Mapping Brackish Aquifers: Future Water Resources

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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*

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

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

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www.twdb.texas.gov

www.facebook.com/twdbboard  @twdb
“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.”

http://www.age-of-the-sage.org
1845: General Zachary Taylor, Corpus Christi “Sulphur Well”
ARTESIAN PARK
FIRST PARK IN CORPUS CHRISTI
1854

ARTESIAN PARK AND SULPHUR WELL

AFTER A CONVENTION OF THE 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, E.
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 150 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

1887-1940s Artesian fountains, pools, and spas

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.
Mineral Wells, TX

http://youhavewatermail.blogspot.com
Cycles of Drought and Planning

1950s Drought of Record


http://www.lrl.state.tx.us/legis/watertimeline.cfm
Texas Water Development Board

Outreach

State Water Plan

$$$

Data

Water Science & Conservation

Texas Natural Resources Information System (TNRIS)

Water Supply & Infrastructure

Finance

Operations & Administration

Texas Water Development Board

“To provide leadership, information, education, and support for planning, financial assistance, and outreach for the conservation and responsible development of water for Texas”
State Water Planning

1961

1968

1984

1990

1992

1997

2002

2007

2012

2017

“top down”

“bottom up”
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 users 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.

Totals by Decade (acre-feet/year)

Needs (Potential Shortages) by Usage Type (acre-feet/year)

Strategy Supplies by Usage Type (acre-feet/year)
Brackish Groundwater
Current Use:
Agriculture
Oil & Gas
Municipal
# Examples of crop salt tolerance

<table>
<thead>
<tr>
<th>Tolerant</th>
<th>Semi-tolerant</th>
<th>Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>date palm</td>
<td>sunflower</td>
<td>pecan</td>
</tr>
<tr>
<td>coconut palm</td>
<td>acala cotton</td>
<td>navy bean</td>
</tr>
<tr>
<td>sugar beet</td>
<td>potato</td>
<td>plum</td>
</tr>
<tr>
<td>garden beet</td>
<td>pima cotton</td>
<td>pear</td>
</tr>
<tr>
<td>alfalfa</td>
<td>tomato</td>
<td>apple</td>
</tr>
<tr>
<td>onion</td>
<td>sweet pea</td>
<td>grape</td>
</tr>
<tr>
<td>turnip</td>
<td>radish</td>
<td>kardota fig</td>
</tr>
<tr>
<td>cabbage</td>
<td>field pea</td>
<td>persimmon</td>
</tr>
<tr>
<td>lettuce</td>
<td>barley</td>
<td>peach</td>
</tr>
<tr>
<td>carrot</td>
<td>wheat</td>
<td>orange</td>
</tr>
<tr>
<td></td>
<td>maize</td>
<td>avocado</td>
</tr>
<tr>
<td></td>
<td>grain sorghum</td>
<td>grapefruit</td>
</tr>
<tr>
<td></td>
<td>oats</td>
<td>lemon</td>
</tr>
<tr>
<td></td>
<td>pumpkin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bell pepper</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sweet potato</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lima bean</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Oil & Gas Water Use in Texas:
Update to the 2011 Mining Water Use Report
Prepared for Texas Oil & Gas Association

2008
~36,000 acre-feet

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

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
“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.”

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

“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

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

### Criteria for BGPZ designation:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must have brackish water</td>
<td>In areas of the state with moderate to high availability and productivity</td>
</tr>
<tr>
<td>Must have hydrogeologic barriers</td>
<td>Sufficient to prevent significant impacts to fresh water availability or quality</td>
</tr>
<tr>
<td>Cannot be within these boundaries</td>
<td>Edwards Aquifer within the Edwards Aquifer Authority, Barton Springs-Edwards Aquifer Conservation District, Harris-Galveston Subsidence District, or Fort Bend Subsidence District</td>
</tr>
<tr>
<td>Cannot be already in use</td>
<td>Brackish water already serving as a significant source of water supply for municipal, domestic, or agricultural</td>
</tr>
<tr>
<td>Cannot be used for wastewater injection</td>
<td>Permitted under Title 2 of Texas Water Code, Chapter 27</td>
</tr>
</tbody>
</table>
Major Aquifers of Texas

Minor Aquifers of Texas
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

Lissie Fm

Willis Fm

Upper Goliad Fm

Upper Goliad Fm

no data

clay

sand

sand

sand with clay

sand with clay

sand with clay

clay with sand

sand with clay

sand

sand with clay

Source: Lower Rio Grande Valley BRACS Study
Log analysis to interpret Total Dissolved Solids

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

<table>
<thead>
<tr>
<th>Well ID</th>
<th>32293</th>
</tr>
</thead>
<tbody>
<tr>
<td>GL Number</td>
<td>48924</td>
</tr>
<tr>
<td>Depth Formation (ft)</td>
<td>1680</td>
</tr>
</tbody>
</table>

**TDS Interpretation**
- TDS Interpreted: 0
- Consensus TDS Method: N/A

**Rwa Method**
- Geophysical Log Used: Induction
- Correction Factors:
  - Source m: N/A
  - Source Porosity: 0.3

**TDS Calculations**
- Rwe: 4.93
- Rw: 3.62
- Rw75: 4.68
- Cw: 2136.75
- TDS: 1154

**Remarifs:**
- Monthly Chart: N/A
- Remarks: see 6715404, 1100 TDS at 2000'
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
Download Our Database!


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.

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

<table>
<thead>
<tr>
<th>Complete Date</th>
<th>Project</th>
<th>Report Number</th>
<th>Funding</th>
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</thead>
<tbody>
<tr>
<td>09/2014</td>
<td>Brackish Groundwater in the Gulf Coast Aquifer, Lower Rio Grande Valley, Texas</td>
<td>383</td>
<td>In-house</td>
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<td></td>
<td><img src="#" alt="Gulf Coast Aquifer GIS Datasets" /></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(128.0 MB)</td>
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</table>

Current and Completed Contracted Projects

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

<table>
<thead>
<tr>
<th>Complete Date</th>
<th>Project</th>
<th>Report Number</th>
<th>Company</th>
<th>Funding</th>
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<tr>
<td>11/2016</td>
<td>Identification of Potential Brackish Groundwater Production Areas - Rustler Aquifer</td>
<td>1600011949</td>
<td>INTERA, Inc.</td>
<td>$200,000</td>
</tr>
</tbody>
</table>
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!
...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
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(512) 463-2865
http://www.twdb.texas.gov/innovativewater/index.asp
2017 Water Plan: