GAM RUN 21-018 MAG:
MODELED AVAILABLE GROUNDWATER FOR THE CARRIZO-WILCOX, QUEEN CITY, SPARTA, AND YEGUA-JACKSON AQUIFERS IN GROUNDWATER MANAGEMENT AREA 13

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July 25, 2022

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EXECUTIVE SUMMARY:

The modeled available groundwater for Groundwater Management Area 13 for the Carrizo-Wilcox, Queen City, Sparta, and Yegua-Jackson aquifers is summarized by decade for the groundwater conservation districts (Tables 1 through 4 respectively) and for use in the regional water planning process (Tables 5 through 8 respectively). The modeled available groundwater estimates for the Carrizo-Wilcox Aquifer range from approximately 470,000 acre-feet per year in 2020 to approximately 575,000 acre-feet per year in 2080 (Table 1). The modeled available groundwater estimates for the Queen City Aquifer range from approximately 23,000 acre-feet per year in 2020 to approximately 18,000 acre-feet per year in 2080 (Table 2). The modeled available groundwater estimates for the Sparta Aquifer range from approximately 6,000 acre-feet per year in 2020 to approximately 4,000 acre-feet per year in 2080 (Table 3). The estimates for the Carrizo-Wilcox, Queen City, and Sparta Aquifers were extracted from the results of a model run using the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (version 2.01). The modeled available groundwater estimates for the Yegua-Jackson Aquifer are approximately 6,700 acre-feet per year from 2020 to 2080 (Table 4). The estimates for the Yegua-Jackson Aquifer were extracted from the results of a model run using the groundwater availability model for the Yegua-Jackson Aquifer (version 1.01). The explanatory report and other materials submitted to the TWDB were determined to be administratively complete on April 15, 2022.

REQUESTOR:

Ms. Kelley Cochran, coordinator of Groundwater Management Area 13.

DESCRIPTION OF REQUEST:

The desired future conditions for the Carrizo-Wilcox, Queen City, and Sparta aquifers described in Resolution 21-02 from Groundwater Management Area 13, adopted November 19, 2021, are:

- *"The first desired future condition for the Carrizo-Wilcox, Queen City and Sparta aquifers in Groundwater Management Area 13 is that 75 percent of the saturated thickness in the outcrop at the end of 2012 remains in 2080. Due to the limitations of the current Groundwater Availability Model, this desired future condition cannot be simulated as documented during 2016 Joint Planning in GMA 13 Technical Memorandum 16-08 (Hutchison, 2017a)."*
- *"In addition, a secondary proposed desired future condition for the Carrizo-Wilcox, Queen City, and Sparta aquifers in Groundwater Management Area 13 is an average drawdown of 49 feet (+/- 5 feet) for all of GMA 13. The drawdown is calculated from the end of 2012 conditions to the year 2080. This desired future condition is consistent with simulation "GMA13_2019_001" summarized during a meeting of Groundwater Management Area 13 members on March 19, 2021."*

The desired future conditions for the Yegua-Jackson Aquifer described in Resolution 21-03 from Groundwater Management Area 13, adopted November 19, 2021 are:

- *"For Gonzales County, the average drawdown from 2010 to 2080 is 3 feet (+/- 1 foot)."*
- *"For Karnes County, the average drawdown from 2010 to 2080 is 1 foot (+/- 1 foot)."*
- *"For all other counties in GMA 13, the Yegua-Jackson is classified as not relevant for purposes of joint planning."*

The Edwards (Balcones Fault Zone), Gulf Coast, and Trinity aquifers were declared not relevant for purposes of joint planning by Groundwater Management Area 13 in Resolution 21-01 (Groundwater Management Area 13 Joint Planning Committee and others, 2022; Appendix B).

On January 14, 2022, Dr. Jordan Furnans, on behalf of Groundwater Management Area 13, submitted the Desired Future Conditions Packet to the TWDB. TWDB staff reviewed the model files associated with the desired future conditions and received clarifications on procedures and assumptions from the Groundwater Management Area 13 Technical Coordinator on March 3, 2022, and on March 7, 2022. Groundwater Management Area 13 adopted two desired future conditions for the Carrizo-Wilcox, Queen City, and Sparta Aquifers and they were not mutually compatible in the groundwater availability model. The

technical coordinator for the groundwater management area confirmed that their intention was for the modeled available groundwater values to be based on the secondary desired future condition and MODFLOW pumping simulation GMA13_2019_001 (Groundwater Management Area 13 Joint Planning Committee and others, 2022; Appendix 2). The first proposed desired future condition was not intended for the calculation of modeled available groundwater.

The model run pumping file, which meets the secondary desired future condition adopted by district representatives of Groundwater Management Area 13 for the Carrizo-Wilcox, Queen City, and Sparta Aquifers, was submitted to the TWDB as supplemental information for the original submittal on February 9, 2022. The model run files, which meet the desired future conditions adopted by district representatives of Groundwater Management Area 13 for the Yegua-Jackson Aquifer, were submitted to the TWDB on January 14, 2022, as part of the Desired Future Conditions Explanatory Report for Groundwater Management Area 13.

In an email dated March 3, 2022, the Technical Coordinator and consultant for Groundwater Management Area 13 confirmed that they intended to use the end of 2011 as the reference year for the drawdown calculations for the Carrizo-Wilcox, Queen City, and Sparta aquifers and they intended to use the end of 2009 as the reference year for the Yegua-Jackson Aquifer. In an email dated March 7, 2022, they also confirmed that the confining unit model layers representing the Reklaw and Weches formations should be included in the desired future condition calculation of average drawdown for the combined Carrizo-Wilcox, Queen City, and Sparta aquifers.

All clarifications are included in the Parameters and Assumptions Section of this report.

METHODS:

The groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Figures 1 through 3) was run using the model files submitted with the explanatory reports (Groundwater Management Area 13 Joint Planning Committee and others, 2022) on January 14 and February 9, 2022. Model-calculated water levels were extracted for the years 2011 (stress period 12) and 2080 (stress period 81). An overall drawdown average was calculated for the entire Groundwater Management Area 13 using all model layers in the average. As described in the Technical Memorandum submitted with the Explanatory Report on January 14, 2022 (Furnans, 2022) drawdowns for cells that became dry during the simulation (water level dropped below the base of the cell) were calculated as the reference year water level elevation minus the elevation of the model cell bottom. The calculated drawdown average was compared with the desired future condition of 49 feet to verify that the pumping scenario achieved the desired future conditions within the stated tolerance of five feet.

The groundwater availability model for the Yegua-Jackson Aquifer (Figure 4) was run using the model files submitted on January 14, 2022. Model-calculated water levels were extracted for the years 2009 (stress period 39) and 2080 (stress period 110). County-wide average drawdowns were calculated for Gonzales and Karnes counties within Groundwater Management Area 13 by averaging the drawdown values for all model layers. There were no dry cells in Karnes County or Gonzales County, so no additional dry cell calculations were needed. The calculated drawdown averages were compared with the desired future conditions for Gonzales and Karnes counties to verify that the pumping scenario achieved the desired future conditions within the stated tolerance of one foot.

The modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Annual pumping rates by aquifer are presented by county and groundwater conservation district, subtotaled by groundwater conservation district, and then summed for Groundwater Management Area 13 (Tables 1 through 4). Annual pumping rates by aquifer are also presented by county, river basin, and regional water planning area within Groundwater Management Area 13 (Tables 5 through 8) in order to be consistent with the format used in the regional water planning process.

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code (2011), "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the modeled available groundwater estimates are described below:

Carrizo-Wilcox, Queen City, and Sparta aquifers

- We used Version 2.01 of the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. See Deeds and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers.
- This groundwater availability model includes eight layers, which generally represent the Sparta Aquifer (Layer 1), the Weches Confining Unit (Layer 2), the Queen City Aquifer (Layer 3), the Reklaw Confining Unit (Layer 4), the Carrizo (Layer 5), the Upper Wilcox (Layer 6), the Middle Wilcox (Layer 7), and the Lower Wilcox (Layer 8). Since the model extends beyond the official TWDB aquifer extents, please note that model layers 1 and 3 instead represent geologic units equivalent to the Sparta and Queen City aquifers, respectively, in those areas falling outside of the official aquifer extents.
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Although the original groundwater availability model was only calibrated to 1999, an analysis during the second round of joint planning (Hutchison, 2017b) verified that the model satisfactorily matched measured water levels for the period from 1999 to 2011. For this reason, TWDB considers it acceptable to use the end of 2011 as the reference year for drawdown calculations.
- Drawdown averages and modeled available groundwater values were based on the TWDB defined aquifer boundaries rather than the model extent.
- Drawdowns for cells that became dry during the simulation (water level dropped below the base of the cell) were calculated as the reference year water level elevation minus the elevation of the model cell bottom. Pumping in dry cells was excluded from the modeled available groundwater calculations for the decades after the cell went dry.
- A tolerance of five feet was assumed when comparing desired future conditions to modeled drawdown results. This tolerance was specified by the GMA in their definition of the desired future conditions.
- Estimates of modeled available groundwater from the model simulation were rounded to the nearest whole number.
- The verification calculation for the desired future conditions is based on an average of all model layers (Layers 1 through 8). The modeled available groundwater

calculations are based on Layer 1 for the Sparta Aquifer, Layer 3 for the Queen City Aquifer, and the sum of Layers 5 through 8 for the Carrizo-Wilcox Aquifer.

Yegua-Jackson Aquifer

- We used version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer. See Deeds and others (2010) for assumptions and limitations of the groundwater availability model.
- This groundwater availability model includes five layers which represent the outcrop of the Yegua-Jackson Aquifer and younger overlying units—the Catahoula Formation (Layer 1), the upper portion of the Jackson Group (Layer 2), the lower portion of the Jackson Group (Layer 3), the upper portion of the Yegua Group (Layer 4), and the lower portion of the Yegua Group (Layer 5).
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).
- Although the original groundwater availability model was only calibrated to 1997, a TWDB analysis (Oliver, 2010) verified that the model satisfactorily matched measured water levels for the period from 1997 to 2009. For this reason, TWDB considers it acceptable to use the end of 2009 as the reference year for drawdown calculations.
- Drawdown averages and modeled available groundwater values were based on the TWDB-defined aquifer boundaries rather than the model extent.
- No dry cells occurred in the simulation in Gonzales County or Karnes County. As these were the only counties with defined desired future conditions, no dry cell considerations were required during the verification calculation for the desired future conditions. Pumping in dry cells was excluded from the modeled available groundwater calculations for the decades after the cell went dry.
- A tolerance of one foot was assumed when comparing desired future conditions to modeled drawdown results. This tolerance was specified by the GMA in their definition of the desired future conditions.
- Estimates of modeled available groundwater from the model simulation were rounded to the nearest whole number.
- The verification calculation for the desired future conditions is based on an average of all model layers representing the Yegua or Jackson formations (Layers 1 through 5). The modeled available groundwater calculations are the sum of all model layers representing the Yegua or Jackson formations (Layers 1 through 5).

RESULTS:

The modeled available groundwater estimates for the Carrizo-Wilcox Aquifer range from approximately 470,000 acre-feet per year in 2020 to approximately 575,000 acre-feet per year in 2080 (Table 1). The modeled available groundwater estimates for the Queen City Aquifer range from approximately 23,000 acre-feet per year in 2020 to approximately 18,000 acre-feet per year in 2080 (Table 2). The modeled available groundwater estimate for the Sparta Aquifer ranges from approximately 6,000 acre-feet per year in 2020 to approximately 4,000 acre-feet per year in 2080 (Table 3). The modeled available groundwater is summarized by groundwater conservation district and county for the Carrizo-Wilcox, Queen City, and Sparta aquifers (Tables 1, 2, and 3 respectively). The modeled available groundwater has also been summarized by county, river basin, and regional water planning area for use in the regional water planning process for the Carrizo-Wilcox, Queen City, and Sparta aquifers (Tables 5, 6, and 7 respectively). Small differences in values between table summaries are due to rounding.

The modeled available groundwater estimate for the Yegua-Jackson Aquifer is approximately 7,000 acre-feet per year from 2020 to 2080 (Table 4). The modeled available groundwater for the Yegua-Jackson Aquifer is summarized by groundwater conservation district and county (Table 4) and by county, river basin, and regional water planning area for use in the regional water planning process (Table 8). Small differences of values between table summaries are due to rounding.

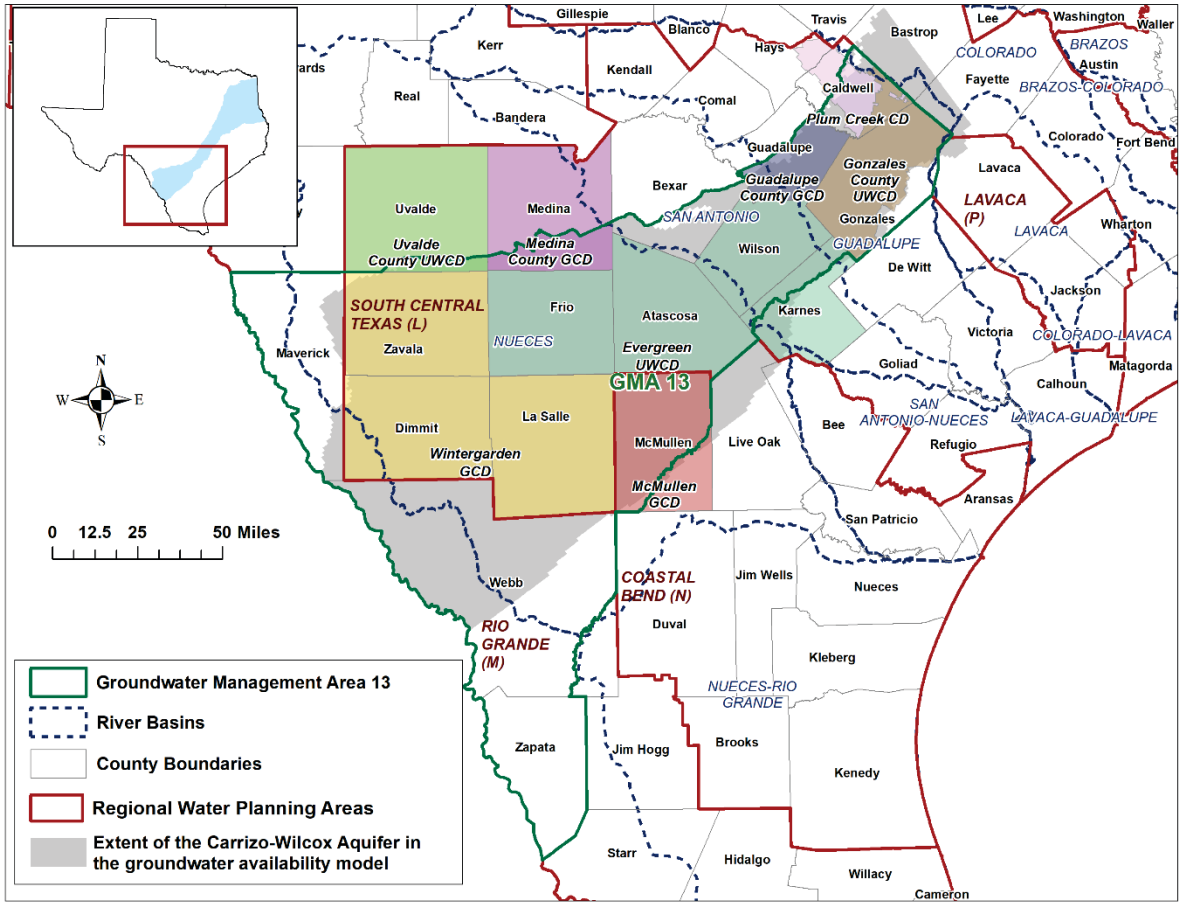

FIGURE 1. GROUNDWATER MANAGEMENT AREA (GMA) 13 BOUNDARY, REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE CARRIZO-WILCOX AQUIFER.

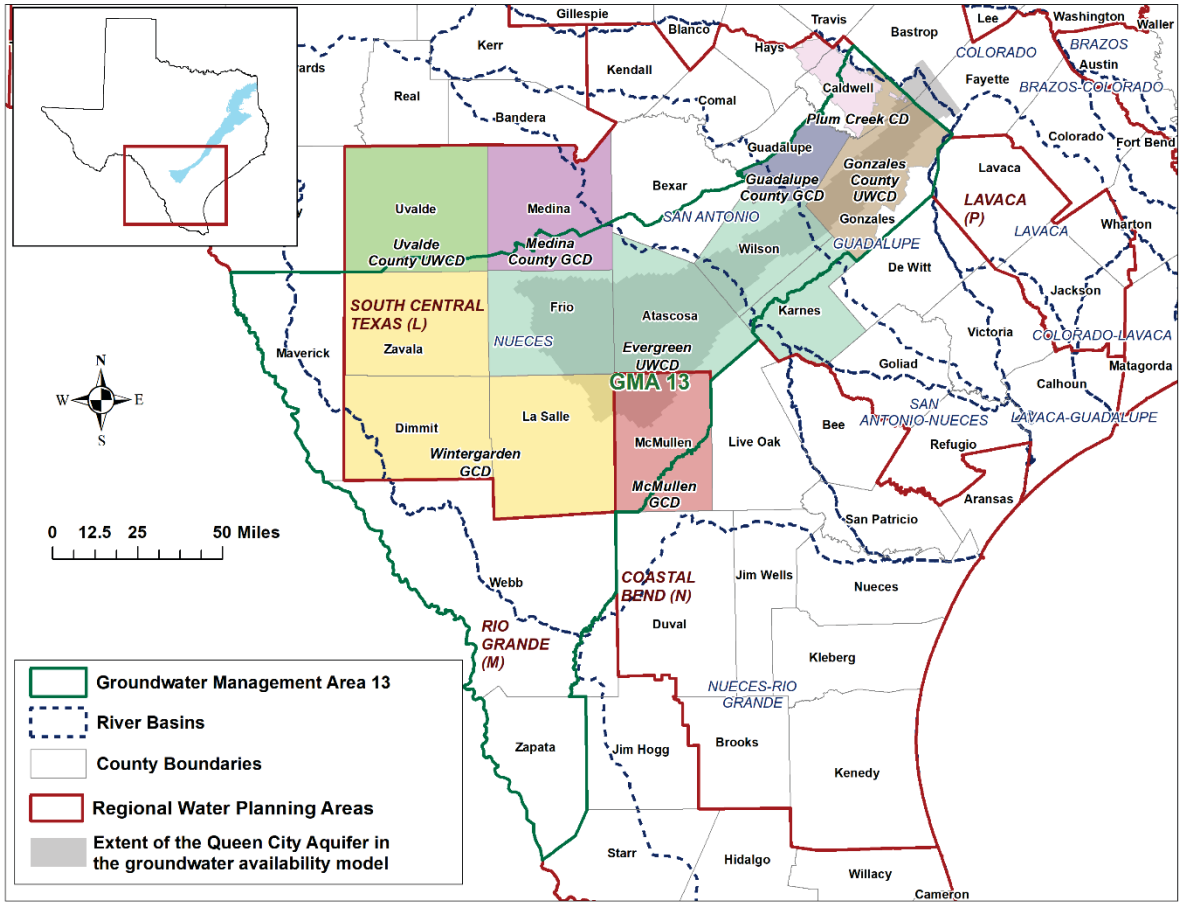

FIGURE 2. GROUNDWATER MANAGEMENT AREA (GMA) 13 BOUNDARY, REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE QUEEN CITY AQUIFER.

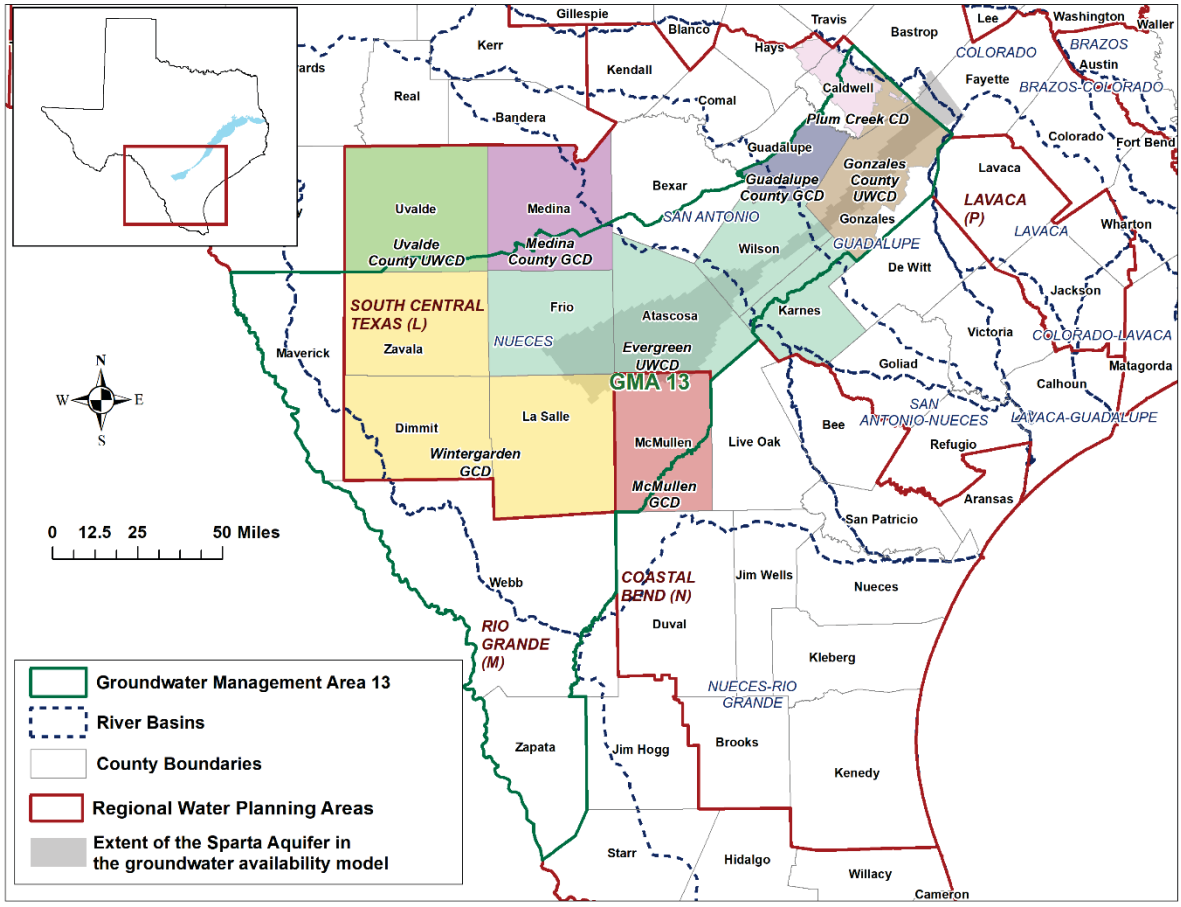

FIGURE 3. GROUNDWATER MANAGEMENT AREA (GMA) 13 BOUNDARY, REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE SPARTA AQUIFER.

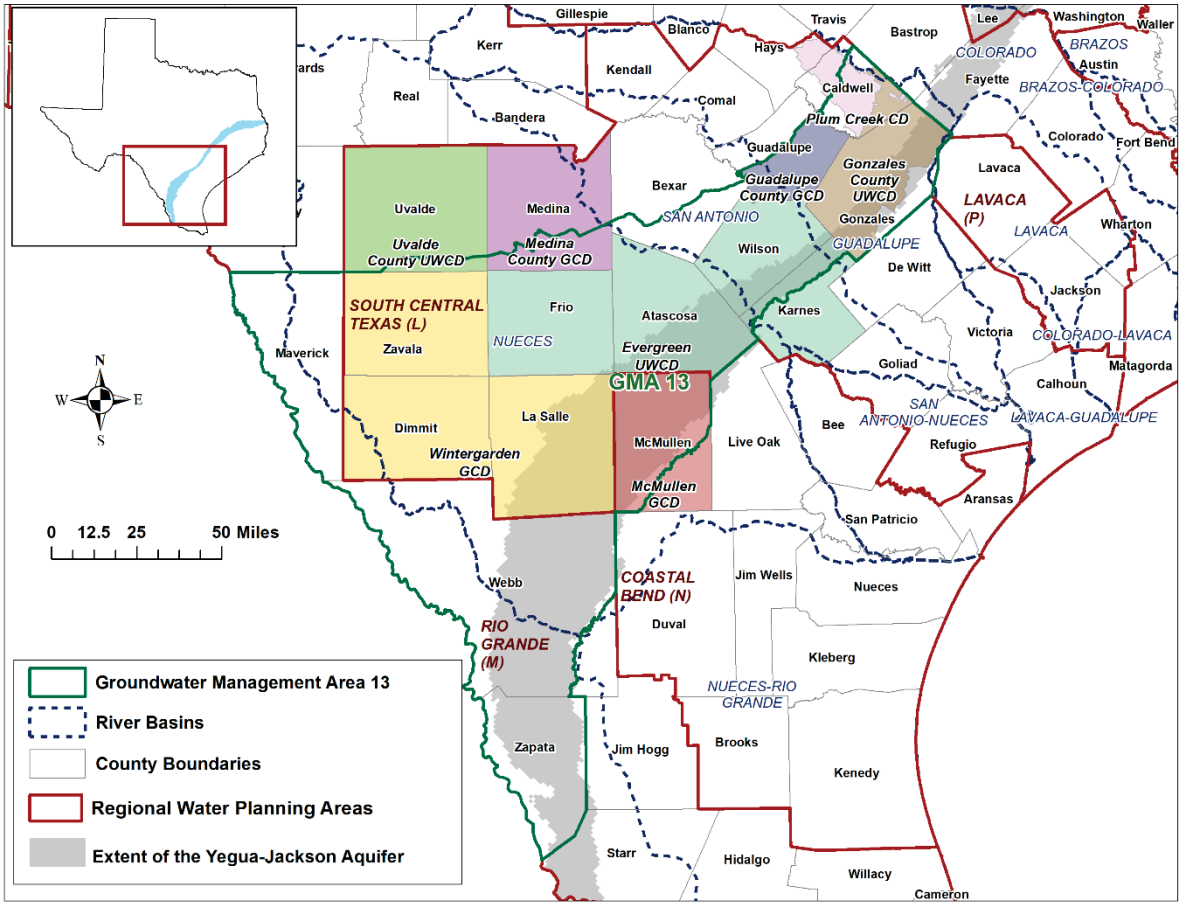

FIGURE 4. GROUNDWATER MANAGEMENT AREA (GMA) 13 BOUNDARY, REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE YEGUA-JACKSON AQUIFER.

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE CARRIZO-WILCOX AQUIFER IN GROUNDWATER MANAGEMENT AREA 13 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Evergreen UWCD	Atascosa	Carrizo-Wilcox	51,924	54,397	55,329	56,828	58,406	59,982	59,982
Evergreen UWCD	Frio	Carrizo-Wilcox	114,827	86,995	85,143	82,950	81,018	79,131	79,131
Evergreen UWCD	Karnes	Carrizo-Wilcox	693	758	843	931	1,001	1,043	1,043
Evergreen UWCD	Wilson	Carrizo-Wilcox	38,229	38,284	43,604	68,609	105,947	125,670	125,670
Evergreen UWCD Total		**Carrizo-Wilcox**	**205,673**	**180,434**	**184,919**	**209,318**	**246,372**	**265,826**	**265,826**
Gonzales County UWCD	Caldwell	Carrizo-Wilcox	468	9,472	16,401	25,510	30,087	30,087	30,087
Gonzales County UWCD	Gonzales	Carrizo-Wilcox	60,431	76,265	90,788	102,373	102,747	103,707	96,161
Gonzales County UWCD Total		**Carrizo-Wilcox**	**60,899**	**85,737**	**107,189**	**127,883**	**132,834**	**133,794**	**126,248**
Guadalupe County GCD	**Guadalupe**	**Carrizo-Wilcox**	**55,637**	**39,563**	**41,668**	**43,315**	**42,118**	**42,199**	**41,659**
McMullen GCD	**McMullen**	**Carrizo-Wilcox**	**7,789**	**7,768**	**4,867**	**4,854**	**4,854**	**4,854**	**4,854**
Medina County GCD	**Medina**	**Carrizo-Wilcox**	**2,635**	**2,628**	**2,635**	**2,628**	**2,628**	**2,628**	**2,628**
Plum Creek CD	**Caldwell**	**Carrizo-Wilcox**	**17,673**	**15,366**	**16,335**	**16,965**	**15,562**	**19,509**	**19,468**
Uvalde County UWCD	**Uvalde**	**Carrizo-Wilcox**	**0**[1]	**0**	**0**	**0**	**0**	**0**	**0**

[1] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE 1 (CONTINUED)

Groundwater Conservation District	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Wintergarden GCD	Dimmit	Carrizo-Wilcox	**3,895**	**3,885**	**3,895**	**3,885**	**3,885**	**3,885**	**3,885**
Wintergarden GCD	La Salle	Carrizo-Wilcox	**6,554**	**6,536**	**6,554**	**6,536**	**6,536**	**6,536**	**6,536**
Wintergarden GCD	Zavala	Carrizo-Wilcox	**38,303**	**36,675**	**35,399**	**35,204**	**35,006**	**34,831**	**34,540**
Wintergarden GCD Total		**Carrizo-Wilcox**	**48,752**	**47,096**	**45,848**	**45,625**	**45,427**	**45,252**	**44,961**
No District-County	Bexar	Carrizo-Wilcox	69,727	68,451	68,928	68,739	67,653	67,849	67,849
No District-County	Caldwell	Carrizo-Wilcox	39	39	39	39	39	39	39
No District-County	Gonzales	Carrizo-Wilcox	0[2]	0	0	0	0	0	0
No District-County	Maverick	Carrizo-Wilcox	547	545	547	545	545	276	276
No District-County	Webb	Carrizo-Wilcox	912	910	912	910	910	910	910
No District-County Total		**Carrizo-Wilcox**	**71,225**	**69,945**	**70,426**	**70,233**	**69,147**	**69,074**	**69,074**
Total for GMA 13		**Carrizo-Wilcox**	**470,283**	**448,537**	**473,887**	**520,821**	**558,942**	**583,136**	**574,718**

[2] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE QUEEN CITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 13 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Evergreen UWCD	Atascosa	Queen City	4,070	4,525	4,537	4,495	4,390	4,285	4,285
Evergreen UWCD	Frio	Queen City	6,702	4,533	4,380	4,231	4,066	3,927	3,927
Evergreen UWCD	Wilson	Queen City	2,631	1,423	1,267	1,123	1,000	892	892
Evergreen UWCD Total		**Queen City**	**13,403**	**10,481**	**10,184**	**9,849**	**9,456**	**9,104**	**9,104**
Gonzales County UWCD	Caldwell	Queen City	4,842	4,829	4,557	4,545	4,545	3,977	3,977
Gonzales County UWCD	Gonzales	Queen City	4,973	4,960	4,973	4,960	4,960	4,500	4,500
Gonzales County UWCD Total		**Queen City**	**9,815**	**9,789**	**9,530**	**9,505**	**9,505**	**8,477**	**8,477**
Guadalupe County GCD	**Guadalupe**	**Queen City**	**0**[3]	**0**	**0**	**0**	**0**	**0**	**0**
McMullen GCD	**McMullen**	**Queen City**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Plum Creek CD	**Caldwell**	**Queen City**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Wintergarden GCD	**La Salle**	**Queen City**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Total for GMA 13		**Queen City**	**23,222**	**20,274**	**19,718**	**19,358**	**18,965**	**17,585**	**17,585**

[3] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE 3. MODELED AVAILABLE GROUNDWATER FOR THE SPARTA AQUIFER IN GROUNDWATER MANAGEMENT AREA 13 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Evergreen UWCD	Atascosa	Sparta	1,218	1,187	1,043	998	961	932	932
Evergreen UWCD	Frio	Sparta	897	623	603	576	557	534	534
Evergreen UWCD	Wilson	Sparta	335	182	163	144	128	114	114
Evergreen UWCD Total		**Sparta**	**2,450**	**1,992**	**1,809**	**1,718**	**1,646**	**1,580**	**1,580**
Gonzales County UWCD	**Gonzales**	**Sparta**	**3,524**	**2,451**	**2,457**	**2,451**	**2,451**	**2,451**	**2,451**
McMullen GCD	**McMullen**	**Sparta**	**0**[4]	**0**	**0**	**0**	**0**	**0**	**0**
Wintergarden GCD	**La Salle**	**Sparta**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total for GMA 13		**Sparta**	**5,974**	**4,443**	**4,266**	**4,169**	**4,097**	**4,031**	**4,031**

TABLE 4. MODELED AVAILABLE GROUNDWATER FOR THE YEGUA-JACKSON AQUIFER IN GROUNDWATER MANAGEMENT AREA 13 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Evergreen UWCD	Karnes	Yegua-Jackson	2,013	2,013	2,013	2,013	2,013	2,013	2,013
Gonzales County UWCD	Gonzales	Yegua-Jackson	4,155	4,155	4,155	4,155	4,155	4,155	4,155
No District-County	Gonzales	Yegua-Jackson	573	573	573	573	573	573	573
Total for GMA 13		**Yegua-Jackson**	**6,741**	**6,741**	**6,741**	**6,741**	**6,741**	**6,741**	**6,741**

[4] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE 5. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE CARRIZO-WILCOX AQUIFER IN GROUNDWATER MANAGEMENT AREA 13. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER.

County	RWPA	River Basin	Aquifer	2030	2040	2050	2060	2070	2080
Atascosa	L	Nueces	Carrizo-Wilcox	54,310	55,241	56,739	58,316	59,890	59,890
Atascosa	L	San Antonio	Carrizo-Wilcox	87	88	89	90	92	92
Bexar	L	Nueces	Carrizo-Wilcox	38,762	38,993	39,134	39,134	39,287	39,287
Bexar	L	San Antonio	Carrizo-Wilcox	29,689	29,935	29,605	28,519	28,562	28,562
Caldwell	L	Colorado	Carrizo-Wilcox	0[5]	0	0	0	0	0
Caldwell	L	Guadalupe	Carrizo-Wilcox	24,877	32,775	42,514	45,688	49,635	49,594
Dimmit	L	Nueces	Carrizo-Wilcox	3,765	3,775	3,765	3,765	3,765	3,765
Dimmit	L	Rio Grande	Carrizo-Wilcox	120	120	120	120	120	120
Frio	L	Nueces	Carrizo-Wilcox	86,995	85,143	82,950	81,018	79,131	79,131
Gonzales	L	Guadalupe	Carrizo-Wilcox	76,265	90,788	102,373	102,747	103,707	96,161
Gonzales	L	Lavaca	Carrizo-Wilcox	0	0	0	0	0	0
Guadalupe	L	Guadalupe	Carrizo-Wilcox	32,400	34,200	35,631	34,655	34,736	34,345
Guadalupe	L	San Antonio	Carrizo-Wilcox	7,163	7,468	7,684	7,463	7,463	7,314
Karnes	L	Guadalupe	Carrizo-Wilcox	0	0	0	0	0	0
Karnes	L	Nueces	Carrizo-Wilcox	0	0	0	0	0	0
Karnes	L	San Antonio	Carrizo-Wilcox	758	843	931	1,001	1,043	1,043
La Salle	L	Nueces	Carrizo-Wilcox	6,536	6,554	6,536	6,536	6,536	6,536
Medina	L	Nueces	Carrizo-Wilcox	2,623	2,630	2,623	2,623	2,623	2,623

[5] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE 5 (CONTINUED)

County	RWPA	River Basin	Aquifer	2030	2040	2050	2060	2070	2080
Medina	L	San Antonio	Carrizo-Wilcox	5	5	5	5	5	5
Uvalde	L	Nueces	Carrizo-Wilcox	0[6]	0	0	0	0	0
Wilson	L	Guadalupe	Carrizo-Wilcox	443	653	762	3,870	3,982	3,982
Wilson	L	Nueces	Carrizo-Wilcox	10,774	11,171	11,578	12,027	12,546	12,546
Wilson	L	San Antonio	Carrizo-Wilcox	27,067	31,780	56,269	90,050	109,142	109,142
Zavala	L	Nueces	Carrizo-Wilcox	36,675	35,399	35,204	35,006	34,831	34,540
Maverick	M	Nueces	Carrizo-Wilcox	542	544	542	542	273	273
Maverick	M	Rio Grande	Carrizo-Wilcox	3	3	3	3	3	3
Webb	M	Nueces	Carrizo-Wilcox	890	892	890	890	890	890
Webb	M	Rio Grande	Carrizo-Wilcox	20	20	20	20	20	20
McMullen	N	Nueces	Carrizo-Wilcox	7,768	4,867	4,854	4,854	4,854	4,854
GMA 13 Total			**Carrizo-Wilcox**	**448,537**	**473,887**	**520,821**	**558,942**	**583,136**	**574,718**

[6] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE 6. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE QUEEN CITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 13. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER.

County	RWPA	River Basin	Aquifer	2030	2040	2050	2060	2070	2080
Atascosa	L	Nueces	Queen City	4,525	4,537	4,495	4,390	4,285	4,285
Caldwell	L	Guadalupe	Queen City	4,829	4,557	4,545	4,545	3,977	3,977
Frio	L	Nueces	Queen City	4,533	4,380	4,231	4,066	3,927	3,927
Gonzales	L	Guadalupe	Queen City	4,960	4,973	4,960	4,960	4,500	4,500
Guadalupe	L	Guadalupe	Queen City	0[7]	0	0	0	0	0
La Salle	L	Nueces	Queen City	1	1	1	1	1	1
Wilson	L	Guadalupe	Queen City	106	95	84	75	67	67
Wilson	L	Nueces	Queen City	181	161	143	127	114	114
Wilson	L	San Antonio	Queen City	1,136	1,011	896	798	711	711
McMullen	N	Nueces	Queen City	3	3	3	3	3	3
GMA 13 Total			**Queen City**	**20,274**	**19,718**	**19,358**	**18,965**	**17,585**	**17,585**

[7] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE 7. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE SPARTA AQUIFER IN GROUNDWATER MANAGEMENT AREA 13. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER.

County	RWPA	River Basin	Aquifer	2030	2040	2050	2060	2070	2080
Atascosa	L	Nueces	Sparta	1,187	1,043	998	961	932	932
Frio	L	Nueces	Sparta	623	603	576	557	534	534
Gonzales	L	Guadalupe	Sparta	2,451	2,457	2,451	2,451	2,451	2,451
La Salle	L	Nueces	Sparta	0[8]	0	0	0	0	0
Wilson	L	Guadalupe	Sparta	12	11	10	9	8	8
Wilson	L	Nueces	Sparta	19	17	15	13	12	12
Wilson	L	San Antonio	Sparta	151	135	119	106	94	94
McMullen	N	Nueces	Sparta	0	0	0	0	0	0
GMA 13 Total			**Sparta**	**4,443**	**4,266**	**4,169**	**4,097**	**4,031**	**4,031**

[8] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE 8. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE YEGUA-JACKSON AQUIFER IN GROUNDWATER MANAGEMENT AREA 13. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER.

County	RWPA	River Basin	Aquifer	2030	2040	2050	2060	2070	2080
Atascosa	L	Nueces	Yegua-Jackson	NR	NR	NR	NR	NR	NR
Frio	L	Nueces	Yegua-Jackson	NR	NR	NR	NR	NR	NR
Gonzales	L	Guadalupe	Yegua-Jackson	4,709	4,709	4,709	4,709	4,709	4,709
Gonzales	L	Lavaca	Yegua-Jackson	19	19	19	19	19	19
Karnes	L	Guadalupe	Yegua-Jackson	292	292	292	292	292	292
Karnes	L	Nueces	Yegua-Jackson	91	91	91	91	91	91
Karnes	L	San Antonio	Yegua-Jackson	1,630	1,630	1,630	1,630	1,630	1,630
La Salle	L	Nueces	Yegua-Jackson	NR	NR	NR	NR	NR	NR
Wilson	L	Guadalupe	Yegua-Jackson	NR	NR	NR	NR	NR	NR
Wilson	L	Nueces	Yegua-Jackson	NR	NR	NR	NR	NR	NR
Wilson	L	San Antonio	Yegua-Jackson	NR	NR	NR	NR	NR	NR
Webb	M	Nueces	Yegua-Jackson	NR	NR	NR	NR	NR	NR
Webb	M	Rio Grande	Yegua-Jackson	NR	NR	NR	NR	NR	NR
Zapata	M	Rio Grande	Yegua-Jackson	NR	NR	NR	NR	NR	NR
McMullen	N	Nueces	Yegua-Jackson	NR	NR	NR	NR	NR	NR
GMA 13 Total			**Yegua-Jackson**	**6,741**	**6,741**	**6,741**	**6,741**	**6,741**	**6,741**

NR: Groundwater Management Area 13 declared the Yegua-Jackson Aquifer not relevant in these areas.

LIMITATIONS:

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> "Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historic time period.

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and groundwater levels in the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

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APPENDIX A

Total Pumping Associated with Modeled Available Groundwater Run for the Carrizo-Wilcox Aquifer Split by Model Layers for Groundwater Management Area 13

TABLE A.1. TOTAL PUMPING SPLIT BY MODEL LAYERS FROM THE MODELED AVAILABLE GROUNDWATER RUN FOR THE CARRIZO-WILCOX AQUIFER IN GROUNDWATER MANAGEMENT AREA 13. THE VALUES ARE SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

GCD	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Evergreen UWCD	Atascosa	Carrizo	50,266	52,745	53,671	55,176	56,754	58,330	58,330
Evergreen UWCD	Atascosa	Upper Wilcox	250	249	250	249	249	249	249
Evergreen UWCD	Atascosa	Middle Wilcox	224	223	224	223	223	223	223
Evergreen UWCD	Atascosa	Lower Wilcox	1,184	1,180	1,184	1,180	1,180	1,180	1,180
Evergreen UWCD	Frio	Carrizo	114,827	86,995	85,143	82,950	81,018	79,131	79,131
Evergreen UWCD	Frio	Upper Wilcox	0[9]	0	0	0	0	0	0
Evergreen UWCD	Frio	Middle Wilcox	0	0	0	0	0	0	0
Evergreen UWCD	Frio	Lower Wilcox	0	0	0	0	0	0	0
Evergreen UWCD	Karnes	Carrizo	693	758	843	931	1,001	1,043	1,043
Evergreen UWCD	Karnes	Upper Wilcox	0	0	0	0	0	0	0
Evergreen UWCD	Karnes	Middle Wilcox	0	0	0	0	0	0	0
Evergreen UWCD	Karnes	Lower Wilcox	0	0	0	0	0	0	0
Evergreen UWCD	Wilson	Carrizo	36,086	32,648	34,096	35,482	36,994	38,730	38,730
Evergreen UWCD	Wilson	Upper Wilcox	125	125	125	125	125	125	125
Evergreen UWCD	Wilson	Middle Wilcox	125	125	125	125	125	125	125
Evergreen UWCD	Wilson	Lower Wilcox	1,893	5,386	9,258	32,877	68,703	86,690	86,690
Evergreen UWCD Total		**Carrizo-Wilcox**	**205,673**	**180,434**	**184,919**	**209,318**	**246,372**	**265,826**	**265,826**

[9] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE A.1. (CONTINUED)

GCD	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Gonzales County UWCD	Caldwell	Carrizo	453	9,457	16,386	25,495	30,072	30,072	30,072
Gonzales County UWCD	Caldwell	Upper Wilcox	15	15	15	15	15	15	15
Gonzales County UWCD	Caldwell	Middle Wilcox	0[10]	0	0	0	0	0	0
Gonzales County UWCD	Caldwell	Lower Wilcox	0	0	0	0	0	0	0
Gonzales County UWCD	Gonzales	Carrizo	47,131	51,908	55,242	55,832	56,206	57,166	49,620
Gonzales County UWCD	Gonzales	Upper Wilcox	0	0	0	0	0	0	0
Gonzales County UWCD	Gonzales	Middle Wilcox	11,096	15,563	20,114	24,556	24,556	24,556	24,556
Gonzales County UWCD	Gonzales	Lower Wilcox	2,204	8,794	15,432	21,985	21,985	21,985	21,985
Gonzales County UWCD Total		**Carrizo-Wilcox**	**60,899**	**85,737**	**107,189**	**127,883**	**132,834**	**133,794**	**126,248**
Guadalupe County GCD	Guadalupe	Carrizo	28,943	14,834	14,627	14,532	14,224	14,624	14,624
Guadalupe County GCD	Guadalupe	Upper Wilcox	0	0	0	0	0	0	0

[10] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE A.1 (CONTINUED)

GCD	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Guadalupe County GCD	Guadalupe	Middle Wilcox	6,609	6,373	7,926	9,428	9,207	9,075	8,986
Guadalupe County GCD	Guadalupe	Lower Wilcox	20,085	18,356	19,115	19,355	18,687	18,500	18,049
Guadalupe County GCD Total		**Carrizo-Wilcox**	**55,637**	**39,563**	**41,668**	**43,315**	**42,118**	**42,199**	**41,659**
McMullen County GCD	McMullen	Carrizo	7,789	7,768	4,867	4,854	4,854	4,854	4,854
McMullen County GCD	McMullen	Upper Wilcox	0[11]	0	0	0	0	0	0
McMullen County GCD	McMullen	Middle Wilcox	0	0	0	0	0	0	0
McMullen County GCD	McMullen	Lower Wilcox	0	0	0	0	0	0	0
McMullen County GCD Total		**Carrizo-Wilcox**	**7,789**	**7,768**	**4,867**	**4,854**	**4,854**	**4,854**	**4,854**
Medina County GCD	Medina	Carrizo	517	515	517	515	515	515	515
Medina County GCD	Medina	Upper Wilcox	0	0	0	0	0	0	0
Medina County GCD	Medina	Middle Wilcox	1,252	1,249	1,252	1,249	1,249	1,249	1,249
Medina County GCD	Medina	Lower Wilcox	866	864	866	864	864	864	864
Medina County GCD Total		**Carrizo-Wilcox**	**2,635**	**2,628**	**2,635**	**2,628**	**2,628**	**2,628**	**2,628**
Plum Creek CD	Caldwell	Carrizo	0	1,990	5,048	5,709	6,046	9,993	9,993
Plum Creek CD	Caldwell	Upper Wilcox	0	0	0	0	0	0	0
Plum Creek CD	Caldwell	Middle Wilcox	5,733	5,717	5,733	5,717	3,977	3,977	3,936
Plum Creek CD	Caldwell	Lower Wilcox	11,940	7,659	5,554	5,539	5,539	5,539	5,539
Plum Creek CD Total		**Carrizo-Wilcox**	**17,673**	**15,366**	**16,335**	**16,965**	**15,562**	**19,509**	**19,468**

[11] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE A.1 (CONTINUED)

GCD	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Uvalde County GCD	Uvalde	Carrizo	0[12]	0	0	0	0	0	0
Uvalde County GCD	Uvalde	Upper Wilcox	0	0	0	0	0	0	0
Uvalde County GCD	Uvalde	Middle Wilcox	0	0	0	0	0	0	0
Uvalde County GCD	Uvalde	Lower Wilcox	0	0	0	0	0	0	0
Uvalde County GCD Total		**Carrizo-Wilcox**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Wintergarden GCD	Dimmit	Carrizo	2,722	2,715	2,722	2,715	2,715	2,715	2,715
Wintergarden GCD	Dimmit	Upper Wilcox	993	990	993	990	990	990	990
Wintergarden GCD	Dimmit	Middle Wilcox	142	142	142	142	142	142	142
Wintergarden GCD	Dimmit	Lower Wilcox	38	38	38	38	38	38	38
Wintergarden GCD	La Salle	Carrizo	4,597	4,584	4,597	4,584	4,584	4,584	4,584
Wintergarden GCD	La Salle	Upper Wilcox	1,957	1,952	1,957	1,952	1,952	1,952	1,952
Wintergarden GCD	La Salle	Middle Wilcox	0	0	0	0	0	0	0
Wintergarden GCD	La Salle	Lower Wilcox	0	0	0	0	0	0	0
Wintergarden GCD	Zavala	Carrizo	27,969	26,368	25,065	24,897	24,699	24,524	24,233
Wintergarden GCD	Zavala	Upper Wilcox	6,329	6,312	6,329	6,312	6,312	6,312	6,312
Wintergarden GCD	Zavala	Middle Wilcox	3,683	3,673	3,683	3,673	3,673	3,673	3,673
Wintergarden GCD	Zavala	Lower Wilcox	322	322	322	322	322	322	322
Wintergarden GCD Total		**Carrizo-Wilcox**	**48,752**	**47,096**	**45,848**	**45,625**	**45,427**	**45,252**	**44,961**
No District-County	Bexar	Carrizo	43,057	42,939	43,346	43,227	43,227	43,423	43,423
No District-County	Bexar	Upper Wilcox	10	10	10	10	10	10	10
No District-County	Bexar	Middle Wilcox	58	58	58	58	58	58	58
No District-County	Bexar	Lower Wilcox	26,602	25,444	25,514	25,444	24,358	24,358	24,358

[12] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.

TABLE A.1 (CONTINUED)

GCD	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
No District-County	Caldwell	Carrizo	NP[13]	NP	NP	NP	NP	NP	NP
No District-County	Caldwell	Upper Wilcox	NP	NP	NP	NP	NP	NP	NP
No District-County	Caldwell	Middle Wilcox	39	39	39	39	39	39	39
No District-County	Caldwell	Lower Wilcox	0[14]	0	0	0	0	0	0
No District-County	Gonzales	Carrizo	0	0	0	0	0	0	0
No District-County	Gonzales	Upper Wilcox	0	0	0	0	0	0	0
No District-County	Gonzales	Middle Wilcox	0	0	0	0	0	0	0
No District-County	Gonzales	Lower Wilcox	0	0	0	0	0	0	0
No District-County	Maverick	Carrizo	543	541	543	541	541	272	272
No District-County	Maverick	Upper Wilcox	0	0	0	0	0	0	0
No District-County	Maverick	Middle Wilcox	2	2	2	2	2	2	2
No District-County	Maverick	Lower Wilcox	2	2	2	2	2	2	2
No District-County	Web	Carrizo	898	896	898	896	896	896	896
No District-County	Web	Upper Wilcox	13	13	13	13	13	13	13
No District-County	Web	Middle Wilcox	1	1	1	1	1	1	1
No District-County	Web	Lower Wilcox	0	0	0	0	0	0	0
No District-County Total		**Carrizo-Wilcox**	**71,225**	**69,945**	**70,426**	**70,233**	**69,147**	**69,074**	**69,074**
Total for GMA 13		**Carrizo-Wilcox**	**470,283**	**448,537**	**473,887**	**520,821**	**558,942**	**583,136**	**574,718**

[13] NP: The aquifer is not present in this part of the county.
[14] A zero value indicates the groundwater availability model pumping scenario did not include any pumping in the aquifer.