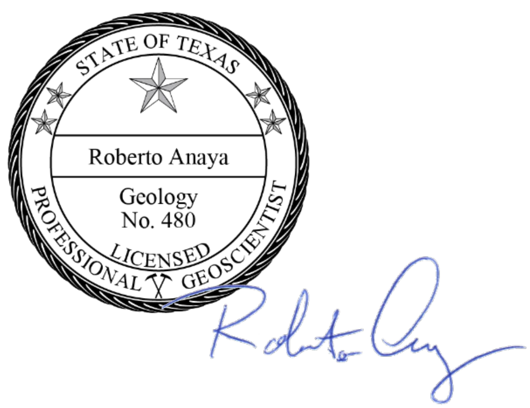
GAM RUN 21-007 MAG: MODELED AVAILABLE GROUNDWATER FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 1

Roberto Anaya, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-463-6115

February 28, 2023



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EXECUTIVE SUMMARY:

The modeled available groundwater for the High Plains Aquifer System within Groundwater Management Area 1 is summarized by decade for the groundwater conservation districts (Tables 1 and 2) and for use in the regional water planning process (Tables 3 and 4). The modeled available groundwater values for the Ogallala Aquifer (inclusive of the Rita Blanca Aquifer) range from 3,192,963 acre-feet per year in 2020 to 1,991,106 acre-feet per year in 2080 (Table 1). The modeled available groundwater values for the Dockum Aquifer range from 288,052 acre-feet per year in 2020 to 241,087 acre-feet per year in 2080 (Table 2).

The modeled available groundwater values for the Ogallala (inclusive of the Rita Blanca Aquifer) and Dockum aquifers were extracted from results of a model simulation using the groundwater availability model for the High Plains Aquifer System (version 1.01). District representatives in Groundwater Management Area 1 declared the Blaine and Seymour aquifers to be non-relevant for the purposes of joint groundwater planning. The explanatory report and other materials submitted to the TWDB were determined to be administratively complete on December 16, 2022.

REQUESTOR:

Mr. Dustin Meyer, Groundwater Management Area 1 coordinator at the time of the request.

DESCRIPTION OF REQUEST:

District representatives in Groundwater Management Area 1 adopted desired future conditions by resolution for the aquifers in the area on August 26, 2021:

Ogallala (inclusive of the Rita Blanca) Aquifer:

- *"At least 40 percent of volume in storage remaining for each 50-year period between 2018 and 2080 in Dallam, Hartley, Moore, and Sherman Counties"*
- *"At least 50 percent of volume in storage remaining for each 50-year period between 2018 and 2080 in Hansford, Hutchison, Lipscomb, Ochiltree, Carson, Donley, Gray, Roberts, Wheeler, and Oldham Counties; and within the Panhandle District portions of Armstrong and Potter Counties"*
- *"At least 80 percent of volume in storage remaining for each 50-year period between 2018 and 2080 in Hemphill County"*
- *"Approximately 20 feet of total average drawdown for each 50-year period between 2012 and 2080 in Randall County and within High Plains District in Armstrong and Potter Counties".*

Dockum Aquifer:

- *"At least 40 percent of the average available drawdown remaining for each 50-year period between 2018 and 2080 in Dallam, Hartley, Moore, and Sherman Counties"*
- *"No more than 30 feet average decline in water levels for each 50-year period between 2018 and 2080 in Oldham and Carson Counties and the Panhandle District portions of Potter and Armstrong Counties"*
- *"Approximately 40 feet average decline in water levels for each 50-year period between 2012 and 2080 in Randall County and within High Plains District in Armstrong and Potter Counties".*

District representatives in Groundwater Management Area 1 determined the Blaine and Seymour aquifers were not relevant for purposes of joint planning.

On January 4, 2022, Mr. Wade Oliver, on behalf of Groundwater Management Area 1, submitted the Desired Future Conditions Explanatory Report and accompanying files to the TWDB. Groundwater Management Area 1 adopted four geographically defined desired future conditions for the Ogallala (inclusive of the Rita Blanca) Aquifer, and three geographically defined desired future conditions for the Dockum Aquifer, as presented above. TWDB staff reviewed the model files associated with the desired future conditions and some of the desired future conditions were initially not mutually compatible with the groundwater availability model results for the High Plains Aquifer System.

The technical coordinator and consultant for Groundwater Management Area 1 confirmed that the intended desired future conditions required clarification for the assumption of "averaging the 50-year periods," as defined in the resolution adopting desired future conditions. Additionally, the technical coordinator and consultant for the Groundwater Management Area 1 confirmed that a 1 percent tolerance was acceptable for the desired future conditions of both the Ogallala (inclusive of the Rita Blanca) Aquifer and the Dockum Aquifer.

The TWDB received clarifications on procedures and assumptions from the Groundwater Management Area 1 technical coordinator on November 10, 2022, and on November 17, 2022, and a letter of administrative completeness was then provided by the TWDB to Groundwater Management Area 1 on December 16, 2022. All clarifications are included in Appendix A of this report.

METHODS:

The groundwater availability model for the High Plains Aquifer System version 1.01 was run using model files submitted with the explanatory report (Groundwater Management Area 1 and Oliver, 2021) for both the Ogallala (inclusive of the Rita Blanca) Aquifer and the Dockum Aquifer (Figures 1 and 2). Model-simulated water levels were extracted for the years 2019 (stress period 1) through 2080 (stress period 62).

Average percent volumes in storage remaining, total average drawdowns, percent of average drawdowns remaining, and average decline in water levels were calculated according to the Desired Future Conditions Explanatory Report provided by Groundwater Management Area 1 (Groundwater Management Area 1, and Oliver, W., INTERA Inc., 2021). The calculated average percent volumes in storage remaining, total average drawdowns, percent of average drawdowns remaining, and average decline in water level values were then analyzed to verify that the annual pumping scenarios characterized in the submitted model files achieved the desired future conditions within a tolerance of one percent.

The modeled available groundwater values were determined by extracting pumping rates at the end of each decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Annual pumping rates by aquifer are summarized by county and groundwater conservation district, subtotaled by groundwater conservation district, and then summed for Groundwater Management Area 1 (Tables 1 and 2). Annual pumping rates by aquifer are summarized by county, river basin, and regional water planning area within Groundwater Management Area 1 (Tables 3 and 4) 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 to manage groundwater production that achieves 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 values are described below:

Ogallala (inclusive of the Rita Blanca Aquifer) and Dockum aquifers

- We used Version 1.01 of the groundwater availability model for the High Plains Aquifer System. See Deeds and Jigmond (2015) for assumptions and limitations of the groundwater availability model for the Ogallala, Rita Blanca, and Dockum aquifers.
- This groundwater availability model includes four layers, which generally represent the Ogallala Aquifer (Layer 1), the Rita Blanca Aquifer (Layer 2), the Upper Unit of the Dockum Aquifer (Layer 3), and the Lower Unit of the Dockum Aquifer (Layer 4). Since active model cells extend beyond the official TWDB aquifer extents, please note that only active model cells within the official TWDB aquifer extents and within Groundwater Management Area 1 were considered for analysis of the desired future conditions and modeled available groundwater values.
- The model was run with MODFLOW-NWT (Niswonger and others, 2011).
- Although the original groundwater availability model was calibrated only to 2012, an analysis during the current round of joint planning (Groundwater Management Area 1 and Oliver, 2021) verified that the model satisfactorily matched measured water levels for the period from 2012 to 2018. For this reason, the TWDB considers it acceptable to use the end of 2018 as the reference year for initial starting water levels for the predictive model simulation from 2019 to 2080.

- Average percent volumes in storage remaining, total average drawdowns, percent of average drawdowns remaining, and average decline in water levels, as well as modeled available groundwater values were based on the active model cells spatially coincident within the official TWDB defined aquifer boundaries.
- Model cells that became dry (when the water level in a model cell drops below the base of the aquifer) at the start of a simulated 50-year duration cycle were excluded from the desired future conditions analysis. Pumping in dry cells were excluded from the modeled available groundwater values for the decades after the cell went dry.
- A tolerance value of one percent was assumed when comparing desired future conditions to modeled results of average percent volumes in storage remaining, total average drawdowns, percent of average drawdowns remaining, and average decline in water levels. This one percent tolerance was specified by the Groundwater Management Area 1 in clarification statements for their desired future conditions resolution (Appendix A).
- Calculations of modeled available groundwater from the model simulation were rounded to the nearest whole number in units of acre-feet per year.
- The verification calculation for the desired future conditions of average percent volume in storage remaining for each 50-year period between 2018 and 2080 in the Ogallala (inclusive of the Rita Blanca) Aquifer for Dallam, Sherman, Hartley, and Moore counties is based on model layer 1 where the Rita Blanca Aquifer does not exist and on an average of model layers 1 and 2 for the area where the extent of the Rita Blanca Aquifer is spatially coincident with the Ogallala Aquifer within Dallam and Hartley counties.

RESULTS:

The modeled available groundwater values for the Ogallala (inclusive of the Rita Blanca Aquifer) Aquifer range from 3,192,963 acre-feet per year in 2020 to 1,991,106 acre-feet per year in 2080 (Table 1). The modeled available groundwater values for the Dockum Aquifer range from approximately 288,052 acre-feet per year in 2020 to 241,087 acre-feet per year in 2080 (Table 2). The modeled available groundwater is summarized by groundwater conservation district and county for the Ogallala (inclusive of the Rita Blanca Aquifer) and Dockum aquifers (Tables 1 and 2). 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 Ogallala (inclusive of the Rita Blanca Aquifer) and Dockum aquifers (Tables 3 and 4).

FIGURE 1. GROUNDWATER MANAGEMENT AREA (GMA) 1 BOUNDARY, RIVER BASINS, COUNTIES, REGIONAL WATER PLANNING AREAS (RWPAS), AND GROUNDWATER CONSERVATION DISTRICTS (GCDS) OVERLAIN ON THE MODEL EXTENT OF THE OGALLALA (INCLUSIVE OF THE RITA BLANCA) AQUIFER.

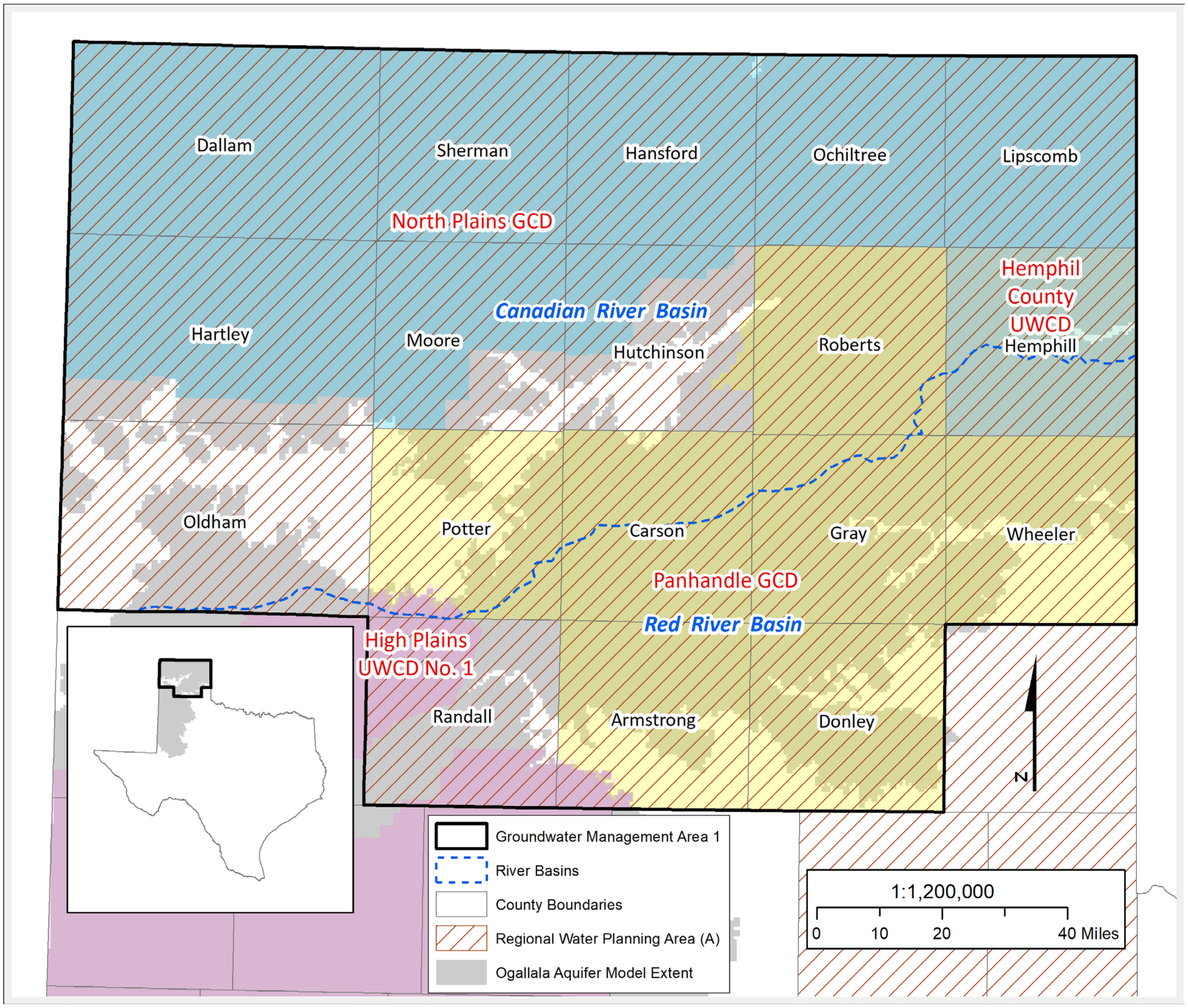

FIGURE 2. GROUNDWATER MANAGEMENT AREA (GMA) 1 BOUNDARY, RIVER BASINS, COUNTIES, REGIONAL WATER PLANNING AREAS (RWPAS), AND GROUNDWATER CONSERVATION DISTRICTS (GCDS) OVERLAIN ON THE MODEL EXTENT OF THE DOCKUM AQUIFER.

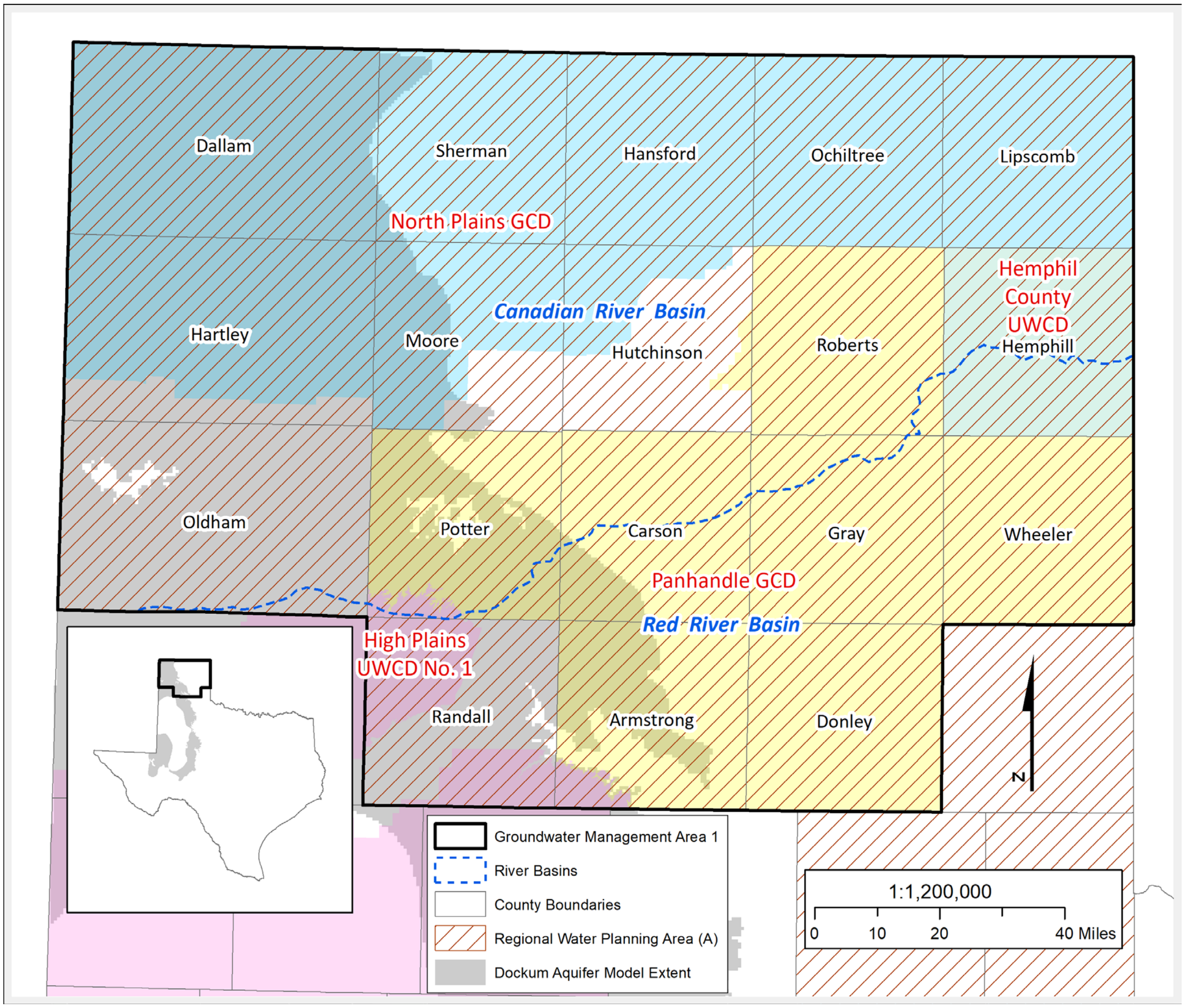

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA (INCLUSIVE OF THE RITA BLANCA AQUIFER) AQUIFER IN GROUNDWATER MANAGEMENT AREA 1 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	Aquifer	2020	2030	2040	2050	2060	2070	2080
Hemphill County UWCD	Hemphill	Ogallala	37,259	45,816	52,208	55,621	58,039	59,257	60,177
Hemphill County UWCD Total		**Ogallala**	**37,259**	**45,816**	**52,208**	**55,621**	**58,039**	**59,257**	**60,177**
High Plains UWCD No.1	Armstrong	Ogallala	5,679	4,713	3,007	1,877	1,181	968	786
High Plains UWCD No.1	Potter	Ogallala	2,348	2,538	2,362	2,049	1,634	1,075	802
High Plains UWCD No.1	Randall	Ogallala	36,992	34,674	29,709	24,585	20,385	17,088	14,559
High Plains UWCD No.1 Total		**Ogallala**	**45,019**	**41,925**	**35,078**	**28,511**	**23,200**	**19,131**	**16,147**
North Plains GCD	Dallam	Ogallala*	319,988	269,575	228,726	194,888	165,787	144,360	128,259
North Plains GCD	Hansford	Ogallala	297,486	295,700	281,612	264,290	247,744	229,800	211,464
North Plains GCD	Hartley	Ogallala†	355,646	270,230	207,754	169,890	144,564	124,366	108,352
North Plains GCD	Hutchinson	Ogallala	77,920	80,189	77,835	74,461	70,609	67,496	64,083
North Plains GCD	Lipscomb	Ogallala	251,489	270,819	263,478	249,968	235,561	218,975	201,984

* Ogallala Aquifer also includes the Rita Blanca Aquifer where they are both spatially coincident within the Dallam County portion of North Plains GCD.
† Ogallala Aquifer also includes the Rita Blanca Aquifer where they are both spatially coincident within the Hartley County portion of North Plains GCD.

TABLE 1 (CONTINUED). MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA (INCLUSIVE OF THE RITA BLANCA AQUIFER) AQUIFER IN GROUNDWATER MANAGEMENT AREA 1 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
North Plains GCD	Moore	Ogallala	140,408	139,745	132,737	121,616	106,134	88,165	73,128
North Plains GCD	Ochiltree	Ogallala	259,676	259,973	247,274	231,502	215,617	199,324	181,295
North Plains GCD	Sherman	Ogallala	290,148	287,657	261,521	226,142	198,338	166,675	145,399
North Plains GCD Total		**Ogallala**	**1,992,761**	**1,873,888**	**1,700,937**	**1,532,757**	**1,384,354**	**1,239,161**	**1,113,964**
Panhandle GCD	Armstrong	Ogallala	56,940	51,726	45,757	40,241	35,089	30,685	27,137
Panhandle GCD	Carson	Ogallala	163,315	166,024	159,756	149,768	141,251	134,365	121,774
Panhandle GCD	Donley	Ogallala	72,747	78,267	77,157	72,601	67,032	60,915	53,337
Panhandle GCD	Gray	Ogallala	177,633	181,648	173,602	160,382	147,045	133,802	121,936
Panhandle GCD	Hutchinson	Ogallala	8,524	10,589	11,798	11,784	11,427	10,775	9,606
Panhandle GCD	Potter	Ogallala	24,022	22,245	19,590	16,477	13,607	10,990	8,821
Panhandle GCD	Roberts	Ogallala	358,704	409,300	394,930	369,335	344,109	317,529	286,594
Panhandle GCD	Wheeler	Ogallala	119,602	132,615	132,787	128,472	121,852	114,269	106,929
Panhandle GCD Total		**Ogallala**	**981,487**	**1,052,414**	**1,015,377**	**949,060**	**881,412**	**813,330**	**736,134**
All Districts Total		**Ogallala**	**3,056,526**	**3,014,043**	**2,803,600**	**2,565,949**	**2,347,005**	**2,130,879**	**1,926,422**

TABLE 1 (CONTINUED). MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA (INCLUSIVE OF THE RITA BLANCA AQUIFER) AQUIFER IN GROUNDWATER MANAGEMENT AREA 1 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
No District-County	Hartley	Ogallala‡	15,555	16,380	15,634	14,309	12,989	11,646	10,434
No District-County	Hutchinson	Ogallala	33,955	32,967	28,372	24,059	20,978	18,576	17,204
No District-County	Moore	Ogallala	8,703	9,681	9,415	8,245	7,122	6,198	5,517
No District-County	Oldham	Ogallala	40,496	39,067	36,192	31,219	26,044	21,393	18,041
No District-County	Randall	Ogallala	37,728	35,877	30,800	25,725	20,992	17,103	13,488
No District Total		**Ogallala**	**136,437**	**133,972**	**120,413**	**103,557**	**88,125**	**74,916**	**64,684**
GMA 1 Total		**Ogallala**	**3,192,963**	**3,148,015**	**2,924,013**	**2,669,506**	**2,435,130**	**2,205,795**	**1,991,106**

‡ Ogallala Aquifer also includes the Rita Blanca Aquifer where they are both spatially coincident within Hartley County and outside of any groundwater district.

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 1 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
High Plains UWCD No.1	Armstrong	Dockum	1,853	835	221	221	221	221	221
High Plains UWCD No.1	Potter	Dockum	2,663	2,657	2,406	2,315	2,281	2,248	2,172
High Plains UWCD No.1	Randall	Dockum	6,997	8,736	9,703	8,428	7,698	7,610	7,782
High Plains UWCD No.1 Total		**Dockum**	**11,513**	**12,228**	**12,330**	**10,964**	**10,200**	**10,079**	**10,175**
North Plains GCD	Dallam	Dockum	15,969	15,522	14,700	14,019	13,513	12,895	12,415
North Plains GCD	Hartley	Dockum	12,402	11,792	11,051	10,334	9,755	9,234	8,831
North Plains GCD	Moore	Dockum	4,496	5,399	5,409	5,064	4,782	4,474	4,213
North Plains GCD	Sherman	Dockum	445	416	310	288	293	288	291
North Plains GCD Total		**Dockum**	**33,312**	**33,129**	**31,470**	**29,705**	**28,343**	**26,891**	**25,750**
Panhandle GCD	Armstrong	Dockum	5,313	7,102	8,122	8,601	8,849	8,904	8,914
Panhandle GCD	Carson	Dockum	6	6	6	6	6	6	6
Panhandle GCD	Potter	Dockum	30,160	37,699	37,853	36,963	35,881	34,685	33,571
Panhandle GCD Total		**Dockum**	**35,479**	**44,807**	**45,981**	**45,570**	**44,736**	**43,595**	**42,491**
All Districts Total		**Dockum**	**80,304**	**90,164**	**89,781**	**86,239**	**83,279**	**80,565**	**78,416**

TABLE 2 (CONTINUED). MODELED AVAILABLE GROUNDWATER FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 1 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
No District-County	Hartley	Dockum	44,260	52,799	53,096	50,432	46,907	42,974	39,311
No District-County	Moore	Dockum	241	560	594	616	643	645	625
No District-County	Oldham	Dockum	144,234	153,787	145,925	135,393	124,861	114,569	105,341
No District-County	Randall	Dockum	19,013	29,231	32,057	31,502	28,550	21,149	17,394
No District Total		**Dockum**	**207,748**	**236,377**	**231,672**	**217,943**	**200,961**	**179,337**	**162,671**
GMA 1 Total		**Dockum**	**288,052**	**326,541**	**321,453**	**304,182**	**284,240**	**259,902**	**241,087**

TABLE 3. MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA (INCLUSIVE OF THE RITA BLANCA AQUIFER) AQUIFER IN GROUNDWATER MANAGEMENT AREA 1 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER FOR EACH DECADE BETWEEN 2030 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

County	RWPA	River basin	Aquifer	2030	2040	2050	2060	2070	2080
Armstrong	A	RED	Ogallala	56,439	48,764	42,118	36,270	31,653	27,923
Carson	A	CANADIAN	Ogallala	68,193	66,220	62,132	57,975	54,708	49,565
Carson	A	RED	Ogallala	97,831	93,536	87,636	83,276	79,657	72,209
Dallam	A	CANADIAN	Ogallala§	269,575	228,726	194,888	165,787	144,360	128,259
Donley	A	RED	Ogallala	78,267	77,157	72,601	67,032	60,915	53,337
Gray	A	CANADIAN	Ogallala	46,240	43,480	39,643	36,480	33,394	30,628
Gray	A	RED	Ogallala	135,408	130,122	120,739	110,565	100,408	91,308
Hansford	A	CANADIAN	Ogallala	295,700	281,612	264,290	247,744	229,800	211,464
Hartley	A	CANADIAN	Ogallala**	286,610	223,388	184,199	157,553	136,012	118,786
Hemphill	A	CANADIAN	Ogallala	24,975	29,168	32,388	34,729	36,110	37,074
Hemphill	A	RED	Ogallala	20,841	23,040	23,233	23,310	23,147	23,103
Hutchinson	A	CANADIAN	Ogallala	123,745	118,005	110,304	103,014	96,847	90,893
Lipscomb	A	CANADIAN	Ogallala	270,819	263,478	249,968	235,561	218,975	201,984
Moore	A	CANADIAN	Ogallala	149,426	142,152	129,861	113,256	94,363	78,645
Ochiltree	A	CANADIAN	Ogallala	259,973	247,274	231,502	215,617	199,324	181,295
Oldham	A	CANADIAN	Ogallala	34,871	32,845	28,578	23,948	19,789	16,869
Oldham	A	RED	Ogallala	4,196	3,347	2,641	2,096	1,604	1,172
Potter	A	CANADIAN	Ogallala	14,672	13,137	11,036	9,214	7,648	6,337
Potter	A	RED	Ogallala	10,111	8,815	7,490	6,027	4,417	3,286
Randall	A	RED	Ogallala	70,551	60,509	50,310	41,377	34,191	28,047
Roberts	A	CANADIAN	Ogallala	386,950	372,064	346,908	322,461	297,068	267,425
Roberts	A	RED	Ogallala	22,350	22,866	22,427	21,648	20,461	19,169

§ Ogallala Aquifer also includes the Rita Blanca Aquifer where they are both spatially coincident within Dallam County and the Canadian River basin.
** Ogallala Aquifer also includes the Rita Blanca Aquifer where they are both spatially coincident within Hartley County and the Canadian River basin.

TABLE 3 (CONTINUED). MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA (INCLUSIVE OF THE RITA BLANCA AQUIFER) AQUIFER IN GROUNDWATER MANAGEMENT AREA 1 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER FOR EACH DECADE BETWEEN 2030 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

County	RWPA	River basin	Aquifer	2030	2040	2050	2060	2070	2080
Sherman	A	CANADIAN	Ogallala	287,657	261,521	226,142	198,338	166,675	145,399
Wheeler	A	RED	Ogallala	132,615	132,787	128,472	121,852	114,269	106,929
GMA 1 Total			**Ogallala**	**3,148,015**	**2,924,013**	**2,669,506**	**2,435,130**	**2,205,795**	**1,991,106**

TABLE 4. MODELED AVAILABLE GROUNDWATER FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 1 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER FOR EACH DECADE BETWEEN 2030 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR.

County	RWPA	River basin	Aquifer	2030	2040	2050	2060	2070	2080
Armstrong	A	RED	Dockum	7,937	8,343	8,822	9,070	9,125	9,135
Carson	A	CANADIAN	Dockum	0	0	0	0	0	0
Carson	A	RED	Dockum	6	6	6	6	6	6
Dallam	A	CANADIAN	Dockum	15,522	14,700	14,019	13,513	12,895	12,415
Hartley	A	CANADIAN	Dockum	64,591	64,147	60,766	56,662	52,208	48,142
Moore	A	CANADIAN	Dockum	5,959	6,003	5,680	5,425	5,119	4,838
Oldham	A	CANADIAN	Dockum	153,694	145,814	135,269	124,727	114,427	105,188
Oldham	A	RED	Dockum	93	111	124	134	142	153
Potter	A	CANADIAN	Dockum	38,004	38,158	37,268	36,186	34,990	33,815
Potter	A	RED	Dockum	2,352	2,101	2,010	1,976	1,943	1,928
Randall	A	RED	Dockum	37,967	41,760	39,930	36,248	28,759	25,176
Sherman	A	CANADIAN	Dockum	416	310	288	293	288	291
GMA 1 Total			**Dockum**	**326,541**	**321,453**	**304,182**	**284,240**	**259,902**	**241,087**

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.

REFERENCES:

Deeds, Neil E. and Jigmond, Marius, 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model: Prepared for Texas Water Development Board, 640 p., http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf.

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Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models, U.S. Geological Survey Groundwater Software.

National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p., http://www.nap.edu/catalog.php?record_id=11972.

Niswonger, R.G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, a Newton formulation for MODFLOW-2005: United States Geological Survey, Techniques and Methods 6-A37, 44 p.

Texas Water Code, 2011, http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf

APPENDIX A

Critical Clarifications requested by the TWDB *(need additional files or potential update to legal DFC Resolutions)***:**

1. Based on TWDB analysis of the High Plains Aquifer System model files provided by the GMA 1 consultant (INTERA, Inc.), some DFCs are unachievable with respect to the current legal phrasing of the DFC Resolution. The TWDB is requesting the following tolerances:
   - A tolerance of 1% for GMA 1 DFCs defined by percent volume in storage remaining in the Ogallala Aquifer (inclusive of Rita Blanca Aquifer).
   - A tolerance of 1% for GMA 1 DFCs defined by percent available drawdown remaining in the Dockum Aquifer.

   Please confirm that the GMA is willing to accept the tolerance clarifications requested above. Alternatively, the GMA or GMA consultant may provide revised High Plains Aquifer System model files for TWDB to review or may revise the DFC Resolution so that the DFCs are achievable without requiring a tolerance.

Other Clarifications requested by the TWDB (*need acknowledgement*)**:**
Note that the tolerances in Clarification #1 were derived from calculations using the following assumptions. If the GMA disagrees with the following assumptions, the requested tolerances may no longer be sufficient for TWDB to declare the DFCs achievable and further action may be required.

Ogallala (inclusive of Rita Blanca) Aquifer:

2. Please confirm that the phrase "percent of volume in storage remaining for each 50-year period between 2018 and 2080" in the DFC Resolution means "the percent of volume remaining in storage averaged over all thirteen 50-year time periods starting from 2018 to 2068 through 2030 to 2080." This interpretation produces calculated storage values consistent with the DFC values provided in the Explanatory Report and supplemental documents provided by the GMA 1 consultant.
3. Please confirm that the phrase "total average drawdown for each 50-year period between 2012 and 2080" in the DFC Resolution means "the total average drawdown averaged over all nineteen 50-year time periods starting from 2012 to 2062 through 2030 to 2080. This interpretation produces calculated drawdown values consistent with the DFC values provided in the Explanatory Report and supplemental documents provided by the GMA 1 consultant.
4. Please confirm that the GMA accepts the following assumptions for calculating modeled drawdown: 1) modeled dry cells are excluded from the calculations, 2) only active model cells within official TWDB aquifer boundaries are included in calculations, and 3) averages are calculated over the entire multi-county area defined

within the resolutions rather than by individual county within those areas. This method produces drawdown values consistent with the DFC values provided in the Explanatory Report and supplemental documents provided by the GMA 1 consultant.

Dockum Aquifer:

5. Please confirm that the phrase "percent of the average available drawdown remaining for each 50-year period between 2018 and 2080" in the DFC Resolution means "the percent of the average available drawdown remaining averaged over all thirteen 50-year time periods starting from 2018 to 2068 through 2030 to 2080." This method produces calculated storage values consistent with the DFC values provided in the Explanatory Report and supplemental documents provided by the GMA 1 consultant.
6. Please confirm that the phrase "average decline in water levels for each 50-year period between 2018 and 2080" in the DFC Resolution means "the average decline in water levels averaged over all thirteen 50-year time periods starting from 2018 to 2068 through 2030 to 2080". This method produces calculated storage values consistent with the DFC values provided in the Explanatory Report and supplemental documents provided by the GMA 1 consultant.
7. Please confirm that the phrase "average decline in water levels for each 50-year period between 2012 and 2080" in the DFC Resolution means "the average decline in water levels averaged over all nineteen 50-year time periods starting from 2012 to 2062 through 2030 to 2080. This method produces calculated storage values consistent with the DFC values provided in the Explanatory Report and supplemental documents provided by the GMA 1 consultant.
8. Please confirm that the GMA accepts the following assumptions for calculating modeled drawdowns: 1) modeled dry cells are excluded from the calculations, 2) only active model cells within official TWDB aquifer boundaries are included in calculations, and 3) averages are calculated over the entire multi-county area defined within the resolutions rather than by individual county within those areas. This method produces drawdown values consistent with the DFC values provided in the Explanatory Report and supplemental documents provided by the GMA 1 consultant.

Optional Clarifications requested by the TWDB *(Typos in Explanatory Report)*[6]:

None

[6] Since the TWDB considers the legal DFC Resolution documents, rather than the Explanatory Report, as the official definition of DFCs, the TWDB does not officially require corrections to the Explanatory Report. However, because the Explanatory Report is often used as a simplified, more-readable summary of the legal DFC Resolution documents, we recommend correcting the Explanatory Report to match the DFC Resolutions in order to avoid confusion.

Informational

For reference, the tables below show the averaged results of DFC analysis calculations provided by the GMA 1 consultant and verified by TWDB for the currently unachievable DFCs:

Bulleted Resolutions	***Percent of volume in storage remaining for each 50-year period between 2018 and 2080***	
	DFC	**Calculated from model**
Ogallala Bullet #2*	>= 50%	49%
Ogallala Bullet #3**	>= 80%	79%

** Refers to Hansford, Hutchinson, Lipscomb, Ochiltree, Carson, Donley, Gray, Roberts, Wheeler, and Oldham counties; and within the Panhandle District portions of Armstrong and Potter counties*
*** refers to Hemphill County*

Resolution Section	***Percent of average available drawdown remaining for each 50-year period between 2018 and 2080***	
	DFC	**Calculated from model**
Dockum Bullet #1*	>= 40%	39%

** Refers to Dallam, Hartley, Moore, and Sherman counties.*

FIGURE A1. LETTER OF AGREEMENT FROM THE GROUNDWATER MANAGEMENT AREA 1 TECHNICAL COORDINATOR FOR CLARIFICATIONS ON PROCEDURES AND ASSUMPTIONS OF THEIR DESIRED FUTURE CONDITIONS RESOLUTION STATEMENTS.

NORTH PLAINS
GROUNDWATER
Conservation District

November 10, 2022

Robert G. Bradley, PG, CTCM
Groundwater Technical Assistance
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711

Dear Mr. Bradley,

Thank you for reaching out to clarify the Desired Future Conditions adopted by the groundwater conservation districts in Groundwater Management Area 1 (GMA 1). The GMA 1 technical consultant and the managers from Hemphill County Underground Water Conservation District, High Plains Underground Water Conservation District, and Panhandle Groundwater Conservation District reviewed the clarifications document attached to this correspondence.

The Districts in GMA 1 agree that the approach presented by the TWDB staff including the tolerances below are consistent with our intent when adopting DFCs:

- A tolerance of 1% for GMA 1 DFCs defined by percent volume in storage remaining in the Ogallala Aquifer (inclusive of Rita Blanca Aquifer).
- A tolerance of 1% for GMA 1 DFCs defined by percent available drawdown remaining in the Dockum Aquifer.

We agree with the TWDB staff assumptions presented in the "Other Clarifications" section of your note on November 9, 2022, relating to Ogallala, Rita Blanca and Dockum aquifers.

We look forward to TWDB's determination of administrative completeness and estimation of modeled available groundwater. If there is anything else we can do to help in this process, please let me know.

Sincerely,

Steven D. Walthour, PG
General Manager

CC. Janet Guthrie – Hemphill County Underground Water Conservation District
Britney Britten – Panhandle Groundwater Conservation District
Jason Coleman– High Plains Underground Water Conservation District
Wade Oliver - Intera

Attachment