Brackish Groundwater in the Gulf Coast Aquifer, Lower Rio Grande Valley, Texas

by

John Meyer, P.G.

Rio Grande Regional Water Authority

December 3, 2014
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.

Source: TWDB General Counsel
Why did we study the Lower Rio Grande Valley?

- Population will more than double in the next 50 years
  1.7 to 3.9 million people

- Municipal water demand will more than double in the next 50 years
  260,000 to 581,000 acre-feet per year

- Brackish groundwater use will more than quadruple in next 50 years
  20,000 to 92,000 acre-feet per year

- Highest density of desalination plants in Texas
  7 existing brackish groundwater desalination plants

  Plans for additional 23 brackish groundwater desalination projects

Source: Region M statistics from 2012 State Water Plan
What did we produce?

- Published report
- GIS Datasets
- BRACS Database
- Well logs

The real value is in the data:

**Stakeholders can use this to evaluate potential groundwater exploration areas.**
Where is the study?

Source: Lower Rio Grande Valley BRACS Study
What were the study objectives?

- Collect water well reports and oil/gas geophysical well logs
- Compile all data into BRACS Database
- Map salinity areas (2-dimensional) with a unique vertical salinity profile
- Create 3-dimensional salinity zone GIS datasets
- Map sand and clay layers within the Gulf Coast Aquifer
- Determine volumes of brackish groundwater
- Water quality parameter maps
- Aquifer property maps
- Study deliverables: Report, Database, GIS Datasets, and well logs
<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>

Source: modified from Winslow and Kister, 1956
How much groundwater is there?

Groundwater Volume

<table>
<thead>
<tr>
<th>Type</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slightly Saline</td>
<td>40 million acre-feet</td>
</tr>
<tr>
<td>Moderately Saline</td>
<td>112 million acre-feet</td>
</tr>
<tr>
<td>Very Saline</td>
<td>123 million acre-feet</td>
</tr>
</tbody>
</table>

Source: Lower Rio Grande Valley BRACS Study
Where is the brackish groundwater?  Salinity Areas A through G

**Salinity Profiles**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS Deep</td>
<td>MS Deep</td>
<td>SS Deep</td>
<td>SS Deep</td>
<td>SS Shallow 2</td>
<td>MS Shallow 4</td>
<td>MS Shallow 4</td>
</tr>
<tr>
<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
</tr>
<tr>
<td>VS Deep</td>
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</tr>
<tr>
<td>Brine</td>
<td>Greater than 35,000</td>
</tr>
</tbody>
</table>

*Source: Lower Rio Grande Valley BRACS Study*
How do we obtain the study report and data?

Download the study at www.twdb.texas.gov

- Report 383
- GIS Files
- BRACS Database and Data Dictionary (OF 12-02)
- Obtain digital well logs (email us for this data)
Decide what do you need?

- Regional plant with many wells? *for example, Southmost*
- Small plant with one or two wells? *for example, North Alamo WSC*

Lots of information to evaluate:
- cost and financing
- project partners
- water needs
- distance to existing infrastructure
- land acquisition
- hydrogeology
- existing water well production in the area
- existing injection well disposal in the area
- concentrate disposal options
- *and so on*
Where do you need it? Draw a circle on the map.

Example:

Source: Lower Rio Grande Valley BRACS Study
Qualitative review of data, using the report.

Source: Lower Rio Grande Valley BRACS Study
Source: Lower Rio Grande Valley BRACS Study
Quantitative review of data using database and GIS files.

• Database
  • Review well control in database
  • Use the salinity zone database form
  • Use the net sand database form
  • Review water quality data
  • Review aquifer property data
  • Build custom queries and display data in GIS

• GIS
  • Three-dimensional salinity zone surfaces
  • Additional well control in area
  • Class II injection wells
  • Map / air photo overlays
BRACS Database: Project salinity zone table

Every project well (>2,900 wells) can be reviewed on this form

Well ID Numbers for BRACS and Groundwater Databases

Well depth, screen data compared to salinity zones

Water quality data, if present

Source: BRACS program
BRACS Database: Project net sand determination tables

Every well used for sand analysis (593 wells) can be reviewed on this form. Wells are in a separate table processed for salinity zones.

<table>
<thead>
<tr>
<th>Net Sand Processing Table</th>
<th>Top Bottom Thickness</th>
<th>Sand %</th>
<th>Formation Net Sand</th>
<th>Formation Present</th>
<th>Well Partial Penetration</th>
<th>Partial Geology Disc</th>
<th>Aquifer Net Sand</th>
<th>Aquifer Present</th>
<th>Well Partial Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record Number</td>
<td>Simplified Lithologic Description</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Sand with Clay</td>
<td>105</td>
<td>65</td>
<td>-99999</td>
<td>Yes</td>
<td>No</td>
<td>Beaumont Fm</td>
<td>201</td>
<td>-99999</td>
</tr>
<tr>
<td>25</td>
<td>Sand with Clay</td>
<td>125</td>
<td>100</td>
<td>-99999</td>
<td>Yes</td>
<td>No</td>
<td>Lissie Fm</td>
<td>100</td>
<td>-99999</td>
</tr>
<tr>
<td>27</td>
<td>Sand with Clay</td>
<td>191</td>
<td>70</td>
<td>-99999</td>
<td>Yes</td>
<td>No</td>
<td>Willis Fm</td>
<td>0</td>
<td>-99999</td>
</tr>
<tr>
<td>28</td>
<td>Sand</td>
<td>205</td>
<td>14</td>
<td>-99999</td>
<td>Yes</td>
<td>No</td>
<td>Upper Gollad Fm</td>
<td>0</td>
<td>-99999</td>
</tr>
<tr>
<td>29</td>
<td>Clay with Sand</td>
<td>213</td>
<td>20</td>
<td>-99999</td>
<td>Yes</td>
<td>No</td>
<td>Lower Gollad Fm</td>
<td>0</td>
<td>-99999</td>
</tr>
<tr>
<td>30</td>
<td>Sand</td>
<td>285</td>
<td>64</td>
<td>-99999</td>
<td>Yes</td>
<td>No</td>
<td>Upper Lagarto Fm</td>
<td>0</td>
<td>-99999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Middle Lagarto Fm</td>
<td>0</td>
<td>-99999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Lagarto Fm</td>
<td>0</td>
<td>-99999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Oakville Fm</td>
<td>0</td>
<td>-99999</td>
</tr>
</tbody>
</table>

**Chicot Aquifer**
- Depth Well: 601
- Depth Hole: 600
- Screen Top: 290
- Screen Bottom: 531

**Evangeline Aquifer**
- Depth Well: 601
- Depth Hole: 600
- Screen Top: 290
- Screen Bottom: 531

**Burkeville Confining Unit**
- Depth Well: 601
- Depth Hole: 600
- Screen Top: 290
- Screen Bottom: 531

**Jasper Aquifer**
- Depth Well: 601
- Depth Hole: 600
- Screen Top: 290
- Screen Bottom: 531

Source: BRACS program
All database tables are available for advanced queries. This data dictionary will help you understand the data.
GIS analysis

✓ All GIS data is available on the web
✓ Fully documented with metadata
✓ Data is described in Report 383 appendices

Example tasks:

• Critically review existing well control
• Review additional well control
• Overlay maps / air photos
• Review three-dimensional salinity zones
• Build cross-sections to better understand three-dimensional sands
• Review distances to existing infrastructure
Additional well control in area.

Water wells:
- green dots
- blue dots
- no dots (TCEQ)

Oil / gas wells:
- black dots

Slightly saline zone bottom depth

0 - 2,500
Due diligence: no surprises!

This log was downloaded from the Texas Commission on Environmental Quality website.

- > 500,000 paper well logs were scanned as pdf files.
- Difficult to use (locations ?)
- However, lots of information

---

<table>
<thead>
<tr>
<th>Date Drilled: 8-1-83</th>
<th>Description and origin of formation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>This is an Agriculture Drain Well</strong></td>
</tr>
</tbody>
</table>

---

***Texas Water Development Board***
Review spatial distribution of wells using cross-sections.

Slightly saline zone bottom depth

Wells used in cross-section
Cross-section A-A'

Well 43075
Well 25668
Well 25686
Well 43105

Depth: 500 feet

Mapped
Slightly Saline
Bottom Depth
Hire a consultant?

- Critically review existing well control
- Evaluate sand character (log shape, continuity between wells, ...)
- Site visit: verify well locations, sample more wells, ...
- Class II well location and history of injection
- Class V well location and history of injection
- Drill test and monitor wells.
  - pumping test
  - evaluate sand character
  - water quality samples
- Construct groundwater model
- Share well data with TWDB ???
Summary

- There is substantial brackish groundwater for development
- This study can support the identification of favorable exploration sites
- Well field drilling and testing is required to provide site-specific details that this study cannot provide
- BRACS study deliverables available on TWDB website
- Geophysical well log files available upon request
- Additional contract reports and deliverables available on TWDB website
- Future efforts:
  - TWDB will solicit contractor to build a new groundwater model in study area to evaluate effect of brackish groundwater pumping on freshwater aquifers and land subsidence
  - TWDB is very interested in obtaining new well data in study area
Conservation and Innovative Water Technologies Division

Sanjeev Kalaswad, Ph.D., P.G. Director
sanjeev.kalaswad@twdb.texas.gov (512) 936-0838

Andrea Croskrey
andrea.croskrey@twdb.texas.gov (512) 463-2865

John E. Meyer, P.G.
john.meyer@twdb.texas.gov (512) 463-8010

Matthew Webb
matthew.webb@twdb.texas.gov (512) 463-6929
Additional slides to answer questions
Recommended Desalination Plants

Source: 2011 Recommended Innovative Strategies of the Regional Water Planning Groups
Existing Desalination Plants

Salinity zones used by plants

SS = Slightly Saline
MS = Moderately Saline

<table>
<thead>
<tr>
<th>ID</th>
<th>Plant Name</th>
<th>Potential Plant Capacity (MGD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>North Alamo Water Supply Corporation (Donna)</td>
<td>2.25</td>
</tr>
<tr>
<td>2</td>
<td>North Alamo Water Supply Corporation (Doolittle)</td>
<td>3.50</td>
</tr>
<tr>
<td>3</td>
<td>North Alamo Water Supply Corporation (Lasara)</td>
<td>1.20</td>
</tr>
<tr>
<td>4</td>
<td>North Alamo Water Supply Corporation (Owassa)</td>
<td>2.00</td>
</tr>
<tr>
<td>5</td>
<td>North Cameron/Hidalgo WA</td>
<td>2.50</td>
</tr>
<tr>
<td>6</td>
<td>Southmost Regional Water Authority</td>
<td>7.50</td>
</tr>
<tr>
<td>7</td>
<td>Valley MUD #2</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Source: Lower Rio Grande Valley BRACS Study
### Water Well Logs

<table>
<thead>
<tr>
<th>Geology (sand, clay, ... depositional environment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well screen</td>
</tr>
<tr>
<td>Aquifer productivity</td>
</tr>
<tr>
<td>Static water level</td>
</tr>
</tbody>
</table>

**Source:** Lower Rio Grande Valley BRACS Study
What is a Geophysical Well Log?

A tool or combination of tools lowered into a borehole on a wireline and retrieved to the surface.

Also known as: electrical logging; wireline logging.

Logs must be corrected for a number of parameters.

Tool response recorded in left and right tracks.

Logs can be used to evaluate the entire aquifer, whereas data from water wells typically ends at the base of fresh to slightly saline water zones.

Source: BRACS program
Log Analysis

BRACS Well ID 42889

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)

Source: Lower Rio Grande Valley BRACS Study
What did we find?

21 Salinity Areas Labeled A - U

Source: Lower Rio Grande Valley BRACS Study
Salinity Areas A through G

Salinity Profiles

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS Deep</td>
<td>MS Deep</td>
<td>MS Shallow 5</td>
<td>SS Deep</td>
<td>SS Shallow 2</td>
<td>SS Deep</td>
<td>MS Shallow 4</td>
<td>MS Shallow 4</td>
</tr>
<tr>
<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
<td>SS Deep</td>
<td>SS Deep</td>
</tr>
<tr>
<td>VS Deep</td>
<td>VS Deep</td>
<td>VS Deep</td>
<td>VS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
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Groundwater Salinity Classification

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<tr>
<th>Classification</th>
<th>Total Dissolved Solids Concentration (units: milligrams per liter)</th>
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Source: Lower Rio Grande Valley BRACS Study
Salinity Areas H through N

Salinity Profiles

<table>
<thead>
<tr>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS Shallow 2</td>
<td>MS Shallow 2</td>
<td>SS Shallow 1</td>
<td>SS Shallow 1</td>
<td>VS Shallow 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS Intermediate</td>
<td>SS Intermediate</td>
<td>MS Shallow 1</td>
<td>MS Intermediate 2</td>
<td>MS Intermediate 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS Deep</td>
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<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Deep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS Deep</td>
<td>VS Deep</td>
<td>VS Deep</td>
<td>VS Deep</td>
<td>VS Deep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BR Deep</td>
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Source: Lower Rio Grande Valley BRACS Study
Salinity Areas O through U

Salinity Profiles

<table>
<thead>
<tr>
<th></th>
<th>O</th>
<th>P</th>
<th>Q</th>
<th>R</th>
<th>S</th>
<th>T</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>VS Shallow 4</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS Intermediate 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>SS Deep</td>
<td>VS Shallow 4</td>
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</tr>
<tr>
<td>MS Deep</td>
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<td>MS Deep</td>
<td>MS Deep</td>
<td>MS Shallow 3</td>
<td>VS Shallow 4</td>
<td>VS Intermediate</td>
<td>Brine Shallow</td>
</tr>
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</table>

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Source: Lower Rio Grande Valley BRACS Study
Slightly Saline Deep Zone

Thickness (feet)

Source: Lower Rio Grande Valley BRACS Study
BRACS Database 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 (red line) records together

Source: BRACS program
TWDB WIID website:  http://wiid.twdb.texas.gov/

WIID: Water Information Integration and Dissemination

Can use this site see / query well locations in an area. Other data is also available by checking the Visible box.