#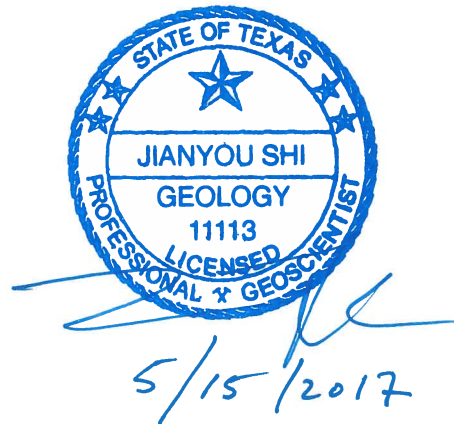 GAM Run 16-028 MAG: Modeled Available Groundwater for the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers in Groundwater Management Area 2

Jerry Shi, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 463-5076
May 12, 2017

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MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA, EDWARDS-TRINITY (HIGH PLAINS), AND DOCKUM AQUIFERS IN GROUNDWATER MANAGEMENT AREA 2

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Groundwater Availability Modeling Section
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May 12, 2017

EXECUTIVE SUMMARY:

Modeled available groundwater for the Ogallala and Edwards-Trinity (High Plains) aquifers in Groundwater Management Area 2 ranges from 3,115,812 acre-feet per year in 2020 to 1,002,728 acre-feet per year in 2070. Modeled available groundwater for the Dockum Aquifer ranges from 30,566 acre-feet per year in 2020 to 29,705 acre-feet per year in 2070. The modeled available groundwater for the Ogallala and Edwards-Trinity (High Plains) aquifers is summarized by groundwater conservation districts and counties in Table 1, and by river basins, regional planning areas, and counties in Table 3. The modeled available groundwater for the Dockum Aquifer is summarized by groundwater conservation districts and counties in Table 2, and by river basins, regional planning areas, and counties in Table 4. The modeled available groundwater for Groundwater Management Area 2 calculated from counties is slightly different from that calculated from groundwater conservation districts because of the process for rounding the values.

The estimates are based on the desired future conditions for the High Plains Aquifer System (the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers) adopted by groundwater conservation district representatives in Groundwater Management Area 2 on October 19, 2016. The Pecos Valley Alluvium and Edwards-Trinity (Plateau) aquifers were declared not relevant for the purpose of joint planning. The Texas Water Development Board (TWDB) determined that the explanatory report and other materials submitted by the district representatives were administratively complete on December 19, 2016.

Please note that, for the High Plains Underground Water Conservation District No. 1, only the portion of relevant aquifers within Groundwater Management Area 2 is covered in this report.

GAM Run 16-028 MAG: Modeled Available Groundwater for the Ogallala, Edwards-Trinity (High Plains), and Dockum Aquifers in Groundwater Management Area 2

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REQUESTOR:

Mr. Jason Coleman, General Manager of High Plains Underground Water Conservation District No. 1 and Coordinator of Groundwater Management Area 2.

DESCRIPTION OF REQUEST:

In a letter dated November 1, 2016, Dr. William Hutchison, on behalf of Groundwater Management Area 2, provided the TWDB with the desired future conditions of the High Plains Aquifer System. The desired future conditions (defined by drawdown) were determined using a number of predictive groundwater flow simulations (Hutchison, 2016a, 2016b, 2016c, and 2016d). The predictive simulations were developed from the groundwater availability model for the High Plains Aquifer System (Version 1.01; Deeds and Jigmond, 2015). The predictive simulations modeled future pumping scenarios from 2013 through 2070 under different climatic conditions, with an initial water level equal to the last stress period (i.e. 2012) of the model by Deeds and Jigmond (2015). The drawdown was calculated as the water level difference between 2012 and 2070.

The desired future conditions for the High Plains Aquifer System, as described in Resolution No. 16-01, were adopted on October 19, 2016 by the groundwater conservation district representatives in Groundwater Management Area 2. The desired future conditions are described below:

Ogallala and Edwards-Trinity (High Plains) Aquifers
- [the] average drawdown of between 23 and 27 feet for all of [Groundwater Management Area] 2 as documented in [Groundwater Management Area] 2 Technical Memorandum 15-01 and [Groundwater Management Area] 2 Technical Memorandum 16-01. The drawdown is calculated from the end of 2012 conditions to the year 2070. The drawdown is expressed as a range due to link between future pumping and future rainfall. Since most of the water use in the Ogallala Aquifer is for irrigation, producers pump more groundwater in dry years than in normal or wet years.

Dockum Aquifer
- [the] average drawdown of 27 feet for all of [Groundwater Management Area] 2. The drawdown is calculated from the end of 2012 conditions to the year 2070 based on Scenario 16 as documented in [Groundwater Management Area] 2 Technical Memorandum 16-01.

After review of the submittal, TWDB sent an email on February 27, 2017 to Mr. Jason Coleman, Coordinator of Groundwater Management Area 2, to clarify pumping location and aquifer boundary. On April 20, 2017 TWDB received the final clarification email from Mr. Jason Coleman. TWDB then preceded the calculation of the modeled available groundwater which is summarized in the following sections.

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METHODS:

To estimate the modeled available groundwater, TWDB used the predictive simulation for Scenario 16 (Hutchison, 2016d). TWDB reviewed the model files submitted by Hutchison (2016d) and slightly modified the groundwater pumping to achieve the adopted desired future conditions for the Ogallala and Edwards-Trinity (High Plains) aquifers. TWDB used the official aquifer boundaries to adjust the pumping in these two aquifers to achieve an average drawdown of 27 feet for all of Groundwater Management Area 2. This scenario represented drought conditions that are similar to the projected conditions used in the regional water planning process. For groundwater management purposes, pumping from this scenario may be adjusted to represent possible responses to various climatic conditions.

For the Dockum Aquifer, TWDB used the modeled extent submitted by Deeds and Jigmond (2015) to adjust the pumping to achieve an average drawdown of 27 feet for all of Groundwater Management Area 2, excluding the pass-through model cells. In addition to the Dockum Aquifer defined by TWDB, the modeled extent also includes the brackish/saline portion of the Dockum Group. According to Technical Memorandum 16-01 (Hutchison, 2016d), the groundwater conservation districts in Groundwater Management Area 2 wanted to include parts of the Dockum Group with poorer water quality for possible future development.

The modeled available groundwater values were extracted from the cell-by-cell budget file of the revised predictive model. Annual pumping rates were then divided by county, river basin, regional water planning area, and groundwater conservation district within Groundwater Management Area 2 (Figures 1 through 4 and Tables 1 through 4).

Modeled Available Groundwater and Permitting
As defined in Chapter 36 of the Texas Water Code, "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 groundwater availability are described below:

- Version 1.01 of the groundwater availability model for the High Plains Aquifer System by Deeds and Jigmond (2015) was revised to construct the predictive model simulation for this analysis. See Hutchison (2016d) for details of the initial assumptions.

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- The model has four layers which represent the Ogallala and Pecos Valley Alluvium aquifers (Layer 1), the Edwards-Trinity (High Plains) and Edwards-Trinity (Plateau) aquifers (Layer 2), the Upper Dockum Aquifer (Layer 3), and the Lower Dockum Aquifer (Layer 4). Pass-through cells exist in layers 2 and 3 where the Dockum Aquifer was absent but provided pathway for flow between the Lower Dockum and the Ogallala or Edwards-Trinity (High Plains) aquifers vertically. These pass-through cells were excluded from the modeled available groundwater calculation.

- The model was run with MODFLOW-NWT (Niswonger and others, 2011). The model uses the Newton Formulation and the upstream weighting package which automatically reduces pumping as heads drop in a particular cell as defined by the user. This feature may simulate the declining production of a well as saturated thickness decreases. Deeds and Jigmond (2015) modified the MODFLOW-NWT code to use a saturated thickness of 30 feet as the threshold (instead of percent of the saturated thickness) when pumping reductions occur during a simulation.

- During the predictive model run, no model cells within Groundwater Management Area 2 went dry.

- For the High Plains Underground Water Conservation District No. 1, only the portion within Groundwater Management Area 2 is covered in this report.

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

RESULTS:

The modeled available groundwater for the Ogallala and Edwards-Trinity (High Plains) aquifers combined that achieves the desired future condition adopted by Groundwater Management Area 2 decreases from 3,115,812 to 1,002,728 acre-feet per year between 2020 and 2070. The modeled available groundwater is summarized by groundwater conservation district and county in Table 1. Table 3 summarizes the modeled available groundwater by county, river basin, and regional water planning area for use in the regional water planning process.

The modeled available groundwater for the Dockum Group and Aquifer that achieves the desired future condition adopted by Groundwater Management Area 2 decreases slightly from 30,566 to 29,705 acre-feet per year between 2020 and 2070. The modeled available groundwater is summarized by groundwater conservation district and county in Table 2. Table 4 summarizes the modeled available groundwater by county, river basin, and regional water planning area for use in the regional water planning process.

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FIGURE 1.   MAP SHOWING THE AREA COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE OGALLALA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2.

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FIGURE 2.   MAP SHOWING THE AREA COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2.

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FIGURE 3.   MAP SHOWING THE AREA COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER AND DOCKUM GROUP WITHIN GROUNDWATER MANAGEMENT AREA 2.

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FIGURE 4.   MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS (ALSO KNOWN AS UNDERGROUND WATER CONSERVATION DISTRICT OR UWCD), COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 2.

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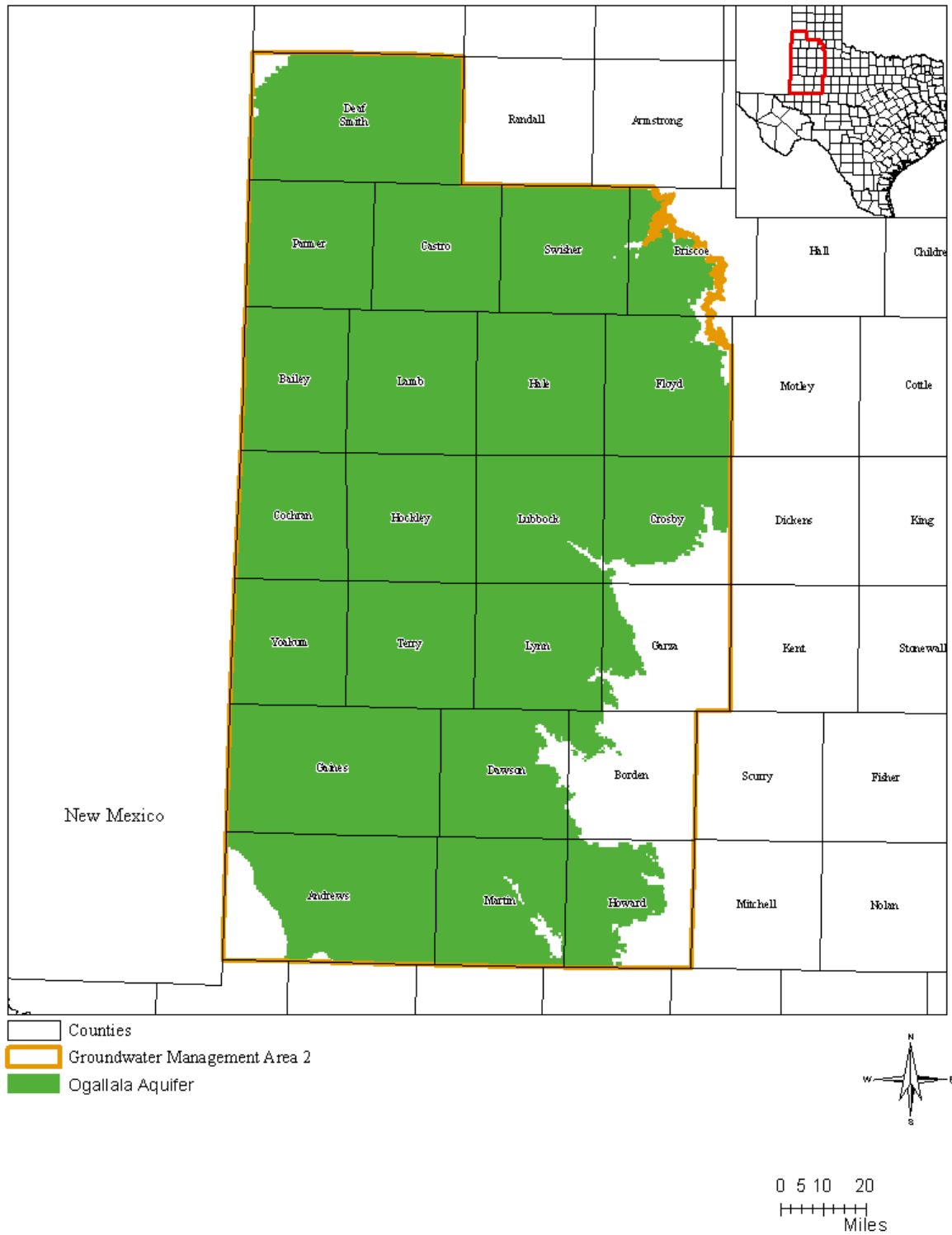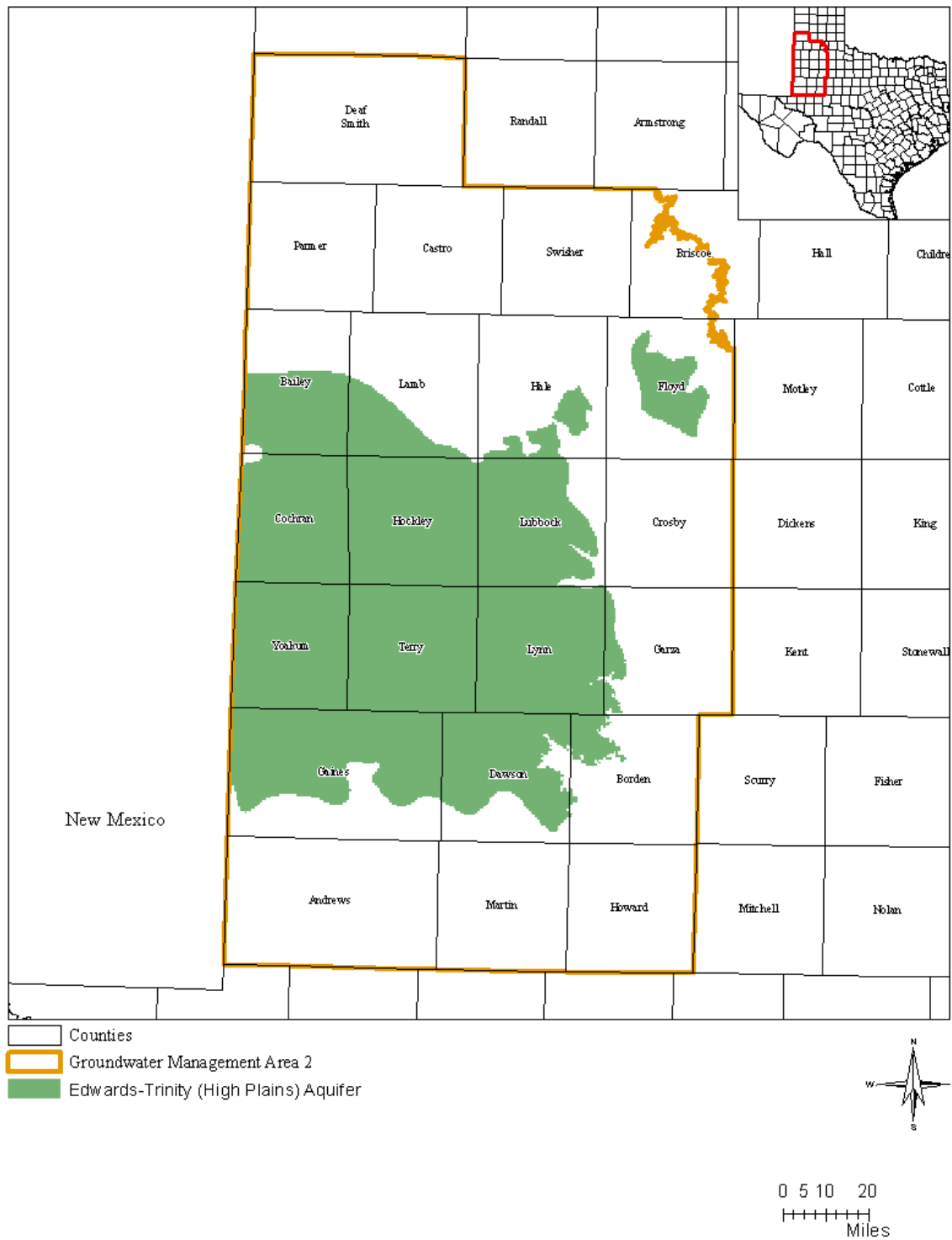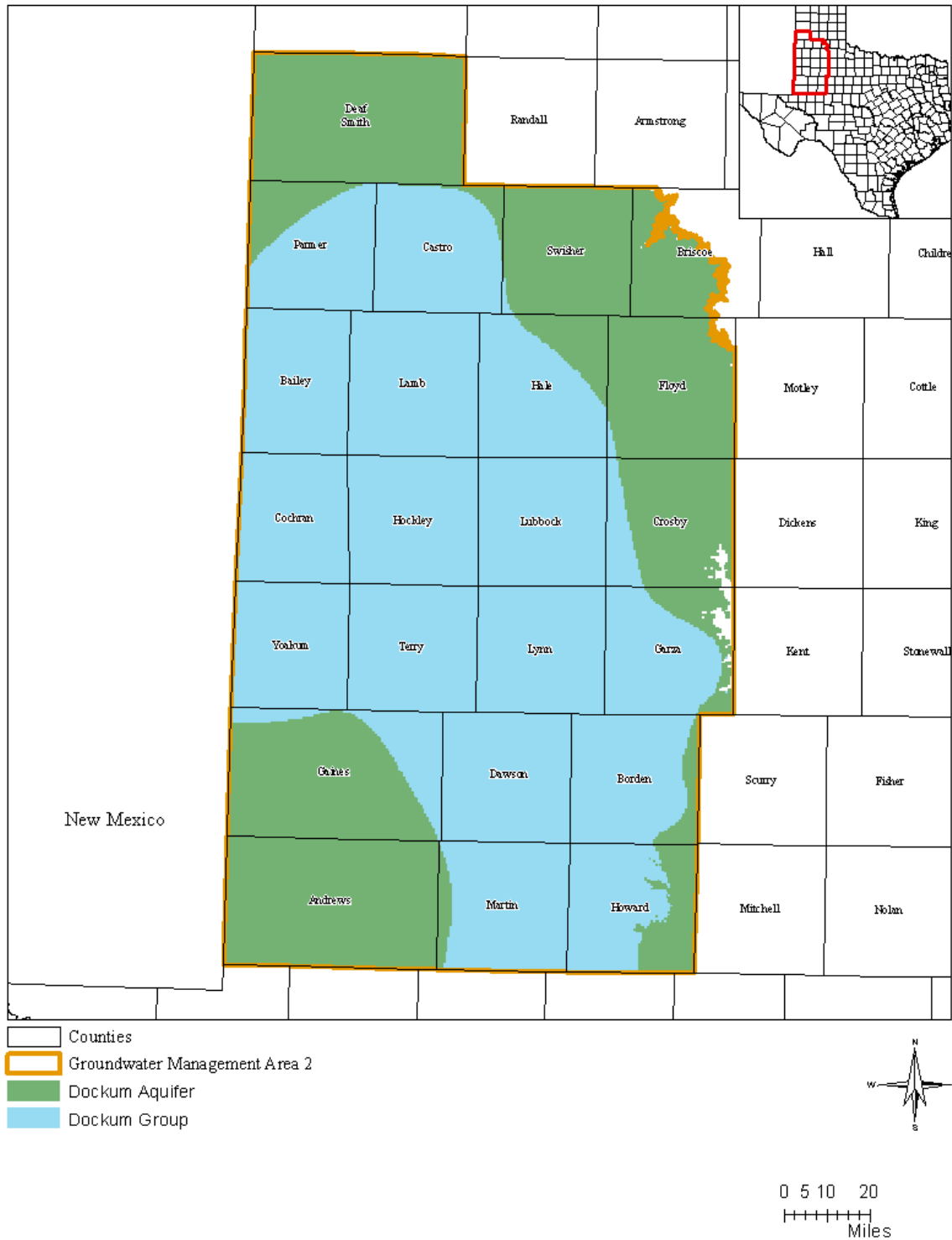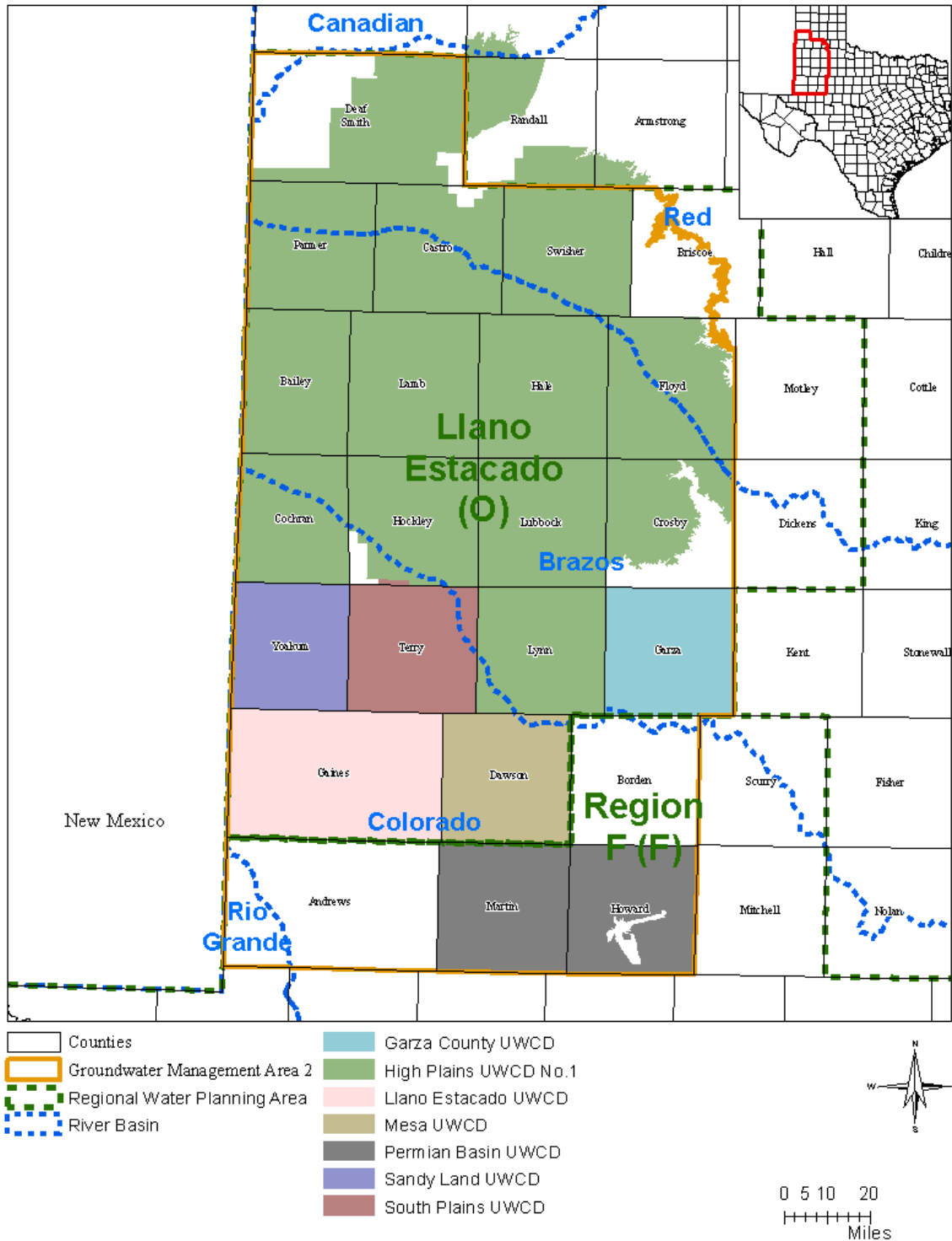
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TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA AND EDWARDS-TRINITY (HIGH PLAINS) AQUIFERS IN GROUNDWATER MANAGEMENT AREA 2 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR. (UWCD = UNDERGROUND WATER CONSERVATION DISTRICT)

Groundwater Conservation District	County	2012	2020	2030	2040	2050	2060	2070
Garza County UWCD Total	**Garza**	**14,932**	**16,297**	**13,648**	**12,395**	**11,657**	**11,180**	**10,855**
High Plains UWCD No.1	Bailey	79,604	97,679	67,307	51,199	42,704	37,858	34,815
High Plains UWCD No.1	Castro	200,692	261,434	181,190	102,732	55,811	35,734	26,291
High Plains UWCD No.1	Cochran	67,032	101,762	79,152	64,503	55,408	47,858	42,674
High Plains UWCD No.1	Crosby	124,336	163,188	108,662	68,885	46,778	35,651	29,619
High Plains UWCD No.1	Deaf Smith	148,161	182,988	118,471	74,107	51,551	40,042	33,785
High Plains UWCD No.1	Floyd	124,867	170,451	94,139	67,802	54,090	46,197	41,537
High Plains UWCD No.1	Hale	283,391	220,111	114,928	70,663	48,719	37,740	31,954
High Plains UWCD No.1	Hockley	132,145	154,091	96,609	71,741	60,822	55,285	52,185
High Plains UWCD No.1	Lamb	244,726	223,477	112,082	71,220	56,582	50,140	46,816
High Plains UWCD No.1	Lubbock	131,793	151,056	121,404	109,134	100,850	94,935	90,798
High Plains UWCD No.1	Lynn	81,678	112,607	96,151	85,494	78,603	74,349	71,640
High Plains UWCD No.1	Parmer	150,001	152,014	91,098	59,259	43,737	35,469	30,537
High Plains UWCD No.1	Swisher	119,658	129,283	71,638	46,284	33,912	27,019	22,783
High Plains UWCD No.1 Total		**1,888,087**	**2,120,141**	**1,352,831**	**943,023**	**729,567**	**618,277**	**555,434**
Llano Estacado UWCD Total	**Gaines**	**266,072**	**277,954**	**218,338**	**184,298**	**162,643**	**147,743**	**138,294**
Mesa UWCD Total	**Dawson**	**122,802**	**172,851**	**123,476**	**96,796**	**82,283**	**74,610**	**69,928**
Permian Basin UWCD	Howard	12,428	19,285	16,865	15,737	15,105	14,738	14,513
Permian Basin UWCD	Martin	41,993	63,463	51,126	43,861	39,793	37,210	35,425
Permian Basin UWCD Total		**54,421**	**82,748**	**67,991**	**59,598**	**54,898**	**51,948**	**49,938**
Sandy Land UWCD Total	**Yoakum**	**131,815**	**138,940**	**92,952**	**69,400**	**58,308**	**52,469**	**48,940**
South Plains UWCD	Hockley	3,527	4,895	2,213	726	389	283	240
South Plains UWCD	Terry	205,507	190,768	132,777	105,892	94,696	88,883	85,518
South Plains UWCD Total		**209,034**	**195,663**	**134,990**	**106,618**	**95,085**	**89,166**	**85,758**

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Groundwater Conservation District	County	2012	2020	2030	2040	2050	2060	2070
No District-County	Andrews	19,037	24,937	21,375	19,795	18,774	18,040	17,474
No District-County	Borden	5,025	5,922	4,639	4,069	3,737	3,421	3,212
No District-County	Briscoe	27,107	29,022	17,637	11,907	9,053	7,445	6,451
No District-County	Castro	3,159	5,859	3,280	2,367	1,814	1,452	1,214
No District-County	Crosby	1,691	3,135	2,918	2,292	1,959	1,783	1,671
No District-County	Deaf Smith	16,585	23,348	18,932	15,981	14,110	12,791	11,821
No District-County	Hockley	10,604	18,445	13,065	5,303	2,577	1,618	1,185
No District-County	Howard	352	550	527	526	534	543	553
Groundwater Management Area 2		**2,770,723**	**3,115,812**	**2,086,599**	**1,534,368**	**1,246,999**	**1,092,486**	**1,002,728**

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TABLE 2.   MODELED AVAILABLE GROUNDWATER FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 2 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR. (UWCD = UNDERGROUND WATER CONSERVATION DISTRICT)

Groundwater Conservation District	County	2012	2020	2030	2040	2050	2060	2070
Garza County UWCD Total	**Garza**	**191**	**911**	**911**	**911**	**911**	**911**	**911**
High Plains UWCD No.1	Bailey	7	833	833	833	833	833	833
High Plains UWCD No.1	Castro	323	425	425	425	425	425	425
High Plains UWCD No.1	Cochran	0	972	972	972	972	972	972
High Plains UWCD No.1	Crosby	2,883	3,787	3,787	3,787	3,787	3,787	3,787
High Plains UWCD No.1	Deaf Smith	2,134	4,395	4,395	4,395	4,395	4,395	4,395
High Plains UWCD No.1	Floyd	2,456	3,226	3,226	3,226	3,226	3,226	3,226
High Plains UWCD No.1	Hale	135	1,121	1,121	1,121	1,121	1,121	1,121
High Plains UWCD No.1	Hockley	28	973	973	973	973	973	973
High Plains UWCD No.1	Lamb	4	923	923	923	923	923	923
High Plains UWCD No.1	Lubbock	3	1,086	1,086	1,086	1,086	1,086	1,086
High Plains UWCD No.1	Lynn	81	912	912	912	912	912	912
High Plains UWCD No.1	Parmer	0	5,450	5,450	5,450	5,450	4,689	4,589
High Plains UWCD No.1	Swisher	1,200	1,576	1,576	1,576	1,576	1,576	1,576
High Plains UWCD No.1 Total		**9,255**	**25,679**	**25,679**	**25,679**	**25,679**	**24,918**	**24,818**
Permian Basin UWCD	Howard	737	1,471	1,471	1,471	1,471	1,471	1,471
Permian Basin UWCD	Martin	6	8	8	8	8	8	8
Permian Basin UWCD Total		**743**	**1,479**	**1,479**	**1,479**	**1,479**	**1,479**	**1,479**
No District-County	Andrews	4	1,319	1,319	1,319	1,319	1,319	1,319
No District-County	Borden	114	900	900	900	900	900	900
No District-County	Crosby	54	71	71	71	71	71	71
No District-County	Deaf Smith	27	6	6	6	6	6	6
No District-County	Hockley	0	83	83	83	83	83	83
No District-County	Howard	1	118	118	118	118	118	118
Groundwater Management Area 2		**10,465**	**30,566**	**30,566**	**30,566**	**30,566**	**29,805**	**29,705**

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TABLE 3.   MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE OGALLALA AND EDWARDS-TRINITY (HIGH PLAINS) AQUIFERS IN GROUNDWATER MANAGEMENT AREA 2. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN.

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Andrews	Region F	Colorado	24,937	21,375	19,795	18,774	18,040	17,474
Bailey	Llano Estacado	Brazos	97,679	67,307	51,199	42,704	37,858	34,815
Borden	Region F	Brazos	842	699	635	597	572	555
Borden	Region F	Colorado	5,080	3,940	3,433	3,140	2,849	2,657
Briscoe	Llano Estacado	Red	29,022	17,637	11,907	9,053	7,445	6,451
Castro	Llano Estacado	Red	107,563	72,432	43,208	25,577	17,236	12,970
Castro	Llano Estacado	Brazos	159,730	112,038	61,892	32,048	19,950	14,535
Cochran	Llano Estacado	Brazos	26,117	21,555	18,919	17,399	16,483	15,900
Cochran	Llano Estacado	Colorado	75,645	57,597	45,584	38,008	31,376	26,775
Crosby	Llano Estacado	Red	3,693	3,503	3,068	2,373	1,888	1,567
Crosby	Llano Estacado	Brazos	162,630	108,077	68,110	46,363	35,547	29,723
Dawson	Llano Estacado	Brazos	1,699	1,456	1,329	1,256	1,210	1,178
Dawson	Llano Estacado	Colorado	171,153	122,020	95,467	81,027	73,400	68,749
Deaf Smith	Llano Estacado	Red	206,336	137,403	90,088	65,661	52,833	45,606
Floyd	Llano Estacado	Red	25,808	25,101	24,583	23,926	22,995	22,109
Floyd	Llano Estacado	Brazos	144,643	69,038	43,219	30,165	23,203	19,428
Gaines	Llano Estacado	Colorado	277,954	218,338	184,298	162,643	147,743	138,294
Garza	Llano Estacado	Brazos	16,297	13,648	12,395	11,657	11,180	10,855
Hale	Llano Estacado	Red	472	455	358	266	197	150
Hale	Llano Estacado	Brazos	219,639	114,473	70,305	48,453	37,543	31,804

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County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Hockley	Llano Estacado	Brazos	130,832	85,716	66,206	56,994	52,150	49,382
Hockley	Llano Estacado	Colorado	46,599	26,171	11,564	6,793	5,037	4,228
Howard	Region F	Colorado	19,835	17,391	16,264	15,638	15,281	15,066
Lamb	Llano Estacado	Brazos	223,477	112,082	71,220	56,582	50,140	46,816
Lubbock	Llano Estacado	Brazos	151,056	121,404	109,134	100,850	94,935	90,798
Lynn	Llano Estacado	Brazos	104,528	88,796	79,406	73,546	69,934	67,598
Lynn	Llano Estacado	Colorado	8,079	7,355	6,088	5,057	4,414	4,042
Martin	Region F	Colorado	63,463	51,126	43,861	39,793	37,210	35,425
Parmer	Llano Estacado	Red	73,758	40,228	24,334	17,703	14,499	12,655
Parmer	Llano Estacado	Brazos	78,257	50,870	34,925	26,034	20,971	17,881
Swisher	Llano Estacado	Red	103,982	60,806	40,124	29,802	23,926	20,249
Swisher	Llano Estacado	Brazos	25,301	10,833	6,160	4,109	3,092	2,534
Terry	Llano Estacado	Brazos	8,367	7,167	6,548	6,142	5,864	5,670
Terry	Llano Estacado	Colorado	182,401	125,610	99,345	88,554	83,019	79,849
Yoakum	Llano Estacado	Colorado	138,940	92,952	69,400	58,308	52,469	48,940
Groundwater Management Area 2			**3,115,814**	**2,086,599**	**1,534,371**	**1,246,995**	**1,092,489**	**1,002,728**

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TABLE 4. **MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 2. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN.**

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Andrews	Region F	Colorado	1,319	1,319	1,319	1,319	1,319	1,319
Bailey	Llano Estacado	Brazos	833	833	833	833	833	833
Borden	Region F	Brazos	284	284	284	284	284	284
Borden	Region F	Colorado	617	617	617	617	617	617
Castro	Llano Estacado	Red	425	425	425	425	425	425
Cochran	Llano Estacado	Brazos	104	104	104	104	104	104
Cochran	Llano Estacado	Colorado	868	868	868	868	868	868
Crosby	Llano Estacado	Brazos	3,858	3,858	3,858	3,858	3,858	3,858
Deaf Smith	Llano Estacado	Red	4,401	4,401	4,401	4,401	4,401	4,401
Floyd	Llano Estacado	Red	250	250	250	250	250	250
Floyd	Llano Estacado	Brazos	2,976	2,976	2,976	2,976	2,976	2,976
Garza	Llano Estacado	Brazos	911	911	911	911	911	911
Hale	Llano Estacado	Red	29	29	29	29	29	29
Hale	Llano Estacado	Brazos	1,092	1,092	1,092	1,092	1,092	1,092
Hockley	Llano Estacado	Brazos	890	890	890	890	890	890
Hockley	Llano Estacado	Colorado	167	167	167	167	167	167
Howard	Region F	Colorado	1,589	1,589	1,589	1,589	1,589	1,589
Lamb	Llano Estacado	Brazos	923	923	923	923	923	923
Lubbock	Llano Estacado	Brazos	1,086	1,086	1,086	1,086	1,086	1,086
Lynn	Llano Estacado	Brazos	791	791	791	791	791	791

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County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Lynn	Llano Estacado	Colorado	121	121	121	121	121	121
Martin	Region F	Colorado	8	8	8	8	8	8
Parmer	Llano Estacado	Red	2,298	2,298	2,298	2,298	2,298	2,298
Parmer	Llano Estacado	Brazos	3,152	3,152	3,152	3,152	2,392	2,291
Swisher	Llano Estacado	Red	1,551	1,551	1,551	1,551	1,551	1,551
Swisher	Llano Estacado	Brazos	25	25	25	25	25	25
Groundwater Management Area 2			**30,568**	**30,568**	**30,568**	**30,568**	**29,808**	**29,707**

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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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