boundary
▲ calculated Fr-Ss	▲ calculated Ms-Vs-Br	— Ms	— Faults (Ewing 1991)
▲ calculated Fr-Ss-Ms	▲ calculated Vs	— Ms-Vs	□ Texas counties
▲ calculated Fr-Ms	▲ calculated Vs-Br	— Ms-Vs-Br	
	▲ calculated Br	— Vs	
		— Vs-Br	



Salinity mapping process (continued)

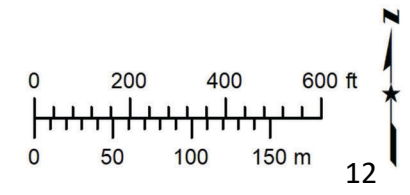


Volume calculation input data



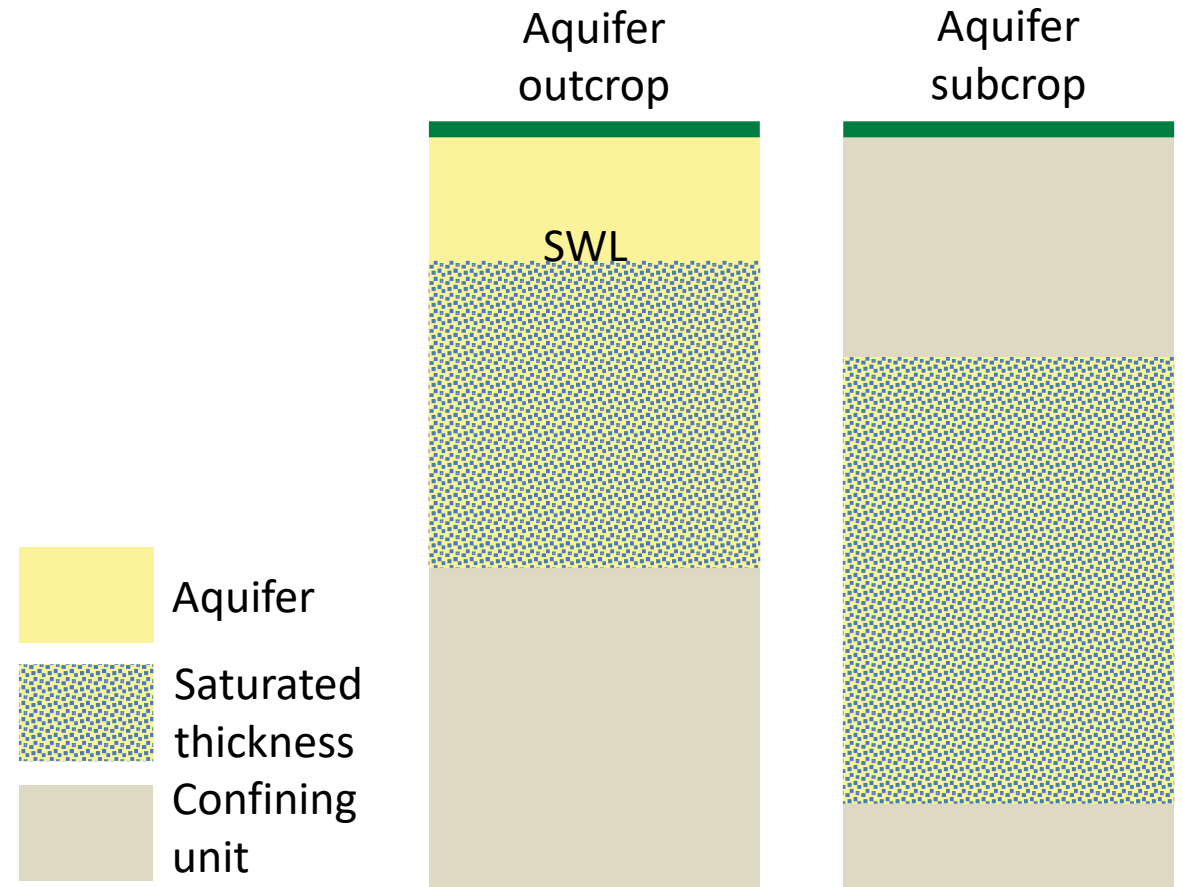
- Texas counties
- Centroid in Gonzales County
- Centroid in Guadalupe County
- Centroid in Wilson County
- ◆ Cell assigned to Gonzales County
- ◆ Cell assigned to Guadalupe County
- ◆ Cell assigned to Wilson County

Projection: Albers
Datum: North American 1983



Volume calculation method

- Using the volume grid for each mapped aquifer
- Volume = [Area] x [Saturated Thickness] x [Specific Yield]
 - Area: 250 feet x 250 feet (grid cell size)
 - Saturated Thickness
 - Subcrop: thickness of net sands
 - Outcrop: [thickness of the static water level] x [percent sand]
 - Specific Yield: value used from other studies
 - Deeds and others (2010) and Young and others (2018)





Volume summary slide

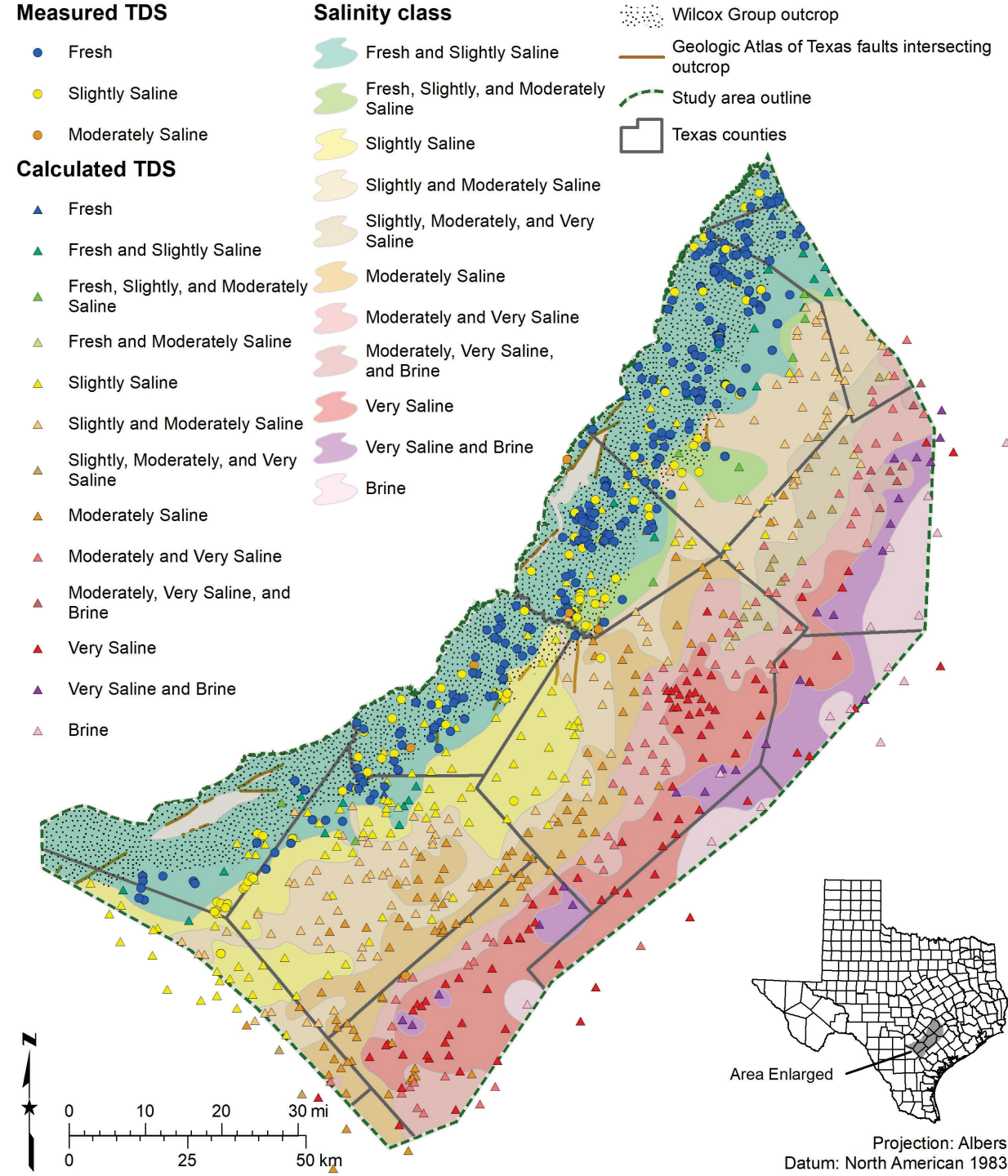
- Significant brackish resources in the study area
- Additional brackish groundwater in mixed classes
- Distribution of brackish groundwater is complex
- Site-specific studies are necessary before developing any well fields

Aquifer	Brackish groundwater* (millions of acre-feet)	Total groundwater (millions of acre-feet)	Brackish groundwater* (km³)	Total groundwater (km³)
Wilcox	111.99	321.24	138.14	396.24
Carrizo	57.49	204.26	70.91	251.95
Queen City	20.29	51.90	25.03	64.02
Sparta	6.34	11.74	7.82	14.48
Yegua	42.96	78.13	52.99	96.37
Total	239.07	667.27	294.89	823.06

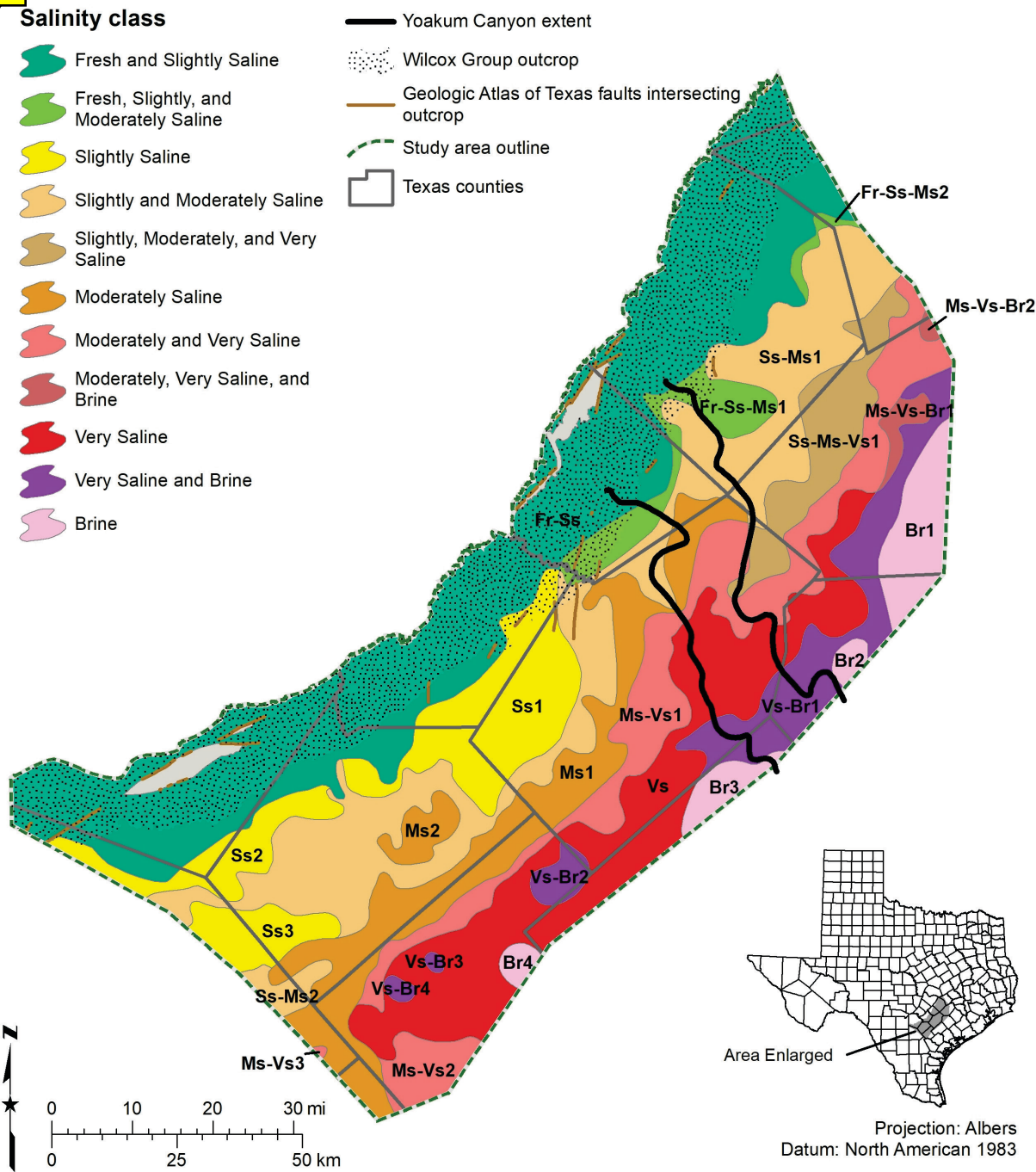
*volume of brackish groundwater in salinity classes that do not contain fresh or saline groundwater

Wilcox Aquifer quick facts

- Up to 3,200 feet thick (975 m)
- Thickest northeast of the San Marcos Arch (structural high)
- Up to 2,100 feet of net sands (640 m)
- Yoakum Canyon – shale filled canyon
- 710 mapped measured water quality samples
- 1,867 calculated TDS values
- 2 to 5 vertical salinity classes per well in mixed wells



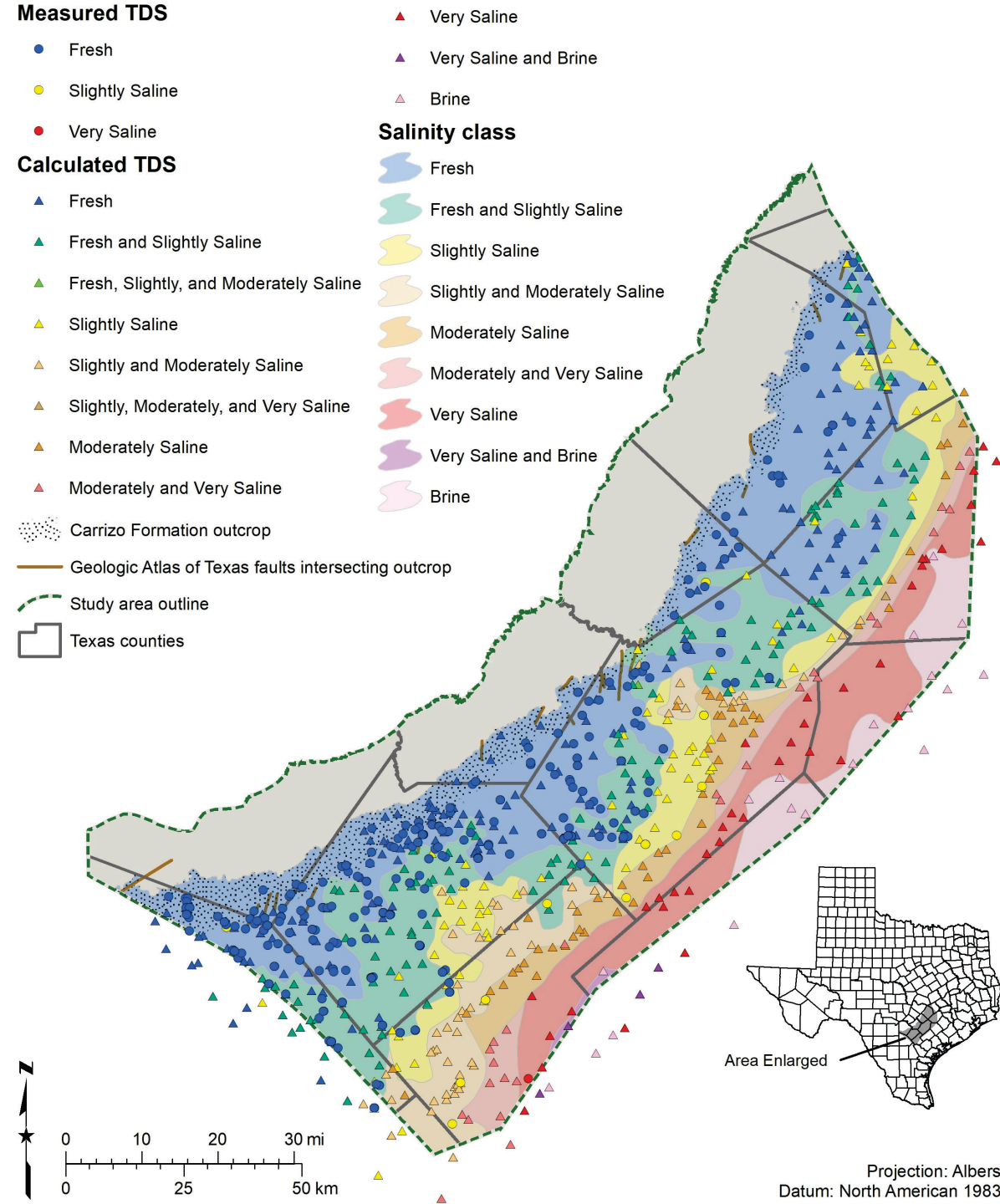
Wilcox salinity map and volume






Salinity class	Volume of groundwater (millions of acre-feet)	Volume of groundwater (km ³)
Fr-Ss	27.95	34.48
Fr-Ss-Ms	7.33	9.04
Ss	21.52	26.54
Ss-Ms	56.62	69.84
Ss-Ms-Vs	19.73	24.34
Ms	33.85	41.75
Ms-Vs	44.03	54.31
Ms-Vs-Br	4.06	5.01
Vs	52.74	65.05
Vs-Br	29.94	36.93
Br	23.47	28.95

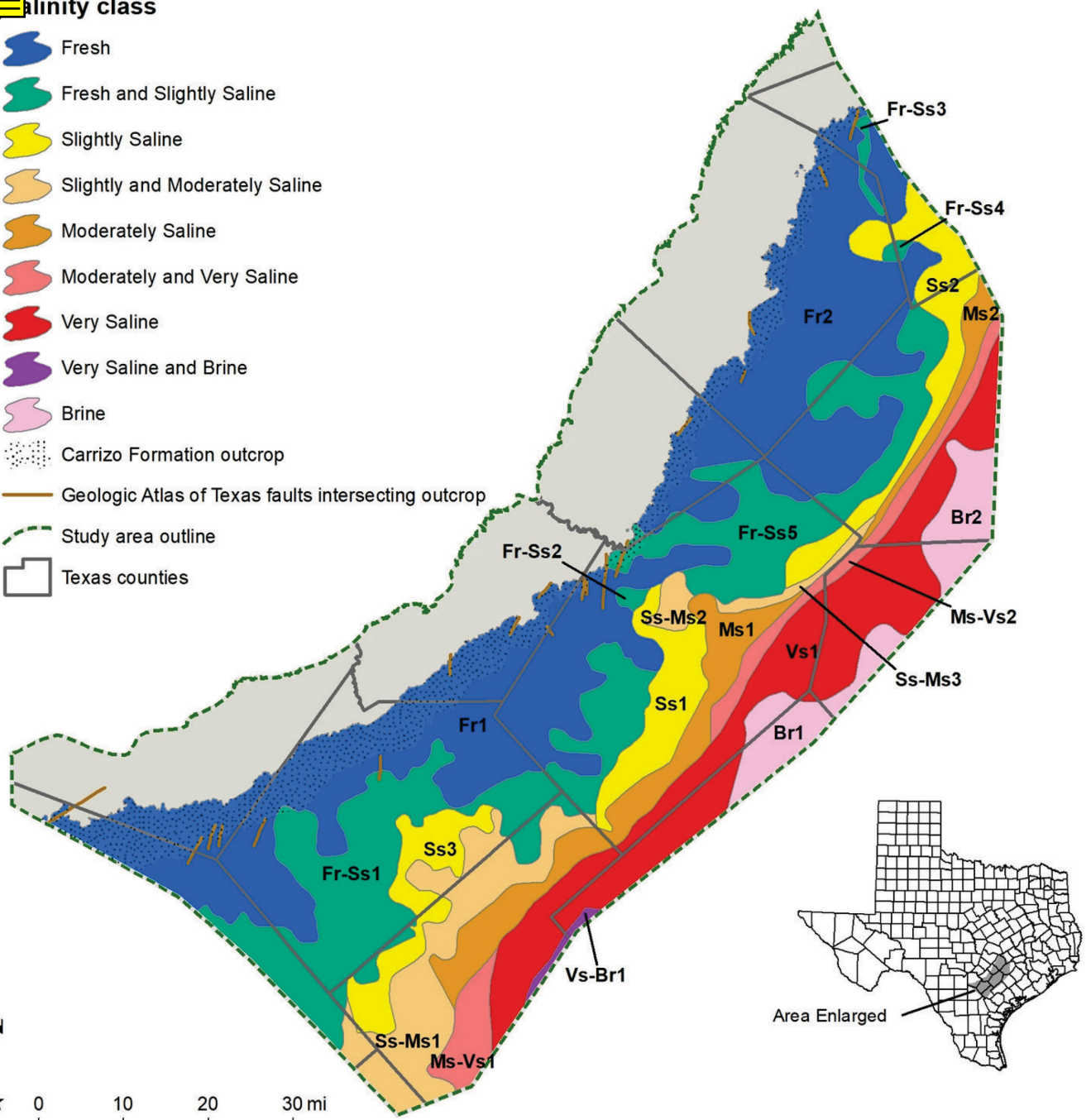
Carrizo Aquifer quick facts

- Up to 1,500 feet thick (457 m)
- Thickest southwest of the San Marcos Arch (structural high)
- Up to 1,000 feet of net sands (305 m)
- 676 mapped measured water quality samples
- 1,283 calculated TDS values
- 2 to 5 vertical salinity classes per well in mixed wells



Salinity class

-  Fresh
-  Fresh and Slightly Saline
-  Slightly Saline
-  Slightly and Moderately Saline
-  Moderately Saline
-  Moderately and Very Saline
-  Very Saline
-  Very Saline and Brine
-  Brine
-  Carrizo Formation outcrop
-  Geologic Atlas of Texas faults intersecting outcrop
-  Study area outline
-  Texas counties



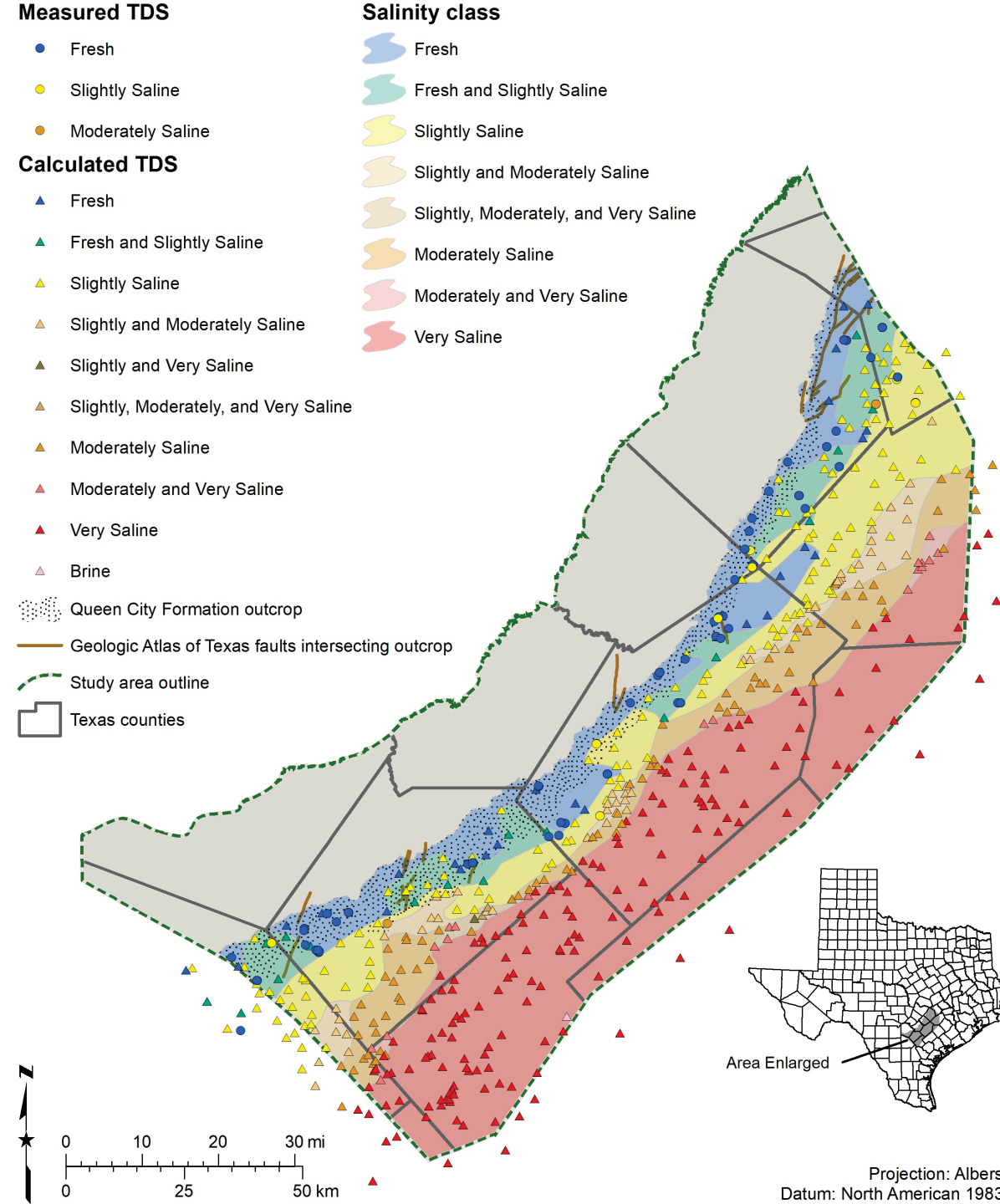
Carrizo salinity map and volume

Salinity class	Volume of groundwater (millions of acre-feet)	Volume of groundwater (km ³)
Fr	46.37	57.20
Fr-Ss	46.69	57.59
Ss	20.40	25.16
Ss-Ms	22.40	27.63
Ms	14.69	18.12
Ms-Vs	8.79	10.84
Vs	33.37	41.16
Vs-Br	0.94	1.16
Br	10.61	13.09













Projection: Albers
Datum: North American 1983

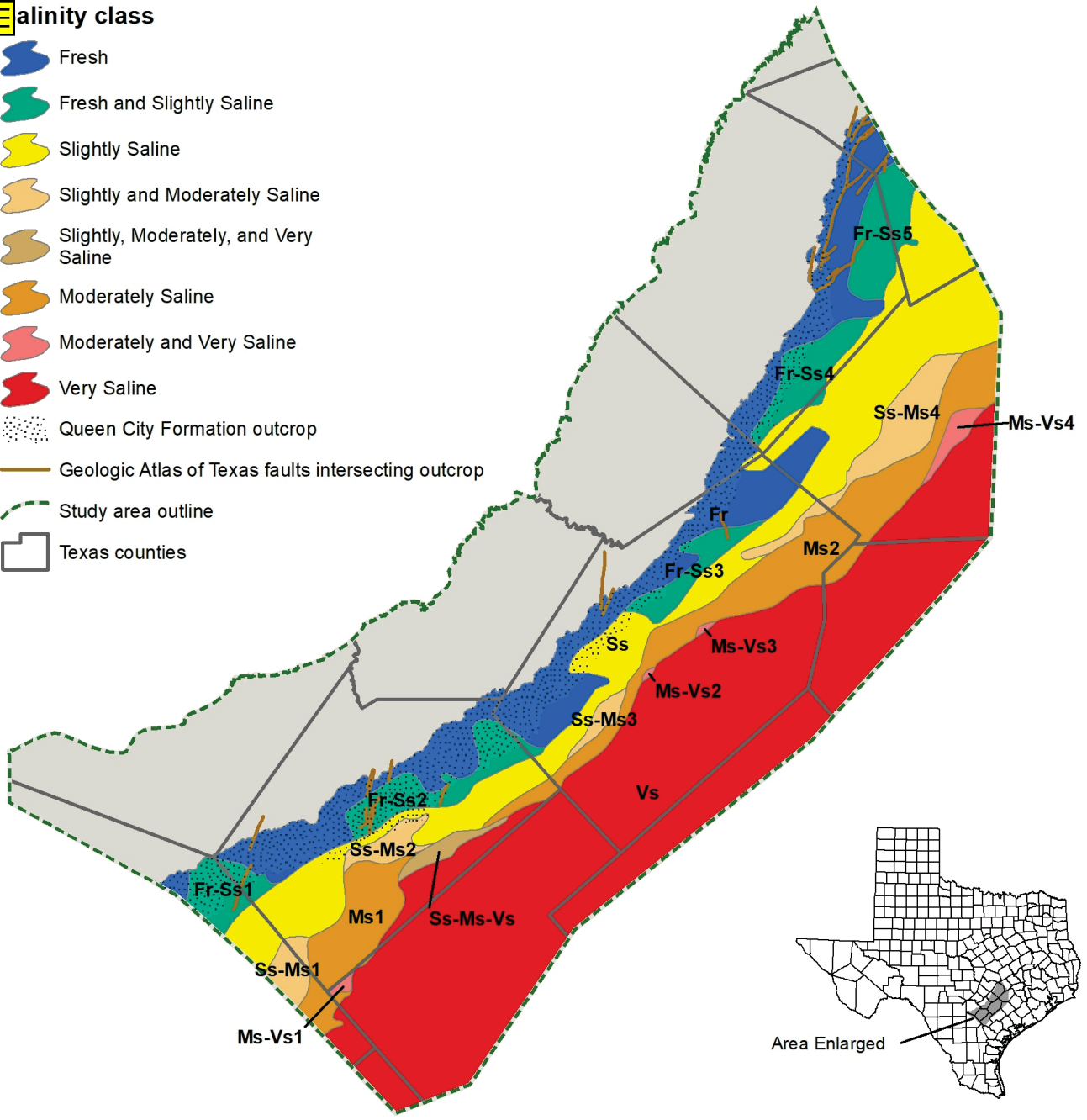
Queen City Aquifer quick facts

- Up to 1,000 feet thick (305 m)
- Up to 600 feet of net sands (183 m)
- 161 mapped measured water quality samples
- 951 calculated TDS values
- 2 to 3 vertical salinity classes per well in mixed wells



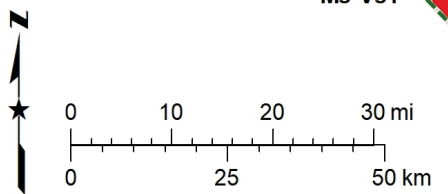
Salinity class

-  Fresh
-  Fresh and Slightly Saline
-  Slightly Saline
-  Slightly and Moderately Saline
-  Slightly, Moderately, and Very Saline
-  Moderately Saline
-  Moderately and Very Saline
-  Very Saline
-  Queen City Formation outcrop
-  Geologic Atlas of Texas faults intersecting outcrop
-  Study area outline
-  Texas counties



Queen City salinity map and volume

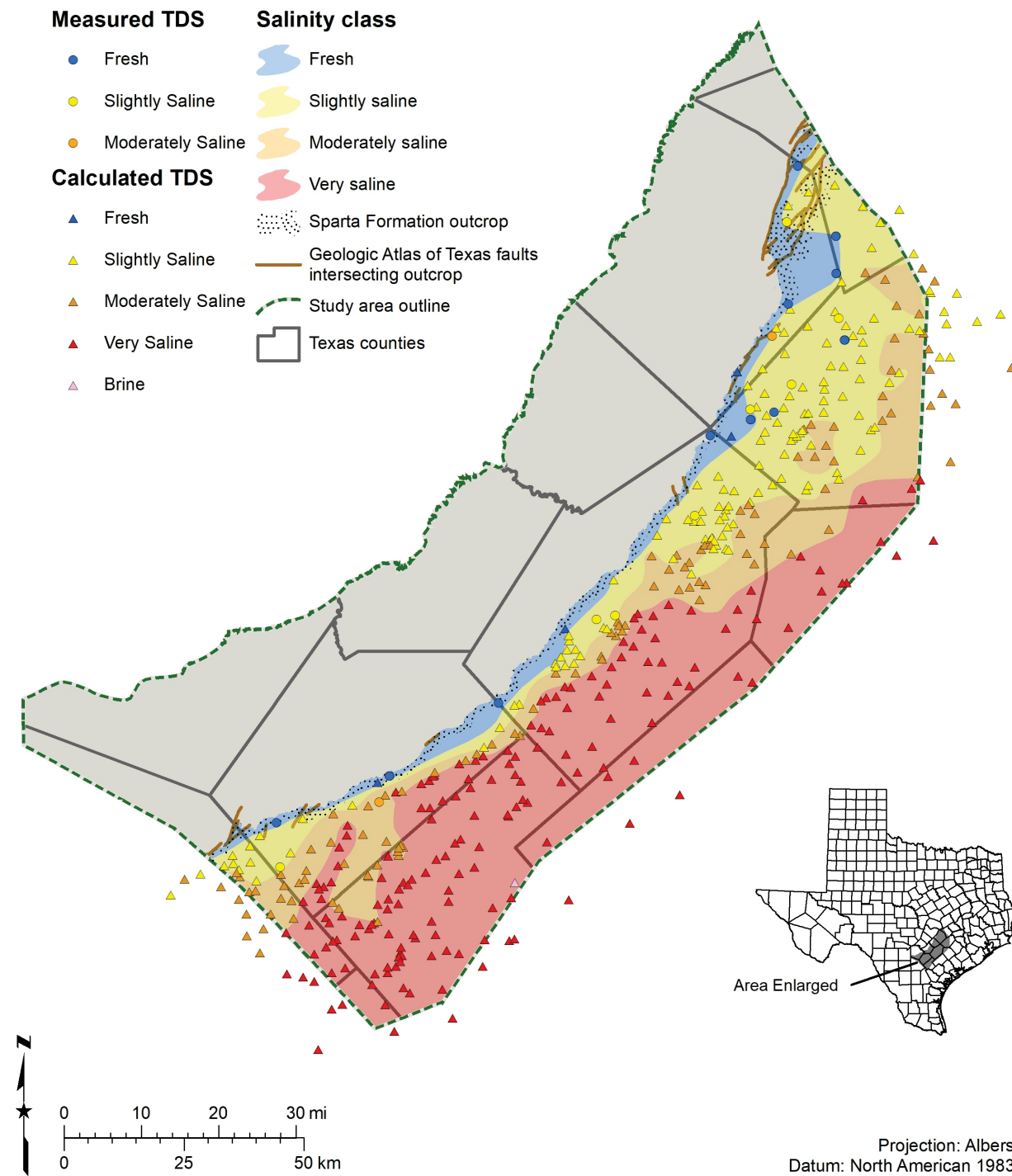
Salinity class	Volume of groundwater (millions of acre-feet)	Volume of groundwater (km ³)
Fr	3.48	4.29
Fr-Ss	4.22	5.21
Ss	10.82	13.35
Ss-Ms	2.87	3.54
Ss-Ms-Vs	0.42	0.52
Ms	6.60	8.14
Ms-Vs	0.38	0.47
Vs	23.11	28.51



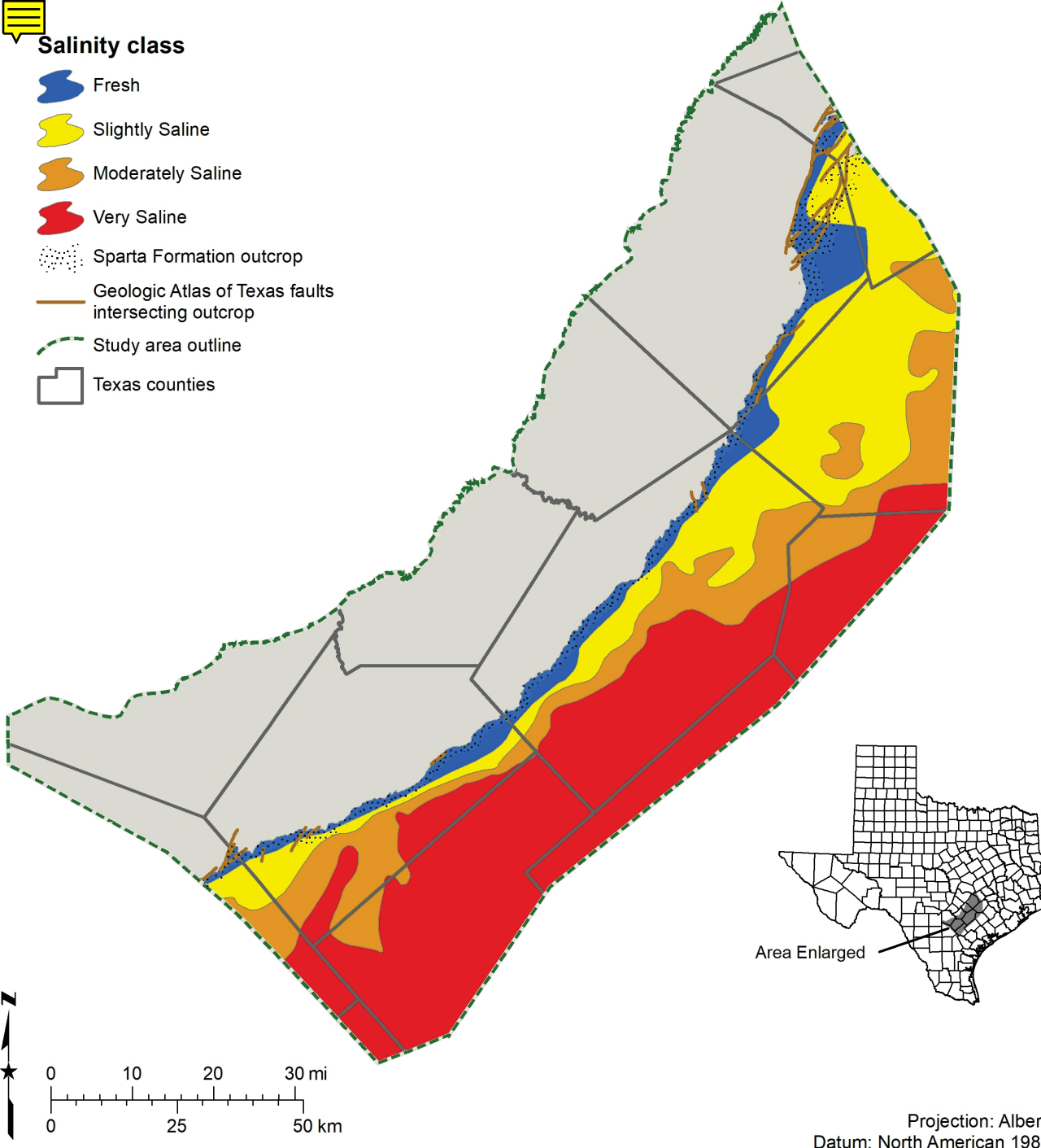
Projection: Albers
Datum: North American 1983

Sparta Aquifer quick facts

- Up to 300 feet thick (91 m)
- Deposited as strandplain/barrier bar system in study area (Ricoy and Brown, 1977)
- Up to 150 feet of net sands (46 m)
- 34 mapped measured water quality samples
- 436 calculated TDS values
- Zero wells mapped with mixed salinity classes



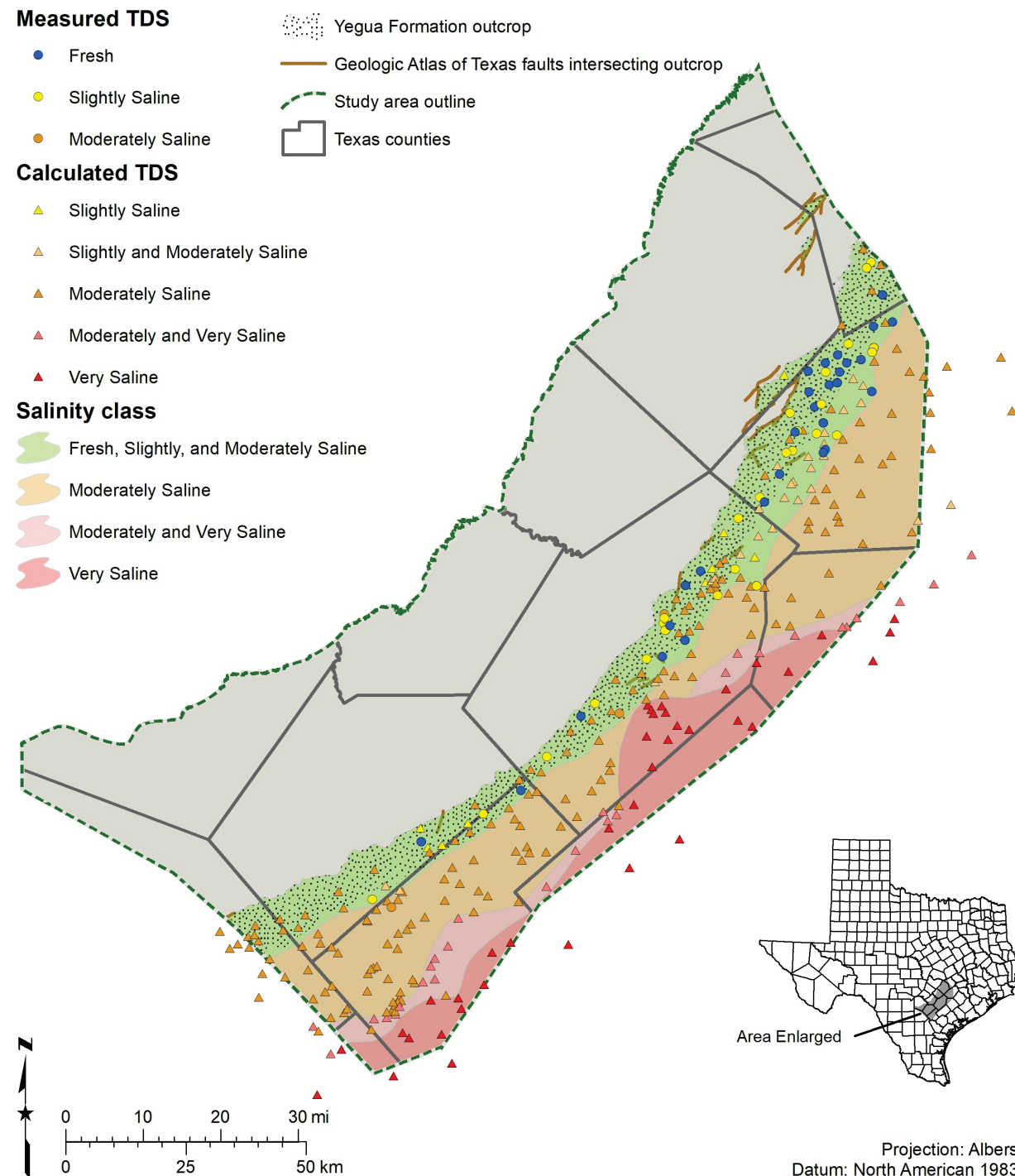
Sparta salinity map and volume



Salinity class	Volume of groundwater (millions of acre-feet)	Volume of groundwater (km ³)
Fr	0.54	0.67
Ss	3.48	4.29
Ms	2.86	3.53
Vs	4.86	5.99

Yegua Aquifer quick facts

- Up to 1,100 feet thick (335 m)
- Up to 500 feet of net sands (152 m)
- 72 mapped measured water quality samples
- 643 calculated TDS values
- 2 to 7 vertical salinity classes per well in mixed wells

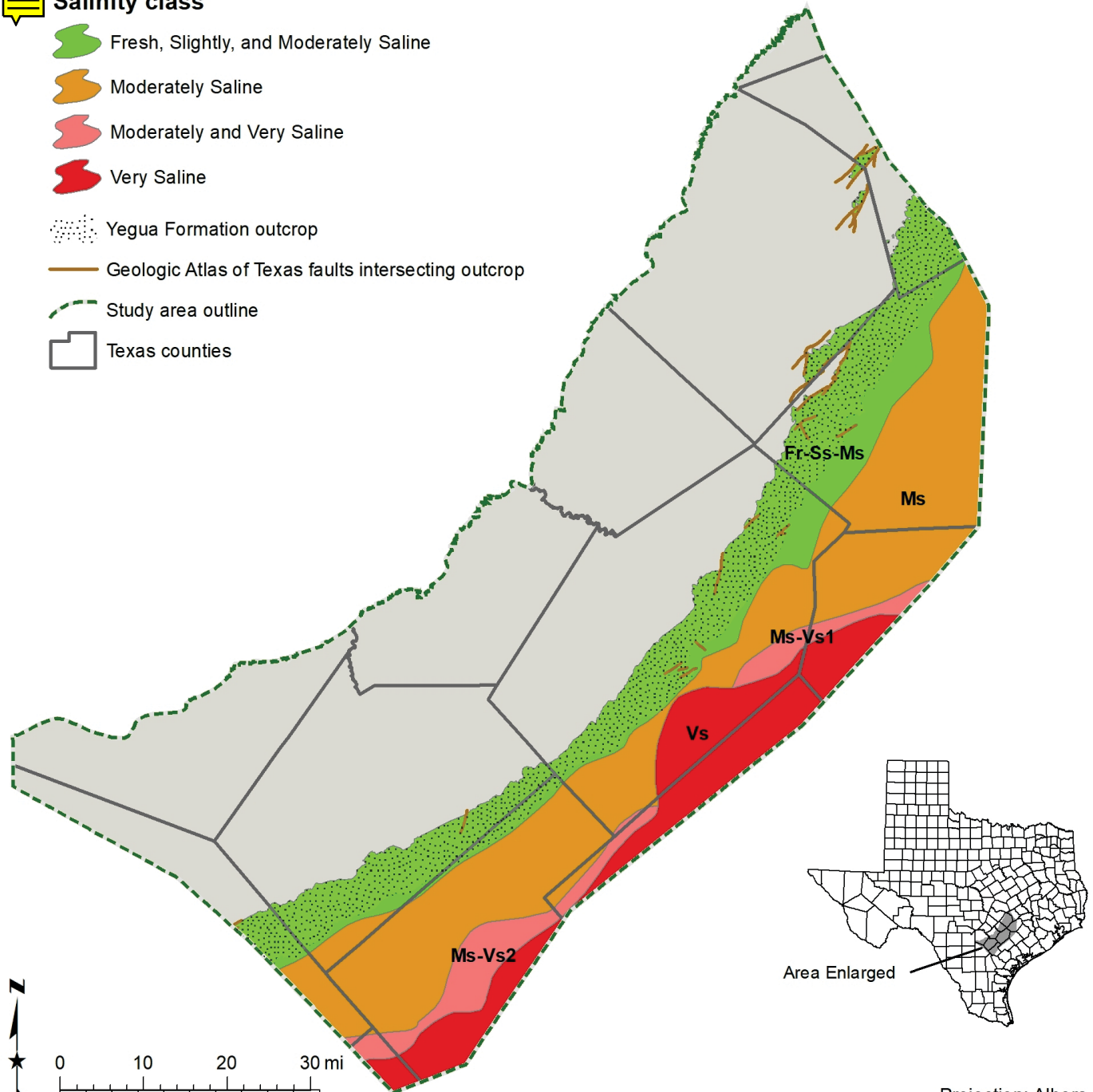




Salinity class

- Fresh, Slightly, and Moderately Saline
- Moderately Saline
- Moderately and Very Saline
- Very Saline

- Yegua Formation outcrop
- Geologic Atlas of Texas faults intersecting outcrop
- Study area outline
- Texas counties



Yegua salinity map and volume

Salinity class	Volume of groundwater (millions of acre-feet)	Volume of groundwater (km ³)
Fr-Ss-Ms	10.16	12.53
Ms	42.96	52.99
Ms-Vs	8.11	10.00
Vs	16.90	20.85

Projection: Albers
Datum: North American 1983

Conclusions

- We hand-contoured more than 6,800 TDS values in 5 aquifers to map groundwater salinity
- We estimate there are more than 230 million acre-feet of brackish groundwater in the study area (284 km³)
- Regional geology seems to influence groundwater salinity
- Study results can be used to locate areas suitable for site-specific desalination studies
- All well points, data, and interpretations are saved in the publicly available BRACS database
- Study report (and GIS datasets) will be available at the TWDB website when published
 - (<http://www.twdb.texas.gov/innovativewater/bracs/studies.asp>)

Questions?

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