Mapping Brackish Aquifers: Future Water Resources

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NGWA Hydrogeophysics and Deep Groundwater Conference
Denver, Colorado
March 20, 2017

The following presentation is based upon professional research and analysis within the scope of the Texas Water Development Board's statutory responsibilities and priorities but, unless specifically noted, does not necessarily reflect official Board positions or decisions.

Brackish Groundwater

saltier than fresh water, less salty than seawater

Groundwater Salinity Classification	Salinity Zone Code	Total Dissolved Solids Concentration (units: milligrams per liter)
Fresh	FR	0 to 1,000
Slightly Saline	SS	1,000 to 3,000
Moderately Saline	MS	3,000 to 10,000
Very Saline	VS	10,000 to 35,000
Brine	BR	Greater than 35,000

Drinking Water Limit

Major/Minor Aquifer Mapped Limit

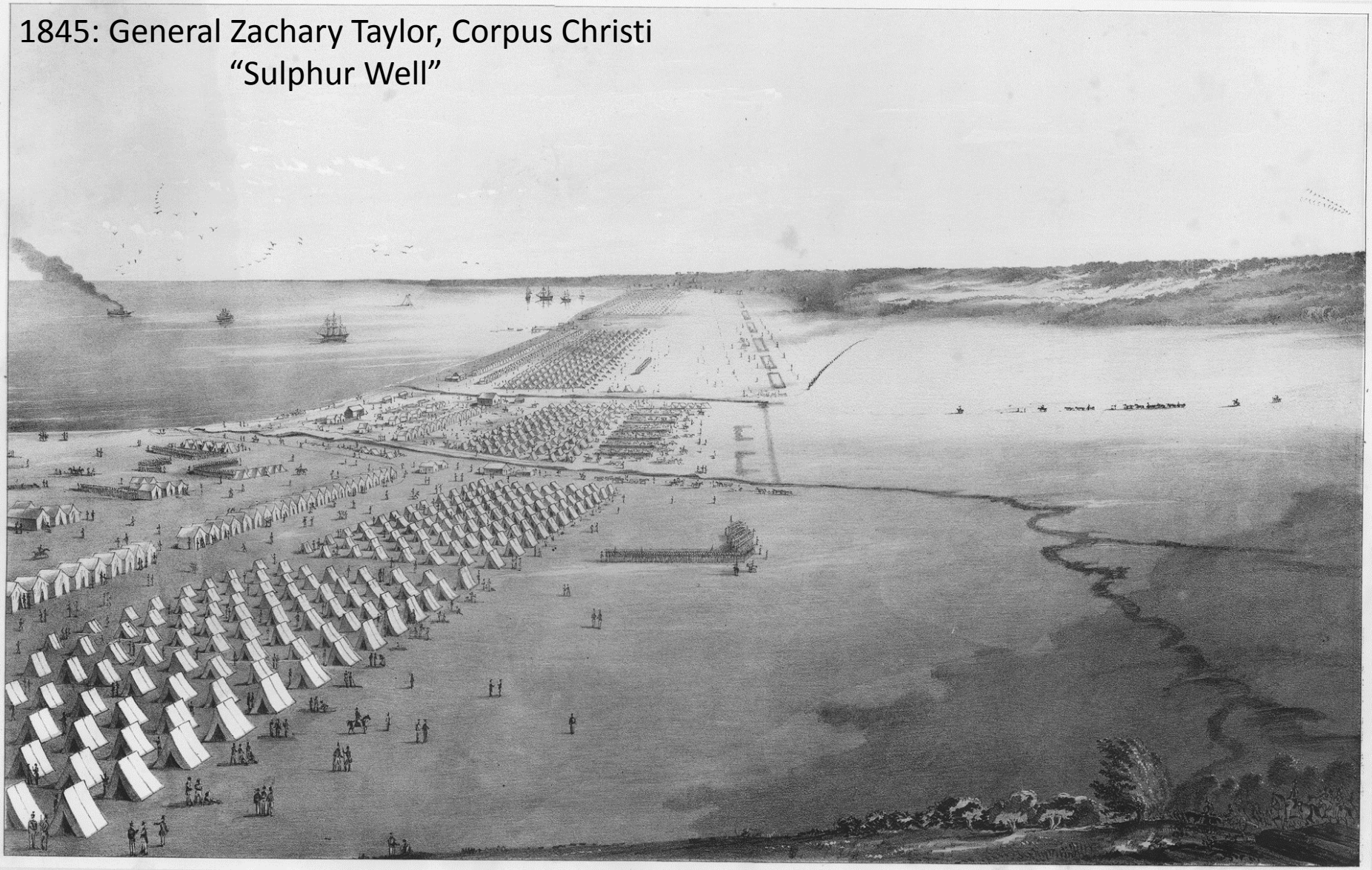
Seawater

1 acre-foot (AF) = 26,000 gallons or 43,560 cubic feet or 1,233 cubic meters
(approximately)

Source: modified from Winslow and Kister, 1956

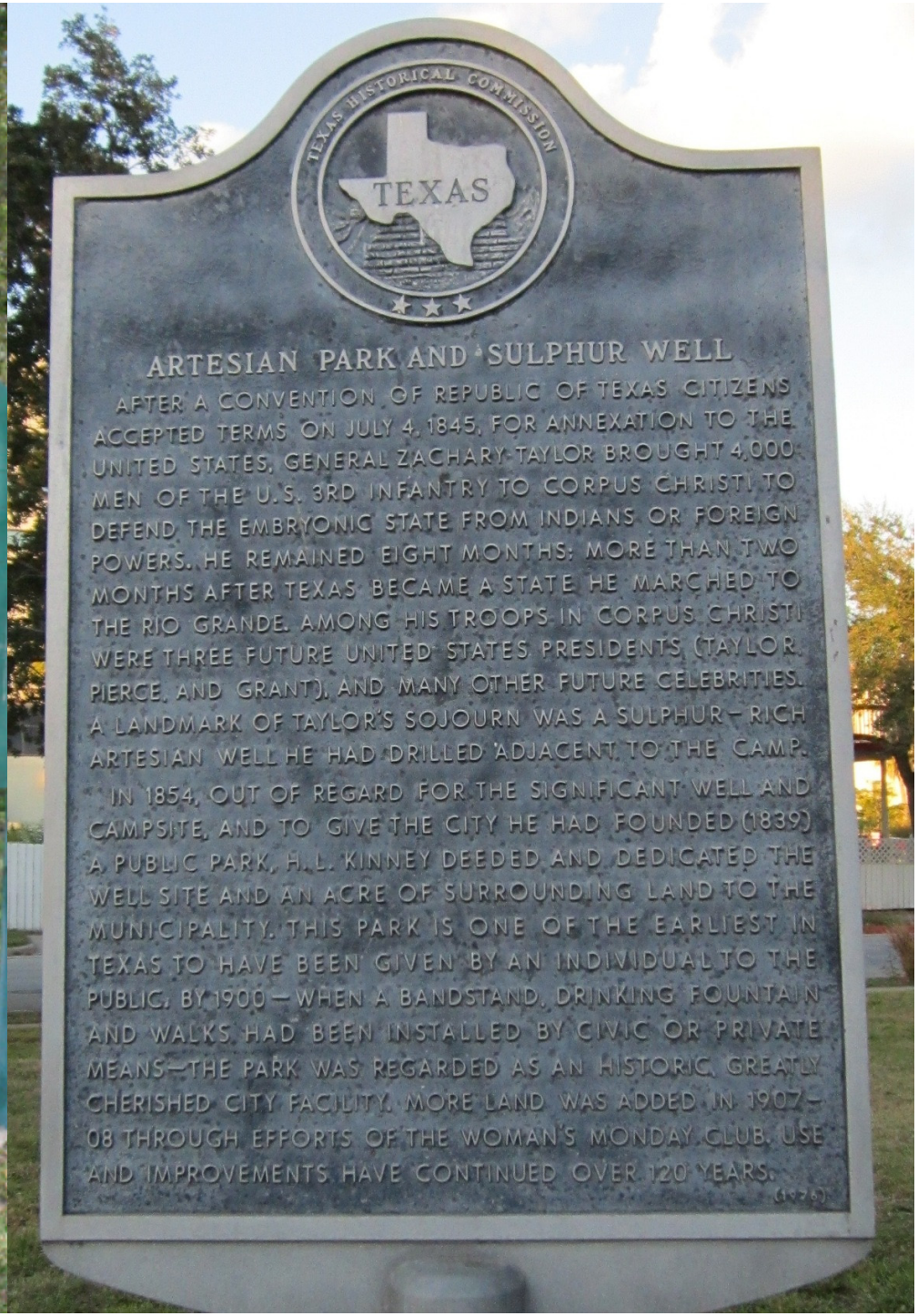
"Those who don't study history are doomed to repeat it. Yet those who *do* study history are doomed to stand by helplessly while everyone else repeats it."

1845: General Zachary Taylor, Corpus Christi
"Sulphur Well"



http://library.uta.edu/usmexicowar/record.php?content_id=53


ARTESIAN
PARK
FIRST PARK IN
CORPUS CHRISTI
1854


TEXAS HISTORICAL COMMISSION
TEXAS
ARTESIAN PARK AND SULPHUR WELL
AFTER A CONVENTION OF REPUBLIC OF TEXAS CITIZENS ACCEPTED TERMS ON JULY 4, 1845, FOR ANNEXATION TO THE UNITED STATES, GENERAL ZACHARY TAYLOR BROUGHT 4,000 MEN OF THE U.S. 3RD INFANTRY TO CORPUS CHRISTI TO DEFEND THE EMBRYONIC STATE FROM INDIANS OR FOREIGN POWERS. HE REMAINED EIGHT MONTHS; MORE THAN TWO MONTHS AFTER TEXAS BECAME A STATE HE MARCHED TO THE RIO GRANDE. AMONG HIS TROOPS IN CORPUS CHRISTI WERE THREE FUTURE UNITED STATES PRESIDENTS (TAYLOR, PIERCE, AND GRANT), AND MANY OTHER FUTURE CELEBRITIES. A LANDMARK OF TAYLOR'S SOJOURN WAS A SULPHUR-RICH ARTESIAN WELL HE HAD DRILLED ADJACENT TO THE CAMP.
IN 1854, OUT OF REGARD FOR THE SIGNIFICANT WELL AND CAMPSITE, AND TO GIVE THE CITY HE HAD FOUNDED (1839) A PUBLIC PARK, H. L. KINNEY DEEDED AND DEDICATED THE WELL SITE AND AN ACRE OF SURROUNDING LAND TO THE MUNICIPALITY. THIS PARK IS ONE OF THE EARLIEST IN TEXAS TO HAVE BEEN GIVEN BY AN INDIVIDUAL TO THE PUBLIC. BY 1900—WHEN A BANDSTAND, DRINKING FOUNTAIN AND WALKS HAD BEEN INSTALLED BY CIVIC OR PRIVATE MEANS—THE PARK WAS REGARDED AS AN HISTORIC, GREATLY CHERISHED CITY FACILITY. MORE LAND WAS ADDED IN 1907-08 THROUGH EFFORTS OF THE WOMAN'S MONDAY CLUB. USE AND IMPROVEMENTS HAVE CONTINUED OVER 120 YEARS.

1855-1858: Pacific Railroad Surveys

Well 1: 560 feet
Well 2: 293 feet
Well 3: 1,047 feet

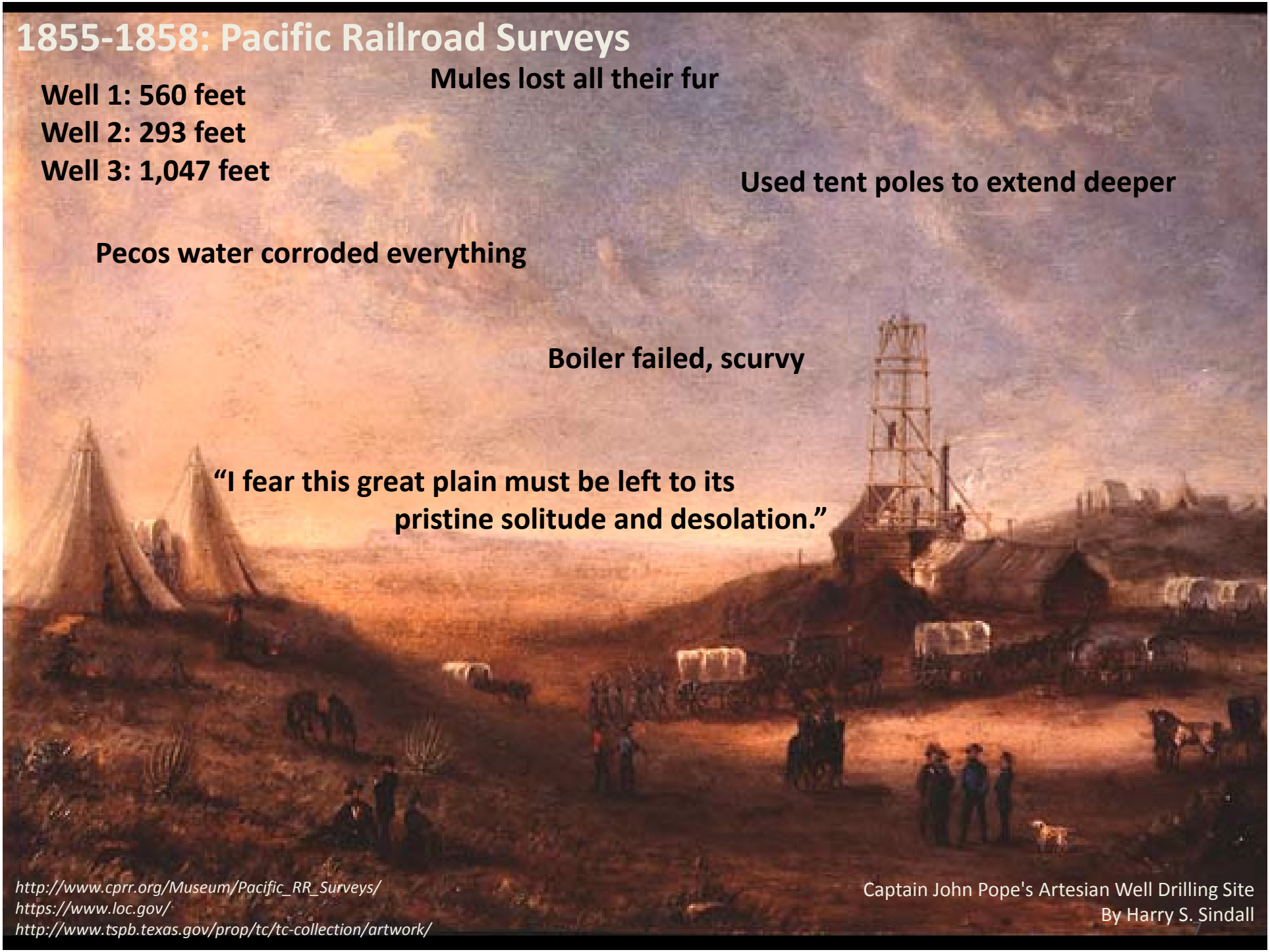
Mules lost all their fur

Used tent poles to extend deeper

Pecos water corroded everything

Boiler failed, scurvy

"I fear this great plain must be left to its pristine solitude and desolation."



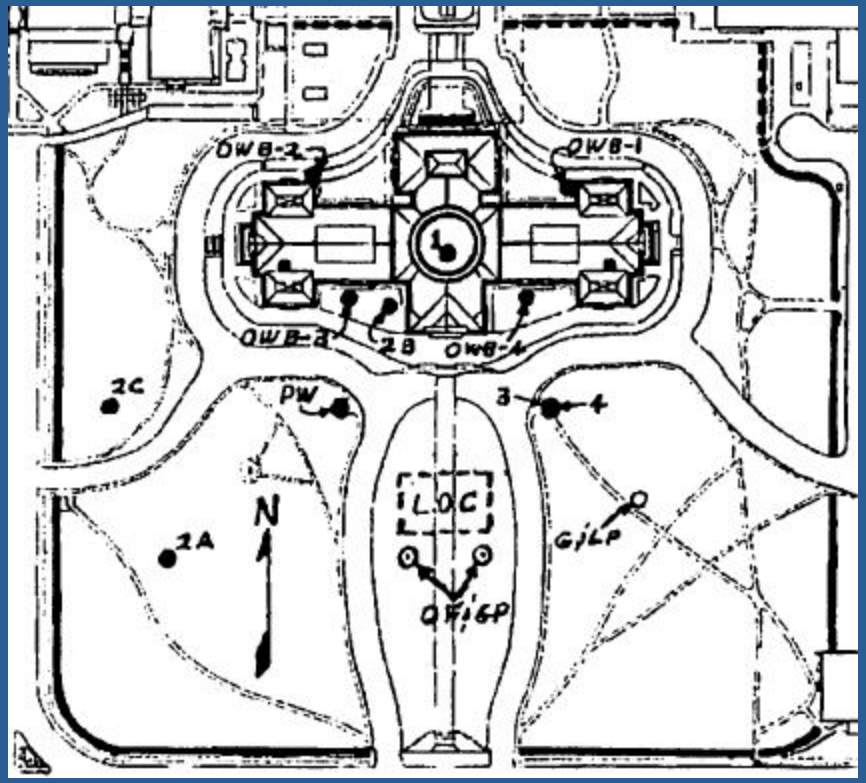
http://www.cprr.org/Museum/Pacific_RR_Surveys/
https://www.loc.gov/
http://www.tspb.texas.gov/prop/tc/tc-collection/artwork/

Captain John Pope's Artesian Well Drilling Site
By Harry S. Sindall

1859-1895 Capitol water wells

August 26, 1856 - The 6th Texas Legislature appropriated $10,000 for a well, trees, and shrubbery for the grounds

- Drilled April 1857-July 1859
- 471ft deep, Edwards Limestone
- First with horse then steam power
- “Old Capital Well” and “Austin Artesian Well”
- Nearby wells produce 3,500-6,200 mg/L

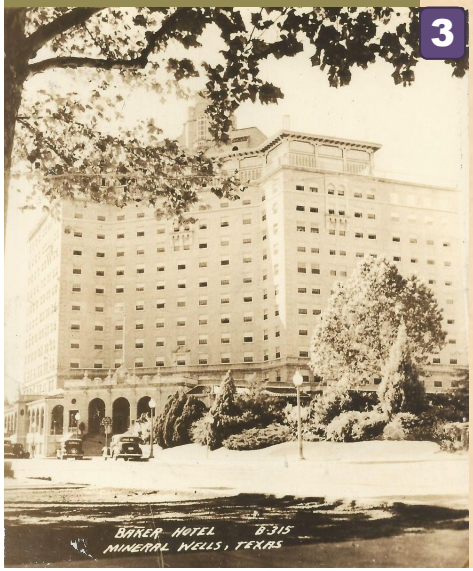


Bluntzer, R.L, 2006, History of water well completions and uses at the State Capitol, 1857-1997, Austin Geological Society Bulletin

1887-1940s Artesian fountains, pools, and spas

1

2



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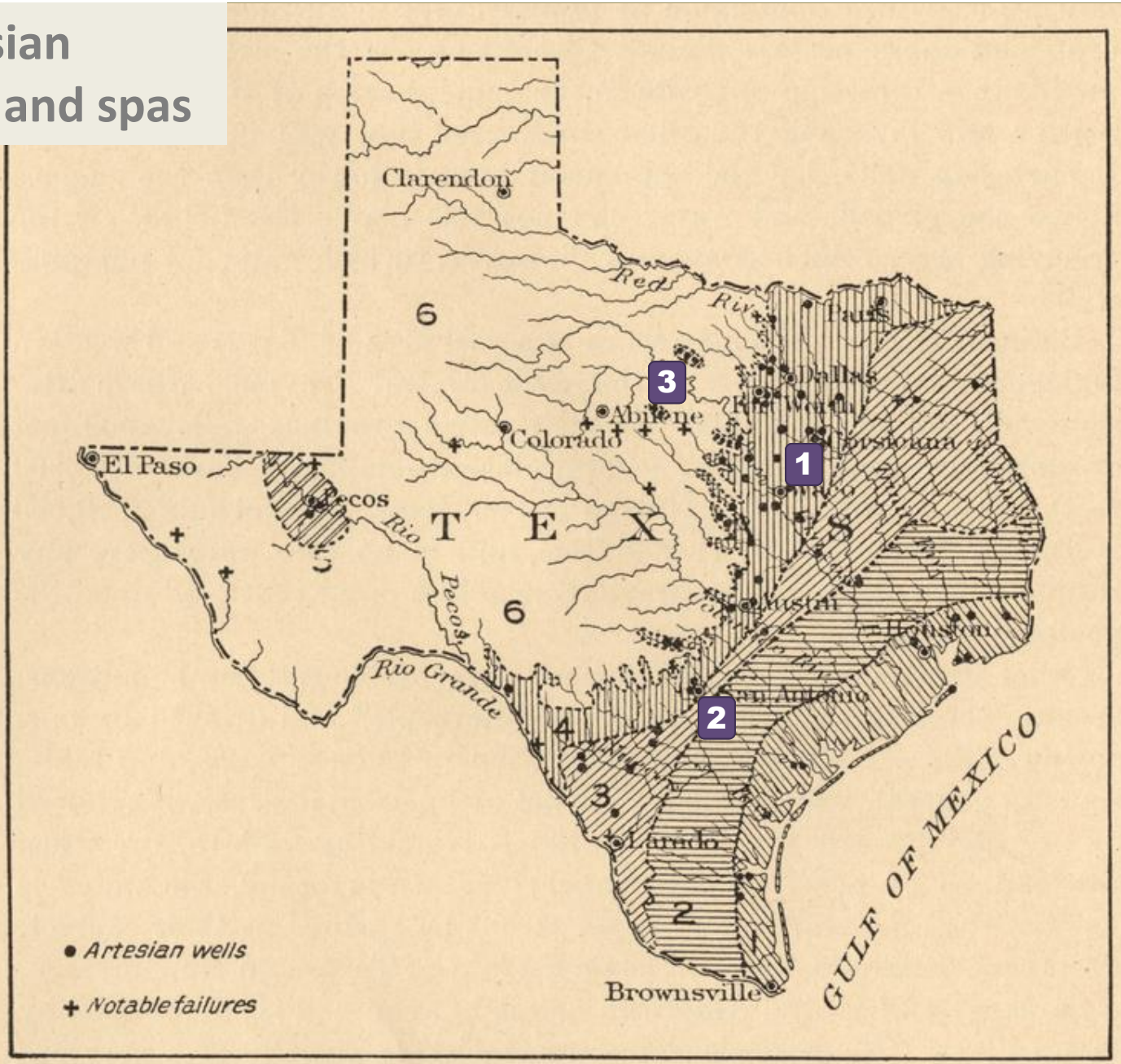


FIG. 44.—Map showing artesian districts of Texas.

1, Coast Prairie system; 2, Hallettsville system; 3, Carrizo system; 4, Black and Grand prairies system; 5, Trans-Pecos Basin system; 6, Stevens County and Jack County systems.

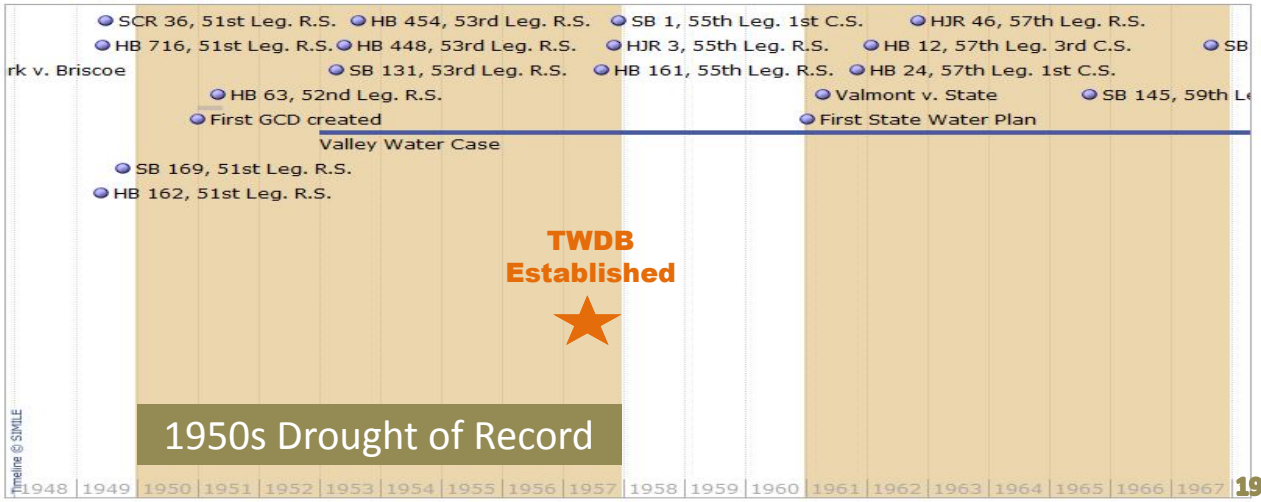
21st Annual Report of the USGS, 1899-1900, Volume VII - Texas

Mineral Wells, TX

http://youhavewatermail.blogspot.com

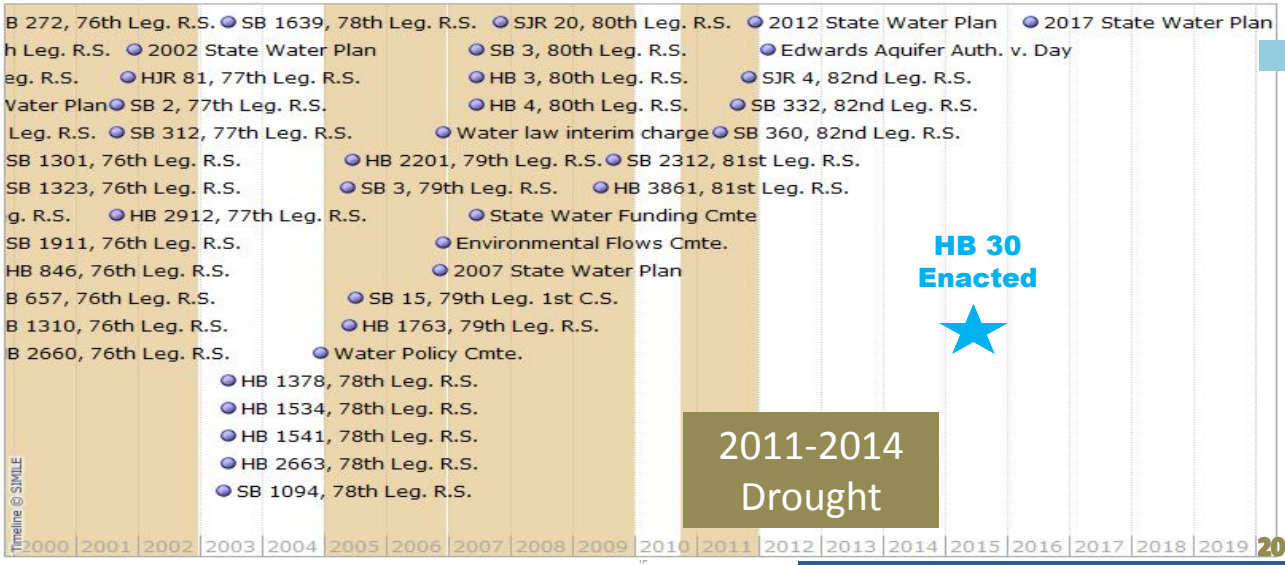
Cycles of Drought and Planning

Texas water law timeline



1968 1969..... 1999

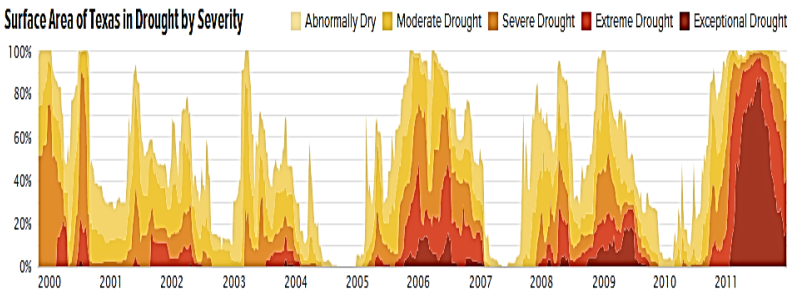
Click and drag on the time line to pan horizontally. Years highlighted in brown are drought years. View Text Time Line



2017 State Water Plan (2020-2070)

HB 30 Deadline

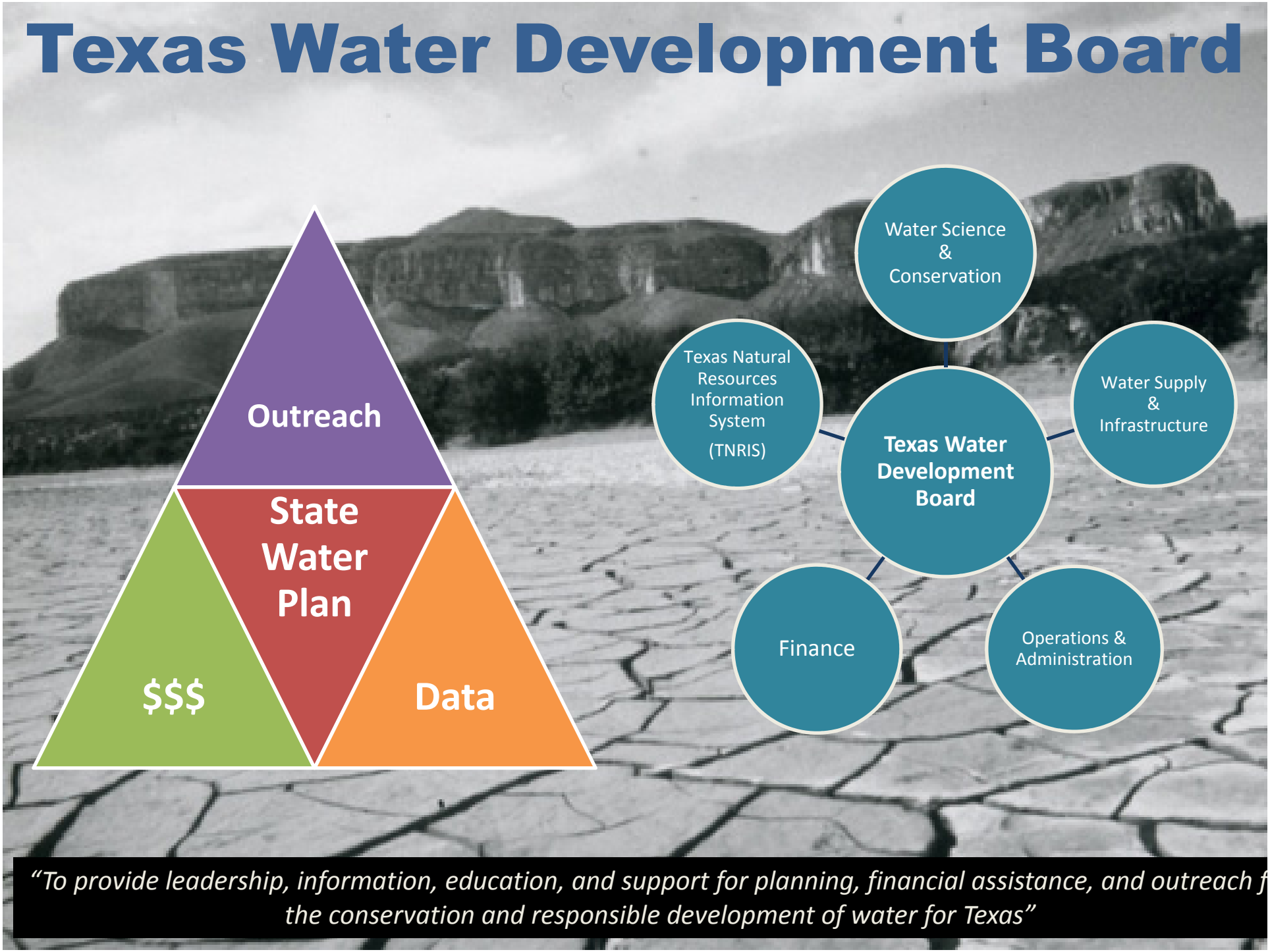
2020 2021 2022 2023 2070



http://www.lrl.state.tx.us/legis/watertimeline.cfm

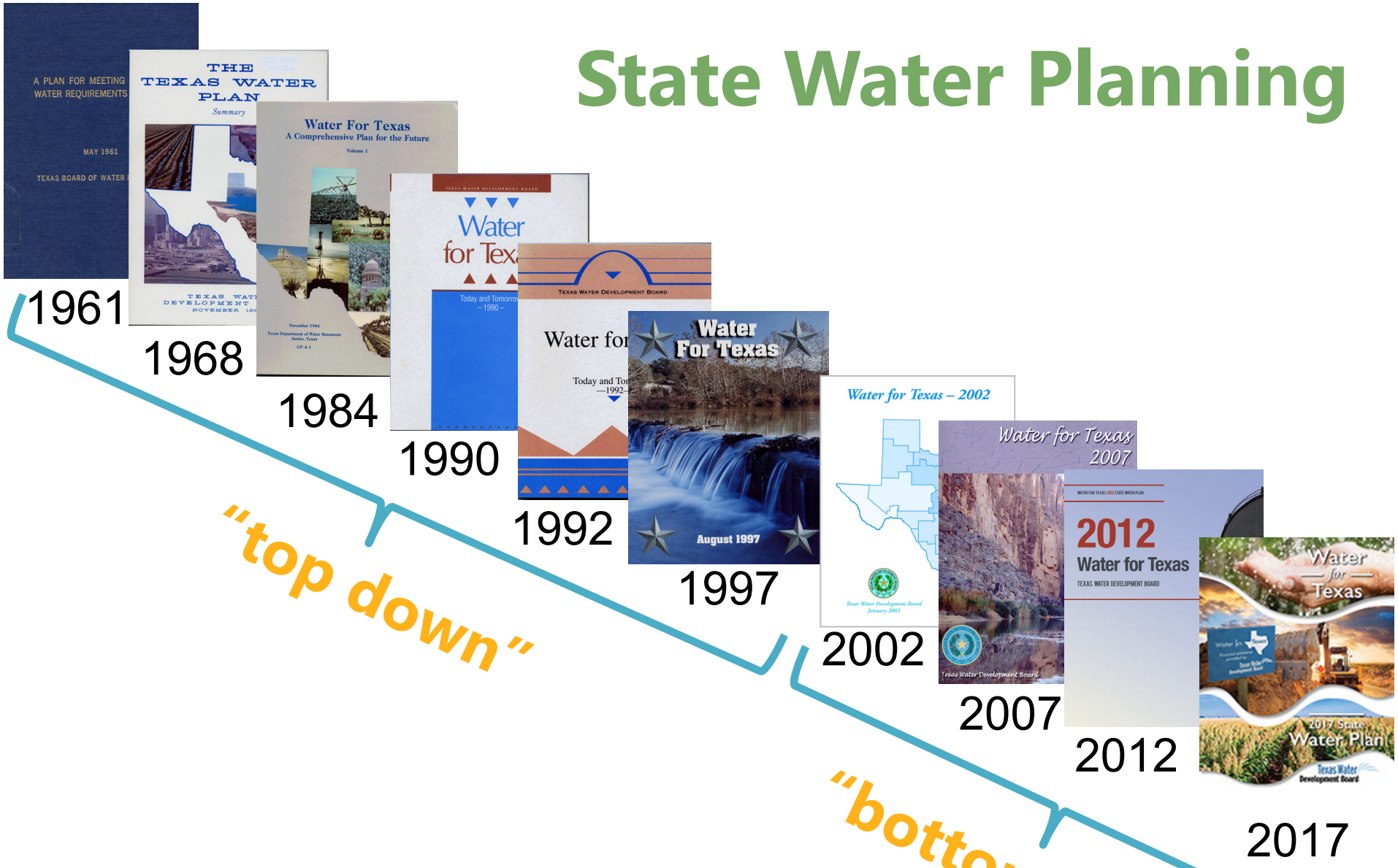
Also see: Fall 2011 Texas Water Resources Institute "tx H2O"
and https://stateimpact.npr.org/texas/drought/
and http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?TX

Texas Water Development Board



"To provide leadership, information, education, and support for planning, financial assistance, and outreach f the conservation and responsible development of water for Texas"

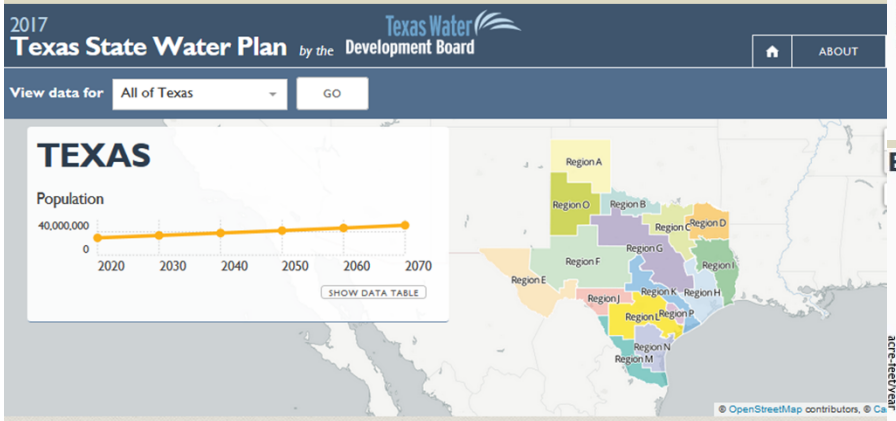
State Water Planning



The State Water Plan

Online and Interactive

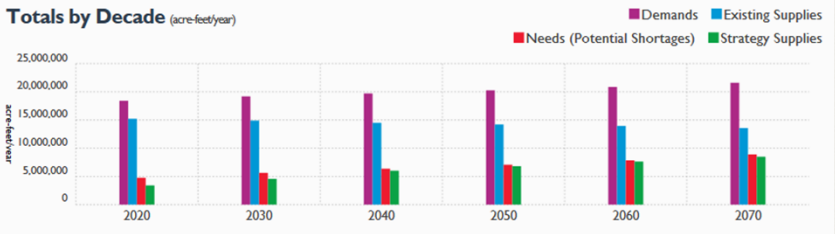
https://2017.texasstatewaterplan.org/statewide

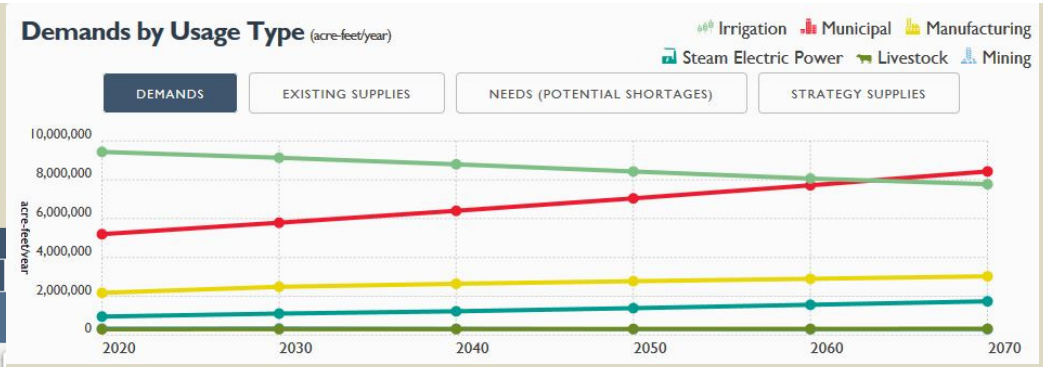


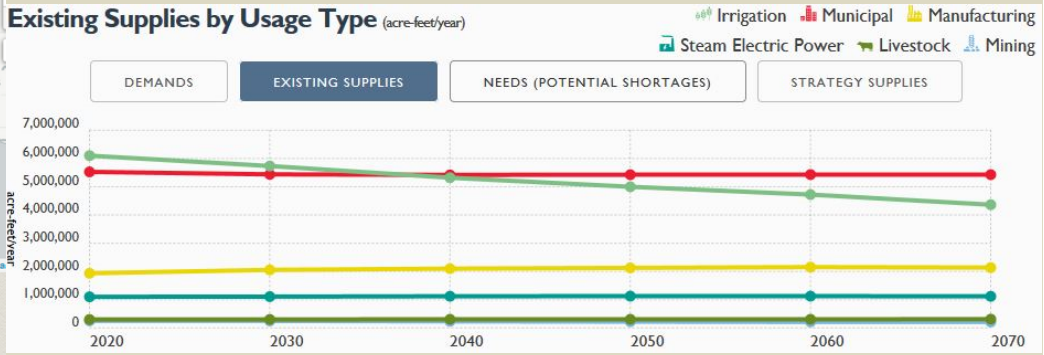
Development of the state water plan is central to the mission of the Texas Water Development Board. Based on 16 regional water plans, the plan addresses the needs of all water user groups in the state – municipal, irrigation, manufacturing, livestock, mining, and steam-electric power – during a repeat of the drought of record that the state suffered in the 1950s. The regional and state water plans consider a 50-year planning horizon: 2020 through 2070.

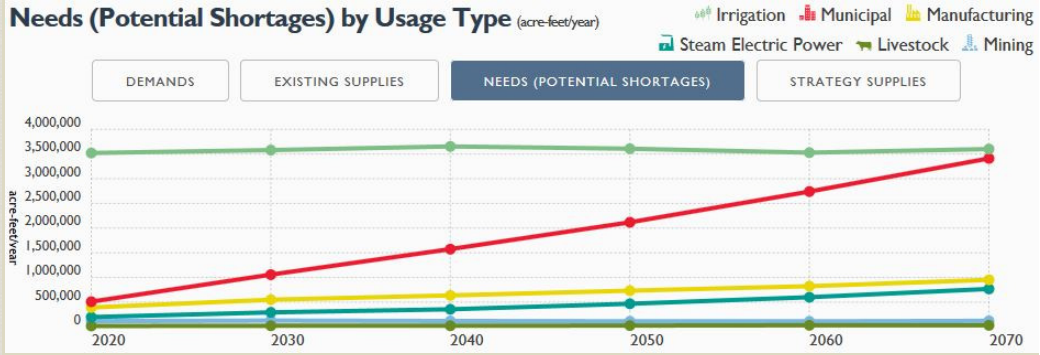
This website lets water users statewide take an up-close look at data in the 2017 State Water Plan and how water needs change over time by showing:

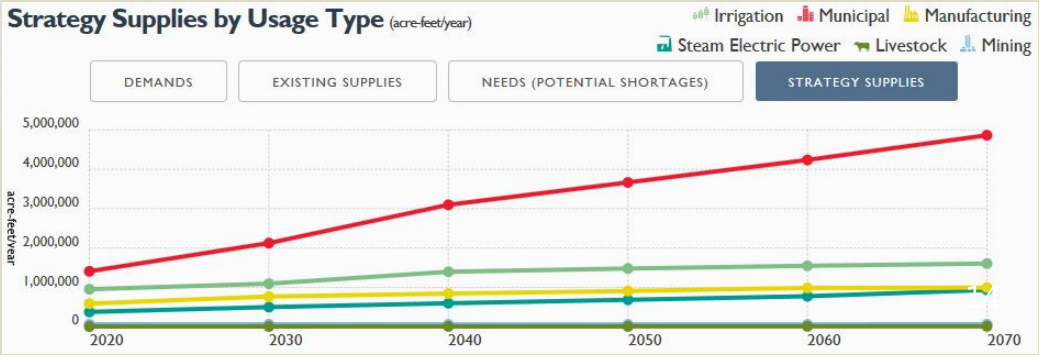
- projected water demands,
- existing water supplies,
- the relative severity and projected water needs (potential shortages),
- the water management strategies recommended to address potential shortages, and
- recommended capital projects and their sponsors.





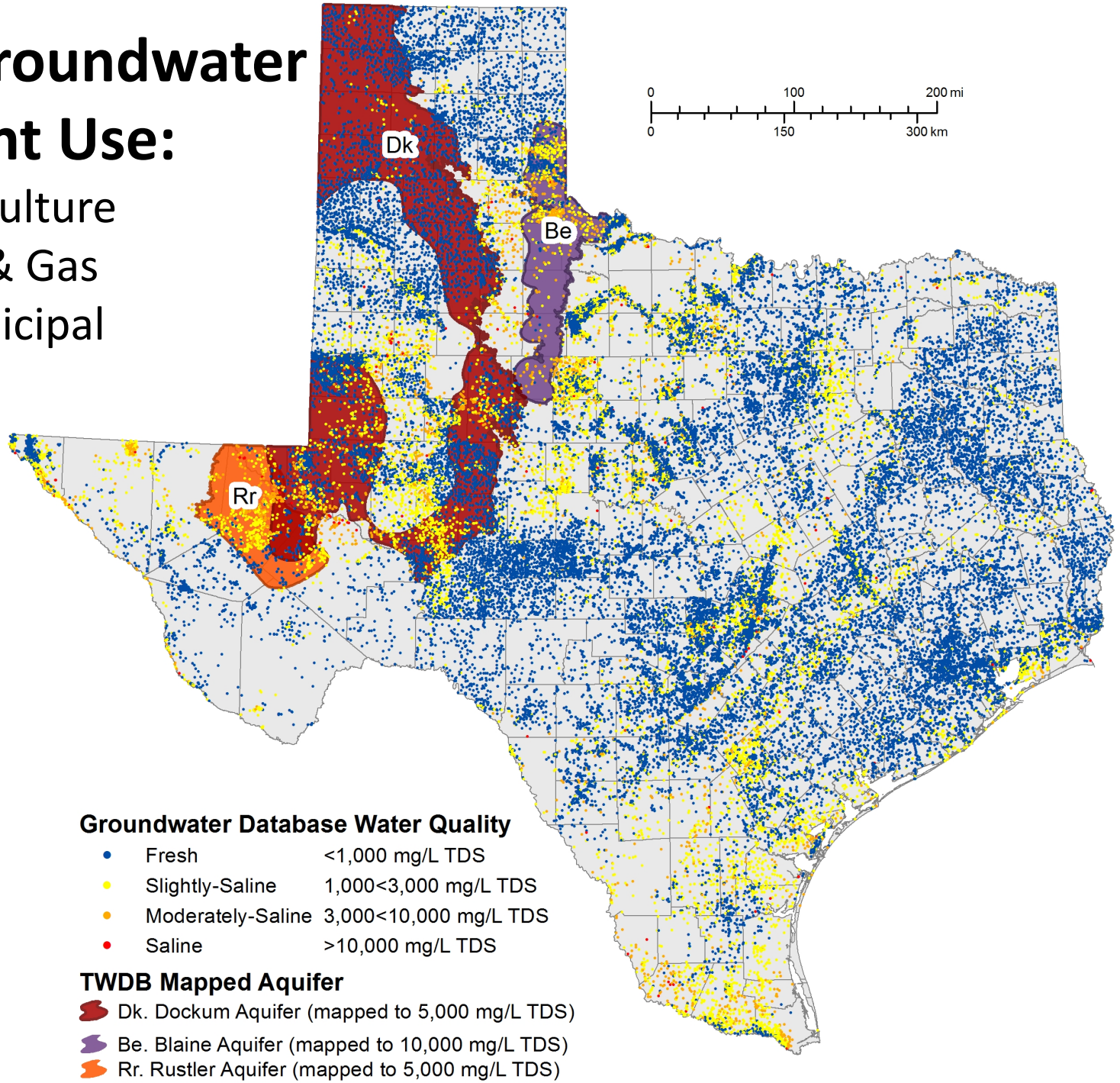






Brackish Groundwater Current Use:

Agriculture
Oil & Gas
Municipal



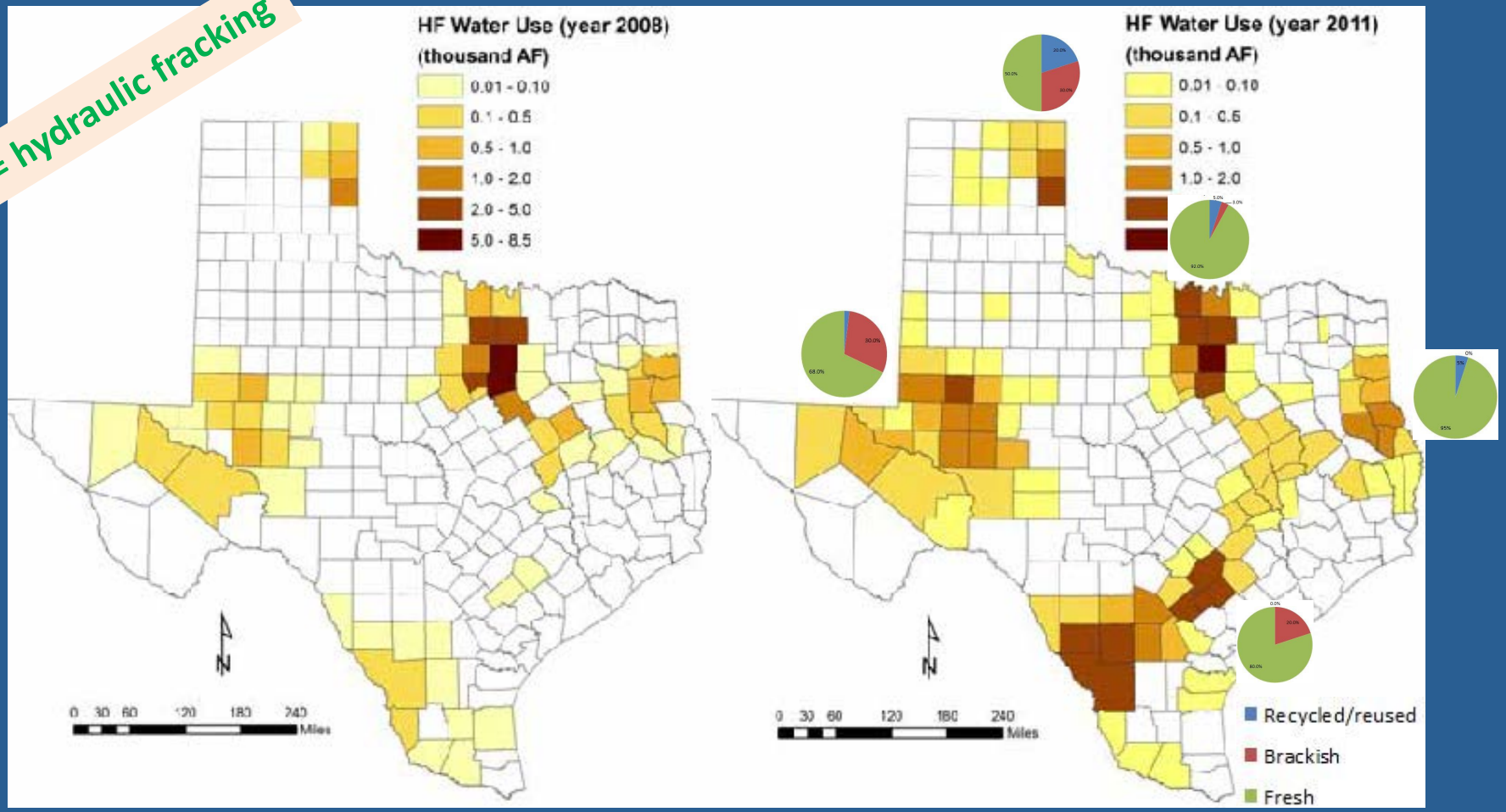
Examples of crop salt tolerance

Tolerant	Semi-tolerant	Sensitive
date palm	sunflower	pecan
coconut palm	acala cotton	navy bean
sugar beet	potato	plum
garden beet	pima cotton	pear
alfalfa	tomato	apple
onion	sweet pea	grape
turnip	radish	kardota fig
cabbage	field pea	persimmon
lettuce	barley	peach
carrot	wheat	orange
	maize	avocado
	grain sorghum	grapefruit
	oats	lemon
	pumpkin	
	bell pepper	
	sweet potato	
	lima bean	

Oil & Gas Water Use in Texas:

Update to the 2011 Mining Water Use Report
Prepared for Texas Oil & Gas Association

HF = hydraulic fracking



2008
~36,000 acre-feet

2011
~81,500 acre-feet
(~17,000 acre-feet of recycled/reuse & brackish water

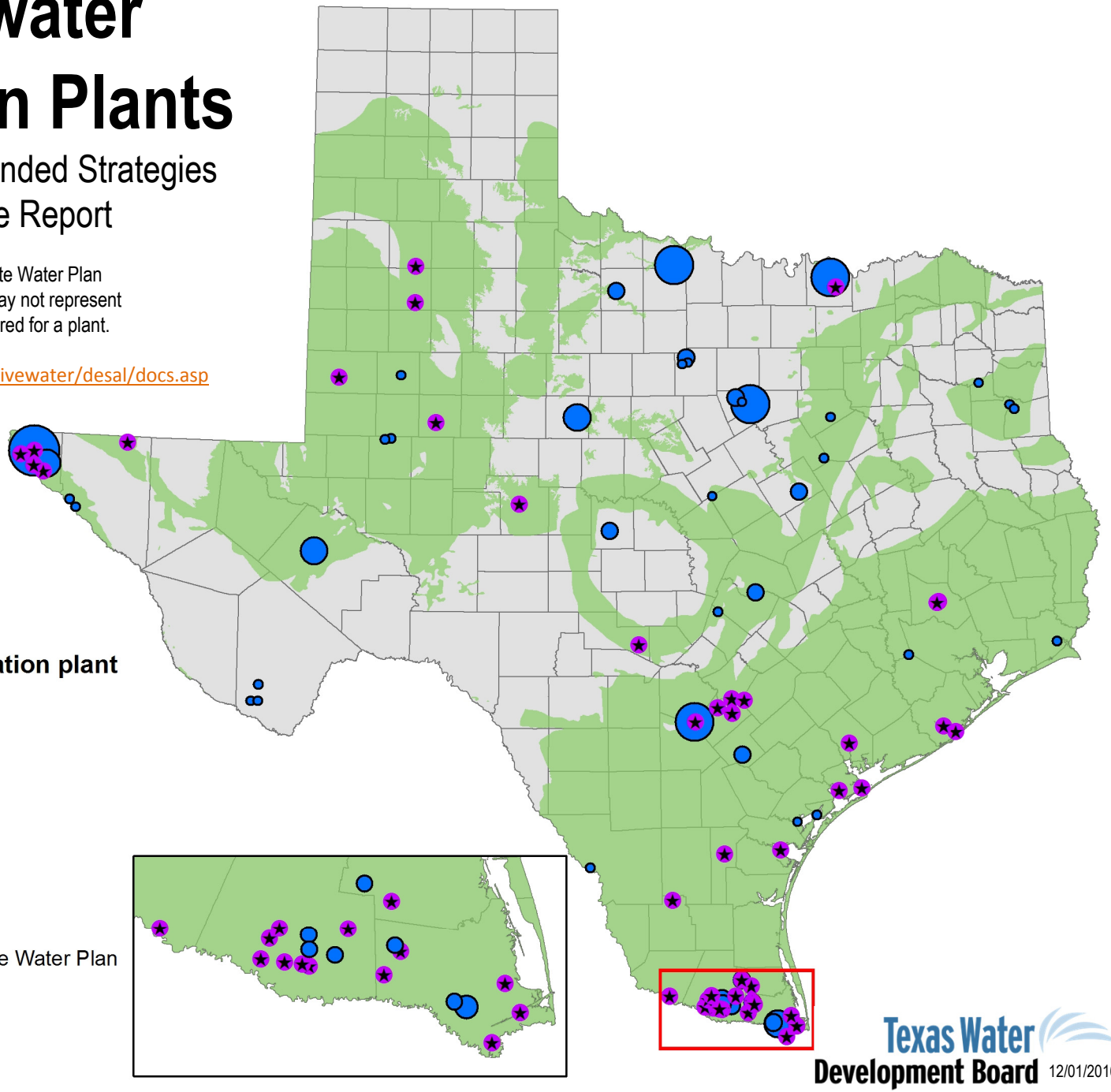
http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/0904830939_2012Update_MiningWaterUse.pdf

Groundwater Desalination Plants

Existing and Recommended Strategies
2016 Legislative Report

Projects from the 2017 State Water Plan
are conceptual and may or may not represent
a precise site being considered for a plant.

http://www.twdb.texas.gov/innovativewater/desal/docs.asp



Existing groundwater desalination plant

Capacity in million gallons per day

- 0.02 - 0.9
- 1 - 4.9
- 5 - 9.9
- 10 - 19.9
- 20 - 30.0

- Recommended plant - 2017 State Water Plan
- Known brackish aquifer extent
- Texas counties

Texas Water Development Board 12/01/2016

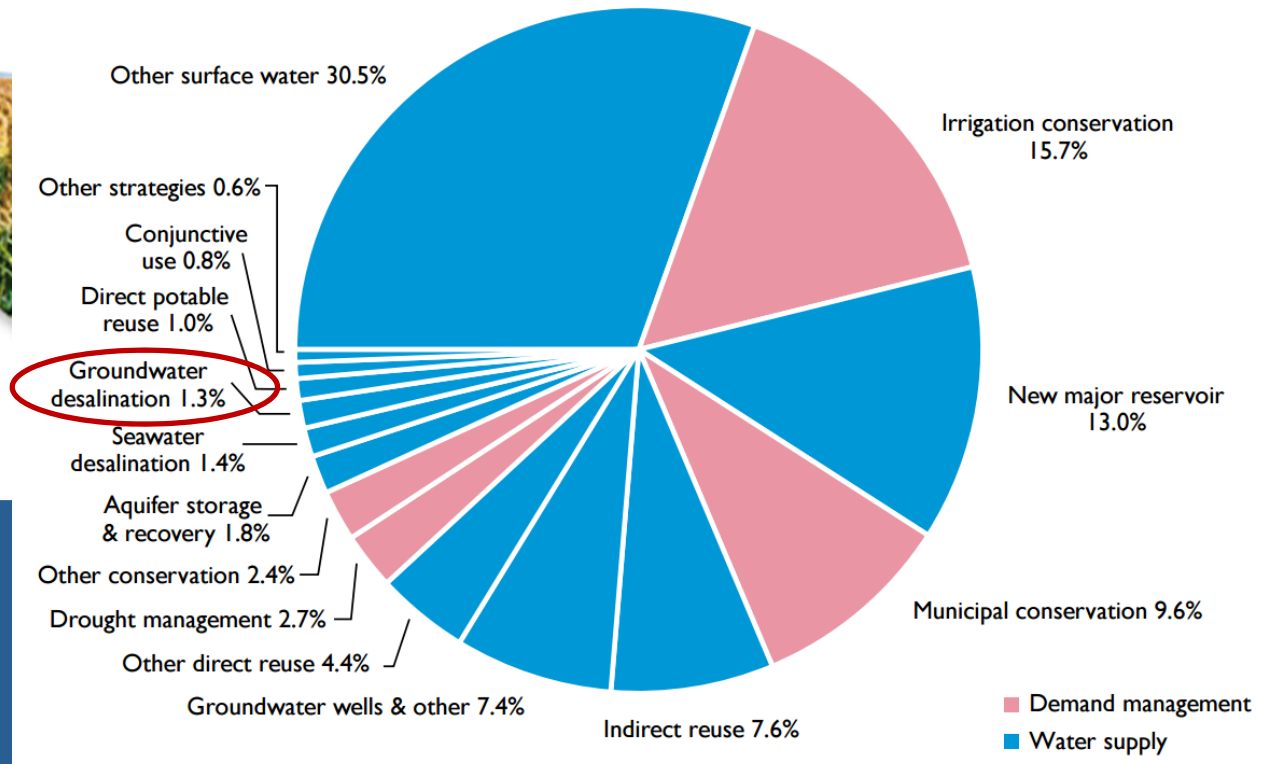
Effected by:

- Location and abundance of the resource
- Energy costs
- Existing infrastructure
- Technology
- Concentrate disposal

"The relatively high cost and site specificity of seawater and brackish groundwater desalination compared to the cost of developing conventional fresh water supplies continue to be an impediment to advancing desalination in Texas. "

http://www.twdb.texas.gov/innovativewater/desal/doc/2016_TheFutureofDesalinationinTexas.pdf

Figure ES.7 - Share of recommended water management strategies by strategy type in 2070

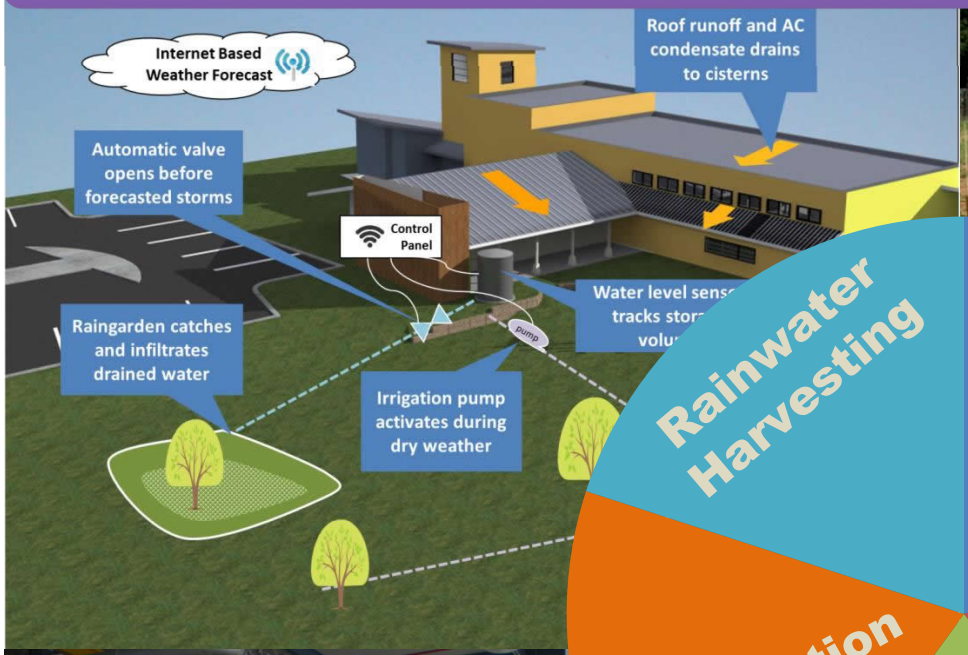


2017 State Water Plan Brackish Groundwater

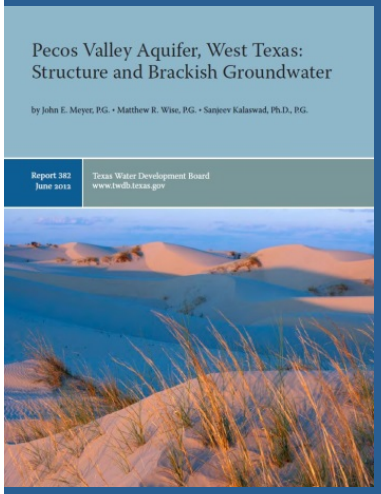
- 111,000 acre-feet (1.3%) water supply filling the gap between projected 2070 demand and supply
- 8 of the 16 Regional Water Planning Areas

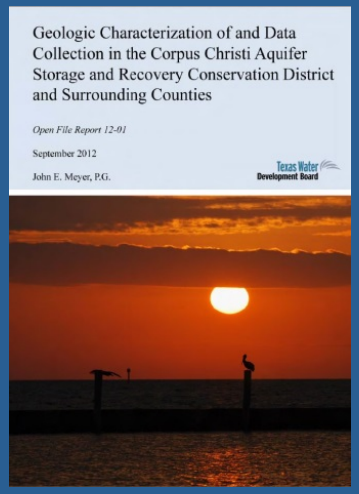
http://www.twdb.texas.gov/waterplanning/swp/index.asp

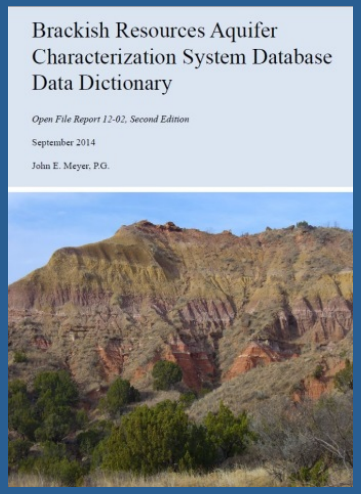
Innovative Water Technologies

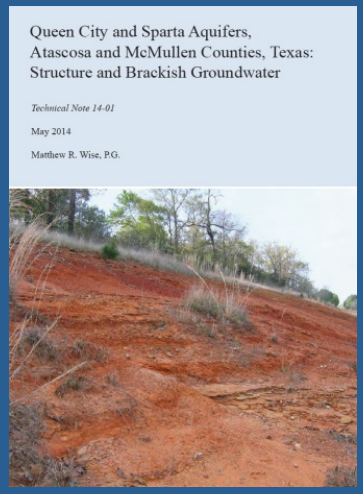


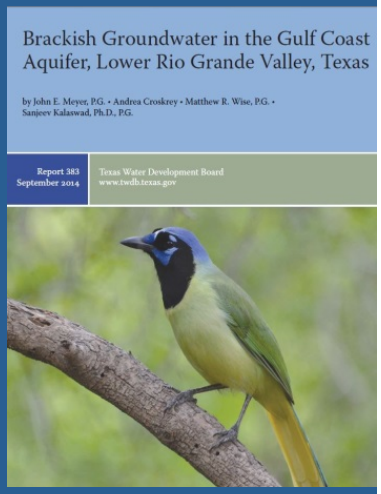
"Our mission is to educate the water community on the use of nontraditional water supplies."







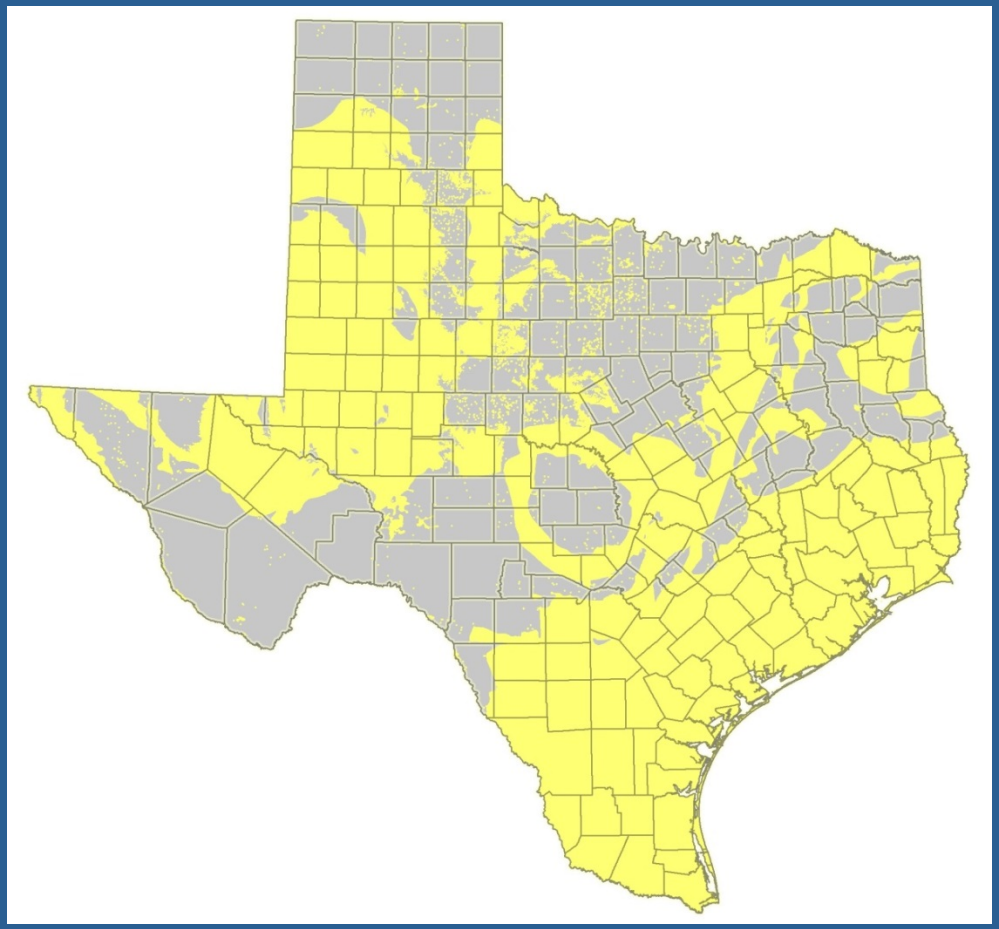




Brackish Resources Aquifer Characterization System (BRACS)

- TWDB program since 2009
- Mapping brackish aquifers
- Knowledge gap
- Legislation

2.7 billion acre-feet in TX!



- Brackish groundwater study done in 2003
- Statewide estimate of the 30 major and minor aquifers
- Prompted funding for regional brackish groundwater studies (a.k.a. the BRACS program)
- Contracted report by LBG-Guyton

http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/2001483395.pdf

House Bill 30

(84th Texas Legislature, 2015)

Directed TWDB to:

- define brackish groundwater production zones
- estimate productivity over 30 & 50 year periods
- recommend groundwater monitoring
- four aquifers due December, 2016
- all aquifer studies due December, 2022
- Work with stakeholders and GCDs

http://www.twdb.texas.gov/innovativewater/bracs/doc/HB_30_enrolled.pdf

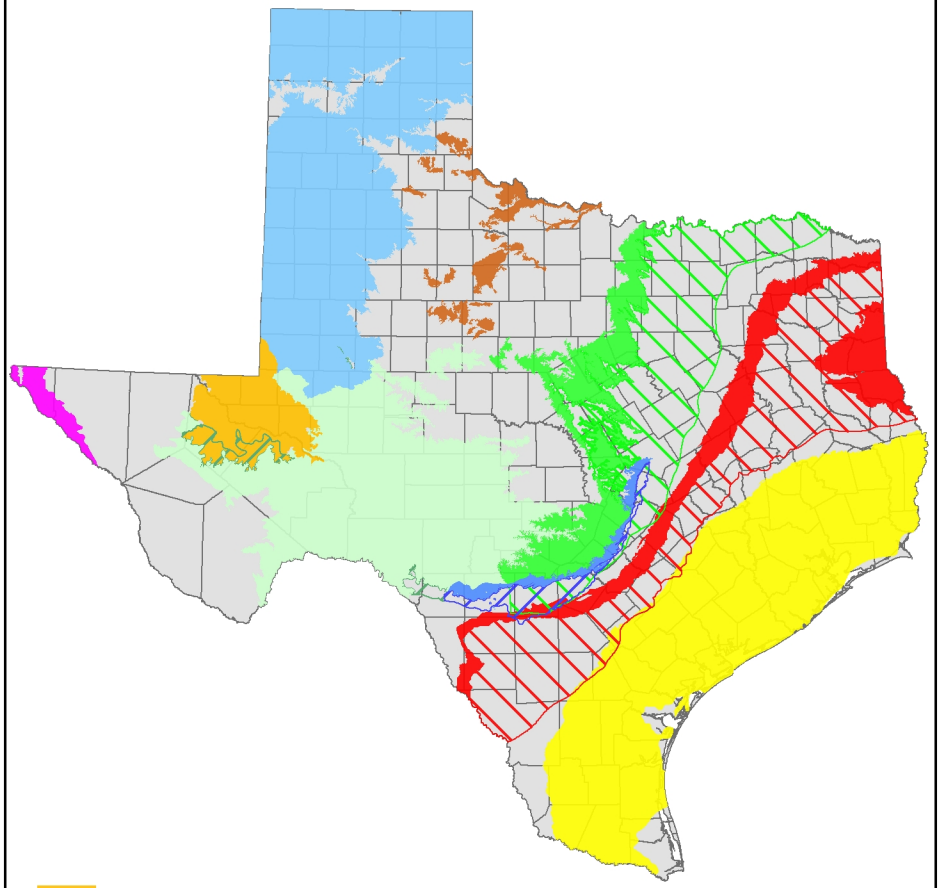
House Bill 30

(84th Texas Legislature, 2015)

Criteria for BGPZ designation:

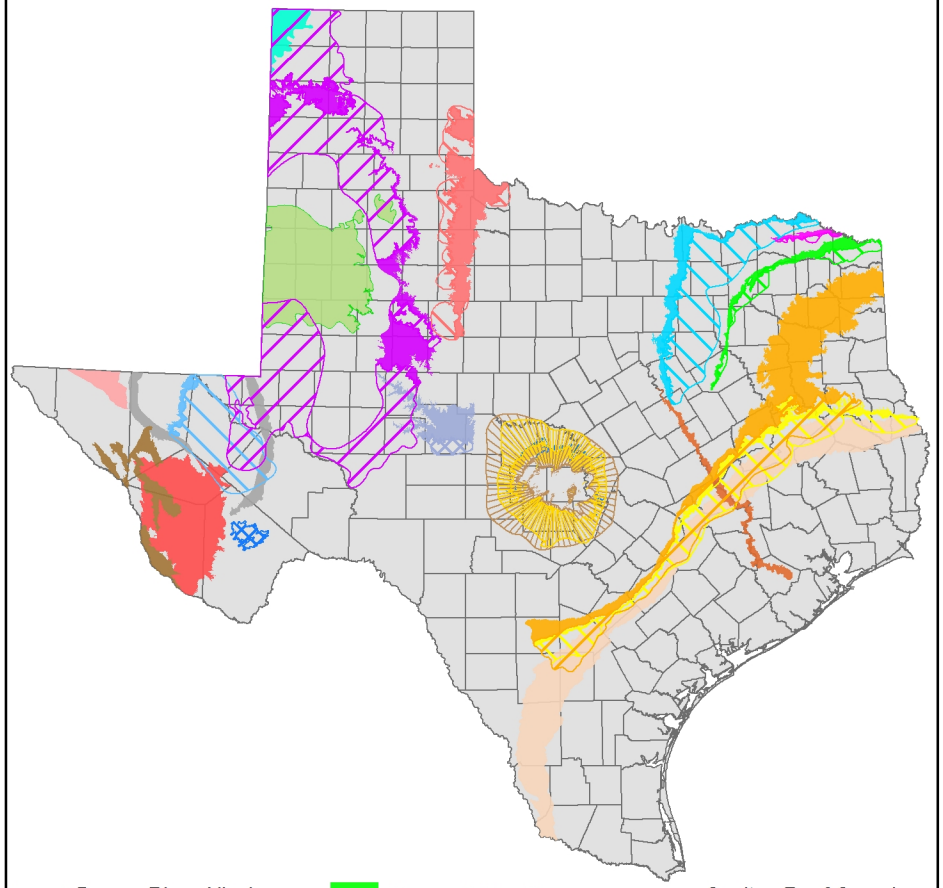
Must have brackish water	In areas of the state with moderate to high availability and productivity
Must have hydrogeologic barriers	sufficient to prevent significant impacts to fresh water availability or quality
Cannot be within these boundaries	Edwards Aquifer within the Edwards Aquifer Authority, Barton Springs-Edwards Aquifer Conservation District, Harris-Galveston Subsidence District, or Fort Bend Subsidence District
Cannot be already in use	Brackish water already serving as a significant source of water supply for municipal, domestic, or agricultural
Cannot be used for wastewater injection	permitted under Title 2 of Texas Water Code, Chapter 27

Major Aquifers of Texas



- Pecos Valley Aquifer
- Seymour Aquifer
- Gulf Coast Aquifer
- Carrizo-Wilcox Aquifer (outcrop)
- Carrizo-Wilcox Aquifer (subcrop)
- Hueco-Mesilla Bolson Aquifers
- Ogallala Aquifer
- Edwards-Trinity Plateau Aquifer (outcrop)
- Edwards-Trinity Plateau Aquifer (subcrop)
- Edwards BFZ Aquifer (outcrop)
- Edwards BFZ Aquifer (subcrop)
- Trinity Aquifer (outcrop)
- Trinity Aquifer (subcrop)
- Texas counties

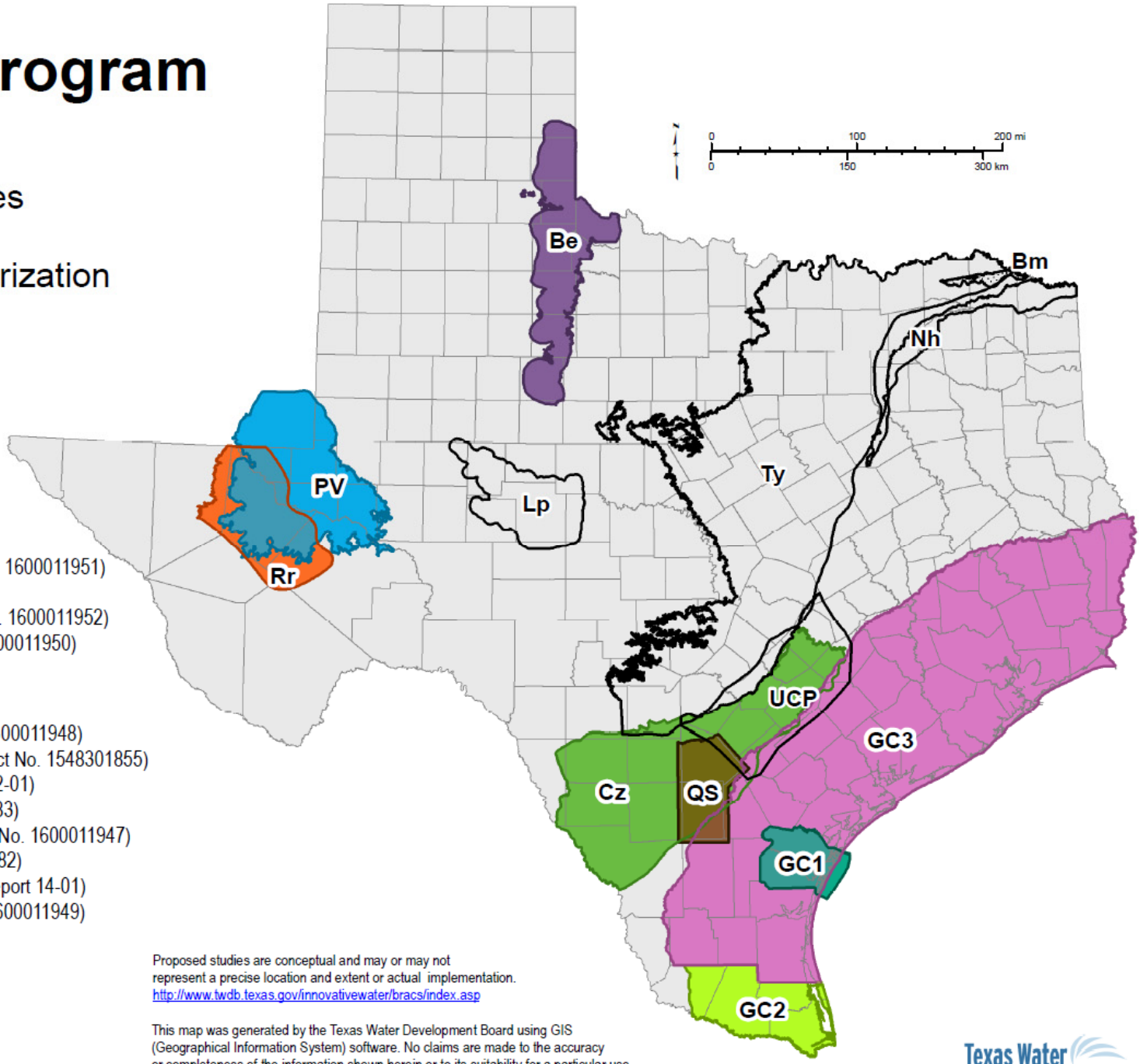
Minor Aquifers of Texas



- Brazos River Alluvium Aquifer
- West Texas Bolsons Aquifers
- Lipan Aquifer
- Yegua Jackson Aquifer
- Igneous Aquifer
- Sparta Aquifer
- Queen City Aquifer
- Nacatoch Aquifer
- Blossom Aquifer
- Woodbine Aquifer
- Rita Blanca Aquifer
- Edwards -Trinity (High Plains) Aquifer
- Dockum Aquifer
- Rustler Aquifer
- Capitan Reef Complex Aquifer
- Blaine Aquifer
- Bone Spring-Victorio Peak Aquifer
- Marble Falls Aquifer
- Marathon Aquifer
- Ellenburger-San Saba Aquifer
- Hickory Aquifer

BRACS Program

Brackish
Resources
Aquifer
Characterization
System



Current studies

- Bm. Blossom Aquifer (Contract No. 1600011951)
- Lp. Lipan Aquifer
- Nh. Nacatoch Aquifer (Contract No. 1600011952)
- Ty. Trinity Aquifer (Contract No. 1600011950)
- UCP. Upper Coastal Plain Aquifers

Completed studies

- Be. Blaine Aquifer (Contract No. 1600011948)
- Cz. Carrizo-Wilcox Aquifer (Contract No. 1548301855)
- GC1. Gulf Coast Aquifer (Report 12-01)
- GC2. Gulf Coast Aquifer (Report 383)
- GC3. Gulf Coast Aquifer (Contract No. 1600011947)
- PV. Pecos Valley Aquifer (Report 382)
- QS. Queen City-Sparta Aquifer (Report 14-01)
- Rr. Rustler Aquifer (Contract No. 1600011949)

Proposed studies are conceptual and may or may not represent a precise location and extent or actual implementation.
http://www.twdb.texas.gov/innovativewater/bracs/index.asp

Texas Water Development Board 2/6/2017

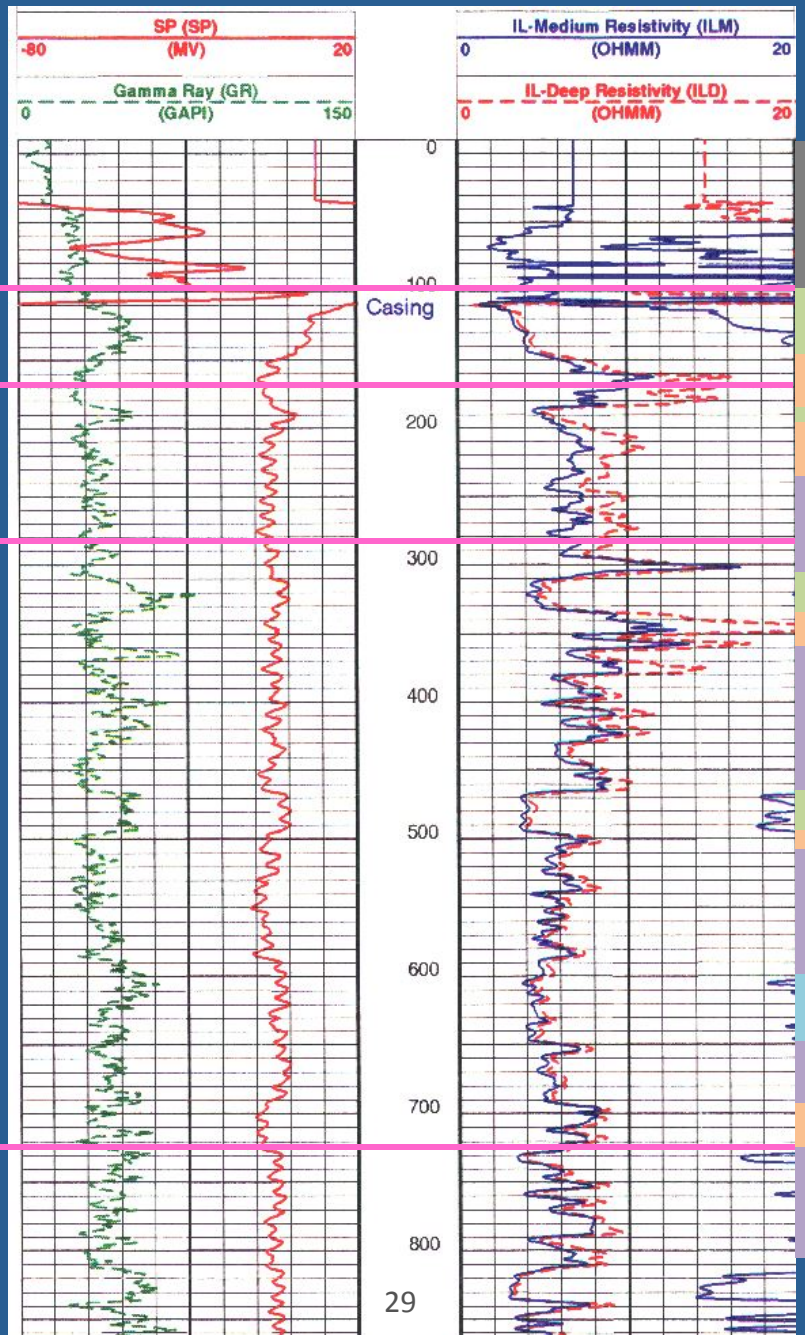
General Methodology

Volume and Quality of Brackish Groundwater

Area (Extent)
X
Thickness (Net Sand)
X
Porosity (Specific Yield)
=
Volume (acre-feet)

Log analysis: Stratigraphy and Lithology

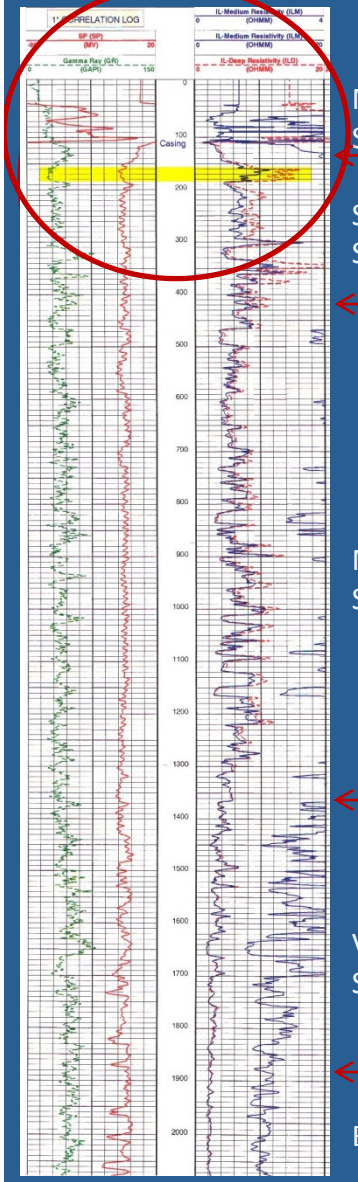
BRACS Well ID 42889



Beaumont Fm	no data
Lissie Fm	clay
	sand
Willis Fm	sand
	sand with clay
Upper Goliad Fm	sand with clay
	sand with clay
	clay with sand
	sand with clay
	sand
Upper Goliad Fm	sand with clay

Source: Lower Rio Grande Valley BRACS Study

Log analysis to interpret Total Dissolved Solids



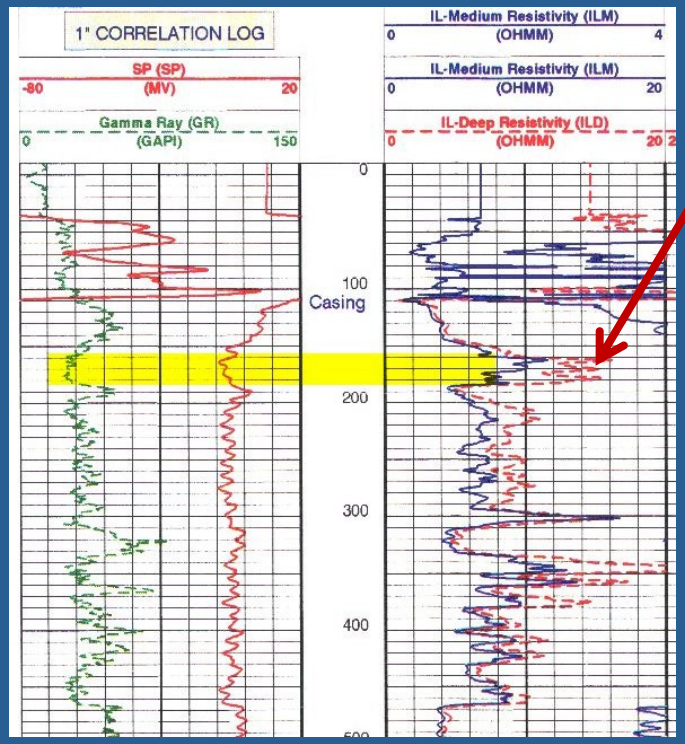
Moderately Saline

Slightly Saline

Moderately Saline

Very Saline

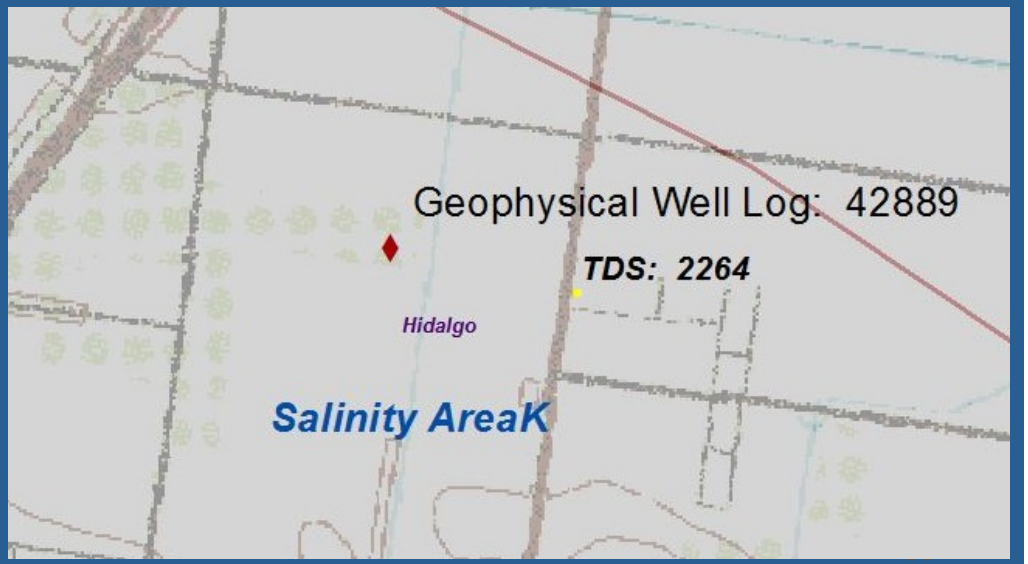
Brine



At 160 ft = 15 ohm-meter

Rwa Minimum Method interpreted TDS = 2,500 mg/L

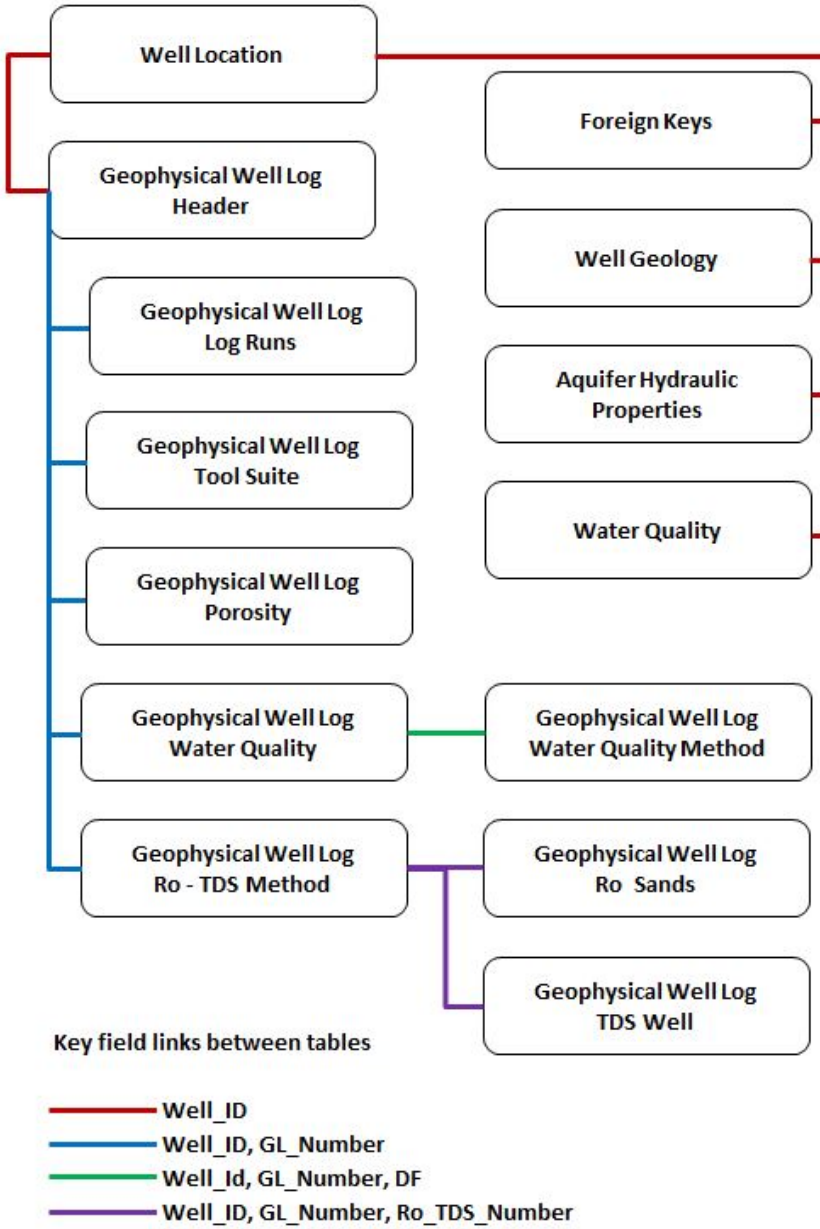
Water Well
TDS concentration = 2,264 mg/L
(well screen 170-349 ft)



BRACS Well ID 42889

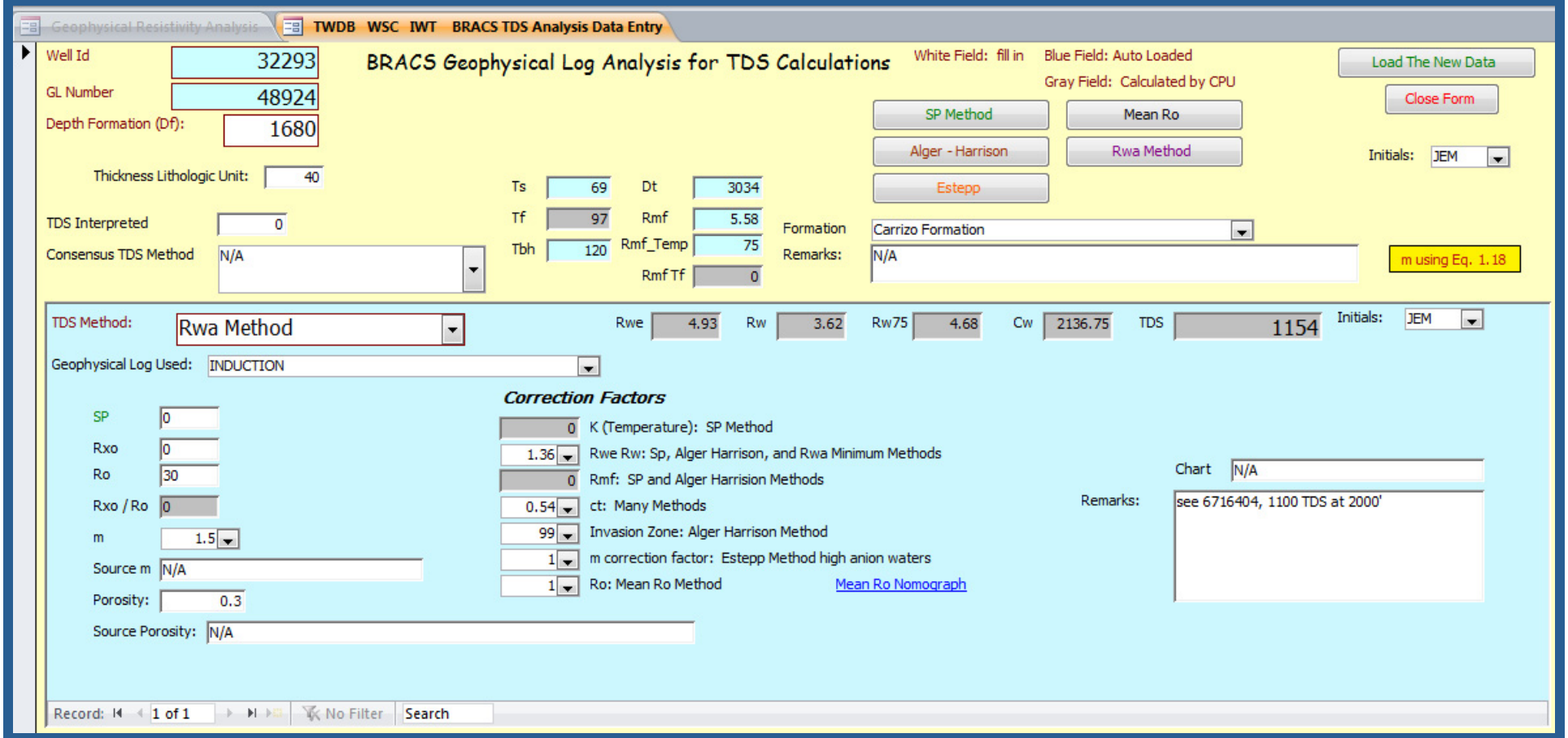
Source: Lower Rio Grande Valley BRACS Study

BRACS Database: Primary Tables

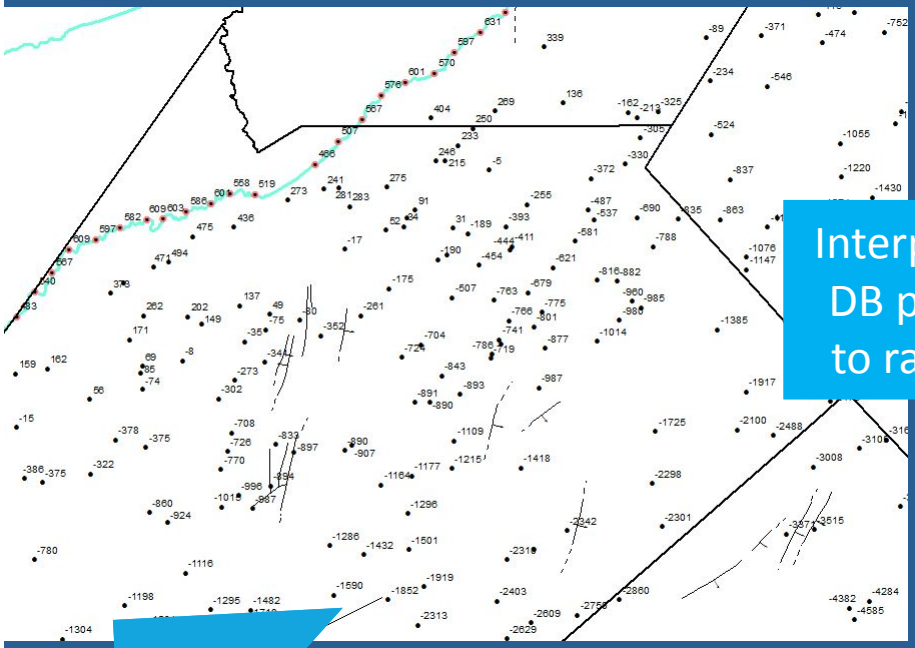


- Microsoft Access Database
- Available on the TWDB web site (with data dictionary)
- Relational table design
- All wells are assigned a unique well id, linking records together

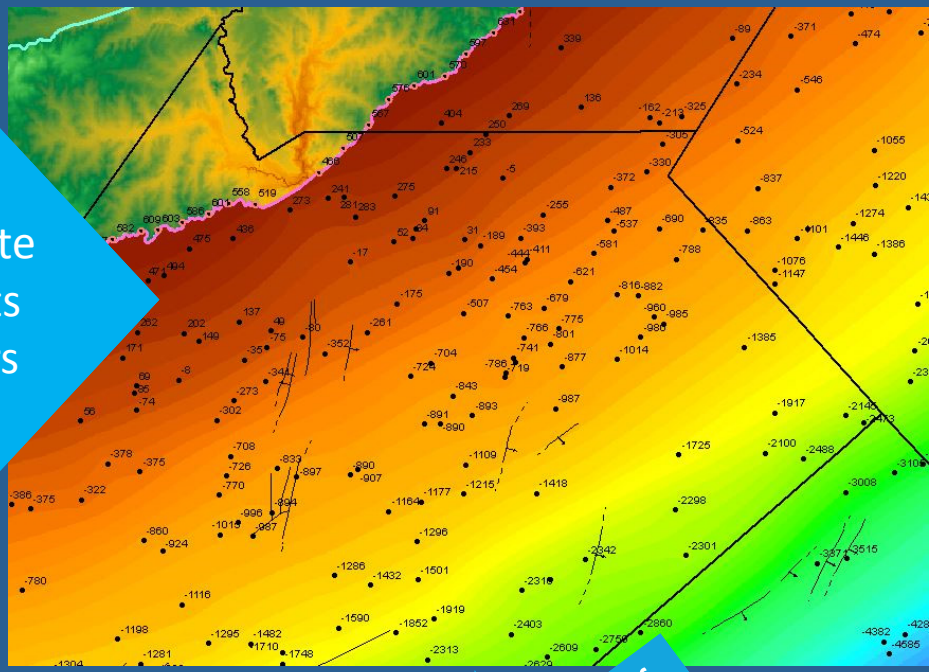
BRACS Database: Water Quality Log Analysis Calculations



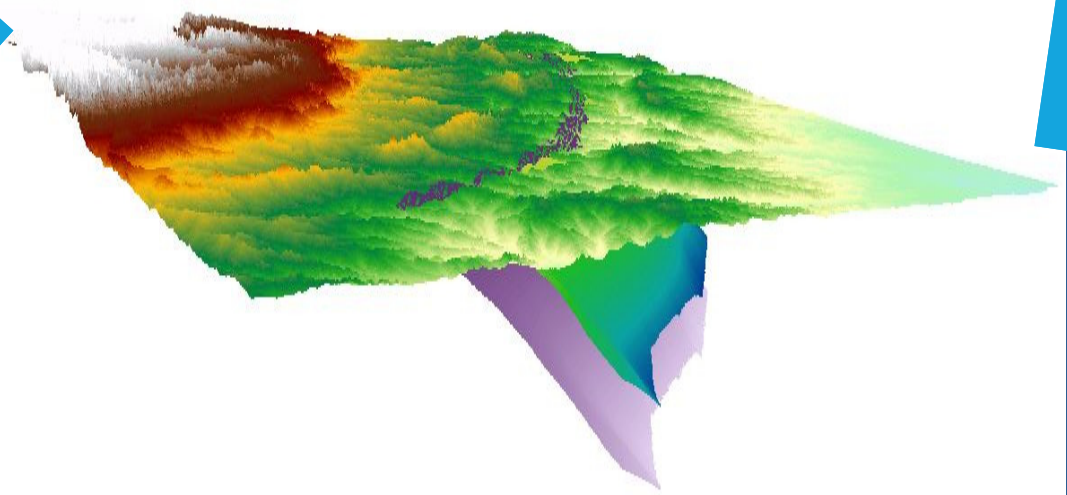
GIS



Interpolate DB points to rasters

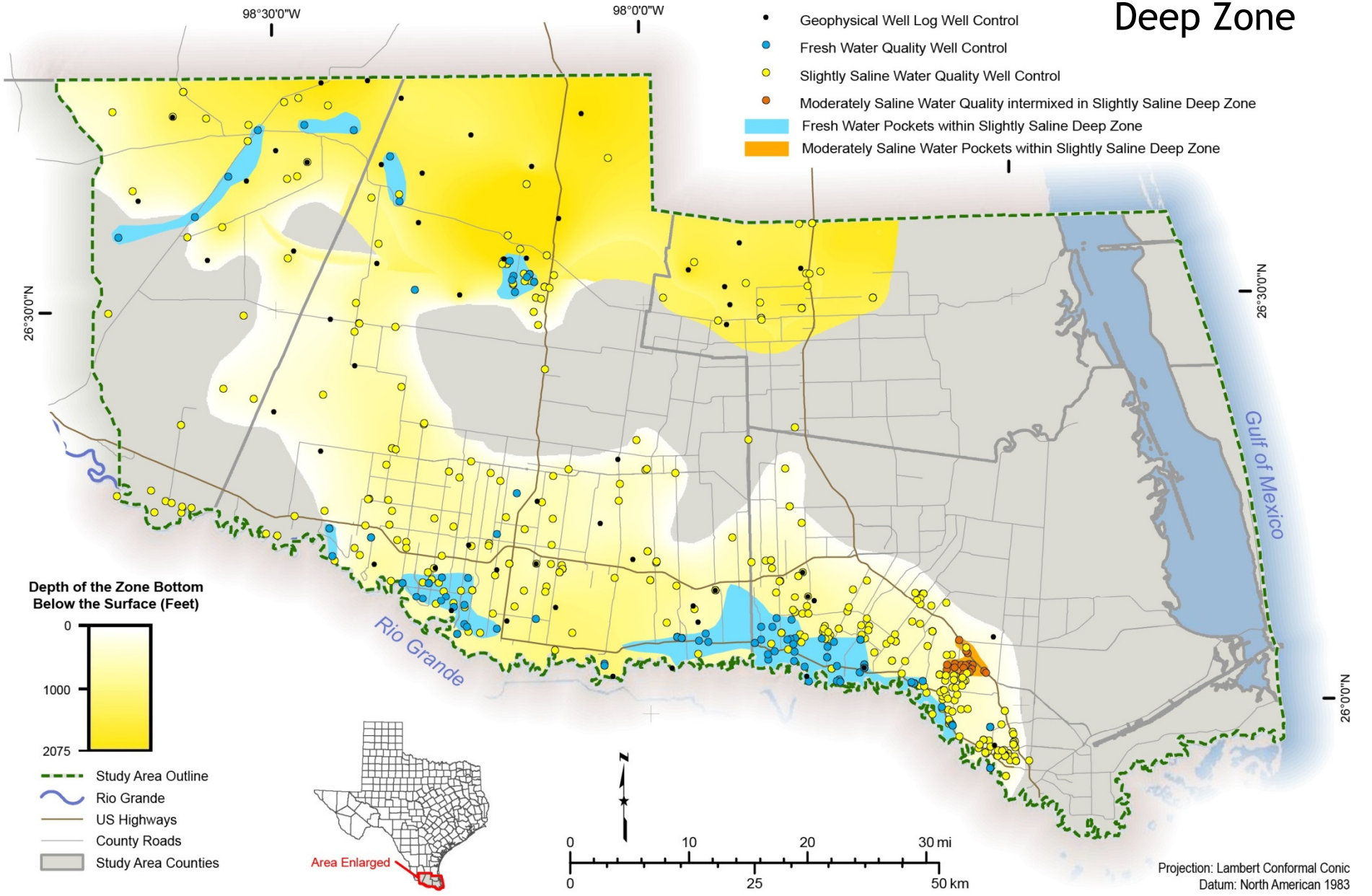


Correct picks in the DB



3D Raster quality control

Lower Rio Grande Valley Gulf Coast Aquifer: Well Control, Slightly Saline Deep Zone



Source: Lower Rio Grande Valley BRACS Study

Texas Water Development Board

Download Our Database!

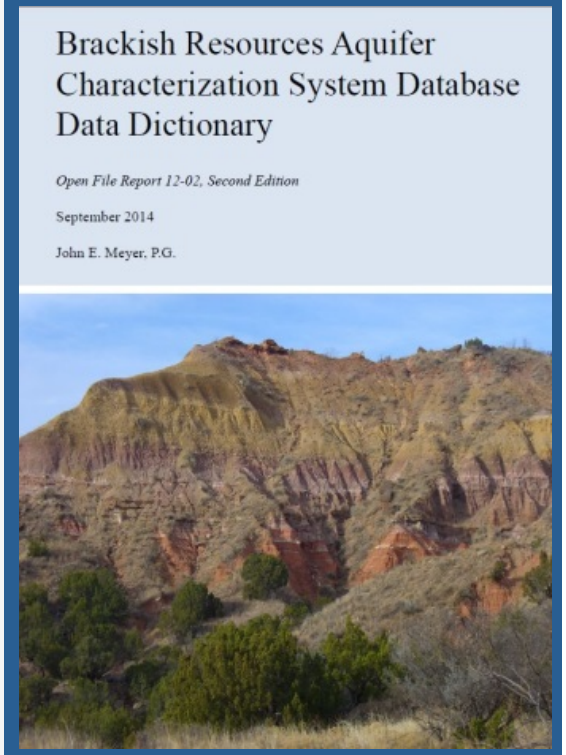
http://www.twdb.texas.gov/innovativewater/bracs/database.asp

The **Brackish Resources Aquifer Characterization System (BRACS) Database** was designed to store well and geology information in support of projects to characterize the brackish groundwater resources of Texas. The BRACS database is fully relational, with self-documenting object naming. The database design relies on extensive use of lookup tables. The BRACS database is a Microsoft Access 2007 format that has been compressed with the WinZip utility. This database will be updated periodically; the date of the last update is embedded in the filename.

This database was developed for use by TWDB staff in support of the BRACS program. The information changes on a daily basis and users should read the disclaimer below. If you have any questions, please contact John Meyer at 512-463-8010.

A data dictionary to accompany the BRACS Database is now available for download. The dictionary describes each primary table in the database and custom tables developed for a study.

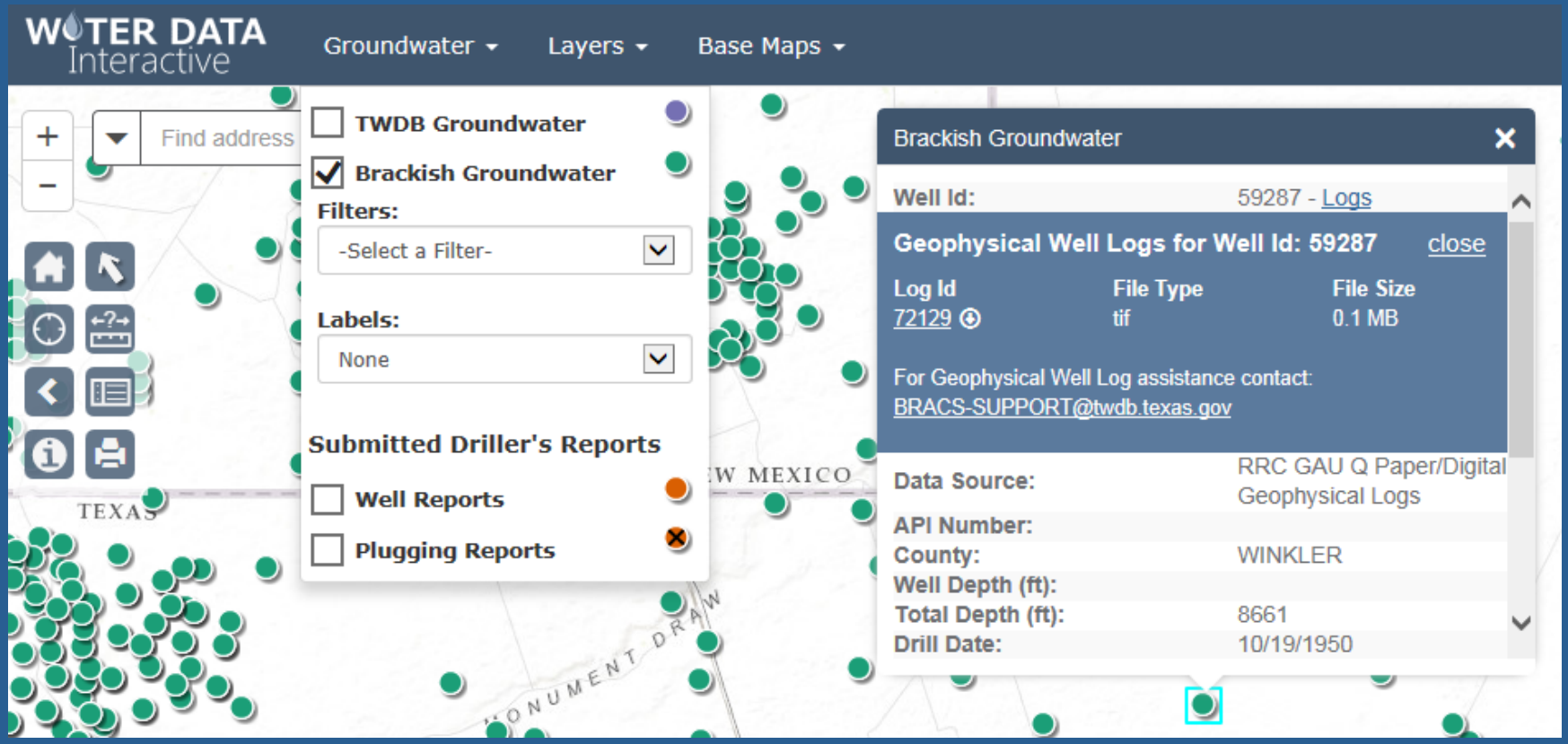
Brackish Resources Aquifer Charaterization System Database Data Dictionary, Second Edition, TWDB Open File Report 12-02, September 2014 (3 MB)



Download Geophysical Well Logs!

1. Download logs on a per well basis using Water Data Interactive website

   https://www2.twdb.texas.gov/apps/waterdatainteractive/groundwaterdataviewer



2. Instructions for requesting a large volume of logs on a county basis

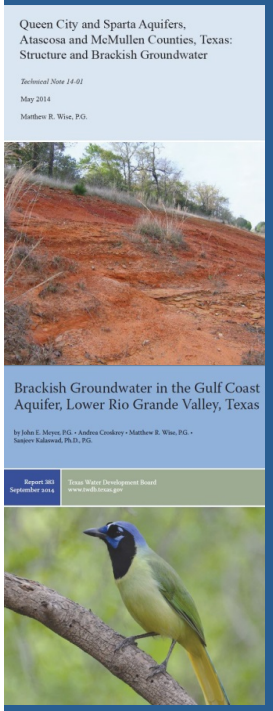
   http://www.twdb.texas.gov/innovativewater/bracs/WellLogs.asp

   BRACS-SUPPORT@twdb.texas.gov

Studies and Contracted Projects

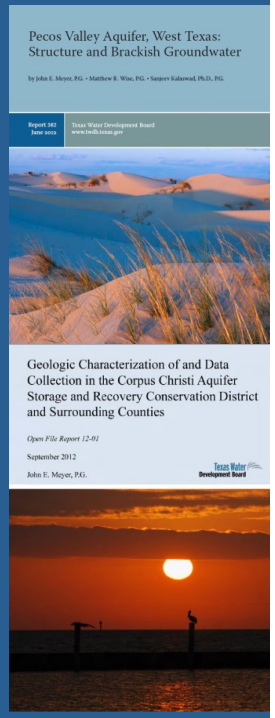
Completed Studies

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



Completed Studies

Complete Date	Project	Report Number	Funding
09/2014	Brackish Groundwater in the Gulf Coast Aquifer, Lower Rio Grande Valley, Texas Gulf Coast Aquifer GIS Datasets (128.0 MB)	383	In-house



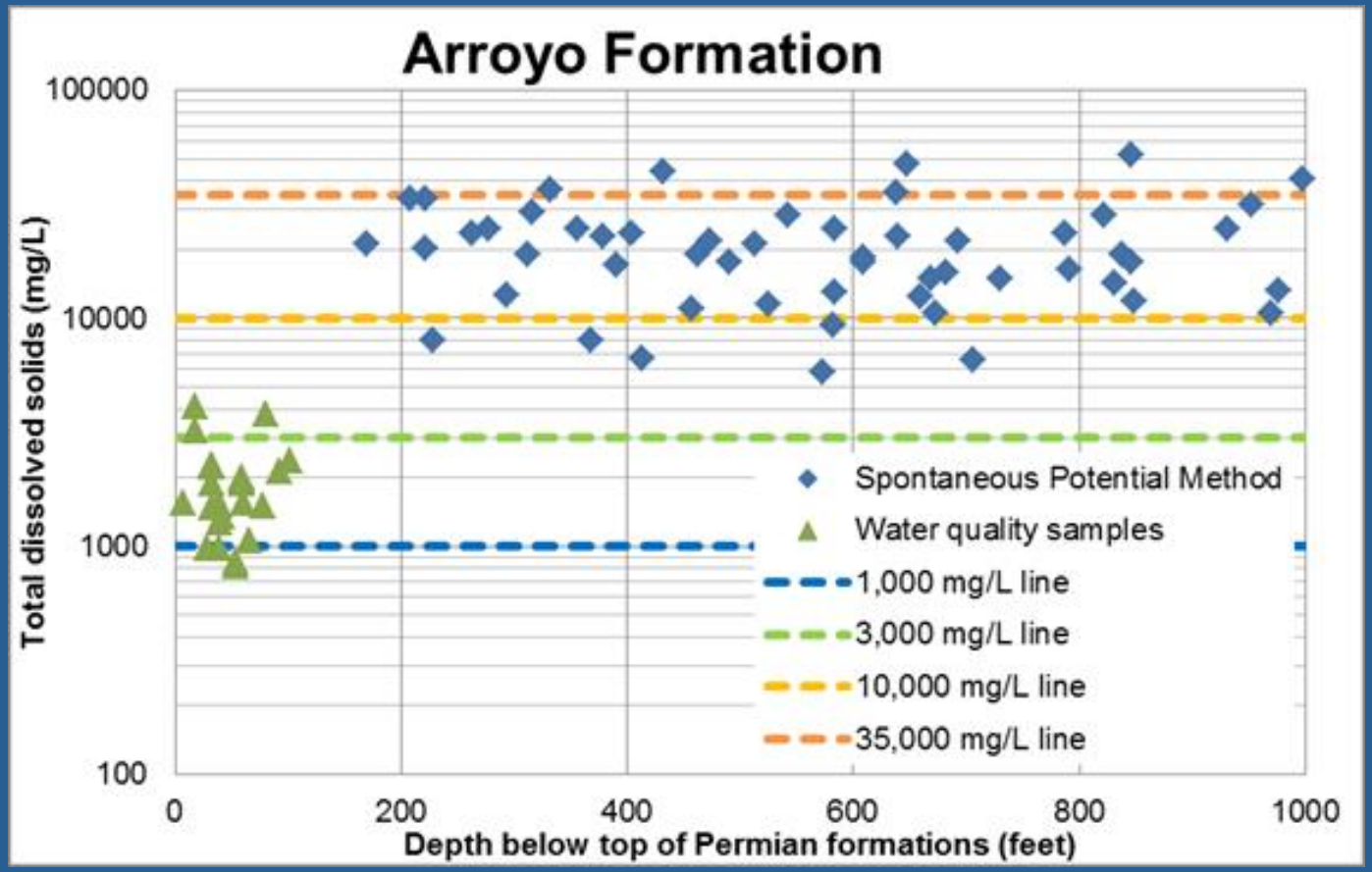
Current and Completed Contracted Projects

http://www.twdb.texas.gov/innovativewater/bracs/projects.asp

11/2016	Identification of Potential Brackish Groundwater Production Areas - Rustler Aquifer	1600011949	INTERA, Inc.	$200,000

Challenges

- Lack of data
  - Publicly available
    - It's mostly shallow and fresh
  - Willing partners
- Quality of existing data
- Software
- Funds
- Lack of tools/on the edge of existing science



DON'T USE SP METHOD FOR CARBONATE AQUIFERS!


STEVEN SPIELBERG Presents
BACK TO THE FUTURE
A ROBERT ZEMECKIS Film
…of brackish groundwater in Texas

Brackish Groundwater in the Future

- 2017: Potential State Legislation
  - Texas House Bill 2377 - rules for permits in brackish groundwater production zones
- 2018, 2020, and 2022: Desalination Reports
- 2022: all brackish groundwater studies completed
- 2070: 8 RWPAs with planned strategies
- As always:
  - Manage and provide data to the public
  - Further the science
  - Provide outreach and technical assistance

Ideas for Future Studies

- Calculating water quality in shaley and high bicarbonate waters
- Evaluating the sensitivity of correlations to different log variables
- Deeper, higher salinity water quality and aquifer properties measurements
- Recharge and sustainability
- Impact of development

Andrea Croskrey, M.S., P.G.

Geologist

Innovative Water Technologies

Texas Water Development Board

andrea.croskrey@twdb.texas.gov

(512) 463-2865

http://www.twdb.texas.gov/innovativewater/index.asp

2017 Water Plan:

http://www.twdb.texas.gov/waterplanning/swp/2017/index.asp