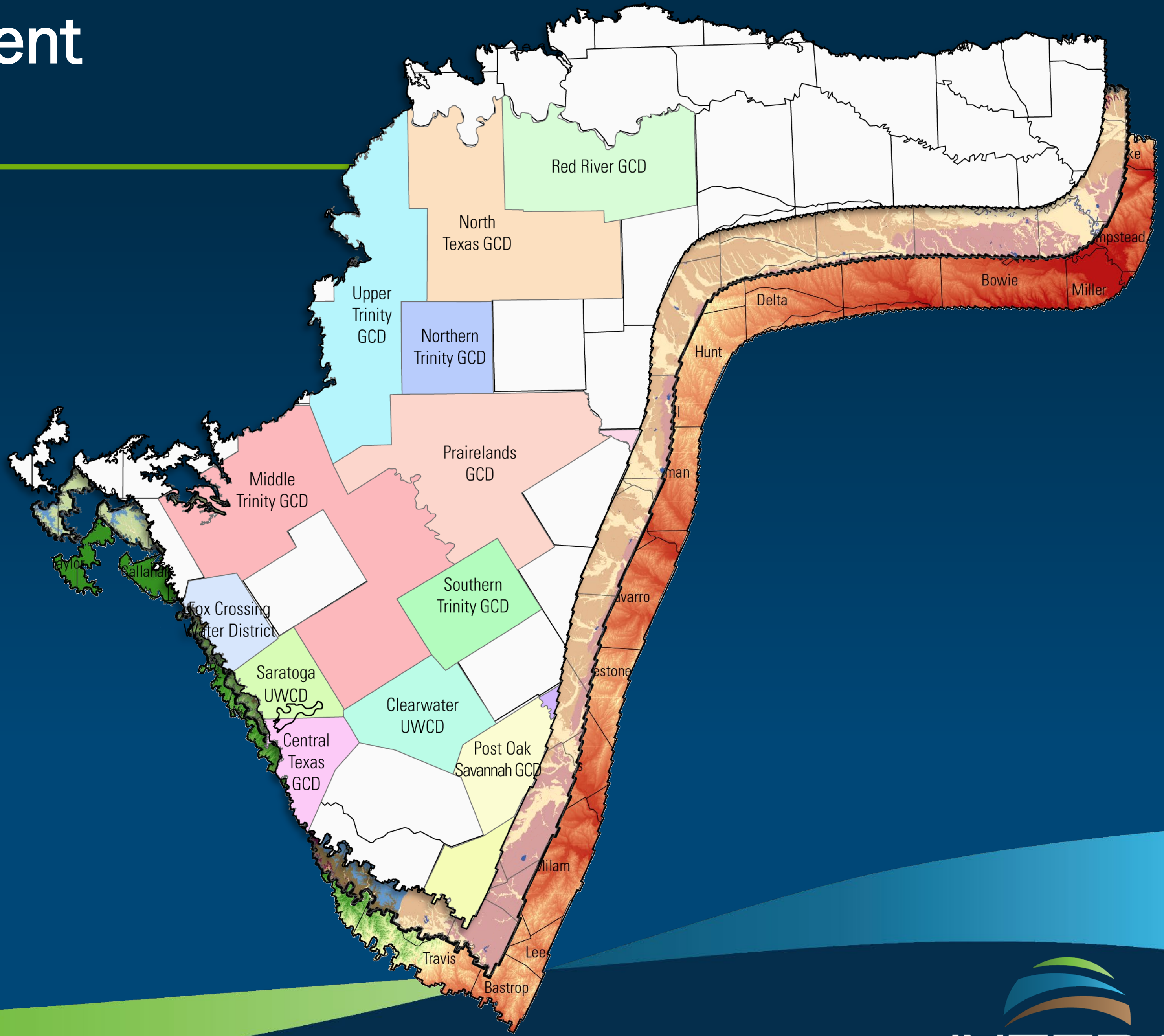
Groundwater Management Area 8 Joint Planning



John Ellis, P.G.
Andres Estrada-Prieto, Ph.D., P.E.

February 25th, 2025

INTERA

Agenda Items (6, 7, 8)

6. Discussion and possible action on the overview and timeline for DFC Joint Planning.

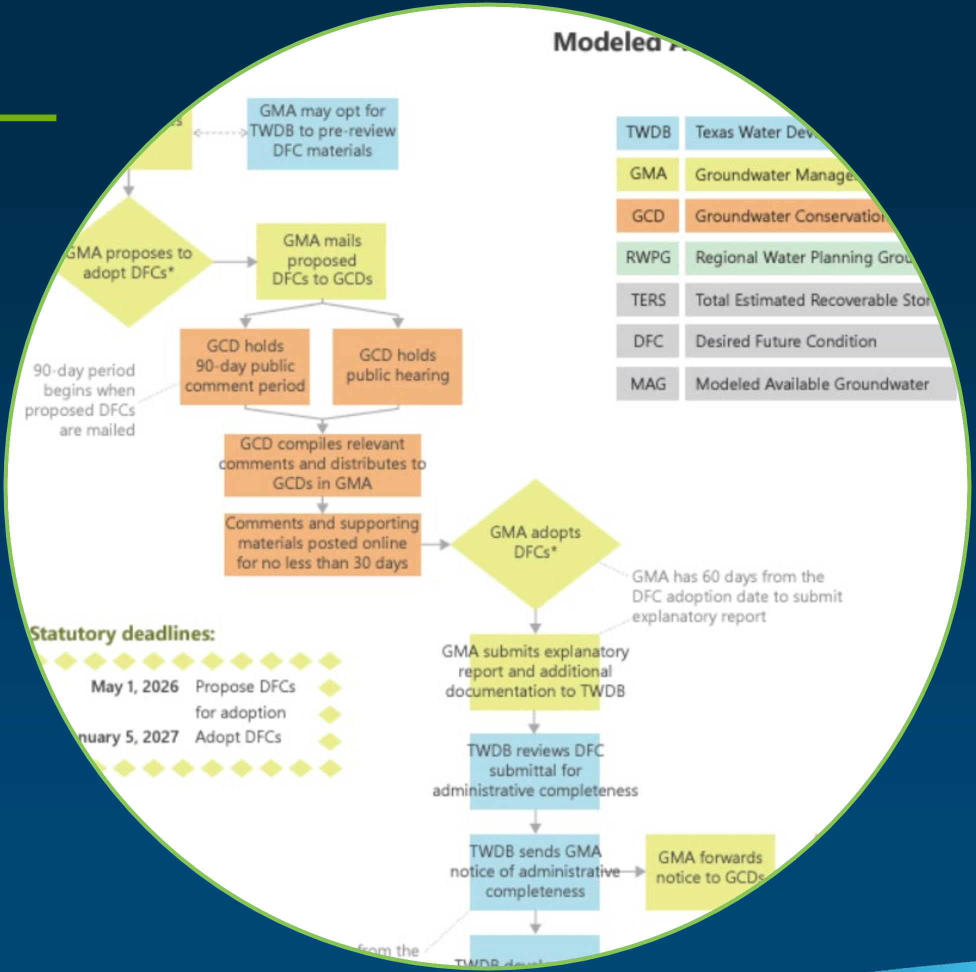
7. Discussion and possible action on the Northern Trinity and Woodbine Aquifer Groundwater Availability Model Update and review timeline.

8. Discussion and possible action on model runs for DFC Joint Planning

INTERA

Agenda Item 6

- Discussion and possible action on the overview and timeline for DFC Joint Planning



INTERA

Consideration of Factors

- Aquifer uses or conditions
- Other environmental impacts
- Impact on subsidence

Meeting #1

- Hydrological conditions
- Water supply needs &management strategies
- Impact on private property rights

Meeting #2

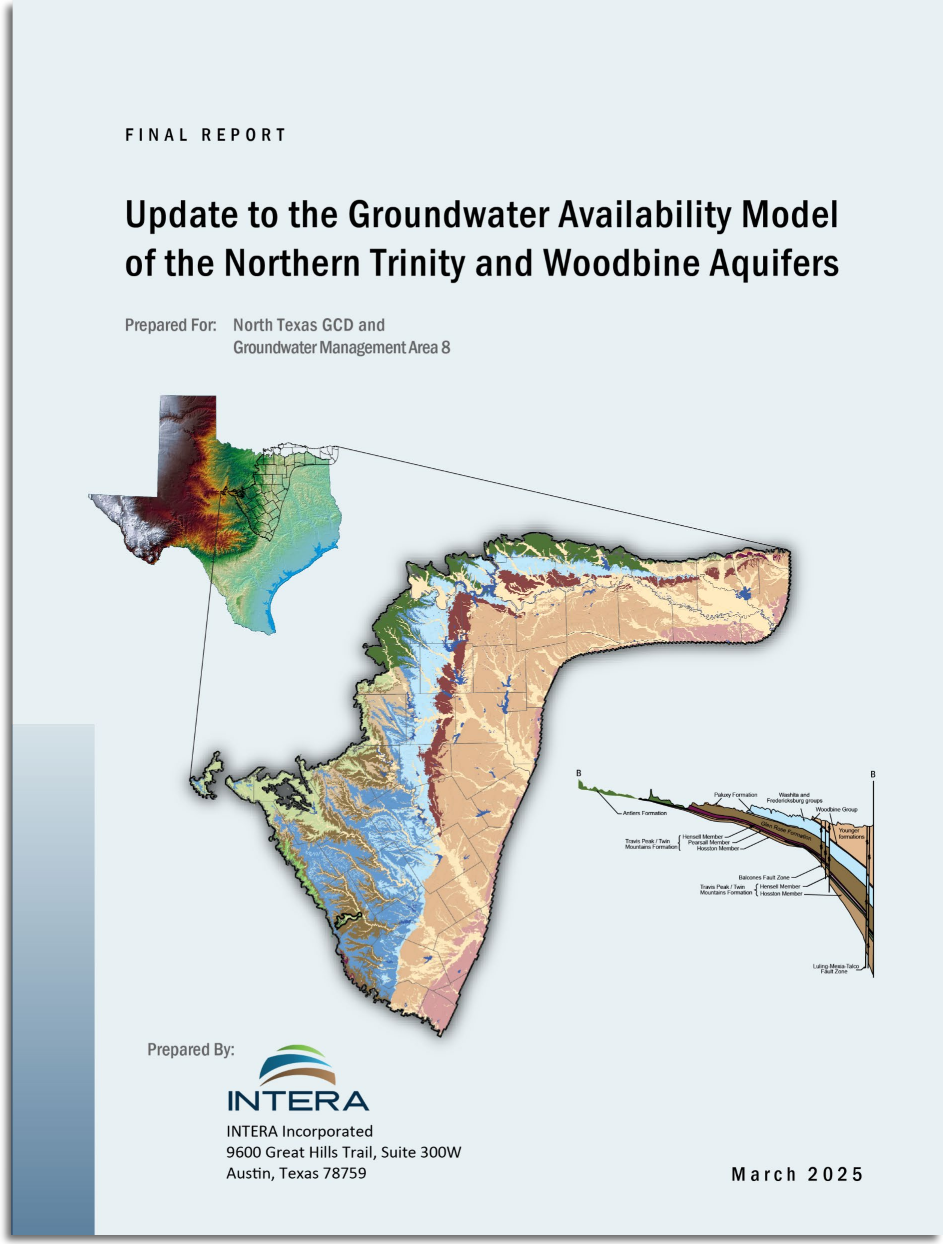
- Socioeconomic impacts
- Feasibility of achieving the DFC
- Any other relevant information

Meeting #3

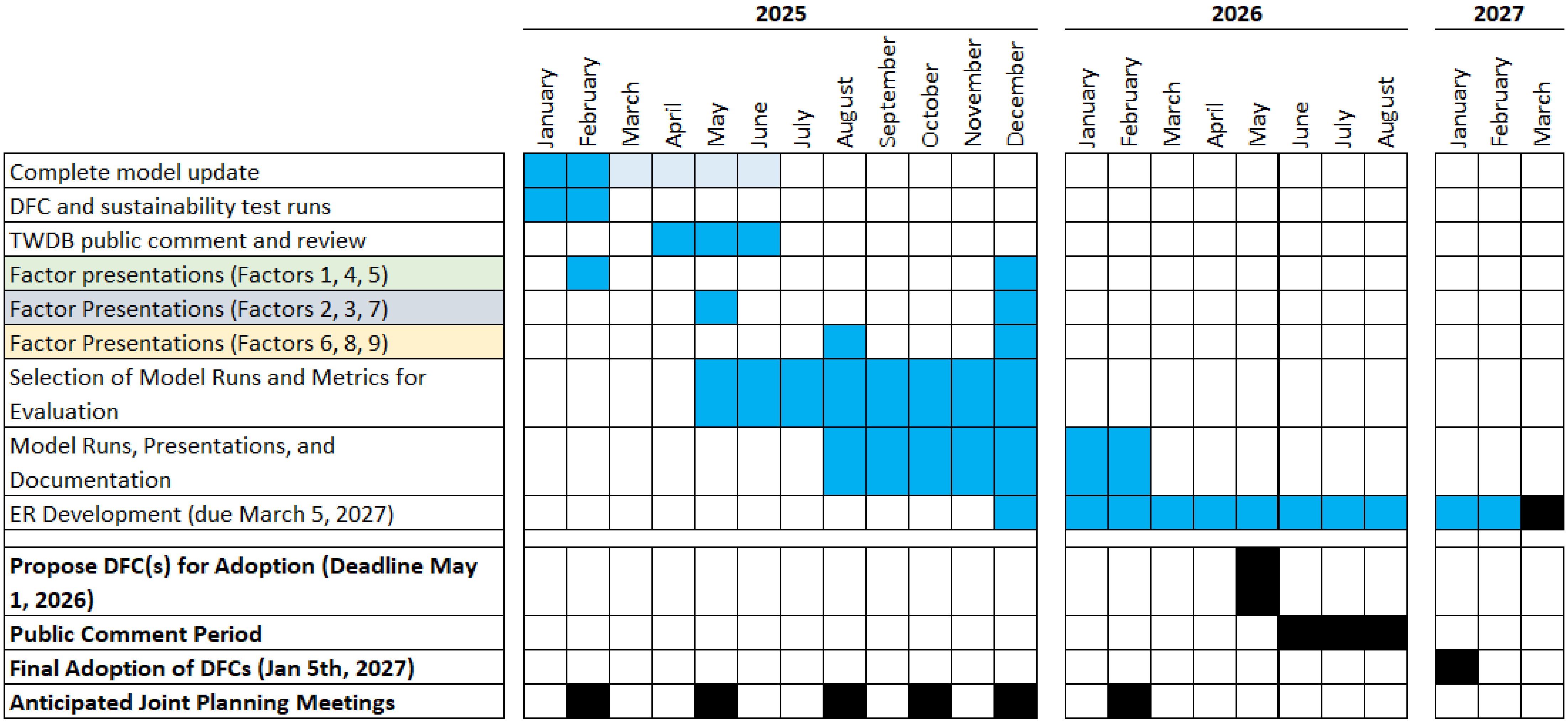
INTERA

NTGAM report

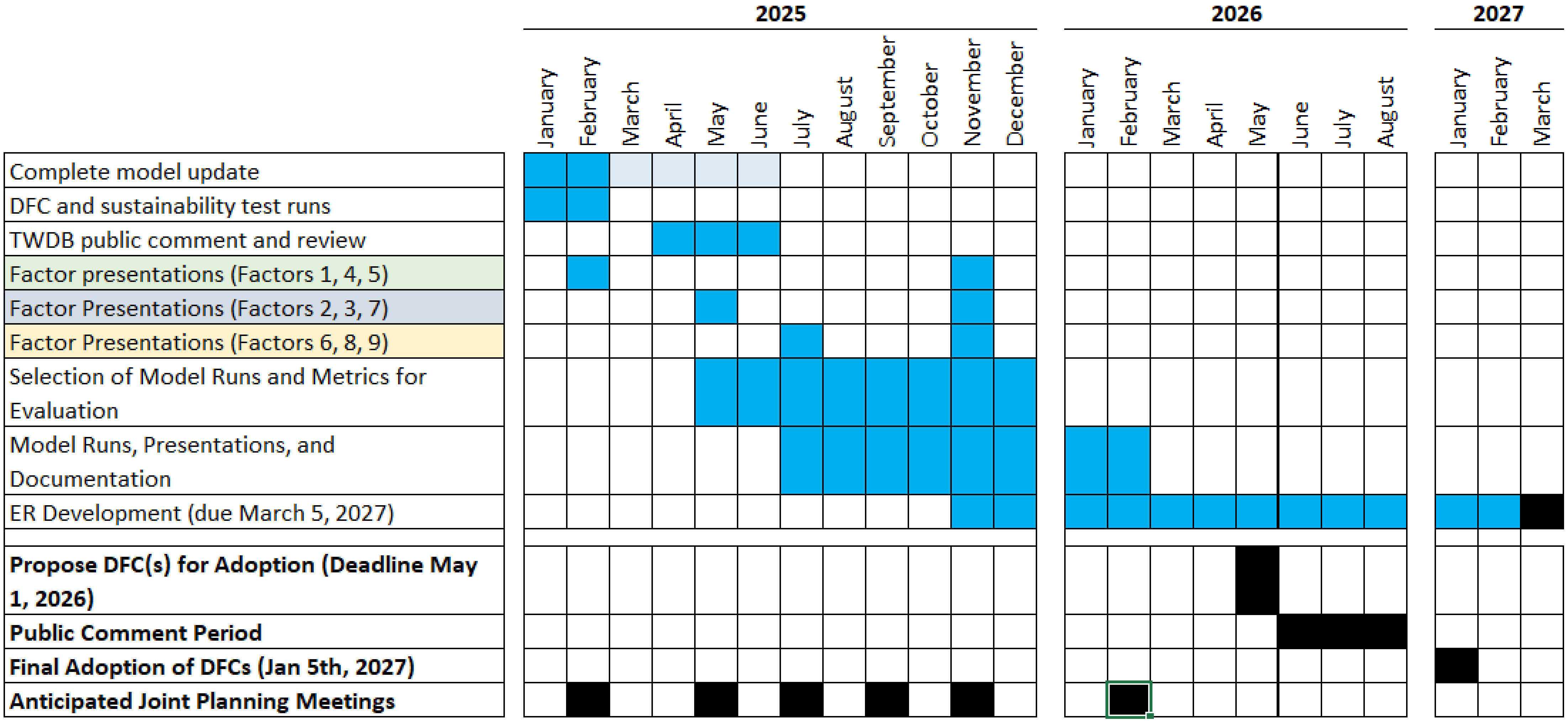
- Report beginning INTERA internal review on March 16th
- Planned submission to TWDB for public comment the first or second week of April
- TWDB public comment period estimated end of April – end of June (60 days)
- 2–3 weeks to complete INTERA response to public comments and changes
- Adoption as GAM could be sometime in July/August



Timeline (option 1)

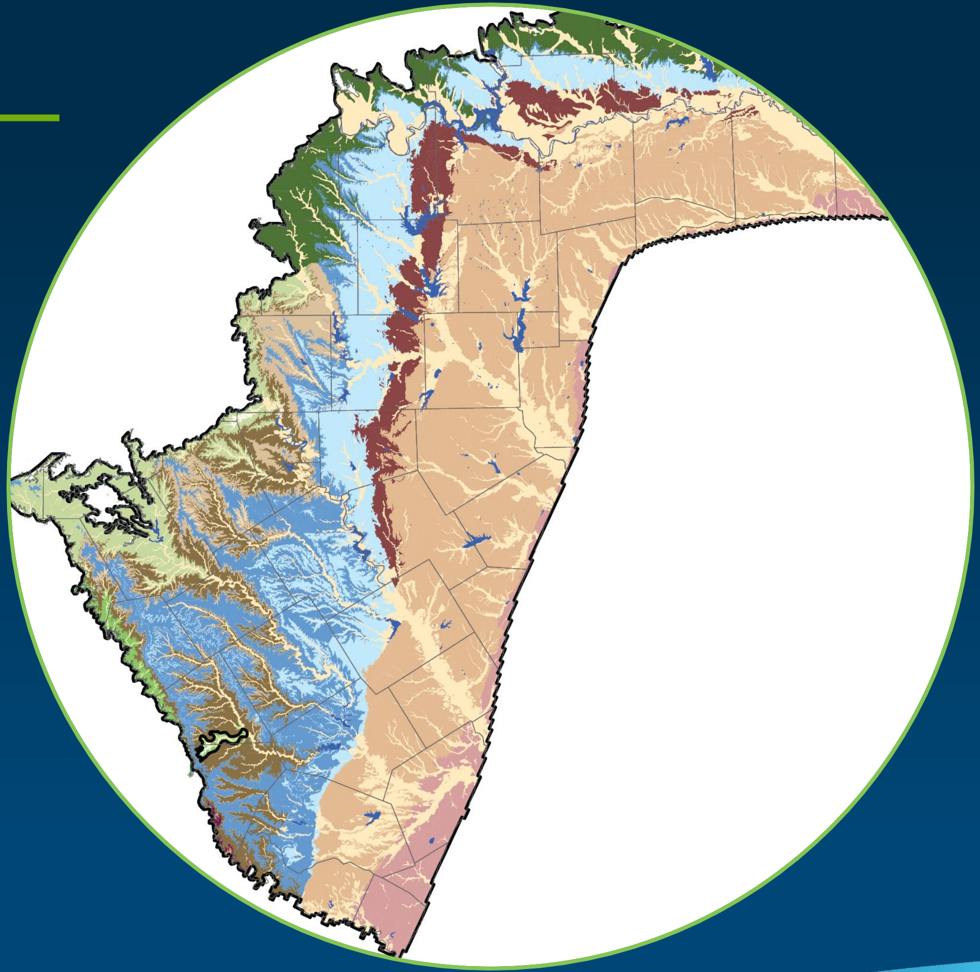


Timeline (option 2)



Agenda Item 7

- Discussion and possible action on the Northern Trinity and Woodbine Aquifer Groundwater Availability Model Update (NTGAM) and review timeline



INTERA

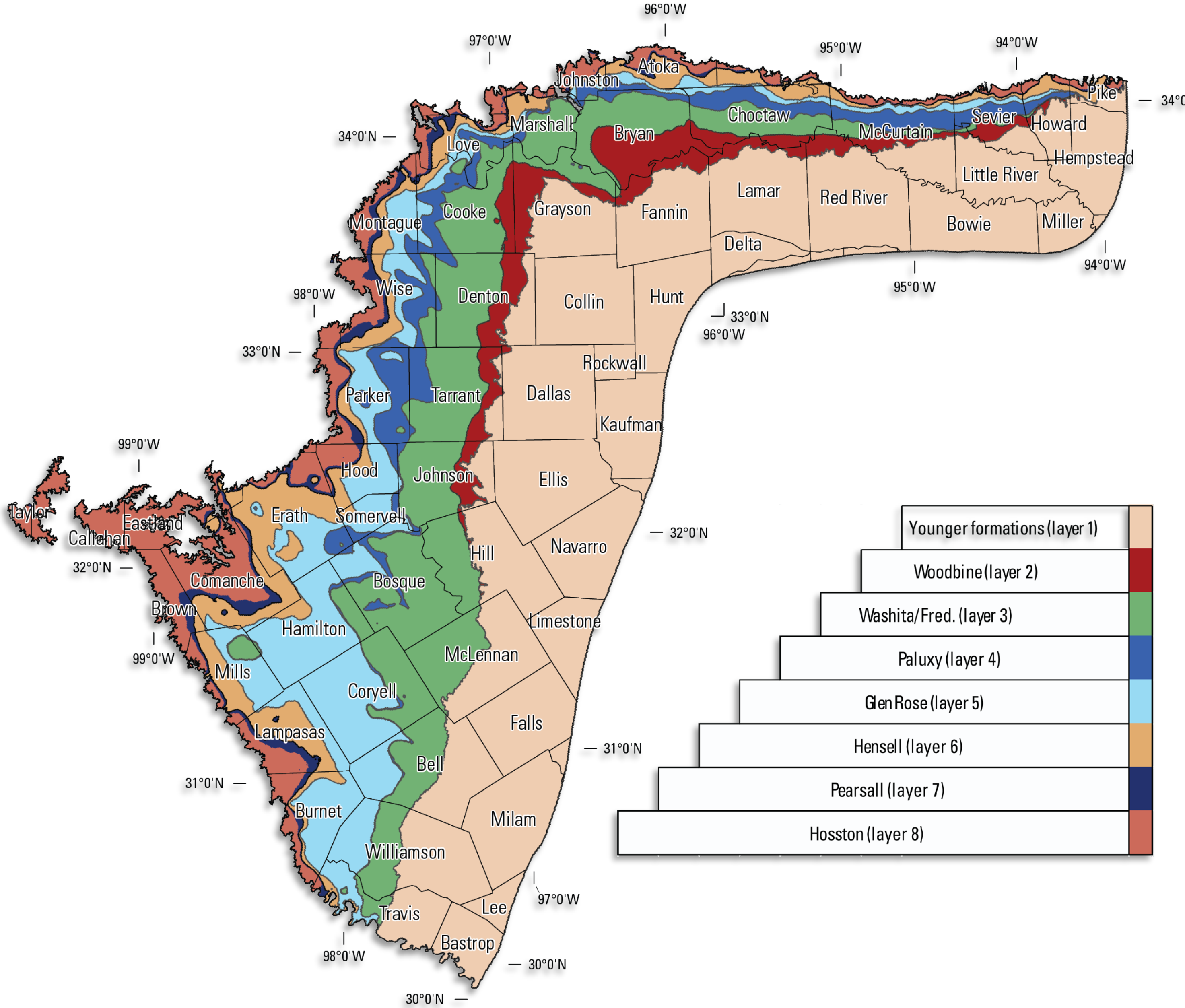
Configuration

Layering

- **Layer 1**: Surficial units/younger formations
- **Layer 2**: Woodbine
- **Layer 3**: Washita/Fredericksburg
- **Layer 4**: Paluxy
- **Layer 5**: Glen Rose
- **Layer 6**: Hensell
- **Layer 7**: Pearsall
- **Layer 8**: Hosston
- Pass-through cells used for units that have outcropped

Time Discretization

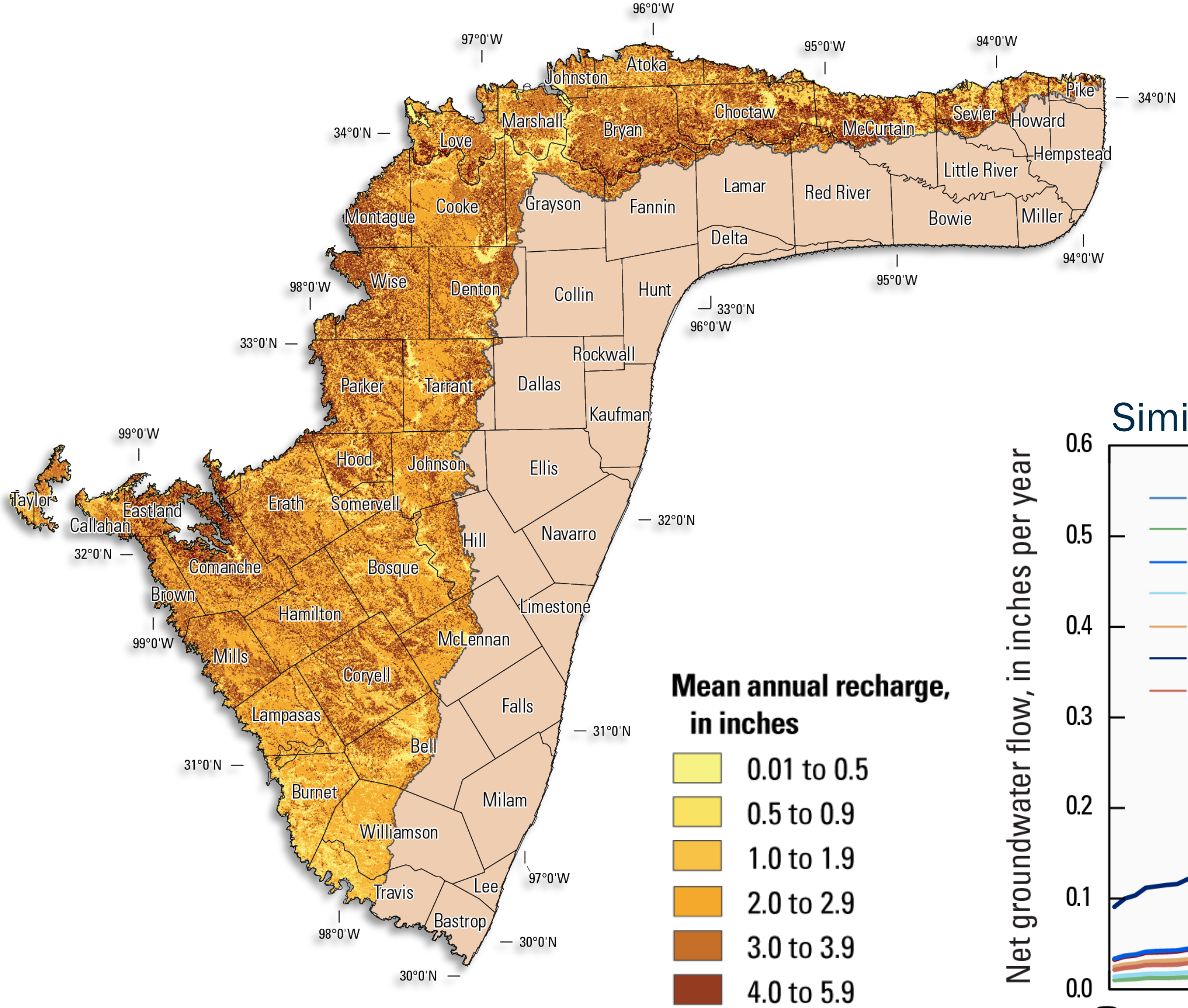
- **1889:** Steady State (Predevelopment)
- **1890–2020:** Annual stress periods
- (extended from the end date of the 2014 model from 2012 to 2020)



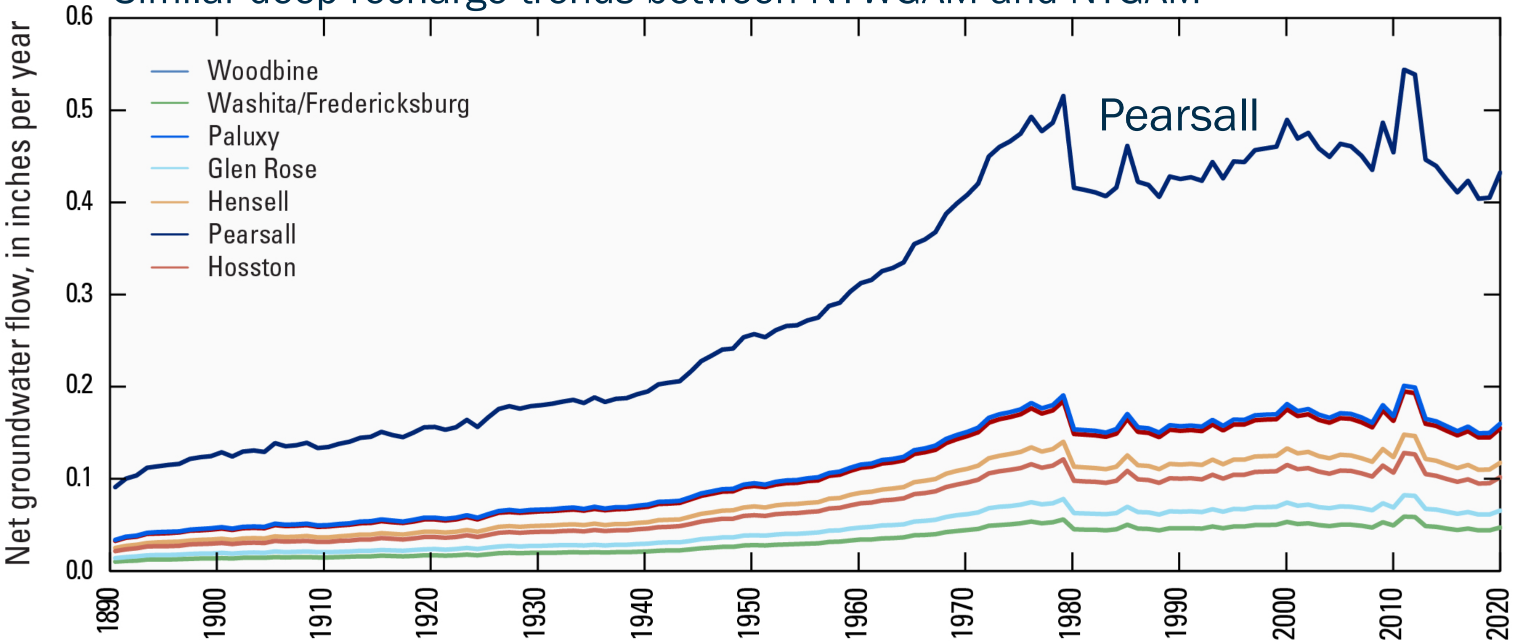
Recharge

- Only a small portion of the surficial recharge infiltrates the deeper areas of the aquifers
- Average deep recharge is 0.07 – 0.3 in/yr

31 in/yr (Precip) → 2.8 in/yr (water table recharge) → 0.07-0.3 in/yr (deep recharge)



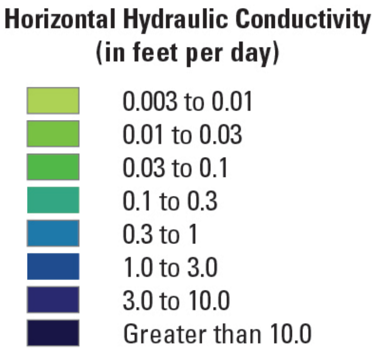
Similar deep recharge trends between NTWGAM and NTGAM

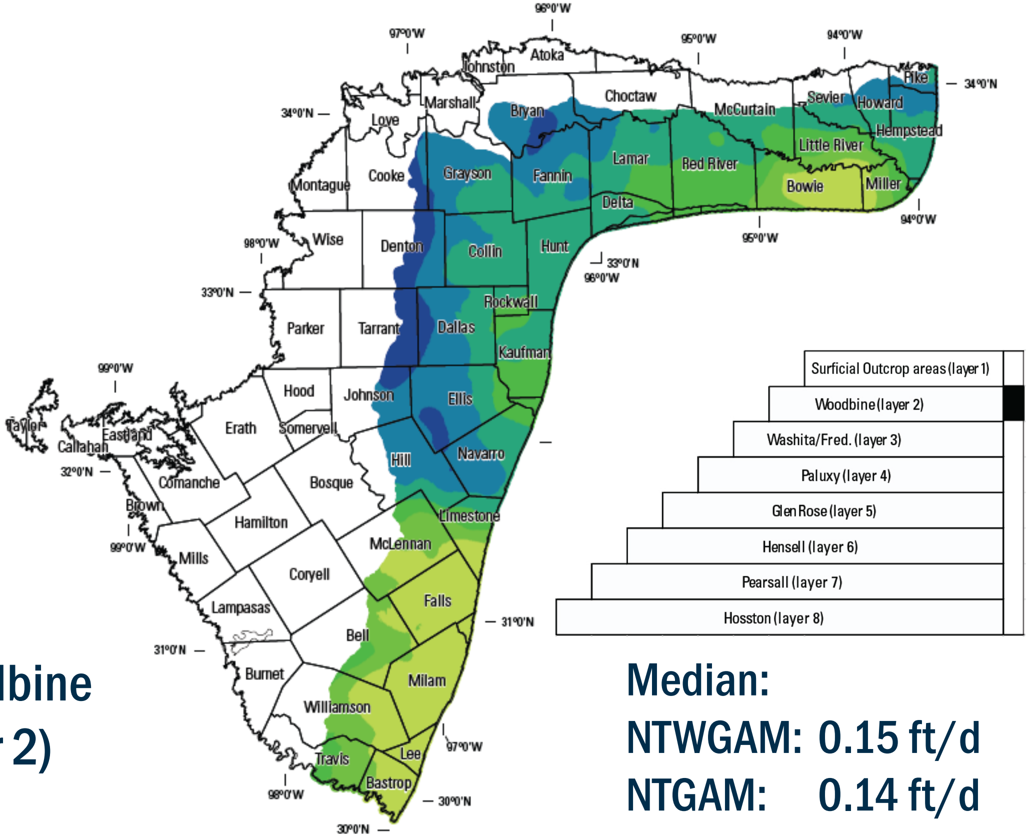


Model Parameters

Horizontal Hydraulic Conductivity

- Ability of aquifer material to transmit water parallel to the surface

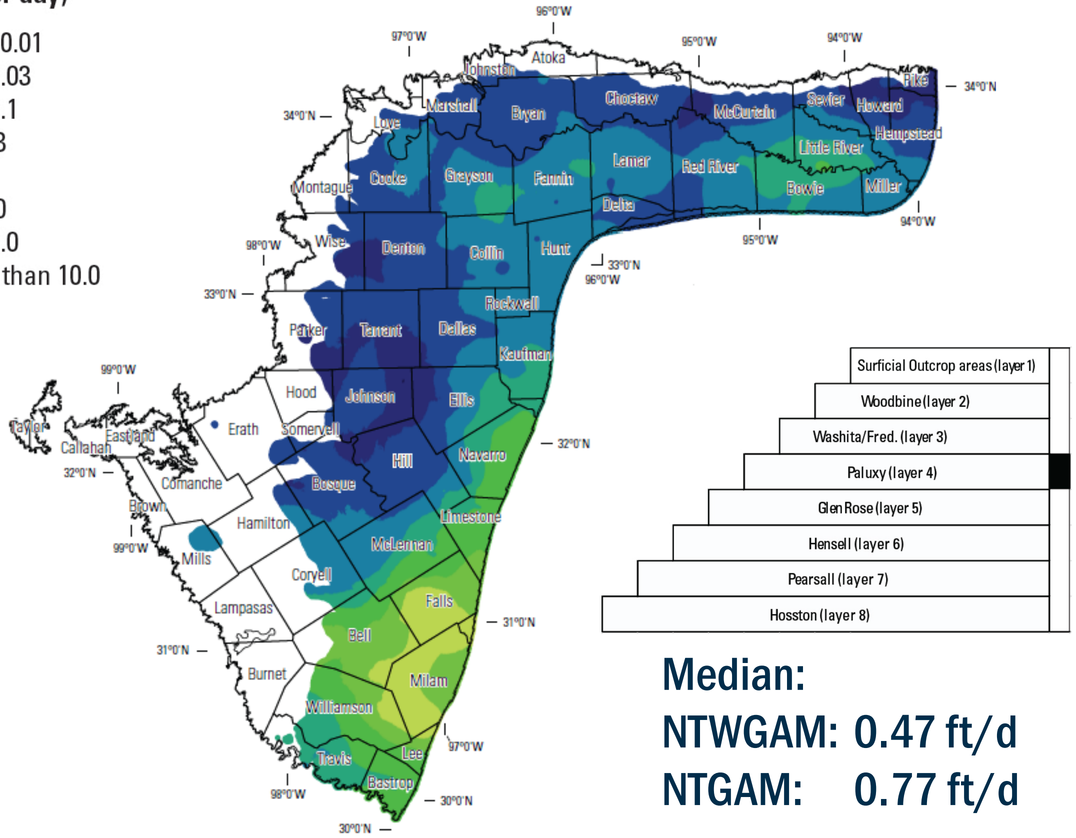




Woodbine (layer 2)

Median:
NTWGAM: 0.15 ft/d
NTGAM: 0.14 ft/d

Paluxy (layer 4)



Median:
NTWGAM: 0.47 ft/d
NTGAM: 0.77 ft/d

- Generally lower values with depth in each aquifer unit

Model Parameters

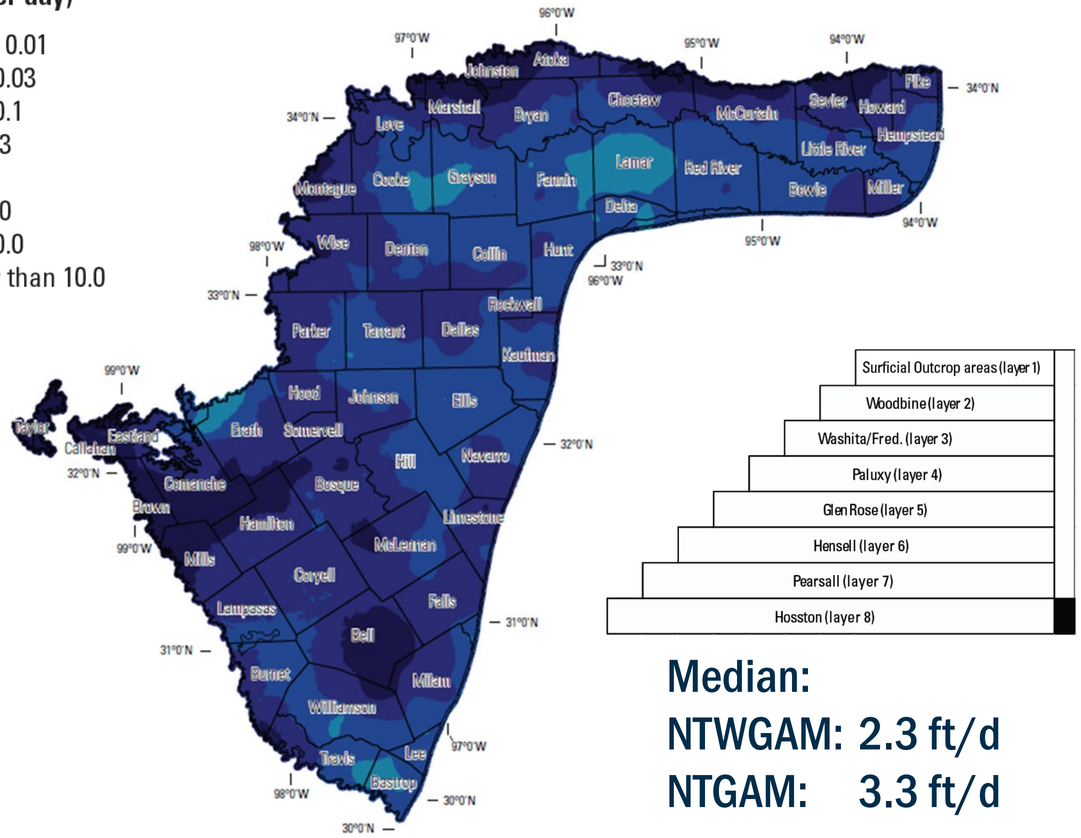
Horizontal Hydraulic Conductivity

- Ability of aquifer material to transmit water parallel to the surface

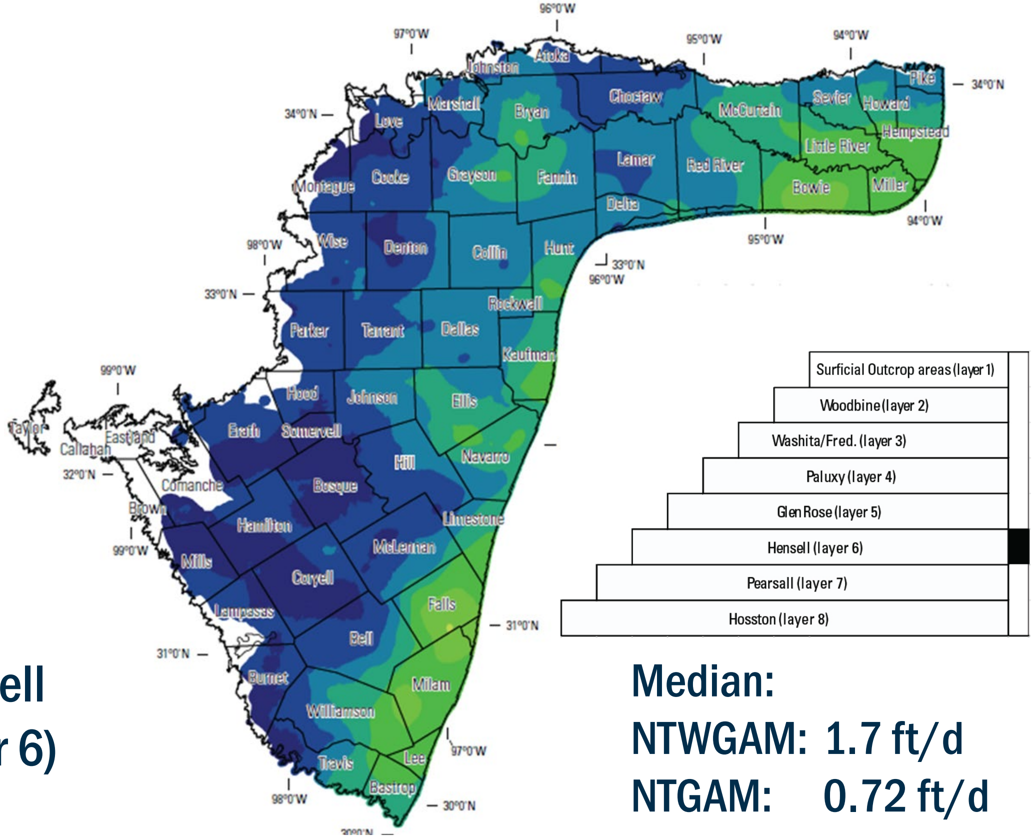
Horizontal Hydraulic Conductivity (in feet per day)

- 0.003 to 0.01
- 0.01 to 0.03
- 0.03 to 0.1
- 0.1 to 0.3
- 0.3 to 1
- 1.0 to 3.0
- 3.0 to 10.0
- Greater than 10.0

Hosston (layer 8)



Median:
NTWGAM: 2.3 ft/d
NTGAM: 3.3 ft/d



Hensell (layer 6)

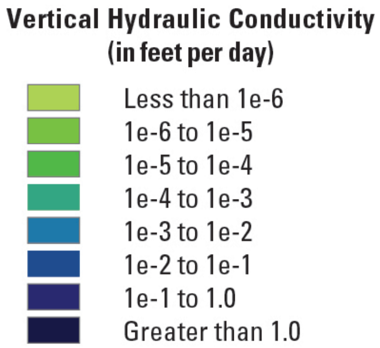
Median:
NTWGAM: 1.7 ft/d
NTGAM: 0.72 ft/d

- Generally lower values with depth in each aquifer unit

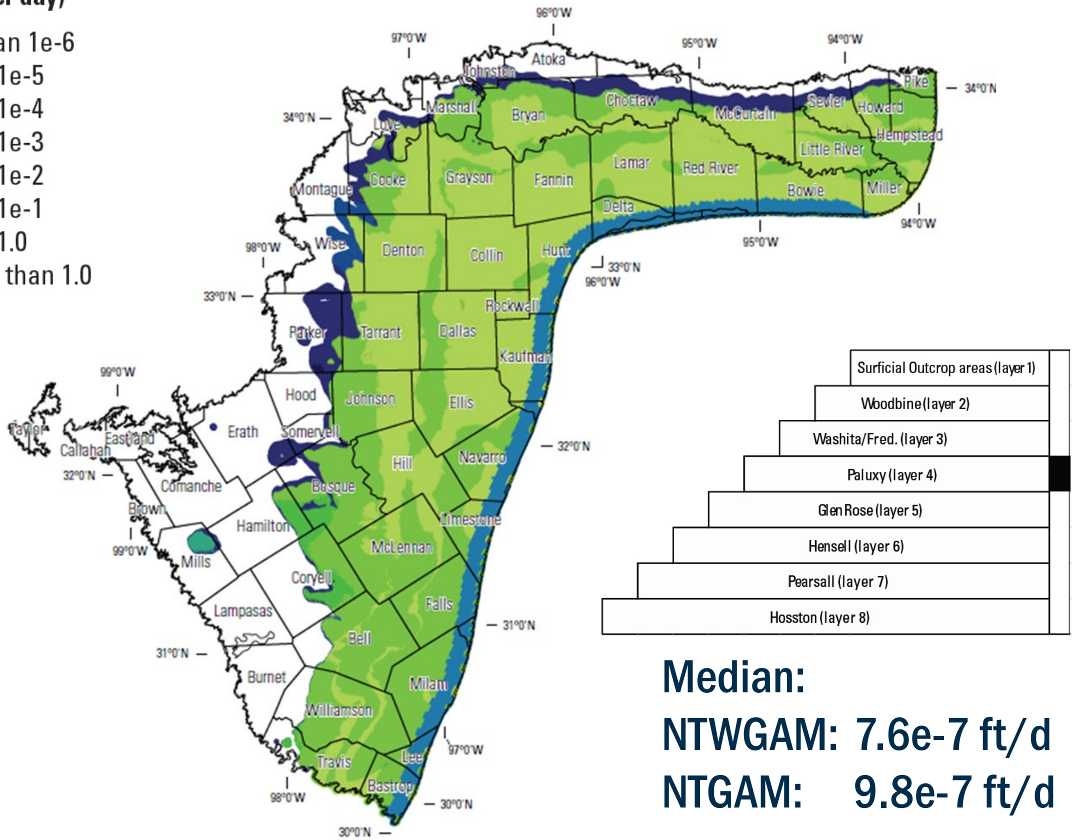
Model Parameters

Vertical Hydraulic Conductivity

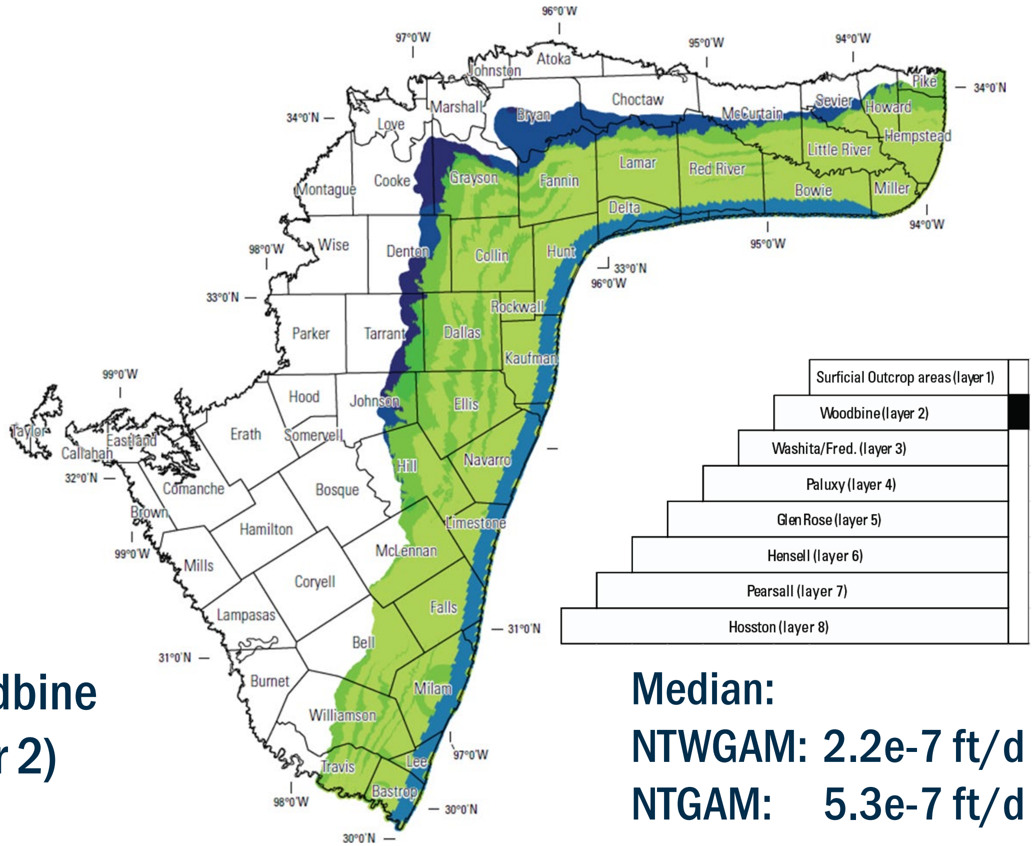
- Measure of how easily water moves through soil/rock due to gravity and pressure differences



Paluxy (layer 4)



Median:
NTWGAM: 7.6e-7 ft/d
NTGAM: 9.8e-7 ft/d



Woodbine (layer 2)

Median:
NTWGAM: 2.2e-7 ft/d
NTGAM: 5.3e-7 ft/d

- Generally lower values with depth in each aquifer unit

Model Parameters

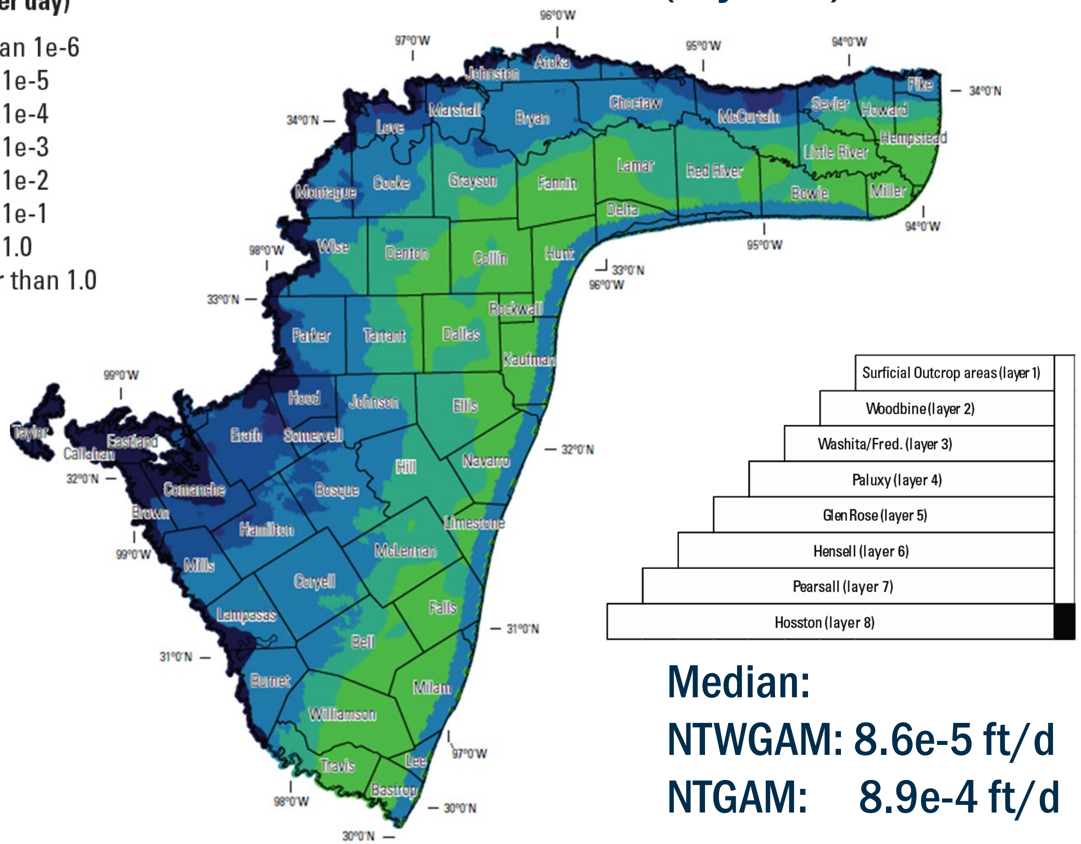
Vertical Hydraulic Conductivity

- Measure of how easily water moves through soil/rock due to gravity and pressure differences

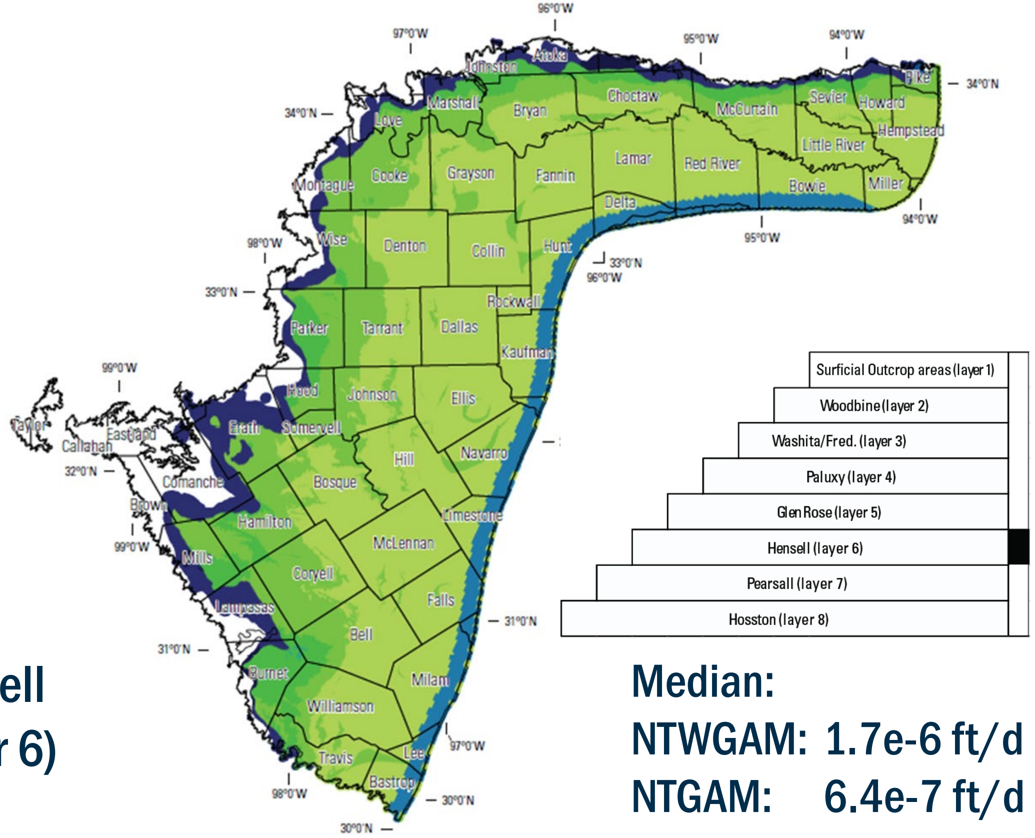
Vertical Hydraulic Conductivity (in feet per day)

- Less than 1e-6
- 1e-6 to 1e-5
- 1e-5 to 1e-4
- 1e-4 to 1e-3
- 1e-3 to 1e-2
- 1e-2 to 1e-1
- 1e-1 to 1.0
- Greater than 1.0

Hosston (layer 8)



Median:
NTWGAM: 8.6e-5 ft/d
NTGAM: 8.9e-4 ft/d



Hensell (layer 6)

Median:
NTWGAM: 1.7e-6 ft/d
NTGAM: 6.4e-7 ft/d

- Generally lower values with depth in each aquifer unit

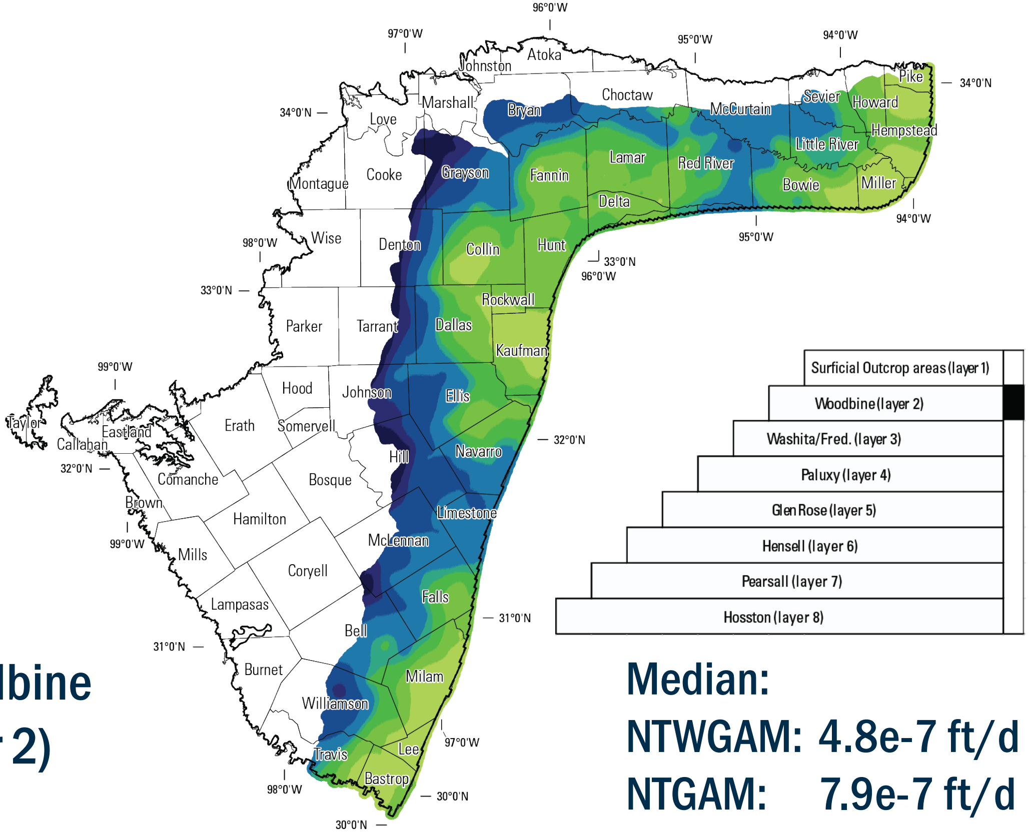
Model Parameters

Specific Storage

- How much water a unit volume of the aquifer can store or release per unit change in water pressure

Specific Storage (1/foot)

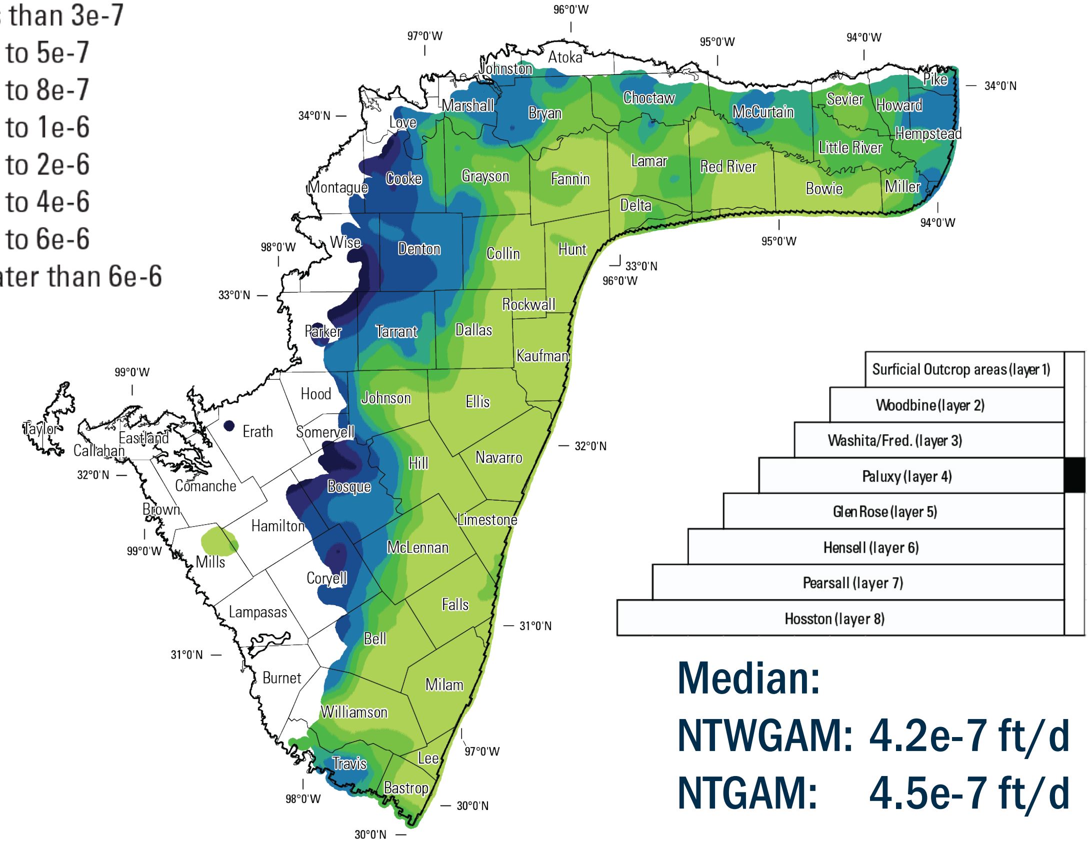
- Less than 3e-7
- 3e-7 to 5e-7
- 5e-7 to 8e-7
- 8e-7 to 1e-6
- 1e-6 to 2e-6
- 2e-6 to 4e-6
- 4e-6 to 6e-6
- Greater than 6e-6



Woodbine (layer 2)

Median:
NTWGAM: 4.8e-7 ft/d
NTGAM: 7.9e-7 ft/d

Paluxy (layer 4)



Median:
NTWGAM: 4.2e-7 ft/d
NTGAM: 4.5e-7 ft/d

- Generally lower values with depth in each aquifer unit

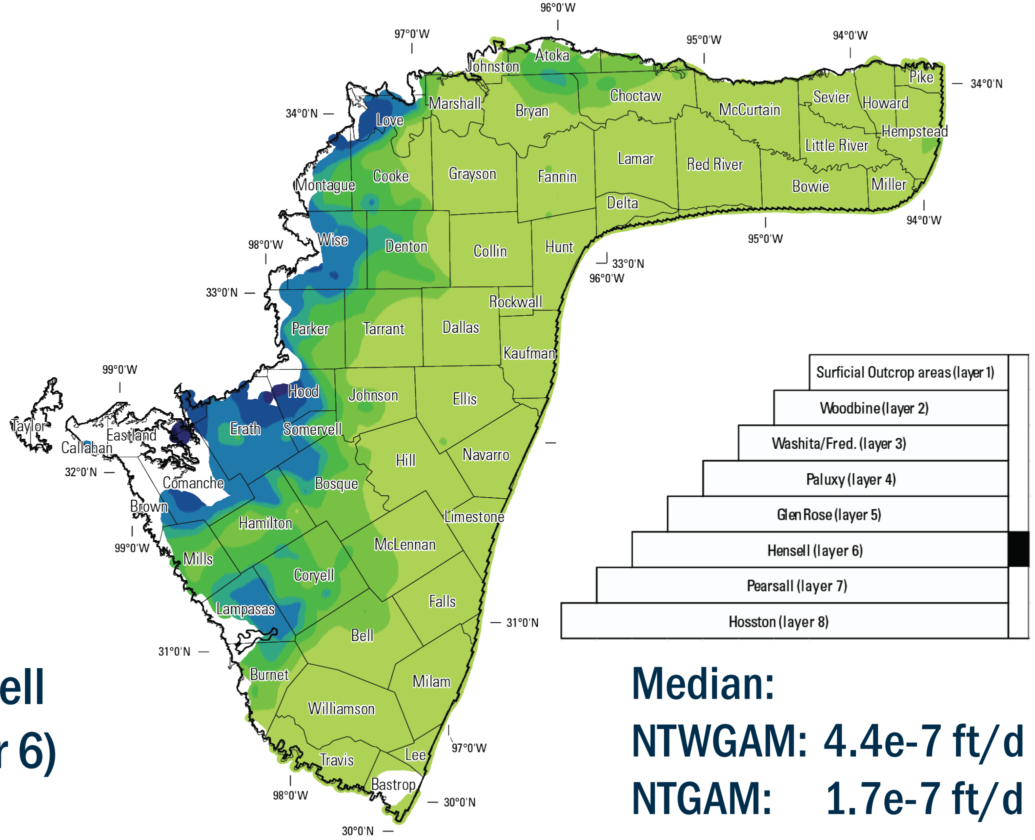
Model Parameters

Specific Storage

- How much water a unit volume of the aquifer can store or release per unit change in water pressure

Horizontal Hydraulic Conductivity (in feet per day)

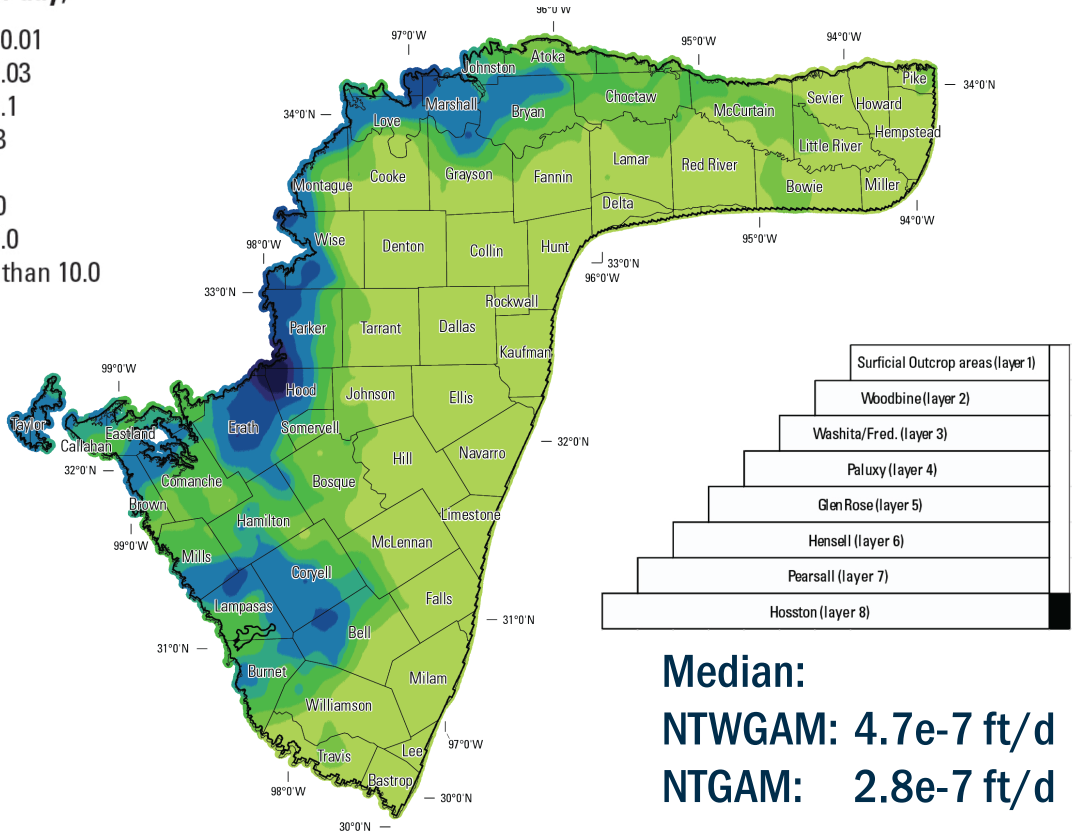
- 0.003 to 0.01
- 0.01 to 0.03
- 0.03 to 0.1
- 0.1 to 0.3
- 0.3 to 1
- 1.0 to 3.0
- 3.0 to 10.0
- Greater than 10.0



Hensell (layer 6)

Median:
NTWGAM: 4.4e-7 ft/d
NTGAM: 1.7e-7 ft/d

Hosston (layer 8)

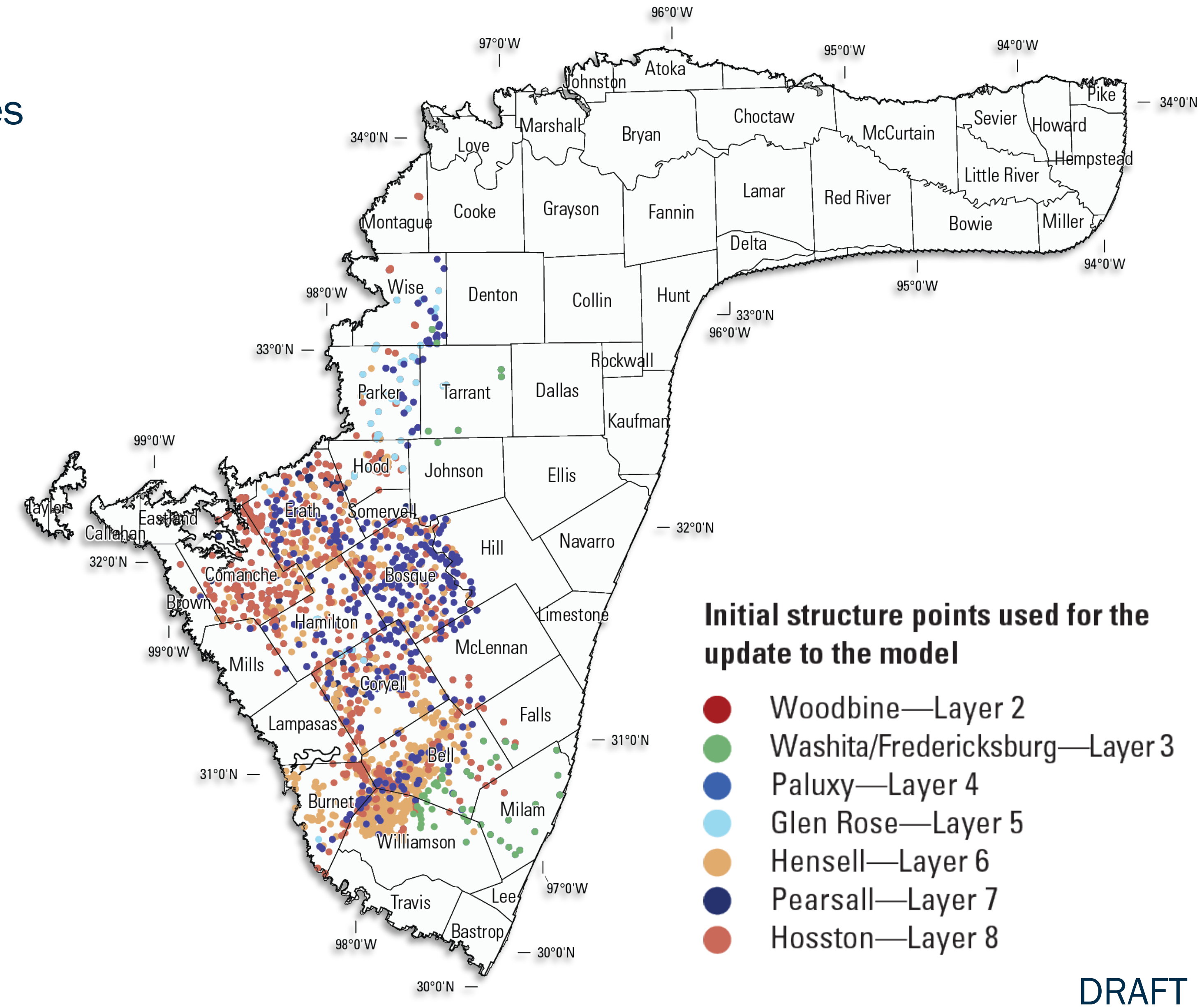


Median:
NTWGAM: 4.7e-7 ft/d
NTGAM: 2.8e-7 ft/d

- Generally lower values with depth in each aquifer unit

Structure Update

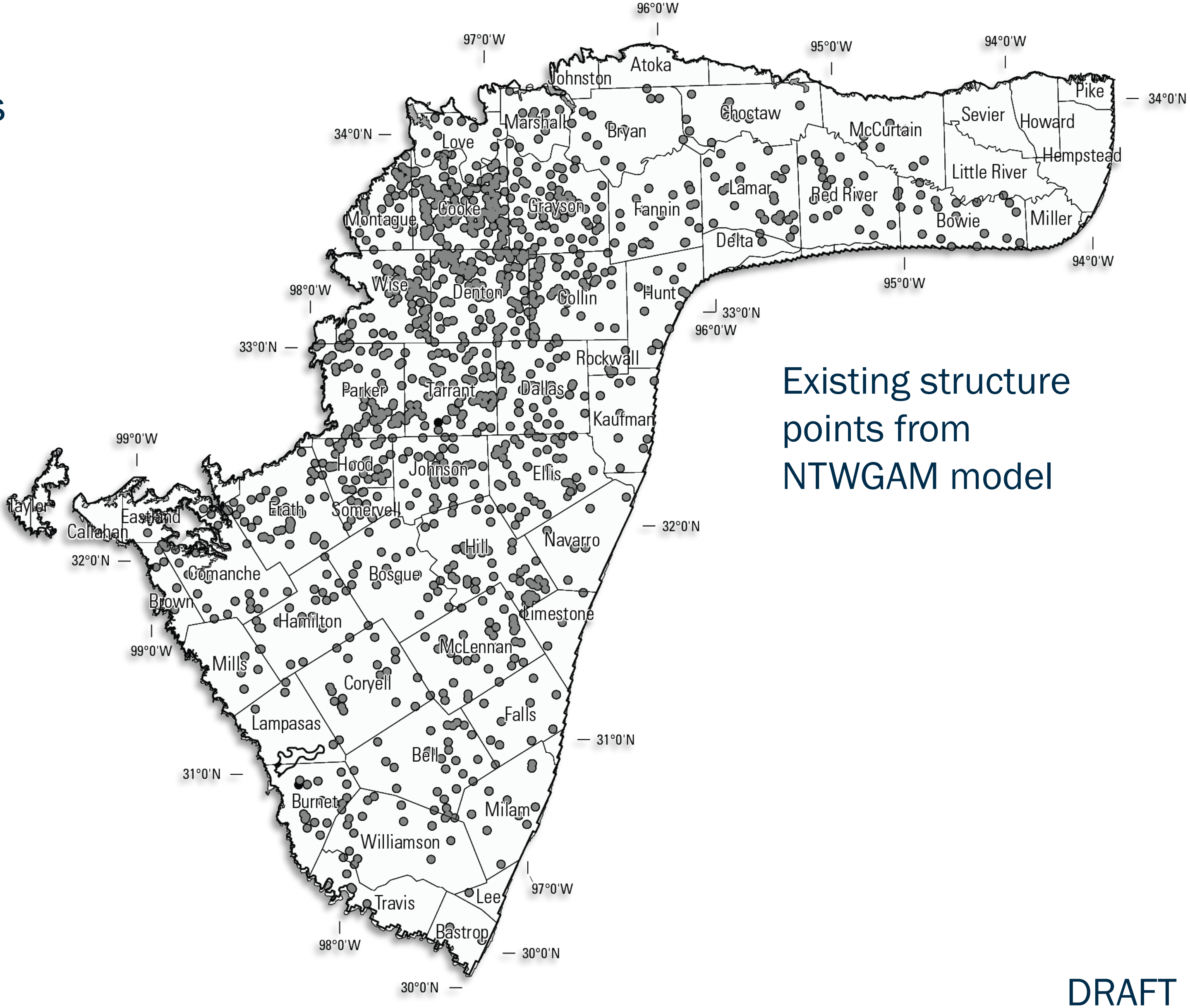
- Focused structure update where differences occur between the NTWGAM and this updated (NTGAM)
- Performed picks from 168 pdfs of geophysical logs from Northern Trinity GCD and UTGCD
- Incorporated new data on structure, including 12 geophysical logs in Milam County
- Evaluated pre-picked structure data from GCDs (CUWCD, CTGCD, MTGCD)
- Did not use new logs if they were within 2 mi of NTWGAM (2014 model)



DRAFT

Structure Update

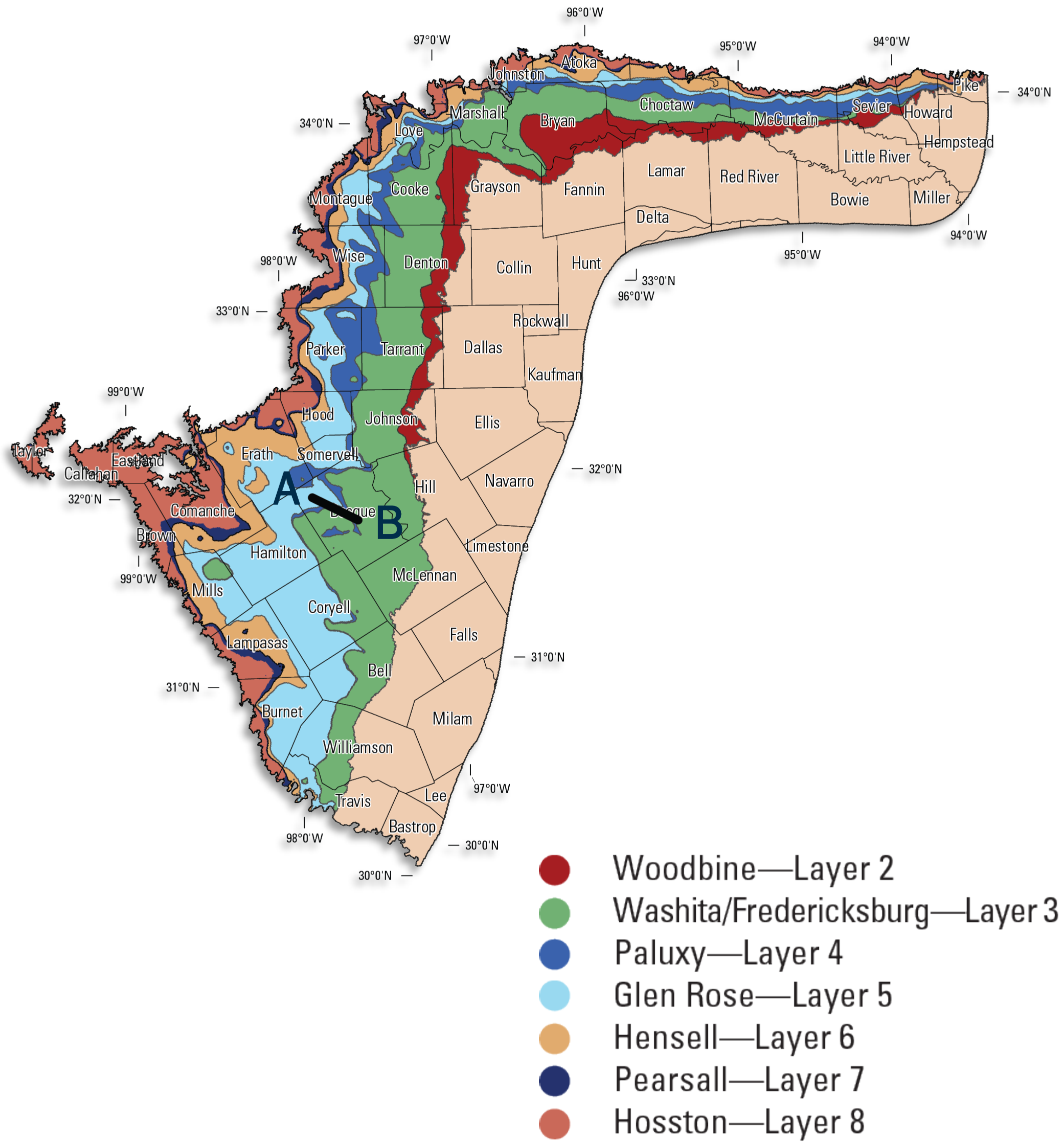
- Focused structure update where differences occur between the 2014 GAM and this updated model
- Incorporated new data on structure, including 12 geophysical logs in Milam County
- Evaluated pre-picked structure data from GCDs (CUWCD, CTGCD, MTGCD)
- Performed picks from 168 pdfs of geophysical logs from Northern Trinity GCD and UTGCD
- Did not use new logs if they were within two mi of NTWGAM logs (2014 model)

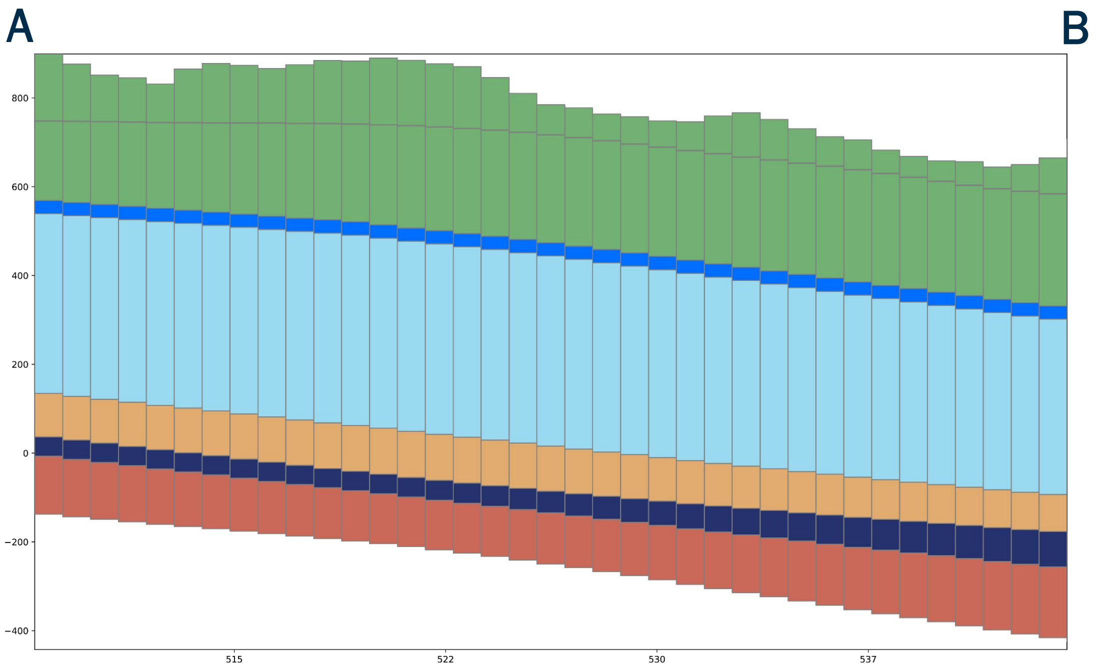


Existing structure points from NTWGAM model

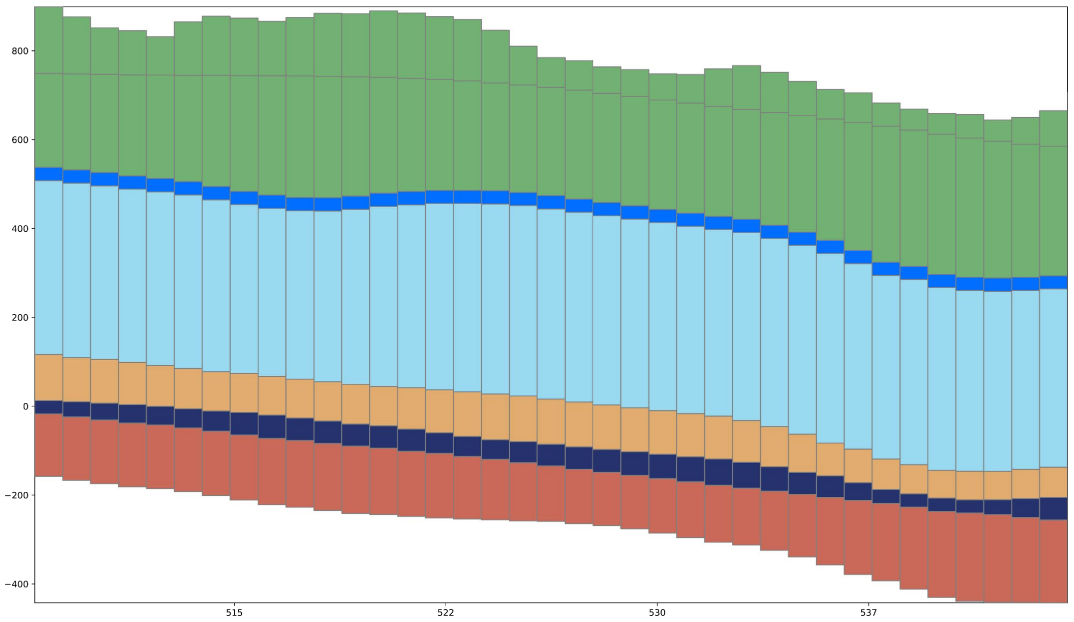
DRAFT

Structure Update



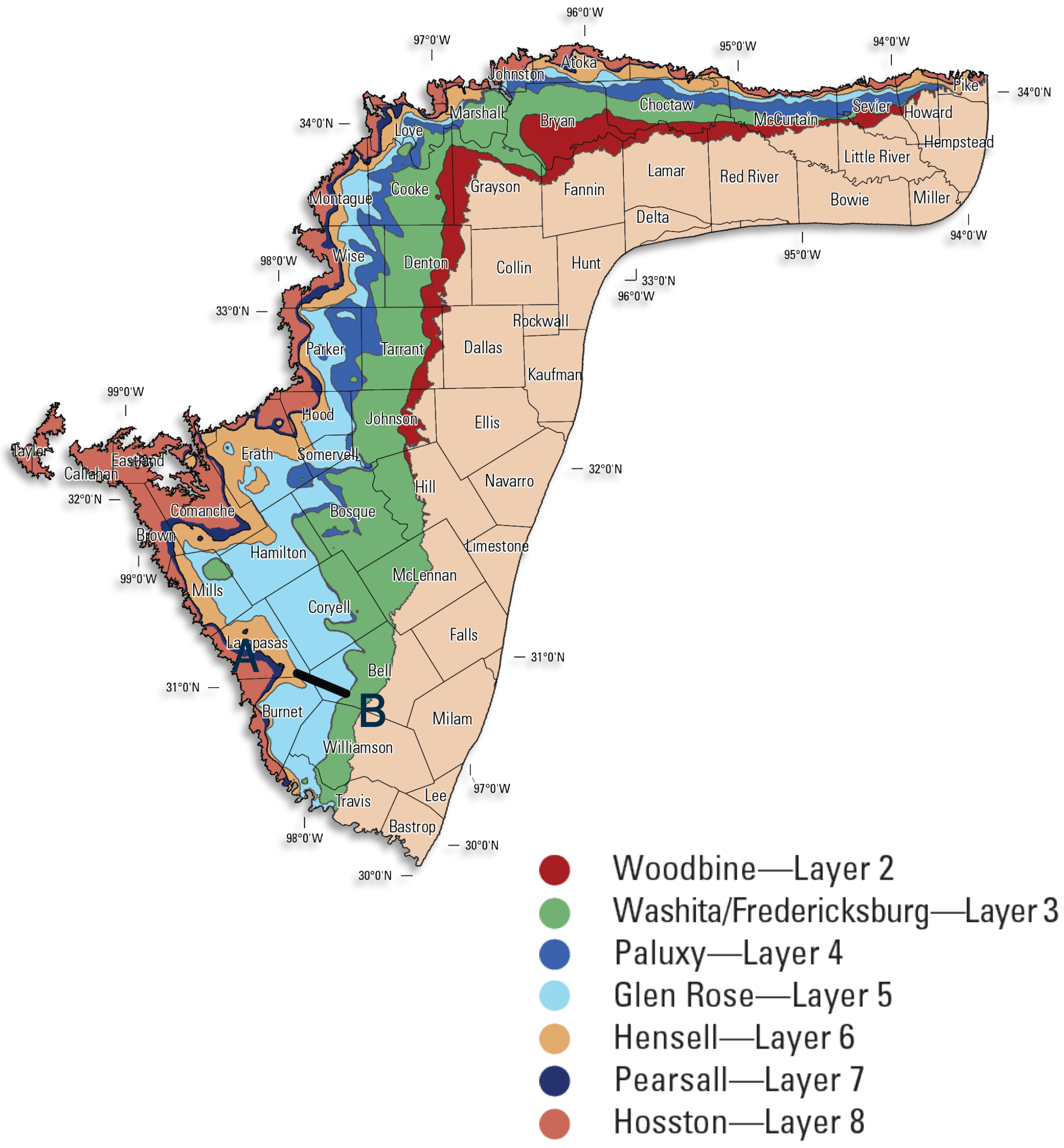


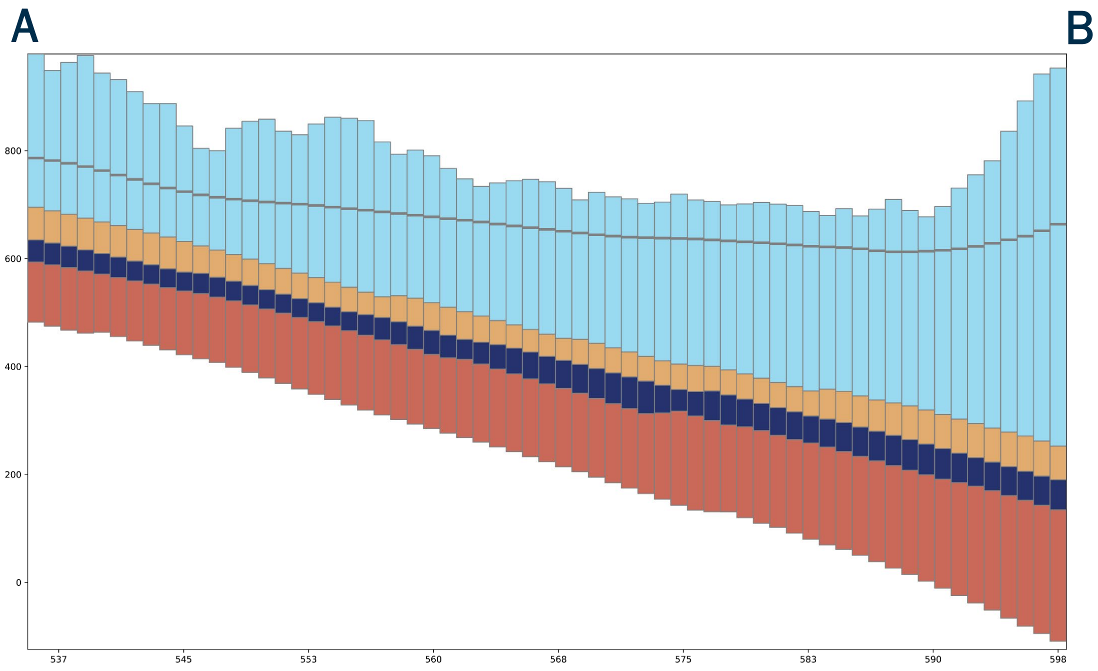
NTWGAM model structure



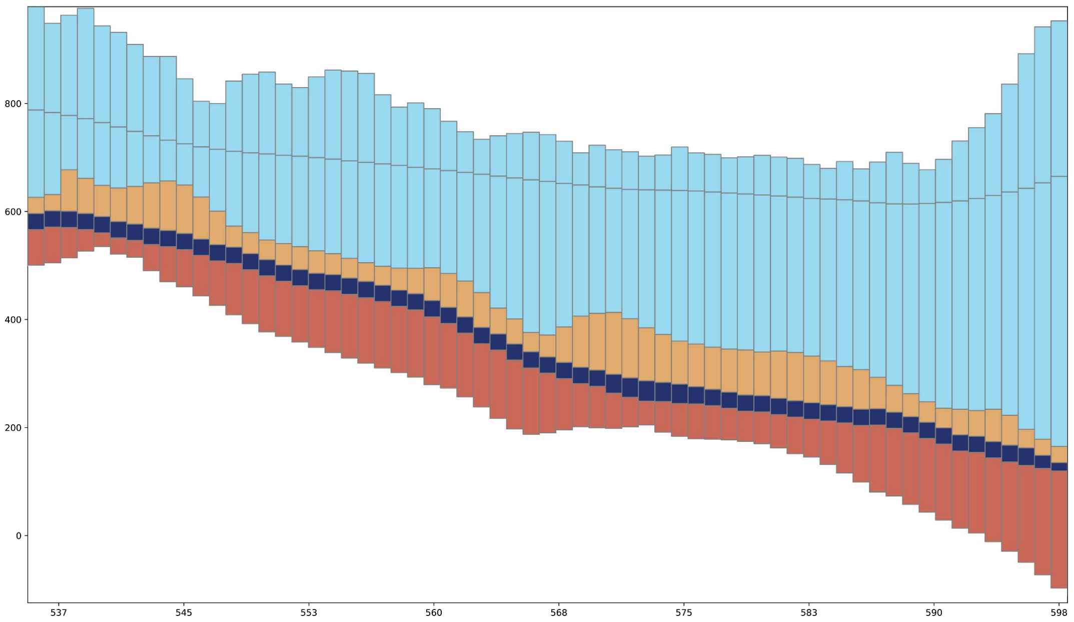
NTGAM model structure

Structure Update





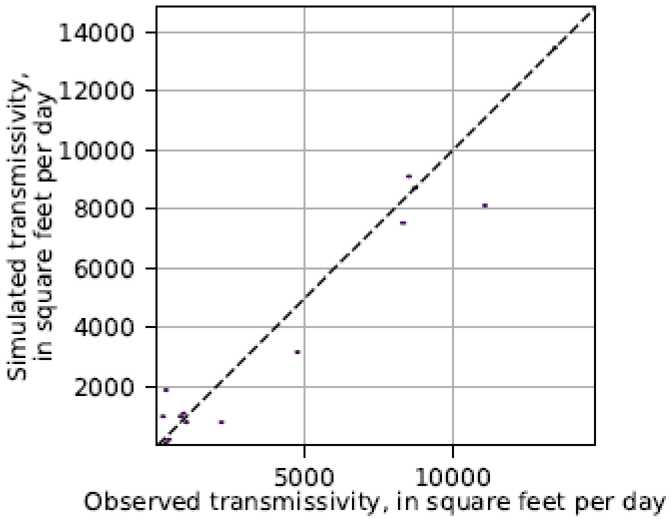
NTWGAM model structure



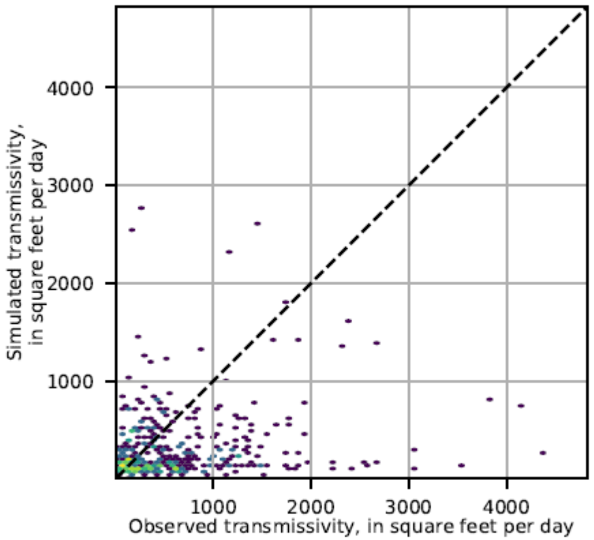
NTGAM model structure

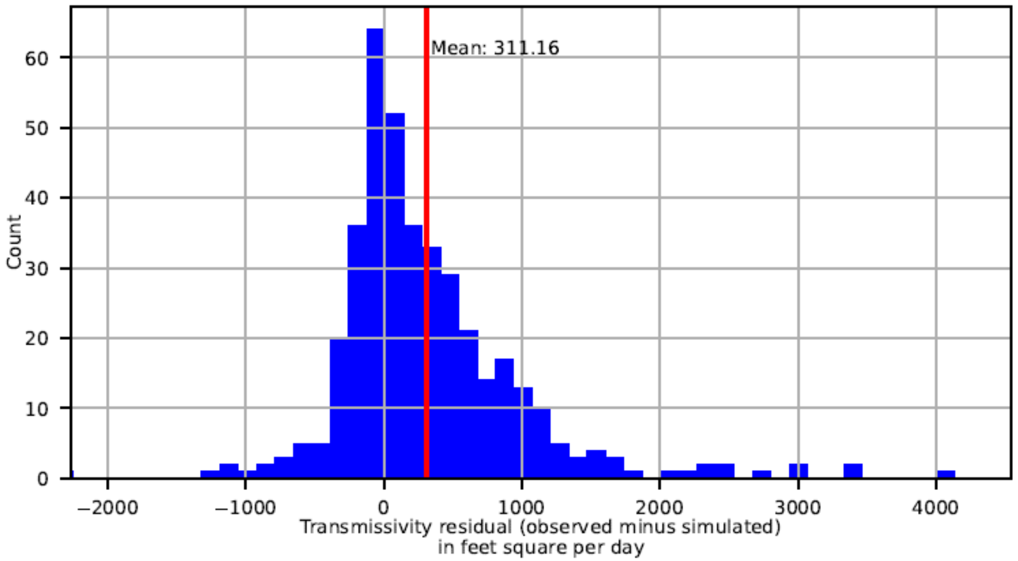
Transmissivity

CUWCD transmissivity residuals, 15 observations



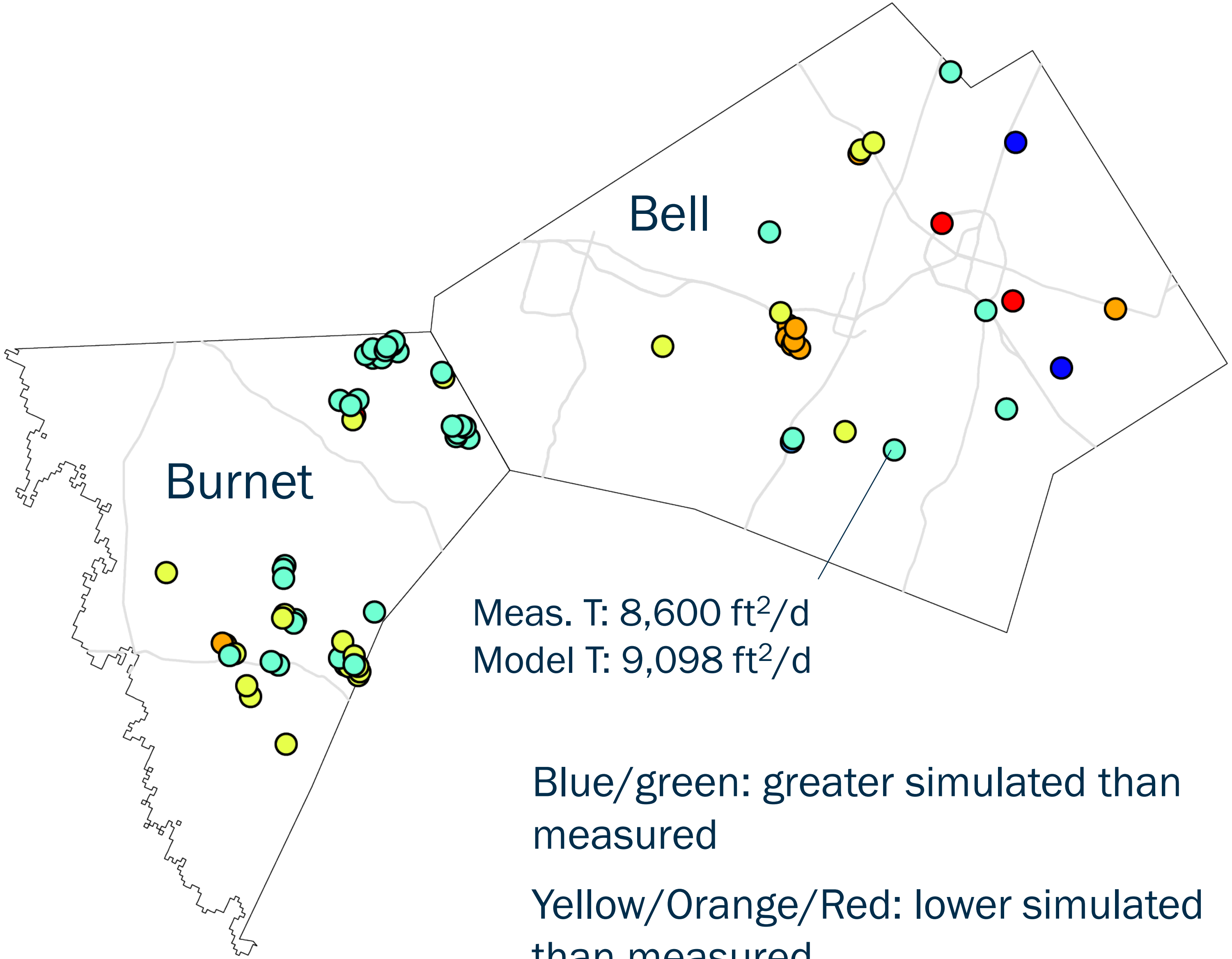
NTWGAM 2014 transmissivity residuals, 395 observations





Transmissivity

- Calibrated to transmissivity at selected locations in the NTGAM model area from 2014 and newer pump tests
- Generally good fit to these values



Blue/green: greater simulated than measured

Yellow/Orange/Red: lower simulated than measured

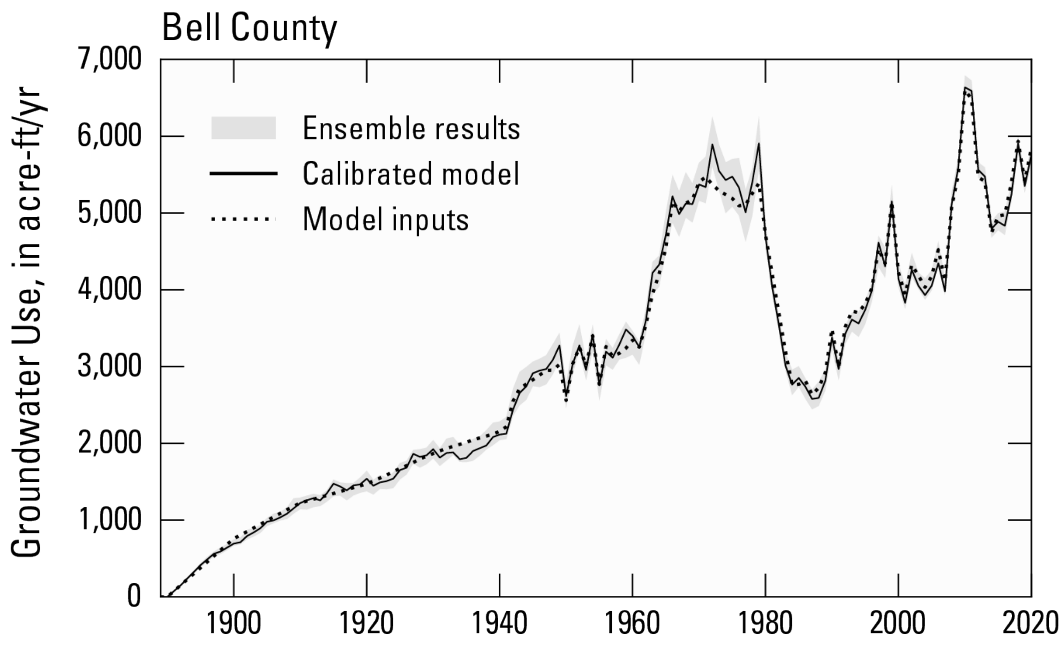
Water Use

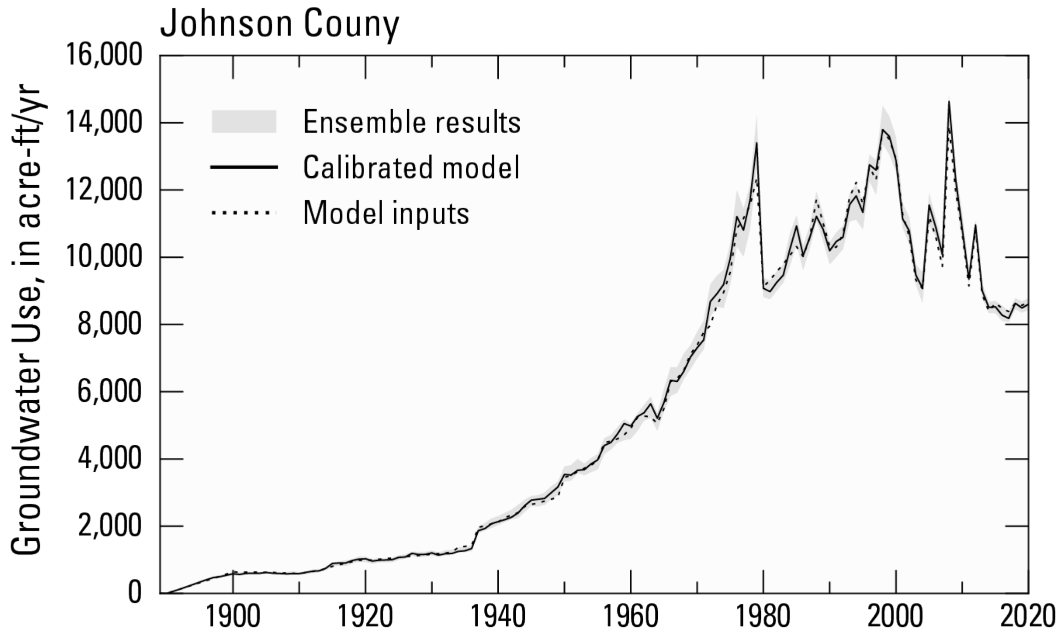
Rural/Domestic GW Use

- Generated estimates from 1980 through 2020
- Population based on census data
- Use population density threshold to obtain rural use.
- Considered the temporal variability of prior estimates during calibration

Layer 1 Water Use

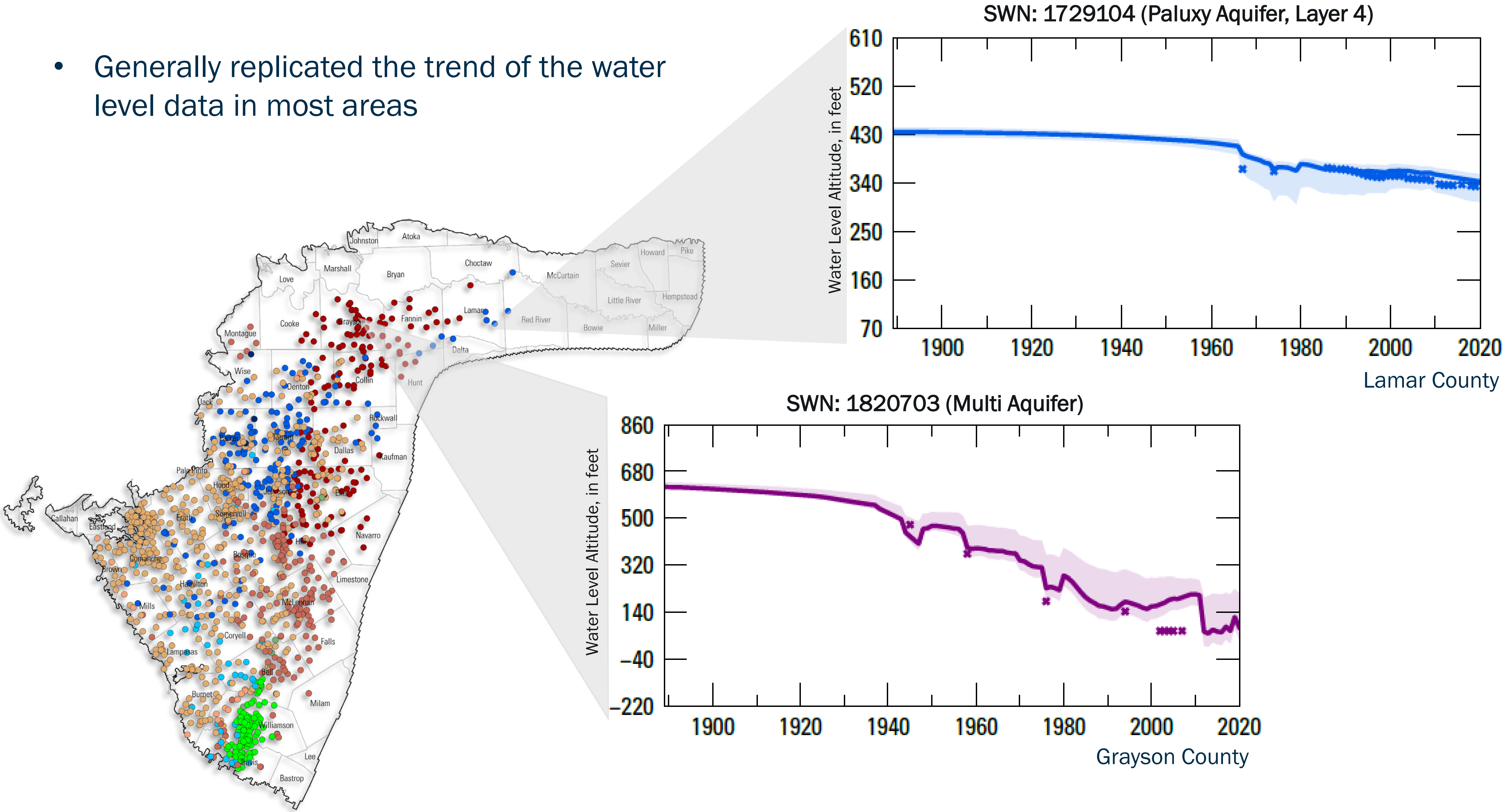
- Groundwater use is simulated in layer 1 just as the 2014 GAM
- Recharge conceptualization—a lot of water moving through layer 1 from recharge points to nearby river and stream cells





Calibration Results

- Generally replicated the trend of the water level data in most areas



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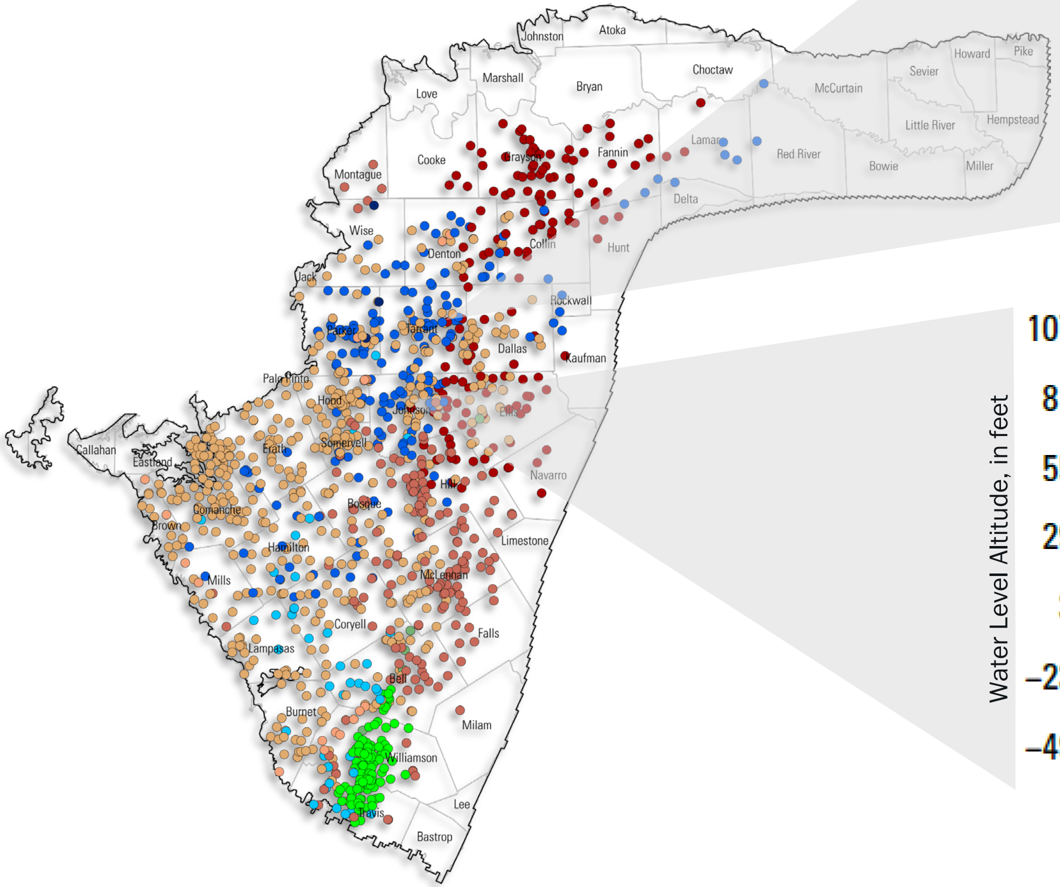
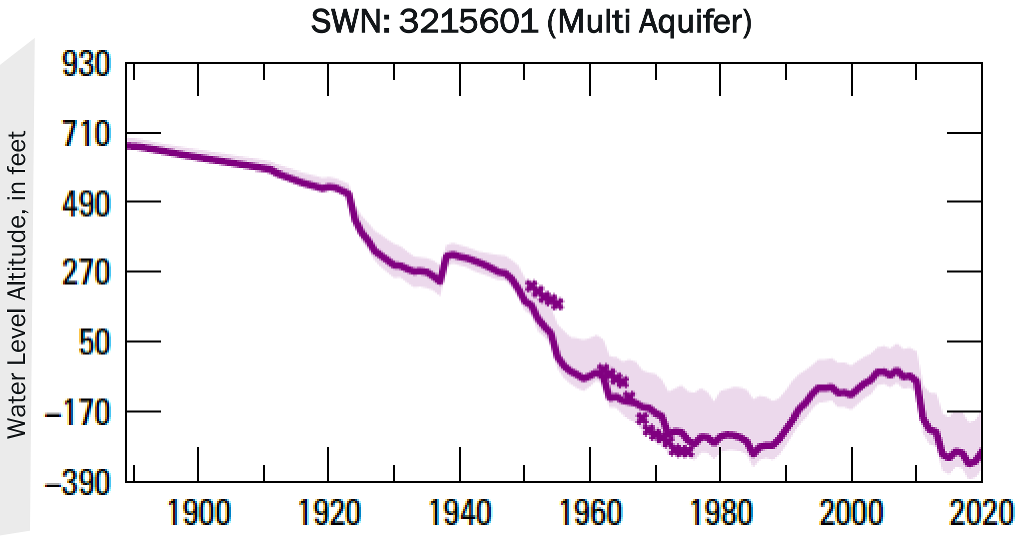
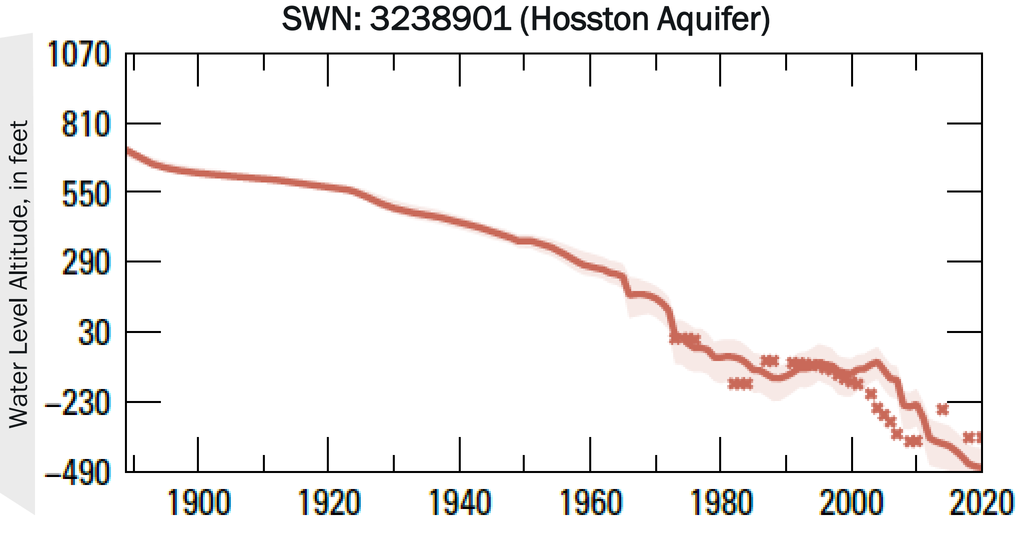




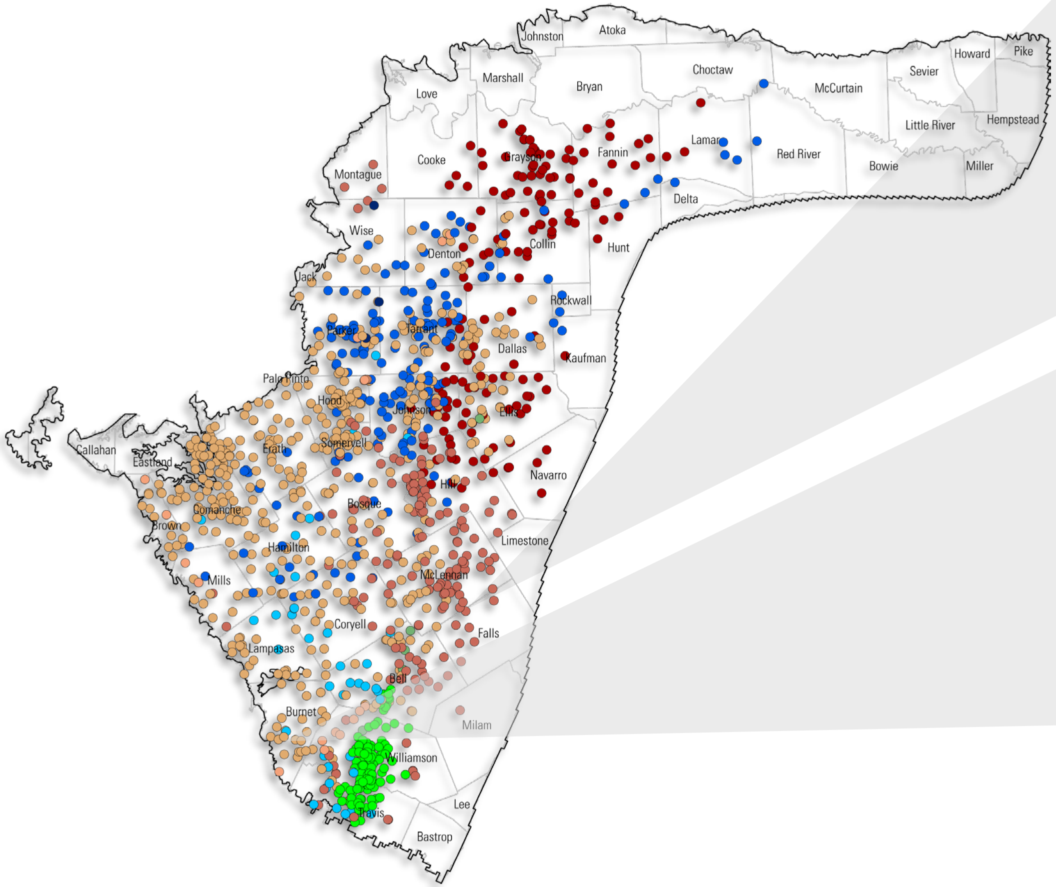
Tarrant County

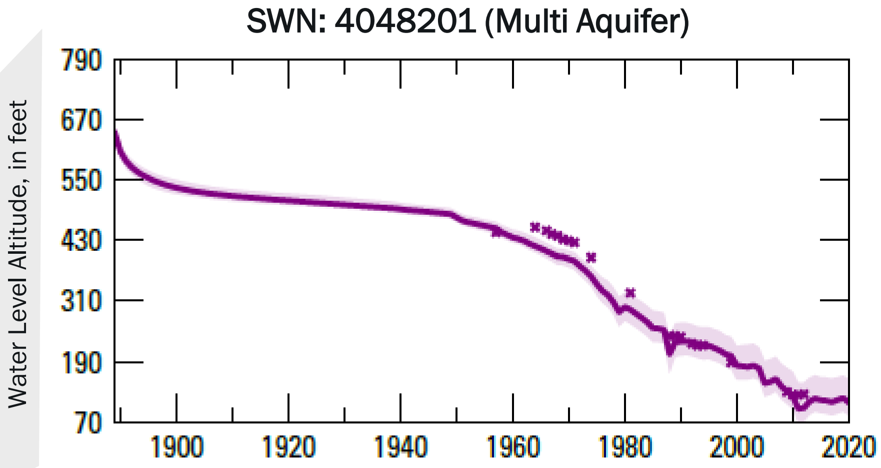


Johnson County

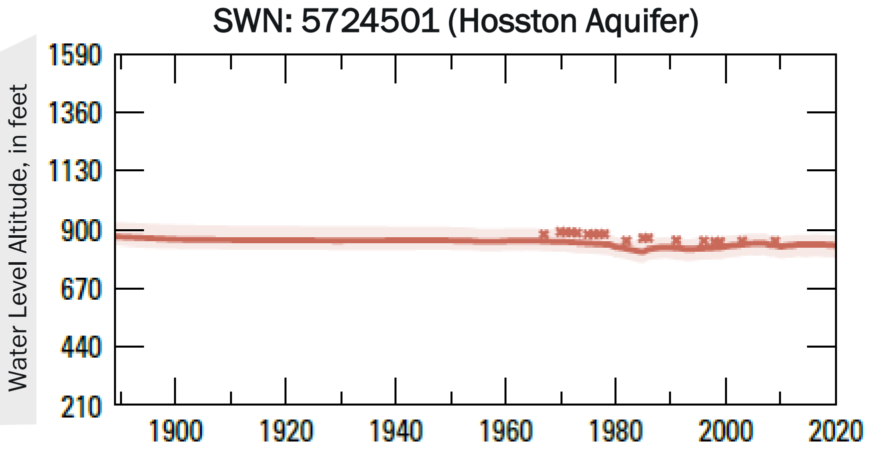
Calibration Results

- Generally replicated the trend of the water level data in most areas





Falls County

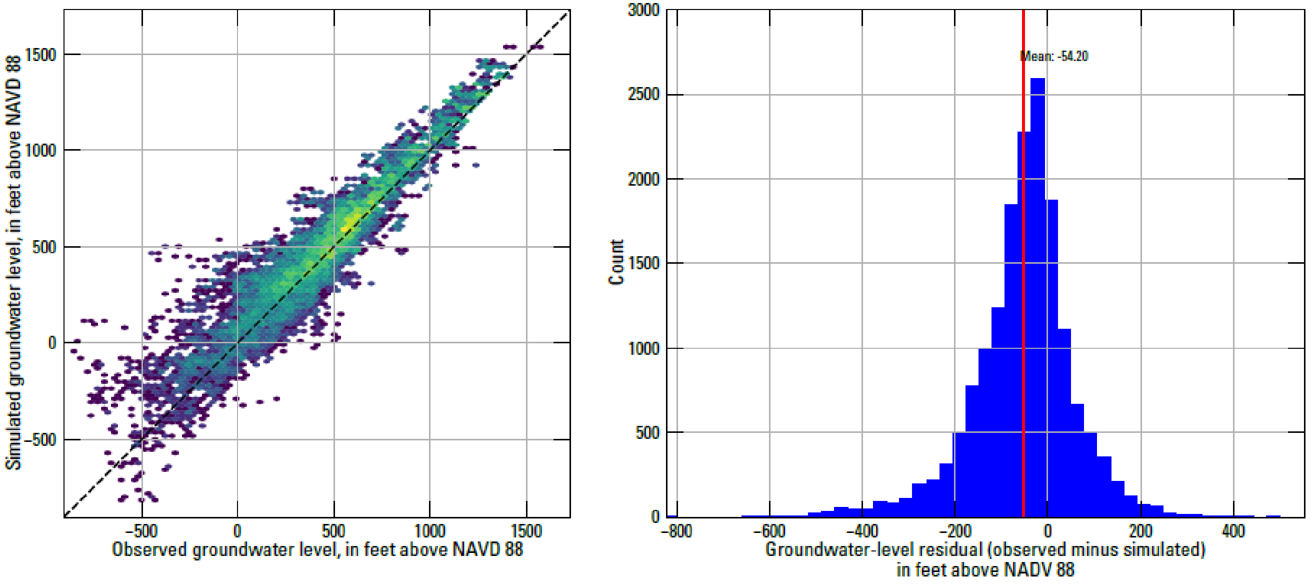


Burnet County

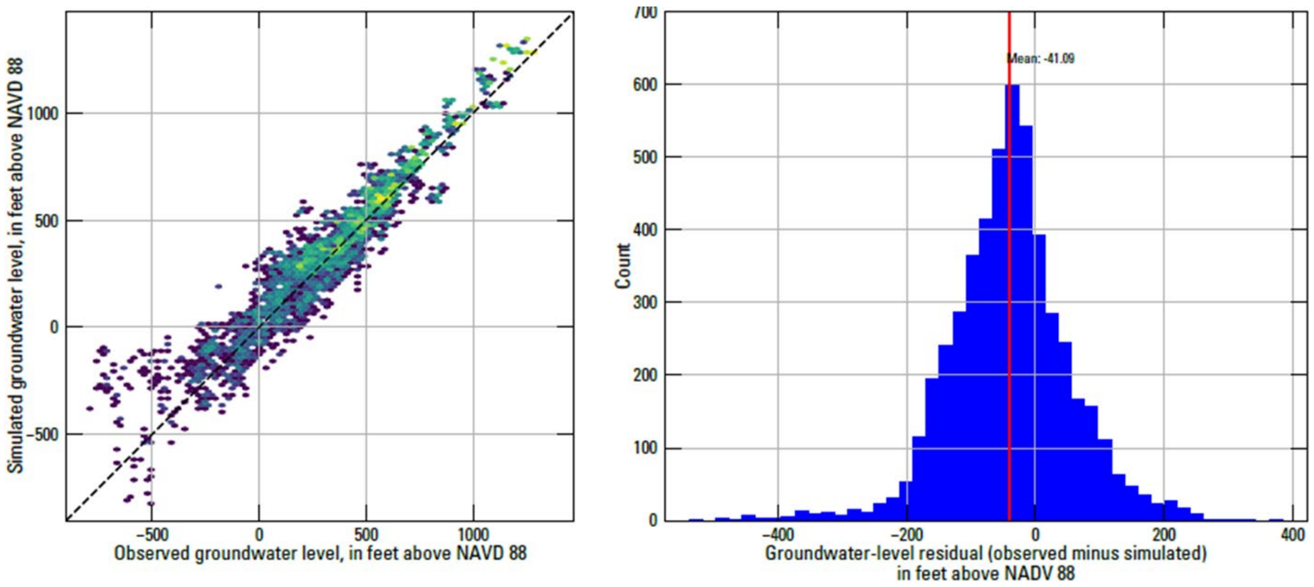
Calibration Results

- Water levels are the primary calibration target
- Focused the calibration on the most accurate water level data
- 45% of the calibration effort focused on wells with screen information and long-term data
- Water levels with greater uncertainty include: (1) wells without screen information, and (2) airline measurements
- Mean residuals of -54 ft for all wells and -41 ft for key wells

All wells used for calibration



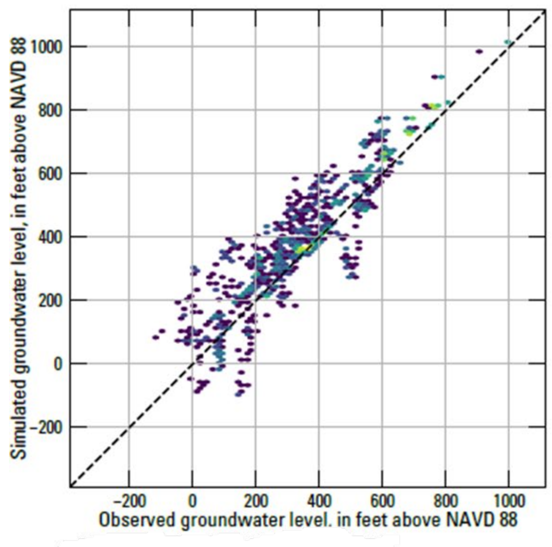
Long-term wells with screen information – All Layers

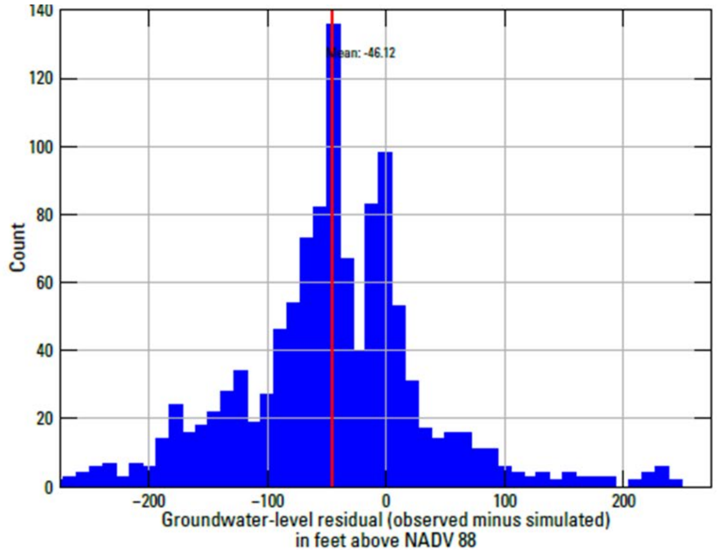


Calibration Results

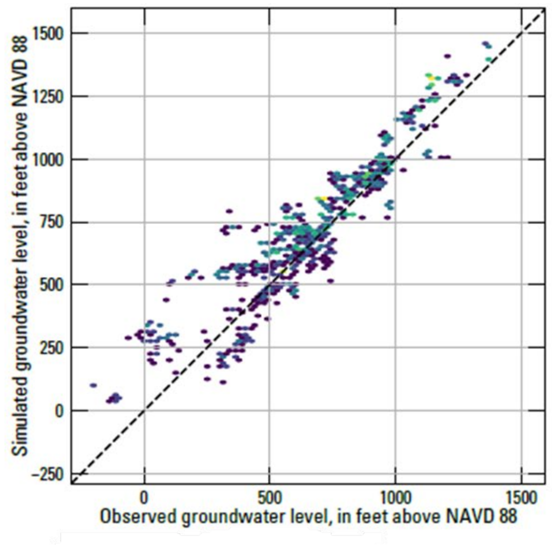
- Water-level data also grouped by layer for calibration
- Residuals of all water levels in Paluxy and Hensell aquifers at right
- Overall normal gaussian distribution of residuals
- Mean residuals of -46 ft for Paluxy and -72 ft for Hensell

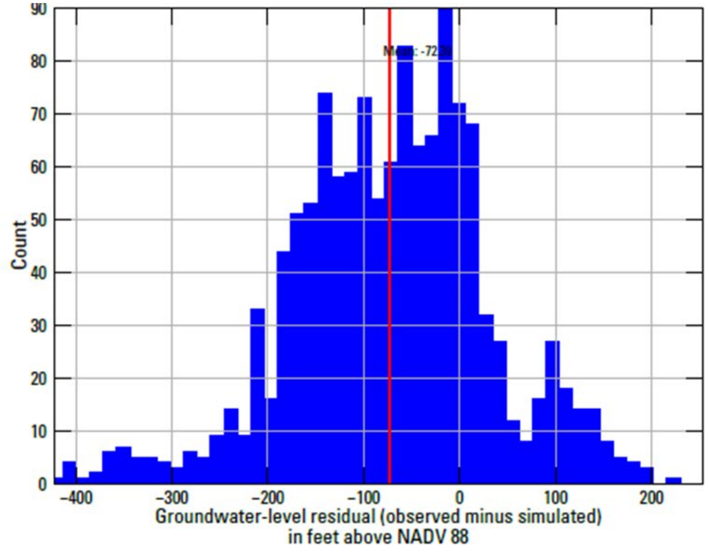
All water levels in Paluxy aquifer





All water levels in Hensell aquifer

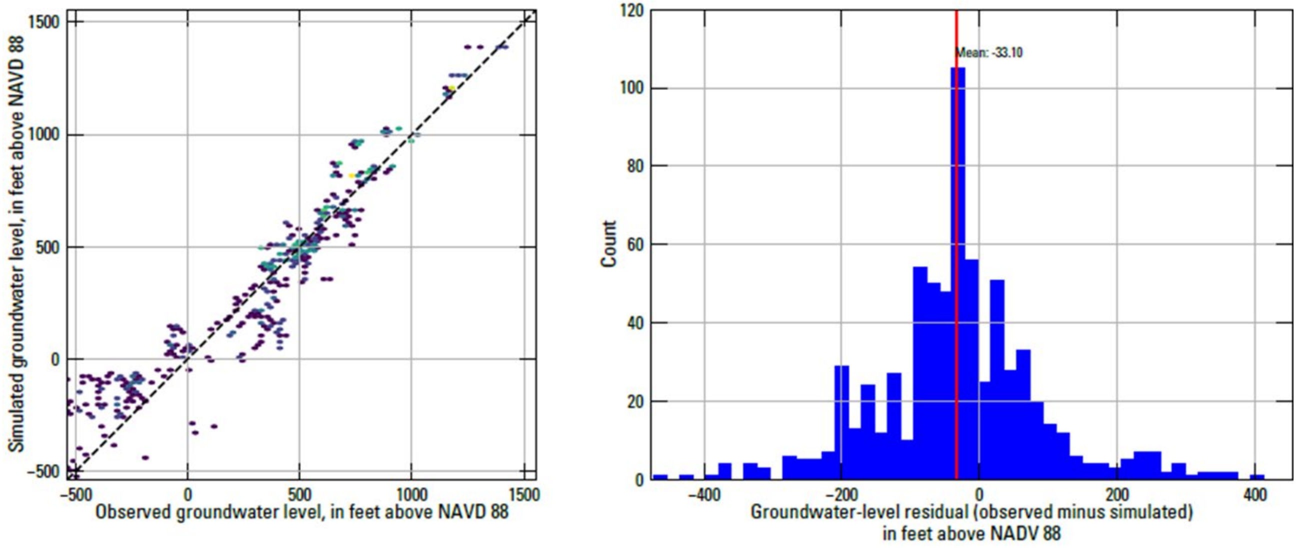




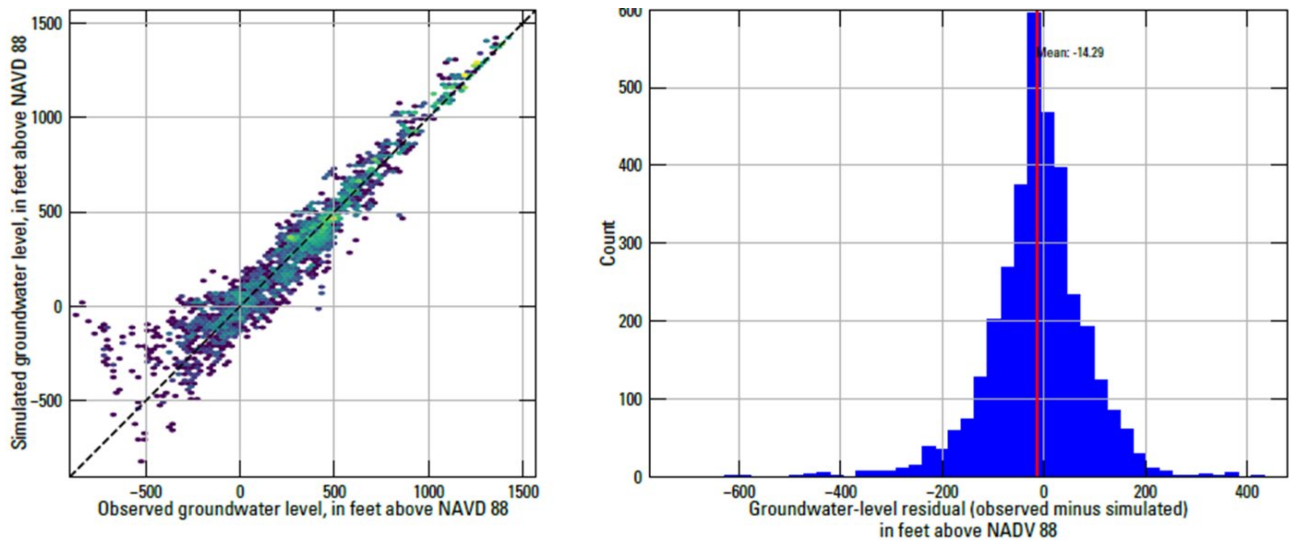
Calibration Results

- Residuals of all water levels in Pearsall and Hosston aquifers at right
- All mean absolute error (MAE) values lower than 10 percent of the measured ranges by layer – **GAM standard**
- Mean residuals of -33 ft for Pearsall and -14 ft for the Hosston
- Best water-level fit attained in **Hosston aquifer**, despite also having largest number of Transmissivity observations

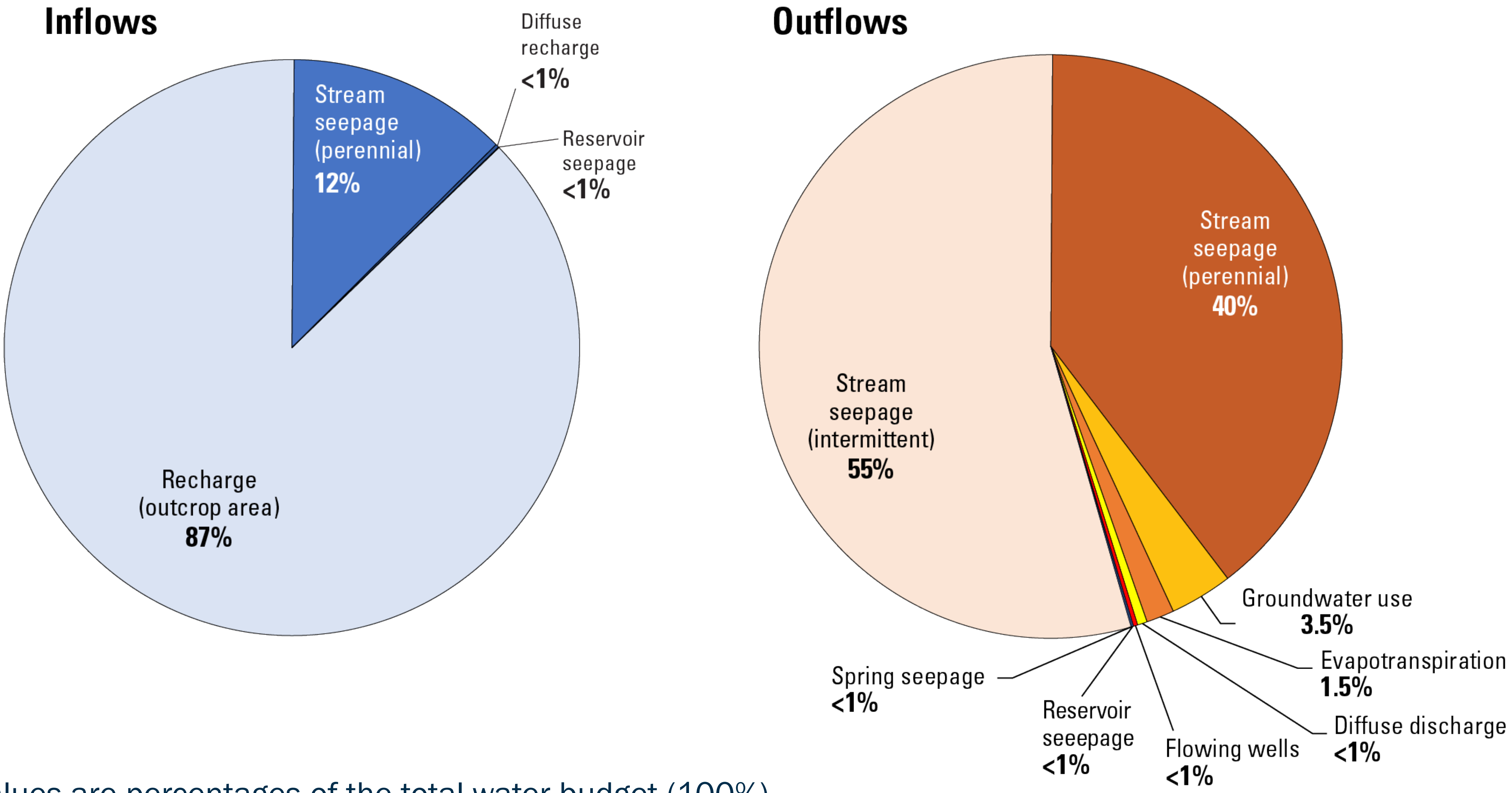
All water levels in Pearsall aquifer



All water levels in Hosston aquifer



Water Budget



These values are percentages of the total water budget (100%)

DFCs and MAG

- *Desired Future Conditions* (DFCs) specified for **GCDs (64)** and **counties (198)** by **aquifer and crop** (outcrop vs. down dip)
- *Modeled Available Groundwater* (MAG) derived from **Run 11** Predictive Simulation for GMA 8 Joint Planning (**2010 – 2080**)
- **For DFCs and MAG**, aquifers include Woodbine, Antlers, Glen Rose, Paluxy, Twin Mountains (multi layer), Travis peak (multi layer), Hensell, and Hosston

<table>
<tr><th>Model Layer</th><th>Region 1</th><th>Region 2</th><th>Region 3</th><th colspan="2">Region 4</th><th colspan="2">Region 5</th></tr>
<tr><td>2</td><td colspan="4">Woodbine</td><td colspan="3">Woodbine (no sand)</td></tr>
<tr><td>3</td><td colspan="7">Washita/Fredericksburg</td></tr>
<tr><td>4</td><td rowspan="5">Antlers</td><td colspan="4">Paluxy</td><td colspan="2">Paluxy (no sand)</td></tr>
<tr><td>5</td><td colspan="6">Glen Rose</td></tr>
<tr><td>6</td><td rowspan="3">Twin Mountains</td><td colspan="2" rowspan="3">Travis Peak</td><td>Hensell</td><td rowspan="3">Travis Peak</td><td>Hensell</td></tr>
<tr><td>7</td><td>Pearsall/Sligo</td><td>Pearsall/Sligo</td></tr>
<tr><td>8</td><td>Hosston</td><td>Hosston</td></tr>
</table>

Shi and Harding, 2022

overlapping aquifers

DFC results

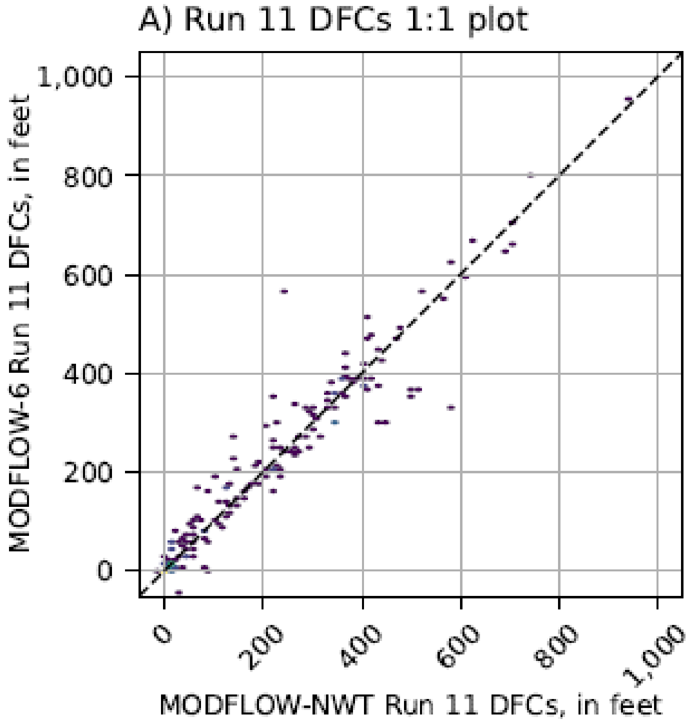
- Incorporated the Run 11 WEL in the NTGAM model. Place the Run 11 WEL file in the NTGAM model and run.
- Comparative DFC results summarized by GCD below (no DFC optimization)
- McLennan County (Southern Trinity GCD) in Hosston and Travis Peak aquifers – MAG reduced by ~8,000 AFY

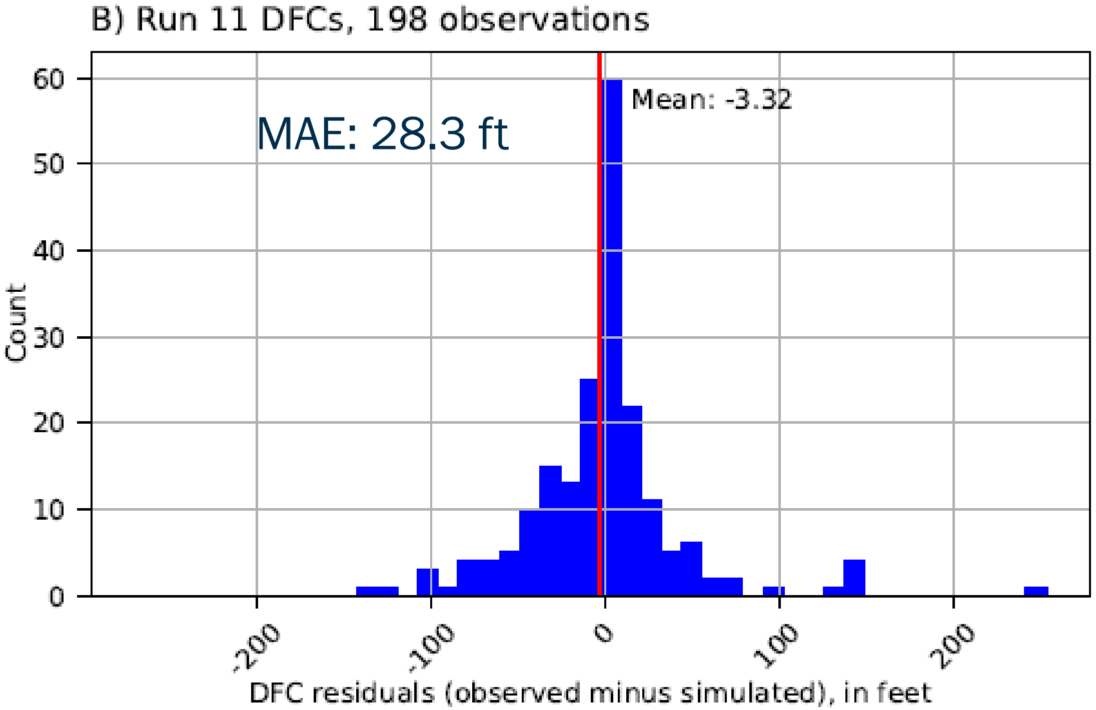
GCD	Average Difference (in feet)
Central Texas GCD	-5
Clearwater UWCD	27
Middle Trinity GCD	-23
North Texas GCD	18
Northern Trinity GCD	-17
Post Oak Savannah GCD	67
Prairielands GCD	-22
Red River GCD	37
Saratoga UWCD	-5
Southern Trinity GCD	62
Upper Trinity GCD	0

NTGAM – NTWGAM [2014 model] (+ recovery; - drawdown), in feet

DFC Optimization

- Optimized Run 11 WEL to fit **198 county DFCs** in predictive MODFLOW 6 simulation
- **Pumping rates within DFC target areas were proportionally adjusted** (not all DFC areas have run 11 wells; overlapping aquifers were adjusted by same proportion: e.g., Hosston and Travis Peak zones)
- Wells outside DFC areas adjusted independently. **All adjustable wells were optimized with a correlation length of 5 miles.**





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- Pumping rates within DFC target areas were proportionally adjusted (not all DFC areas have run 11 wells; overlapping aquifers were adjusted by same proportion, such as the Hosston and Travis Peak zones)
- Wells outside DFC areas adjusted independently. All adjustable wells were optimized with a correlation length of 5 miles.

GCD	Average Raw Difference (in feet)	Average Optimized Difference (in feet)
Central Texas GCD	-5	-1
Clearwater UWCD	27	-24
Middle Trinity GCD	-23	-17
North Texas GCD	18	-11
Northern Trinity GCD	-17	-2
Post Oak Savannah GCD	67	-9
Prairielands GCD	-22	-9
Red River GCD	37	6
Saratoga UWCD	-5	-5
Southern Trinity GCD	62	11
Upper Trinity GCD	0	18

NTGAM – NTWGAM [2014 model] (+ rebound; - drawdown), in feet

MAG Comparison

- **DFC Optimization:** average MAG decrease by ~7% across GMA 8 GCDs, particularly in Central Texas GCD– Calibration to aquifer test data reduced Transmissivity.

MAG Increase & Decrease with respect to Run 11 MAG (from NTWGAM [2014] model)

GCD	MAG % Difference	MAG AFY Difference (in acre feet)
Central Texas GCD	-47	-498
Clearwater UWCD	10	1765
Middle Trinity GCD	-15	-373
North Texas GCD	5	267
Northern Trinity GCD	-8	-138
Post Oak Savannah GCD	N/A*	N/A*
Prairielands GCD	-9	19
Red River GCD	2	-140
Saratoga UWCD	46	226
Southern Trinity GCD	-12	-3316
Upper Trinity GCD	-8	-469

*Post Oak Savannah GCD does not have a MAG established for GMA 8 from the 2021 planning cycle

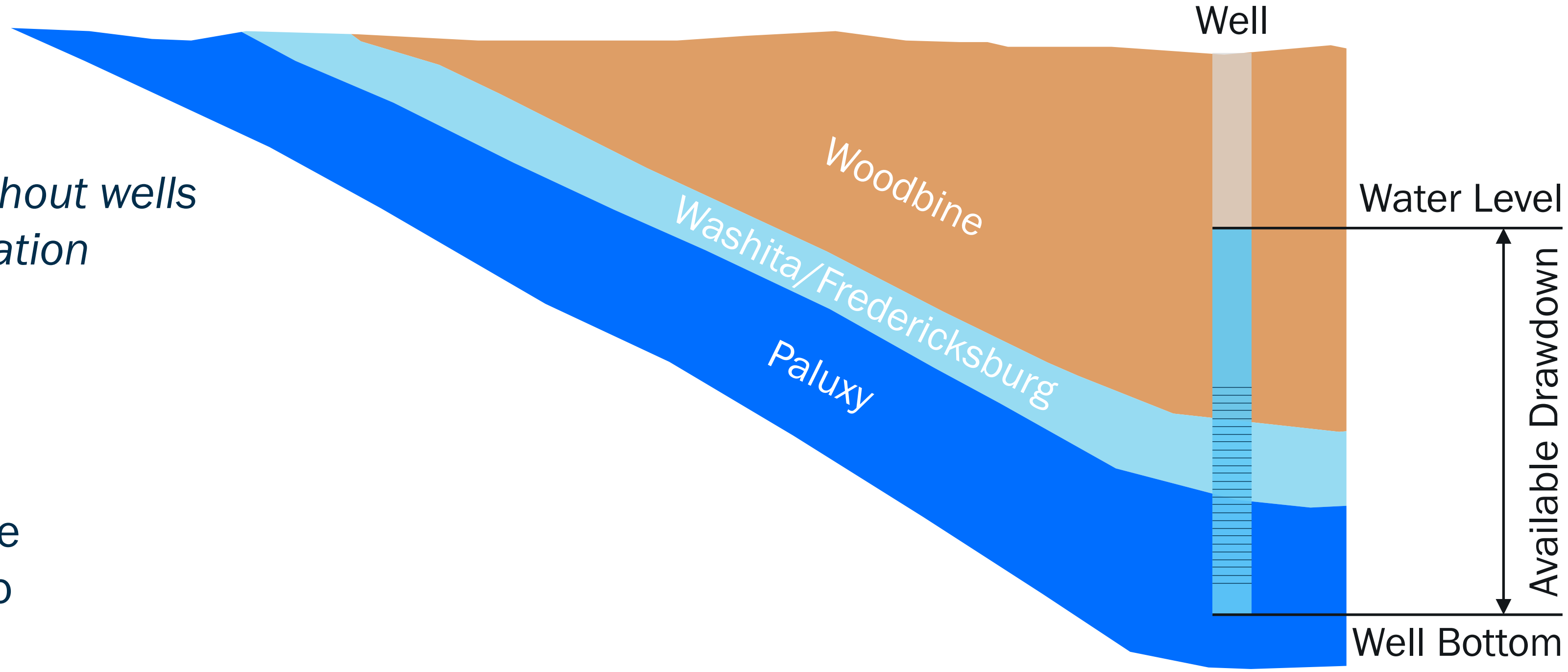
Drawdown Optimization

Available drawdown = Initial Water Level – Total Depth of Well

- The goal was to quantify MAG when available drawdown at the end of the predictive period (2080) matches the starting condition (2010) – **100 % Available Drawdown in 2080**
- Optimized Run11 WEL to match the 2080 median available drawdown to the 2010 median available drawdown on a County basis using NTWGAM calibration database

Counties without wells in the calibration database:

- Brown
- Callahan
- Jack
- Limestone
- Palo Pinto
- Taylor
- Shackelford



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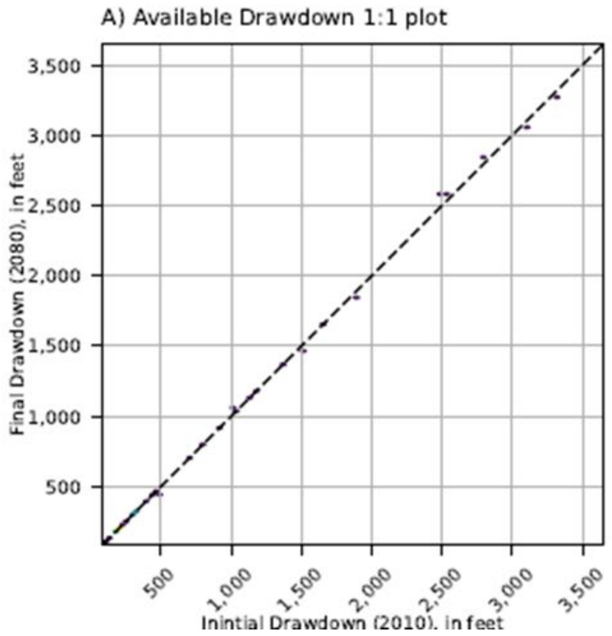
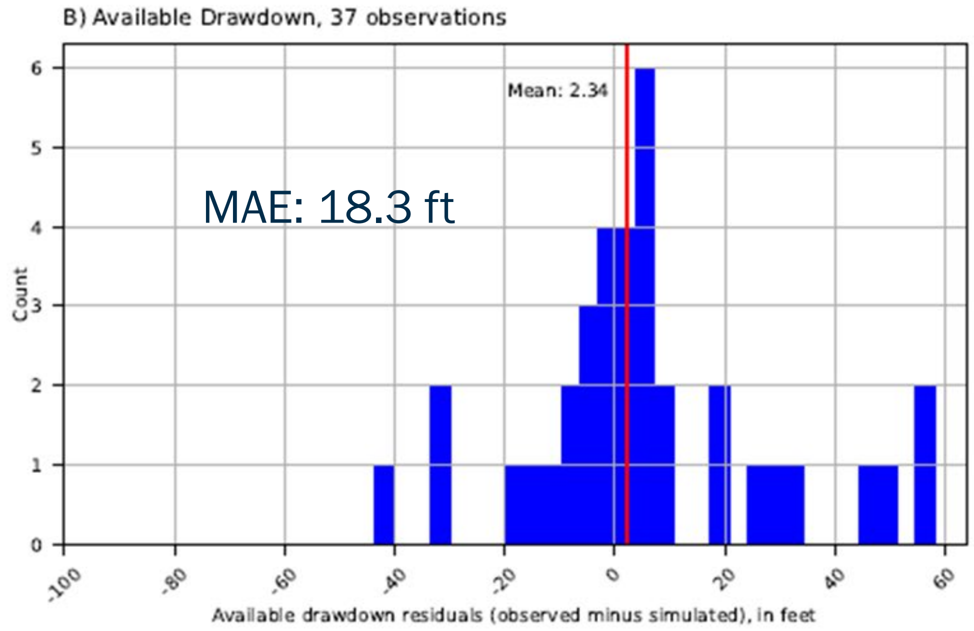




MAG Comparison

- **100% Sustainable Drawdown:** average decrease in MAG by ~45% across GMA 8 GCDs.

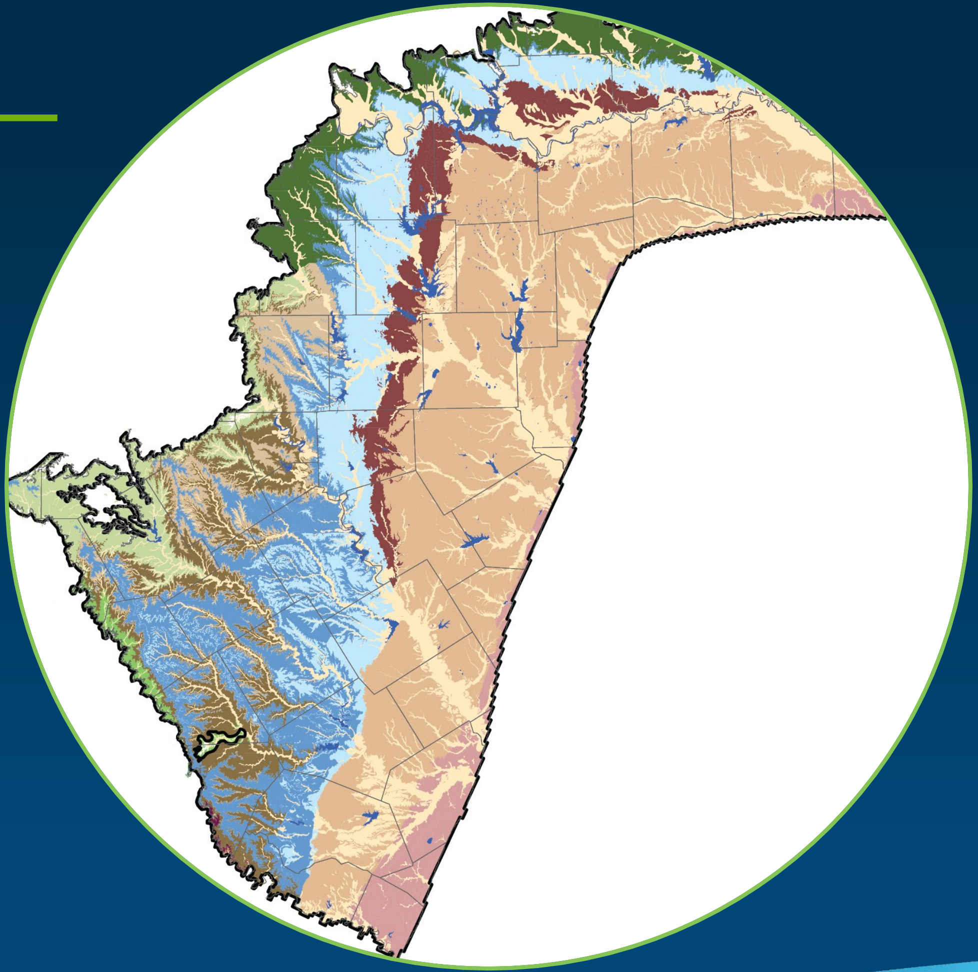
MAG Decrease with respect to Run 11 MAG (from NTWGAM [2014] model)

GCD	MAG % Difference	MAG AFY Difference (in acre feet)
Central Texas GCD	-54	-577
Clearwater UWCD	-80	-2924
Middle Trinity GCD	-47	-1061
North Texas GCD	-61	-2136
Northern Trinity GCD	-17	-397
Post Oak Savannah GCD	N/A*	N/A*
Prairielands GCD	-35	-391
Red River GCD	-55	-2426
Saratoga UWCD	-37	-172
Southern Trinity GCD	-26	-4875
Upper Trinity GCD	-50	-1504
Total	**-45**	**-1193**

*Post Oak Savannah GCD does not have a MAG established for GMA 8 from the 2021 planning cycle

Agenda Item 8

- Discussion and possible action on model runs for DFC Joint Planning



INTERA

GMA 8 DFCs

By aquifer for GMA 8

GMA 8 Adopted DFCs -Aquifer-Wide Scale (in feet)	
Woodbine	146
Paluxy	193
Glen Rose	148
Twin Mountain	345
Travis Peak	207
Hensell	148
Hosston	262
Antlers	193

By aquifer for each GCD

GMA 8 Adopted DFCs - GCD Scale (in feet)

GCD	Wood-bine	Paluxy	Glen Rose	Twin Mtn	Travis Peak	Hensell	Hosston	Antlers
Central Texas GCD	—	—	2	—	19	7	21	—
Clearwater UWCD	—	17	83	—	333	145	375	—
Middle Trinity GCD	—	5	29	8	98	77	124	12
North Texas GCD	263	690	366	601	—	—	—	305
Northern Trinity GCD	6	105	163	348	—	—	—	177
Post Oak Savannah GCD	—	—	241	—	412	261	412	—
Prairielands GCD	44	44	142	170	323	201	364	—
Red River GCD	209	830	335	405	291	—	—	321
Saratoga UWCD	—	—	1	—	6	1	11	—
Southern Trinity GCD	6	41	148	—	504	242	582	—

INTERA

GMA 8 DFCs

GMA 8 Adopted DFCs - County Scale (in feet)

GCD	County	Woodbine	Paluxy	Glen Rose	Twin Mountain	Travis Peak	Hensell	Hosston	Antlers
Red River GCD	Fannin	259	709	305	400	291	—	—	269
	Grayson	163	943	364	445	—	—	—	364
North Texas GCD	Collin	482	729	366	560	—	—	—	596
	Cooke	2	—	—	—	—	—	—	191
	Denton	22	558	367	752	—	—	—	416
Northern Trinity GCD	Tarrant	6	105	163	348	—	—	—	177
Prairielands GCD	Ellis	76	128	220	413	380	290	390	—
	Hill	20	45	149	—	365	211	413	—
	Johnson	4	57	66	184	235	120	329	—
	Somervell	—	4	4	50	64	17	120	—
Middle Trinity GCD	Bosque	—	6	53	—	189	139	232	—
	Comanche	—	—	2	—	4	2	3	12
	Coryell	—	5	15	—	107	70	141	—
	Erath	—	6	6	8	25	12	35	14
Southern Trinity GCD	McLennan	6	41	148	—	504	242	582	—
Clearwater UWCD	Bell	—	17	83	—	333	145	375	—
Post Oak Savannah GCD	Milam	—	—	241	—	412	261	412	—
Central Texas GCD	Burnet	—	—	2	—	19	7	21	—
Saratoga UWCD	Lampasas	—	—	1	—	6	1	11	—

INTERA

GMA 8 DFCs

By outcrop and subcrop (in feet)

County	Antlers	Paluxy	Glen Rose	Twin Mountains
Hood -Outcrop	—	6	9	13
Hood-Downdip	—	—	39	72
Montague-Outcrop	40	—	—	—
Montague-Downdip	—	—	—	—
Parker-Outcrop	42	6	20	7
Parker-Downdip	—	2	50	68
Wise-Outcrop	60	—	—	—
Wise-Downdip	154	—	—	—

Edwards BFZ

County	Adopted Desired Future Condition
Bell	Maintain at least 100 acre-feet per month of stream/spring flow in Salado Creek during a repeat of the drought of record
Travis	Maintain at least 42 acre-feet per month of aggregated stream/spring flow during a repeat of the drought of record
Williamson	Maintain at least 60 acre-feet per month of aggregated stream/spring flow during a repeat of the drought of record

Llano Uplift (in feet)

County	Ellenburger-San Saba	Hickory	Marble Falls
Brown	3	3	3
Burnet	12	11	11
Lampasas	16	16	16
Mills	9	9	9

INTERA

Groundwater Management Area 8

February 25, 2025

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Clarification / Disclaimer

- GCDs in GMA 8 will determine DFCs, not the hydrogeologic consultant.
- Chapter 36 of the Texas Water Code contains concepts that blend legal and technical issues. INTERA and AGS are not law firms, and do not provide legal advice. Any statements relating to regulatory or legal issues shall not be considered legal advice.
- INTERA and AGS may provide commentary based on our experience working with groundwater conservation districts, permitting, joint groundwater planning, GCD rules and management plans, water supply entities, and our general understanding of industry practices.

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9 Factors to consider

Aquifer Uses or Conditions	Supply Needs & Management Strategies	Hydrological Conditions
Environmental Impacts	Subsidence Impacts	Socioeconomic Impacts
Private Property Rights	DFC Feasibility	Other Relevant Information

Agenda Item 9

Presentation by AGS, discussion and possible action by District Representatives on three of the nine factors in accordance with TWC 36.108(d):

a. Aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another

b. Other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water; and

c. The impact on subsidence

Balance test for Desired Future Conditions

Highest Practicable Level of Groundwater Production

Conservation, Preservation, Protection, Recharging, and Prevention of Waste of Groundwater, and Control of Subsidence

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Factor 1- Aquifer Uses and Conditions

(1) AQUIFER USES OR CONDITIONS WITHIN THE MANAGEMENT AREA, INCLUDING CONDITIONS THAT DIFFER SUBSTANTIALLY FROM ONE GEOGRAPHIC AREA TO ANOTHER;

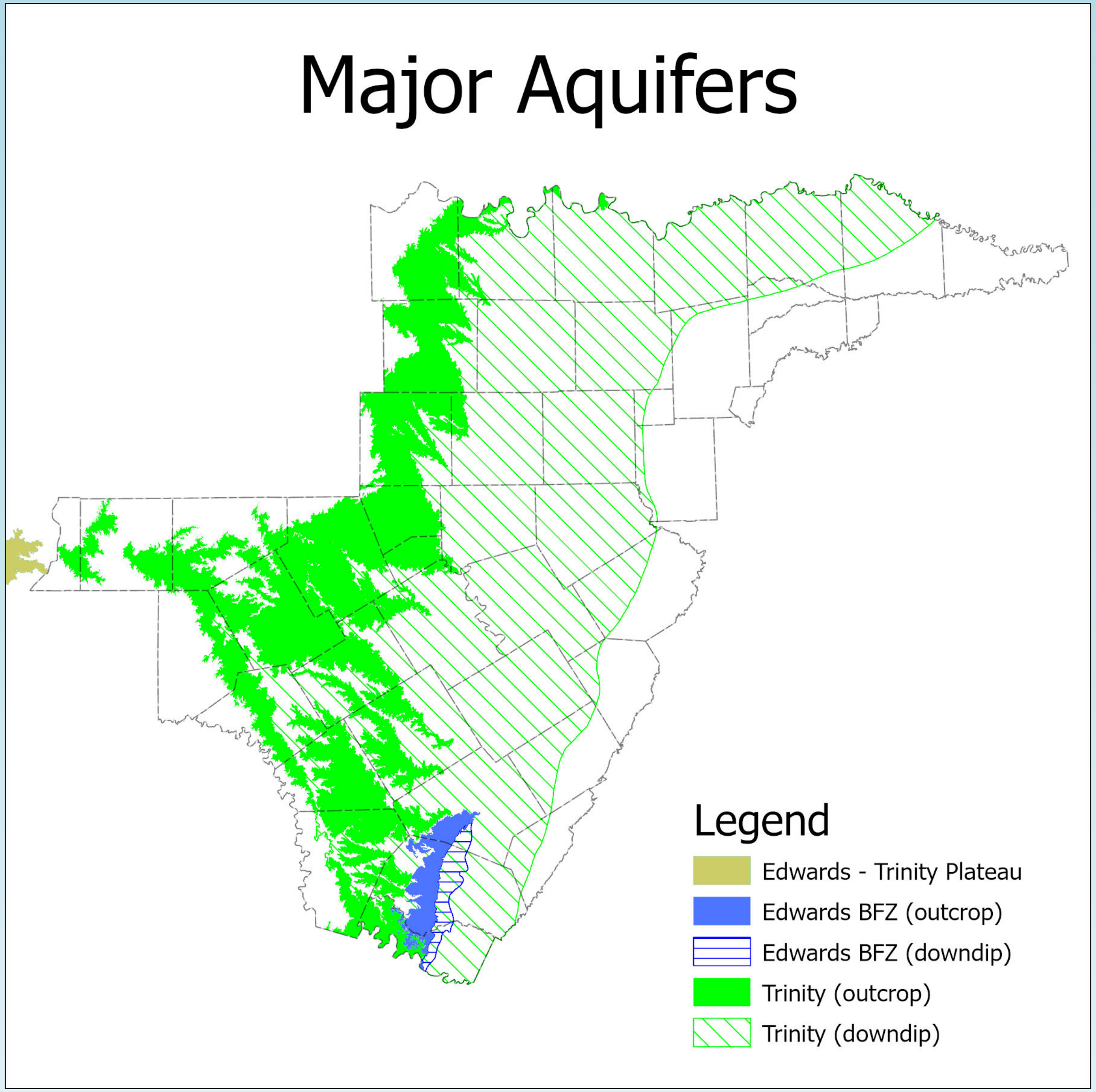
Groundwater Acronyms and Definitions

- **GCD - Groundwater Conservation District:** any district or authority created under Section 52, Article III, or Section 59, Article XVI, Texas Constitution, that has the authority to regulate the spacing of water wells, the production from water wells, or both. (TWC Ch. 36)
- **GMA - Groundwater Management Area:** an area designated and delineated by the Texas Water Development Board under Chapter 35 as an area suitable for management of groundwater resources. (TWC Ch. 36)
- **DFC - Desired Future Condition:** a quantitative description, adopted in accordance with Section 36.108, of the desired condition of the groundwater resources in a management area at one or more specified future times. (TWC Ch. 36)
- **MAG - Modeled Available Groundwater:** the amount of water that the executive administrator (of TWDB) determines may be produced on an average annual basis to achieve a desired future condition established under Section 36.108. (TWC Ch. 36)
- **Aquifer:** a rock unit that can yield economically usable quantities of water to a well.
- **Water Level (Head):** the level to which water rises in a well. A measure of the pressure in an aquifer.
- **Drawdown:** a water level change (usually drop) at a well or on a regional basis.
- **Recharge:** the amount of water that infiltrates to the water table of an aquifer.

GMA 8 Aquifers

Major Aquifers

- Trinity
- Edwards-BFZ
- Edwards-Trinity (Plateau)*

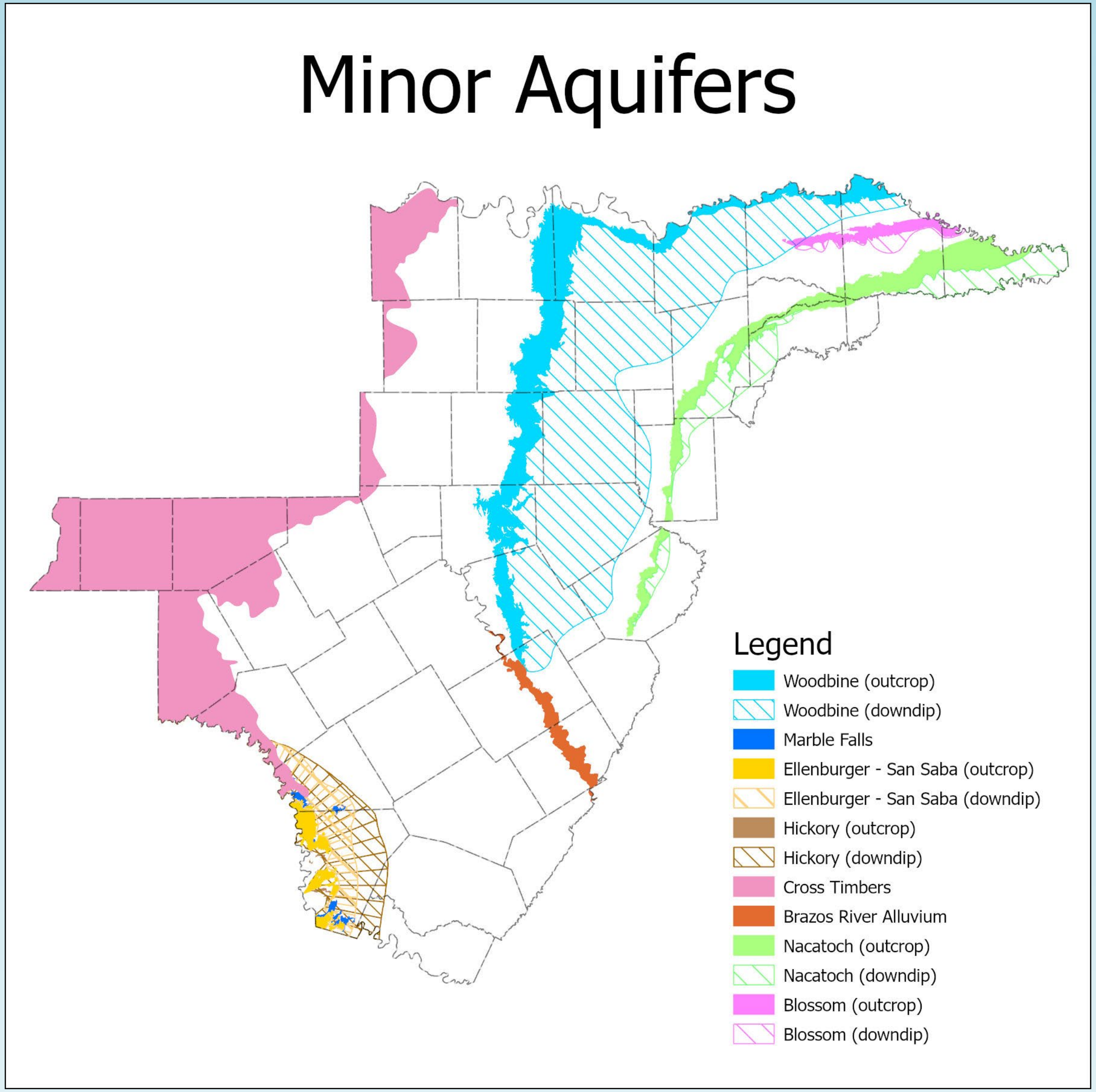


* Non-relevant in last round of planning

GMA 8 Aquifers

Minor Aquifers

- Woodbine
- Ellenburger-San Saba
- Hickory
- Marble Falls
- Blossom*
- Brazos River Alluvium*
- Cross Timbers*
- Nacatoch*
- *Other Aquifers*



* Non-relevant in last round of planning

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Aquifer Uses

- Includes the following per TWDB:
  - *<u>Municipal</u>- city-owned, districts, WSCs, or private utilities supplying residential, commercial (non-goods-producing businesses), and institutional, and non-surveyed municipal (rural domestic)*
  - *<u>Manufacturing</u>- process water use reported by large manufacturing plants*
  - *<u>Livestock</u>*
  - *<u>Irrigation</u>*
  - *<u>Mining</u>- includes water used in the mining of oil, gas, coal, sand, gravel, and other materials*
  - *<u>Steam-Electric Power</u>- consumptive use of water by large power generation plants*

Aquifer Uses and Conditions

- Aquifer Uses
  - *2022 TWDB historic use data*
  - *Total pumping in GMA 8 in 2022 = 271,713 acre-feet*
- Aquifer Conditions
  - *General conditions presented today*
  - *Details on hydrologic conditions for each aquifer will be presented with the "hydrologic conditions" factor discussion*

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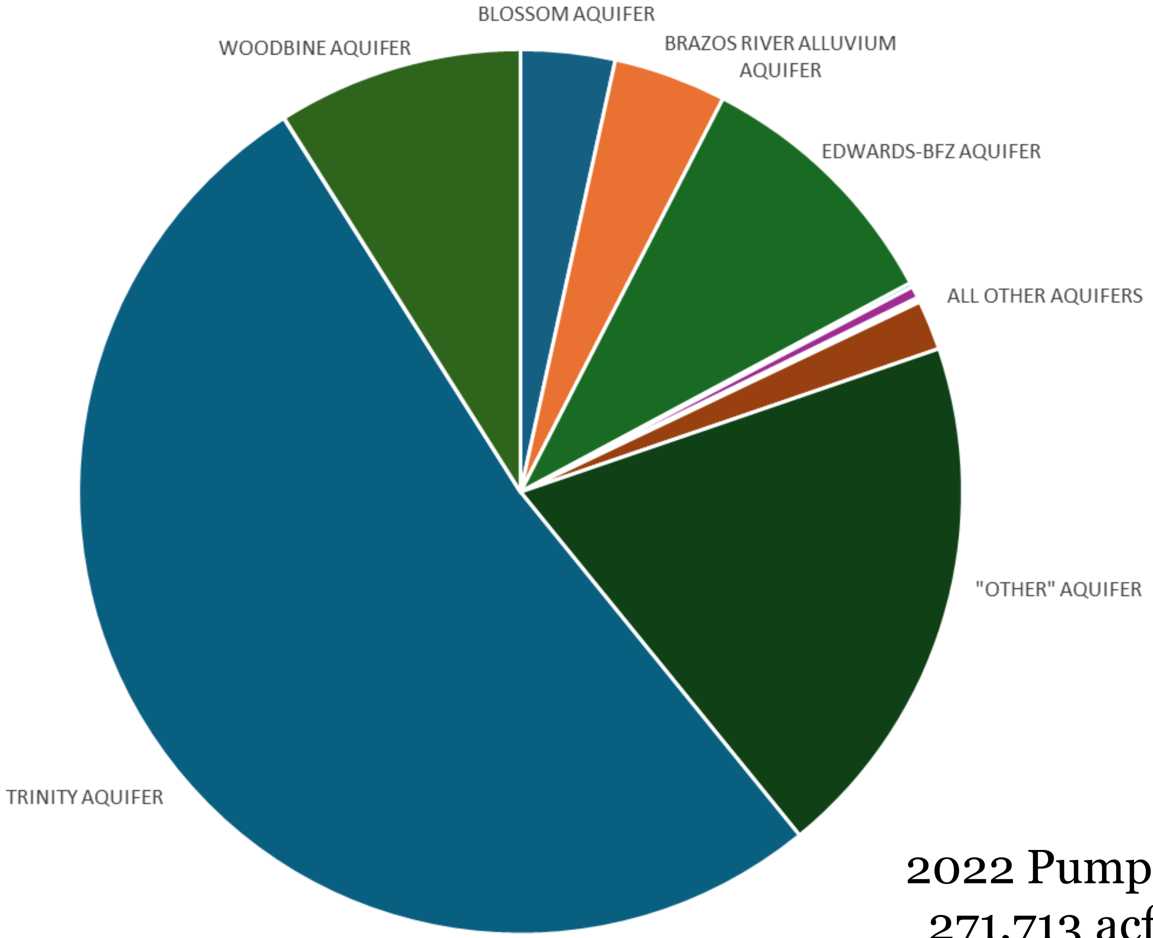
2022 Groundwater Pumping in GMA 8



2022 Pumping = 271,713 acft/yr

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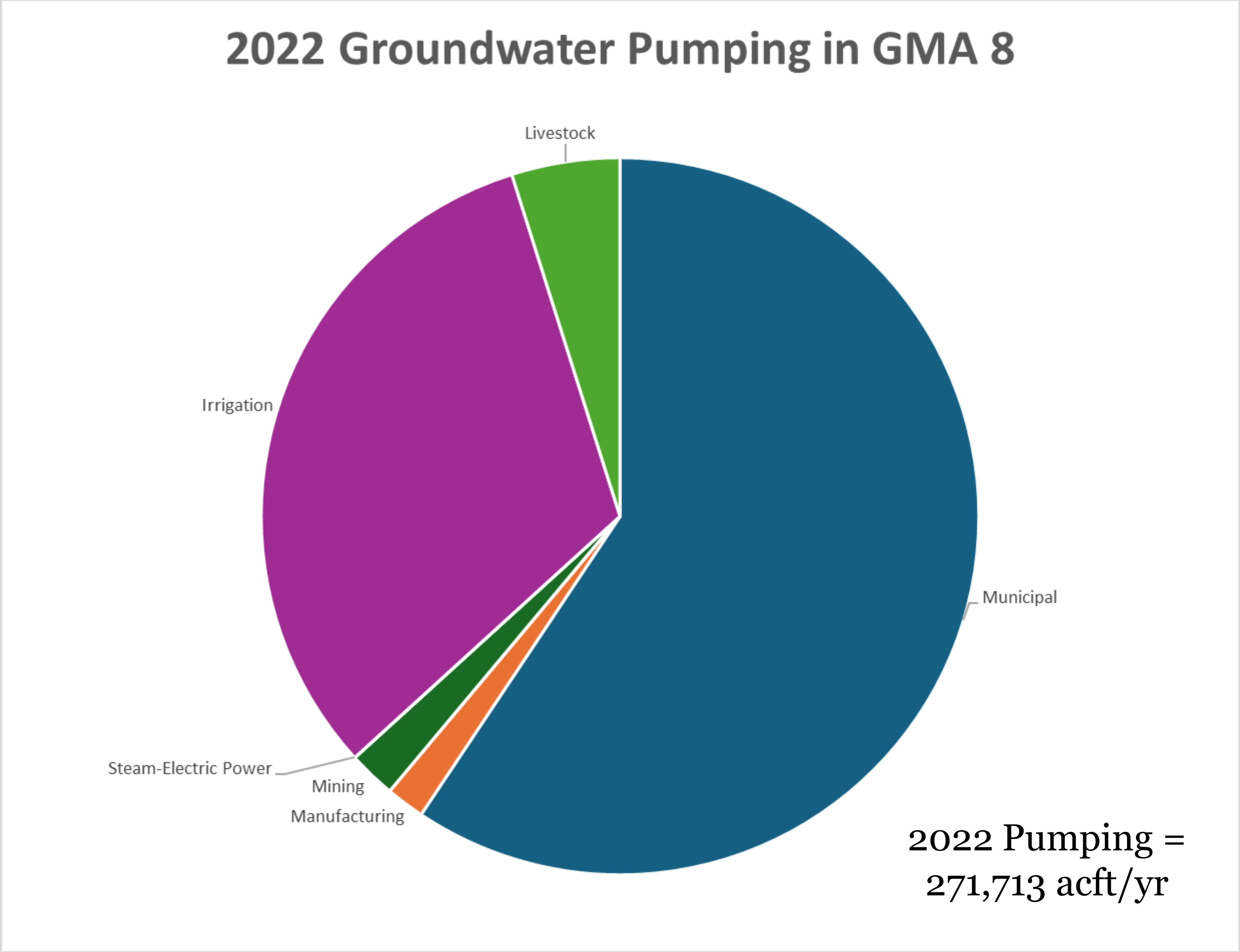

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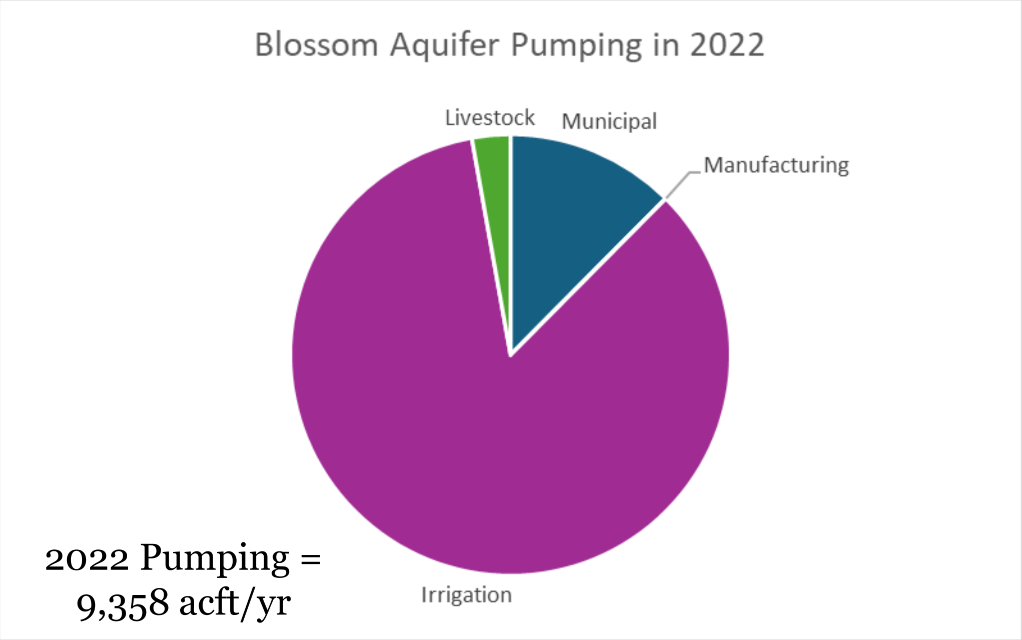

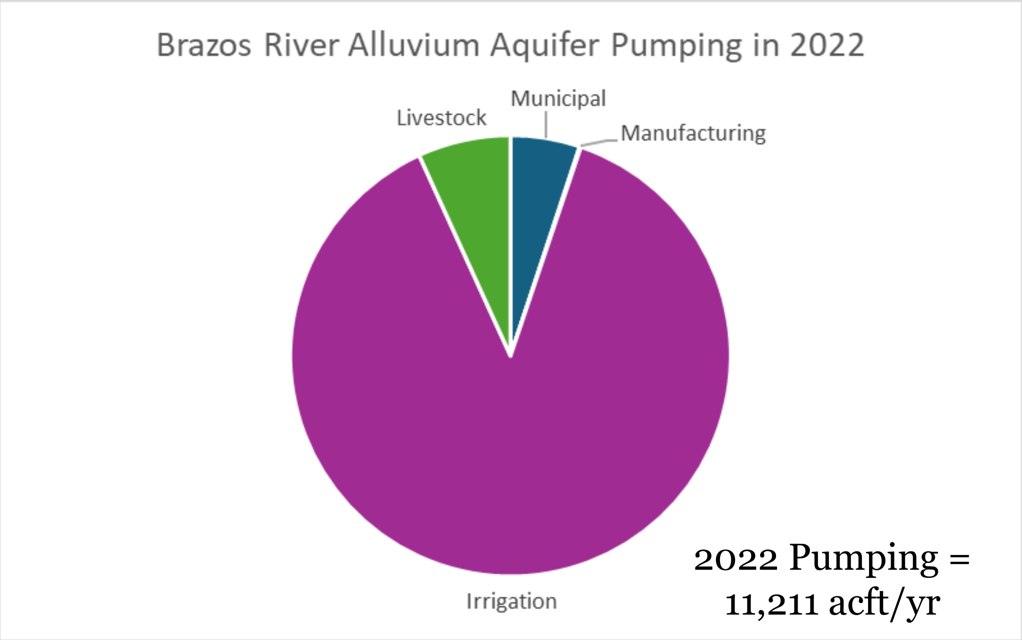

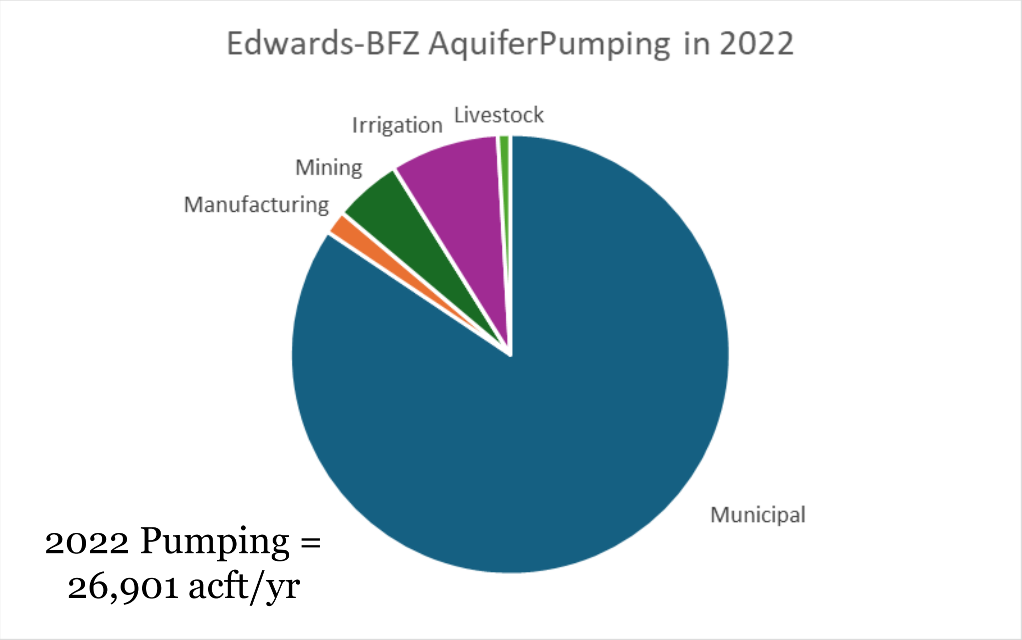

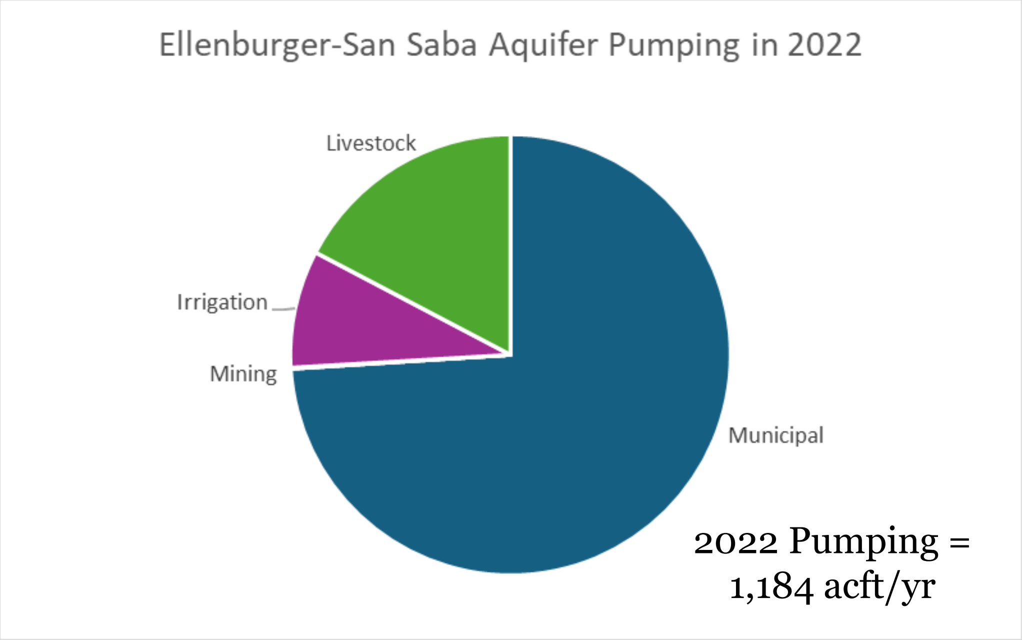

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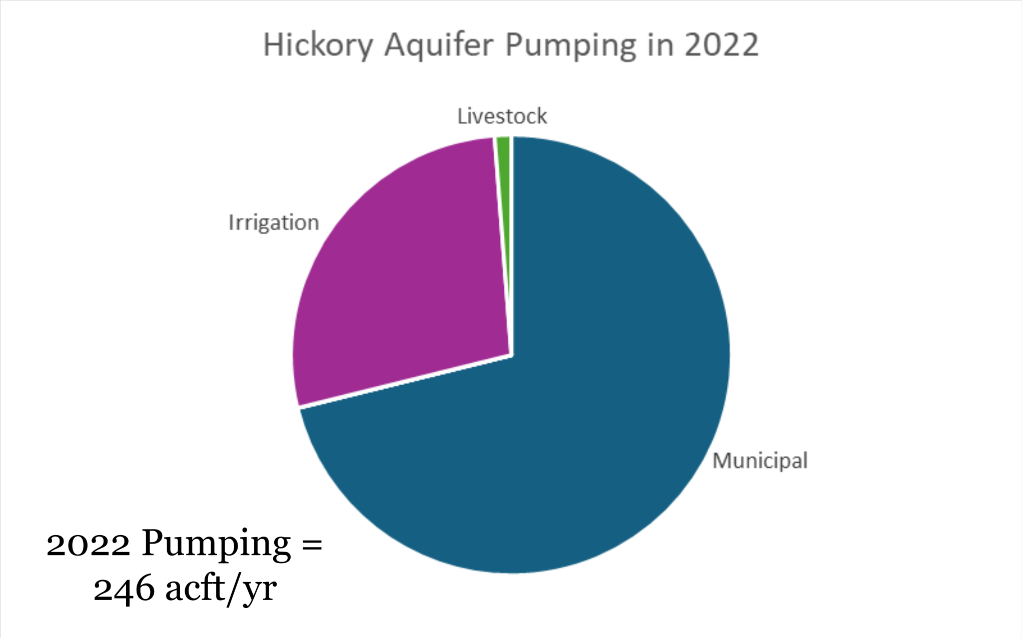

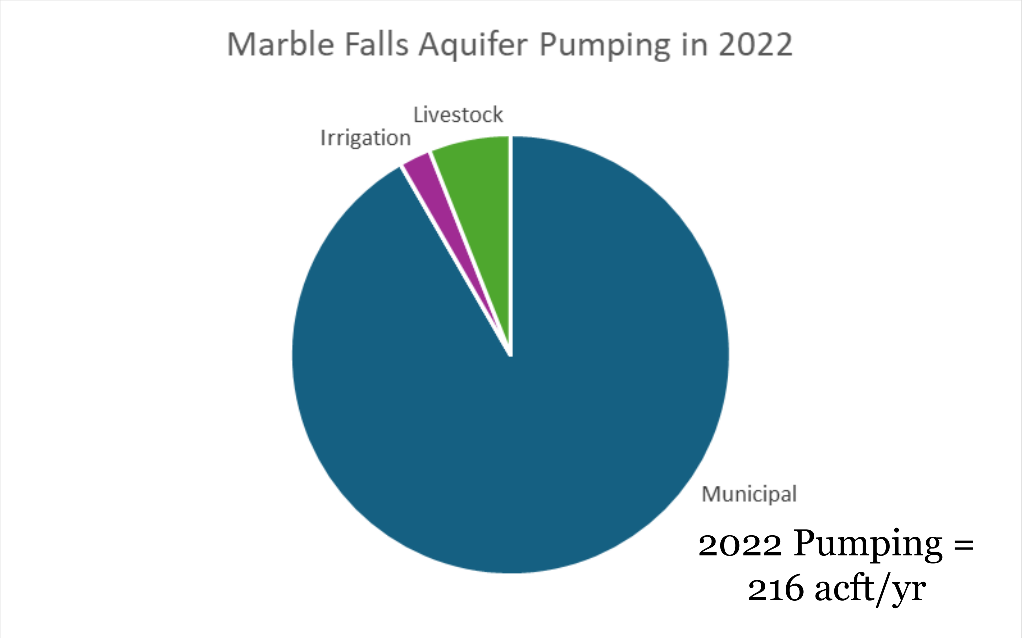

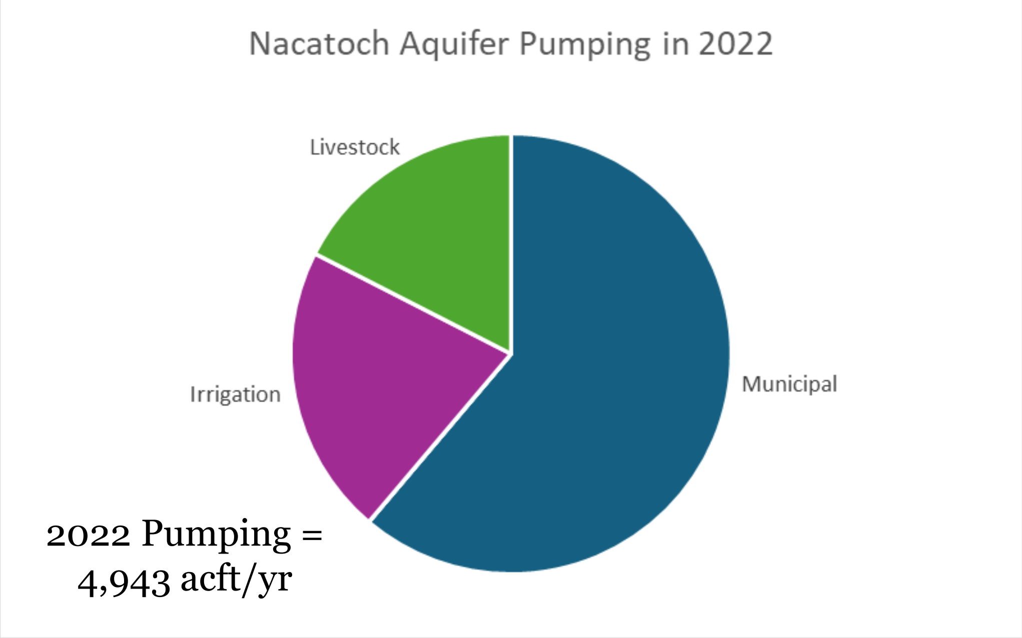

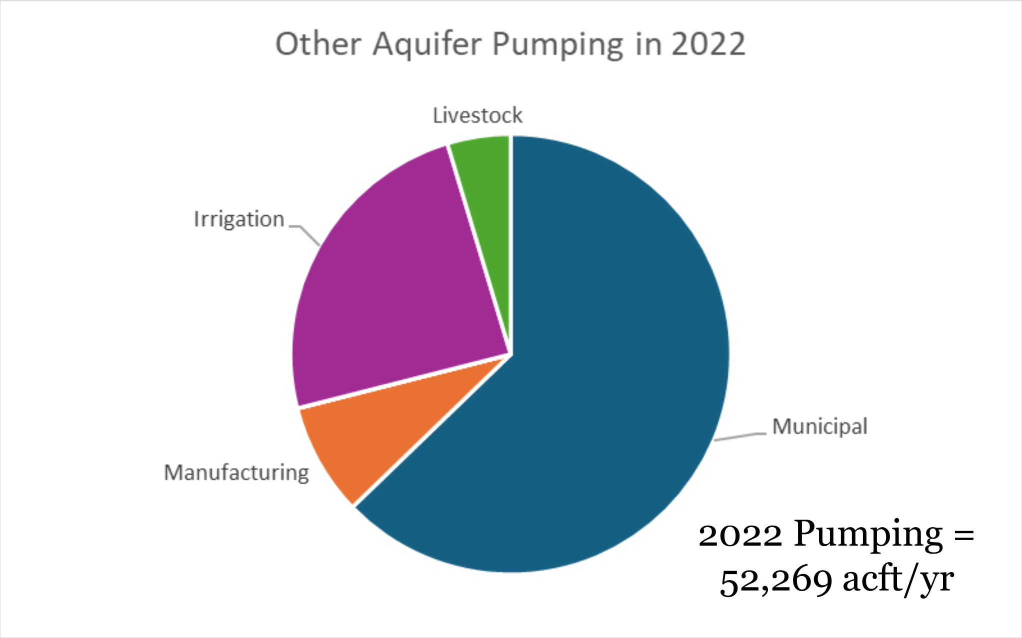

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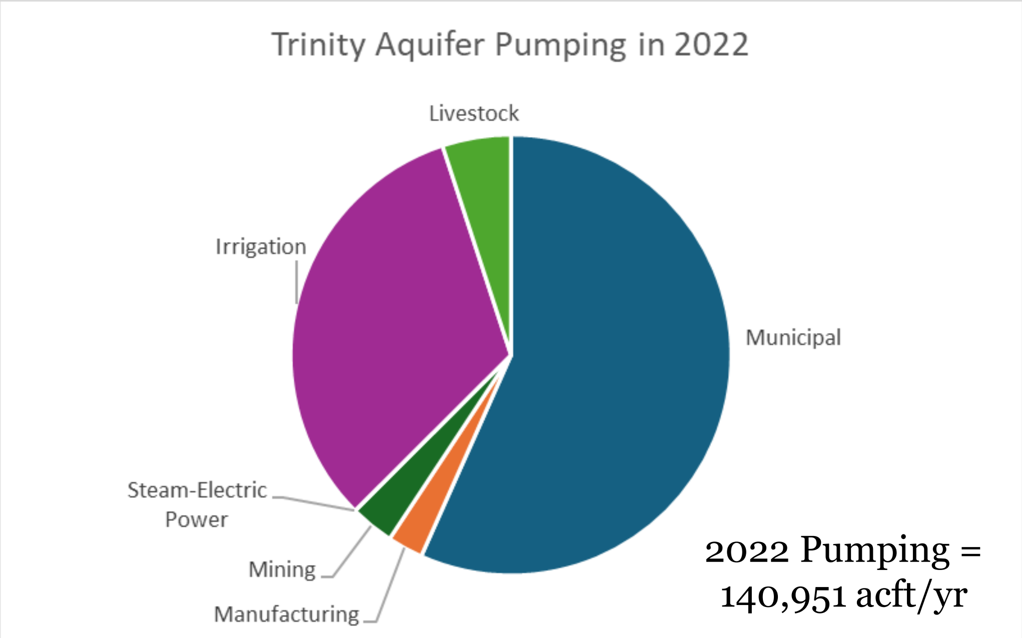
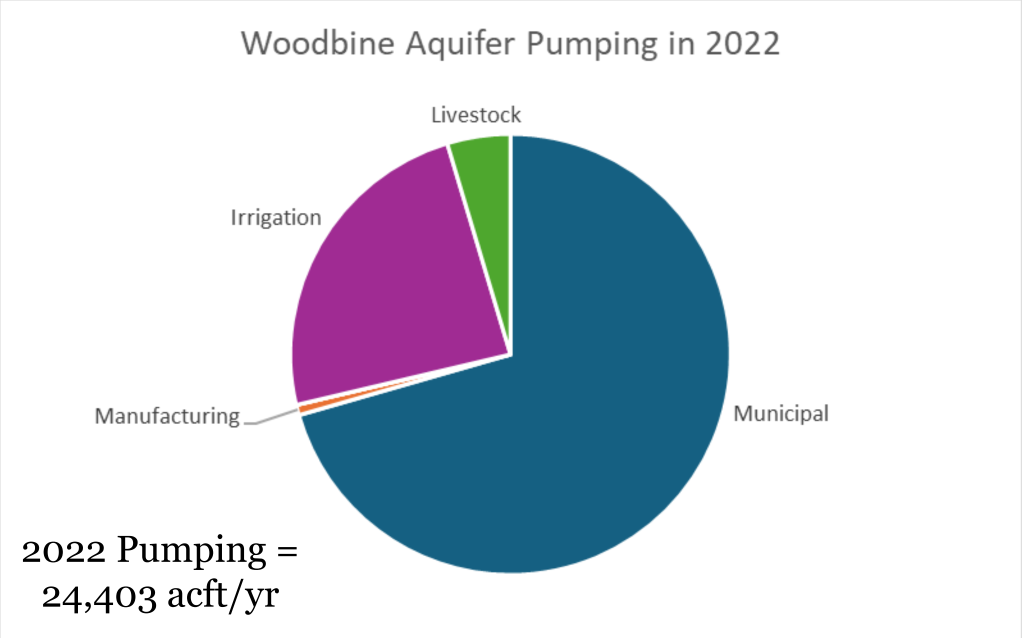
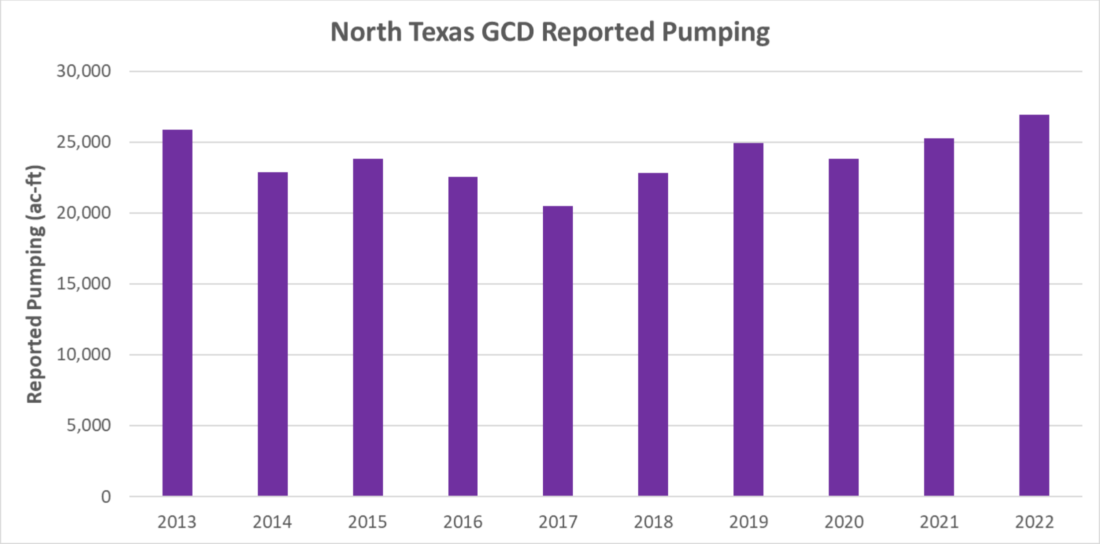
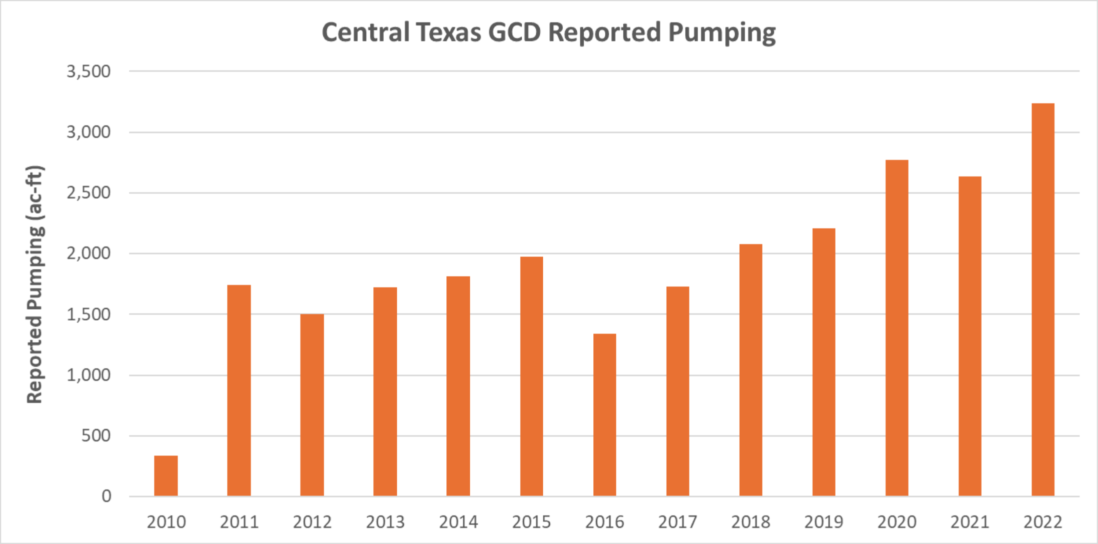
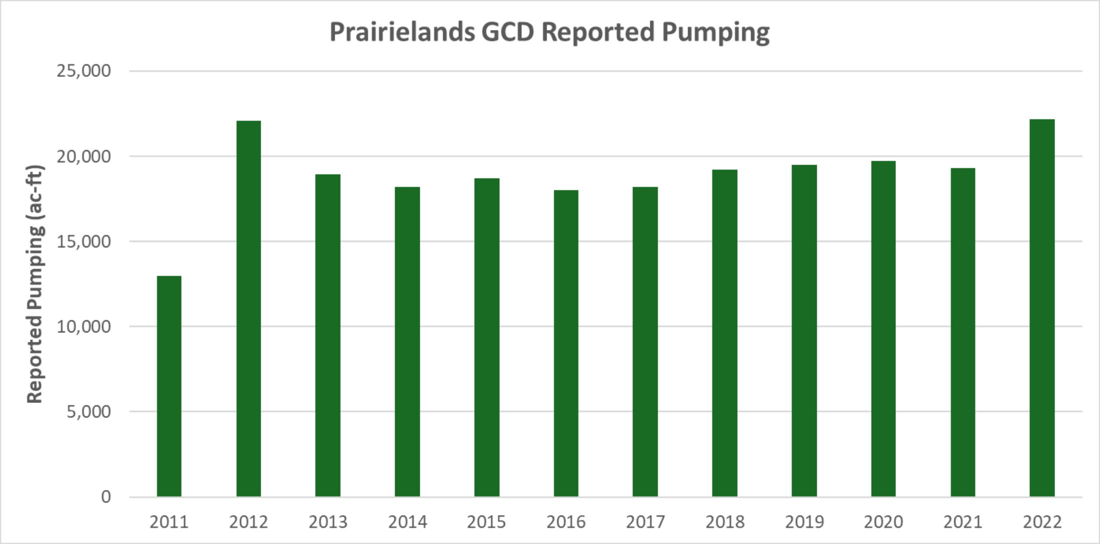

Trinity Aquifer Pumping in 2022
Livestock
Irrigation
Municipal
Steam-Electric Power
Mining
Manufacturing
2022 Pumping = 140,951 acft/yr


Woodbine Aquifer Pumping in 2022
Livestock
Irrigation
Manufacturing
Municipal
2022 Pumping = 24,403 acft/yr

Historic Pumping Amounts







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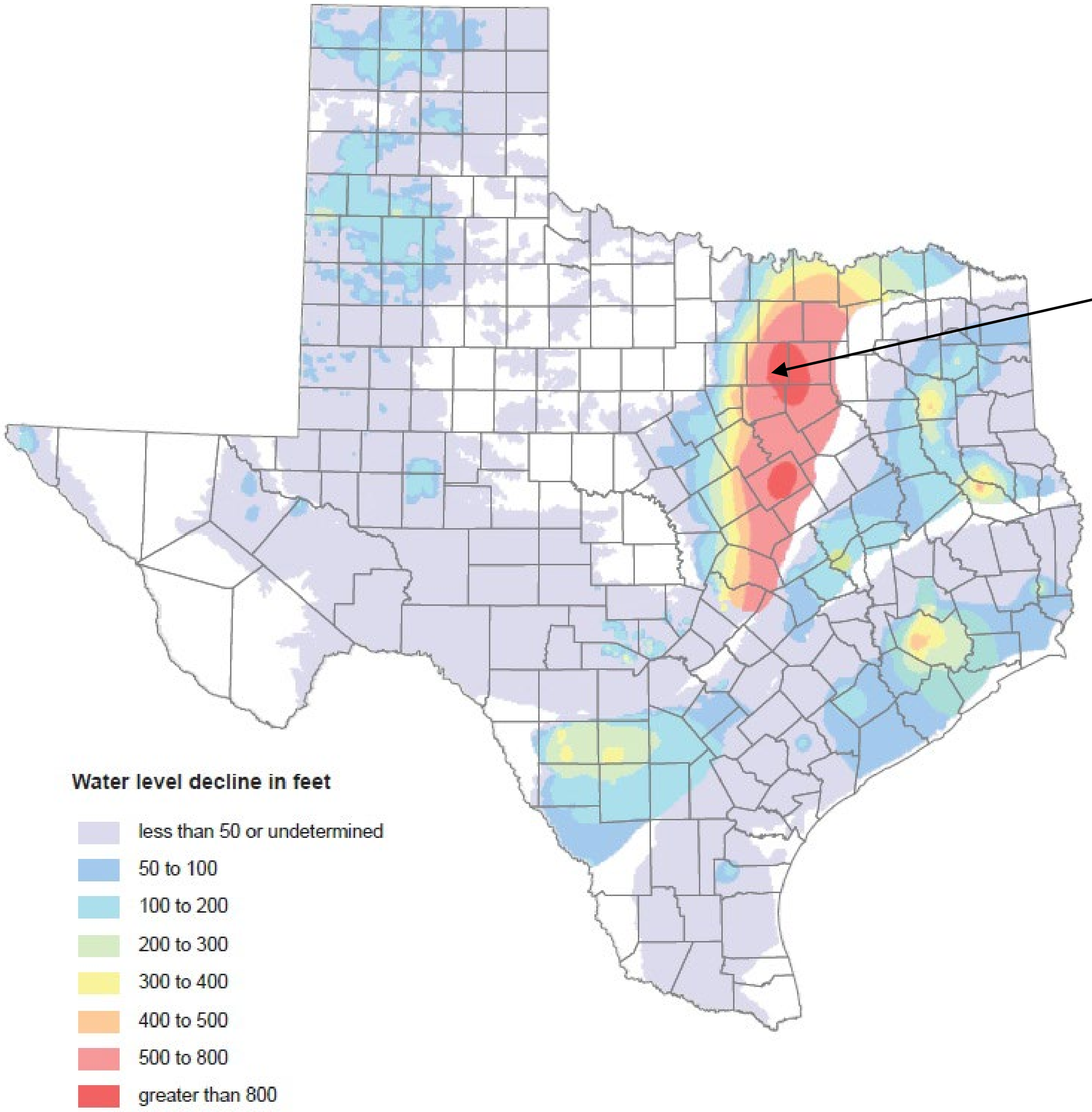
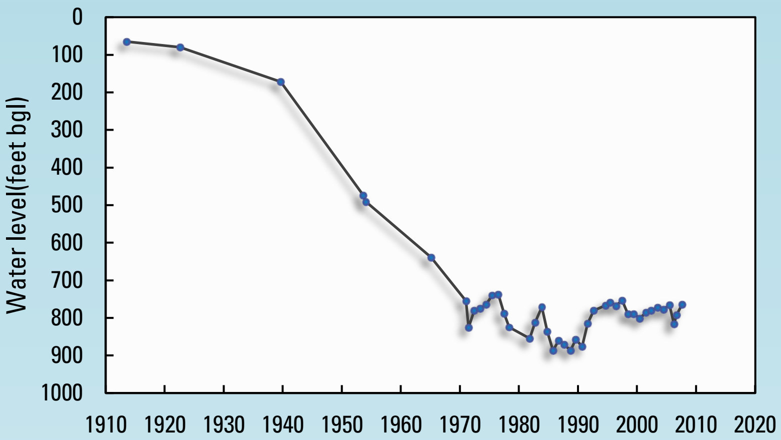


Source: George and others, 2011



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Factor 4 – Other Environmental Impacts

(4) OTHER ENVIRONMENTAL IMPACTS, INCLUDING IMPACTS ON SPRING FLOW AND OTHER INTERACTIONS BETWEEN GROUNDWATER AND SURFACE WATER;

Environmental Impacts: Introduction

- No new model runs in the planning cycle (yet)
- Information for factor based on information from last planning cycle
- No significant changes from last cycle model run results expected
- If modeling results indicate significant changes from conclusions presented, then re-visit this factor discussion when new model results are available

Environmental Impacts: Spring Locations

TWDB (2013a) Springs
- Woodbine Aquifer
- Wash/Fred Groups
- Northern Trinity Aquifer
- unknown

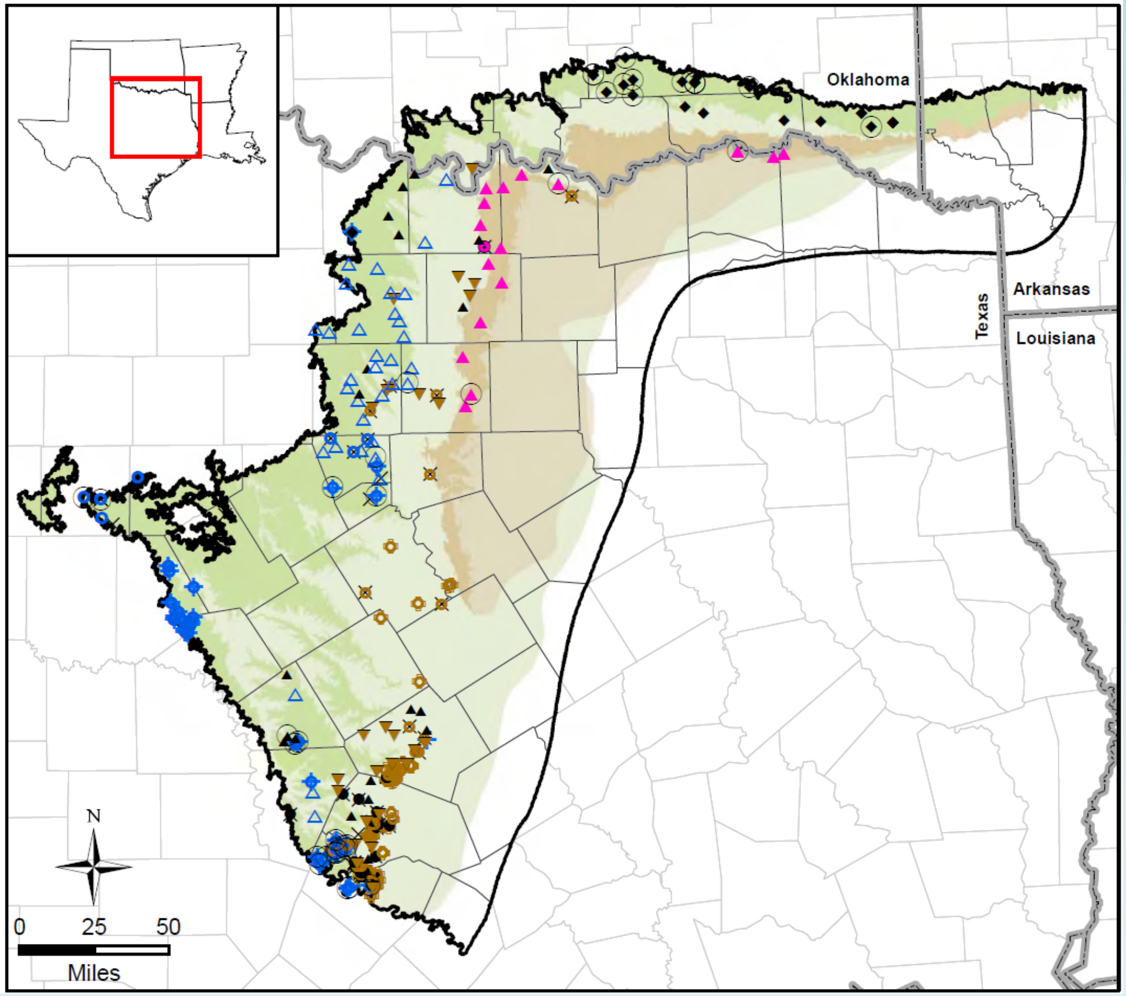
Heitmuller and Reece (2003) Springs
- Wash/Fred Groups
- Northern Trinity Aquifer
- unknown

Spring with Flow Measurement

Brune (2002) Springs (approx. location)
- Woodbine Aquifer
- Wash/Fred Groups
- Northern Trinity Aquifer
- unknown

USGS (2013b) Springs
- unknown

- Woodbine Aquifer Outcrop
- Woodbine Aquifer Downdip
- Trinity Aquifer Outcrop
- Trinity Aquifer Downdip
- Active Model Boundary
- County Boundary
- State Boundary



Source: Deeds and others, 2014

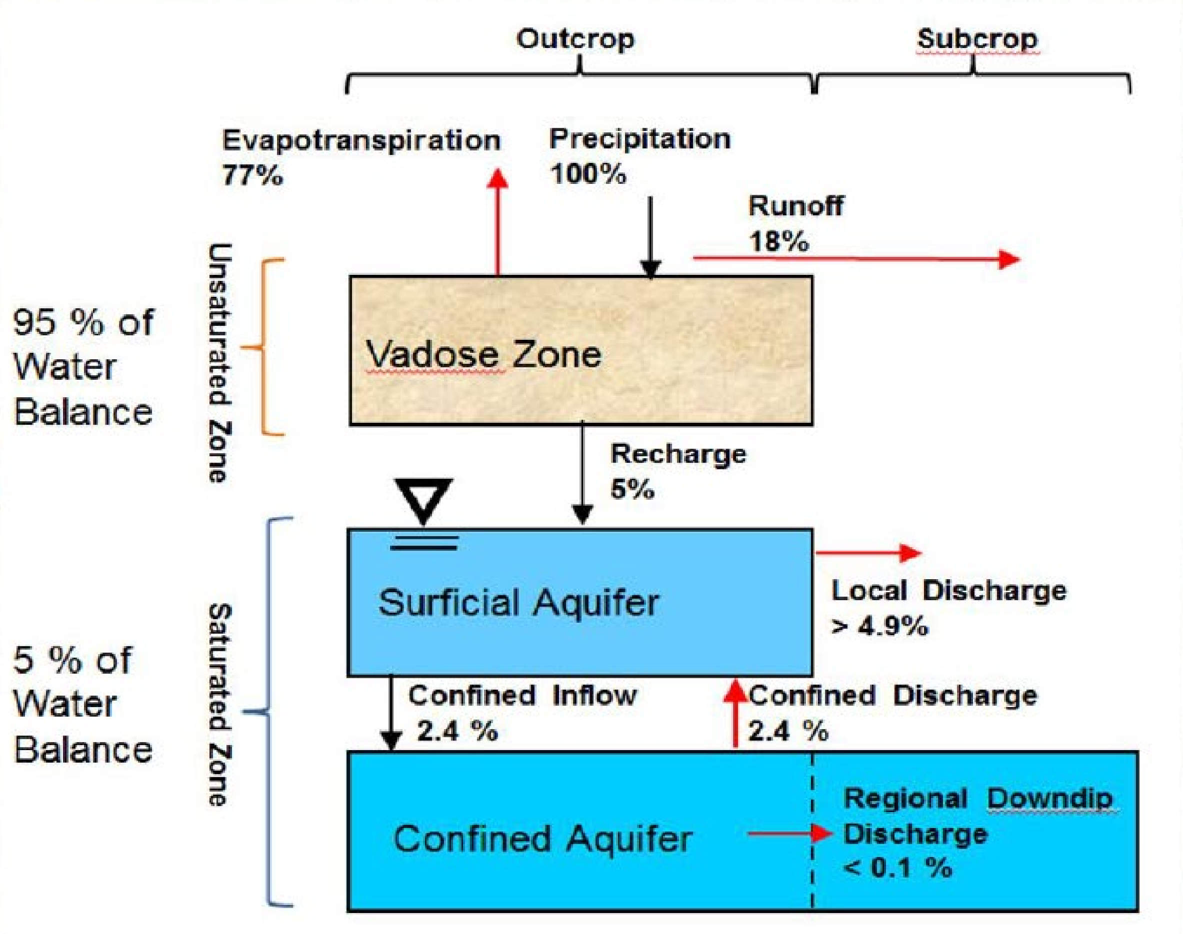
Environmental Impacts: Spring Discharge and Streamflow

- Southern portion of GMA 8 has the greatest density of springs
- Most are in the Washita/Fredericksburg, which includes Edwards BFZ
- Many located in far western extent of GMA 8
- Springs flow when the water level elevation of the aquifer is higher that the spring elevation
- Water level declines reduce spring flow in the model

Environmental Impacts Summary

- NTGAM includes boundary conditions to represent:
  - *Springs*
  - *Ephemeral streams*
  - *Perennial streams*
- Water budgets from Run 10 (last planning cycle) in existing ER indicate reduced spring flows and baseflows where DFCs include water level decline in aquifer outcrop areas

Conceptual Total Water Balance



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Environmental Impacts:
ER Run 10 Water Budget Examples

NTGCD Run 10 - Johnson County - Wash/Fred Aquifer							
Component	2010	2020	2030	2040	2050	2060	2070
Lateral Flow	-2,882	-2,920	-2,927	-2,944	-2,960	-2,969	-2,977
Leakage (Above)	1,105	1,022	1,039	1,068	1,096	1,122	1,140
Leakage (Below)	-4,767	-4,214	-4,234	-4,279	-4,313	-4,336	-4,354
Recharge	17,488	17,488	17,488	17,488	17,488	9,023	17,488
Perennial	-145	-125	-122	-120	-119	-104	-117
Ephemeral	-15,345	-14,345	-13,842	-13,474	-13,168	-12,558	-12,499
Evapotranspiration	0	0	0	0	0	0	0
Springs	-22	-20	-20	-19	-19	-18	-18
Reservoir	122	124	125	127	128	129	130
Wells	-2,554	-2,554	-2,554	-2,554	-2,554	-2,554	-2,554
Flowing	0	0	0	0	0	0	0
Storage	7,093	5,636	5,140	4,800	4,514	12,356	3,854
Total	92	92	92	92	93	92	93

18% decline

30% decline

NTGCD Run 10 - Somervell County - Hensell Aquifer							
Component	2010	2020	2030	2040	2050	2060	2070
Lateral Flow	2,051	1,909	1,834	1,791	1,761	1,740	1,722
Leakage (Above)	1,984	2,335	2,480	2,557	2,602	2,624	2,646
Leakage (Below)	-720	-1,035	-1,139	-1,194	-1,227	-1,249	-1,266
Recharge	308	308	308	308	308	164	308
Perennial	-1,935	-1,681	-1,564	-1,488	-1,435	-1,343	-1,353
Ephemeral	0	0	0	0	0	0	0
Evapotranspiration	0	0	0	0	0	0	0
Springs	0	0	0	0	0	0	0
Reservoir	0	0	0	0	0	0	0
Wells	-2,127	-2,127	-2,127	-2,127	-2,127	-2,127	-2,127
Flowing	0	0	0	0	0	0	0
Storage	440	292	208	154	118	191	70
Total	0	0	0	0	0	0	0

Summary of Impacts to Springs and Perennial/Ephemeral Streams

GCD or County	Percent Difference from 2010 to 2070 **Perennial**	Percent Difference from 2010 to 2070 **Ephemeral**	Percent Difference from 2010 to 2070 **Springs**
Clearwater UWCD	18	34	79
Middle Trinity GCD	19	16	100
ND Brown	0	9	11
Central Texas GCD	35	14	0
ND Callahan	0	8	0
North Texas GCD	11	14	18
ND Dallas	31	0	0
ND Eastland	0	14	0
Prairielands GCD	29	19	20
Red River GCD	7	11	0
ND Hamilton	16	21	0
Upper Trinity GCD	36	21	24
ND Jack	0	38	0
ND Lamar	2	5	16
Saratoga UWCD	7	7	3
Southern Trinity GCD	17	26	0
ND Mills	-3	7	0
ND Palo Pinto	0	12	0
ND Red River	4	5	0
Northern Trinity GCD	15	19	28
ND Taylor	0	2	0
ND Travis	NA	22	0
ND Williamson	NA	31	0

*Positive values indicate decline, and negative values indicate increase

Factor 5- Subsidence

(5) THE IMPACT ON SUBSIDENCE;

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Key Factors Impacting Subsidence

- Degree of consolidation
- Clay layer distribution, thickness, and compressibility
- Amount and timing of water level changes
- Lowest historical water level

TWDB Subsidence Tool- What is it?

- Developed in 2017
- Helps GCDs identify risk of subsidence due to groundwater pumping
- Capable of identifying risk of subsidence in all major/minor aquifers in Texas

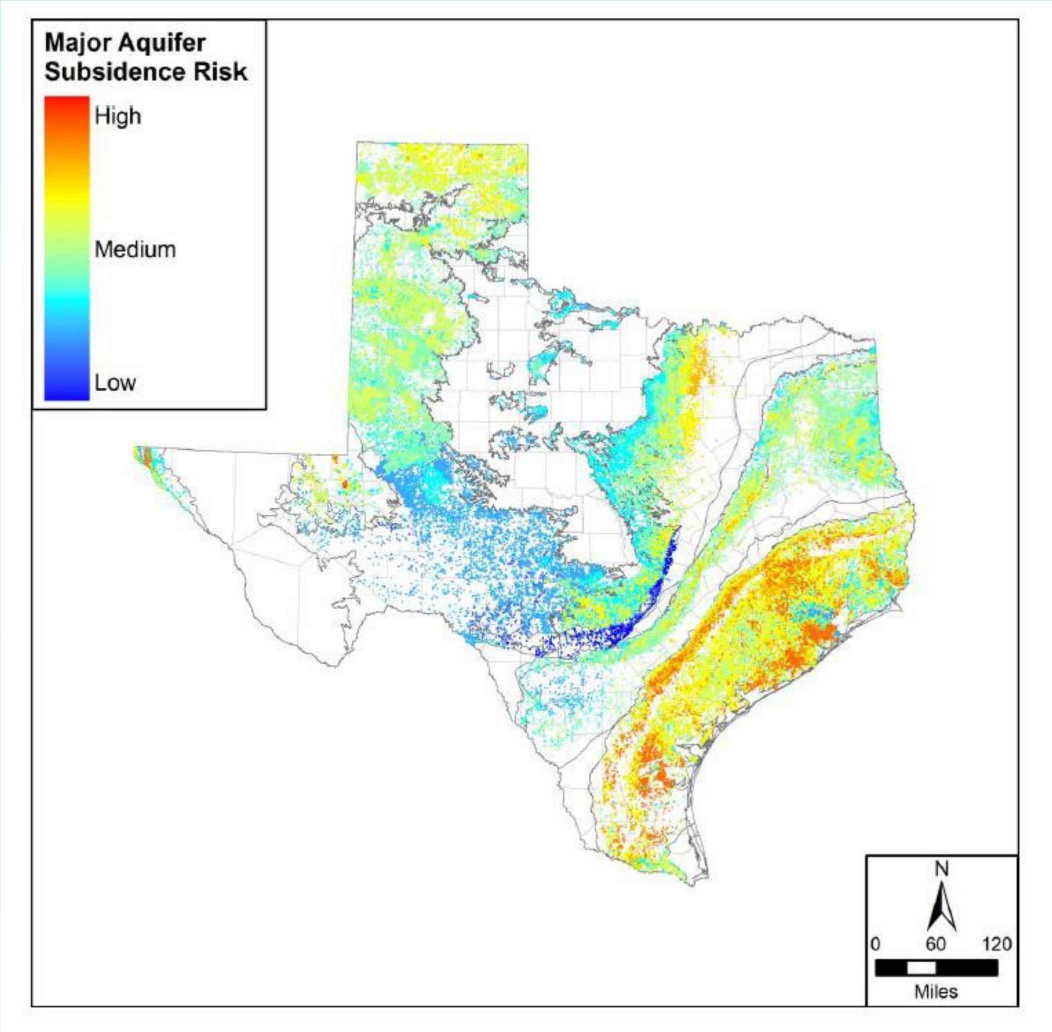
Subsidence: Using the Tool

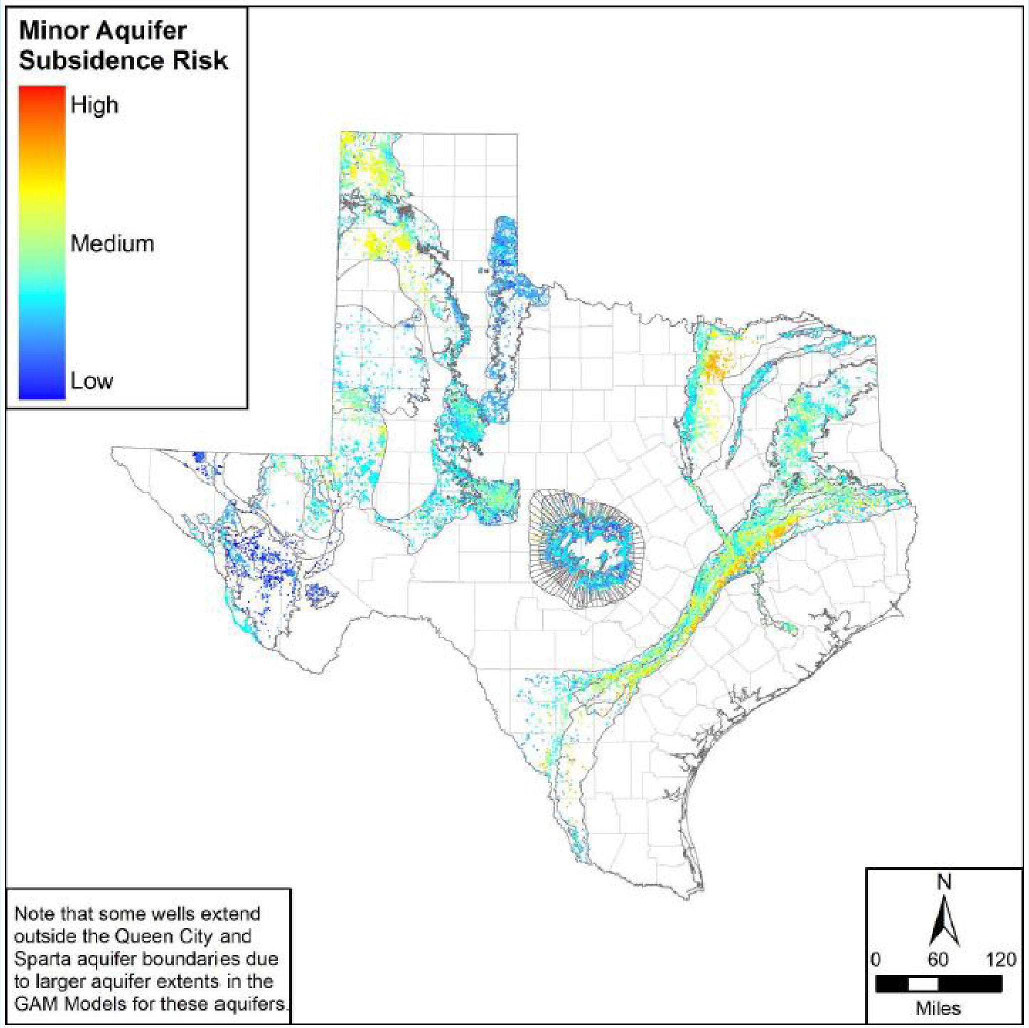
- Tool requires a Tool requires a geophysical log, adequate water level data, water quality data, and the DFC
- The log is used to determine aquifer top, bottom, thickness, and clay thickness in the aquifer
- Ideally, a predevelopment water level, a 2010 water level, and a current water level is available
- Current GCD or TWDB observation wells are the best candidates.

Subsidence

- How Is Subsidence Estimated?
  - *Saturated thickness and extent of clay*
  - *Clay compressibility*
  - *Aquifer lithology*
  - *Pre consolidation characterization*
  - *Predicted DFC water level decline*

Visualizing the Subsidence Risk





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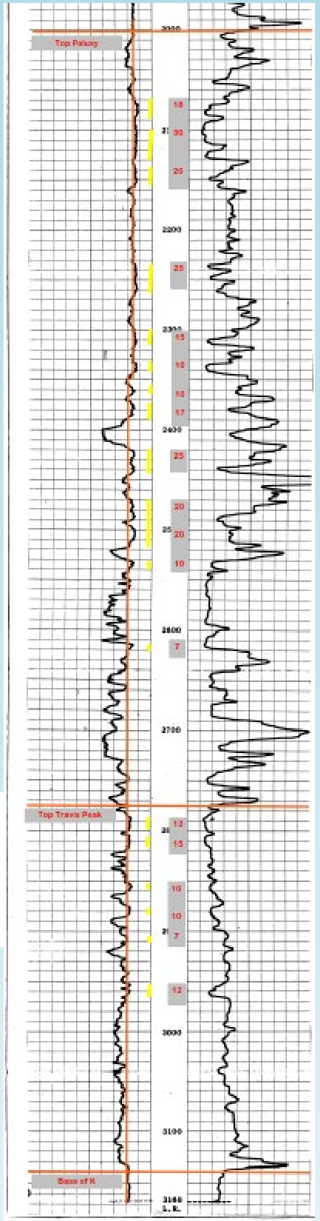
The localized evaluation process

1. Identify the downdip area
2. Find TWBD or GCD wells that meet available data criteria
3. Analyze logs to determine aquifer thickness and clay thickness
4. Calculate the risk using the tool

Rockett SUD 33-26-902
Clay thickness = 294 feet



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