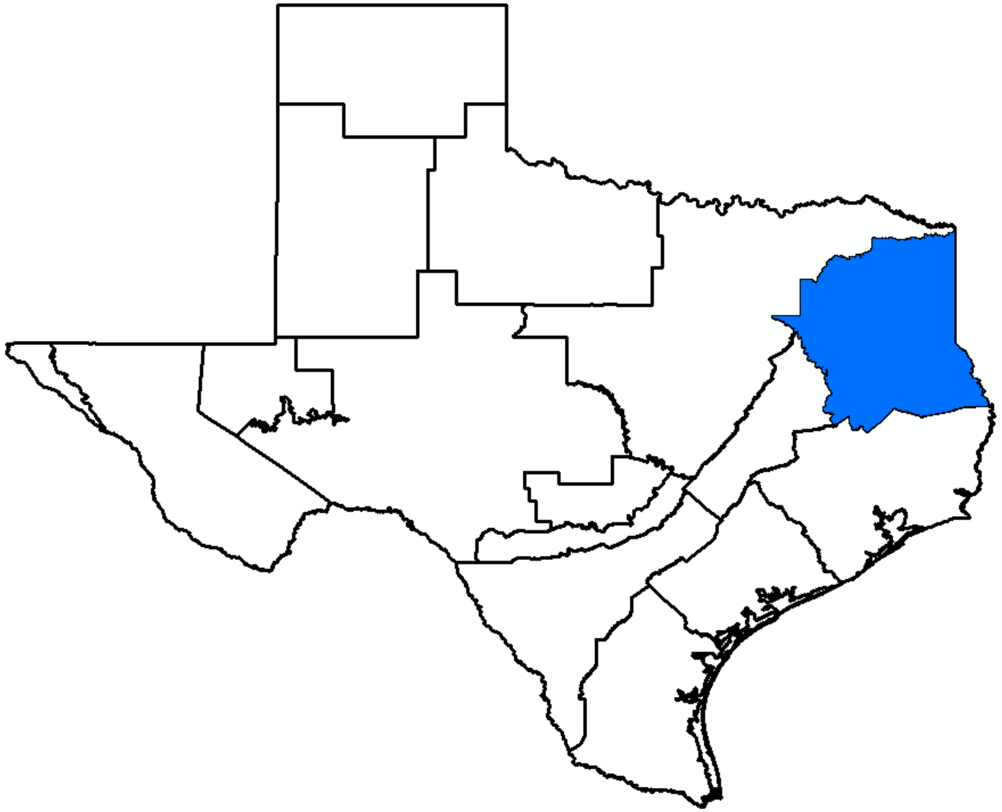
GMA 11 Joint Planning
Rounds 1 to 3 (History)
Round 4 (Current Round)



William R. Hutchison, Ph.D., P.E., P.G.

GMA 11 Meeting

October 14, 2025

Introduction

- Involved with Joint Planning Process since 2009
  - 2010 Joint Planning
    - TWDB Director of Groundwater Resources Division (2009 to 2011)
    - Provided technical assistance to all 15 GMAs (lead in 9)
  - 2016 Joint Planning
    - Consultant for 6 GMAs (2, 3, 4, 7, 11 and 13)
  - 2021 Joint Planning
    - Consultant for 5 GMAs (2, 3, 4, 7, and 11)
  - Current Round of Joint Planning
    - Consultant for 5 GMAs (2, 3, 7, 11, and 13)
- Expert Witness for Texas (Texas v. New Mexico and Colorado) since 2012
  - Key technical issue: impacts of groundwater pumping on streamflow

Objectives for Today

- Statutory deadline for Proposed Desired Future Condition (DFC)
  - May 1, 2026
  - Only decisions today relate to direction for next several weeks work
- Presentation includes a detailed history of previous rounds of joint planning
  - Recent increase in interest
  - Provided for background and context for public
  - Slides are intended to be used as a reference
- Focus of the meeting is a discussion of the statutory factors for this round of joint planning
  - Will be documented in explanatory report (draft completed in Spring 2026)
- Recommendations included for additional simulations (alternative DFCs) to be discussed in early 2026

Summary

- Groundwater Availability is defined in statute
  - Modeled Available Groundwater
- Total storage is not relevant and is not a good factor for joint planning
  - Misleading and is used to advance false narratives
  - Factor should be removed from joint planning process
- Heavy reliance on state water plan needs pushes GMAs to higher groundwater availabilities
  - DFCs should focus on aquifer capabilities, not on meeting “inexpensive” needs
  - Some other factors should be removed or modified by legislature
- In 2021, GMA 11 advanced concepts related to “maximum sustainable pumping” without recognition
  - This round of joint planning represents an opportunity to refine this concept to include additional elements of sustainable use

Topics

- Background
  - Groundwater Conservation Districts
  - History of Groundwater Availability in Texas
  - What is GMA 11?
- Overview of Aquifers of GMA 11 and Models
- Summary of Joint Planning Process (DFCs and MAGs)
- Review past and current DFCs and MAGs (2010, 2016, 2021)
- Factor review of this round of joint planning
- Recommendations for Next Steps
- Proposed Budget Update

What Do Groundwater Conservation Districts Do? Planning vs. Management vs. Regulation

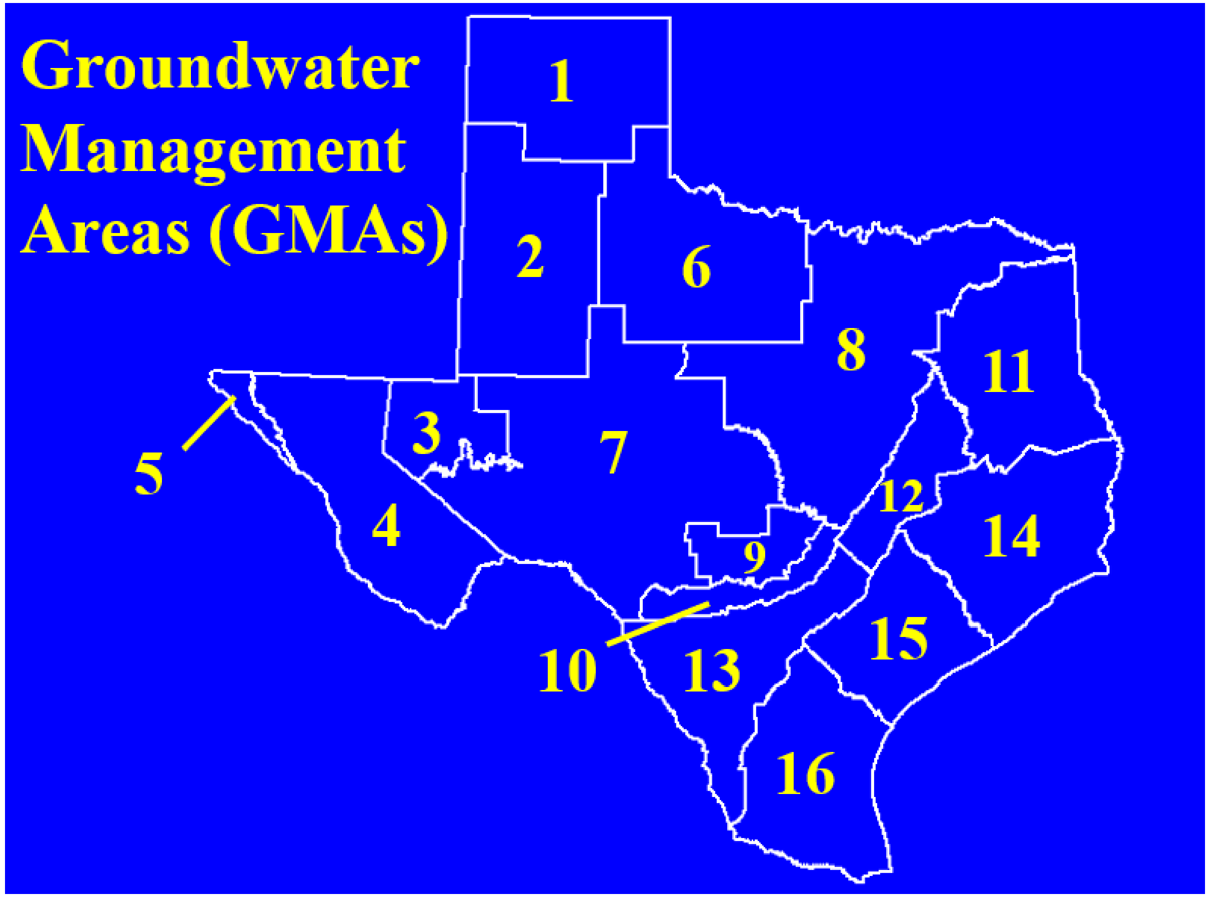
- Planning (Joint Planning Process in GMA 11)
  - Desired future conditions (DFC)
  - Modeled available groundwater (MAG)
- Management (GCD Management Plan)
  - Goal 8 (Addressing in a quantitative manner the desired future conditions (DFC) of the groundwater resources in the District)
- Regulation (GCD Rules)
  - Permitting

Groundwater Availability History

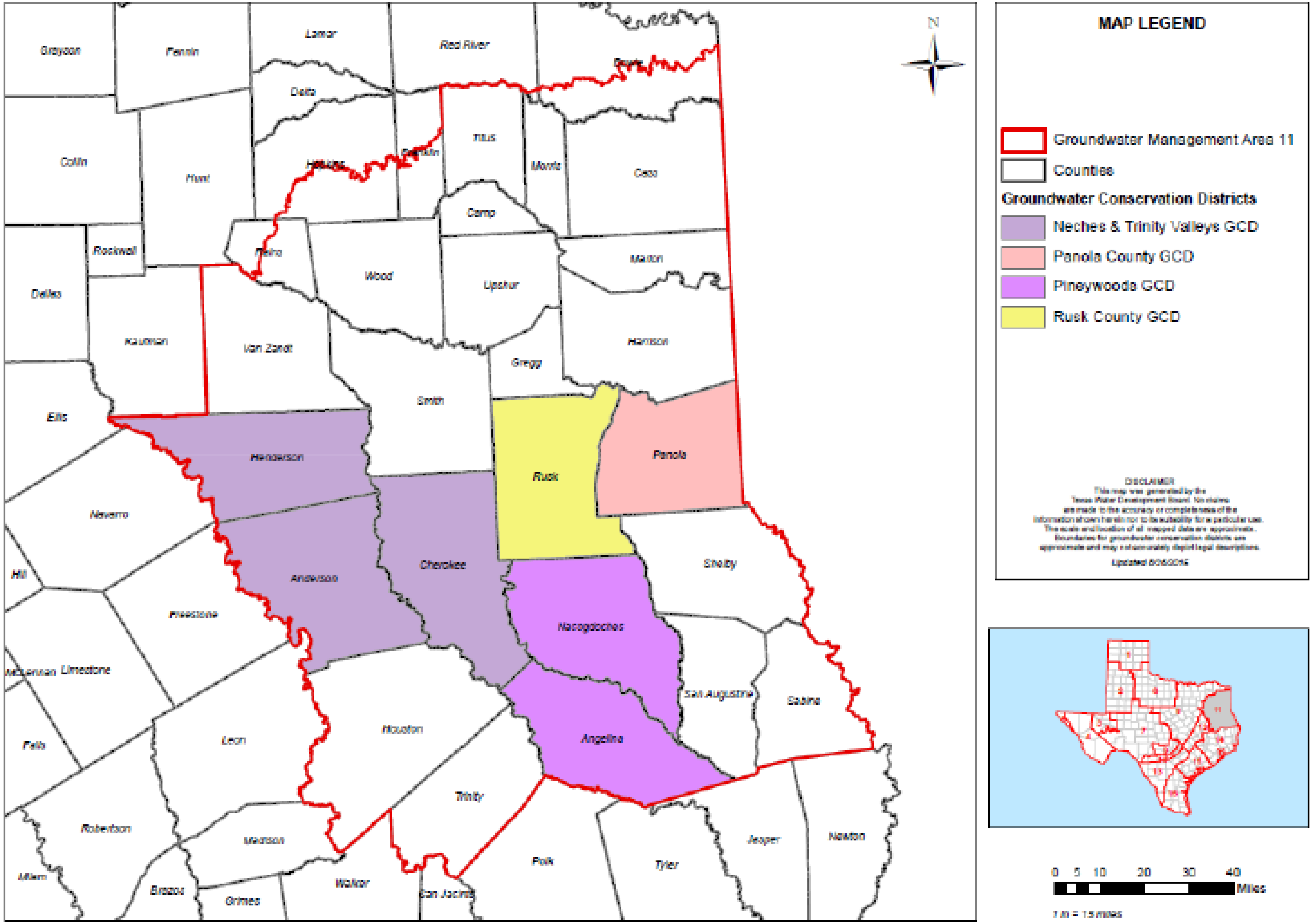
- Before 1997: TWDB determined groundwater availability for state water plan purposes
  - Groundwater Conservation Districts (GCDs) were not required to adopt these estimates
- Senate Bill 1 (1997): groundwater availability for planning shifted to Regional Planning Groups
  - No requirement for documentation and no standard for consistency with stated goals
  - GCD Management Plans had to be consistent with these estimates
  - GCDs could "appeal" the groundwater availability estimate to TWDB
- HB 1763 (2005): defining groundwater availability shifted to GCDs
  - Joint planning process (GCDs in a Groundwater Management Area)

Groundwater Management Areas (GMA)

- GMA 11 is one of 16 Groundwater Management Areas
  - Only 15 involved in joint planning (GMA 5 has no GCDs)
- Each Groundwater Conservation District (GCD) is in at least one GMA
- GCDs in GMAs conduct Joint Groundwater Planning every five years
  - Desired Future Conditions (DFC)
  - Modeled Available Groundwater (MAG)



Groundwater Management Area 11



Geologic Formations in GMA 11 (Youngest to Oldest)

- Alluvium
- Jackson
- Yegua
- Sparta
- Weches
- Queen City
- Reklaw
- Carrizo
- Wilcox

Geologic Formations in GMA 11 (Youngest to Oldest)

GMA 11 Aquifers

- Alluvium
- Jackson
- Yegua
- Sparta
- Weches
- Queen City
- Reklaw
- Carrizo
- Wilcox

Yegua-Jackson

Sparta

Queen City

Carrizo-Wilcox

Geologic Formations in GMA 11 (Youngest to Oldest)

- Alluvium
- Jackson
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- Reklaw
- Carrizo
- Wilcox

GMA 11 Aquifers

Yegua-Jackson

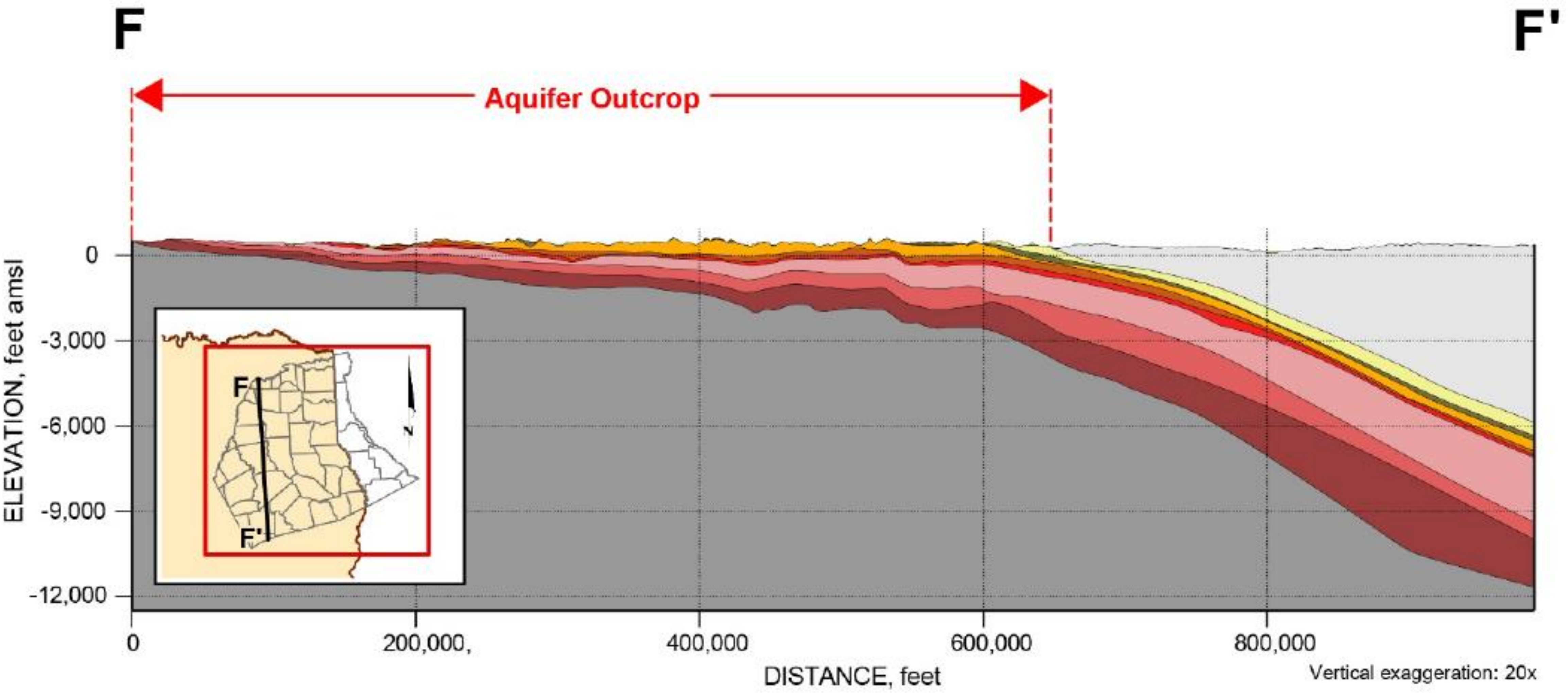
Sparta

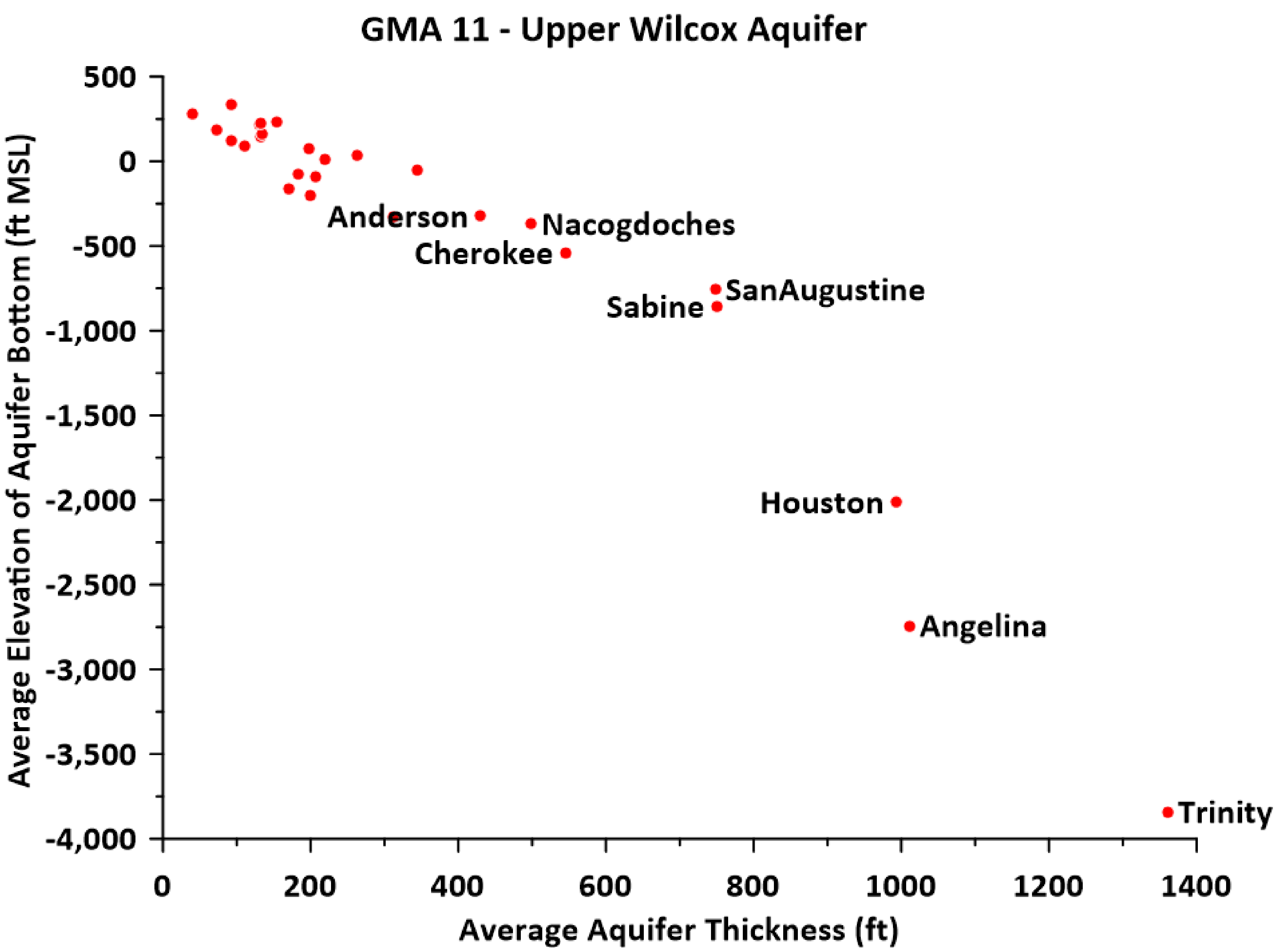
Queen City

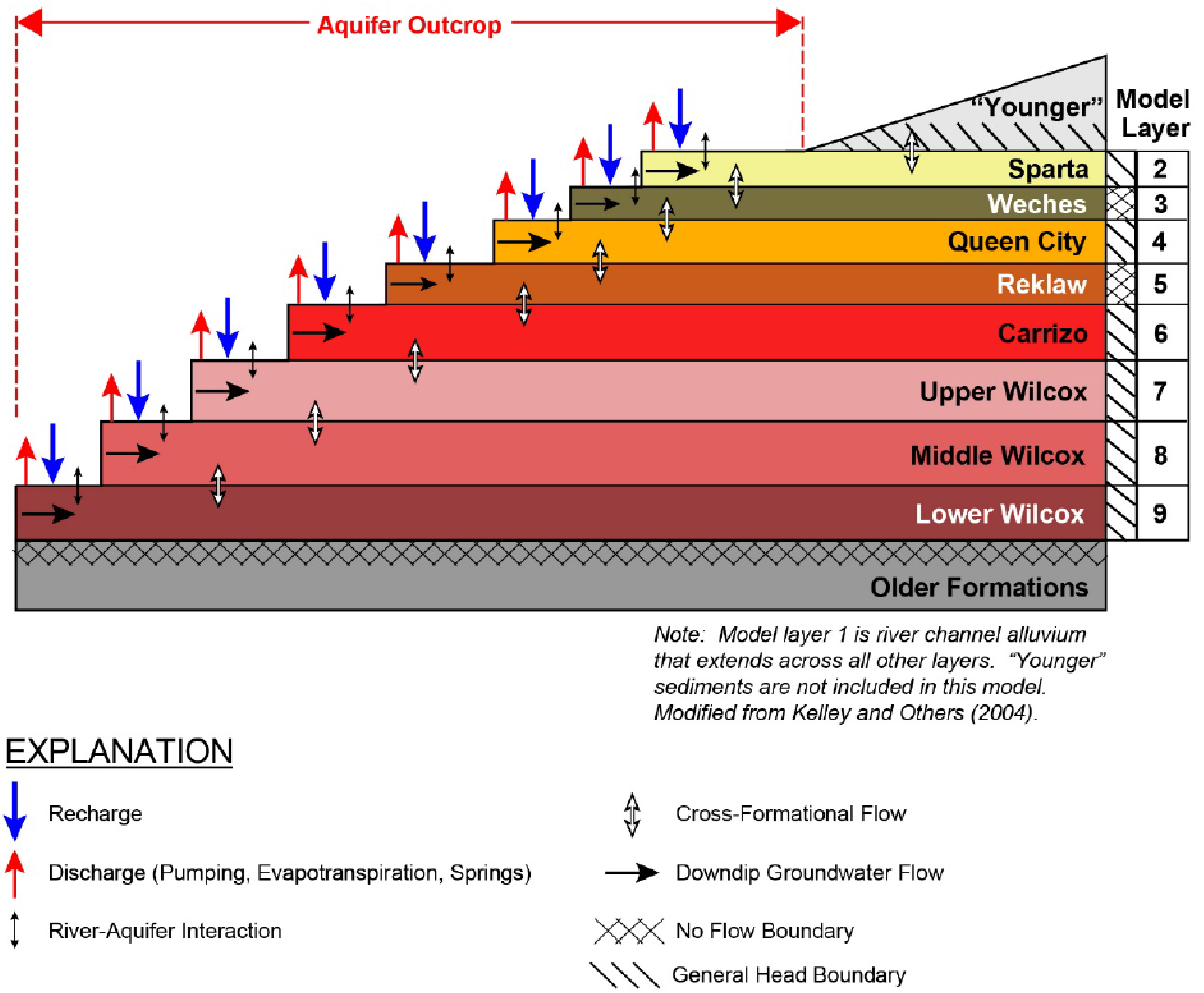
"Minor" Aquifers

Carrizo-Wilcox

"Major" Aquifer


F
F'
Aquifer Outcrop
ELEVATION, feet amsl
0
-3,000
-6,000
-9,000
-12,000
0
200,000,
400,000
600,000
800,000
DISTANCE, feet
Vertical exaggeration: 20x
F
F'


GMA 11 - Upper Wilcox Aquifer
Average Elevation of Aquifer Bottom (ft MSL)
500
0
-500
-1,000
-1,500
-2,000
-2,500
-3,000
-3,500
-4,000
Anderson
Nacogdoches
Cherokee
SanAugustine
Sabine
Houston
Angelina
Trinity
0
200
400
600
800
1000
1200
1400
Average Aquifer Thickness (ft)


Aquifer Outcrop
"Younger"
Model Layer
Sparta
2
Weches
3
Queen City
4
Reklaw
5
Carrizo
6
Upper Wilcox
7
Middle Wilcox
8
Lower Wilcox
9
Older Formations
Note: Model layer 1 is river channel alluvium that extends across all other layers. "Younger" sediments are not included in this model. Modified from Kelley and Others (2004).
EXPLANATION
Recharge
Discharge (Pumping, Evapotranspiration, Springs)
River-Aquifer Interaction
Cross-Formational Flow
Downdip Groundwater Flow
No Flow Boundary
General Head Boundary

Groundwater Availability Models (GAMs)

- In GMA 11, GAMs are used by TWDB to calculate Modeled Available Groundwater (MAG)
- Models are a simplification of a groundwater system
  - Groundwater occurrence and movement in aquifers
  - Simulates horizontal and vertical movement of groundwater (aquifers are connected)
  - Simulates surface water/groundwater interactions
- GAMs are not like weather forecasting models
- GAMs are analytical tools
  - Best use: compare “impacts” of alternative scenarios for decision making (e.g. DFCs)

GAM History in GMA 11 (1)

- First GAM of area: Fryar and others (2003)
  - Carrizo-Wilcox Aquifer only
  - Model grid size = 640 acres
  - Calibration period ended in 1999
- Updated by Kelley and others (2004)
  - Added Sparta and Queen City Aquifers
  - Model grid size = 640 acres
  - Calibration period ended in 1999
- GMA 11 attempted to update calibration period in 2015 and 2016
  - Highlighted limitations of 2004 GAM
  - Recommended that an updated model be completed in 2016 explanatory report

GAM History in GMA 11 (2)

- TWDB contracted with GSI Environmental to update the model in 2017
- Work completed in 2020 (Panday and others, 2020)
  - Officially released by TWDB in April 2021
- Model grid size: 10 acres to 640 acres
- Added alluvial layer for improved surface water-groundwater interaction simulation
- Calibration period ended in 2013

Texas Water Development Board Contract Report Number #1648302063

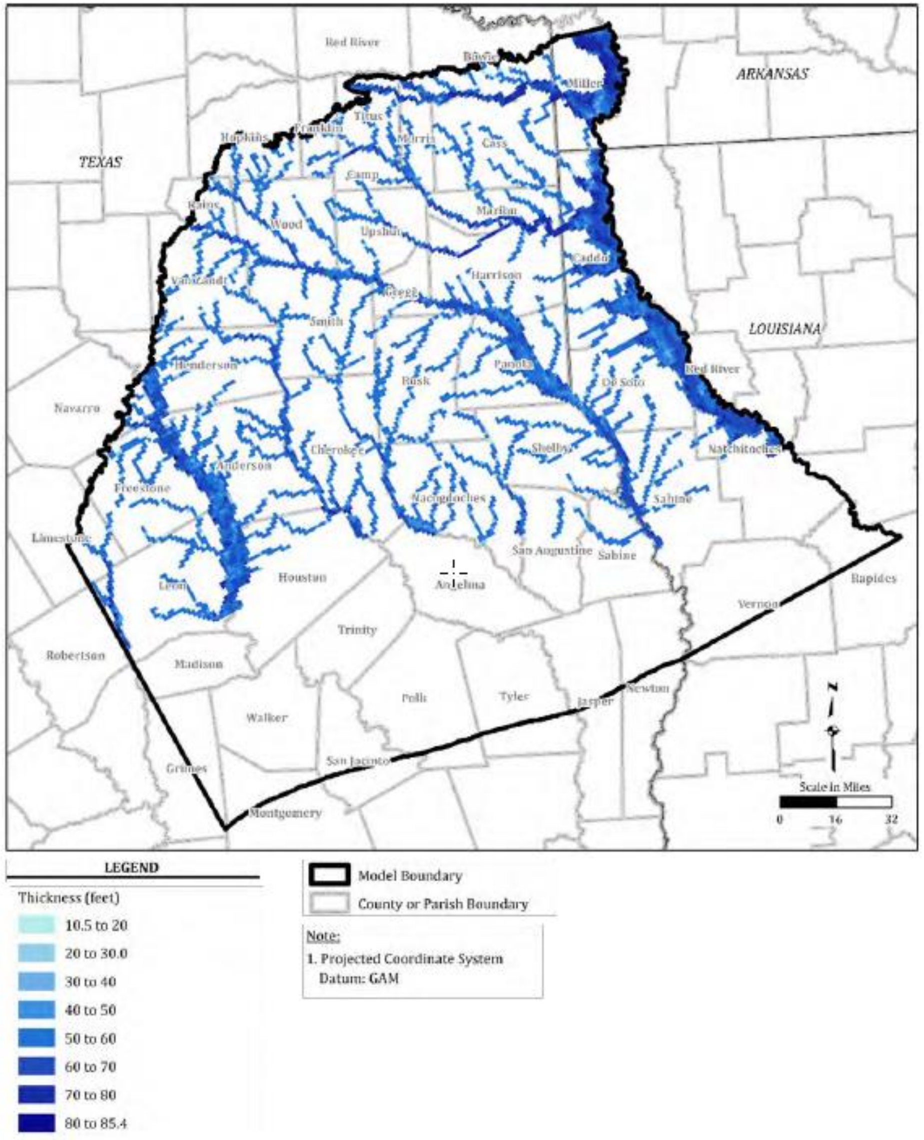


Figure 2.4-4. Modeled Thickness of Quaternary Alluvium (Model Layer 1)

Joint Planning and Groundwater Availability

- Before 2005
  - Regional Planning Groups set “Groundwater Availability”
  - No standard approach
  - Numerous examples where groundwater availability was not consistent with stated goals of regional plan
  - No formal mechanism where neighboring GCDs were informed of inter-district impacts of planning goals
- After 2005
  - Mandatory joint planning among GCDs
  - Consistent approach in neighboring GCDs
  - Formal process to incorporate data and models into planning decisions and the establishment of “available groundwater”

Desired Future Condition (DFC)

- Quantified conditions of groundwater
  - Specified time or times in the future
- Broad Policy Goal
- GMA 11 has used drawdown as the DFC metric
- Updated every five years

Modeled Available Groundwater (MAG)

- The amount of pumping necessary to achieve the desired future condition
- TWDB calculation
  - In GMA 11: Model simulations
- Statute defines two uses for MAGs:
  - “Groundwater Availability” in Regional Water Plans
  - One factor in GCD permitting decisions
- GCDs are required to manage to the DFC (not the MAG)

Groundwater Availability = DFC + MAG

Groundwater Availability = Policy + Science

Groundwater Availability = DFC + MAG

DFC Process Since 2011

- Consider 9 specific factors
- “Proposed” DFC
- Public comments and public hearings
- District summary reports
- “Final” DFC
- “Explanatory Report”

Nine Factors

1. Aquifer uses or conditions
2. State water plan needs and water management strategies
3. Hydrological conditions
   - Recoverable storage (from TWDB)
   - Groundwater budget
4. Other environmental impacts
5. Subsidence
6. Socioeconomic impacts
7. The impact on the interests and rights in private property
8. The feasibility of achieving the desired future condition
9. Any other relevant information

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7. The impact on the interests and rights in private property
8. The feasibility of achieving the desired future condition
9. Any other relevant information

In Addition….

- The desired future conditions proposed must provide a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the management area.

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Joint Planning Process Tasks and Timing

- Consider 9 specific factors
- “Proposed” DFC and Draft Explanatory Report
- Public comments and public hearings
- District summary reports
- “Final” DFC
- Final Explanatory Report
- Submit to TWDB for Review of Administrative Completeness

Joint Planning Process Tasks and Timing

Before 5/1/2026

- Consider 9 specific factors
- "Proposed" DFC and Draft Explanatory Report

- Public comments and public hearings
- District summary reports
- "Final" DFC
- Final Explanatory Report
- Submit to TWDB for Review of Administrative Completeness

Joint Planning Process Tasks and Timing

- Consider 9 specific factors
- "Proposed" DFC and Draft Explanatory Report

Before 5/1/2026

- Public comments and public hearings
- District summary reports
- "Final" DFC
- Final Explanatory Report
- Submit to TWDB for Review of Administrative Completeness

After Vote on "Proposed" DFC

Joint Planning Process Tasks and Timing

- Consider 9 specific factors
- "Proposed" DFC and Draft Explanatory Report

Before 5/1/2026

- Public comments and public hearings
- District summary reports
- "Final" DFC
- Final Explanatory Report
- Submit to TWDB for Review of Administrative Completeness

After Vote on "Proposed" DFC

Deadline to Approve DFC = 1/5/2027

Review Past and Current DFCs and MAGs

- Concepts behind DFCs
  - Insight into “balancing” requirement
- Comparison of MAGs by aquifer in first three rounds of joint planning

Past and Current DFCs (All Expressed as Average Drawdowns)

- 2010
  - Focus was on increasing "availability" in Queen City Aquifer
- 2016
  - Focus was on meeting State Water Plan needs
  - Limitations with the 2004 GAM were documented
- 2021
  - New GAM demonstrated that 2016 MAGs were not possible (aquifer limits)
  - Reduced 2016 MAGs to achieve "maximum sustainable pumping"
    - Using current distribution of wells, pumping is the same in each county-aquifer-river basin unit from 2014 to 2080

Past Balancing Efforts

- In 2010, no statutory requirement for balancing
- In 2016, 875 letters seeking participation were sent by GMA 11 (no response)
  - One public comment (expressed support from Region D since MAGs were adequate to meet groundwater management strategies)
- In 2021, no input and no public comments
  - Developed “maximum sustainable pumping” in response to signals from legislature and capabilities of updated GAM

Maximum Sustainable Pumping

- Carlos Rubenstein and Vanessa Puig-Williams were preparing a report in late 2022 and sought my input
- I spoke with them on a zoom call on December 8, 2022
  - Highlighted the maximum sustainable pumping approach taken in GMA 11
- Report was released in January 2023
  - No mention of GMA 11
  - Page 21 and 22 of the report claims that there has been no sustainable yield analysis in Texas
  - Much of the discussion is a critique of Total Estimated Recoverable Storage (TERS), as a joint planning factor
  - Included a poorly posed question: “How much groundwater can be pumped from an aquifer without causing groundwater declines?”
    - Simple answer: Zero; any pumping will cause groundwater level decline

Sustainable Yield

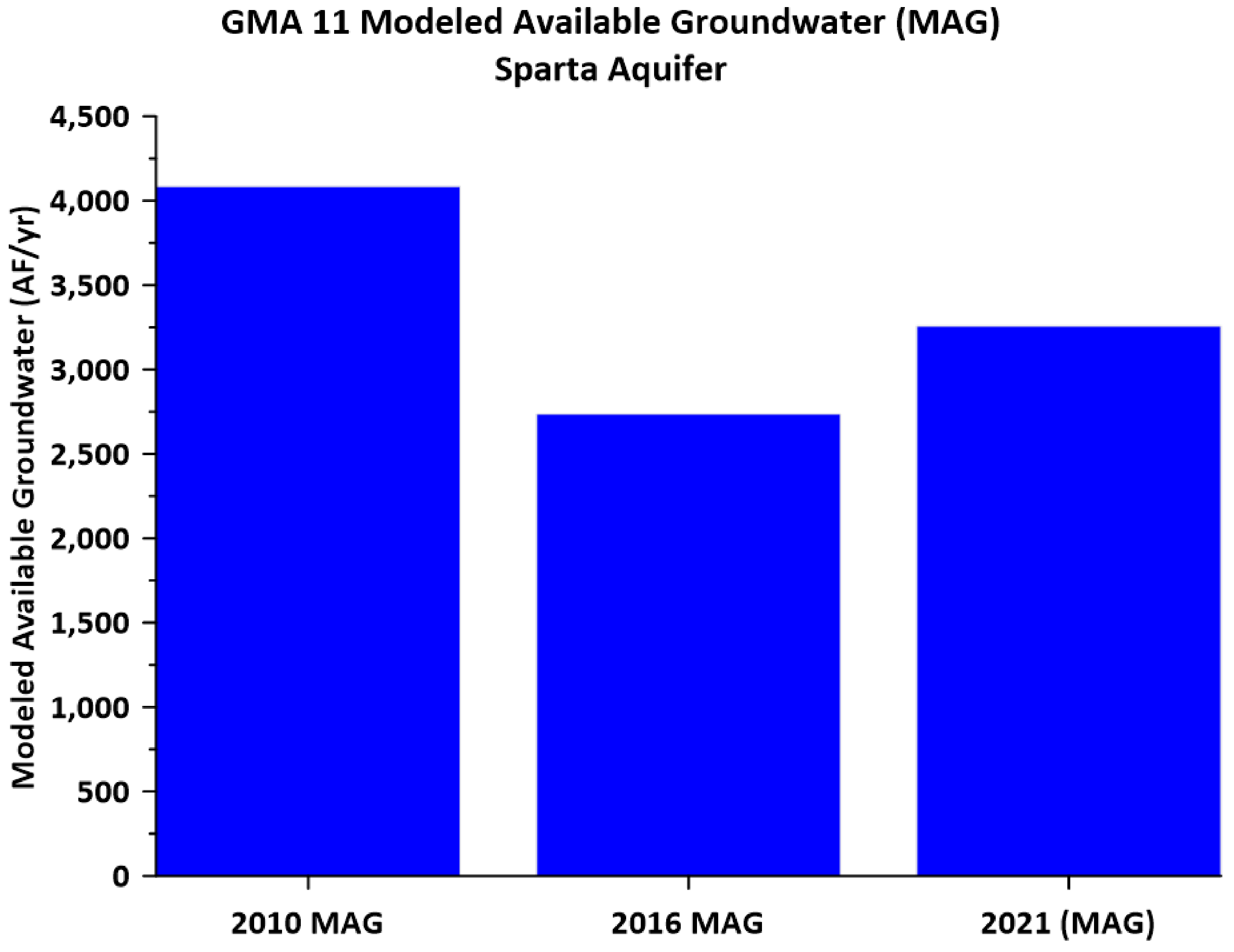
- Definition: the amount of water that can be pumped from an aquifer over a specified period without causing negative or undesirable effects
    - Undesirable effects can be hydrogeologic, environmental, or economic
- Because of the vague definition of “undesirable effects” this sustainable yield can be twisted to mean almost anything
    - Most recent literature cautions against thinking that a single number can define “sustainable yield”
- From a joint planning perspective, task is to quantify, analyze, and balance “predicted” decline with other alternative scenarios (what is an “acceptable” decline?)

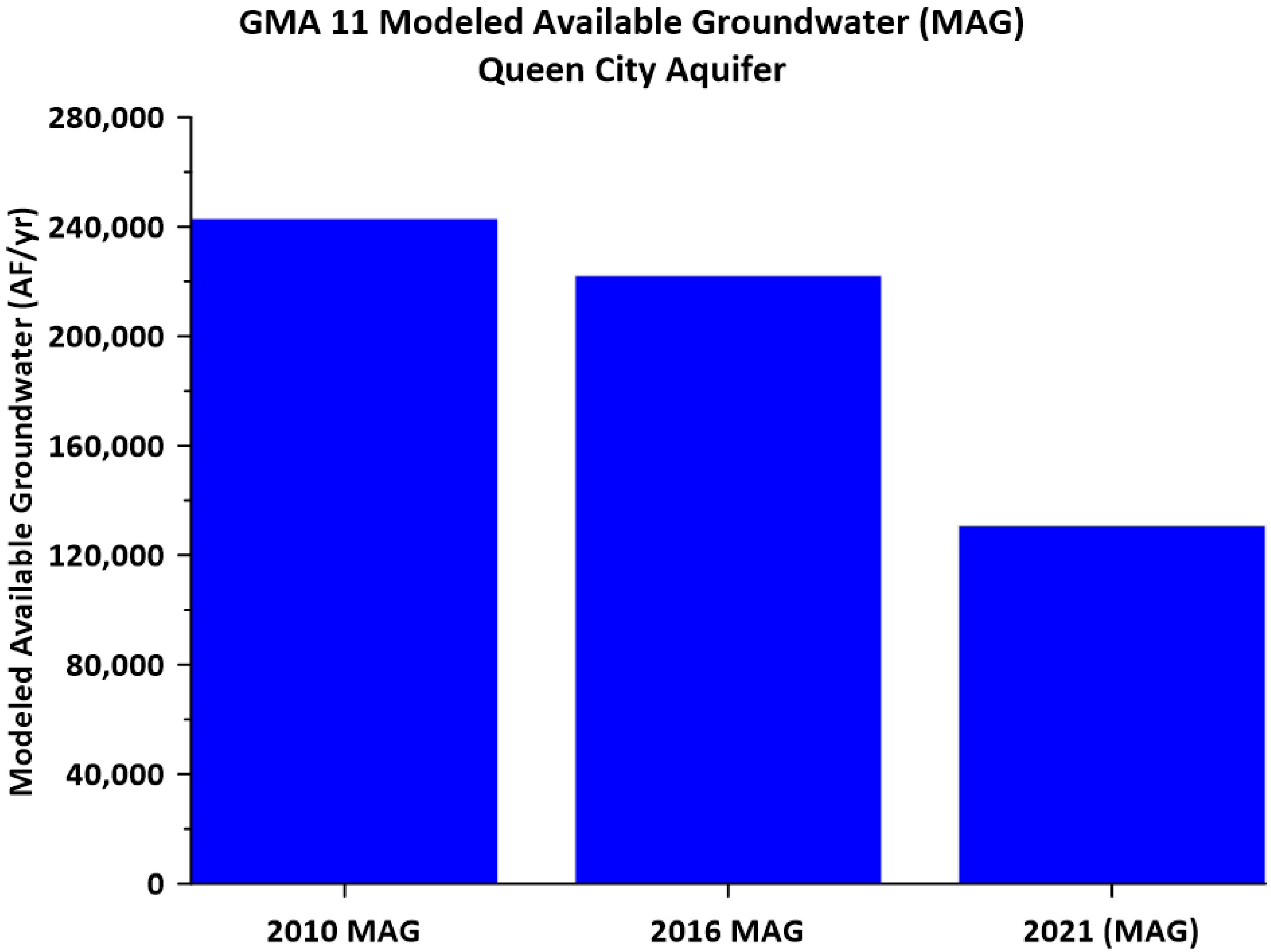
GMA 11 Considerations

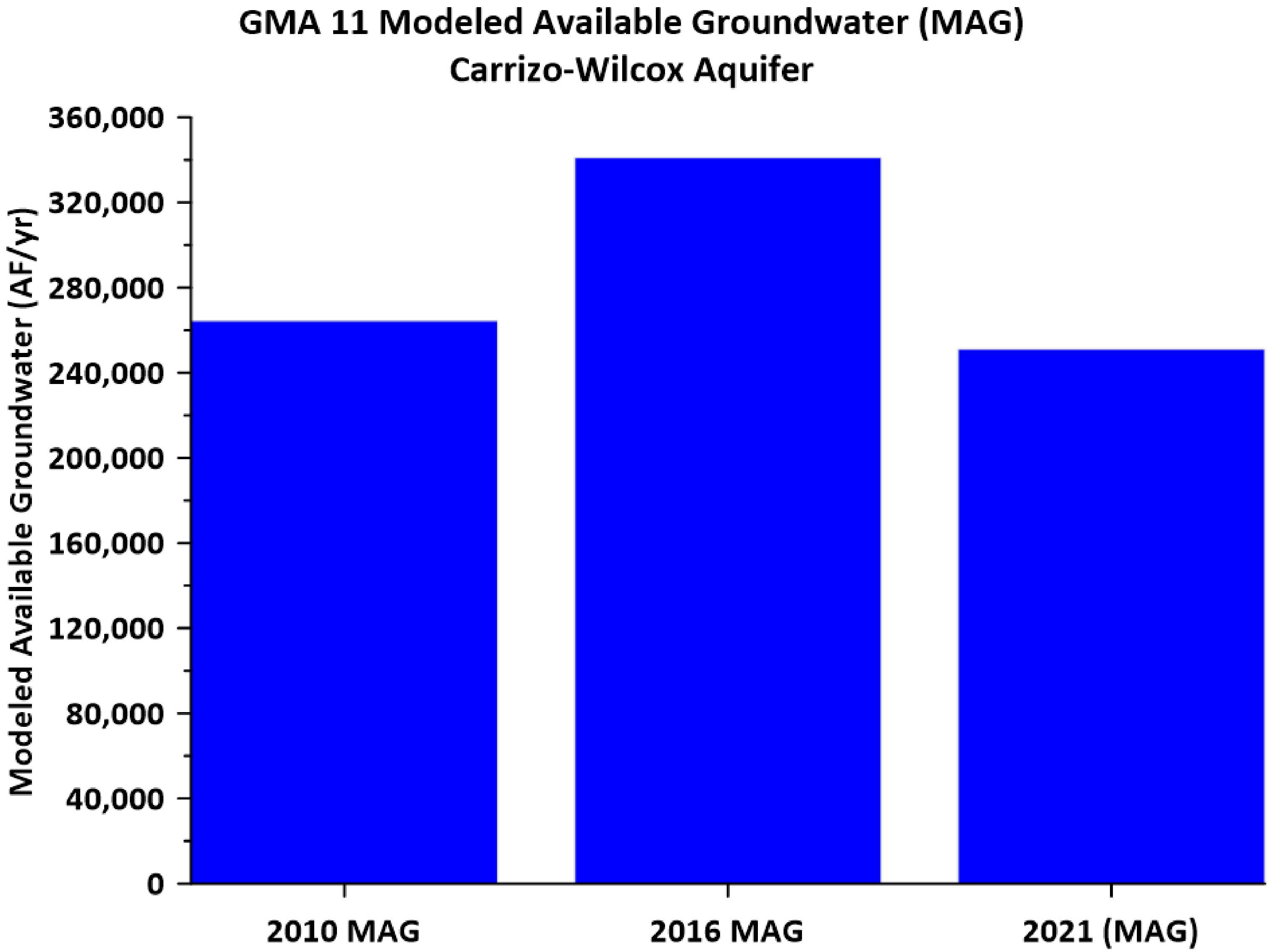
- Maximum sustainable pumping and sustainable yield are different
- GMA 11 has adopted a DFC that recognizes aquifer limits
  - As other factors are raised (via public participation), the maximum sustainable pumping provides a foundation to refine simulations to address issues of “sustainability”
- Two specific metrics to evaluate “sustainability” or “sustainable yield” (discussed later in presentation):
  - Impacts to streamflow
  - Quantifying number of “dry wells”

Past and Current MAGs

- Modeled Available Groundwater is the pumping that will achieve the Desired Future Condition
- Calculated with GAM by TWDB


GMA 11 Modeled Available Groundwater (MAG)
Sparta Aquifer
Modeled Available Groundwater (AF/yr)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2010 MAG
2016 MAG
2021 (MAG)


GMA 11 Modeled Available Groundwater (MAG)
Queen City Aquifer
Modeled Available Groundwater (AF/yr)
280,000
240,000
200,000
160,000
120,000
80,000
40,000
0
2010 MAG
2016 MAG
2021 (MAG)


GMA 11 Modeled Available Groundwater (MAG)
Carrizo-Wilcox Aquifer
Modeled Available Groundwater (AF/yr)
360,000
320,000
280,000
240,000
200,000
160,000
120,000
80,000
40,000
0
2010 MAG
2016 MAG
2021 (MAG)

Reduction in MAG (2021 vs. 2016)

- 2016 MAGs met all State Water Plan needs
- 2021 MAGs represented a reduction due to aquifer limitations
  - Fully documented in 2021 GMA 11 Explanatory Report and associated Technical Memoranda
- Region I consultants misrepresented 2021 DFC and MAG (January 2024 meeting)
  - Raised concern that groundwater availability declined
  - Region I will have to “allocate the decreases in water supply”

From Page 3 of Region I – East Texas Regional Water Planning Group Minutes (1/10/2024 meeting)

- “Andy (Donnelly) reported that some of the GMAs received an updated groundwater availability model in the middle of their planning cycle, and the groups did not have time to make the adjustments needed”
- “John McFarland (Pineywoods GCD) pointed out that GMA 11 used the updated model and pumping estimates from the State, but time was not an issue in calculating water availability”
- “James Beach explained some of the possible problems with the model updates and that the data may need to be adjusted in future planning cycles”

Is the GAM Accurate?

- Groundwater models are developed with an objective
- The update to the GAM for GMA 11 was focused on developing a tool for use in joint planning
  - Not the same as a local scale model to assess local scale issues (e.g. permit application review)
- TWDB has published standards to assess model calibration
  - Updated GAM (2021) meets those standards

TWDB Standard for Assessing Calibration Overall Model Results

- Scaled absolute residual mean < 0.10
- Overall Model
  - All targets = 0.046 (18,421 data points)
  - Downdip targets = 0.050 (12,395 data points)
  - Outcrop targets = 0.061 (6,026 data points)

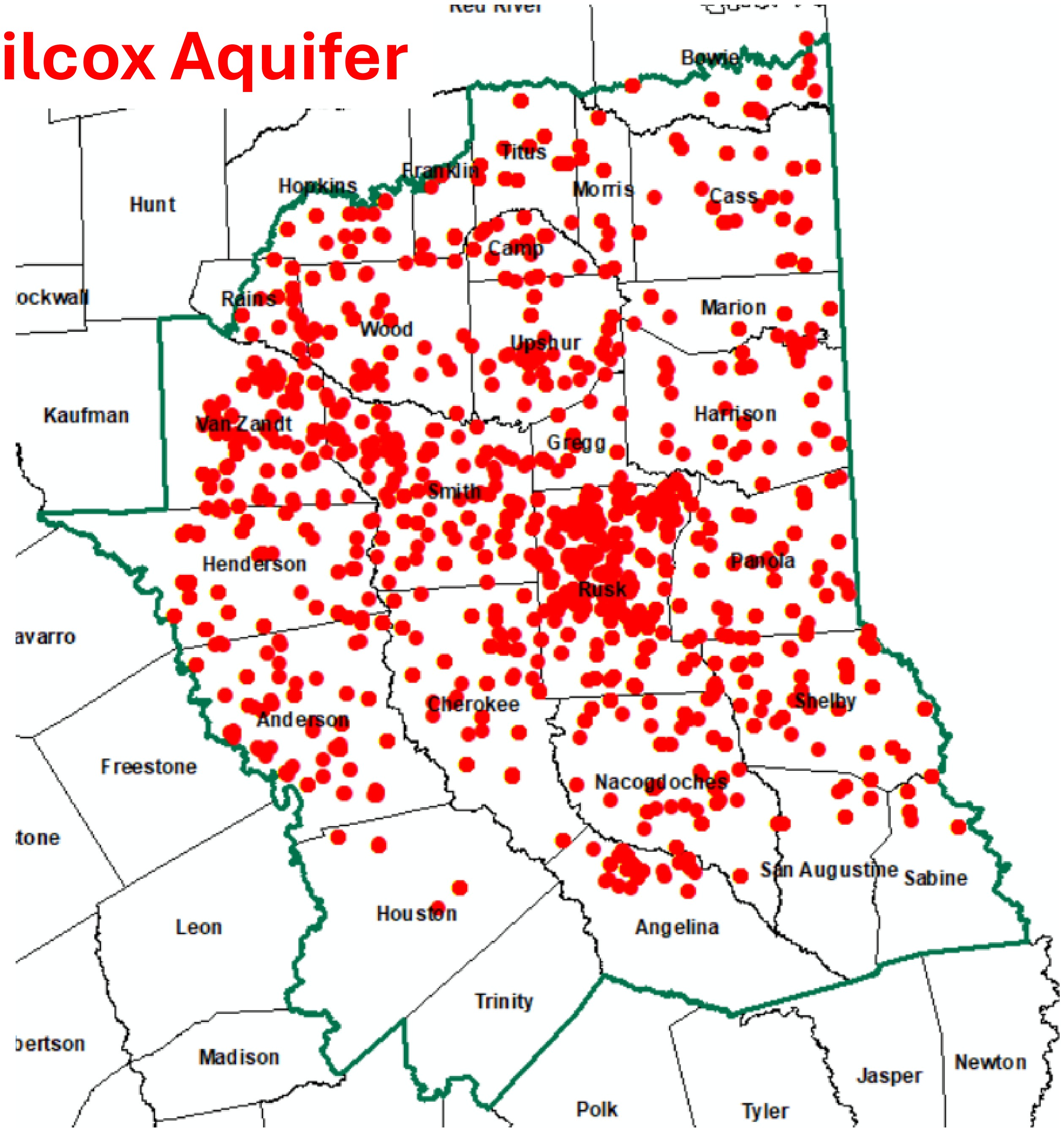
TWDB Standard for Assessing Calibration Layer Results

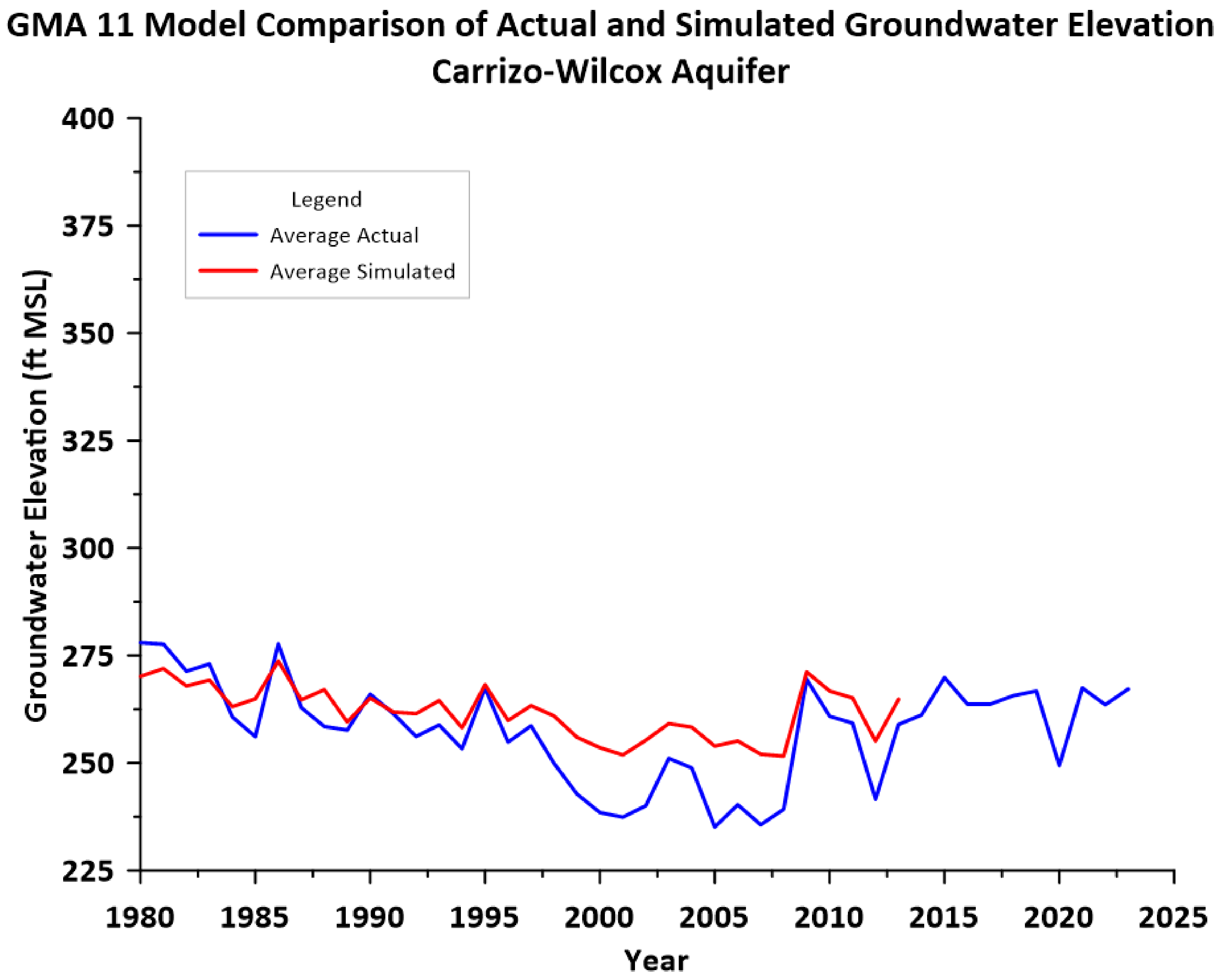
- Scaled absolute residual mean < 0.10
- Layer-specific
  - Alluvium = 0.074 (707 data points)
  - Sparta = 0.070 (681 data points)
  - Queen City = 0.086 (1,629 data points)
  - Carrizo = 0.065 (4,969 data points)
  - Upper Wilcox = 0.065 (3,458 data points)
  - Middle Wilcox = 0.043 (4,147 data points)
  - Lower Wilcox = 0.040 (2,830 data points)

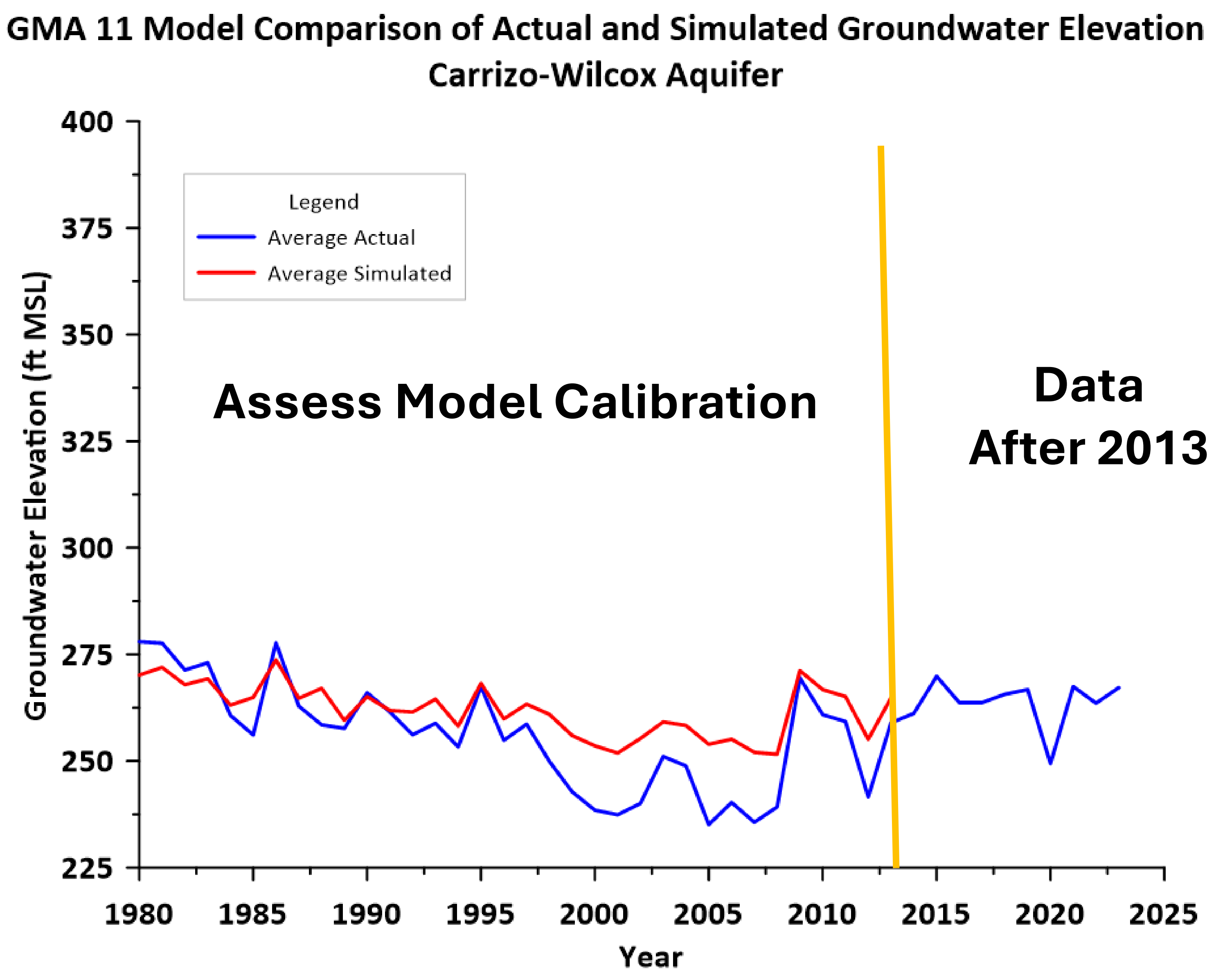
Independent Check on Model Calibration as Tool for Joint Planning

- TWDB database of measured groundwater elevations (1980 to 2013)
  - Sparta Aquifer: 27 wells (435 data points)
  - Queen City Aquifer: 125 wells (1,797 data points)
  - Carrizo-Wilcox Aquifer: 969 wells (7,920 data points)

Carrizo-Wilcox Aquifer




GMA 11 Model Comparison of Actual and Simulated Groundwater Elevation
Carrizo-Wilcox Aquifer
Legend
Average Actual
Average Simulated
Groundwater Elevation (ft MSL)
400
375
350
325
300
275
250
225
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year


GMA 11 Model Comparison of Actual and Simulated Groundwater Elevation
Carrizo-Wilcox Aquifer
Legend
Average Actual
Average Simulated
Assess Model Calibration
Data
After 2013
Groundwater Elevation (ft MSL)
Year
400
375
350
325
300
275
250
225
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025

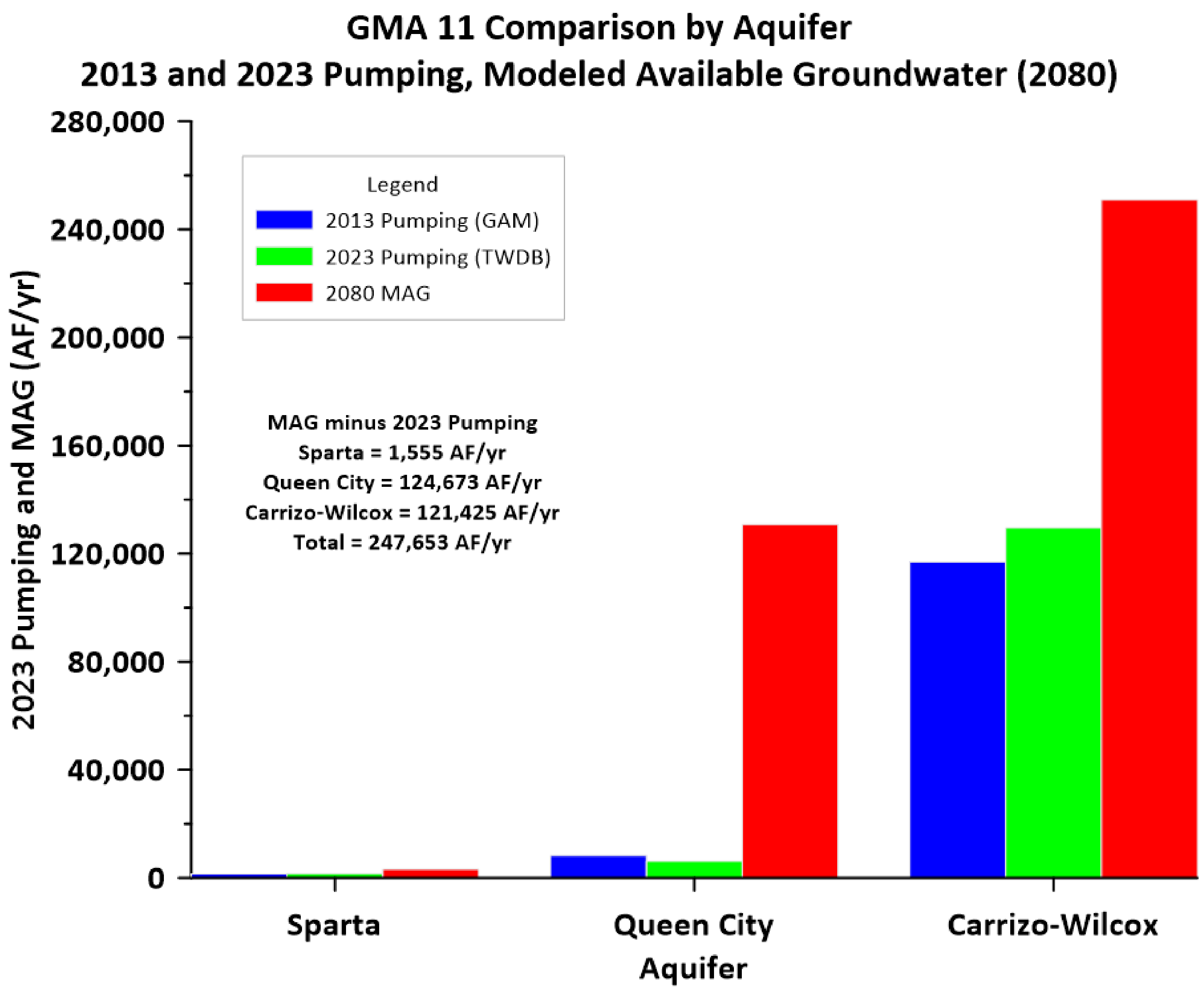
Nine Joint Planning Factors

- Summary today
- Full documentation will be included in Explanatory Report

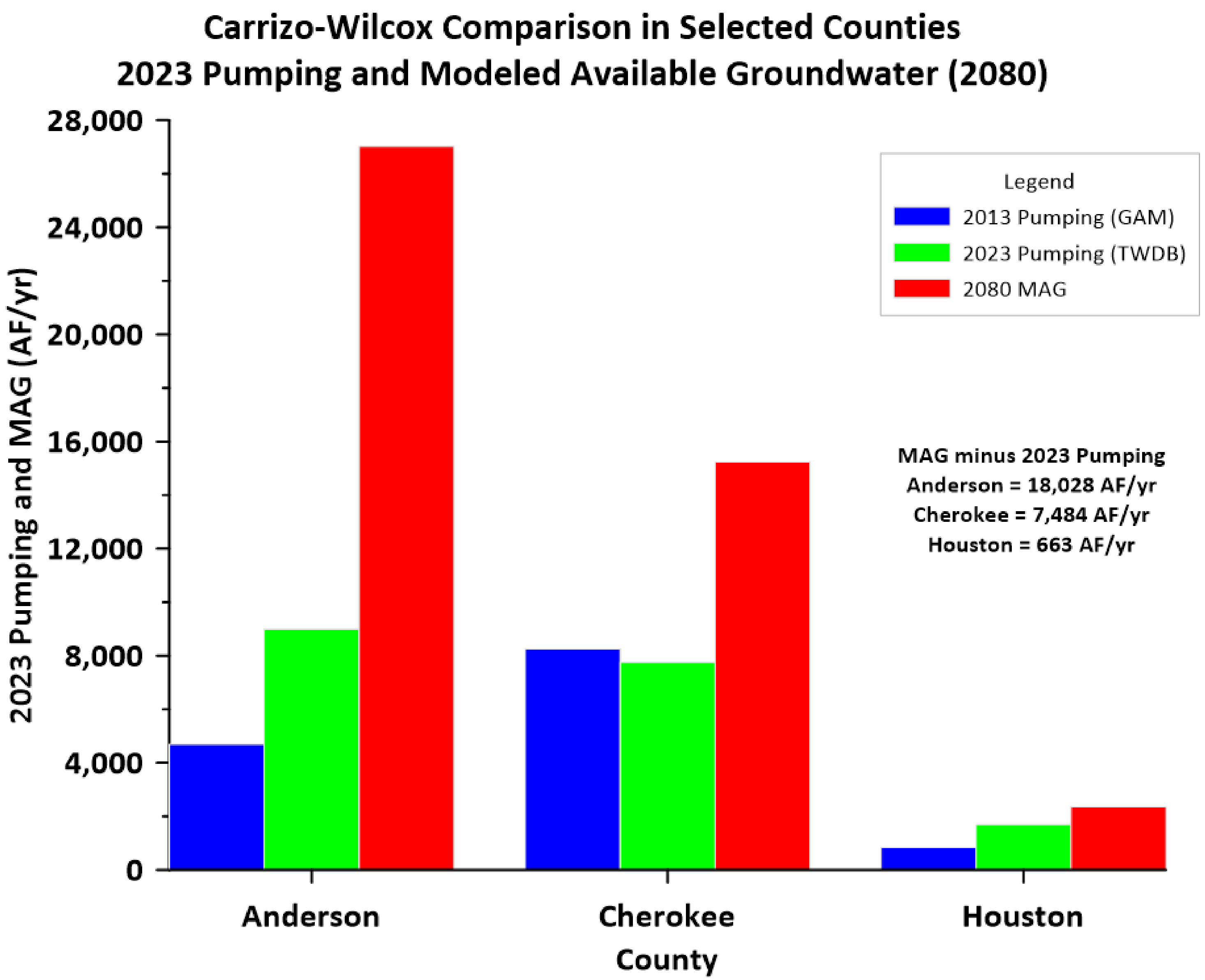
Nine Factors

1. Aquifer uses or conditions
2. State water plan needs and water management strategies
3. Hydrological conditions
   - Recoverable storage (from TWDB)
   - Groundwater budget
4. Other environmental impacts
5. Subsidence
6. Socioeconomic impacts
7. The impact on the interests and rights in private property
8. The feasibility of achieving the desired future condition
9. Any other relevant information

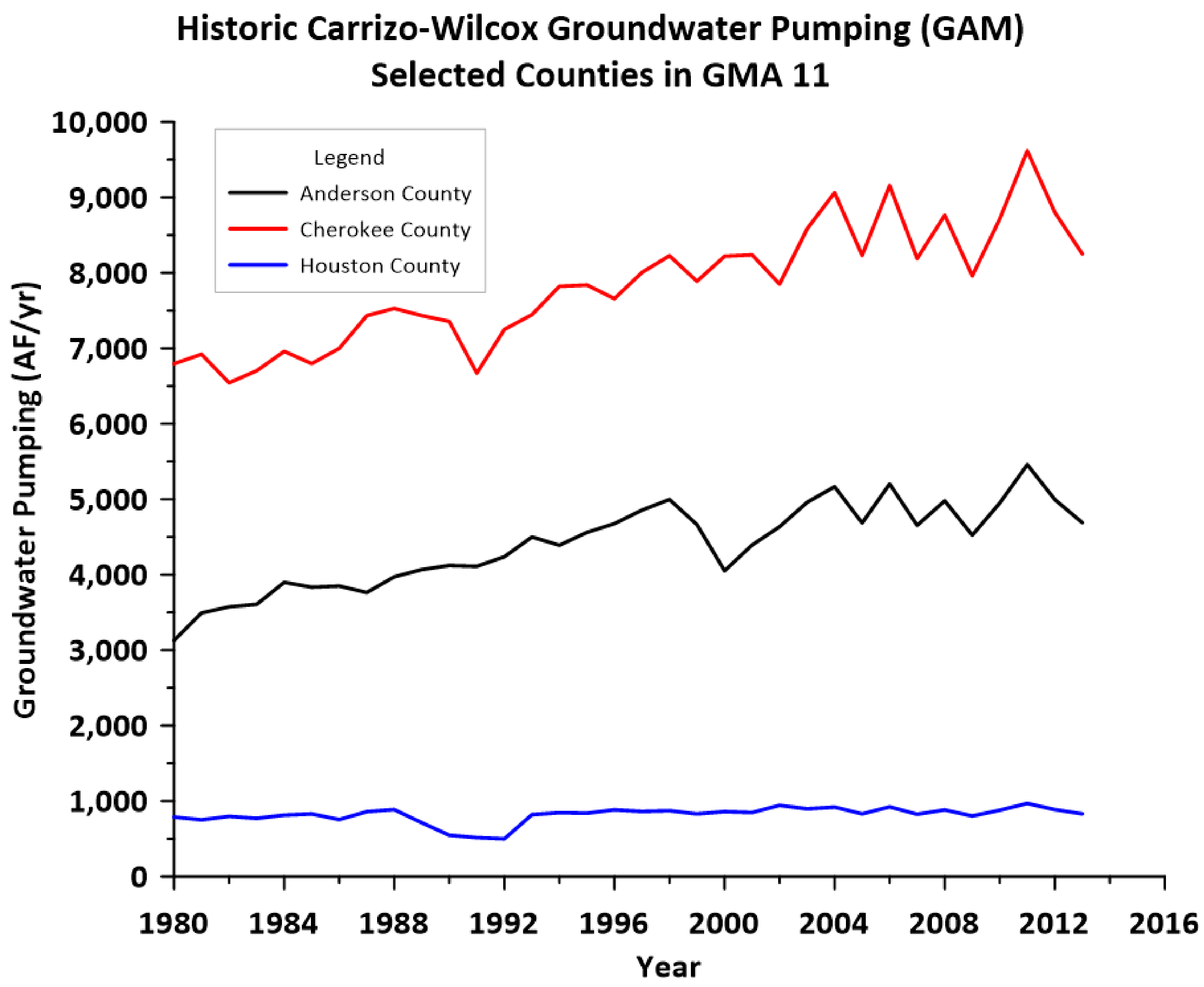
DFC Factor 1


GMA 11 Comparison by Aquifer
2013 and 2023 Pumping, Modeled Available Groundwater (2080)
2023 Pumping and MAG (AF/yr)
280,000
240,000
200,000
160,000
120,000
80,000
40,000
0
Legend
2013 Pumping (GAM)
2023 Pumping (TWDB)
2080 MAG
MAG minus 2023 Pumping
Sparta = 1,555 AF/yr
Queen City = 124,673 AF/yr
Carrizo-Wilcox = 121,425 AF/yr
Total = 247,653 AF/yr
Sparta
Queen City
Carrizo-Wilcox
Aquifer

DFC Factor 1


Carrizo-Wilcox Comparison in Selected Counties
2023 Pumping and Modeled Available Groundwater (2080)
28,000
24,000
20,000
16,000
12,000
8,000
4,000
0
2023 Pumping and MAG (AF/yr)
Legend
2013 Pumping (GAM)
2023 Pumping (TWDB)
2080 MAG
MAG minus 2023 Pumping
Anderson = 18,028 AF/yr
Cherokee = 7,484 AF/yr
Houston = 663 AF/yr
Anderson
Cherokee
Houston
County

DFC Factor 1


Historic Carrizo-Wilcox Groundwater Pumping (GAM)
Selected Counties in GMA 11
Legend
Anderson County
Cherokee County
Houston County
Groundwater Pumping (AF/yr)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1980
1984
1988
1992
1996
2000
2004
2008
2012
2016
Year

DFC Factor 1

MAG Context (Examples)

	Anderson	Cherokee
2023 "Existing Pumping" in Carrizo-Wilcox Aquifer	9,000	8,000
Modeled Available Groundwater in 2080 (MAG)	27,000	15,000
MAG minus 2023 Pumping	18,000	7,000

	Anderson	Cherokee
Projected 2080 Pumping (Extrapolation of GAM Trends)	12,000	12,000
Modeled Available Groundwater in 2080 (MAG)	27,000	15,000
MAG minus Projected 2080 Pumping	15,000	3,000

DFC Factor 2

Regional Water Plan/State Water Plan

- Previously described Region I issues
  - 2021 MAG vs 2016 MAG
- If GMA 11 adopts different DFCs, it is possible that MAGs may be reduced further in 2026/2027
- Fundamental policy question as part of balancing:
  - More weight to aquifer limits or to state water plan needs?

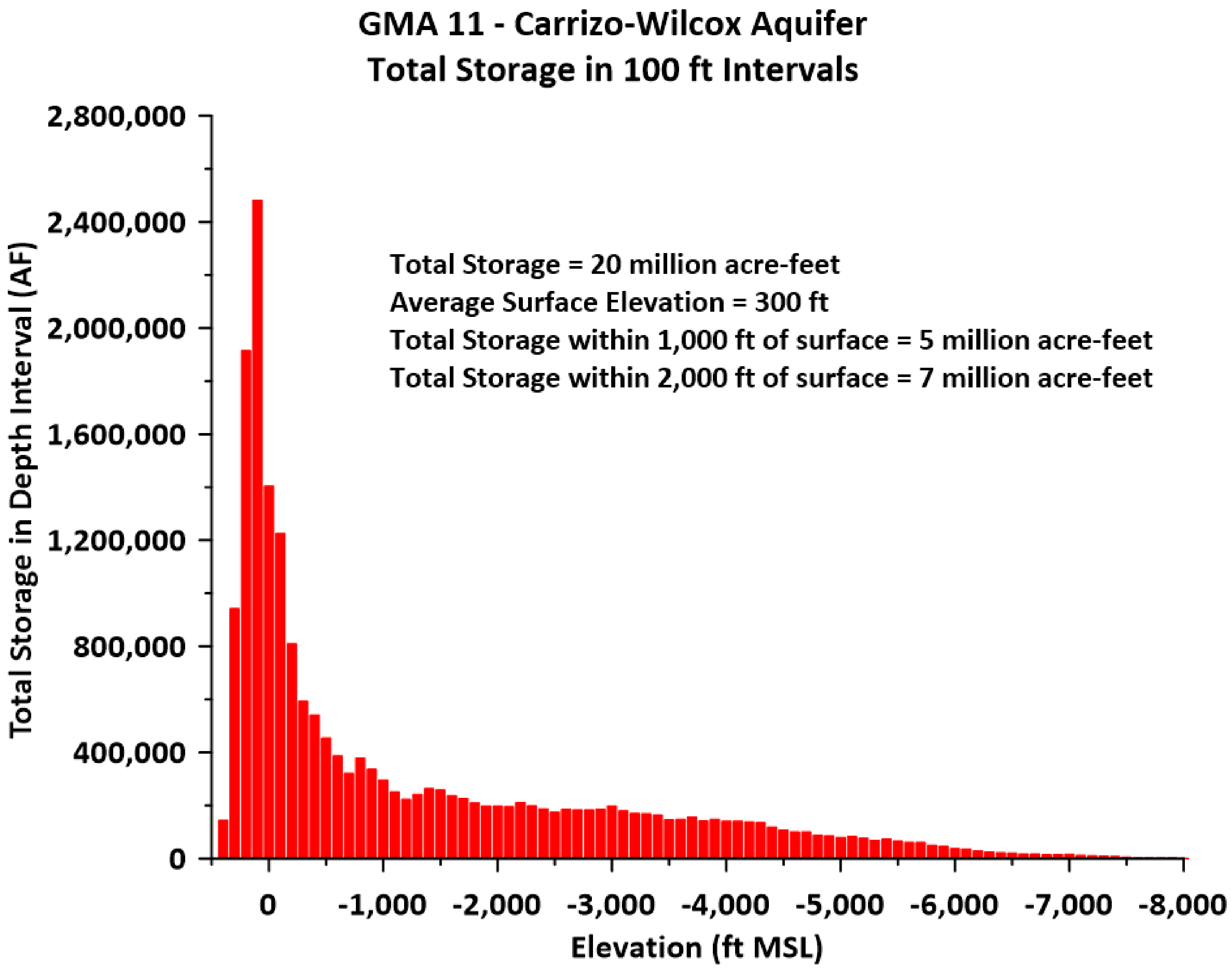
DFC Factor 3

Storage (Physical Availability?)

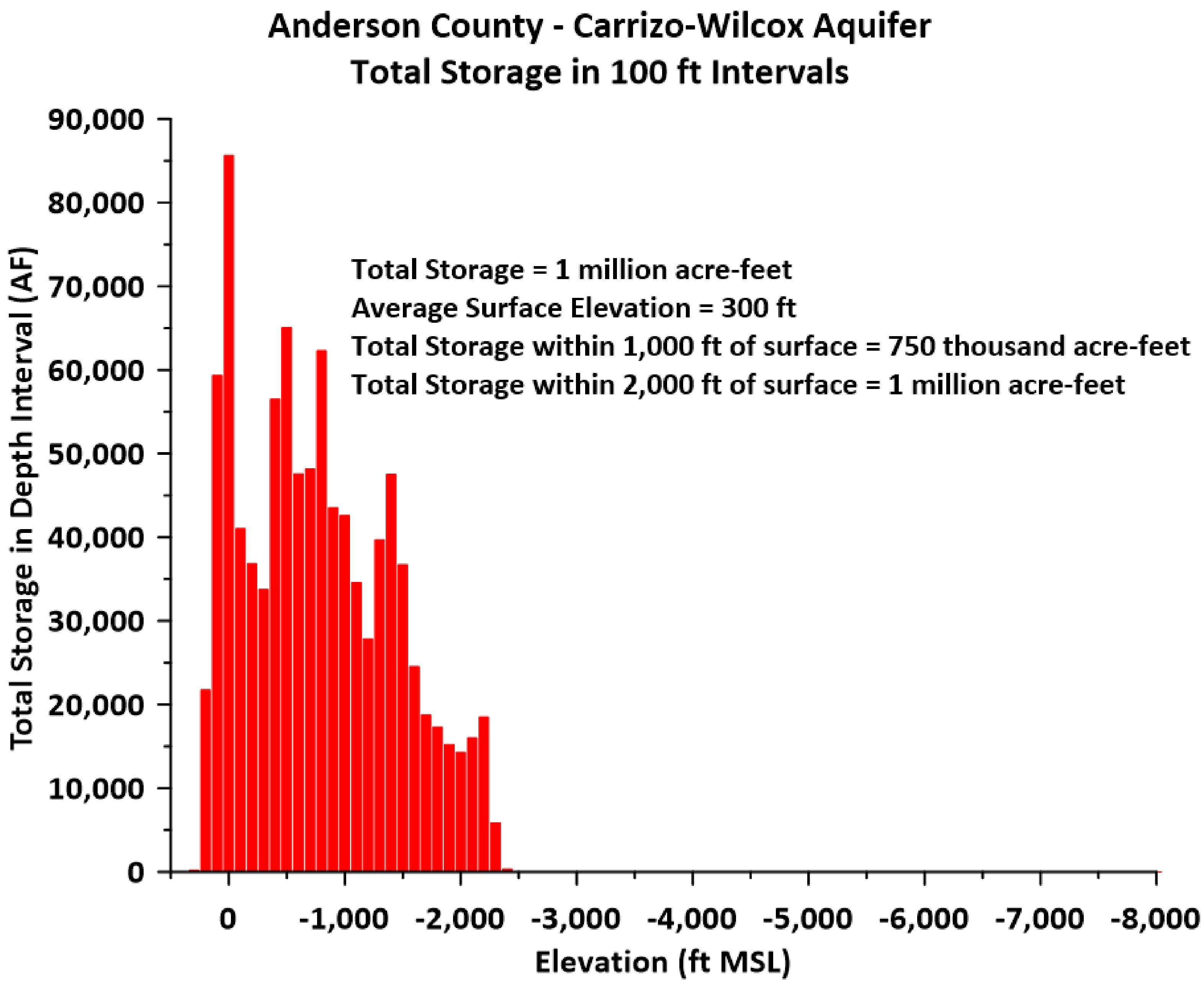
- TWDB Storage Estimates
  - Total Estimated Recoverable Storage or TERS
- 2021 Explanatory Report Estimates
- Refined Estimates from 2021 (Unofficial)

Total Groundwater Storage in GMA 11

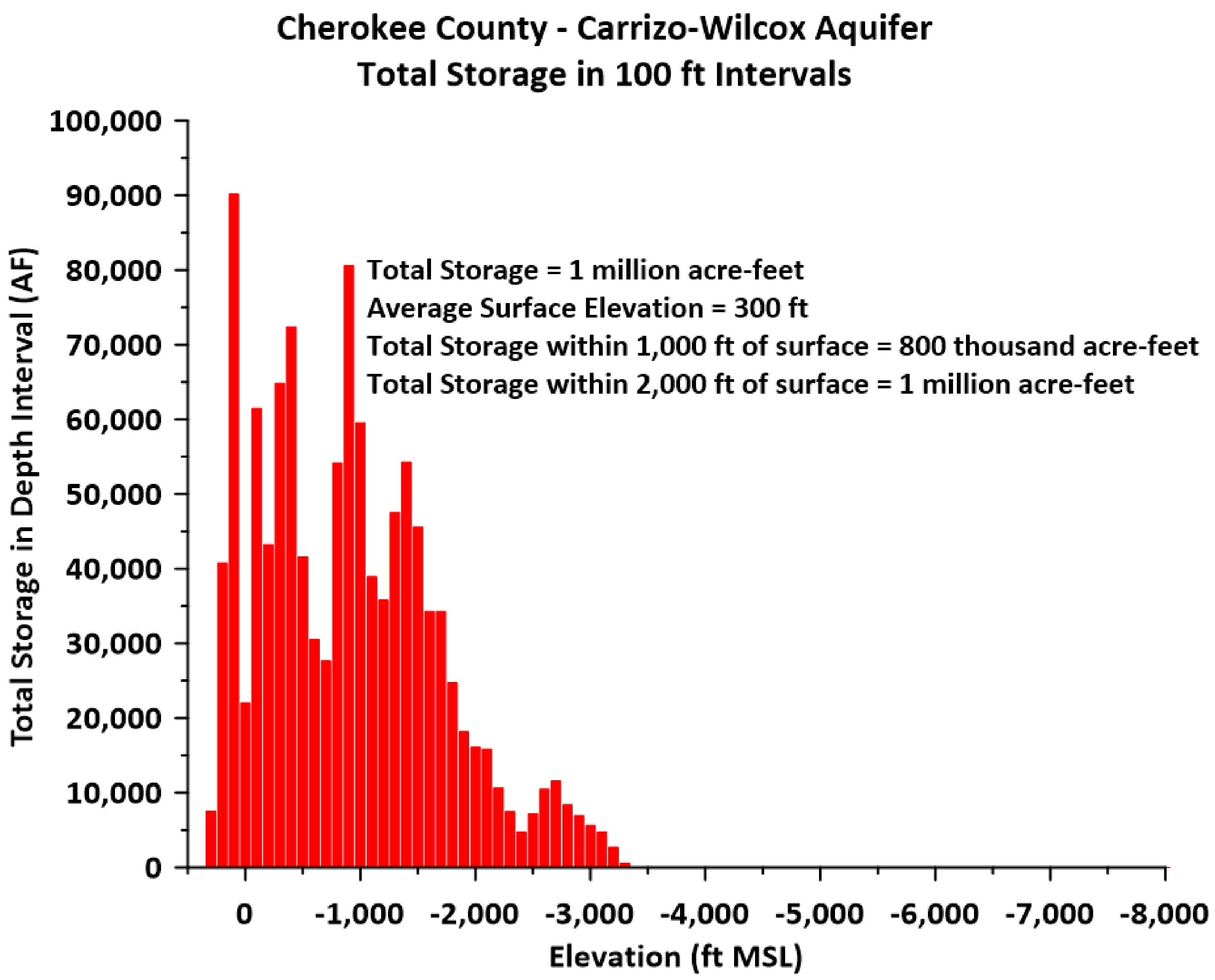
- **TWDB (2014) = 2,071 million acre-feet (2 billion AF)**
  - Based on 2004 GAM parameters
  - 2021 Explanatory Report discussed that this estimate may be too high
- Updated "unofficial" estimate (for this round of joint planning)
  - Confined Artesian = 1.2 million AF
  - Confined Saturated = 13.1 million AF
  - Unconfined = 14.8 million AF
  - **Total = 29 million AF**
    - **Carrizo-Wilcox Aquifer Total = 20 million AF**


GMA 11 - Carrizo-Wilcox Aquifer
Total Storage in 100 ft Intervals
Total Storage = 20 million acre-feet
Average Surface Elevation = 300 ft
Total Storage within 1,000 ft of surface = 5 million acre-feet
Total Storage within 2,000 ft of surface = 7 million acre-feet
Total Storage in Depth Interval (AF)
2,800,000
2,400,000
2,000,000
1,600,000
1,200,000
800,000
400,000
0
0
-1,000
-2,000
-3,000
-4,000
-5,000
-6,000
-7,000
-8,000
Elevation (ft MSL)

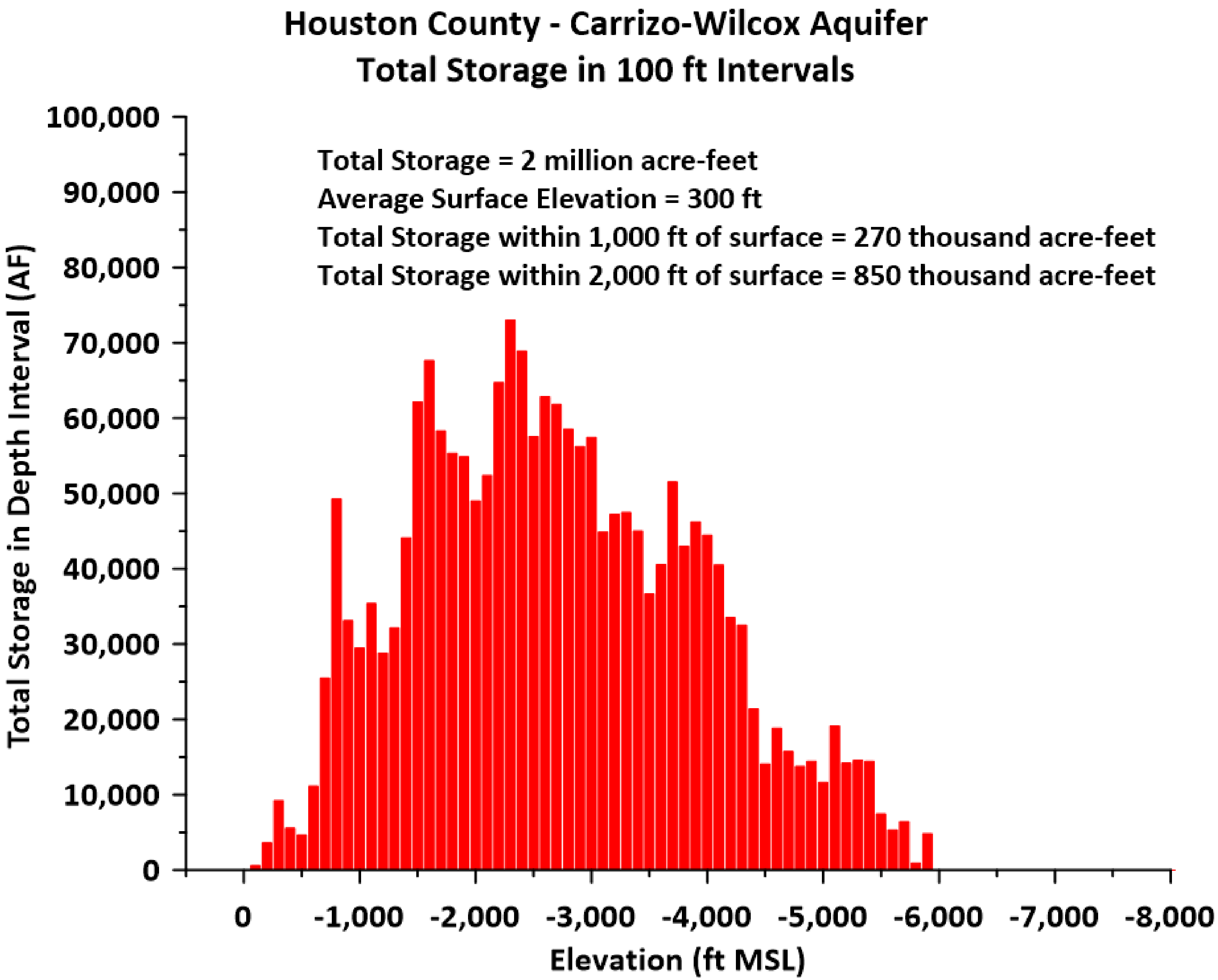
DFC Factor 3


Anderson County - Carrizo-Wilcox Aquifer
Total Storage in 100 ft Intervals
Total Storage = 1 million acre-feet
Average Surface Elevation = 300 ft
Total Storage within 1,000 ft of surface = 750 thousand acre-feet
Total Storage within 2,000 ft of surface = 1 million acre-feet
Total Storage in Depth Interval (AF)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
-1,000
-2,000
-3,000
-4,000
-5,000
-6,000
-7,000
-8,000
Elevation (ft MSL)

DFC Factor 3


Cherokee County - Carrizo-Wilcox Aquifer
Total Storage in 100 ft Intervals
Total Storage = 1 million acre-feet
Average Surface Elevation = 300 ft
Total Storage within 1,000 ft of surface = 800 thousand acre-feet
Total Storage within 2,000 ft of surface = 1 million acre-feet
Total Storage in Depth Interval (AF)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
-1,000
-2,000
-3,000
-4,000
-5,000
-6,000
-7,000
-8,000
Elevation (ft MSL)

DFC Factor 3


Houston County - Carrizo-Wilcox Aquifer
Total Storage in 100 ft Intervals
Total Storage = 2 million acre-feet
Average Surface Elevation = 300 ft
Total Storage within 1,000 ft of surface = 270 thousand acre-feet
Total Storage within 2,000 ft of surface = 850 thousand acre-feet
Total Storage in Depth Interval (AF)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
-1,000
-2,000
-3,000
-4,000
-5,000
-6,000
-7,000
-8,000
Elevation (ft MSL)

DFC Factor 3

Total Estimated Recoverable Storage

- Not a useful factor (should be dropped as a factor for joint planning)
- Frequently misused to advance a false narrative
  - “Proposed pumping is a small fraction of total storage”
- Groundwater pumping is from a dynamic system
  - Impacts of pumping can be analyzed with groundwater budgets

Groundwater Budget Analysis

- Documented in 2021 Explanatory Report
- Focuses on an analysis of "capture"
- Literature on "capture" dates to 1940
- Increased pumping impacts:
  - Reduced storage
  - Induced inflow
  - Captured outflow
- Literature in 1982 and 2002 noted that groundwater models are ideal tools to analyze "capture"
  - Also emphasized that natural rate of recharge is not relevant
- Side Note: from 2009 to (at least) 2011, TWDB groundwater modeler employment interview questions included a hypothetical capture analysis

ground water

From Ground Water
Vol. 40, No. 4
July-August 2002

DFC Factor 3

Issue Paper/

The Water Budget Myth Revisited: Why Hydrogeologists Model

by John D. Bredehoeft[1]

Abstract/

Within the ground water community, the idea persists that if one can estimate the recharge to a ground water system, one then can determine the size of a sustainable development. Theis addressed this idea in 1940 and showed it to be wrong—yet the myth continues. The size of a sustainable ground water development usually depends on how much of the discharge from the system can be "captured" by the development. Capture is independent of the recharge; it depends on the dynamic response of the aquifer system to the development. Ground water models were created to study the response dynamics of ground water systems; it is one of the principal reasons hydrogeologists model.

DFC Factor 3

DFC Results in a Pumping Increase Compared to Historic Pumping

- “Maximum Sustainable Pumping”
  - Assumed current distribution of wells
  - Pumping is “sustained” from 2014 to 2080
- Average pumping:
  - 1981 to 2013: 129,718 AF/yr
  - 2014 to 2080: 385,088 AF/yr
  - Increase: 255,370 AF/yr

DFC Factor 3

From 2021 Explanatory Report

Table 8. Summary of Sources of Increased Pumping

	AF/yr	Percentage of Pumping Increase
Pumping Increase	255,370	100
Induced Inflow		
Overlying Formations	2,929	1.15
Alluvium	184,089	72.09
Outside Texas	3,878	1.52
GMA 8	1	0.00
GMA 12	8,476	3.32
GMA 14	8,647	3.39
Captured Outflow		
Evapotranspiration	39,220	15.36
Storage Reduction		
Confined	947	0.37
Unconfined	7,317	2.87
Recharge Difference	-134	-0.05

DFC Factor 3

From 2021 Explanatory Report

Table 8. Summary of Sources of Increased Pumping

	AF/yr	Percentage of Pumping Increase
Pumping Increase	255,370	100
Induced Inflow		
Overlying Formations	2,929	1.15
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Evapotranspiration	39,220	15.36
Storage Reduction		
Confined	947	0.37
Unconfined	7,317	2.87
Recharge Difference	-134	-0.05

Pumping increase: 255,000 AF/yr

From 2021 Explanatory Report

Table 8. Summary of Sources of Increased Pumping

DFC Factor 3

		AF/yr	Percentage of Pumping Increase
Pumping Increase		255,370	100
Induced Inflow			
	Overlying Formations	2,929	1.15
	Alluvium	184,089	72.09
	Outside Texas	3,878	1.52
	GMA 8	1	0.00
	GMA 12	8,476	3.32
	GMA 14	8,647	3.39
Captured Outflow			
	Evapotranspiration	39,220	15.36
Storage Reduction			
	Confined	947	0.37
	Unconfined	7,317	2.87
Recharge Difference		-134	-0.05

3% of pumping increase is from storage

DFC Factor 3

From 2021 Explanatory Report

Table 8. Summary of Sources of Increased Pumping

	AF/yr	Percentage of Pumping Increase
Pumping Increase	255,370	100
Induced Inflow		
Overlying Formations	2,929	1.15
Alluvium	184,089	72.09
Outside Texas	3,878	1.52
GMA 8	1	0.00
GMA 12	8,476	3.32
GMA 14	8,647	3.39
Captured Outflow		
Evapotranspiration	39,220	15.36
Storage Reduction		
Confined	947	0.37
Unconfined	7,317	2.87
Recharge Difference	-134	-0.05

72% of pumping increase is from induced inflow of surface water

DFC Factor 3

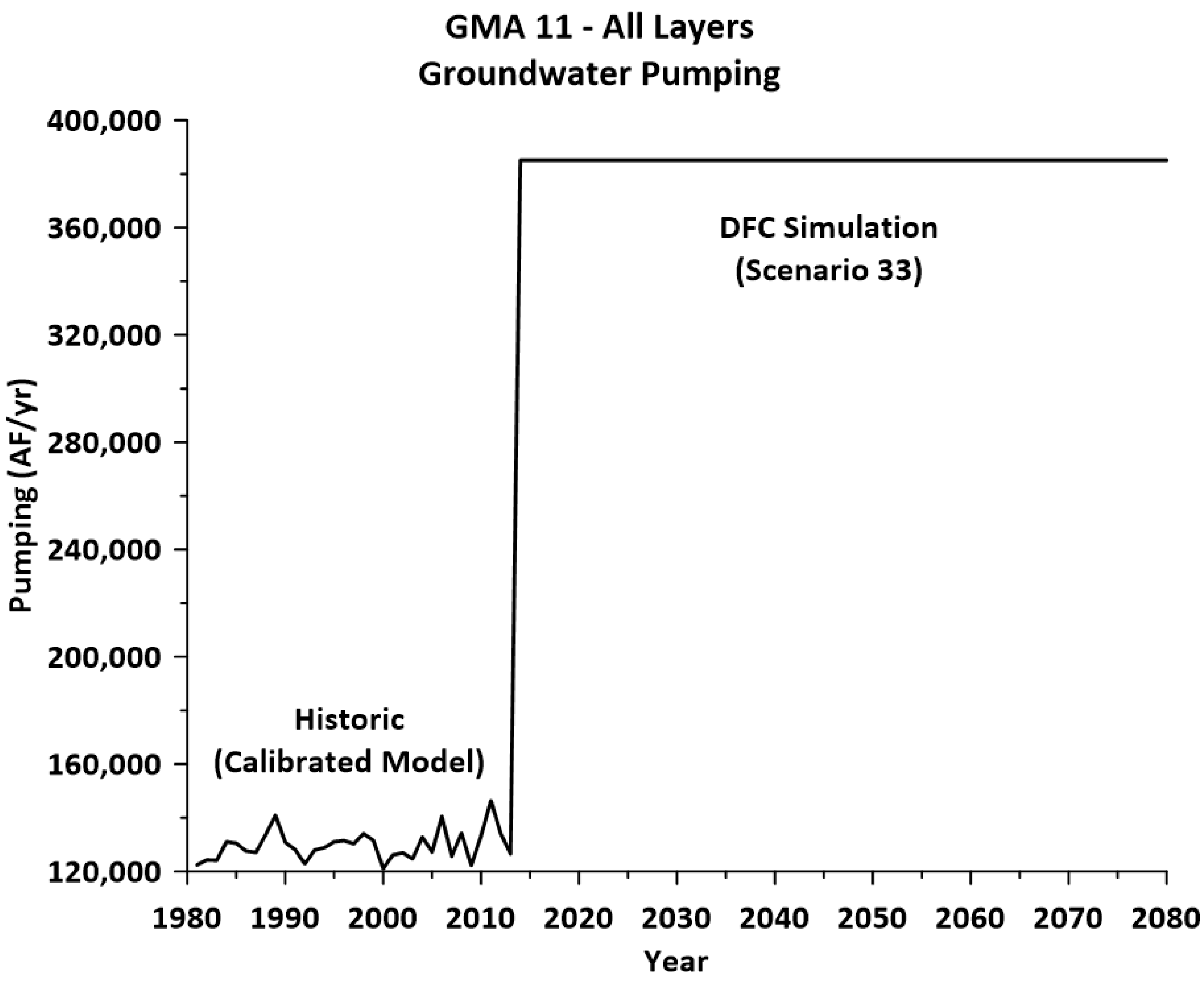
From 2021 Explanatory Report

Table 8. Summary of Sources of Increased Pumping

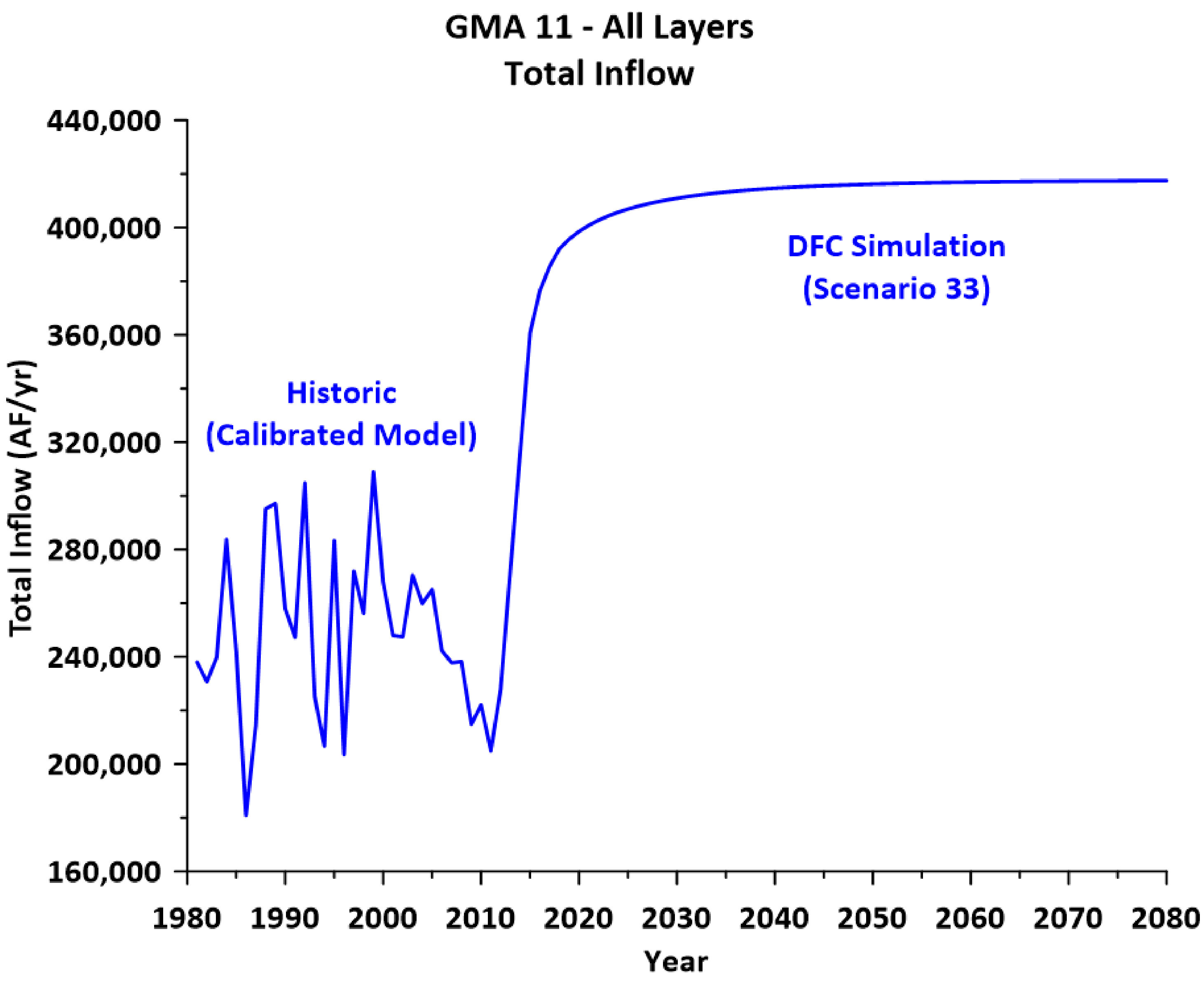
	AF/yr	Percentage of Pumping Increase
Pumping Increase	255,370	100
Induced Inflow		
Overlying Formations	2,929	1.15
Alluvium	184,089	72.09
Outside Texas	3,878	1.52
GMA 8	1	0.00
GMA 12	8,476	3.32
GMA 14	8,647	3.39
Captured Outflow		
Evapotranspiration	39,220	15.36
Storage Reduction		
Confined	947	0.37
Unconfined	7,317	2.87
Recharge Difference	-134	-0.05

15% of pumping increase is from reduced evapotranspiration

DFC Factor 3

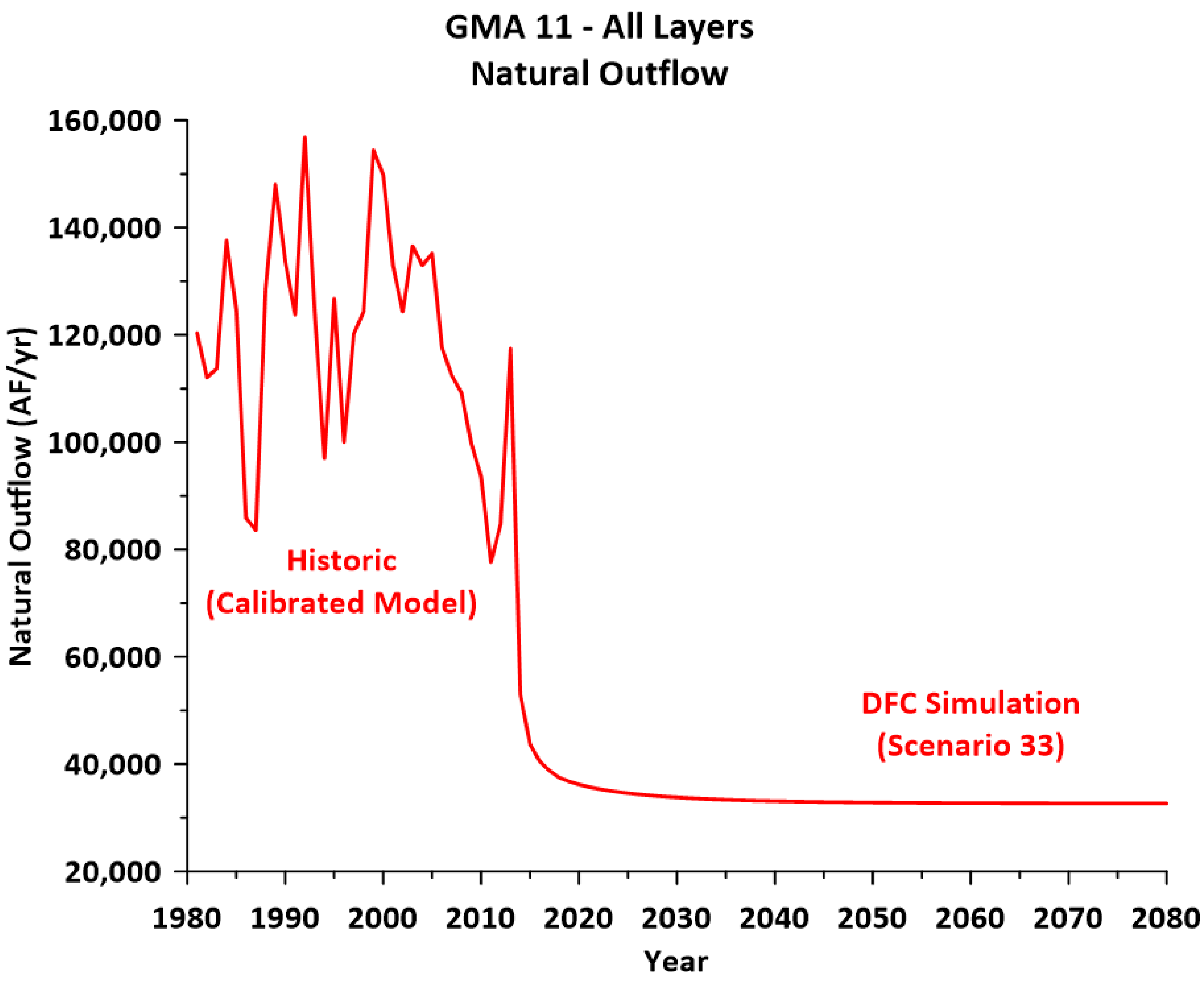

GMA 11 - All Layers
Groundwater Pumping
400,000
360,000
320,000
280,000
240,000
200,000
160,000
120,000
Pumping (AF/yr)
DFC Simulation
(Scenario 33)
Historic
(Calibrated Model)
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
Year

DFC Factor 3



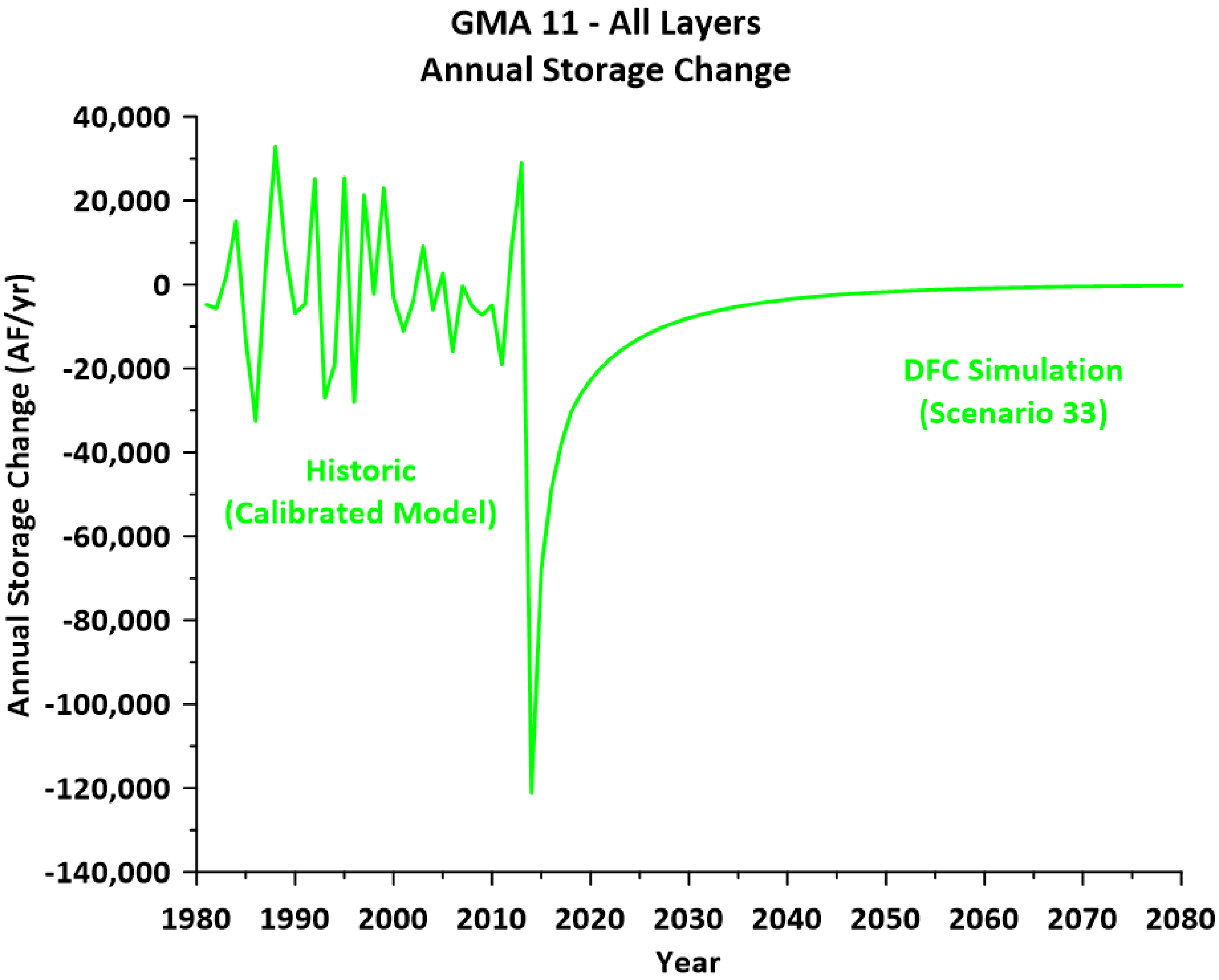
GMA 11 - All Layers
Total Inflow
Total Inflow (AF/yr)
440,000
400,000
360,000
320,000
280,000
240,000
200,000
160,000
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
Year
Historic
(Calibrated Model)
DFC Simulation
(Scenario 33)

DFC Factor 3

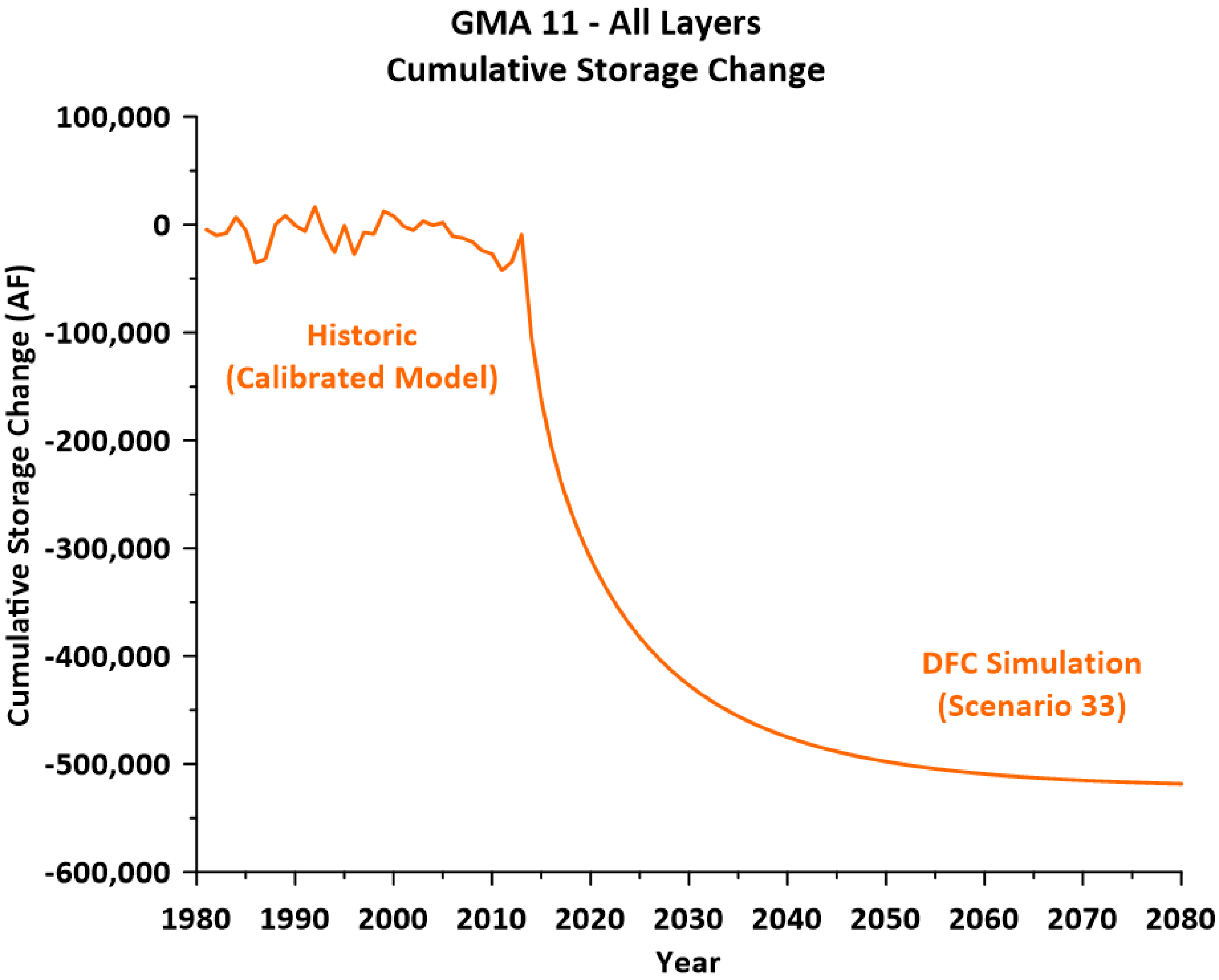


GMA 11 - All Layers
Natural Outflow
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
Natural Outflow (AF/yr)
Historic
(Calibrated Model)
DFC Simulation
(Scenario 33)
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
Year

DFC Factor 3


GMA 11 - All Layers
Annual Storage Change
Annual Storage Change (AF/yr)
40,000
20,000
0
-20,000
-40,000
-60,000
-80,000
-100,000
-120,000
-140,000
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
Year
Historic
(Calibrated Model)
DFC Simulation
(Scenario 33)

DFC Factor 3



GMA 11 - All Layers
Cumulative Storage Change
100,000
0
-100,000
-200,000
-300,000
-400,000
-500,000
-600,000
Cumulative Storage Change (AF)
Historic
(Calibrated Model)
DFC Simulation
(Scenario 33)
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
Year

Storage Analysis

- Pumping Increase = 255,000 AF/yr
  - Cumulative Pumping (2014 to 2080) = 17.1 million AF
- Cumulative Storage Decline = 518,000 AF
- Cumulative Storage Decline is about 3 % of Cumulative Pumping
- Cumulative Storage Decline is about 2 % of Initial Total Storage

Storage Analysis

- Pumping Increase = 255,000 AF/yr
  - Cumulative Pumping (2014 to 2080) = 17.1 million AF
- Cumulative Storage Decline = 518,000 AF
- Cumulative Storage Decline is about 3 % of Cumulative Pumping
- Cumulative Storage Decline is about 2 % of Initial Total Storage

What are the impacts of a 2 % decline in total storage?

Will be covered in discussion of Factors 6 and 7

Other Environmental Impacts

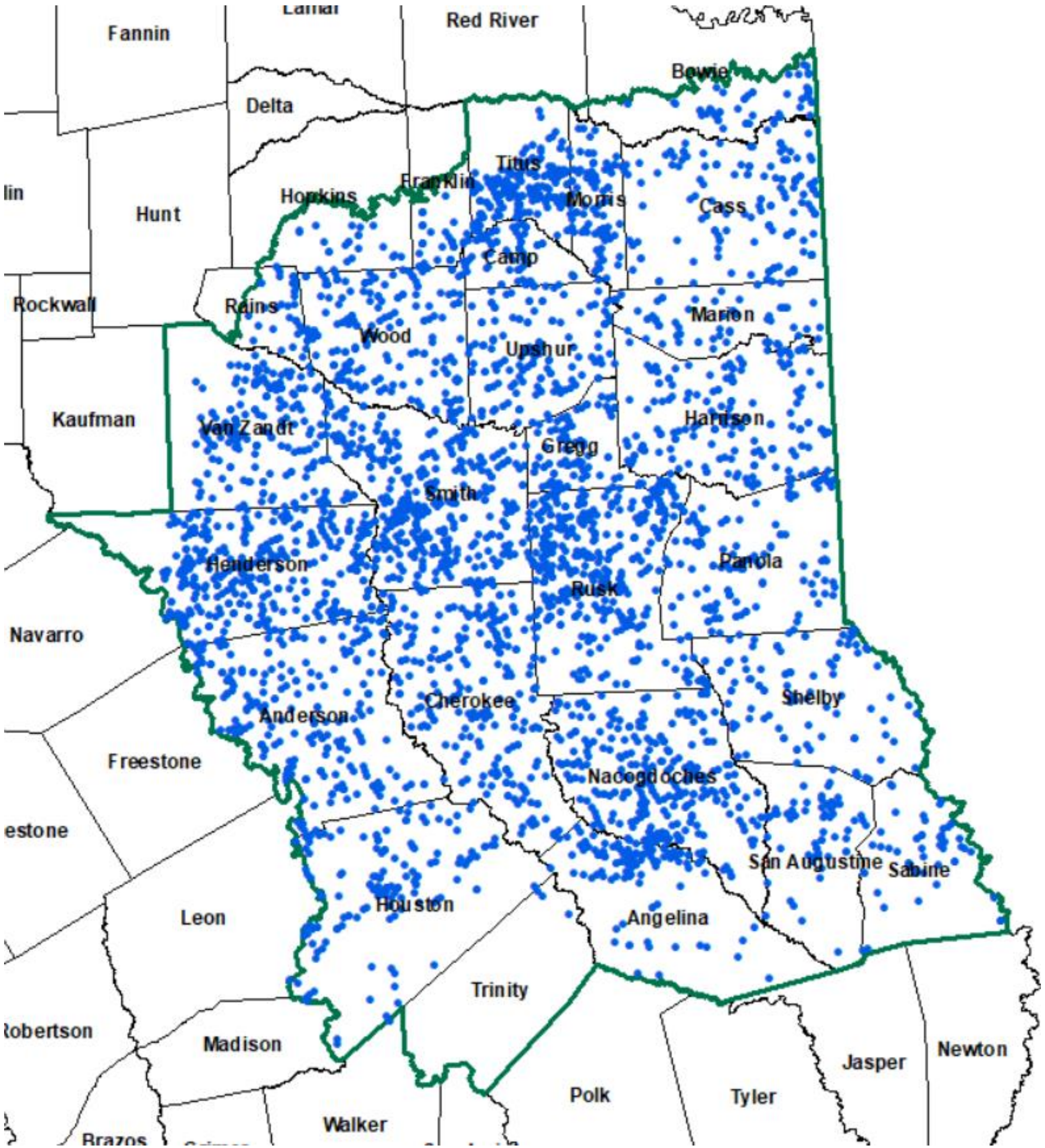
- Recommend that current round of joint planning focus on surface water impacts for this factor
- Work is in progress to develop more detailed groundwater budgets for "induced inflow" for current round of joint planning
  - Main rivers
  - Tributaries
  - Lakes
- Will be documented in tech memo and explanatory report
- Side note: reduced evapotranspiration used to be considered "conservation" of water (1950s and 1960s)
  - Definition is different today

Subsidence

- Historically, not an issue in aquifers of GMA 11
- 2021 Explanatory report documented results of the TWDB Subsidence Tool (0 is low risk, 10 is high risk)
  - Sparta = 3.91(subsidence of 0 feet)
  - Queen City = 4.22 (subsidence of 0 feet)
  - Carrizo-Wilcox = 4.53 (subsidence of 0.16 feet)

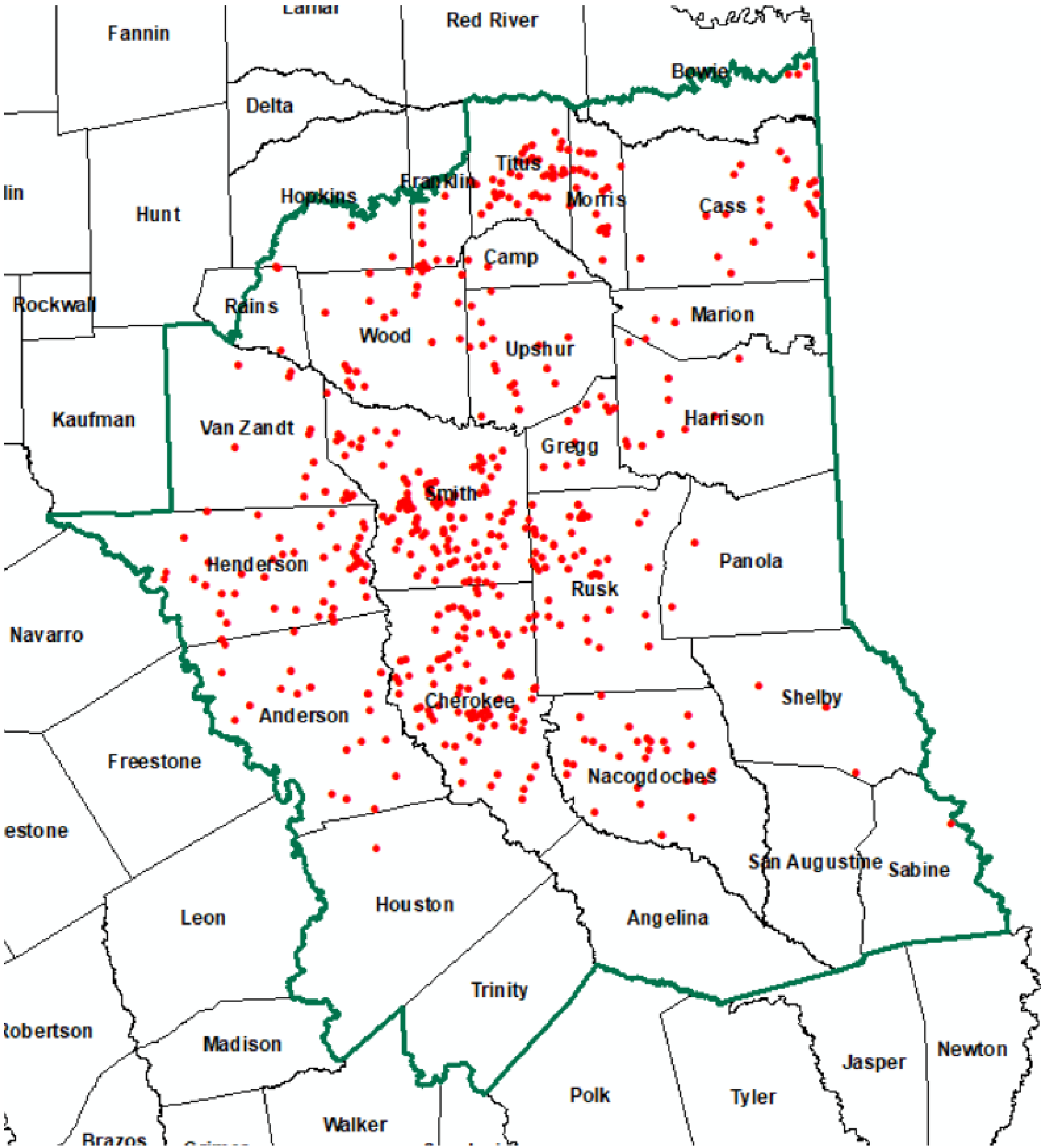
Well Locations in GMA 11

- TWDB Database (Well Locations and Depths)
- 5,786 wells in GMA 11
- 4,217 wells with good depths (depicted on map)



Dry Wells in 2080

- For each well in database:
  - Compared simulated 2080 groundwater elevation to well bottom elevation (plus 20 feet)
  - 568 wells would be dry by 2080
  - Categorized by county and model layer



DFC Factors 6 and 7

Dry Well Analysis – County Based

County	Number of Wells in Database	Number of Dry Wells	Average Depth of Dry Wells (ft)	Dry Wells (% of Total)
Anderson	237	24	209	10
Angelina	118	0	0	0
Bowie	50	3	61	6
Camp	80	4	143	5
Cass	162	29	84	18
Cherokee	255	93	273	36
Franklin	40	11	178	28
Gregg	107	14	182	13
Harrison	188	14	133	7
Henderson	370	46	233	12
Hopkins	25	2	159	8
Houston	155	1	130	1
Marion	61	3	112	5
Morris	98	22	79	22

County	Number of Wells in Database	Number of Dry Wells	Average Depth of Dry Wells (ft)	Dry Wells (% of Total)
Nacogdoches	315	27	162	9
Panola	136	2	120	1
Rains	31	3	58	10
Rusk	428	51	238	12
Sabine	55	1	20	2
SanAugustine	65	0	0	0
Shelby	105	3	79	3
Smith	375	116	287	31
Titus	190	42	151	22
Trinity	3	0	0	0
Upshur	150	18	208	12
VanZandt	218	16	270	7
Wood	200	23	268	12
GMA 11	**4,217**	**568**	**219**	**13**

DFC Factors 6 and 7

Dry Well Analysis – Model Layer Based

Layer	Formation	Number of Wells in Database	Number of Dry Wells	Average Depth of Dry Wells (ft)	Dry Wells (% of Total)
1	Alluvium	80	19	44	24
2	Sparta	155	7	58	5
3	Weches	58	21	96	36
4	Queen City	288	139	131	48
5	Reklaw	231	42	188	18
6	Carrizo	423	119	328	28
7	Upper Wilcox	1,224	162	270	13
8	Middle Wilcox	989	52	216	5
9	Lower Wilcox	769	7	122	1
GMA 11		**4,217**	**568**	**219**	**13**

DFC Factors 6 and 7

Dry Well Analysis – Model Layer Based

Layer	Formation	Number of Wells in Database	Number of Dry Wells	Average Depth of Dry Wells (ft)	Dry Wells (% of Total)
1	Alluvium	80	19	44	24
2	Sparta	155	7	58	5
3	Weches	58	21	96	36
4	Queen City	288	139	131	48
5	Reklaw	231	42	188	18
6	Carrizo	423	119	328	28
7	Upper Wilcox	1,224	162	270	13
8	Middle Wilcox	989	52	216	5
9	Lower Wilcox	769	7	122	1
GMA 11		**4,217**	**568**	**219**	**13**

Additional Simulations are Recommended

- Propose scenarios with reduced Queen City and Carrizo-Wilcox pumping
  - Update the dry well analysis
  - Compare with current DFC/MAG pumping
  - GMA 11 can balance production with conservation (maintain existing wells)
- Results of additional simulations will also include evaluating and comparing impacts to surface water (discussed earlier)

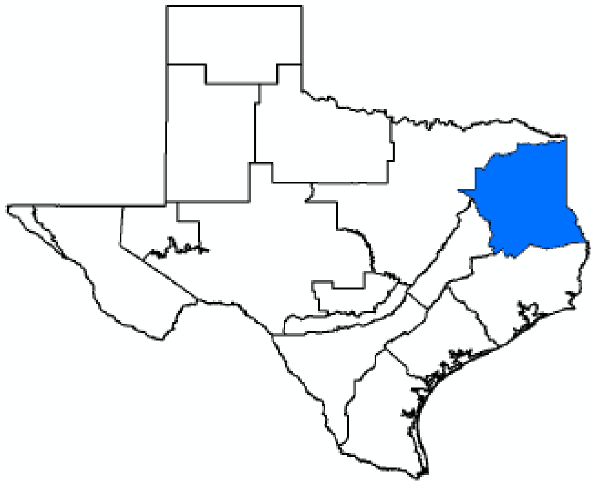
GMA 11 Meeting
May 15, 2024

- Compared measured drawdown with simulated drawdowns
- Draft report and presentation at GMA 11 meeting
- Conclusion:
  - Actual drawdowns are less than simulated drawdowns (DFC)
  - Expected conclusion given the "high" pumping associated with the MAG
- This work is consistent with new requirements of HB 2078

Draft Report

DFC Factor 8

Comparison of Measured Drawdown with Simulated Drawdowns from the Desired Future Conditions Adopted in 2021 in Groundwater Management Area 11



Prepared for:
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GMA 11 Administrative Coordinator
Panola Groundwater Conservation District
419 W. Sabine St.
Carthage, TX 75633

Prepared by:
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Brenham, TX 77833
512-745-0599
billhutch@texasgw.com

May 2, 2024

Other Relevant Information

- None

Recommendations

- Additional GAM simulations for this round of joint planning:
  - Reduced Queen City pumping
  - Reduced Carrizo-Wilcox pumping
- Evaluate GAM output from additional simulations
  - Number of dry wells
  - Surface water impacts
- Compare alternative scenarios with current DFC simulation
  - Information for GMA 11's balancing task
- GAM Update
  - Need to update and improve GAM (for next round of joint planning)
  - Detailed recommendations will be developed

Recommend Adaptive Management and Reject Regional Correlative Rights

- Current Joint Planning Process is “Adaptive Management”
  - Update DFCs every five years
  - Use updated data, information, models
  - Explanatory report identifies issues for improvement during next cycle
  - Acknowledges uncertainty and seeks to constantly improve knowledge
- Regional Correlative Rights
  - Can rely too heavily on storage (poor metric)
  - Seeks “regulatory certainty” now when groundwater data and models are constantly improving
  - Homogenizes a system with inherent variability
    - Equal outcomes for groundwater at 500 ft depth and 5,000 ft depth
    - Equal outcomes for areas of high transmissivity and low transmissivity
  - Attempts to factor in differences ignores the fact that local data will constantly improve with new groundwater development
    - Compromises the “regulatory certainty” that is sought

Recommended Factor Update (for consideration during legislative interim)

1. Past DFC Achievement
2. Historic and Projected Groundwater Pumping
   - TWDB estimates
   - GAM estimates
   - RWPG estimates
3. Analysis of Hydrogeologic Impacts of DFC
   - Storage decline
   - Induced inflow
   - Captured outflow
   - Subsidence
4. Analysis of Dry Wells
5. Any other relevant information

Summary

- Groundwater Availability is defined in statute
    - Modeled Available Groundwater
- Total storage is not relevant and is not a good factor for joint planning
    - Misleading and is used to advance false narratives
    - Factor should be removed from joint planning process
- Heavy reliance on state water plan needs pushes GMAs to higher groundwater availabilities
    - DFCs should focus on aquifer capabilities, not on meeting "inexpensive" needs
    - Some other factors should be removed or modified by legislature
- In 2021, GMA 11 advanced concepts related to "maximum sustainable pumping" without recognition
    - This round of joint planning represents an opportunity to refine this concept to include additional elements of sustainable use

Budget Approved at Last GMA 11 Meeting (May 15, 2024)

Task Number	Task Description	Task Cost (with Task 2)	Completion
1	Preparation, Travel, and Attendance for GMA 11 meetings ($1,500/meeting, assume 5)	$7,500	Ongoing thru 2026
2	DFC Comparison	$6,500	May 2024
3	Factor Documentation	$6,000	Dec 2025
4	Draft Explanatory Report and Not Relevant Documentation	$7,500	Jan 2026
5	Revise Draft based on Public Comments	$2,000	Aug 2026
6	Prepare Final Explanatory Report and Not Relevant Documentation, Submit to TWDB	$2,000	Jan 2027
Total		**$31,500**	

Assumes No New Simulations
Assumes Lump Sum Invoicing at Completion of Task (Except for Task 1, invoiced after each meeting)

Proposed Budget Update

Task Number	Task Description	Task Cost	Past Invoices	Current Invoice	Remaining Budget	Completion
1	Preparation, Travel, and Attendance for GMA 11 meetings ($1,500/meeting, assume 5)	$7,500	$1,500	$1,500	$4,500	Ongoing through 2026
2	Comparison of DFC with Measured Data (HB 2078)	$6,500	$6,500	$0	$0	May 2024
3	Factor Evaluation and Presentation	$6,000	$0	$6,000	$0	Oct 2025
4	GAM Simulations and Tech Memo	$12,000	$0	$0	$12,000	Feb 2026
5	Draft Explanatory Report and Not Relevant Documentation	$8,000	$0	$0	$8,000	Mar or Apr 2026
6	Respond to Public Comments and Revise Draft Explanatory Report Comments	$5,000	$0	$0	$5,000	Sept or Oct 2026
7	Prepare Final Explanatory Report and Not Relevant Documentation, Submit to TWDB	$5,000	$0	$0	$5,000	Dec 2026 or Jan 2027
	Total	**$50,000**	**$8,000**	**$7,500**	**$34,500**	
	Individual District Share	**$12,500**	**$2,000**	**$1,875**	**$8,625**	

Assumes Lump Sum Invoicing at Completion of Task (Except Task 1, invoiced after each meeting)
Assumes Individual Invoice for Each GCD (1/4 of total)