Agenda Item 5c:
Examples of Evaluating Desired Future Conditions

Agenda Item 5d:
District Adoption of GMA 12 Desired Future Conditions for Relevant District Aquifers

Bill Hutchison, Ph.D., P.E., P.G.

Lost Pines Groundwater Conservation District Board Meeting

January 18, 2023

Objectives

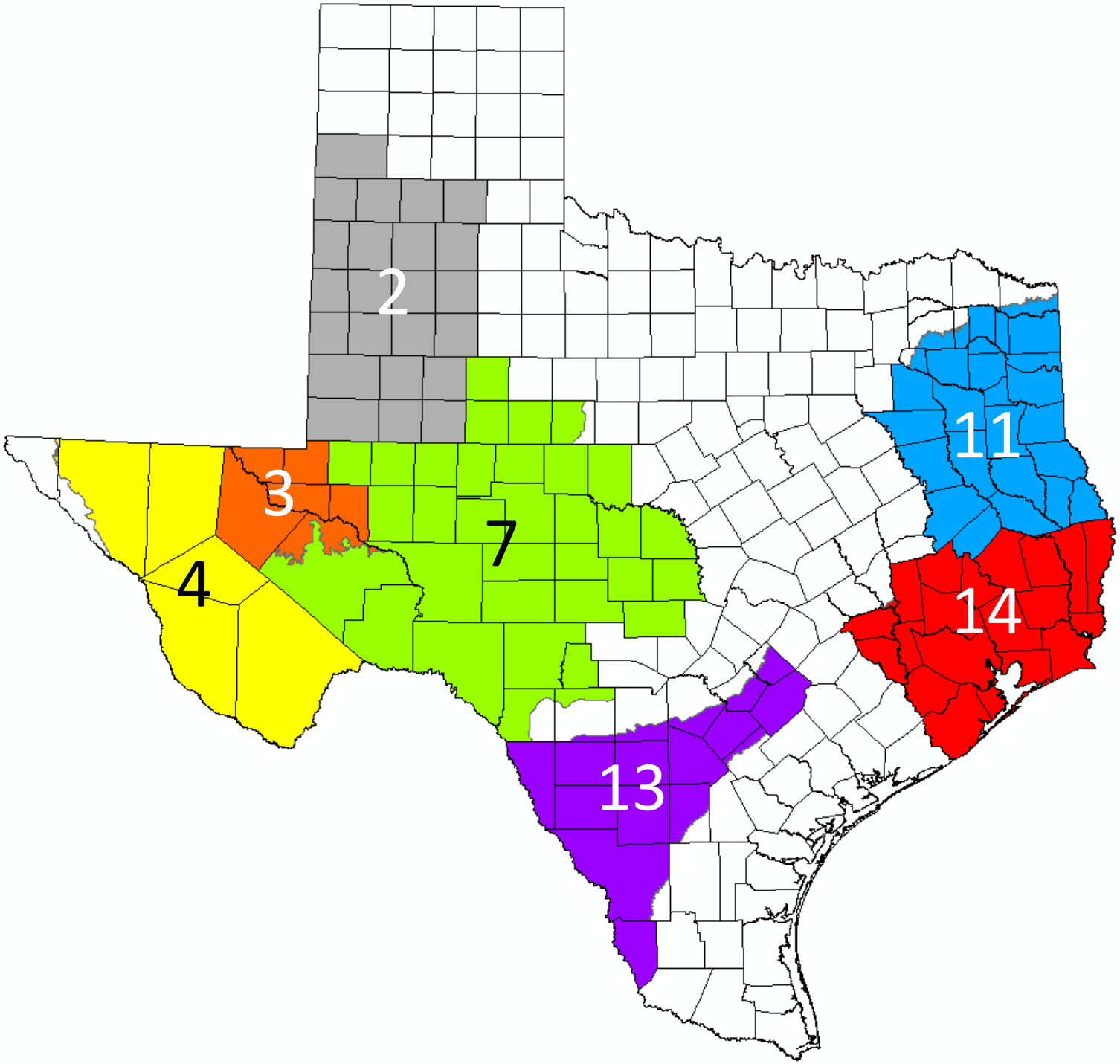
- 5c: Provide an overview of how other GMAs/GCDs compare actual data with DFCs
  - If these approaches are viewed as suitable for use in Lost Pines GCD, the Technical Memorandum associated with Task 1 of workplan (Agenda Item 5a) will be drafted accordingly and discussed with staff, appropriate Board Committees and full Board
- 5d: Discuss LPGCD Board adoption of GMA 12 Desired Future Conditions for relevant District aquifers

Three Basic Functions of a GCD

- Planning
  - DFCs (Joint Planning)
- Management
  - Goals and Objectives (Management Plan)
  - Includes a specific goal to “address” DFCs
    - Goal 8 of TWDB Checklist: Addressing the desired future condition established under TWC 36.108 (31 TAC 356.52(a)(1)(H); TWC 36.107(a)(8)
- Regulation
  - Implementation and Achievement of Management Plan Goals and Objectives (Rules)

Experience Background

- 2009 to 2011: Director, Texas Water Development Board Groundwater Division
  - Coordinated Technical Assistance to GCDs in initial round of joint planning (took the lead on 9 of 15 GMAs)
- 2011 to present: Consultant to GCDs and GMAs
  - GMAs: Joint Planning (2nd and 3rd rounds)
  - GCDs: Management Plans, including evaluation of DFCs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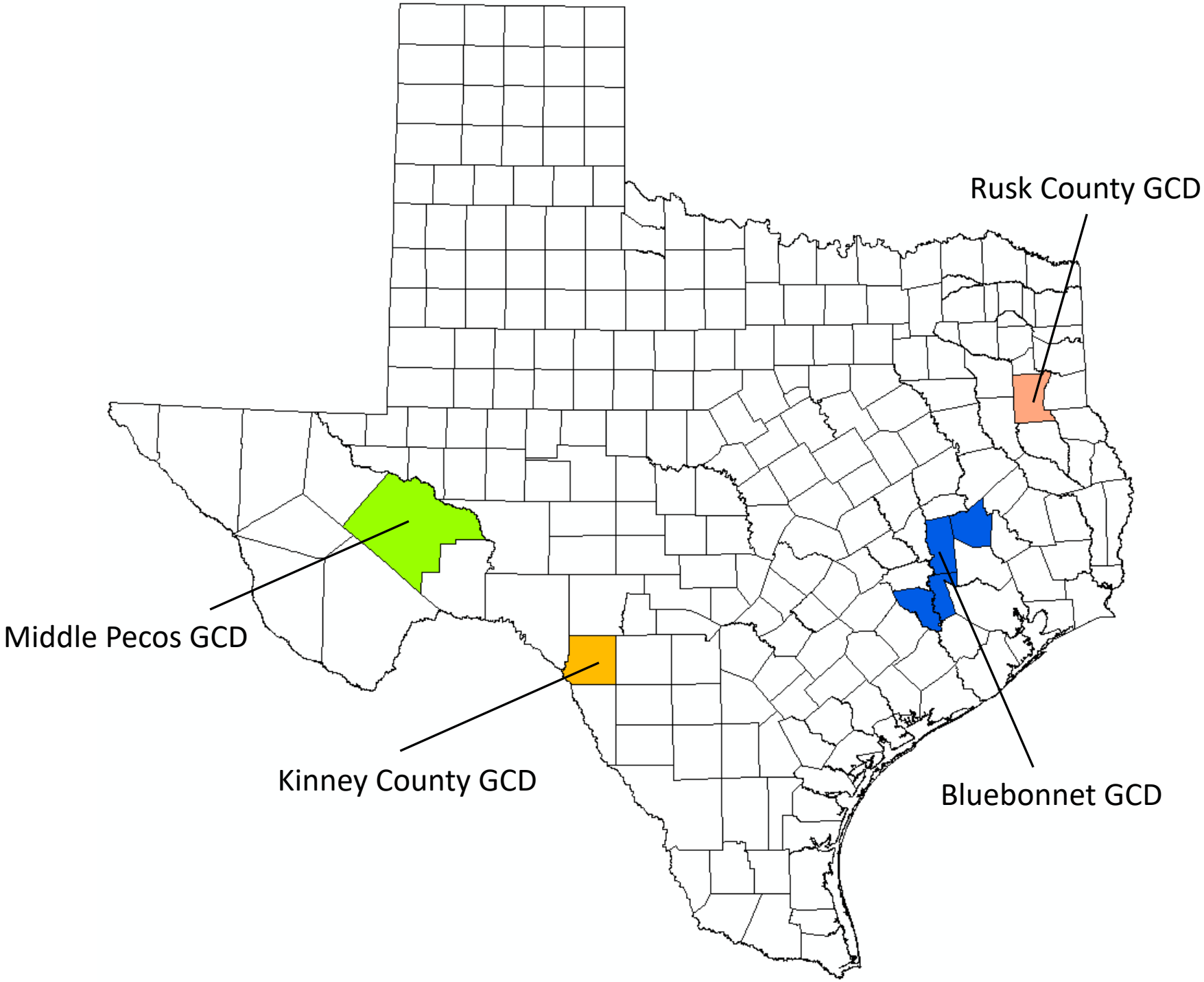
Rusk County GCD
Middle Pecos GCD
Kinney County GCD
Bluebonnet GCD

Expression of Drawdown DFCs

- GMA-wide average
- GCD-wide average
- County-wide average
- Aquifer-wide average (model layer)
- GCD/Aquifer average
- County/Aquifer average

Predictive GAM Run with Increased Pumping (compared to historic)

- Common simulation to evaluate alternative DFCs (GMA 12 included)
- GAM provides the basis to quantify impacts:
  - Decreased groundwater elevations (drawdown)
  - Increased inflow to an area (including induced surface water flows)
  - Decreased outflow from an area (including captured baseflow and spring flow)
- Among the GAM outputs are simulated future groundwater elevations

Expressing a DFC with Average Drawdown

- Simulated drawdown
  - Calculated as the difference in groundwater elevations between a starting year and an ending year of interest for any model cell
- Averaging drawdowns is a way to summarize the degree of pumping impact
  - GAMs are finite difference models
  - Many grid cells cover an area of interest (county/aquifer)
  - Average drawdown = sum of drawdowns over a specified area divided by number of cells in the specified area

Hypothetical Example of Average Drawdown (Full Area)

2	4	6	4	2
4	6	8	6	4
6	8	10	8	6
4	6	8	6	4
2	4	6	4	2

Average = 5.2 ft

Hypothetical Example of Average Drawdown (Areas with wells)

	4			
4			6	
	8	10	8	6

Average = 6.6 ft

Compare Simulated Drawdown with “Actual” Drawdown

- Drawdown can be calculated in a single well
  - Difference in groundwater levels over two specified time periods
- Compare simulated drawdown in a specific cell with actual drawdown from a specific monitoring well
- Comparison at specific points honors the overall model simulation
  - Pumping amounts
  - Pumping distribution
  - Avoids limitations of the averaging process

GMA 11/ Rusk County GCD Example

- Uses 2016 DFC for Carrizo Aquifer

Draft Report

Evaluation of Carrizo-Wilcox Groundwater Elevations and Changes in Rusk County for 2018

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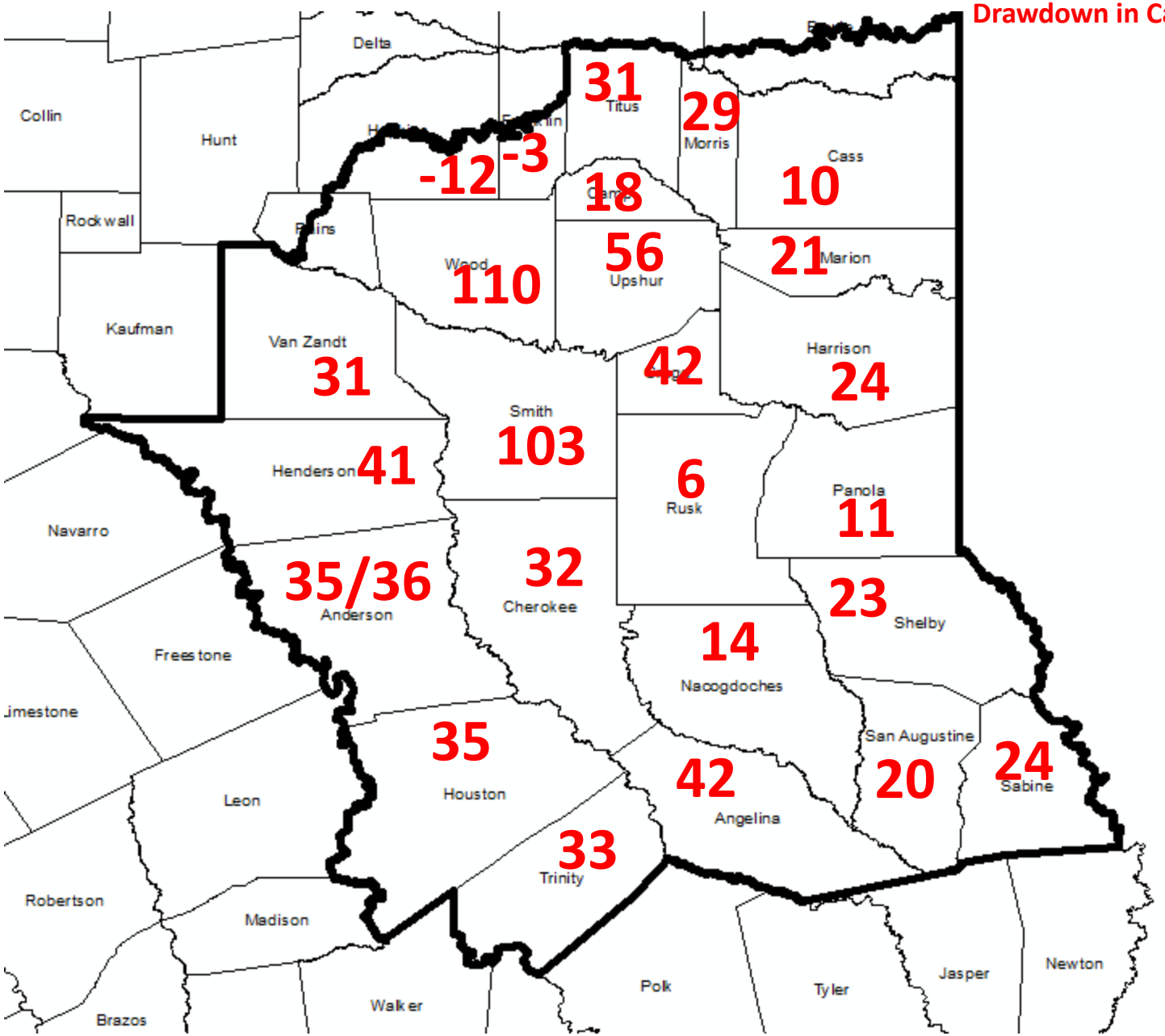
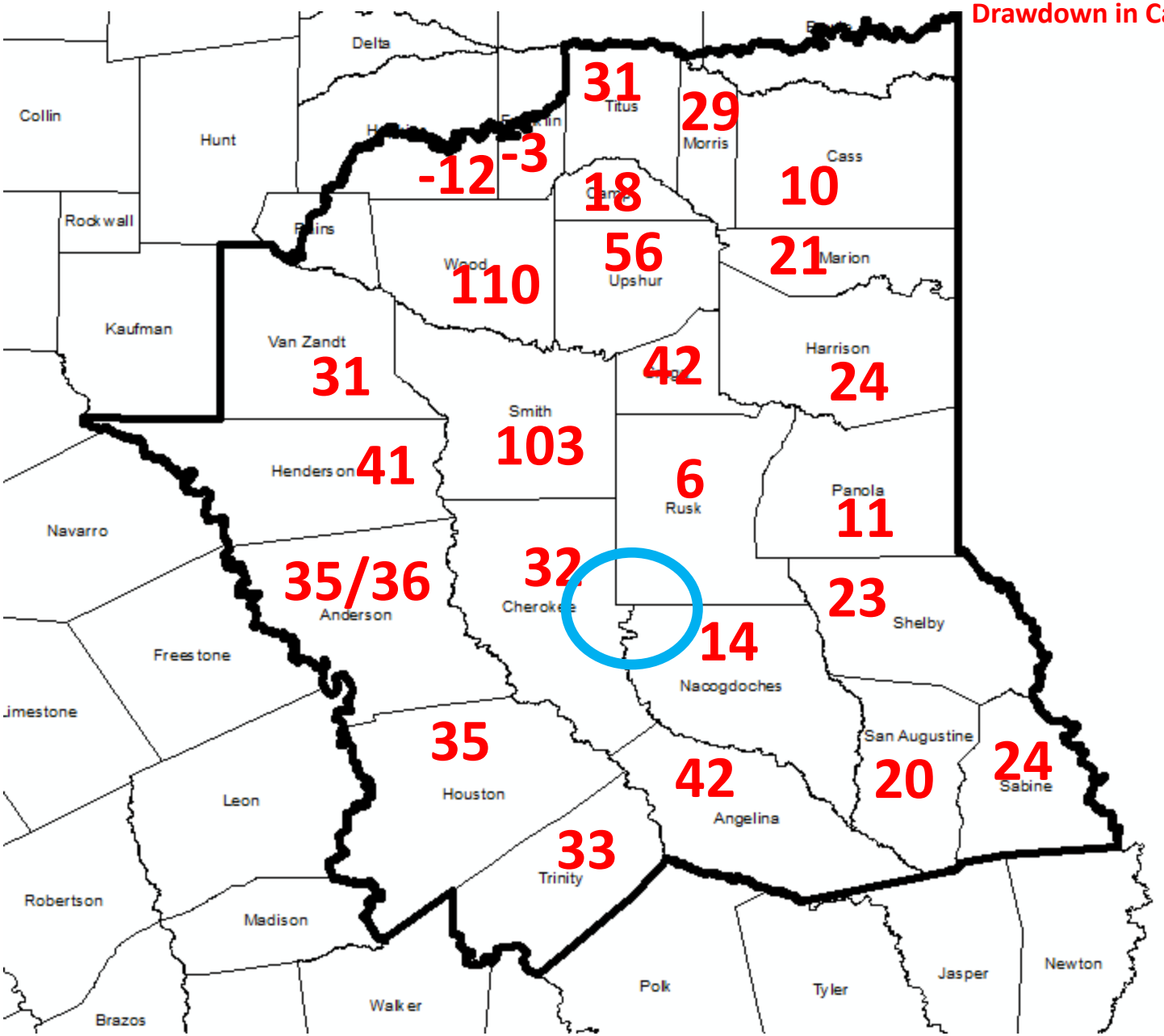
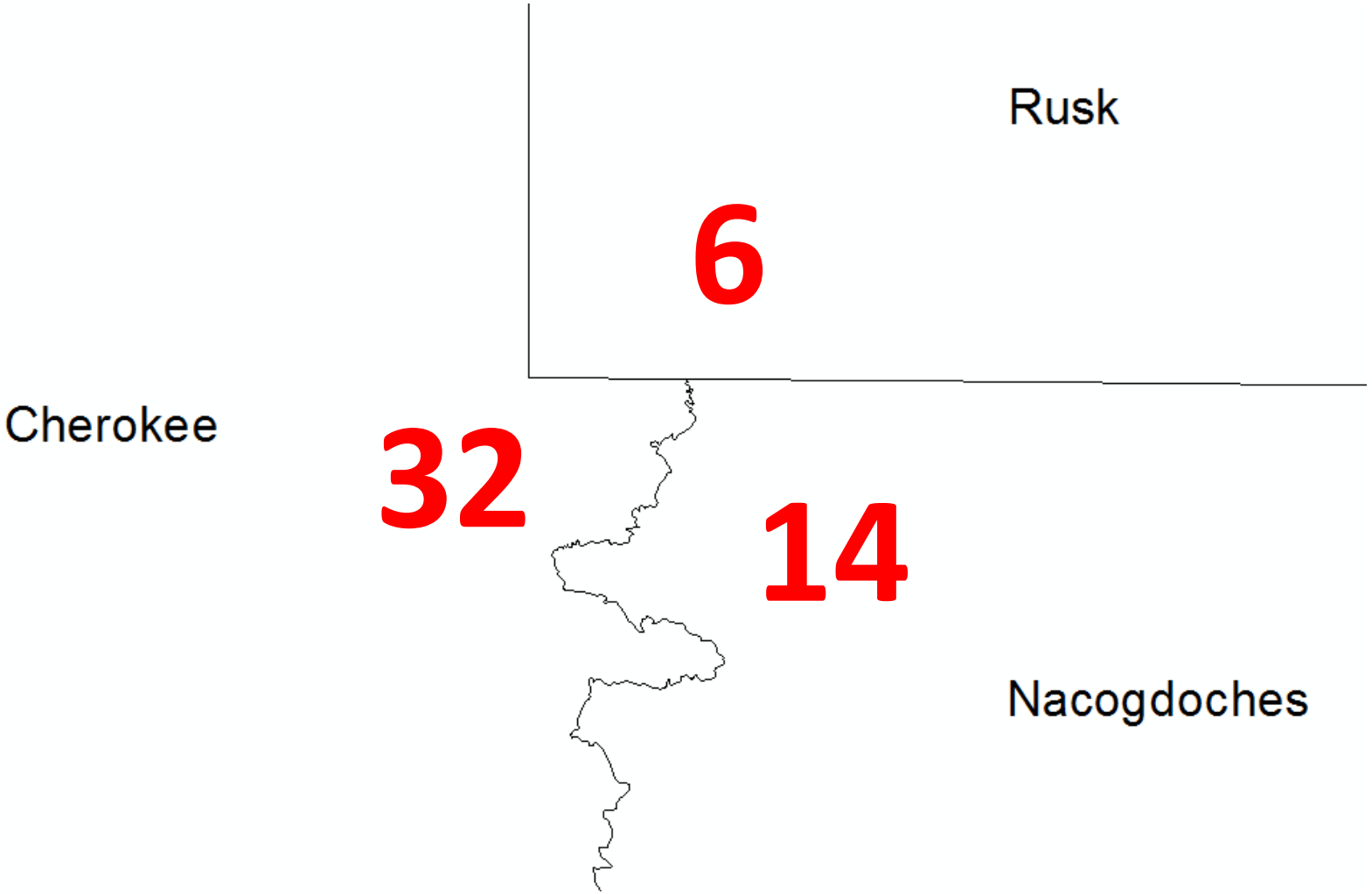
August 16, 2019

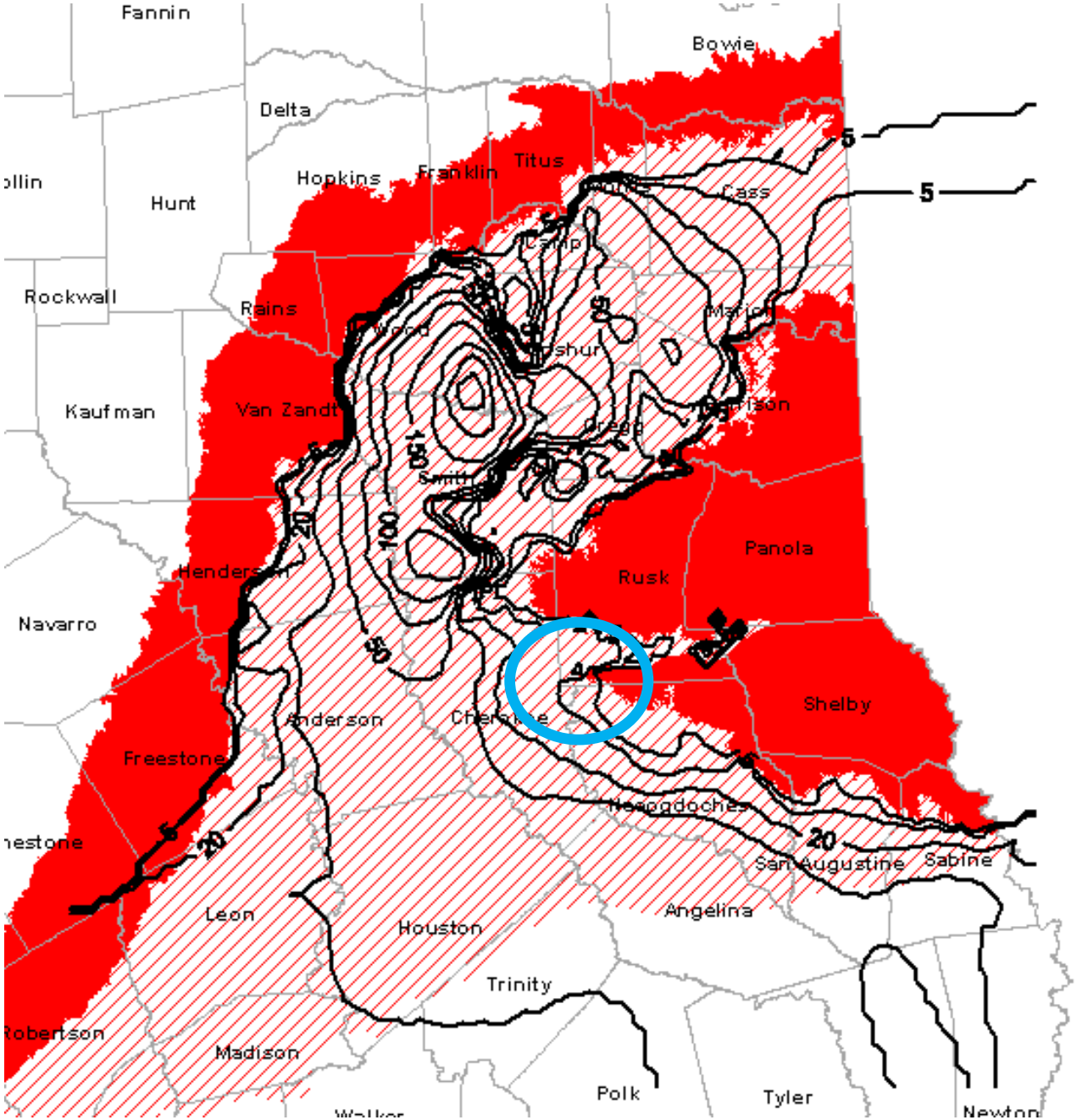
Adopted 2016 Desired Future Condition in GMA 11:
Drawdown in Carrizo Aquifer



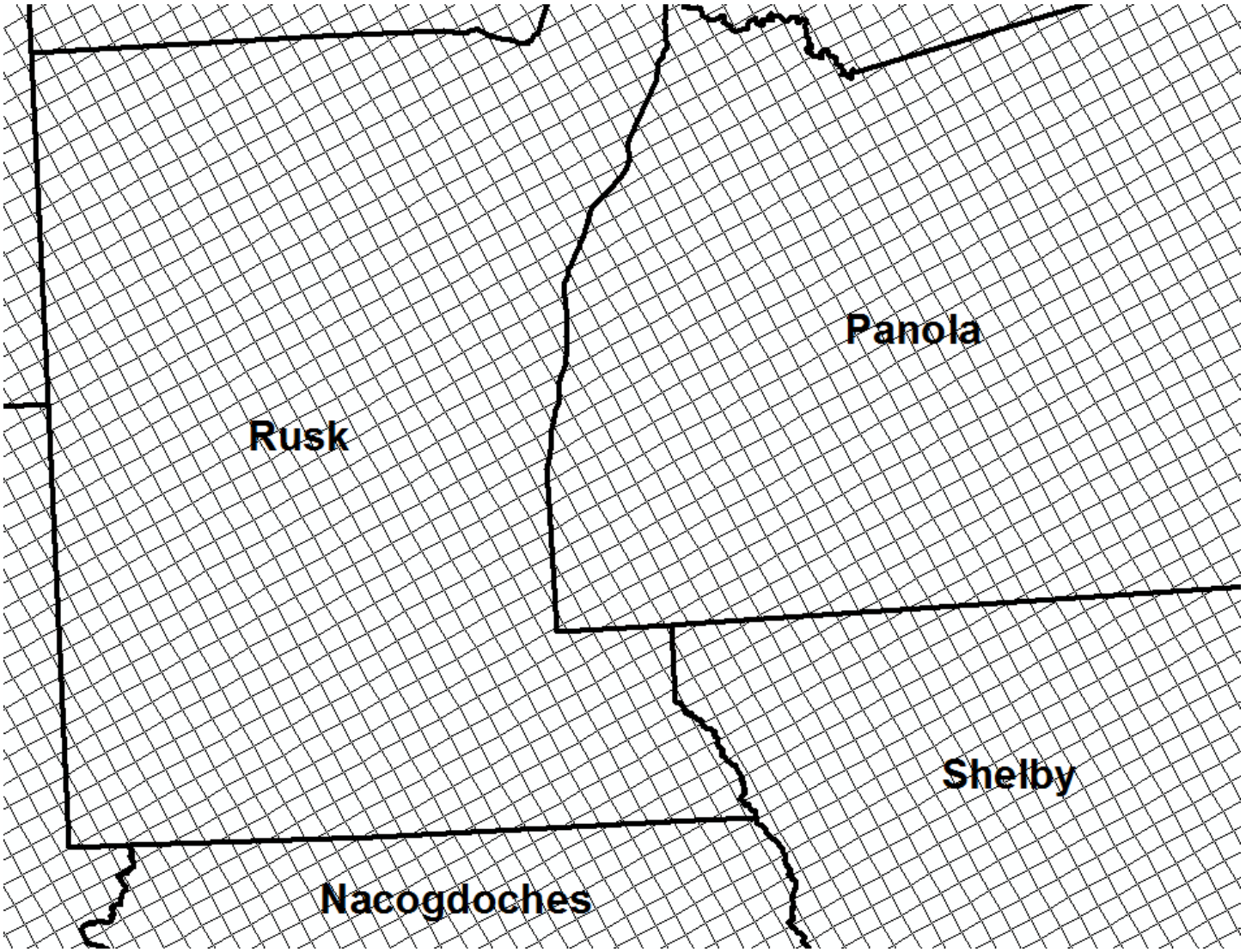
Adopted 2016 Desired Future Condition in GMA 11:
Drawdown in Carrizo Aquifer




Rusk
6
Cherokee
32
14
Nacogdoches

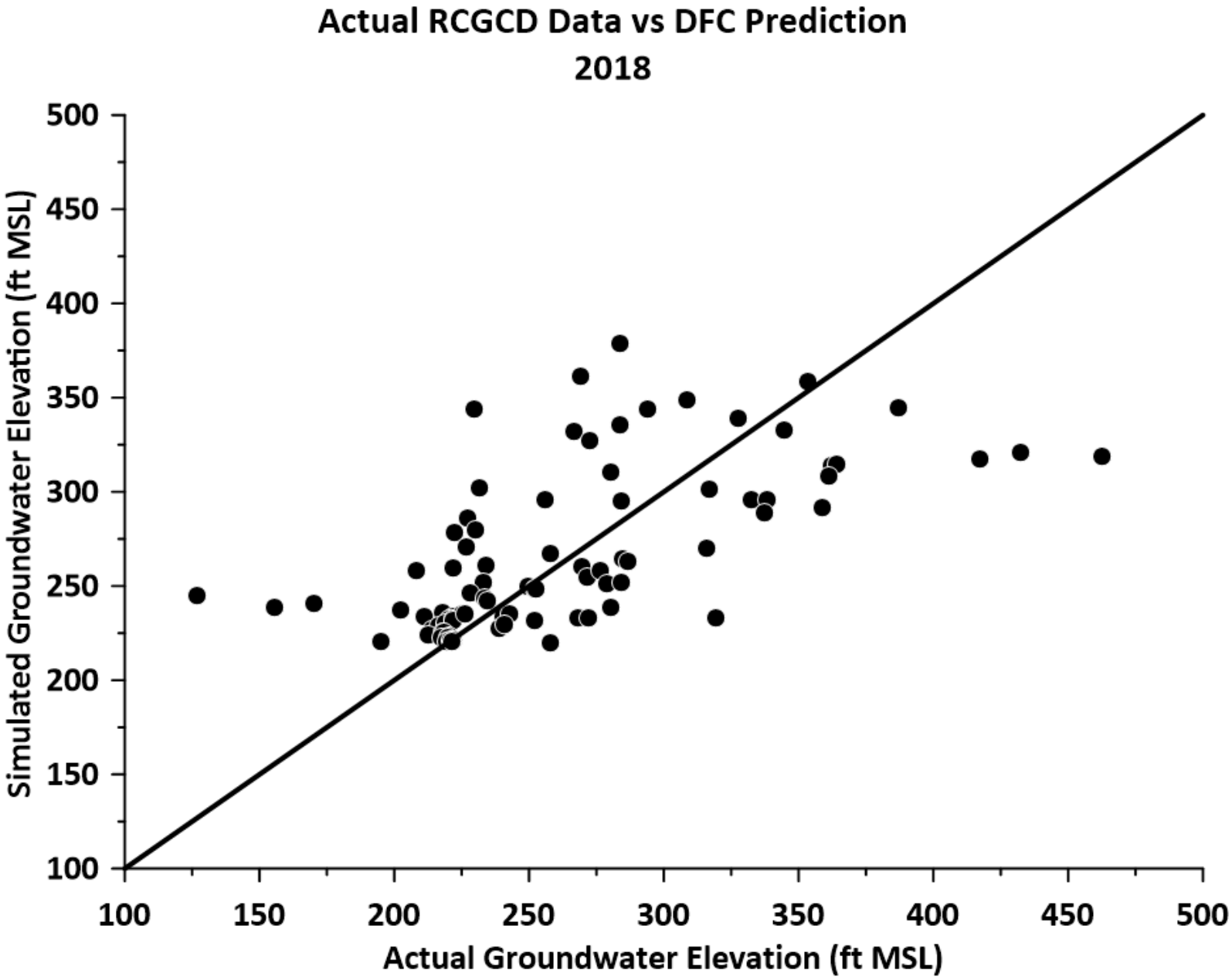

Fannin
Bowie
Delta
Titus
Hopkins
Franklin
Hunt
Cass
Rockwall
Rains
Marion
Kaufman
Van Zandt
Panola
Rusk
Navarro
Shelby
Anderson
Freestone
Houston
Angelina
Sabine
San Augustine
Leon
Trinity
Madison
Polk
Tyler
Newton
5
5
20
20

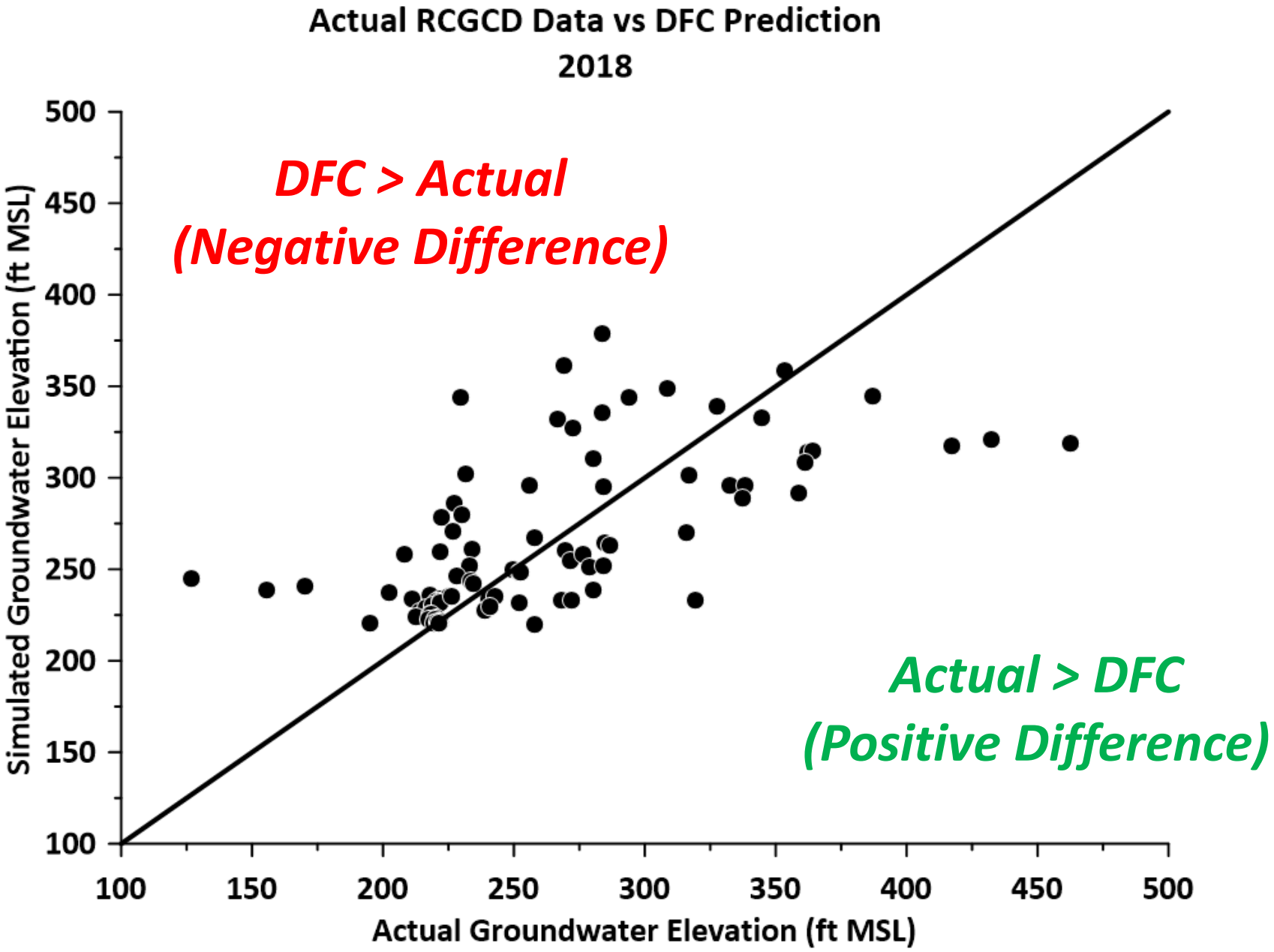
GMA 11 Example
(Old GAM Model Grid)



Rusk County GCD
2018 Comparison (Carrizo Aquifer)

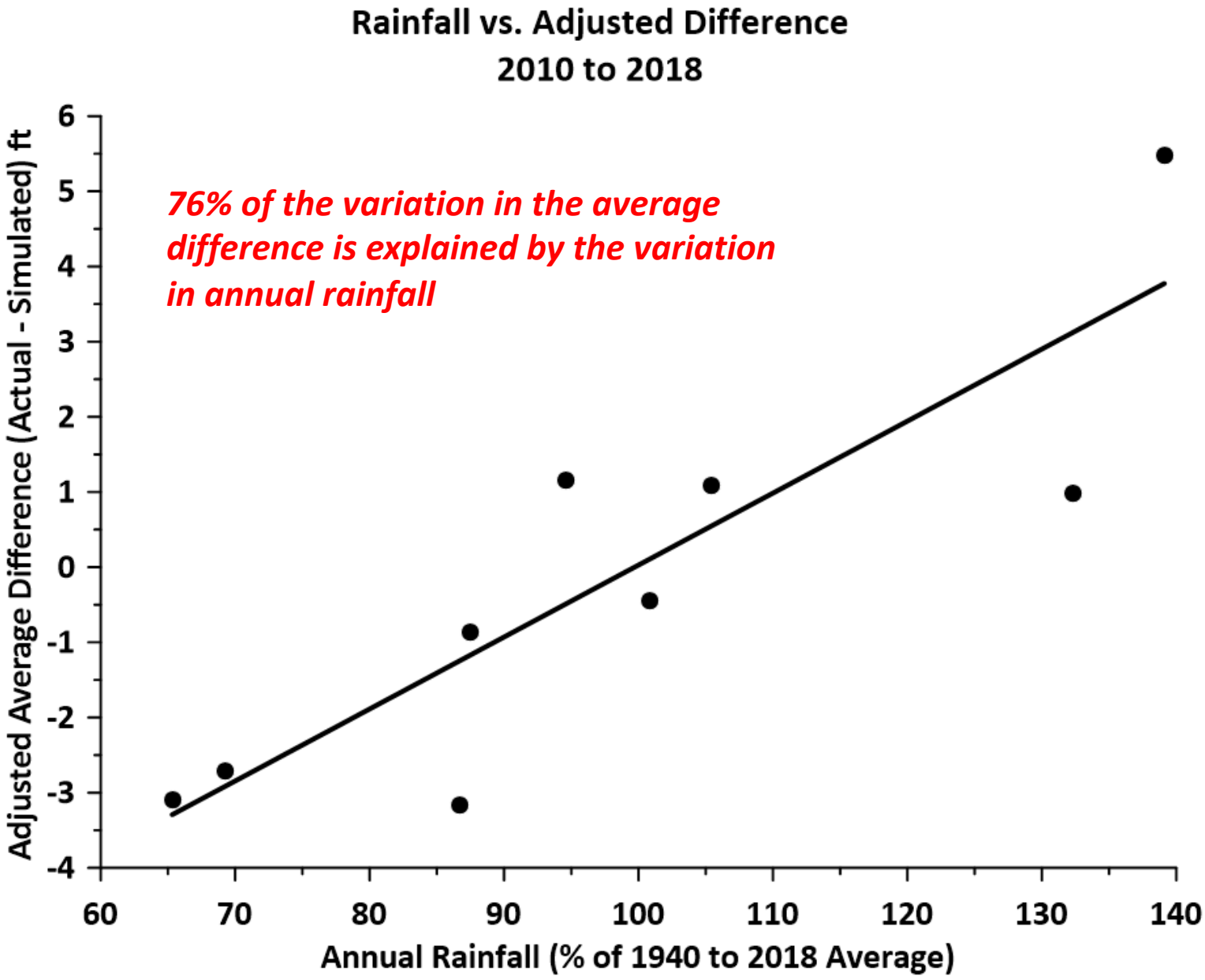
- RCGCD Data = 86 Wells
- Extracted point estimates of DFC simulation groundwater elevations at these well locations from model (Scenario 4)


Actual RCGCD Data vs DFC Prediction
2018
Simulated Groundwater Elevation (ft MSL)
Actual Groundwater Elevation (ft MSL)
100
150
200
250
300
350
400
450
500


Actual RCGCD Data vs DFC Prediction
2018
DFC > Actual
(Negative Difference)
Actual > DFC
(Positive Difference)
Simulated Groundwater Elevation (ft MSL)
Actual Groundwater Elevation (ft MSL)
100
150
200
250
300
350
400
450
500

Rusk County GCD
Comparison with Precipitation

- Groundwater elevation rise during wet years and fall during dry years
- Combined effect of:
  - Increase recharge during wet years
  - Decrease recharge during dry years
  - Increased pumping during dry years
  - Decreased pumping during wet years


Rainfall vs. Adjusted Difference
2010 to 2018
76% of the variation in the average difference is explained by the variation in annual rainfall
Adjusted Average Difference (Actual - Simulated) ft
6
5
4
3
2
1
0
-1
-2
-3
-4
60
70
80
90
100
110
120
130
140
Annual Rainfall (% of 1940 to 2018 Average)

Middle Pecos GCD Example

- Edwards-Trinity (Plateau) and Pecos Valley Aquifers

Final Report

Comparison of Groundwater Elevations and Drawdowns: GAM DFC Simulation and Measured Data from TWDB

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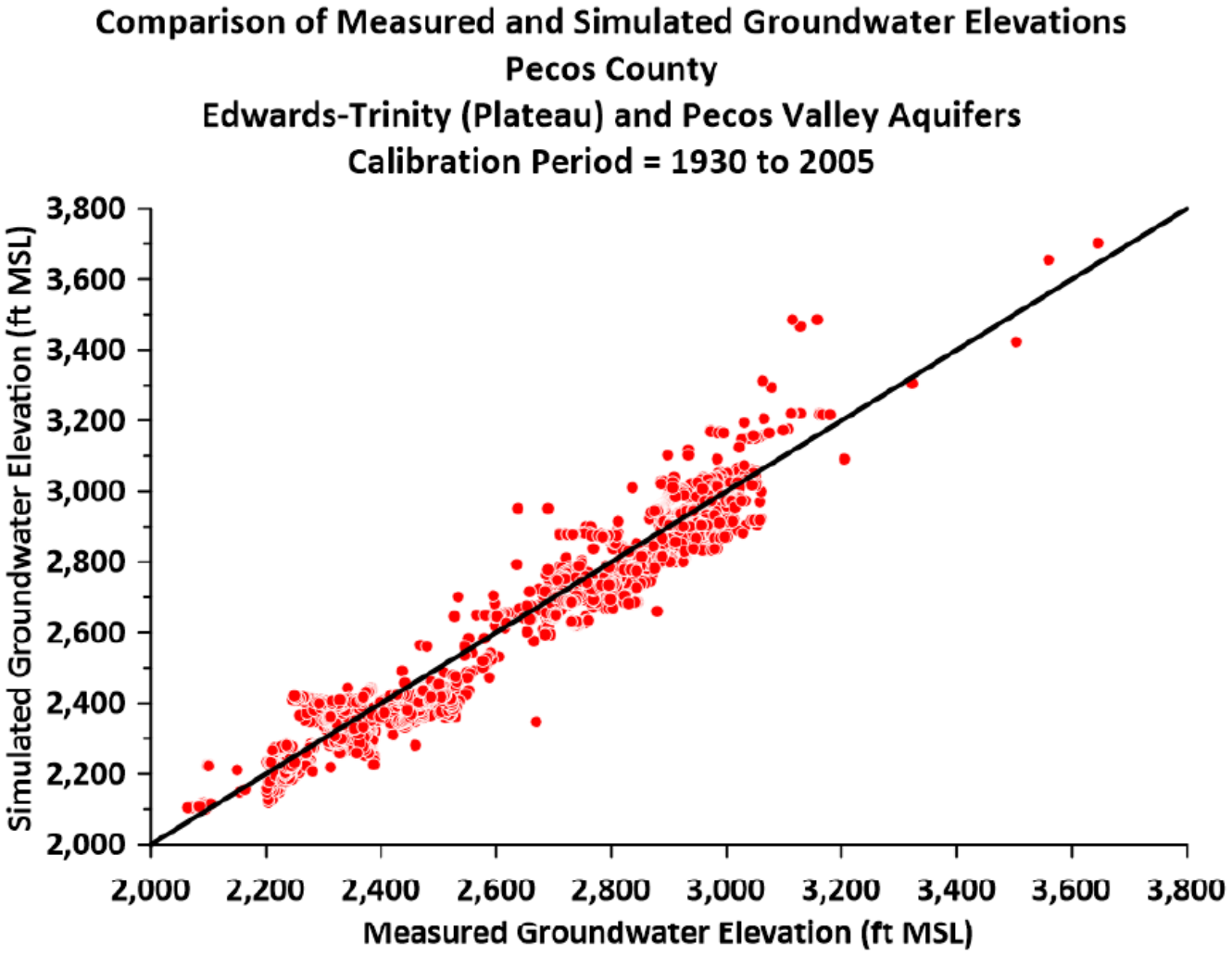
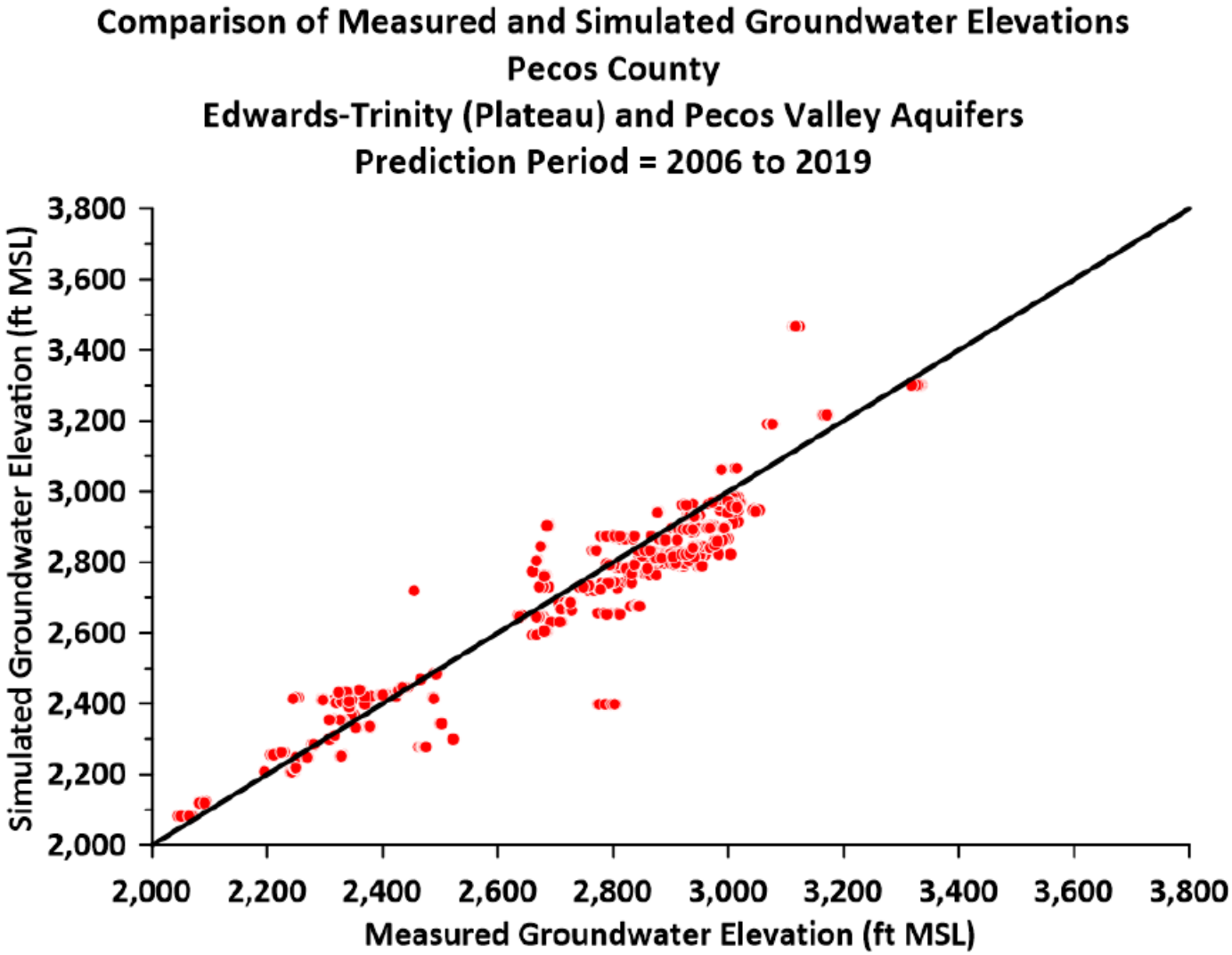
June 8, 2020

Initial Step: GAM Calibration Evaluation



Compare Predictive Period of DFC Simulation



Select Wells with 2005 Data (DFC Baseline)

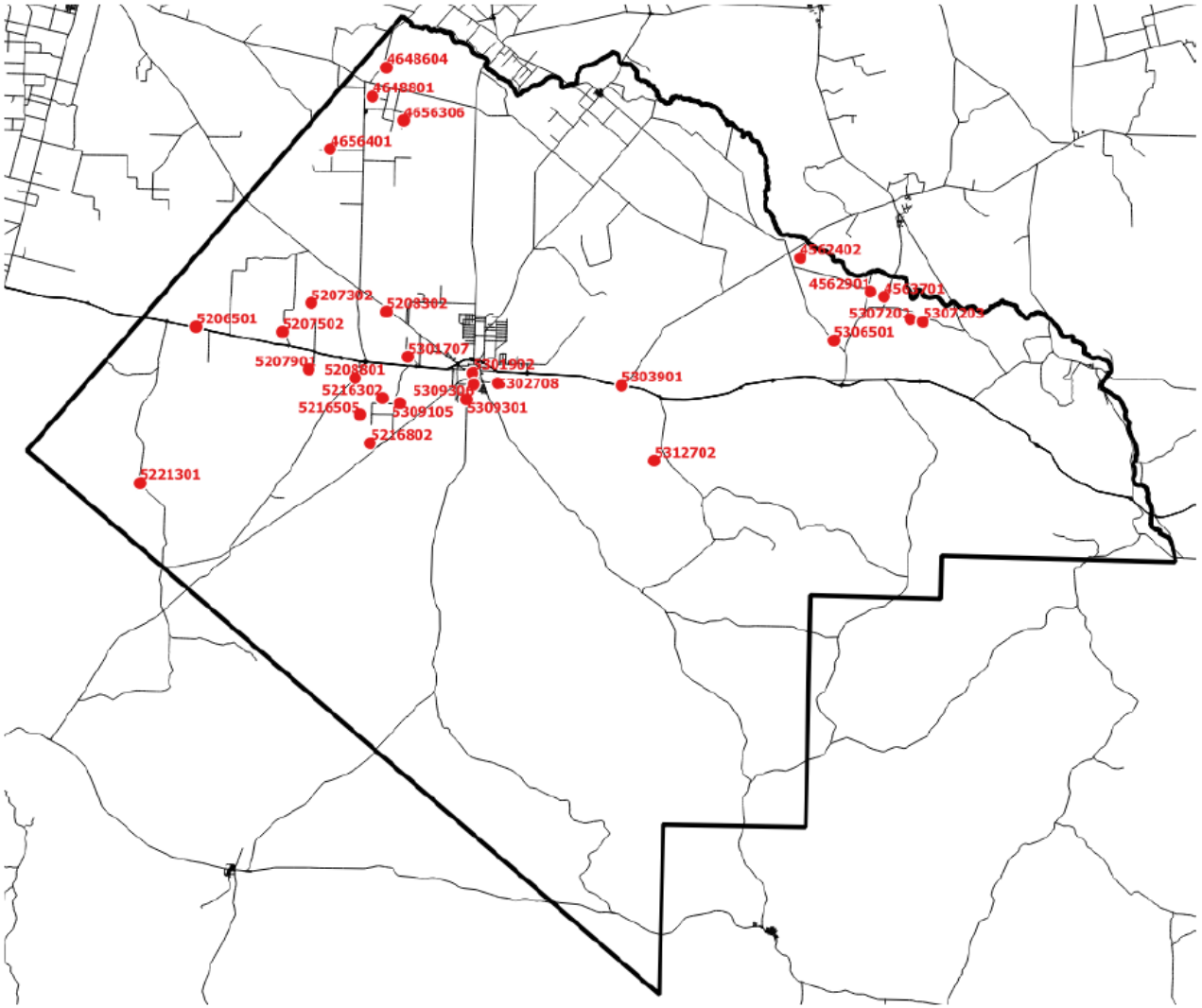
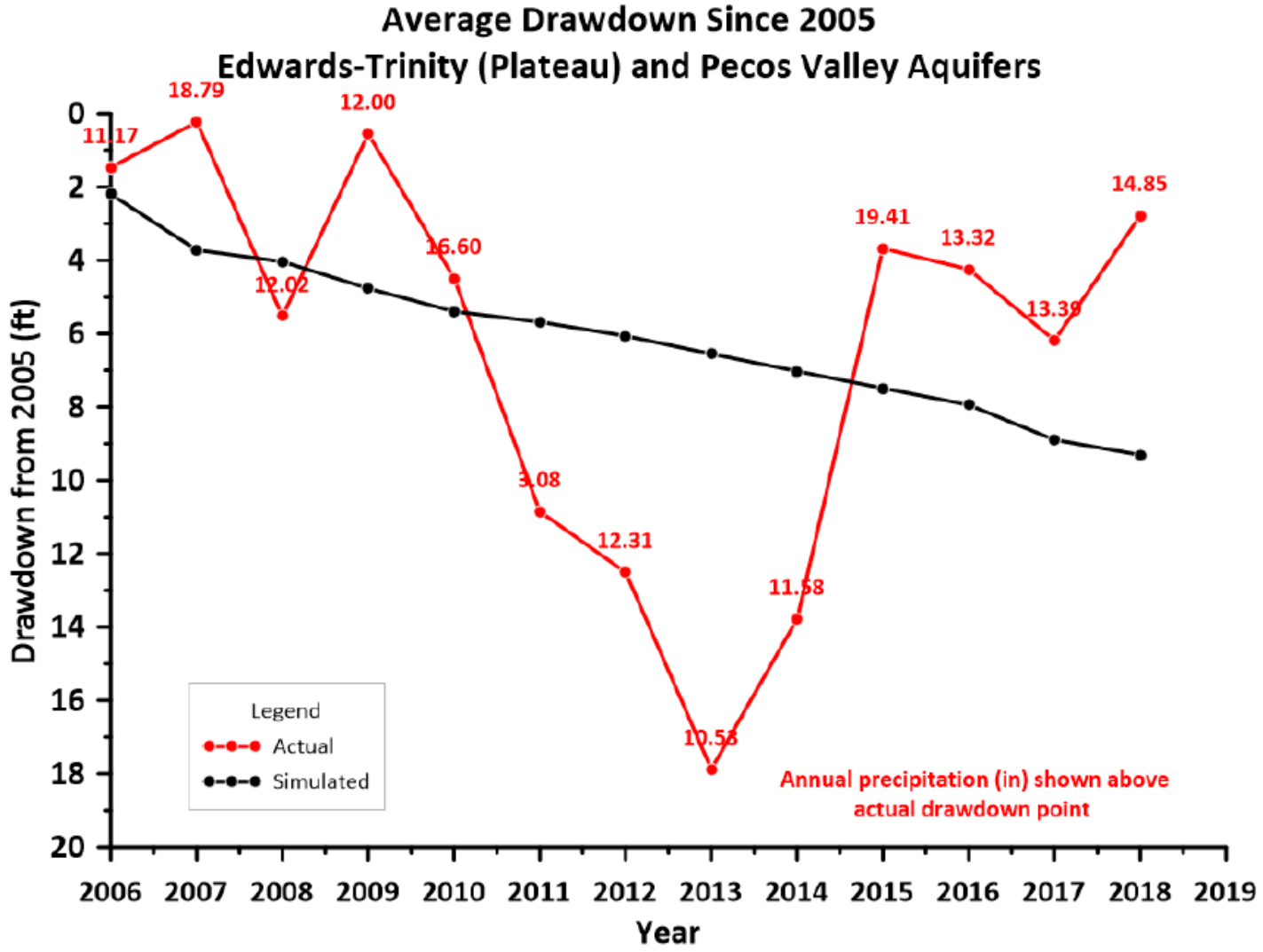


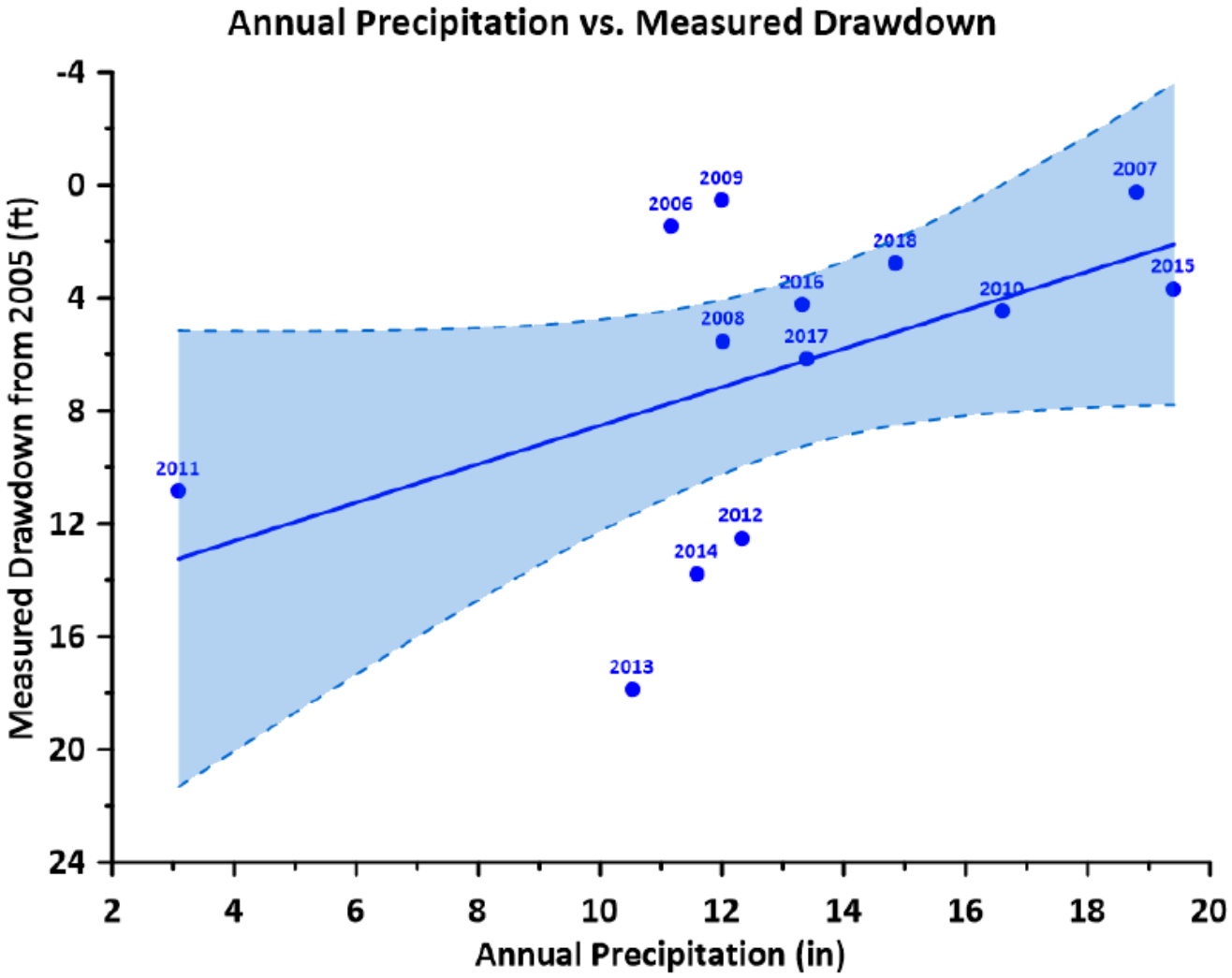
Table of Average Drawdown (2006 to 2019)

Year	Number of Wells	Average Measured Drawdown (ft from 2005)	Average Simulated Drawdown (ft from 2005)
2006	17	1.47	2.20
2007	17	0.23	3.72
2008	14	5.52	4.04
2009	21	0.55	4.76
2010	15	4.49	5.40
2011	19	10.85	5.68
2012	21	12.51	6.06
2013	21	17.87	6.55
2014	21	13.78	7.02
2015	21	3.68	7.49
2016	21	4.24	7.94
2017	16	6.18	8.90
2018	17	2.78	9.31
2019	1	13.11	17.07

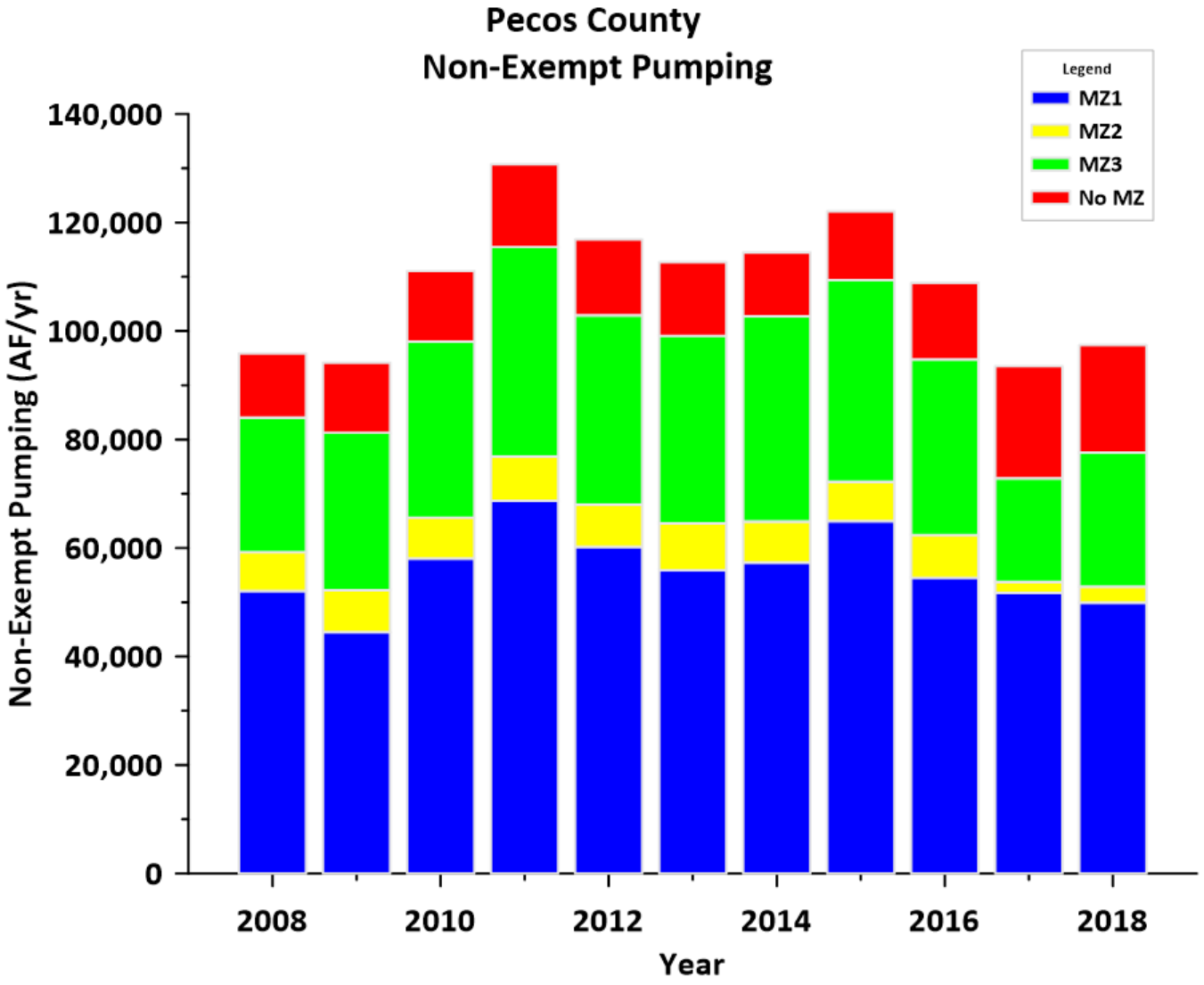
Summary Graph of Average Drawdown (2006 to 2019)



Annual Precipitation vs. Measured Drawdown



Summary of Pumping



GMA 14 Example

- Second round of joint planning:
  - Example of “reverse-engineering” to develop DFCs
    - Single model runs with specific pumping amounts
  - Petition filed against Lone Star GCD
- Third round of joint planning
  - Goals:
    - Avoid criticism of “reverse engineering”
    - Avoid “project-based” GAM simulations
  - Develop a GMA-wide DFC approach that was more focused on aquifer capabilities and variability
  - Resulted in a GMA-wide DFC statement:
    - “In each county in GMA 14, no less than 70 percent median available drawdown remaining in 2080 or no more than an average of 1.0 additional foot of subsidence between 2009 and 2080”

Bluebonnet GCD Comparison of DFC and Actual Data for all of GMA 14

- Part of BGCD overall evaluation of new approach

Draft Report

Comparison of Measured Drawdown with Simulated Drawdowns from the Desired Future Conditions Adopted in 2021 in Groundwater Management Area 14

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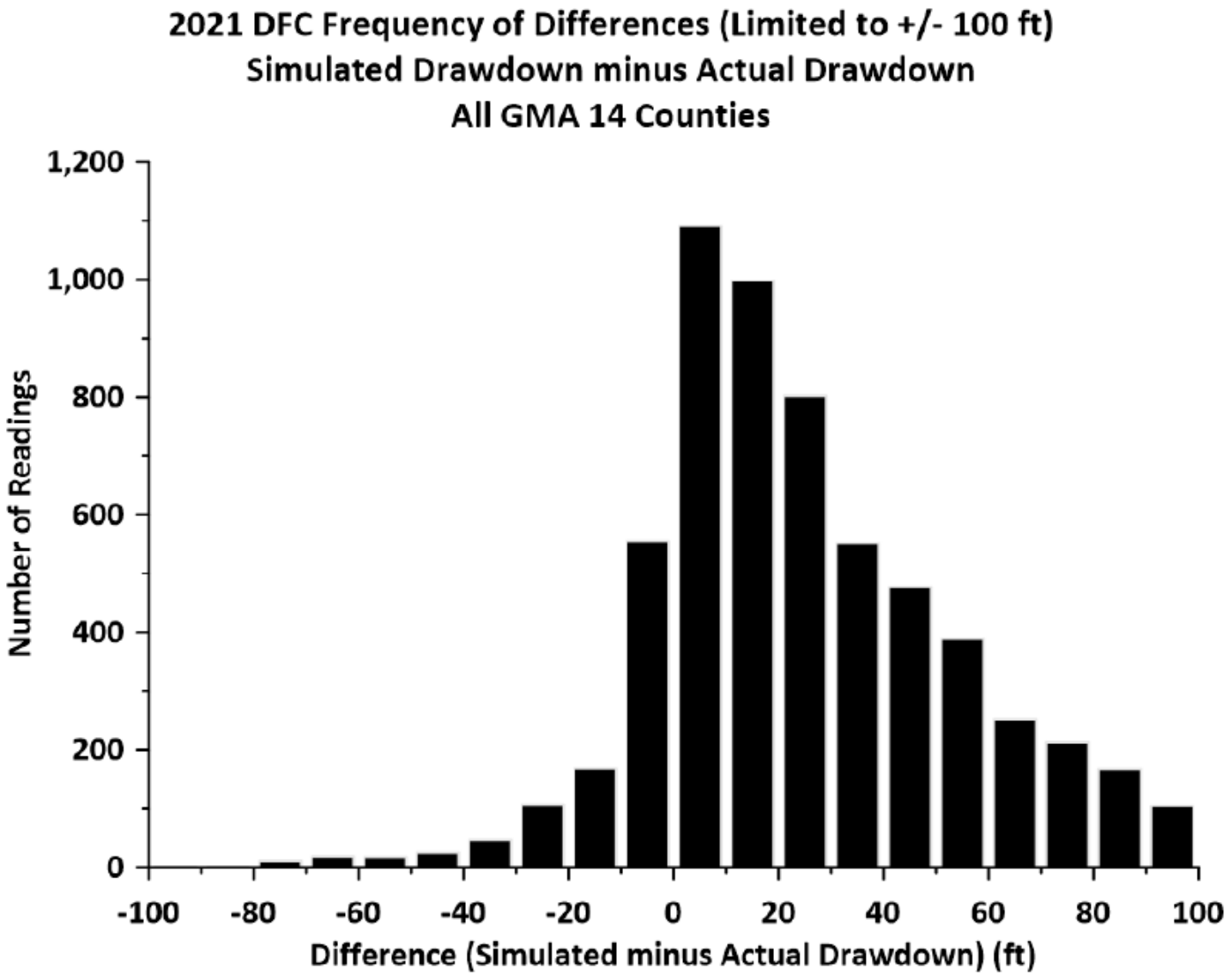
February 11, 2022

GMA 14 Actual Data Points

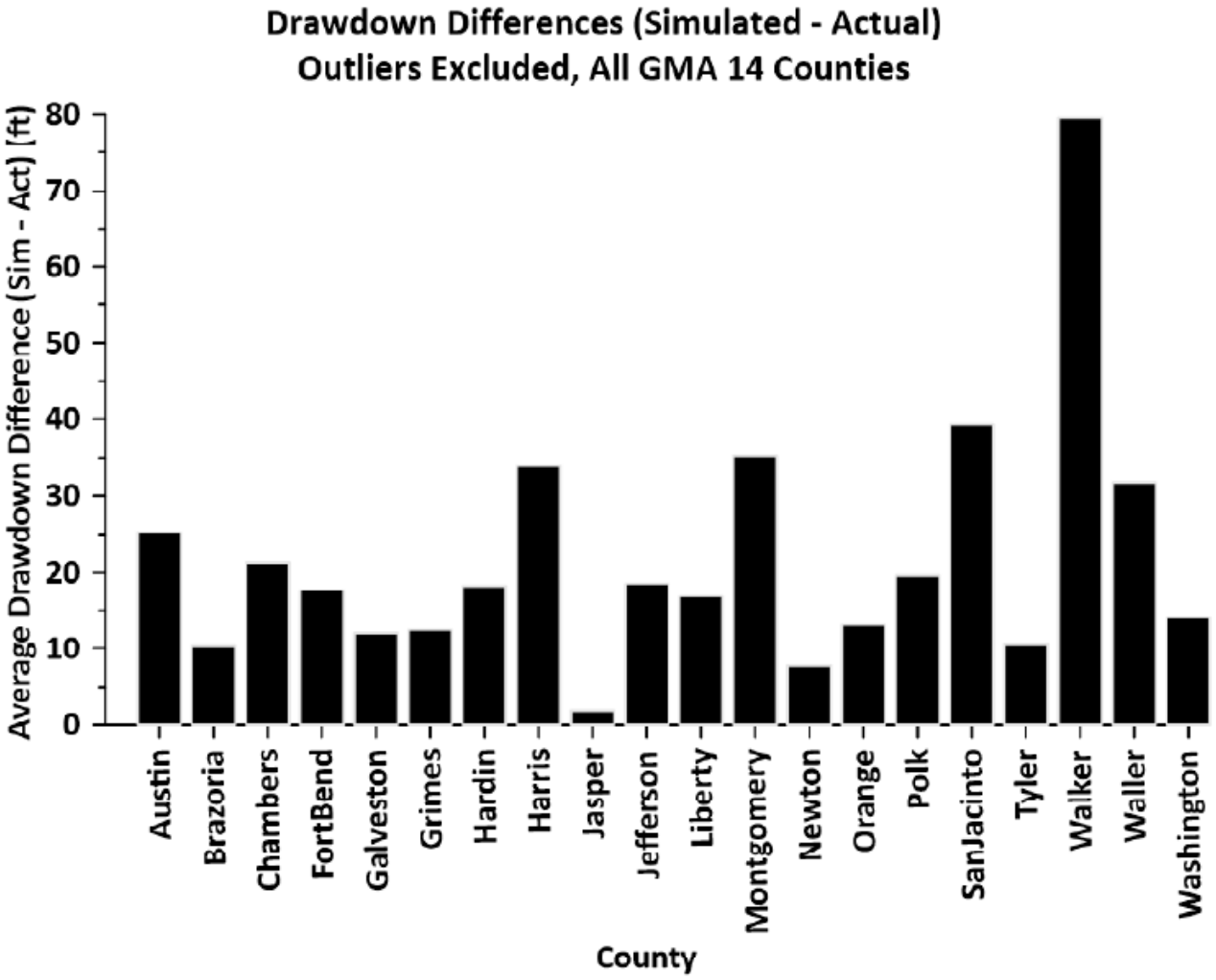
Table 4. Number of Actual Drawdown Data Points for Current DFC for Each County-Model Layer Unit

County	Layer 1	Layer 2	Layer 3	Layer 4	Total
Austin	12	24	11	0	47
Brazoria	202	36	0	0	238
Chambers	70	9	0	0	79
FortBend	206	430	0	0	636
Galveston	185	137	0	0	322
Grimes	0	26	0	89	115
Hardin	23	21	0	0	44
Harris	690	2,171	41	92	2,994
Jasper	48	93	0	59	200
Jefferson	59	0	0	0	59
Liberty	20	170	19	0	209
Montgomery	116	459	185	730	1,490
Newton	34	36	0	24	94
Orange	105	0	0	0	105
Polk	0	10	3	56	69
SanJacinto	0	7	40	40	87
Tyler	12	26	8	40	86
Walker	0	0	0	46	46
Waller	0	111	6	10	127
Washington	0	13	0	25	38
Total	1,782	3,779	313	1,211	7,085

Frequency of Differences



Drawdown Differences by County



Summary of Examples

- Adopted DFC expressed as average drawdown for a particular county-aquifer unit represents a convenient summary of impacts of increased pumping
- Comparison of actual drawdown data from wells needs to be compared to simulated drawdown at that geographic point (not an overall county-aquifer DFC average)
- With sufficient monitoring well coverage, comparisons can be meaningful with consideration of
  - Recharge (DFC = average recharge assumption)
  - Pumping (actual may be higher or lower than model simulation in response to drought or other conditions)

Finally

- Important to note that DFCs are updated every five years
- Updates to DFCs should ideally be based on:
  - Updated and improved monitoring
  - Updated GAMs
  - Updated management goals (relative to future pumping increases)

Agenda Item 5d

Simplified Joint Planning Process

Step	Activity	Responsibility
1	Proposed DFC	GMA
2	Public Comment	GCD
3	GMA Adoption of DFC	GMA
4	Submittal of Resolution, Explanatory Report, Model Files to TWDB	GMA
5	TWDB Letter: Submittal is Administrativly Complete	TWDB
6	GCD Adoption	GCD
7	Modeled Available Groundwater Report	TWDB

GCD Adoption of DFC

- This step (and explanatory report and TWDB letter) were added in 2011 (i.e. not part of the initial round of joint planning)
  - Petition process to challenge "reasonableness of DFC" was changed (filed against district(s) instead of against GMA)
  - GCD approval is the action now that is "petitioned"
- Three basic approaches with GMAs 2, 3, 4, 7, 11, 13, 14:
  - Agenda item – approve as a normal agenda item (motion and second)
  - Written resolution – approve resolution ***(LPGCD approach)***
  - Written resolution with report detailing implementation approach – approve resolution (report is for transparency and detailed documentation purposes)

Bluebonnet GCD Example

- Detailed report due to GMA-wide nature of DFC statement

Final Report

Implementation of GMA 14 Desired Future Condition Based on Multi-Metric Simulation (70% Available Drawdown, 1 Foot of Subsidence, 30K Pumping Limit, 2016 Pumping Distribution)

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April 27, 2021

Summary Table (BGCD)

Table 1. Recommended BGCD-Specific DFCs
Based on GMA 14-Wide DFC: 70% Available Drawdown Remaining, One Foot Additional Average Subsidence, 30K Pumping Increase Limit, 2016 Pumping Distribution

County	Aquifer	Recommended BGCD-Specific Desired Future Conditions		Expected Modeled Available Groundwater (Pumping in AF/yr from 2010 to 2080)
		Average Drawdown in ft from 2009 to 2080	Maximum Subsidence in ft from 1890 to 2080	
Austin	Chicot	54	3.39	2,892
	Evangeline	38		41,706
	Burkeville	39		0
	Jasper	165		1,971
Grimes	Chicot	35	0.25	0
	Evangeline	26		15,907
	Burkeville	26		0
	Jasper	147		35,546
Walker	Chicot	1	0.17	0
	Evangeline	16		3,141
	Burkeville	7		0
	Jasper	96		39,279
Waller	Chicot	50	5.39	791
	Evangeline	59		54,336
	Burkeville	60		0
	Jasper	218		329

From GMA 12 DFC Resolution (11/30/2021)

Based on the principle of using the GAM as a joint planning tool and the fact that the GAM predictions contain uncertainty, GMA 12 considered the DFCs to be compatible and physically possible if the difference between modeled drawdown results and the DFC drawdown targets are within a 10 percent variance for all aquifers in the Queen City-Sparta/Carrizo-Wilcox GAM of the GAM simulation. Factors considered for determining tolerance criteria include:

- model calibration results and statistics;
- information used to calibrate the GAM;
- aquifer and recharge information collected since the GAM was developed;
- sensitivity of the GAM calibration and GAM predictions to change in the model parameters; and
- range of uncertainty in the model parameters including historical and future pumping, temporal variation in recharge distribution and magnitude.

From GMA 12 DFC Resolution (11/30/2021)

Based on the principle of using the GAM as a joint planning tool and the fact that the GAM predictions contain uncertainty, GMA 12 considered the DFCs to be compatible and physically possible if the difference between modeled drawdown results and the DFC drawdown targets are within a 10 percent variance for all aquifers in the Queen City-Sparta/Carrizo-Wilcox GAM of the GAM simulation. Factors considered for determining tolerance criteria include:

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- information used to calibrate the GAM;
- aquifer and recharge information collected since the GAM was developed;
- sensitivity of the GAM calibration and GAM predictions to change in the model parameters; and
- range of uncertainty in the model parameters including historical and future pumping, temporal variation in recharge distribution and magnitude.

From TWDB Guidance Document

- "How to Submit a Groundwater Availability Model Run or Aquifer Assessment for the Development of Modeled Available Groundwater"
  - http://www.twdb.texas.gov/groundwater/dfc/documents.asp
- From Page 2:

What needs to be submitted for desired future condition model runs or aquifer assessments?

TWDB staff must be able to replicate the approach and assumptions used to develop the desired future conditions.

From TWDB Guidance Document

- "How to Submit a Groundwater Availability Model Run or Aquifer Assessment for the Development of Modeled Available Groundwater"
  - http://www.twdb.texas.gov/groundwater/dfc/documents.asp
- From Page 3 (part of same heading as page 2):

h. Description methodology employed to extract data from model such as: method and assumptions used to average drawdowns or springflows, including descriptions of the different aquifers/layers under consideration, any subdivision or geologic strata located in whole or in part within the groundwater management area, the stress period and year being used for initial heads in predictive runs—reference condition, and the periods and years for which drawdowns were calculated. If dry cells exist, please include a description of how dry cells were treated.

From TWDB Guidance Document

- "How to Submit a Groundwater Availability Model Run or Aquifer Assessment for the Development of Modeled Available Groundwater"
  - http://www.twdb.texas.gov/groundwater/dfc/documents.asp
- From page 5:

What happens after I submit my model runs or aquifer assessments?

- The TWDB will send written acknowledgment to the groundwater management area technical coordinator upon receipt of the final desired future condition packet submittal or draft submittal.
- Requests for any clarifications required to develop modeled available groundwater estimates will come through your TWDB groundwater management area liaison. The most common items requiring clarification during the last round of joint planning include:
  - Whether to use the aquifer extent or the model extent for calculations
  - Dry cell assumptions
  - Variance assumptions. For example, if the variation of averaged drawdowns is within 5 percent of the desired future condition, the modeled desired future condition is deemed achieved.

From TWDB Guidance Document

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  - Whether to use the aquifer extent or the model extent for calculations
  - Dry cell assumptions
  - Variance assumptions. For example, if the variation of averaged drawdowns is within 5 percent of the desired future condition, the modeled desired future condition is deemed achieved.

Variance Issue

- TWDB runs GAM and tries to match average drawdown listed in DFC resolution to model output of the DFC simulation
  - Part of evaluation of administrative completeness (quality control check on simulation)
- For some GMAs, TWDB had issues matching average drawdowns
  - Guidance document now suggests a “fudge factor”
  - Should not be an issue if the GMA consultant’s methods for calculating average drawdown are well documented and presented as required by guidance document (goal is replication)
  - Note the placement in the guidance document (anticipated in requests for clarification)

Summary

- Nothing in statute (Chapter 36 of Water Code) or TWDB Administrative Rules provides a means for GCDs to adopt a DFC using the “variance” criteria
- Nothing in statute (Chapter 36 of Water Code) or TWDB Administrative Rules provide any means for GCDs to “adopt” or consider a variance related to a MAG (modeled available groundwater) amount
  - MAG reports are issued by TWDB and not subject to any formal action or review by GCDs
  - MAGs are one factor for GCD to consider when issuing a permit

From Resolution (Agenda Item 5d)

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of the Lost Pines Groundwater Conservation District that:

1. The following DFCs are hereby established for the Sparta, Queen City, Carrizo, Calvert Bluff, Simsboro, and Hooper Aquifers as the DFCs that apply to Lost Pines:

GCD	Average Aquifer Drawdown (ft) Measured from January 2011 through December 2070					
	Sparta	Queen City	Carrizo	Calvert Bluff	Simsboro	Hooper
Lost Pines GCD	22	28	134	132	240	138

Questions and Discussion

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