Draft Technical Memorandum 1

Pumping Comparison: Previous GAM, Previous GAM Update, Updated GAM, and 2021 Preliminary MAG Southern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifer

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Table of Contents

List of Tables

List of Figures

Appendix

1.0 Executive Summary

This technical memorandum presents county-aquifer pumping estimates from the old GAM (including the update), the new GAM, and estimates of the Modeled Available Groundwater values associated with the 2021 desired future condition for GMA 13.

This technical memorandum also presents GMA 13 pumping estimates from the new GAM broken down by outcrop and downdip pumping.

2.0 Background

One of the uses of the updated Groundwater Availability Model for the Southern Portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers documented in the main report will be to support the Joint Planning Process that leads to the adoption of desired future conditions by the groundwater conservation districts in Groundwater Management Area 13 and the calculation of the modeled available groundwater by TWDB. As part of the work associated with developing the updated Groundwater Availability Model, five technical memoranda appear in the Appendix of the report:

- Technical Memorandum 1: Pumping Comparisons
- Technical Memorandum 2: Pumping Sensitivity
- Technical Memorandum 3: Recharge Sensitivity
- Technical Memorandum 4: Calculation of Drawdown from Existing Modeled Available Groundwater Using Updated Groundwater Availability Model
- Technical Memorandum 5: Calculation of Future Pumping from Existing Desired Future Conditions Using Updated Groundwater Availability Model

This technical memorandum summarizes a comparison of pumping output from:

- Old GAM from 1975 to 1999
- Old GAM update from 2000 to 2011
- Updated GAM (this GAM) from 1980 to 2017
- Estimated Modeled Available Groundwater (MAG) from 2021 Desired Future Condition

Pumping comparisons were completed for each county-aquifer unit in GMA 13. Table 1 summarizes the county-aquifer units with data. Hydrographs with the comparisons are presented in Appendix A.

Table 1. County-Aquifer Units with Pumping Comparisons

County	Sparta	Queen City	Carrizo-Wilcox
Atascosa	X	X	X
Bexar	No	No	X
Caldwell	No	X	X
Dimmit	No	X	X
Frio	X	X	X
Gonzales	X	X	X
Guadalupe	No	No	X
Karnes	No	No	X
LaSalle	X	X	X
Maverick	No	No	X
McMullen	X	X	X
Medina	No	No	X
Uvalde	No	No	X
Webb	No	No	X
Wilson	X	X	X
Zavala	X	X	X

This technical memorandum also summarizes the GMA 13 outcrop, downdip, and total pumping from the new GAM for the Sparta, Queen City, and Carrizo-Wilcox aquifers.

3.0 Parameters and Assumptions

3.1 County-Aquifer Pumping Comparison

Pumping estimates were extracted from model output (i.e. the cbb file) using FORTRAN programs. All files (cbb files, FORTRAN source code, FORTRAN executables, and pumping output) are provided on the share site:

- The directory named *getpump7599* includes all files associated with the old GAM with a calibration period of 1975 to 1999.
- The directory named *getpump0011* includes all files associated with the updated calibration period of the old GAM (2000 to 2011).
- The directory named *CalibPump* includes all files associated with the new GAM with a calibration period of 1981 to 2017.
- The directory named *getMAG* includes all files associated with the test run of the most recent desired future condition simulation. Although the actual modeled available groundwater values will be eventually developed by the Texas Water Development

Board, these estimates are assumed to be reasonably similar to the future MAGs for comparative purposes.

All output from these post-processors are also gathered in the directory *AllPumpData*. Please note that the output files are organized by county and model, with each file containing pumping from each of the three aquifers (Sparta, Queen City, Carrizo-Wilcox). Files names follow this convention:

- Old7599"county" = old GAM (1975 to 1999)
- Old0011"county" = old GAM (2000 to 2011)
- Tot"county" = new GAM (1980 to 2017)
- MAG"county" = future simulation associated with 2021 desired future condition (2012 to 2080)

Each output file has seven columns:

1. County Code
2. County Names
3. Year number of simulation
4. Year
5. Sparta Aquifer Pumping (AF/yr)
6. Queen City Aquifer Pumping (AF/yr)
7. Carrizo-Wilcox Pumping (AF/yr)

3.2 Outcrop and Downdip Pumping in GMA 13 – New GAM

The directory named *OCDDPump* includes the new GAM cbb file for the calibration period, a FORTRAN post-processor (*CalibPump.f95)* and the output from the post-processor (*gma13calpump.dat*) that includes pumping from GAM 13 from 1981 to 2017 split out by outcrop and downdip pumping.

The file *gma13calpump.dat* has 10 columns. The first column is the year. Columns 2 to 4 contain outcrop pumping from GMA 13 for the Sparta (column 2), Queen City (column 3), and Carrizo-Wilcox (column 4). Columns 5 to 7 contain the downdip pumping from GMA 13 for the Sparta (column 5), Queen City (column 6), and Carrizo-Wilcox (column 7). Columns 8 to 10 contain the total pumping from GMA 13 for the Sparta (column 8), Queen City (column 9), and Carrizo-Wilcox (column 10).

4.0 Methods and Results

4.1 County-Aquifer Pumping Comparison

As noted above, comparison hydrographs are presented in Appendix A organized by county (alphabetically) then aquifer (by stratigraphic depth).

The hydrographs can be viewed as a resource to evaluate the similarities and differences in the historic pumping estimates of the old GAM and the new GAM, and the assumptions of future pumping embedded in the desired future condition simulation adopted by GMA 13 in 2021 using the old GAM.

In general, the pumping estimates in the old GAM from 1975 to 1999 and the new GAM for the same time period are similar. Also, in general, the pumping estimates associated with the update of the old GAM from 2000 to 2011 are lower than the pumping estimates from the new GAM for the same time period. The old GAM update was limited to adjusting pumping to match groundwater elevation targets. Since the old GAM tended to over predict drawdown, the low pumping estimates from this exercise yielded pumping estimates that are generally lower than the pumping estimates from the new GAM.

Comparisons of the MAG values with the historic pumping are difficult to generally characterize. Some MAG values are within or slightly lower than the historic pumping while some MAG values are significantly higher than the historic pumping (due to the inclusion of new pumping wells). Some MAG values increase over the simulation period (2012 to 2080), while some MAG values decrease over the simulation period. Where MAG values decrease slightly during the simulation period, it is possible that these suggest that dry cells that resulted in reduced pumping. The improvements in the model code and the construction of the new GAM will eliminate the issue of dry cells to a large extent. However, reductions in input pumping are still possible, and simulations need to evaluate these in more detail to understand the sustainability of any proposed pumping.

4.2 Outcrop and Downdip Pumping in GMA 13 – New GAM

Bar graphs for GMA 13 pumping (with outcrop and downdip pumping separated) are presented below as:

- Figure 1: Sparta Aquifer
- Figure 2: Queen City Aquifer
- Figure 3: Carrizo-Wilcox Aquifer

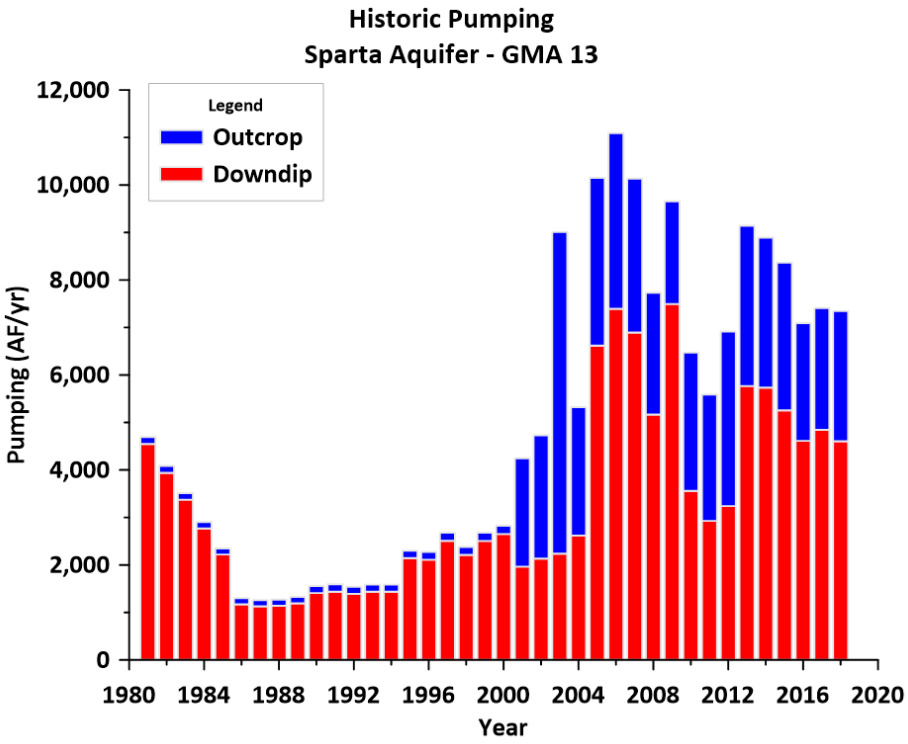


Figure 1. GMA 13 Historic Pumping - Sparta Aquifer

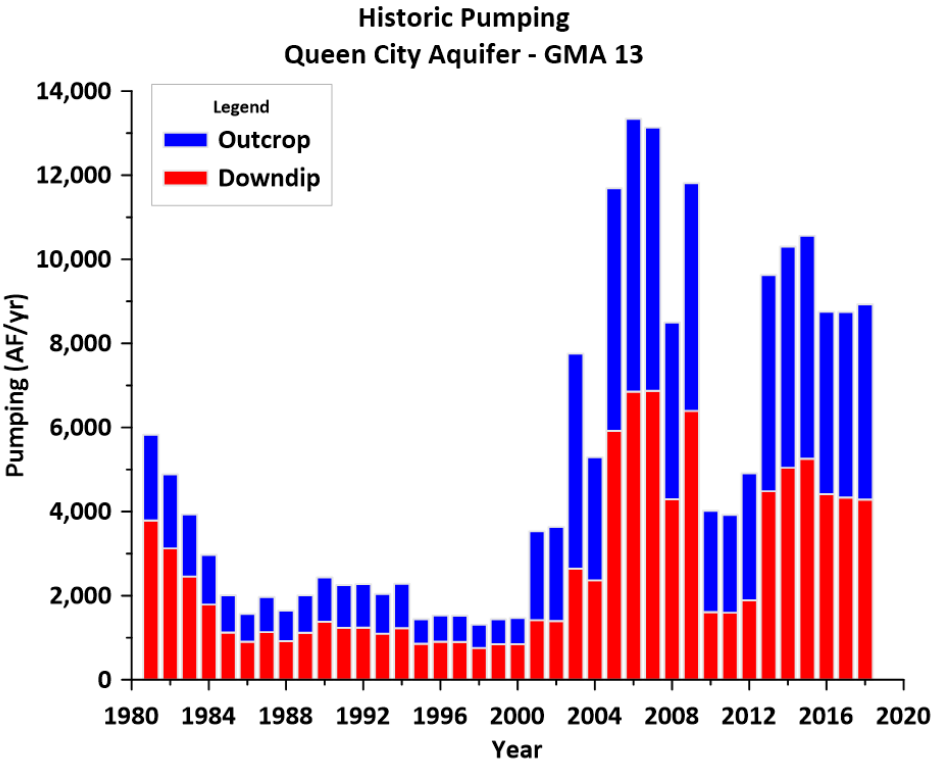


Figure 2. GMA 13 Historic Pumping - Queen City Aquifer

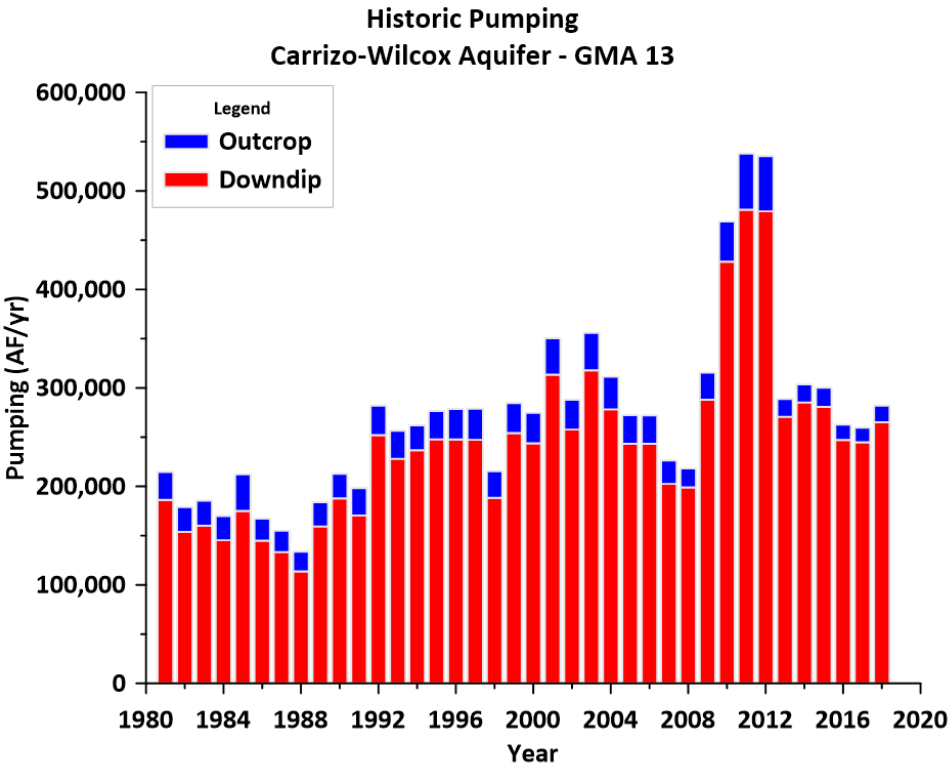


Figure 3. GMA 13 Historic Pumping - Carrizo Wilcox Aquifer

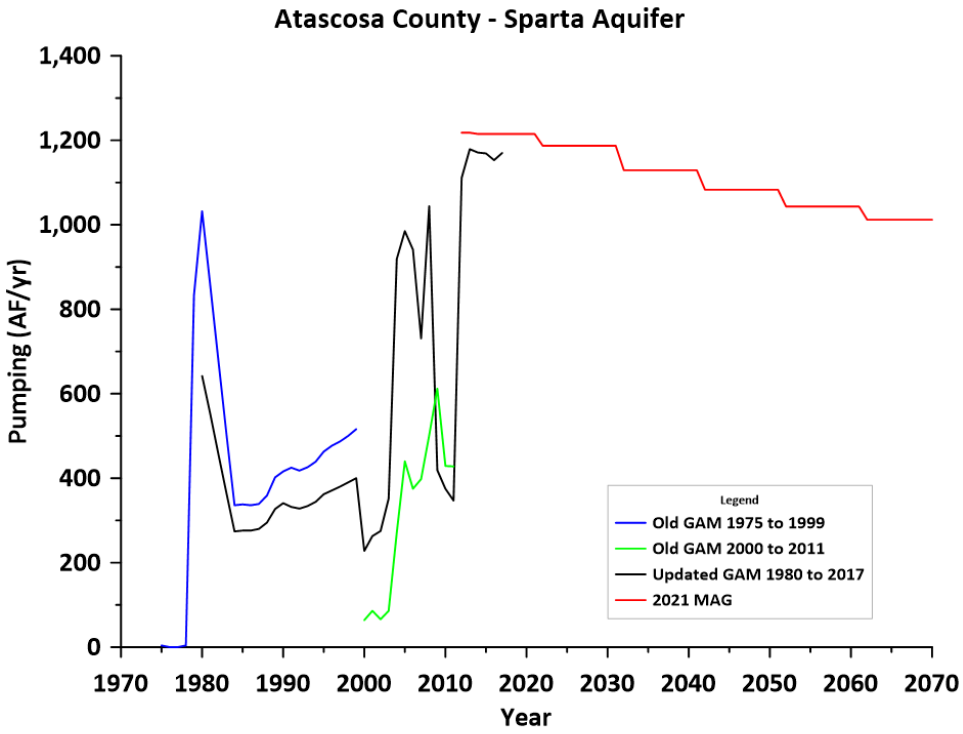
5.0 Limitations

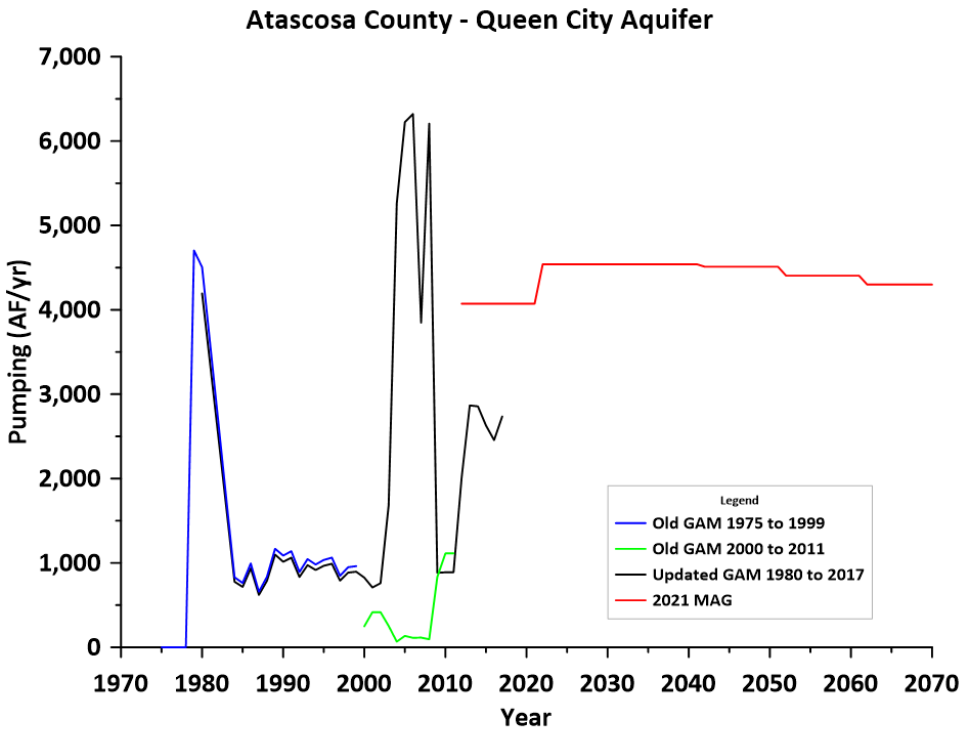
The historic county-aquifer pumping estimates are useful to provide a general sense of pumping in each of the county-aquifer units but are estimates and not based on a rigorous metering program. These estimates can be used as part of the joint planning process to understand and characterize trends of historic pumping but are limited when viewed on a close scale.

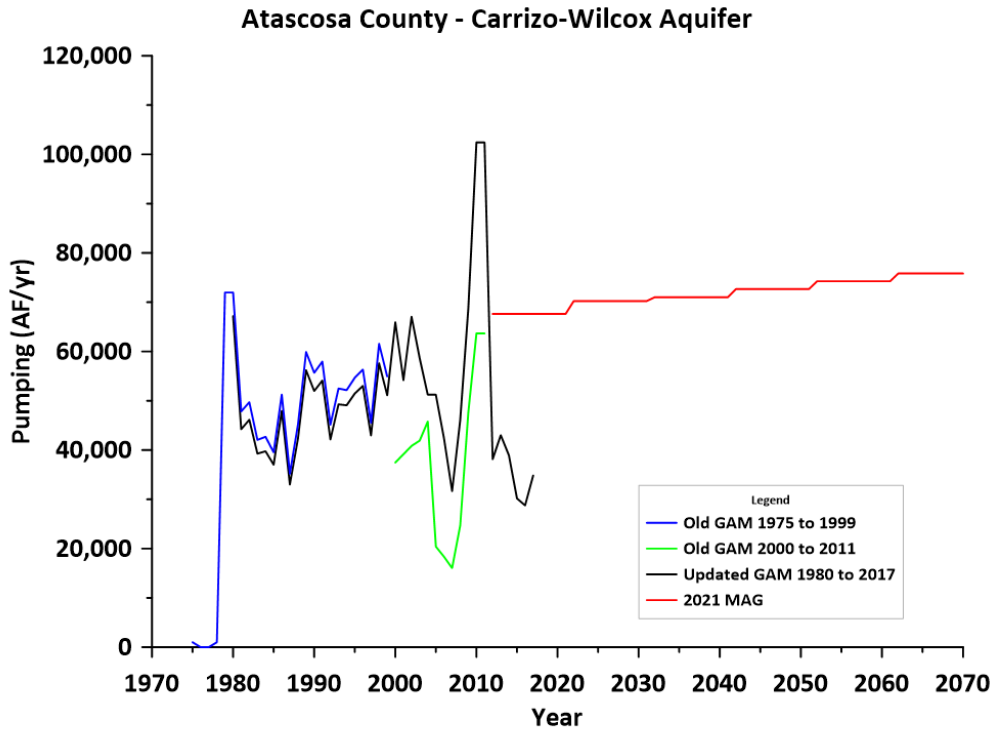
Similar to the county-aquifer pumping estimates, the GMA 13 pumping estimates from the new GAM that are split into outcrop and downdip pumping provide a basic conceptual understanding of the relative pumping in each aquifer between the outcrop area and the downdip area. This is particularly useful since the current primary DFC in GMA 13 is tied to saturated thickness of the outcrop area. This issue is evaluated in greater detail in Technical Memoranda 2 and 3.

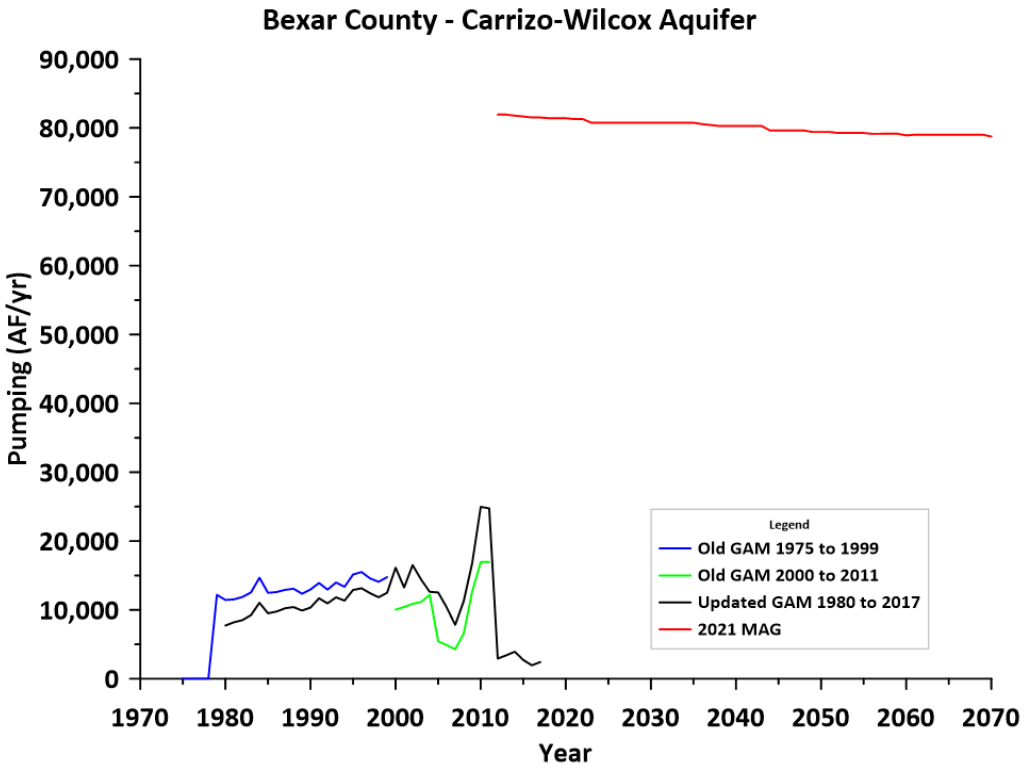
Appendix A

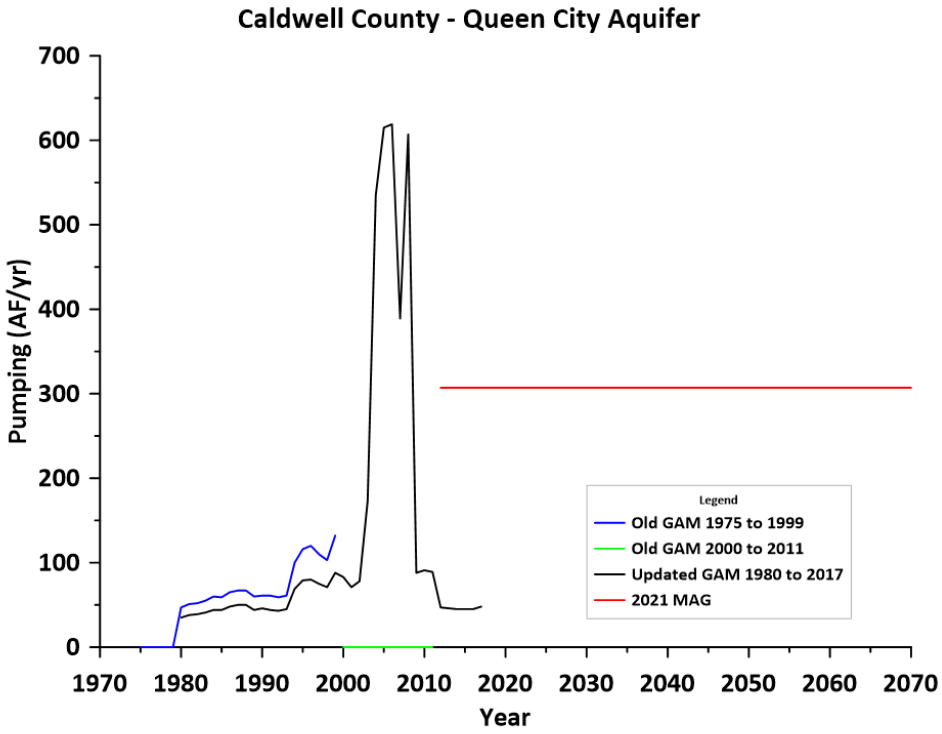
County-Aquifer Pumping Comparisons

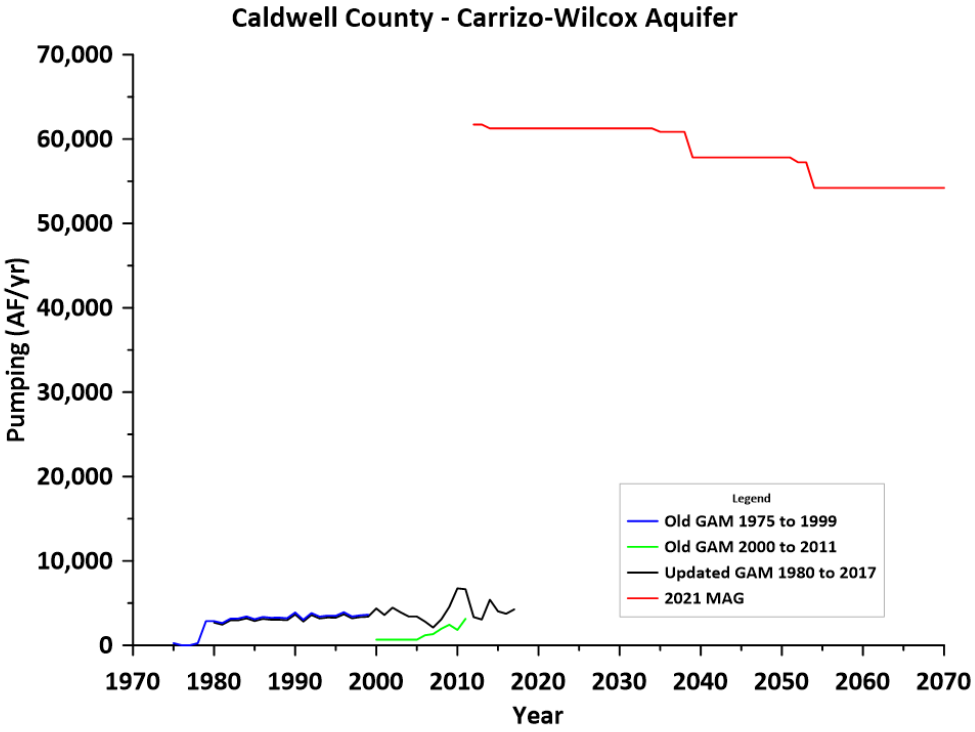

Atascosa County - Sparta Aquifer
Pumping (AF/yr)
1,400
1,200
1,000
800
600
400
200
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

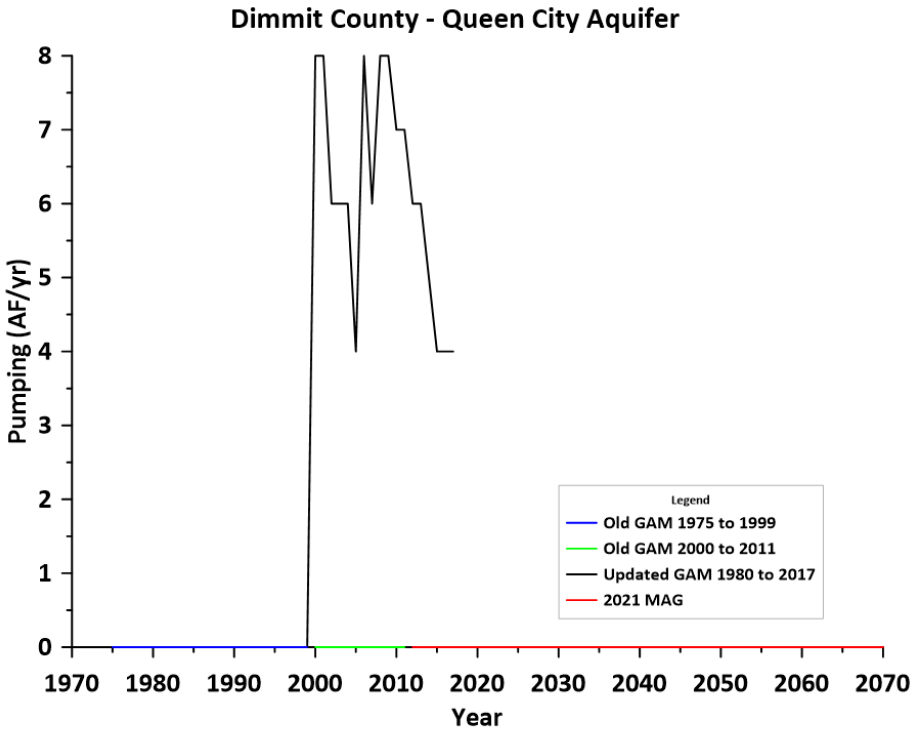

Atascosa County - Queen City Aquifer
Pumping (AF/yr)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

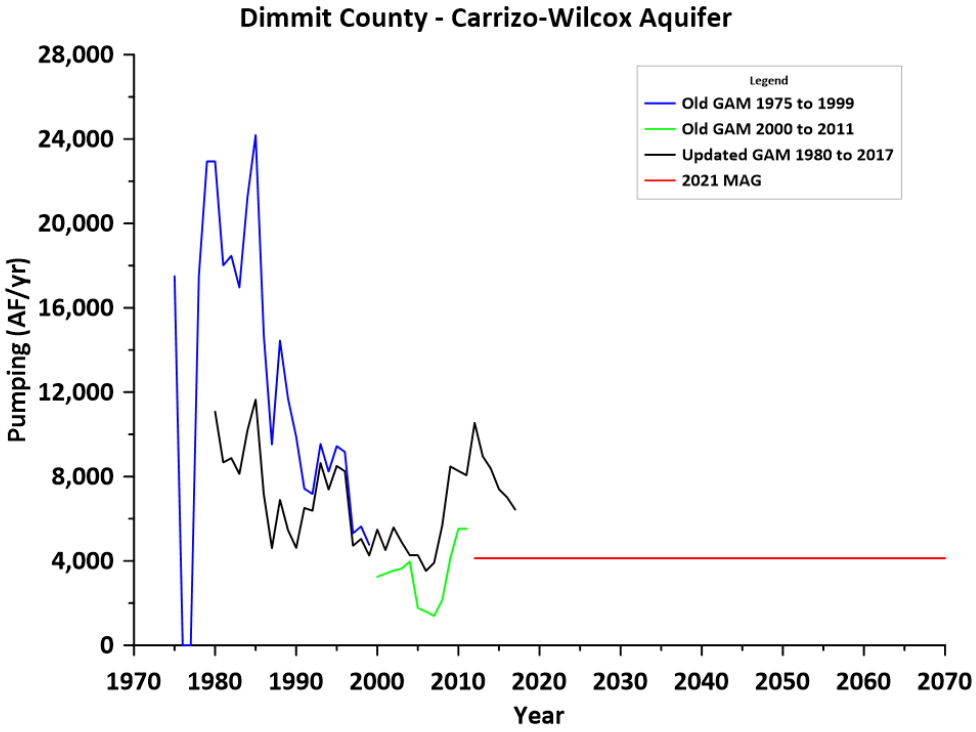

Atascosa County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
120,000
100,000
80,000
60,000
40,000
20,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

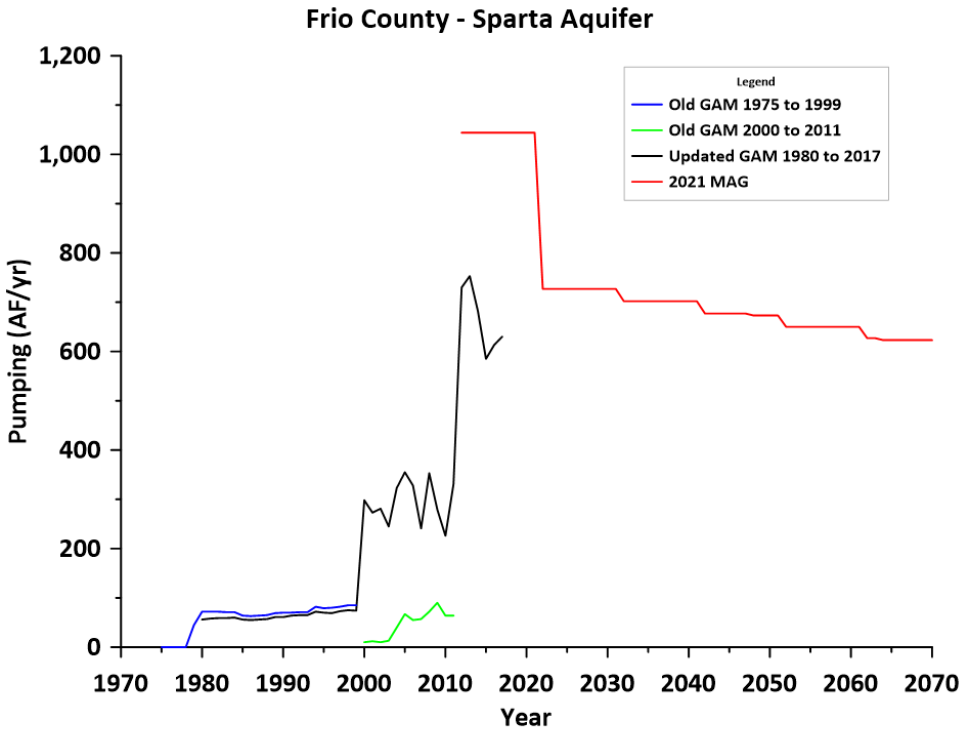

Bexar County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

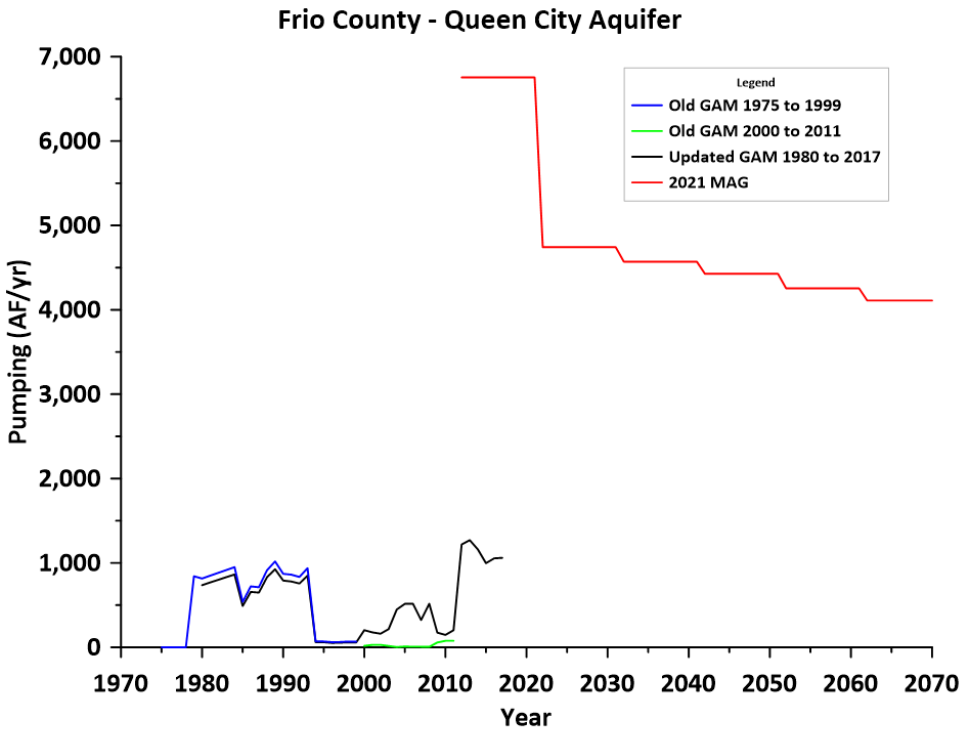

Caldwell County - Queen City Aquifer
Pumping (AF/yr)
0
100
200
300
400
500
600
700
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

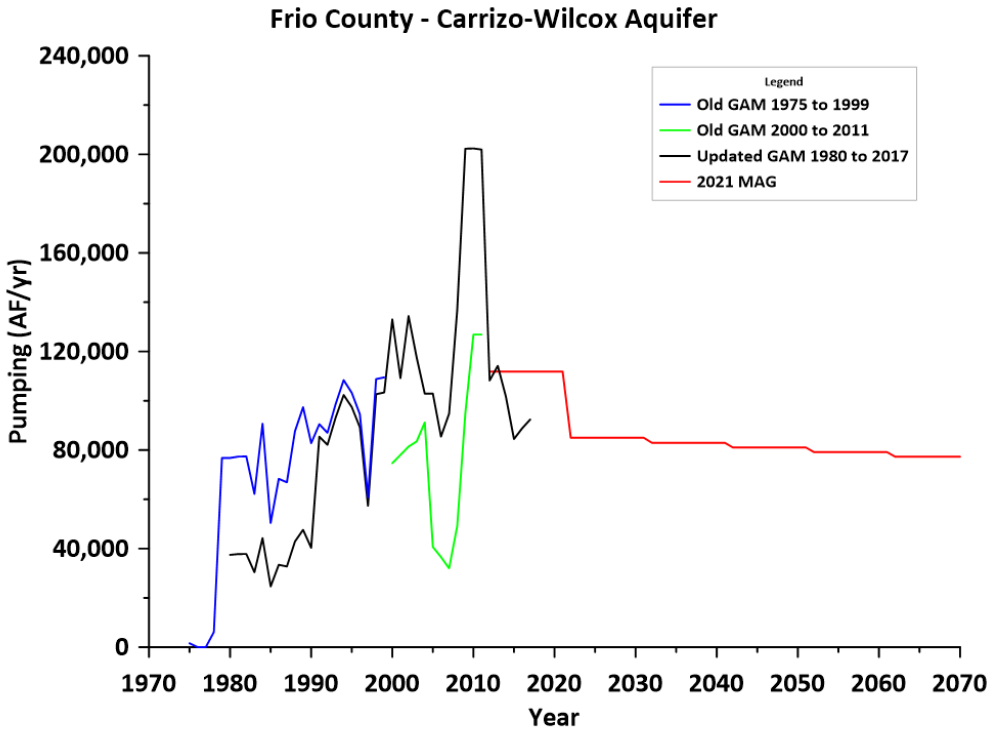

Caldwell County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

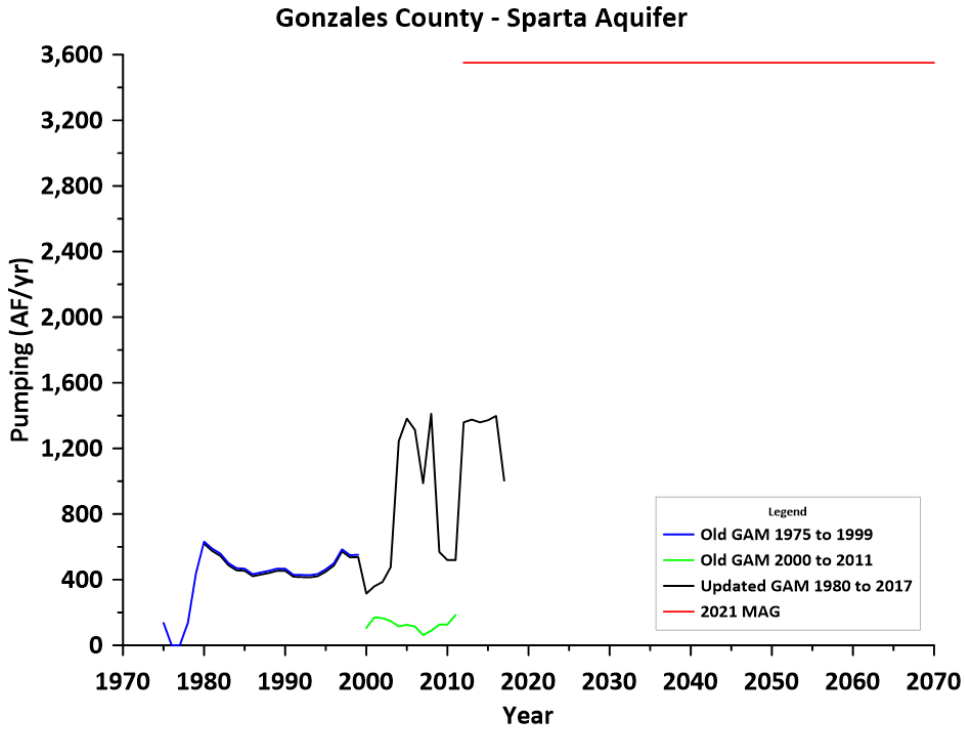

Dimmit County - Queen City Aquifer
Pumping (AF/yr)
0
1
2
3
4
5
6
7
8
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

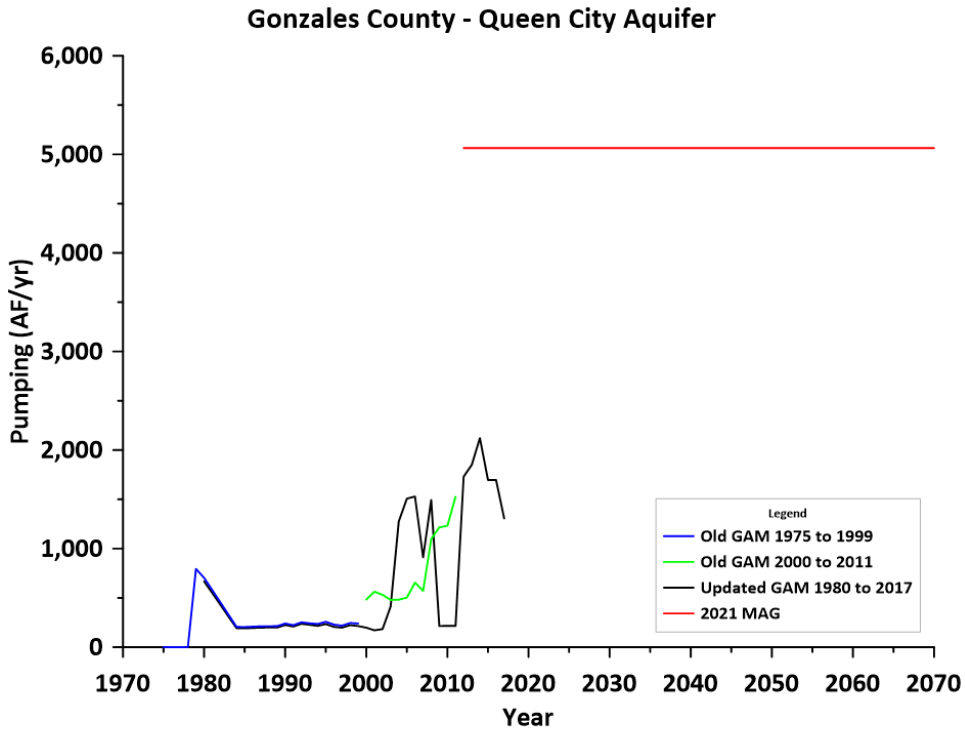

Dimmit County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
0
4,000
8,000
12,000
16,000
20,000
24,000
28,000
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

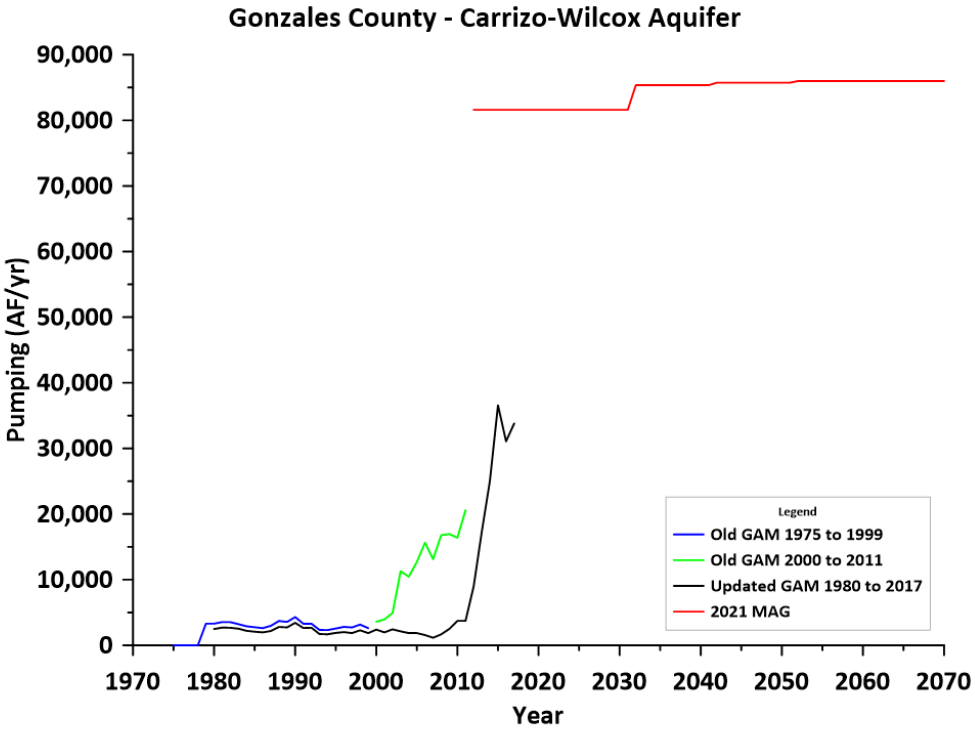

Frio County - Sparta Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
1,200
1,000
800
600
400
200
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year

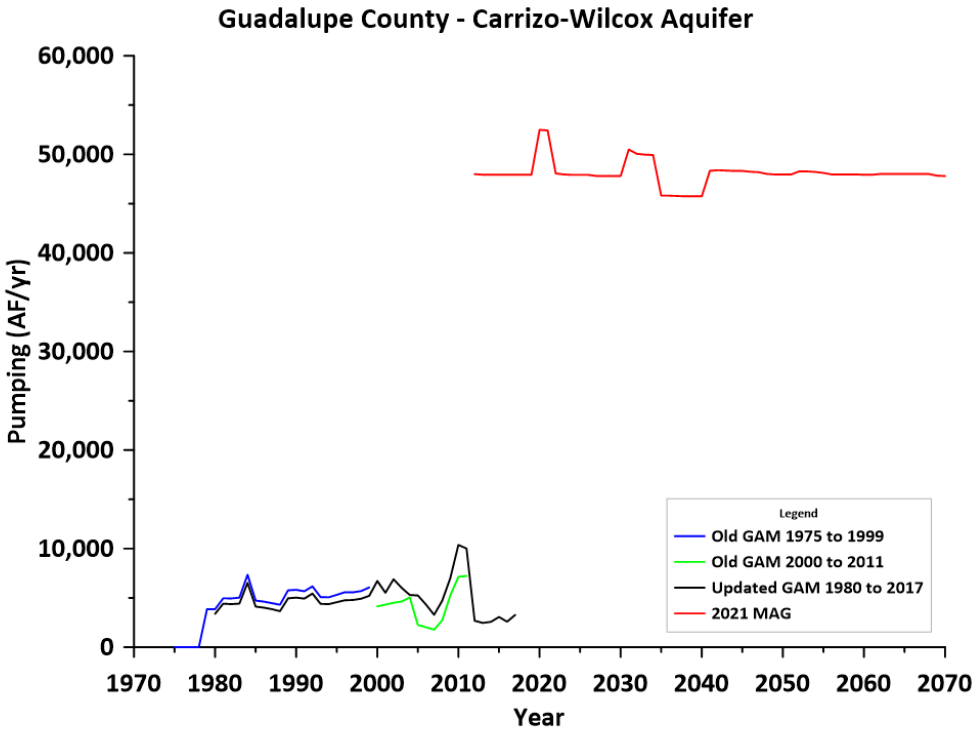

Frio County - Queen City Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year

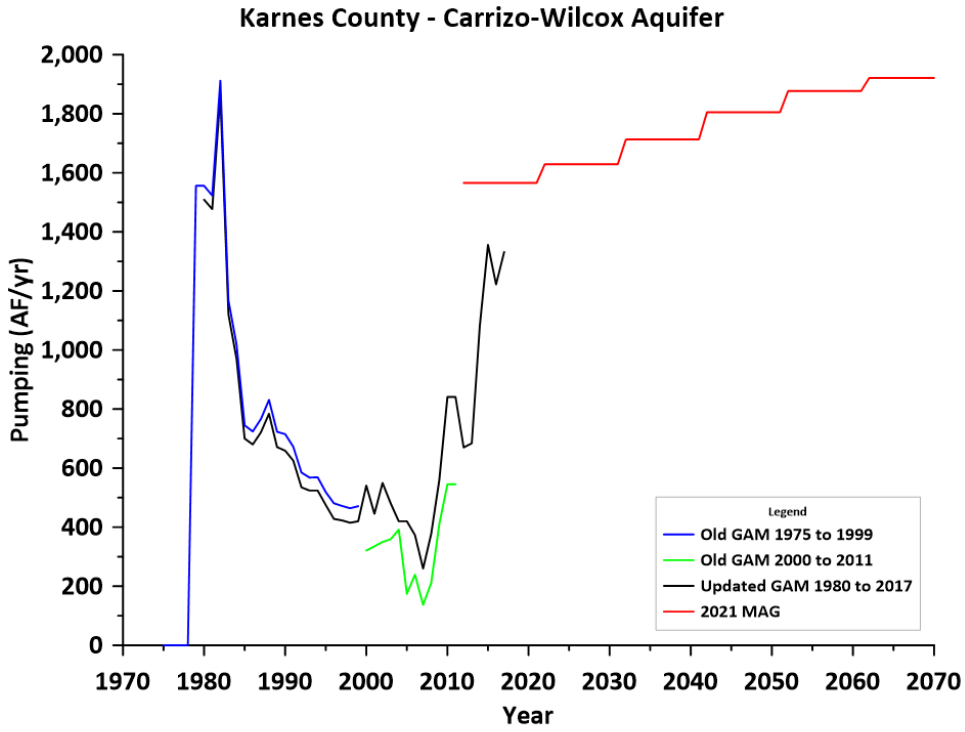

Frio County - Carrizo-Wilcox Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
240,000
200,000
160,000
120,000
80,000
40,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year

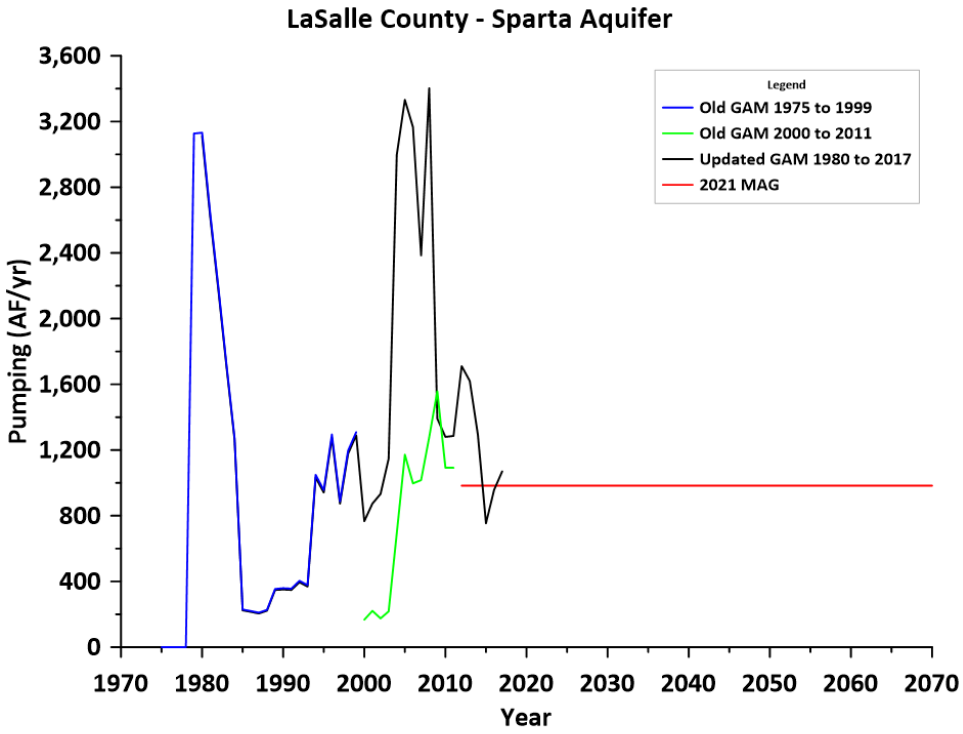

Gonzales County - Sparta Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
3,600
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year

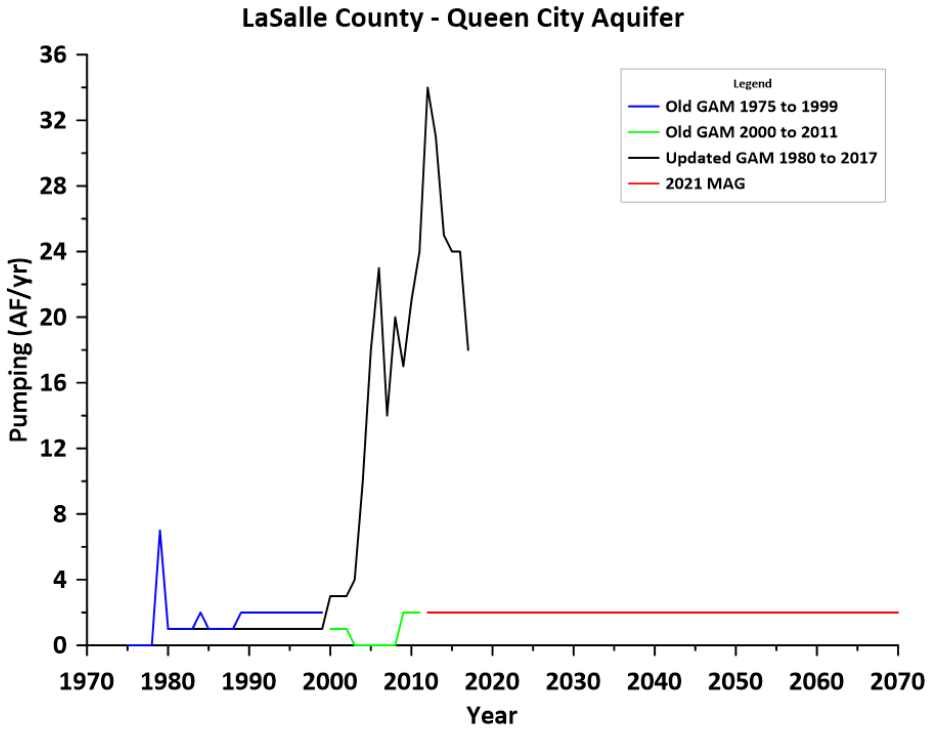

Gonzales County - Queen City Aquifer
Pumping (AF/yr)
6,000
5,000
4,000
3,000
2,000
1,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

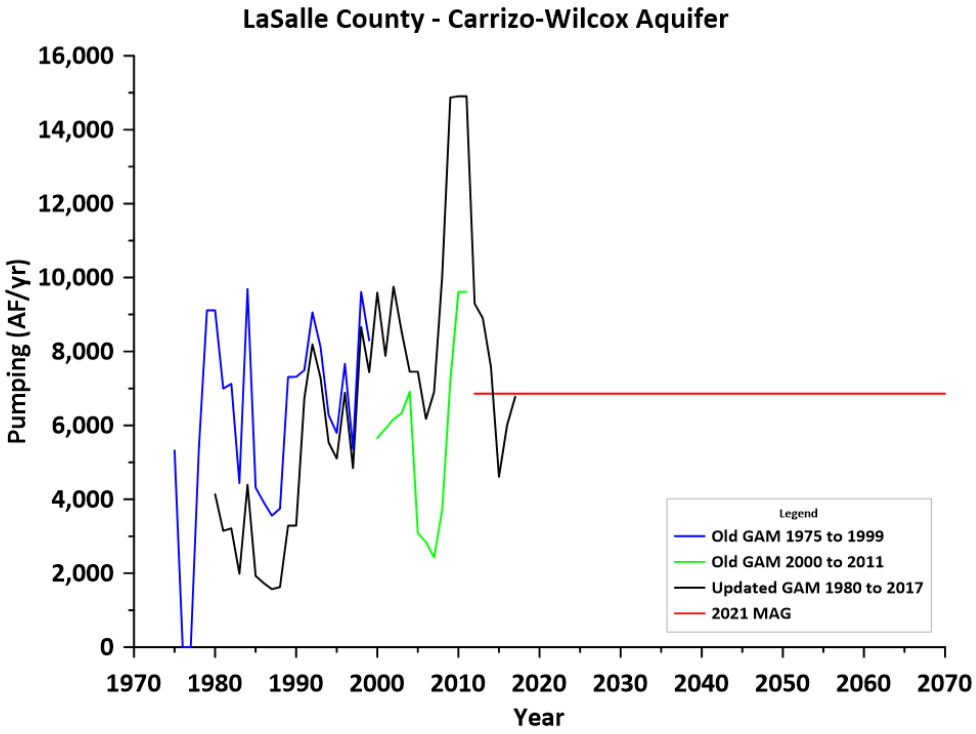

Gonzales County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

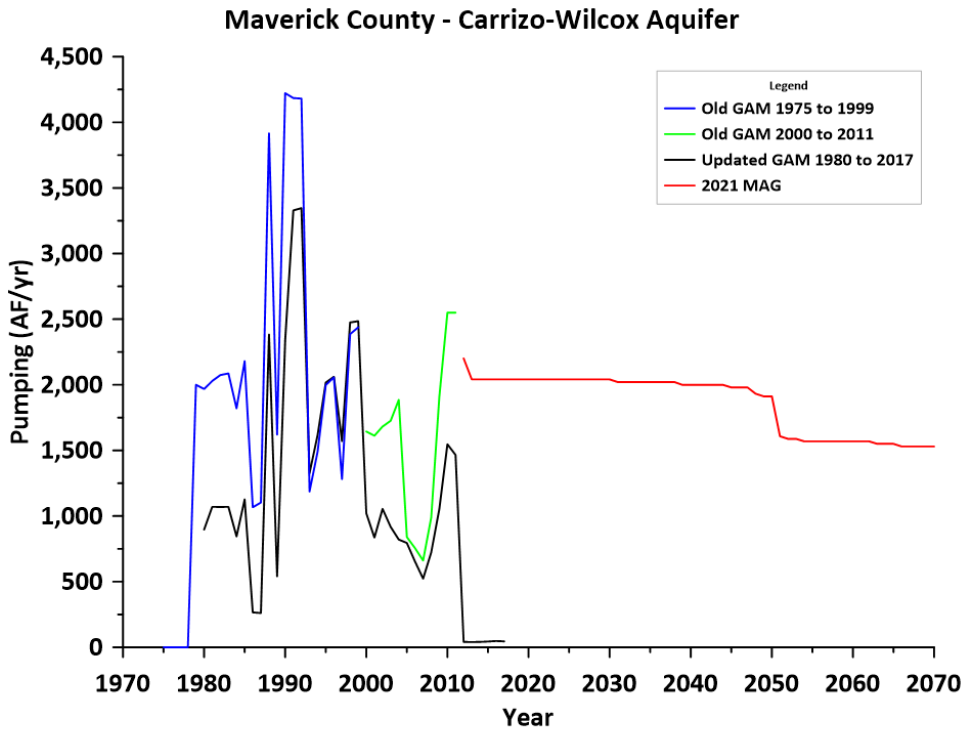

Guadalupe County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
60,000
50,000
40,000
30,000
20,000
10,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

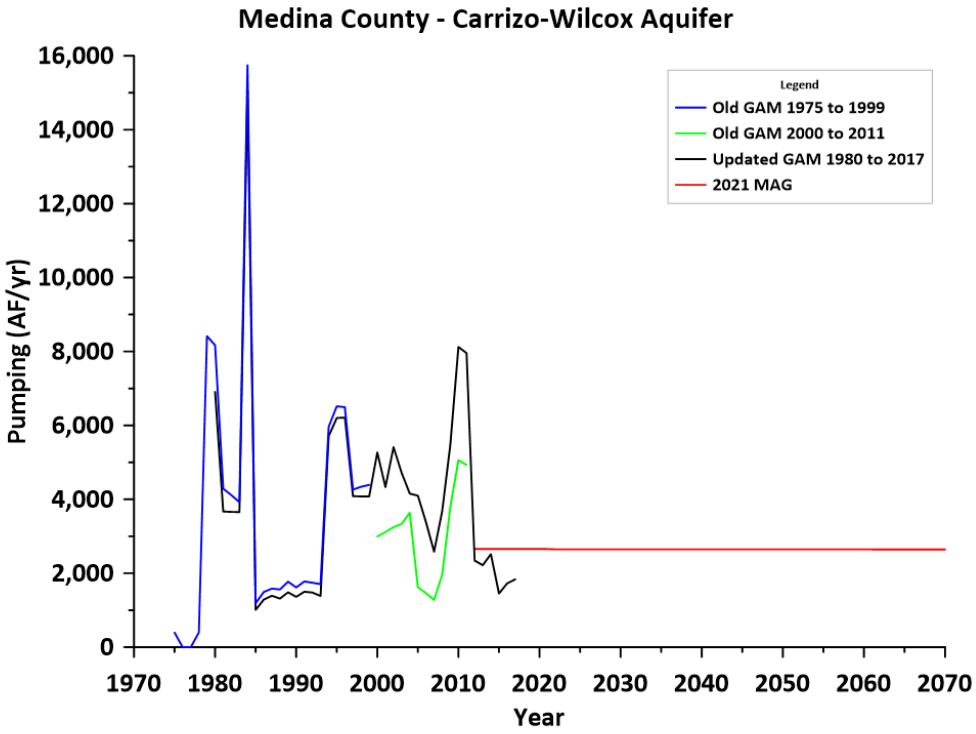

Karnes County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

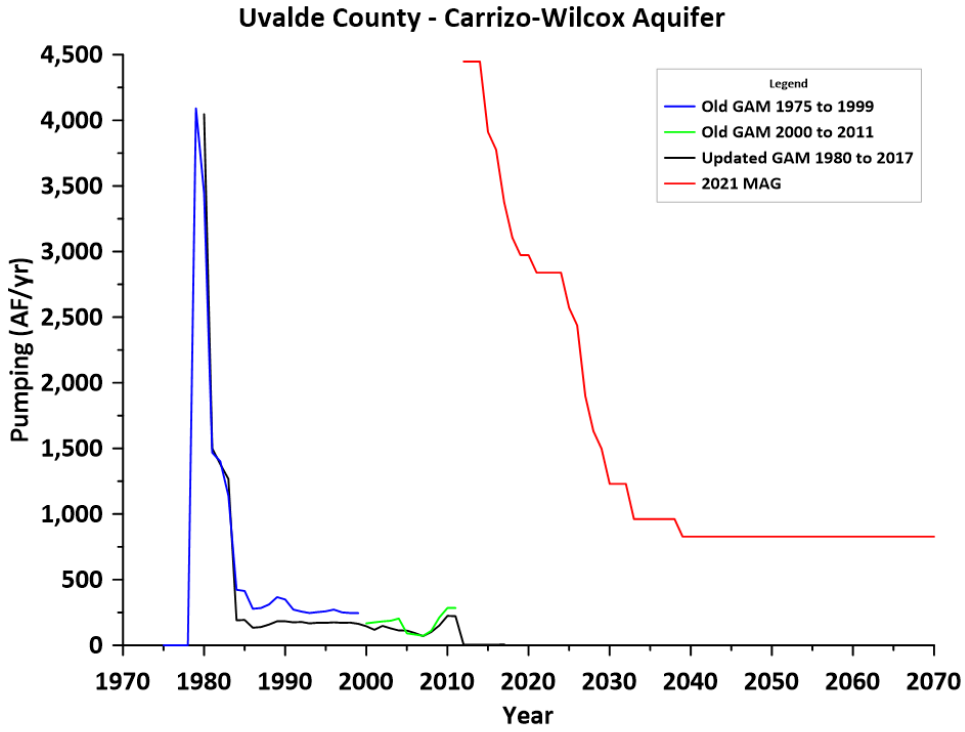

LaSalle County - Sparta Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
3,600
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year

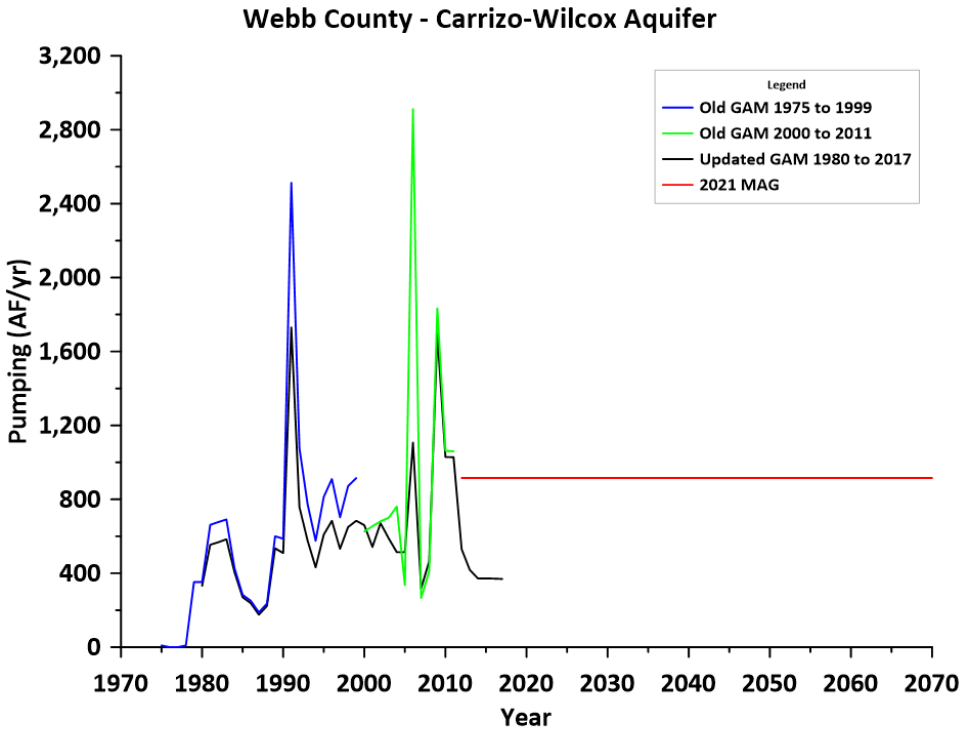

LaSalle County - Queen City Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
36
32
28
24
20
16
12
8
4
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year

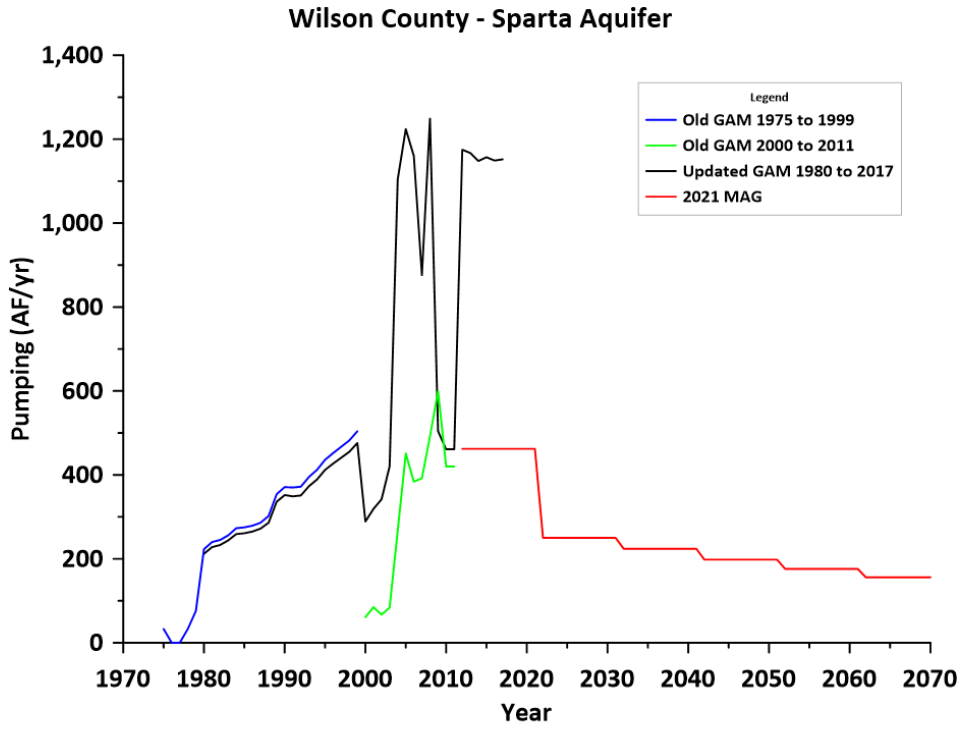

LaSalle County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

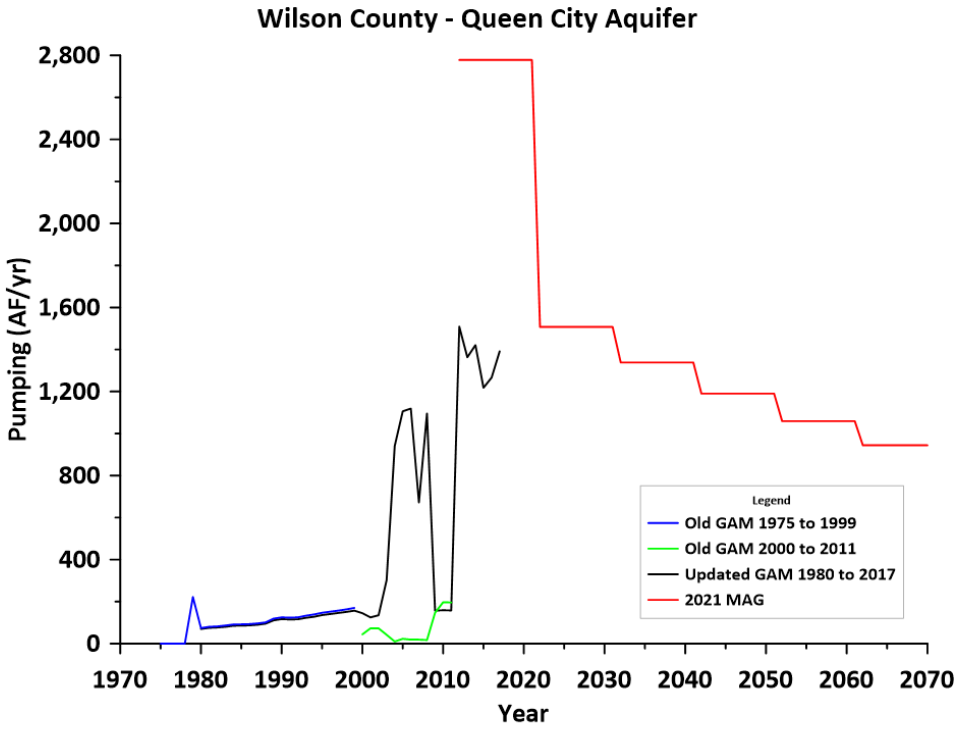

Maverick County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG

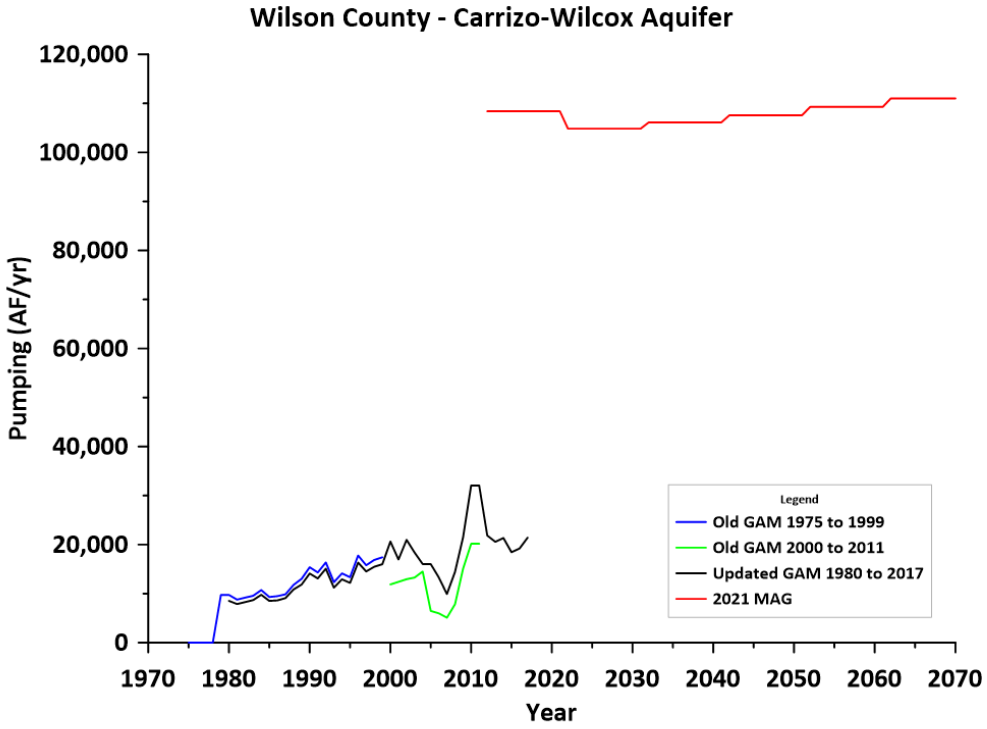

Medina County - Carrizo-Wilcox Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year

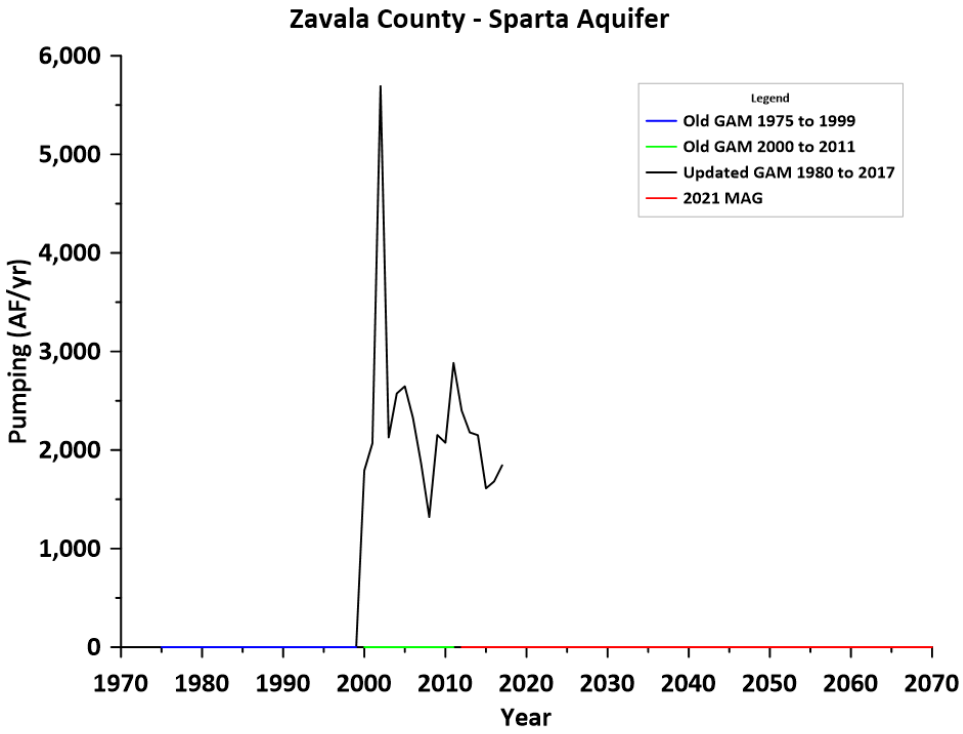

Uvalde County - Carrizo-Wilcox Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year

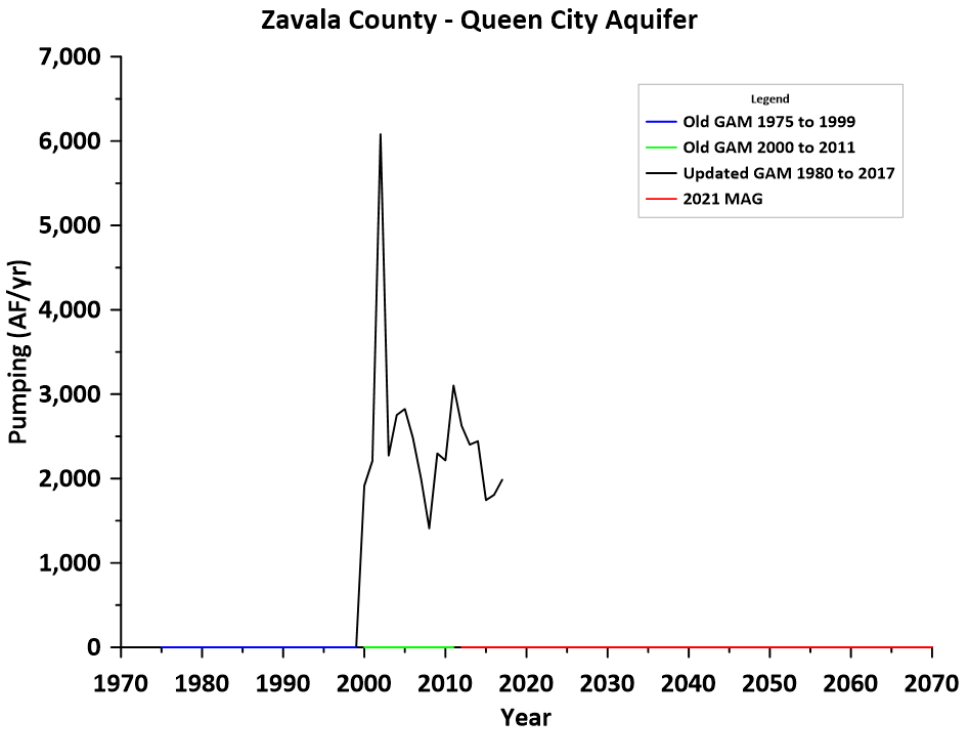

Webb County - Carrizo-Wilcox Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year

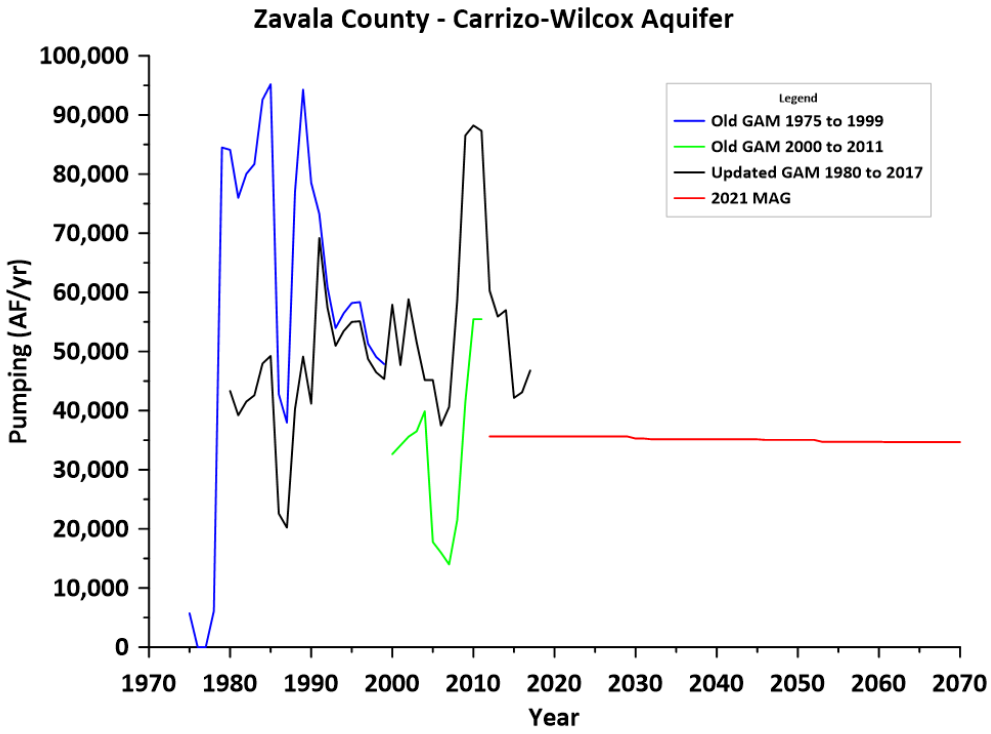

Wilson County - Sparta Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
1,400
1,200
1,000
800
600
400
200
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year


Wilson County - Queen City Aquifer
Pumping (AF/yr)
2,800
2,400
2,000
1,600
1,200
800
400
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG


Wilson County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
120,000
100,000
80,000
60,000
40,000
20,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG


Zavala County - Sparta Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
6,000
5,000
4,000
3,000
2,000
1,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year


Zavala County - Queen City Aquifer
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG
Pumping (AF/yr)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year


Zavala County - Carrizo-Wilcox Aquifer
Pumping (AF/yr)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
Year
Legend
Old GAM 1975 to 1999
Old GAM 2000 to 2011
Updated GAM 1980 to 2017
2021 MAG