GAM RUN 17-024 MAG:
MODELED AVAILABLE GROUNDWATER FOR THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS IN GROUNDWATER MANAGEMENT AREA 11

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June 19, 2017

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EXECUTIVE SUMMARY:

The modeled available groundwater for Groundwater Management Area 11 for the Carrizo-Wilcox, Queen City, and Sparta aquifers is summarized by decade for the groundwater conservation districts (Tables 2 through 4 respectively) and for use in the regional water planning process (Tables 5 through 7 respectively). The modeled available groundwater estimates for the Carrizo-Wilcox Aquifer range from approximately 349,000 acre-feet per year in 2010 to approximately 341,000 acre-feet per year in 2070 (Table 2). The modeled available groundwater estimates for the Queen City Aquifer range from approximately 223,000 acre-feet per year in 2010 to approximately 222,000 acre-feet per year in 2070 (Table 3). The modeled available groundwater estimate for the Sparta Aquifer is approximately 2,700 acre-feet per year for each decade from 2010 to 2070 (Table 4). The estimates were extracted from results of a model run using the groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (version 2.01). The model run files, which meet the desired future conditions adopted by district representatives of Groundwater Management Area 11, were submitted to the Texas Water Development Board (TWDB) on February 15, 2017, as part of the Desired Future Conditions Explanatory Report for Groundwater Management Area 11. The explanatory report and other materials submitted to the Texas Water Development Board (TWDB) were determined to be administratively complete on March 13, 2017.

REQUESTOR:

Ms. Leah Adams, coordinator of Groundwater Management Area 11.

DESCRIPTION OF REQUEST:

In a letter dated February 15, 2017, Dr. William R. Hutchison, on behalf of Groundwater Management Area 11, provided the TWDB with the desired future conditions of the Carrizo-Wilcox, Queen City, and Sparta aquifers adopted by the groundwater conservation districts in Groundwater Management Area 11. The desired future conditions for the Carrizo-Wilcox, Queen City, and Sparta aquifers are described in Attachment B of the Resolution to Adopt Desired Future Conditions for Aquifers in Groundwater Management Area 11, adopted January 11, 2017, by the groundwater conservation districts within Groundwater Management Area 11. The desired future conditions, excerpted from Attachment B, are presented below:

"Table 5 [Table 1 below] from GMA 11 Technical Memorandum 16-02 (Draft 2), dated March 25, 2016 lists the proposed desired future conditions, and is presented below [Table 1]. As described in the technical memorandum, the proposed desired future conditions are average drawdowns (in feet) from year 2000 conditions to 2070 conditions were largely based on GAM Scenario 4. Based on an analysis of model output and model limitations, the output from the model was modified to develop the proposed desired future conditions as follows:

- Layers 2 and 4 (the confining units) were eliminated, and Table 5 includes only aquifer units. Areas that have no active cells are designated as NP (for not present).
- Layers 5, 6, 7, and 8 are combined, and a single drawdown value for the Carrizo-Wilcox Aquifer are [sic] listed.
- All areas that are less than 200 square miles are eliminated (noted as NRS, or not relevant for purposes of joint planning due to size of area).
- Areas with negative drawdown that are greater than 200 square miles have had the negative drawdown cells eliminated from the average drawdown calculation, effectively assuming that those cells have a zero drawdown, and that the negative drawdown areas are a result of model limitations, as discussed (designated in yellow).
- The desired future condition in Panola County for the Carrizo-Wilcox Aquifer is listed as 3 feet. The actual average using all data from the model is 2 feet. If the areas with negative drawdown are assumed to be zero, the revised average is 4 feet. As presented at the March 22, 2016 GMA 11 meeting, Mr. Wade Oliver (representing the Panola County GCD) evaluated the average drawdown under Scenario 4 using an alternative analytical modeling approach and concluded that the drawdown was 3 feet. Thus, Mr. Oliver's result is consistent with the midpoint between the two GAM-based drawdown approaches."

TABLE 1. DRAWDOWN FOR USE AS DESIRED FUTURE CONDITIONS (2000 TO 2070 IN FEET) [TABLE 5 FROM GMA 11 TECHNICAL MEMORANDUM 16-02 (DRAFT 2), DATED MARCH 25, 2016].).

County	Sparta	Queen City	Carrizo-Wilcox
Anderson	NRS	9	90
Angelina	16	NRS	48
Bowie	NP	NP	5
Camp	NP	NRS	33
Cass	NP	10	68
Cherokee	NRS	14	99
Franklin	NP	NP	14
Gregg	NP	NRS	58
Harrison	NP	1	18
Henderson	NP	5	50
Hopkins	NP	NP	3
Houston	3	6	80
Marion	NP	24	45
Morris	NP	NRS	46
Nacogdoches	5	4	29
Panola	NP	NP	3
Rains	NP	NP	1
Rusk	NP	NRS	23
Sabine	1	NP	9
San Augustine	2	NP	7
Shelby	NP	NP	1
Smith	NP	17	119
Titus	NP	NRS	11
Trinity	9	NRS	51
Upshur	NP	9	77
Van Zandt	NP	NRS	21
Wood	NP	5	89
Grand Total	4	10	56

Notes: NP = Not present
NRS = Not relevant due to size (less than 200 square miles)
Yellow Cells represent average drawdown calculations that assume negative drawdown is zero (model artifact and model limitation)
Green Cell represents the recommended DFC for Panola County as described above

TWDB staff reviewed the model files associated with the desired future conditions and received clarification on procedures and assumptions from the Groundwater Management Area 11 Technical Coordinator on March 13 and 15, 2017. Questions included whether drawdown averages and modeled available groundwater values are based on official aquifer extent or model extent, whether to include dry cells in drawdown averaging, methods for calculating Panola County drawdown, and how to re-calculate average drawdowns for counties with net negative average drawdowns. The clarifications are included in the Parameters and Assumptions Section of this report.

The Groundwater Management Area 11 Technical Coordinator was notified on May 3, 2017 that the modeled available groundwater values for several counties would not necessarily match the pumping values presented in Technical Memorandum 16-02 (Hutchison, 2016). The pumping values presented in Technical Memorandum 16-02 appear to be based on the model extent, while the modeled available groundwater values have been extracted based on the official aquifer.

METHODS:

The groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Figures 1 through 4) was run using the model files submitted with the explanatory report (Hutchison, 2017). Model-calculated drawdowns were extracted for the year 2070. Drawdown averages were calculated for each county by aquifer and for the entire Groundwater Management Area 11 by aquifer. As specified in the desired future condition resolution and further clarification, drawdown for cells that became dry during the simulation (water level dropped below the base of the cell) were excluded from the averaging. The calculated drawdown averages were compared with the desired future conditions to verify that the pumping scenario achieved the desired future conditions within 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 11 (Tables 2 through 4). Annual pumping rates by aquifer are also presented by county, river basin, and regional water planning area within Groundwater Management Area 11 (Tables 5 through 7).

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:

- We used Version 2.01 of the groundwater availability model for the northern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. See Fryar and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the northern 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). Layers represent equivalent geologic units outside of the official aquifer extents. In the case of Layers 6 through 8 in areas where the Upper, Middle, or Lower Wilcox are not distinct, then the corresponding layer represents part of an adjoining Wilcox unit.

- In the Sabine Uplift area, the Simsboro Formation (Middle Wilcox Aquifer) is not distinguishable and the Wilcox Group is informally divided into the Upper Wilcox and the Lower Wilcox aquifers (Fryar and others, 2003). In the current version of the groundwater availability model, layers 6 and 7 represent the Upper Wilcox and Lower Wilcox aquifers in this area. Layer 8 is included in the model in this area, but it is of nominal thickness.

- The model was run with MODFLOW-96 (Harbaugh and others, 1996).

- Drawdown averages and modeled available groundwater values were based on the official aquifer boundaries rather than the extent of the model area (Figures 2, 3, and 4).

- Drawdown for cells where water levels dropped below the base elevation of the cell causing the cell to become inactive (dry cells) were excluded from the averaging.

- If a county with an area greater than 200 square miles had a net negative drawdown average the average was re-calculated by assuming all negative drawdowns were zero. The zero values were included in the averaging. This assumption applies to San Augustine County in the Sparta Aquifer and Wood County in the Queen City Aquifer as noted in Table 1. It also applies to Hopkins and Rains counties in the Carrizo-Wilcox Aquifer although those counties were not noted in Table 1 (Table 1 of the Resolution).

- A tolerance of one foot was assumed when comparing desired future conditions (Table 1, average drawdown values per county) to model drawdown results.

- Drawdown for Panola County was estimated from the groundwater availability modeling results and the average drawdown is within the one foot tolerance of the desired future condition for Panola County (model results drawdown = 2 feet and desired future condition drawdown= 3 feet).

- Estimates of modeled available groundwater from the model simulation were rounded to whole numbers.

RESULTS:

The modeled available groundwater estimates for the Carrizo-Wilcox Aquifer range from approximately 349,000 acre-feet per year in 2010 to approximately 341,000 acre-feet per year in 2070 (Table 2). The modeled available groundwater estimates for the Queen City Aquifer range from approximately 223,000 acre-feet per year in 2010 to approximately 222,000 acre-feet per year in 2070 (Table 3). The modeled available groundwater estimate for the Sparta Aquifer is approximately 2,700 acre-feet per year for each decade from 2010 to 2070 (Table 4). The modeled available groundwater is summarized by groundwater conservation district and county for the Carrizo-Wilcox, Queen City, and Sparta aquifers (Tables 2, 3, and 4 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 of values between table summaries are due to rounding.

The Gulf Coast, Nacatoch, Trinity, and Yegua-Jackson aquifers were declared non-relevant for the purpose of adopting desired future conditions by the Groundwater Management Area 11 Districts; therefore, modeled available groundwater values were not calculated for those aquifers.

FIGURE 1. **GROUNDWATER MANAGEMENT AREA (GMA) 11 BOUNDARY, RIVER BASINS, AND COUNTIES OVERLAIN ON THE EXTENT OF THE CARRIZO-WILCOX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS.**

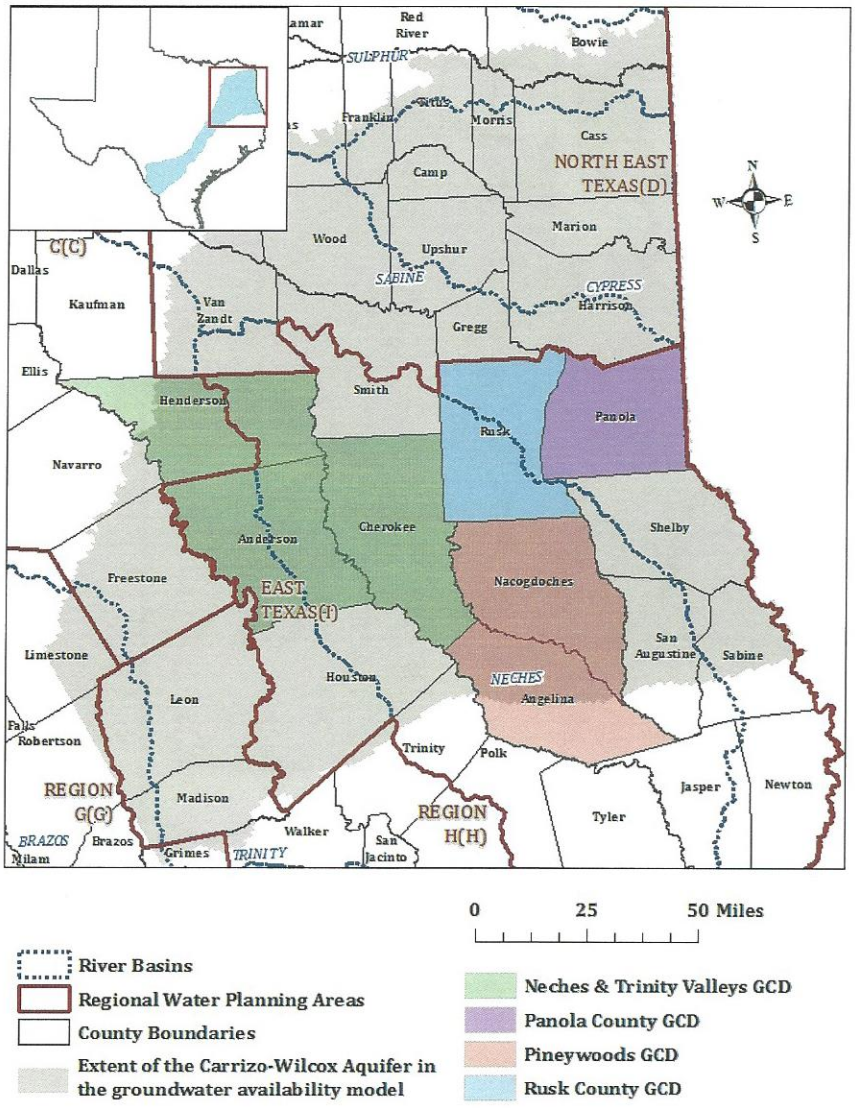

FIGURE 2. **REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE CARRIZO-WILCOX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS.**

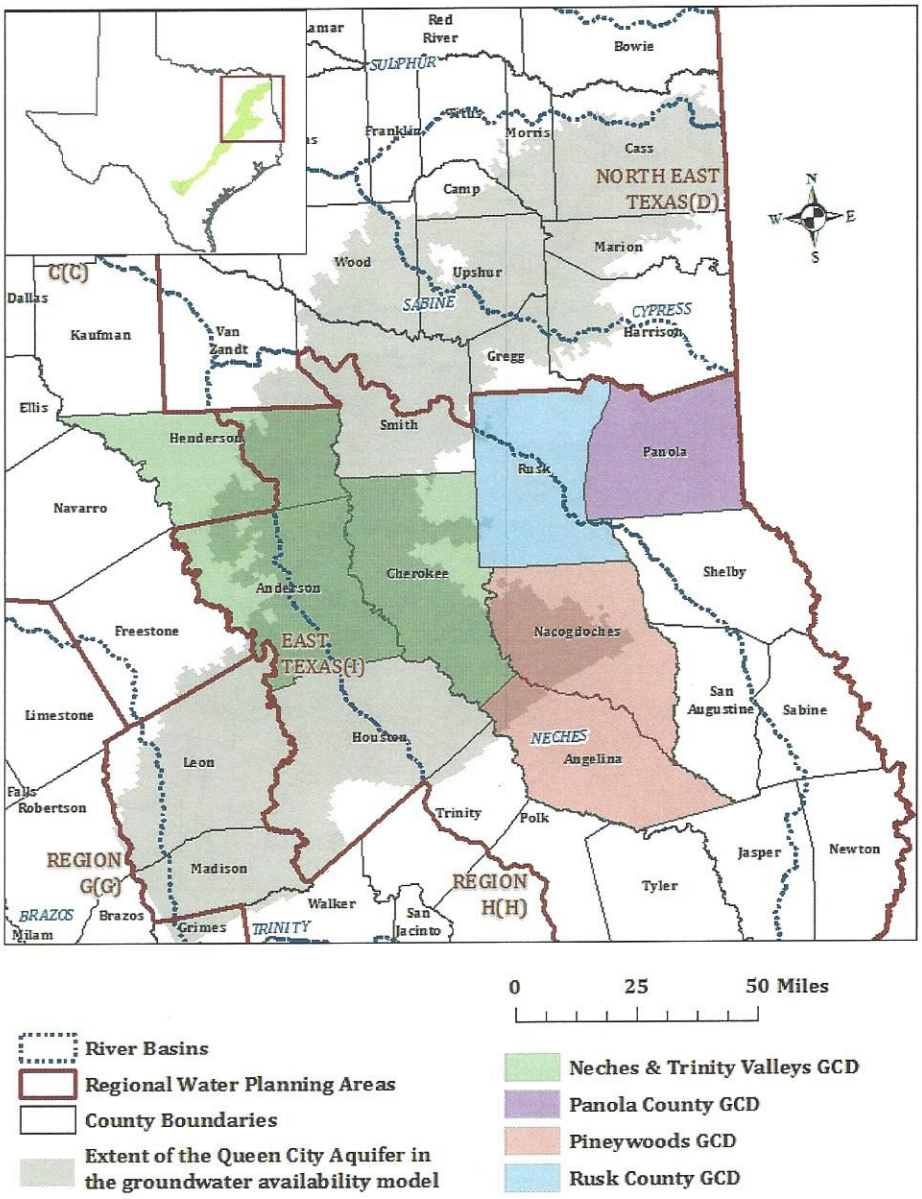

FIGURE 3. REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE QUEEN CITY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS.

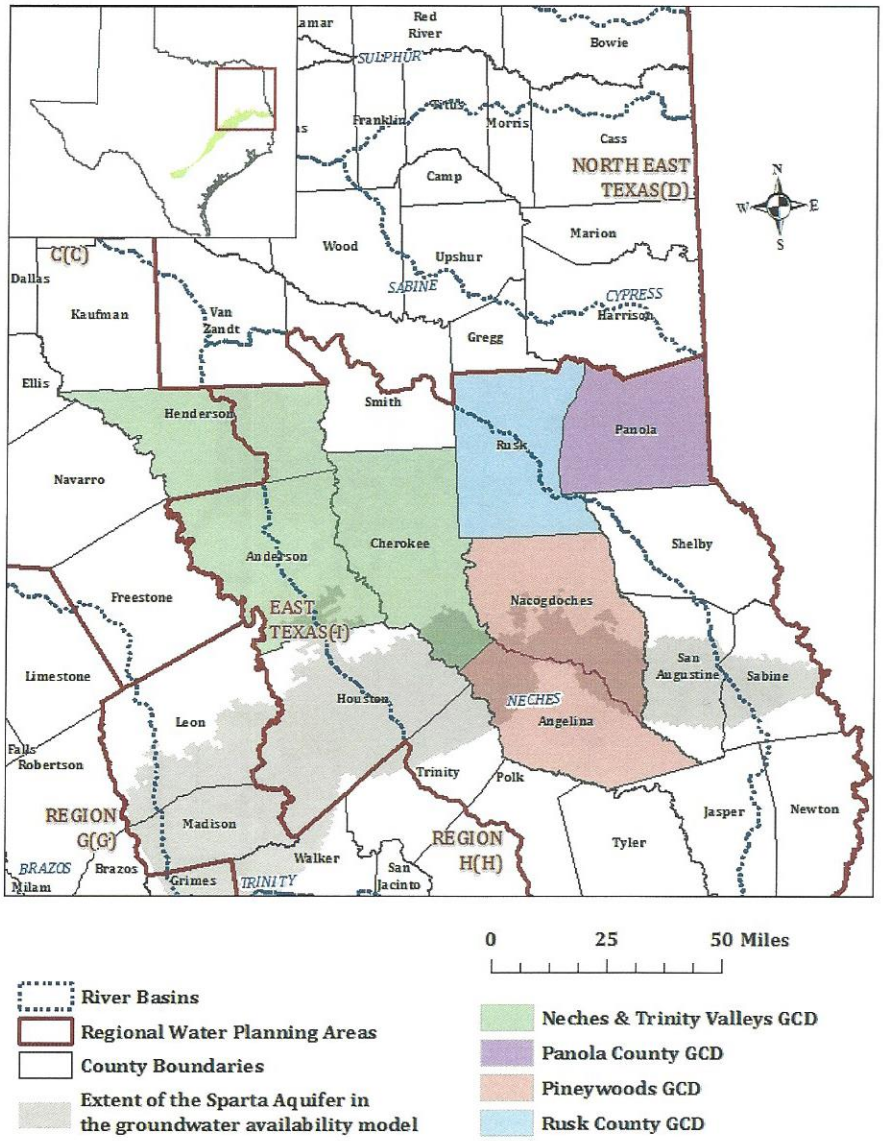

FIGURE 4. REGIONAL WATER PLANNING AREAS (RWPAS), RIVER BASINS, GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES OVERLAIN ON THE EXTENT OF THE SPARTA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS.

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE CARRIZO-WILCOX AQUIFER IN GROUNDWATER MANAGEMENT AREA 11 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
Neches & Trinity Valleys GCD	Anderson	Carrizo-Wilcox	29,088	29,088	29,088	29,088	29,088	29,088	29,088
Neches & Trinity Valleys GCD	Cherokee	Carrizo-Wilcox	20,933	20,933	20,933	20,933	20,933	20,933	20,470
Neches & Trinity Valleys GCD	Henderson	Carrizo-Wilcox	13,866	13,866	13,866	13,866	13,768	13,614	13,585
Neches & Trinity Valleys GCD Total		**Carrizo-Wilcox**	**63,886**	**63,886**	**63,886**	**63,886**	**63,789**	**63,634**	**63,143**
Panola County GCD	Panola	**Carrizo-Wilcox**	**8,376**	**8,376**	**8,218**	**8,218**	**8,218**	**8,068**	**8,068**
Pineywoods GCD	Angelina	Carrizo-Wilcox	27,591	27,591	27,591	27,591	27,591	27,591	27,591
Pineywoods GCD	Nacogdoches	Carrizo-Wilcox	24,181	24,181	24,181	24,181	24,181	24,181	24,181
Pineywoods GCD Total		**Carrizo-Wilcox**	**51,773**	**51,773**	**51,773**	**51,773**	**51,773**	**51,773**	**51,773**
Rusk County GCD Total	Rusk	**Carrizo-Wilcox**	**20,847**	**20,837**	**20,837**	**20,837**	**20,818**	**20,818**	**20,818**
Total (GCDs)		**Carrizo-Wilcox**	**144,882**	**144,872**	**144,714**	**144,714**	**144,598**	**144,293**	**143,801**
No District-County	Bowie	Carrizo-Wilcox	10,845	9,872	9,558	9,278	9,278	8,999	8,999
No District-County	Camp	Carrizo-Wilcox	4,050	4,050	4,050	4,050	4,050	4,050	4,050
No District-County	Cass	Carrizo-Wilcox	18,078	18,023	17,925	17,863	17,786	17,702	17,626
No District-County	Franklin	Carrizo-Wilcox	9,786	9,786	9,786	9,786	9,786	9,786	9,786
No District-County	Gregg	Carrizo-Wilcox	8,041	8,041	8,041	8,041	8,041	8,041	8,041
No District-County	Harrison	Carrizo-Wilcox	11,165	11,035	10,961	10,921	10,873	10,853	10,827
No District-County	Hopkins	Carrizo-Wilcox	6,392	6,392	6,392	6,392	6,392	6,392	6,392
No District-County	Houston	Carrizo-Wilcox	26,294	26,294	26,294	26,294	26,294	26,294	26,294
No District-County	Marion	Carrizo-Wilcox	2,729	2,726	2,726	2,726	2,726	2,726	2,726

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
No District-County	Morris	Carrizo-Wilcox	2,627	2,569	2,569	2,569	2,569	2,569	2,569
No District-County	Rains	Carrizo-Wilcox	1,922	1,839	1,839	1,839	1,802	1,802	1,745
No District-County	Red River	Carrizo-Wilcox	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
No District-County	Sabine	Carrizo-Wilcox	3,606	3,606	3,606	3,606	3,606	3,606	3,606
No District-County	San Augustine	Carrizo-Wilcox	1,439	1,439	1,439	1,439	1,439	1,439	1,439
No District-County	Shelby	Carrizo-Wilcox	11,210	10,894	10,441	10,305	9,723	9,287	9,100
No District-County	Smith	Carrizo-Wilcox	35,951	35,951	35,925	35,925	35,925	35,912	35,889
No District-County	Titus	Carrizo-Wilcox	10,354	10,052	9,902	9,672	9,624	9,573	9,472
No District-County	Trinity	Carrizo-Wilcox	368	368	368	368	368	368	368
No District-County	Upshur	Carrizo-Wilcox	7,132	7,132	7,132	7,132	7,132	7,132	7,132
No District-County	Van Zandt	Carrizo-Wilcox	10,330	10,330	10,330	10,157	10,098	10,098	9,971
No District-County	Wood	Carrizo-Wilcox	21,544	21,457	21,413	21,338	21,316	21,292	21,237
No District-County Total		**Carrizo-Wilcox**	**203,863**	**201,856**	**200,696**	**199,700**	**198,827**	**197,920**	**197,268**
Total for GMA 11		**Carrizo-Wilcox**	**348,745**	**346,728**	**345,410**	**344,414**	**343,424**	**342,213**	**341,069**

[1]A desired future condition was not specified for the Carrizo-Wilcox Aquifer in Red River County; however, other counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater.

TABLE 3. MODELED AVAILABLE GROUNDWATER FOR THE QUEEN CITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 11 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
Neches & Trinity Valleys GCD	Anderson	Queen City	19,101	19,101	19,101	19,101	19,101	19,101	19,101
Neches & Trinity Valleys GCD	Cherokee	Queen City	23,211	23,211	23,211	23,211	23,211	23,039	22,866
Neches & Trinity Valleys GCD	Henderson	Queen City	15,412	15,412	15,412	15,412	15,412	15,412	15,412
Neches & Trinity Valleys GCD Total		**Queen City**	**57,725**	**57,725**	**57,725**	**57,725**	**57,725**	**57,552**	**57,380**
Pineywoods GCD	Angelina	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Pineywoods GCD	Nacogdoches	Queen City	2,985	2,985	2,985	2,985	2,985	2,985	2,985
Pineywoods GCD Total		**Queen City**	**2,985**	**2,985**	**2,985**	**2,985**	**2,985**	**2,985**	**2,985**
Rusk County GCD Total	**Rusk**	**Queen City**	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Total (GCDs)		**Queen City**	**60,710**	**60,710**	**60,710**	**60,710**	**60,710**	**60,537**	**60,365**
No District-County	Camp	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
No District-County	Cass	Queen City	38,509	38,509	38,509	38,509	38,509	38,509	38,509
No District-County	Gregg	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
No District-County	Harrison	Queen City	10,071	10,071	10,071	10,071	10,071	10,071	10,071
No District-County	Houston	Queen City	2,301	2,301	2,301	2,301	2,301	2,301	2,301
No District-County	Marion	Queen City	15,407	15,407	15,407	15,407	15,407	15,338	15,271
No District-County	Morris	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
No District-County	Smith	Queen City	59,034	59,034	59,034	59,034	58,904	58,709	58,578
No District-County	Titus	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
No District-County	Trinity	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
No District-County	Upshur	Queen City	27,391	27,391	27,391	27,197	27,197	27,197	27,145

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
No District-County	Van Zandt	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
No District-County	Wood	Queen City	10,046	10,046	10,046	10,046	10,046	10,046	10,046
No District-County Total		**Queen City**	**162,759**	**162,759**	**162,759**	**162,566**	**162,435**	**162,172**	**161,922**
Total for GMA 11		**Queen City**	**223,469**	**223,469**	**223,469**	**223,275**	**223,145**	**222,709**	**222,287**

[1]Counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater. For additional information in pumping in the model run see Table 6 from Technical Memorandum 16-02 (Hutchison, 2016).

TABLE 4. MODELED AVAILABLE GROUNDWATER FOR THE SPARTA AQUIFER IN GROUNDWATER MANAGEMENT AREA 11 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2010 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2010	2020	2030	2040	2050	2060	2070
Neches & Trinity Valleys GCD	Anderson	Sparta	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Neches & Trinity Valleys GCD	Cherokee	Sparta	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Neches & Trinity Valleys GCD Total		**Sparta**	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Pineywoods GCD	Angelina	Sparta	371	371	371	371	371	371	371
Pineywoods GCD	Nacogdoches	Sparta	365	365	365	365	365	365	365
Pineywoods GCD Total		**Sparta**	**737**	**737**	**737**	**737**	**737**	**737**	**737**
Total (GCDs)		**Sparta**	**737**	**737**	**737**	**737**	**737**	**737**	**737**
No District-County	Houston	Sparta	1,454	1,454	1,454	1,454	1,454	1,454	1,454
No District-County	Sabine	Sparta	197	197	197	197	197	197	197
No District-County	San Augustine	Sparta	166	166	166	166	166	166	166
No District-County	Trinity	Sparta	182	182	182	182	182	182	182
No District-County Total		**Sparta**	**1,999**	**1,999**	**1,999**	**1,999**	**1,999**	**1,999**	**1,999**
Total for GMA 11		**Sparta**	**2,736**	**2,736**	**2,736**	**2,736**	**2,736**	**2,736**	**2,736**

[1]Counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater. For additional information in pumping in the model run see Table 6 from Technical Memorandum 16-02 (Hutchison, 2016).

TABLE 5. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE CARRIZO-WILCOX AQUIFER IN GROUNDWATER MANAGEMENT AREA 11. 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	2020	2030	2040	2050	2060	2070
Anderson	I	Neches	Carrizo-Wilcox	23,335	23,335	23,335	23,335	23,335	23,335
Anderson	I	Trinity	Carrizo-Wilcox	5,753	5,753	5,753	5,753	5,753	5,753
Angelina	I	Neches	Carrizo-Wilcox	27,591	27,591	27,591	27,591	27,591	27,591
Bowie	D	Sulphur	Carrizo-Wilcox	9,872	9,558	9,278	9,278	8,999	8,999
Camp	D	Cypress	Carrizo-Wilcox	4,050	4,050	4,050	4,050	4,050	4,050
Cass	D	Cypress	Carrizo-Wilcox	15,159	15,132	15,132	15,119	15,106	15,094
Cass	D	Sulphur	Carrizo-Wilcox	2,864	2,794	2,731	2,667	2,596	2,532
Cherokee	I	Neches	Carrizo-Wilcox	20,933	20,933	20,933	20,933	20,933	20,470
Franklin	D	Cypress	Carrizo-Wilcox	7,765	7,765	7,765	7,765	7,765	7,765
Franklin	D	Sulphur	Carrizo-Wilcox	2,021	2,021	2,021	2,021	2,021	2,021
Gregg	D	Cypress	Carrizo-Wilcox	862	862	862	862	862	862
Gregg	D	Sabine	Carrizo-Wilcox	7,179	7,179	7,179	7,179	7,179	7,179
Harrison	D	Cypress	Carrizo-Wilcox	6,183	6,109	6,070	6,036	6,016	5,990
Harrison	D	Sabine	Carrizo-Wilcox	4,851	4,851	4,851	4,837	4,837	4,837
Henderson	C	Trinity	Carrizo-Wilcox	7,829	7,829	7,829	7,732	7,577	7,548
Henderson	I	Neches	Carrizo-Wilcox	6,036	6,036	6,036	6,036	6,036	6,036
Hopkins	D	Cypress	Carrizo-Wilcox	313	313	313	313	313	313
Hopkins	D	Sabine	Carrizo-Wilcox	2,842	2,842	2,842	2,842	2,842	2,842
Hopkins	D	Sulphur	Carrizo-Wilcox	3,237	3,237	3,237	3,237	3,237	3,237
Houston	I	Neches	Carrizo-Wilcox	22,488	22,488	22,488	22,488	22,488	22,488
Houston	I	Trinity	Carrizo-Wilcox	3,806	3,806	3,806	3,806	3,806	3,806
Marion	D	Cypress	Carrizo-Wilcox	2,726	2,726	2,726	2,726	2,726	2,726
Morris	D	Cypress	Carrizo-Wilcox	2,166	2,166	2,166	2,166	2,166	2,166
Morris	D	Sulphur	Carrizo-Wilcox	402	402	402	402	402	402
Nacogdoches	I	Neches	Carrizo-Wilcox	24,181	24,181	24,181	24,181	24,181	24,181
Panola	I	Cypress	Carrizo-Wilcox	6	6	6	6	6	6

County	RWPA	River Basin	Aquifer	2020	2030	2040	2050	2060	2070
Panola	I	Sabine	Carrizo-Wilcox	8,370	8,212	8,212	8,212	8,062	8,062
Rains	D	Sabine	Carrizo-Wilcox	1,839	1,839	1,839	1,802	1,802	1,745
Red River	D	Sulphur	Carrizo-Wilcox	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Rusk	I	Neches	Carrizo-Wilcox	11,769	11,769	11,769	11,750	11,750	11,750
Rusk	I	Sabine	Carrizo-Wilcox	9,068	9,068	9,068	9,068	9,068	9,068
Sabine	I	Neches	Carrizo-Wilcox	356	356	356	356	356	356
Sabine	I	Sabine	Carrizo-Wilcox	3,249	3,249	3,249	3,249	3,249	3,249
San Augustine	I	Neches	Carrizo-Wilcox	1,149	1,149	1,149	1,149	1,149	1,149
San Augustine	I	Sabine	Carrizo-Wilcox	290	290	290	290	290	290
Shelby	I	Neches	Carrizo-Wilcox	2,577	2,288	2,151	2,018	2,018	2,018
Shelby	I	Sabine	Carrizo-Wilcox	8,317	8,154	8,154	7,705	7,269	7,081
Smith	D	Sabine	Carrizo-Wilcox	13,246	13,220	13,220	13,220	13,206	13,196
Smith	I	Neches	Carrizo-Wilcox	22,705	22,705	22,705	22,705	22,705	22,693
Titus	D	Cypress	Carrizo-Wilcox	7,215	7,064	6,834	6,786	6,735	6,634
Titus	D	Sulphur	Carrizo-Wilcox	2,838	2,838	2,838	2,838	2,838	2,838
Trinity	H	Trinity	Carrizo-Wilcox	99	99	99	99	99	99
Trinity	I	Neches	Carrizo-Wilcox	269	269	269	269	269	269
Upshur	D	Cypress	Carrizo-Wilcox	5,442	5,442	5,442	5,442	5,442	5,442
Upshur	D	Sabine	Carrizo-Wilcox	1,689	1,689	1,689	1,689	1,689	1,689
Van Zandt	D	Neches	Carrizo-Wilcox	4,317	4,317	4,317	4,317	4,317	4,317
Van Zandt	D	Sabine	Carrizo-Wilcox	4,629	4,629	4,456	4,397	4,397	4,270
Van Zandt	D	Trinity	Carrizo-Wilcox	1,384	1,384	1,384	1,384	1,384	1,384
Wood	D	Cypress	Carrizo-Wilcox	2,053	2,053	2,053	2,053	2,053	2,053
Wood	D	Sabine	Carrizo-Wilcox	19,404	19,360	19,285	19,263	19,239	19,184
GMA 11 Total			**Carrizo-Wilcox**	**346,728**	**345,410**	**344,414**	**343,424**	**342,213**	**341,069**

[1] A desired future condition was not specified for the Carrizo-Wilcox Aquifer in Red River County; however, other counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater.

TABLE 6. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE QUEEN CITY AQUIFER IN GROUNDWATER MANAGEMENT AREA 11. 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	2020	2030	2040	2050	2060	2070
Anderson	I	Neches	Queen City	11,828	11,828	11,828	11,828	11,828	11,828
Anderson	I	Trinity	Queen City	7,274	7,274	7,274	7,274	7,274	7,274
Angelina	I	Neches	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Camp	D	Cypress	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Cass	D	Cypress	Queen City	35,499	35,499	35,499	35,499	35,499	35,499
Cass	D	Sulphur	Queen City	3,010	3,010	3,010	3,010	3,010	3,010
Cherokee	I	Neches	Queen City	23,211	23,211	23,211	23,211	23,039	22,866
Gregg	D	Cypress	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Gregg	D	Sabine	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Harrison	D	Cypress	Queen City	7,762	7,762	7,762	7,762	7,762	7,762
Harrison	D	Sabine	Queen City	2,310	2,310	2,310	2,310	2,310	2,310
Henderson	C	Trinity	Queen City	3,345	3,345	3,345	3,345	3,345	3,345
Henderson	I	Neches	Queen City	12,067	12,067	12,067	12,067	12,067	12,067
Houston	I	Neches	Queen City	2,043	2,043	2,043	2,043	2,043	2,043
Houston	I	Trinity	Queen City	258	258	258	258	258	258
Marion	D	Cypress	Queen City	15,407	15,407	15,407	15,407	15,338	15,271
Morris	D	Cypress	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Nacogdoches	I	Neches	Queen City	2,985	2,985	2,985	2,985	2,985	2,985
Rusk	I	Neches	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Rusk	I	Sabine	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Smith	D	Sabine	Queen City	28,343	28,343	28,343	28,213	28,018	27,887
Smith	I	Neches	Queen City	30,692	30,692	30,692	30,692	30,692	30,692
Titus	D	Cypress	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Trinity	H	Trinity	Queen City	0	0	0	0	0	0
Trinity	I	Neches	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]

County	RWPA	River Basin	Aquifer	2020	2030	2040	2050	2060	2070
Upshur	D	Cypress	Queen City	19,642	19,642	19,448	19,448	19,448	19,396
Upshur	D	Sabine	Queen City	7,749	7,749	7,749	7,749	7,749	7,749
Van Zandt	D	Neches	Queen City	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Wood	D	Cypress	Queen City	986	986	986	986	986	986
Wood	D	Sabine	Queen City	9,060	9,060	9,060	9,060	9,060	9,060
GMA 11 Total			**Queen City**	**223,469**	**223,469**	**223,276**	**223,145**	**222,709**	**222,287**

[1]Counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater. For additional information in pumping in the model run see Table 6 from Technical Memorandum 16-02 (Hutchison, 2016).

TABLE 7. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE SPARTA AQUIFER IN GROUNDWATER MANAGEMENT AREA 11. 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	2020	2030	2040	2050	2060	2070
Anderson	I	Neches	Sparta Aquifer	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Anderson	I	Trinity	Sparta Aquifer	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Angelina	I	Neches	Sparta Aquifer	371	371	371	371	371	371
Cherokee	I	Neches	Sparta Aquifer	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]	NULL[1]
Houston	I	Neches	Sparta Aquifer	477	477	477	477	477	477
Houston	I	Trinity	Sparta Aquifer	977	977	977	977	977	977
Nacogdoches	I	Neches	Sparta Aquifer	365	365	365	365	365	365
Sabine	I	Neches	Sparta Aquifer	37	37	37	37	37	37
Sabine	I	Sabine	Sparta Aquifer	160	160	160	160	160	160
San Augustine	I	Neches	Sparta Aquifer	163	163	163	163	163	163
San Augustine	I	Sabine	Sparta Aquifer	3	3	3	3	3	3
Trinity	H	Trinity	Sparta Aquifer	29	29	29	29	29	29
Trinity	I	Neches	Sparta Aquifer	154	154	154	154	154	154
GMA 11 Total			**Sparta Aquifer**	**2,736**	**2,736**	**2,736**	**2,736**	**2,736**	**2,736**

[1] Counties with fewer than 200 square miles of aquifer were noted as not relevant due to size (NRS) in the desired future condition statement. Areas which are not relevant due to size are listed with a NULL value for modeled available groundwater. For additional information in pumping in the model run see Table 6 from Technical Memorandum 16-02 (Hutchison, 2016).

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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