Groundwater 101 Workshop

Presented by TWDB
Groundwater Staff:

- Larry French, Director, Groundwater Division
- Janie Hopkins, Manager, Groundwater Monitoring Section
- Bryan Anderson, Team Lead, Groundwater Data Team
- Rima Petrossian, Manager, Groundwater Technical Assistance Section
- Cindy Ridgeway, Manager, Groundwater Availability Modeling Section
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<tr>
<th>Topic</th>
<th>Presenter</th>
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<td>Welcome, Introductions</td>
<td>L. French</td>
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<td>Texas Groundwater Basics</td>
<td>L. French</td>
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<tr>
<td>Groundwater Monitoring and Data</td>
<td>J. Hopkins</td>
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<td>Water Data Interactive</td>
<td>B. Anderson</td>
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<td>Groundwater Availability Modeling</td>
<td>C. Ridgeway</td>
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<td>Groundwater Availability and New Topics</td>
<td>L. French</td>
</tr>
<tr>
<td>Open Discussion/Q&amp;A</td>
<td>All</td>
</tr>
</tbody>
</table>
Groundwater and Aquifers

Larry French, P.G.
Director
Groundwater Division
What is an **aquifer**?

- an aquifer is geologic media that can yield economically usable amounts of water.

  - Dirt and rocks

  - Depends on who’s using it
Groundwater and Texas

- 62 percent of the 13.7 million acre-feet of water used in 2014
- 76 percent of groundwater is used for irrigation
- Cities and domestic users accounted for 18 percent of groundwater use
- Groundwater provides more than one-third of water used by cities
Solid indicates outcrop areas (the part of an aquifer that lies at the land surface).

Hatched indicates subsurface areas (the part of an aquifer that lies or dips below other formations).
Solid indicates outcrop areas (the part of an aquifer that lies at the land surface)

Hatched indicates subsurface areas (the part of an aquifer that lies or dips below other formations)

The Edwards-Trinity (High Plains) and Rita Blanca aquifers are entirely subsurface.

George and others, 2011
A new (minor) aquifer may be born!
How much groundwater?

Total estimated quantity of fresh and brackish to saline groundwater in Texas aquifers is 16.8 billion acre-feet.

- Major aquifers - 12.6 billion acre-feet
- Minor aquifers - 4.24 billion acre-feet
Surface water and groundwater use by county

- > 55% groundwater
- 45 to 55% groundwater and surface water
- > 55% surface water

Source: Texas Water Development Board

[Map of Texas showing water use by county]
Total water level declines in the major aquifers.
Groundwater Monitoring Programs

Janie Hopkins, P.G.
Groundwater Monitoring Manager
Texas Water Development Board

Mission:

“Sustainable and affordable water for Texas”

• Grants and loans
• Water planning
• Data collection
TWDB monitoring goals & uses

• To determine groundwater-level trends
• To publish near real-time levels on-line
  o Drought triggers
  o Local groundwater management
• Regional groundwater management
• Model development & calibration
• To establish and characterize naturally occurring, baseline groundwater quality and any changes that may have occurred over time
TWDB monitoring networks

- 200+ automatic water level recorder wells
- 7,500 water level network wells
- 1,200 – 1,600 water quality network wells & springs (4-year cycle)

• Wells are completed in 9 major, 21 minor, and several undesignated or local aquifers

• Representative number of wells per county, per aquifer determined by amount pumped
Types of wells monitored: irrigation, stock, domestic, public water supply, & unused (water levels only)
~60 percent of Texas has a district
~90 percent of groundwater pumped is pumped from inside a district

Number of groundwater conservation districts through the decades

Groundwater conservation districts
TWDB continuous water level recorders

Recorder sites operated by TWDB and cooperators

- Texas Water Development Board (91 wells)
- Groundwater Conservation Districts (127 wells)

Legend:
- Major aquifers
- Minor aquifers (only shown where there is no major aquifer)
Water Data for Texas
https://waterdatafortexas.org/groundwater

Automated Groundwater Level Wells
Additional funding for the TWDB recorder program

**Supplemental Environmental Projects ("SEPs")**

SEPs are environmentally beneficial projects that a respondent agrees to undertake in settlement of an enforcement action. Dollars directed to TCEQ-approved environmental projects may be used to offset assessed penalties in enforcement actions.

<table>
<thead>
<tr>
<th>#</th>
<th>Project Description</th>
<th>Cost</th>
<th>Beneficiaries</th>
<th>Location</th>
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<tbody>
<tr>
<td>46</td>
<td>2013-11 Lower Rio Grande Water Quality Initiative: Assist communities in the Lower Rio Grande region (from the Falcon Dam to the Gulf of Mexico) by working with TCEQ, EPA, Comisión Nacional del Agua, and Comisión Estatal del Agua de Tamaulipas to improve Rio Grande water quality.</td>
<td>$100</td>
<td>EAQ, IHW², IWD, MLM, MM³, PWS, MSW, MWD, PST², PWS, WQ, WR</td>
<td>Statewide</td>
</tr>
<tr>
<td></td>
<td>Texas Water Development Board 2014-05 Water-Level Recorder Data in Every Texas County: Extend existing groundwater level monitoring network in every Texas County and make the data available to the public via the Water Data for Texas website. (pdf)</td>
<td>$500</td>
<td>EAQ, IHW², IWD, MLM, MM³, PWS, MSW, MWD, PST², PWS, WQ, WR</td>
<td>Statewide</td>
</tr>
</tbody>
</table>
Water level changes from 2014 to 2015 in Central Texas recorder wells

**SWN 68-19-806**
Bexar County, Glen Rose Formation, Trinity Aquifer
Well Depth: 710 feet
TWDB water level network wells

Wells measured by TWDB and cooperators in FY2016
- Texas Water Development Board (2,052 measurements)
- U.S. Geological Survey (1,287 measurements)
- Other cooperators (12,745 measurements)

- Major Aquifers
- Minor Aquifers (only shown where there is no major aquifer)
- Total wells (6,983)
TWDB water quality network wells

Sites sampled by TWDB and cooperators in FY2016
- Texas Water Development Board (192 samples)
- Groundwater conservation districts and other cooperators (289 samples)

- Major aquifers
- Minor aquifers (only shown where there is no major aquifer)
- Total sites (481)
National Ground Water Monitoring Network

Principal aquifers in the U.S.

Collaborative effort between the U.S. Geological Survey and state agencies
TWDB wells in the National Ground Water Monitoring Network

820 wells with water levels
(includes 117 recorder wells)
572 sites with water quality
Water Data Interactive

- **TexMesonet**
  An interactive mapping application for viewing a network of selected weather stations and rain gages throughout the state of Texas. The application displays current weather conditions, radar and 24 hour time series graphs.

- **Texas FLOOD Viewer**
  An interactive mapping application for viewing current conditions and up-to-date information for flooding in your area.

- **Groundwater Data Viewer**
  This interactive mapping application provides access to water-related data for Texas. The viewer contains several GIS datasets relating to water resources, including TWDB groundwater data, brackish groundwater data, and data.

- **Major Aquifer 3D Viewer**
  A three dimensional interactive viewer for exploring the major aquifers of Texas. After choosing an aquifer, users can choose to be re-directed to a 3D viewer that allows visual manipulation of the subsurface model. The
Location of records for 1.5+ million water wells drilled in Texas since the late 1890s

**Groundwater Database**

- **140,000** groundwater database well records, 1896 - present: TWDB, Groundwater Data Viewer
- **15,000+** sites with recent & historical water levels & quality; remainder legacy

**Submitted Driller’s Report Database**

- **300,000+** submitted driller's reports, 2001 - present: TWDB, Groundwater Data Viewer

**Water Well Viewer (TCEQ)**

- **800,000** submitted driller's reports, 1962 – 2001: TCEQ, Water Well Viewer
- **400,000+** sites with no records or records at local groundwater districts
- **15,000+** sites with recent & historical water levels & quality; remainder legacy

Scanned report images only, generally lacking lat-long
Water Data Interactive

2017 State Water Plan
To ensure the ongoing vitality of our economy, Texas’ citizens, water experts, and government agencies collaborate in a comprehensive water planning process. We plan so that Texans will have enough water in the

click to show more

Water Data for Texas
This website is a product of the Texas Water Development Board (TWDB) Water Science Conservation Division and is made possible by the support of management and staff at TWDB. This project is part of our ongoing efforts to

click to show more

GEMSS/2
The Geospatial Emergency Management Support System (GEMSS) was developed by the Texas Natural Resources Information System (TNRIS), a part of the Texas Water Development Board, using the Hazard Mitigation Grant

click to show more
Water Data for Texas

* reservoirs
* recorder wells
* drought resources
* coastal gages

State Well Number 6837203 is 50.71 feet below land surface on 2016-11-29
TWDB Monitoring Section Contacts

Bryan Anderson - 512/475-3302
Data Team Lead
Water-Level Program Supervisor

Blake Neffendorf - 512/463-8044
Recorder Program Supervisor

Chris Muller - 512/936-0846
Groundwater Quality Program Supervisor

Janie Hopkins - 512/936-0841
Groundwater Monitoring Section Manager
Texas Water Development Board
Groundwater-Related Databases

Bryan Anderson
Groundwater Data Team Lead
Groundwater Division
Texas Water Development Board
TWDB databases

• Groundwater Database (GWDB)
• Submitted Drillers Reports (SDR) Database
• Brackish Resources Aquifer Characterization System (BRACS) Database

– Some wells exist in all three databases
Groundwater Database (GWDB)

• Main purpose to collect and store data to help identify the natural properties of the aquifers in Texas
  – Water levels, water quality, geophysical logs, etc.
• Mostly legacy data with about 10% of the wells visited by TWDB or cooperators for data collection
• Intention was not to create an inventory of all wells drilled in the state
Submitted Drillers Reports Database (SDR)

• Cooperation with Texas Department of Licensing and Regulation (TDLR) Water Well Drillers and Pump Installers Program
• Well reports & plugging reports
• Began data collection in 2001
• Well reports previous to 2002 available at the Texas Commission on Environmental Quality (TCEQ) Water Well Map Viewer
Brackish Resources Aquifer Characterization System Database (BRACS)

- Designed to store well and geology information in support of projects to characterize the brackish groundwater resources of Texas
- Compiles well information from several sources
- Currently limited to study areas in the state
GWDB reports and downloads
http://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp
<table>
<thead>
<tr>
<th>State Well Number</th>
<th>Coordinates</th>
<th>County</th>
<th>River Basin</th>
<th>GMA</th>
<th>RWPA</th>
<th>GCD</th>
<th>Grid Number</th>
<th>Aquifer</th>
<th>Aquifer Code</th>
<th>Owner</th>
<th>Driller</th>
<th>Well Type</th>
<th>Well End Date</th>
<th>Casing Intervals</th>
<th>Land Surface Elevation</th>
<th>Water Number</th>
<th>Land Surface Elevation</th>
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<th>Casing Intervals</th>
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<tbody>
<tr>
<td>6655207</td>
<td>29° 14' 13&quot; N 093° 43' 51&quot; W</td>
<td>Atascosa</td>
<td>L - South Central Texas</td>
<td>Evergreen</td>
<td>UWCD</td>
<td>68052</td>
<td>Carizo-Wilcox</td>
<td>City of Lyle</td>
<td>Oliver Well Service</td>
<td>Withdrawal of Water</td>
<td>9/16/1991</td>
<td>106</td>
<td>721</td>
<td>1</td>
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<td>76</td>
<td>106</td>
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<td>Evergreen</td>
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<td>68052</td>
<td>Carizo-Wilcox</td>
<td>City of Lyle</td>
<td>Oliver Well Service</td>
<td>Withdrawal of Water</td>
<td>9/16/1991</td>
<td>106</td>
<td>721</td>
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<td>68055</td>
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<td>100</td>
<td>76</td>
<td>538</td>
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SDR reports and downloads
http://www.twdb.texas.gov/groundwater/data/drillersdb.asp
<table>
<thead>
<tr>
<th>Well Report Tracking Number</th>
<th>Well Report Tracking Number</th>
<th>Type Of Work</th>
<th>Proposed Use</th>
<th>Owner Name</th>
<th>County</th>
<th>Well Address</th>
<th>Latitude DD</th>
<th>Longitude DD</th>
<th>Grid Number</th>
<th>Drilling Start Date</th>
<th>Drilling End Date</th>
<th>Drilling Company</th>
<th>Lic No</th>
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<tbody>
<tr>
<td>438549</td>
<td>New Well</td>
<td>Domestic</td>
<td>Domestic</td>
<td>Tammy Hickman</td>
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<td>623 Rabbit Run Road, Arkansas Pass, 78336</td>
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<td>-97.1369440</td>
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<td>437601</td>
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<td>9/12/2016</td>
<td>9/12/2016</td>
<td>Michael Roy Deyo</td>
<td>180</td>
</tr>
</tbody>
</table>
BRACS Database


Except where noted, all of the information provided is believed to be accurate and reliable; however, TWDB assumes no responsibility for any errors. Further, TWDB assumes no responsibility for the use of the information provided. PLEASE NOTE that users of these data are responsible for checking the accuracy, completeness, currency and/or suitability of all information themselves. TWDB makes no guarantees or warranties as to the accuracy, completeness, currency, or suitability of the information provided via the BRACS Database. TWDB specifically disclaims any and all liability for any claims or damages that may result from providing BRACS data or the information it contains. Well data and interpretations will be posted during the course of a BRACS study, however data is subject to change prior to publication of the study.

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.
Water Data Interactive
http://www.twdb.texas.gov/mapping/index.asp

TexMesonet
An interactive mapping application for viewing a network of selected weather stations and rain gauges throughout the state of Texas. The application displays current weather conditions, radar and 24 hour time series graphs.

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Major Aquifer 3D Viewer
A three dimensional interactive viewer for exploring the major aquifers of Texas. After choosing an aquifer, users
Water Data for Texas

https://waterdatafortexas.org/groundwater
State Well Number 0712401 is 251.21 feet below land surface on 2016-12-13.
Questions & Feedback

Groundwater Data Team
GroundwaterData@twdb.texas.gov

Bryan Anderson
Texas Water Development Board
bryan.anderson@twdb.texas.gov
(512) 475-3302
Groundwater Management

Rima Petrossian, Ph.D., P.G., C.P.G.
Manager
Groundwater Technical Assistance
Background

- Water rights in Texas dependent on source
  - Surface Water
    - Owned by the State
    - Requires permission of State
  - Groundwater
    - Generally belongs to landowner
    - Pump and capture whatever water is available, regardless of the effects on neighboring wells (Rule of Capture)
    - Groundwater conservation districts modify the Rule of Capture through spacing and tract size, correlative rights, historical use, subsidence mitigation...
1949 policy underpinnings: “...underground water isn’t worth a dime if it is left undeveloped.”

- U.S. Geological Survey geologist, W. L. Broadhurst, later to be employed by High Plains Underground Water Conservation District No.1
- Judge I.B. Holt from Lamb County
  - Proposed H.B. 162 establishing groundwater conservation districts in 1949 after a short drought
- Local control established, first districts in the High Plains in 1951
• GCD develops management plan (coordinates w/ surface water management entity)

• TWDB staff assists management plan development; the Executive Administrator approves management plans; serves as a non-voting member of each groundwater management area

• GMA is a map unit comprised of groundwater conservation districts

• RWPG uses groundwater availability for quantifying groundwater

• TCEQ provides regulatory oversight as needed

• SAO may audit District finances
Joint planning (Texas Water Code 36.108)

• Groundwater conservation districts meet at least annually to decide on relevant aquifers’ future desired conditions
  ✓ these are aquifer conditions used to quantify the amount of groundwater to be extracted from the aquifer
  ✓ this is a locally established policy goal
GCD duties

• Texas Water Code Chapter 36 authorizes
  – Setting rules to limit groundwater production
    • tract size
    • spacing
  – Permit and register wells
  – Controlling land subsidence
  – Preventing degradation of water quality
  – Preventing waste of groundwater
  – Coordinate planning with regions, surface water entities, and stakeholders, in groundwater management areas
  – Keeping records of groundwater production and use
Goals

- **as applicable:**
  - Providing the most efficient use of groundwater (1949)
  - Controlling and preventing waste of groundwater (1949)
    - “Waste” defined in TWC §36.001(8)(A)-(G)
  - Controlling and preventing subsidence (1997)
    - generally coastal districts
  - Addressing *conjunctive* surface water management issues (1997)
  - Addressing natural resource issues (1997)
Goals

• Drought conditions (2001)

• Addressing where appropriate and cost-effective
  ➢ Conservation (2001)
  ➢ Recharge enhancement (arguably 1949)
  ➢ Rainwater harvesting (2005)
  ➢ Precipitation enhancement (2005)
  ➢ Brush control (2005)
Goals

- Address the **desired future conditions** of the groundwater resources (2005)
  - Monitor progress
    - Spring flow
    - Drawdown
    - Groundwater elevation minimum
    - Groundwater volume in storage
  - Compare to the desired future condition
TWDB: where we fit into the plan

• Following Chapter 16 and 36 statutes we
  ➢ help with technical information
  ➢ provide management plan reviews
  ➢ approve or deny management plans for administrative completeness
  ➢ measure wells and collect water samples for maintaining a state well database
  ➢ collect and analyze data, develop groundwater models, and write reports
Contact:
Rima Petrossian
Manager, Groundwater Technical Assistance
512-936-2420
Groundwater Availability Modeling: What’s a GAM?

Cindy Ridgeway, P.G.
Manager
Groundwater Availability Modeling
Overview

• What’s a GAM?
• Why do we model?
• Where are we modeling?
• Questions?
What’s a GAM?
GAM = groundwater availability model

- GAMs are regional-scale groundwater assessment tools
- GAMs use publicly available code—MODFLOW (model code by U.S. Geological Survey)
- GAMs are developed through a structured process with public involvement.
- GAMs are publicly available models
Why do we model?
It’s in statute...

• Section 16.012 STUDIES, INVESTIGATIONS, SURVEYS, Water Code, Subsection (l) The executive administrator shall obtain or develop *groundwater availability models* for major and minor aquifers in coordination with groundwater conservation districts and regional water planning groups ... Modeling of major aquifers shall be completed not later than October 1, 2004.
How do we use groundwater models?

Per Statute:
• Groundwater management areas can use to assist in determining desired future conditions.
• TWDB uses when calculating estimated Modeled Available Groundwater.
• TWDB uses when calculating Total Estimated Recoverable Storage.
• TWDB provides groundwater conservation districts with water budget data for their management plans.
• Assist with information for House Bill 30/House Bill 1232
• Use for analysis of reasonableness for desired future condition petitions
Where do we model?
Minor aquifers

High Plains Aquifer System model includes Rita Blanca, Dockum, and Edwards-Trinity (High Plains) minor aquifers.

Model development in progress

(Updated December 2016)
GAMs are good!

http://www.twdb.texas.gov/groundwater/models/index.asp

Check out aquifers in 3D!

http://www2.twdb.texas.gov/apps/waterdatainteractive/gamsdataviewer
Groundwater Availability and New Topics

Larry French, P.G.
Director
Groundwater Division
What is groundwater availability?

Policy + Science = Groundwater Availability

Desired Future Conditions + GAM or other tool = Modeled Available Groundwater

Goal: informed decision-making
GMAs with adopted desired future conditions
DFC appeals – then and now (as of 12/16)

Note: Law governing DFC appeals was substantially changed in 2015. Previously GMA-based and now GCD-based.
What is a MAG?

"Modeled available groundwater" means the amount of water that may be produced on an average annual basis to achieve a desired future condition.
Districts in groundwater management areas
Establish
Desired Future Conditions
and deliver to TWDB

TWDB provides estimates of Modeled Available Groundwater to districts and regional planning groups

Regional planning groups include estimates of total pumping and Modeled Available Groundwater in regional water plans

Districts consider Modeled Available Groundwater in plans and permitting
GMAs with new or upgraded groundwater availability models
Some facts about modeled available groundwater...

### All GMAs

<table>
<thead>
<tr>
<th>Year</th>
<th>Modeled Available Groundwater</th>
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<tbody>
<tr>
<td>2010</td>
<td>12,000,000</td>
</tr>
<tr>
<td>2020</td>
<td>10,000,000</td>
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<tr>
<td>2030</td>
<td>8,000,000</td>
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<tr>
<td>2040</td>
<td>6,000,000</td>
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<td>2050</td>
<td>4,000,000</td>
</tr>
<tr>
<td>2060</td>
<td>2,000,000</td>
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</tbody>
</table>

### Proportion of Modeled Available Groundwater

- **GMA 1**: Largest proportion
- **GMA 2**: Second largest proportion
- **GMA 3**: Third largest proportion
- **GMA 4**: Smaller proportion
- **GMA 5**: Smaller proportion
- **GMA 6**: Smaller proportion
- **GMA 7**: Smaller proportion
- **GMA 8**: Smaller proportion
- **GMA 9**: Smaller proportion
- **GMA 10**: Smaller proportion
- **GMA 11**: Smaller proportion
- **GMA 12**: Smaller proportion
- **GMA 13**: Smaller proportion
- **GMA 14**: Smaller proportion
- **GMA 15**: Smaller proportion
- **GMA 16**: Smallest proportion

Sources: [www.twdb.texas.gov](http://www.twdb.texas.gov), [www.facebook.com/twdbboard](http://www.facebook.com/twdbboard), [@twdb](http://@twdb)
Groundwater management areas (GMAs) = Texas
Development of DFCs

GMAs = Texas

Major and minor aquifers
GMAs = Texas

Major and minor aquifers

GCDs

Development of DFCs
Areas with MAGs

Development of DFCs
GMAs = Texas

Major and minor aquifers

DFCs

GCDs

Areas without DFCs

‘non-relevant’ areas (no MAGs)
GMAs = Texas

Major and minor aquifers

DFCs

GCDs

Areas without DFCs

‘other’ local aquifer areas (no MAGs) & ‘non-relevant’ areas (no MAGs)
GMAs = Texas

Major and minor aquifers

DFCs

GCDs

Areas without DFCs

‘other’ local aquifer areas (no MAGs) & ‘non-relevant’ areas (no MAGs)

RWPGs responsible for availability estimates

www.twdb.texas.gov  www.twitter.com/twdbboard  @twdb
MAG Peak Factor

• A percentage (e.g., greater than 100%) that is applied to a MAG value reflecting the annual groundwater availability that, for planning purposes, shall be considered temporarily available for pumping consistent with DFCs.

• Provides temporary accommodation of increased groundwater demands by accommodating anticipated fluctuations in pumping.

• Does not limit permitting or guarantee approval of any future permit applications.

• Requires review and approval by relevant groundwater conservation districts, groundwater management areas, and the TWDB Executive Administrator.
Groundwater-surface water

• Nearly all aquifers contribute some groundwater to baseflow of streams/rivers
• Statewide, an estimated 9.3 million acre-feet per year, on average, discharges from aquifers to surface water.
• Gulf Coast Aquifer discharges about 3.8 million acre-feet per year
• About half of the aquifers contribute less than 50,000 acre-feet per year to streams/rivers
• Largest contributors of groundwater are in East Texas, Hill Country, and major springs in West Texas.
Tributary and non-tributary aquifers

- Percentage of streamflow attributable to inflows of groundwater ranges from 14 percent (several aquifers) to 72 percent (Edwards [Balcones Fault Zone] Aquifer)
- All aquifers with surface outcrops are tributary
- Only the Rita Blanca Aquifer is considered non-tributary
- Deep, buried portions of aquifers may be non-tributary in character
Brackish groundwater production zones
Thank you for attending!

• Larry French, Director, Groundwater Division
• Janie Hopkins, Manager, Groundwater Monitoring Section
• Bryan Anderson, Team Lead, Groundwater Data Team
• Rima Petrossian, Manager, Groundwater Technical Assistance Section
• Cindy Ridgeway, Manager, Groundwater Availability Modeling Section