PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT

MANAGEMENT PLAN 2017-2022

Effective August 29, 2017

P.O. Box 1314
Stanton, Texas 79782

Table of Contents

District Mission Statement 1

Time Period For This Plan 1

Statement of Guiding Principles 1

General Description, Location and Extent 2

Groundwater Resources 4

Ogallala Aquifer 4

Edwards-Trinity (Plateau) Aquifer 6

Modeled Available Groundwater and Desired Future Condition 8

Amount of Groundwater Being Used within District on an Annual Basis 8

Annual Amount of Recharge From Precipitation to Groundwater Resources within the District 8

Annual Amount of Water that Discharges from the Aquifer to Springs and any Surface Water Bodies within each aquifer of the District 9

Annual Volume of Flow into the District, out of the District and between Aquifers in the District 9

Surface Water Resources 9

Projected Surface Water Supply 9

Projected Groundwater Supply and Demand 9

Projected Total Demand for Water 9

Water Supply Needs 9

Water Management Strategies 9

Management of Groundwater Resources 10

Method for Tracking the District's Progress in Achieving Management Goals 10

Actions, Procedures, Performance and Avoidance for Plan Implementation 10

Goal 1.0 Providing the most Efficient Use of Groundwater 11

Goal 2.0 Controlling and Preventing Waste of Groundwater 11

Goal 3.0 Drought Conditions 12

Goal 4.0 Conservation, Recharge Enhancement, Rainwater Harvesting, Precipitation Enhancement and Brush Control where appropriate and cost effective 12

Goal 5.0 Desired Future Conditions adopted by the District 13

Goals Determined Not to be Applicable to District 14

List of Tables

Table 1 Board of Directors of the Permian Basin Underground Water Conservation District 2

List of Figures

Figure 1 District Boundaries and Aquifers of the Permian Basin Underground Water Conservation District 3

Figure 2 Aerial Extent of the Ogallala Aquifer 5

Figure 3 Aerial Extent of the Edward-Trinity (Plateau) Aquifer 7

Appendices

Appendix A Estimated Historical Water Use And 2017 State Water Plan Datasets

Appendix B GAM Run 16-013

Appendix C GAM Run 16-028 MAG

District Mission Statement

The Permian Basin Underground Water Conservation District (the District) will develop, promote, and implement management strategies to provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater resources, over which it has jurisdictional authority, for the benefit of the people that the District serves.

Time Period for this Plan

This plan becomes effective upon adoption by the Permian Basin Underground Water Conservation District Board of Directors and certified as administratively complete by the Texas Water Development Board. The plan will remain in effect for five years from the date of approval or until a revised plan is adopted and approved.

Statement of Guiding Principles

The District was formed, and has been operated from its inception, with the guiding belief that the ownership and pumpage of groundwater is a private property right. The Board will continue to support that right.

The Board is elected by the registered voters of the District, under the general Election laws of Texas. The rules promulgated to date by the Board were carefully thought out, were the result of specific needs, and were adopted after public input. These rules provide a fair and equitable opportunity for all water users to produce and use water from the aquifer for beneficial purposes. Interpretation and enforcement of the rules of the District are carried out by the District's staff, at the direction of the Board.

This management document is intended to be used as a tool to provide continuity in the management of the District. It will be used by the District staff as a guide to insure that all aspects of the goals of the District are carried out. It will be referred to by the Board for future planning, as well as a document to measure the performance of the staff on an annual basis.

Conditions can change over time which may cause the Board to modify this document. The dynamic nature of this plan shall be maintained so the District can continue to best serve the needs of the constituents. At the very least, the Board will review and readopt this plan every five years according to Statute.

In the opinion of the Board, the goals, management objectives, and performance standards put forth in this planning document have been set at a reasonable level considering existing and future fiscal and technical resources. Conditions may change which could cause change in the management objectives defined to reach the stated goals. Whatever the future holds, the following guidelines will be used to insure that the management objectives are set at a sufficient level to be realistic and effective:

- The District's constituency will determine if the District's goals are set at a level that is both meaningful and attainable; through their voting right, the public will appraise the District's overall performance in the process of electing or re-electing Board members.
- The duly elected Board will guide and direct the District staff and will gauge the achievement of the goals set forth in this document.
- The interests and needs of the District's constituency shall control the direction of the management of the District.
- The Board will endeavor to maintain local control of the privately owned resource over which the District has jurisdictional authority.

General Description, Location and Extent

The District was created on April 25, 1985 when Governor Mark White signed HB 2382, 69th Legislature, in to law. The District was confirmed by voter approval, the initial Board elected, and an ad valorem tax rate cap of $0.02/$100 valuation was set in an election held in September 1985. Table 1 lists the current Board of Directors, office held, County served, and term.

Table 1: Board of Directors of the Permian Basin Underground Water Conservation District:

Office	Name	County	Term Ends
President	John Campbell	At Large	May 2018
Vice-President	Richie Tubb	Howard	May 2020
Secretary	Raymond Straub Jr.	Martin	May 2018
Member	Kent Robinson	Howard	May 2018
Member	Brad Tunnell	Martin	May 2020

Originally, the jurisdictional extent of the District was the same as Martin County, Texas. However, in 1991, the voters in the northwest portion of Howard County approved the annexation of that portion of their county into the District.

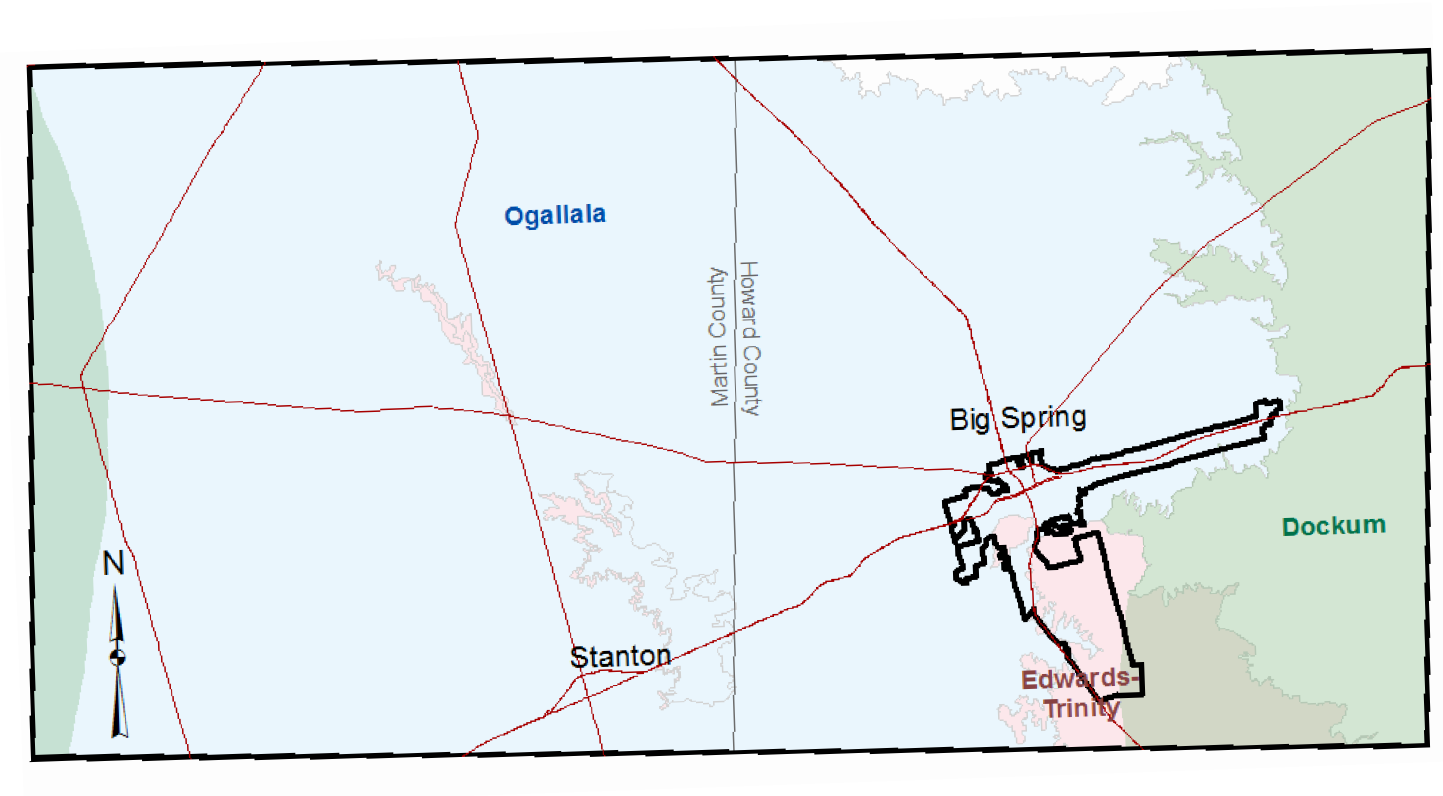
In 2001 the District annexed all of Howard County save and except City Limits of Big Spring, Texas, the City Limits of Coahoma, Texas, and adjacent areas as shown in figure 1.

The District now covers approximately 1754 square miles of West Texas (Figure 1). Stanton, the county seat of Martin County, is the largest municipality in the District, having a population of 2492.

The District is bordered on the west by Andrews County, on the north by Dawson and Borden Counties, on the south by Midland and Glasscock Counties, and on the east by Mitchell County with Scurry County to the Northeast and Sterling County to the Southeast.

The economy of the District is predominated by the oil and gas industry and to a lesser extent by agriculture. The major agricultural products coming from the area include beef cattle, cotton and grain sorghum.

Figure 1: District Boundaries and Aquifers of the Permian Basin Underground Water Conservation District



Groundwater Resources

The District has jurisdictional authority over all groundwater that lies within the District's boundaries. There are two major aquifers that occur within the District: the Ogallala and the Edwards-Trinity (Plateau). The following is a description of these formations that may be beneficial to District constituents.

Ogallala Aquifer

The Ogallala Aquifer is the primary source of groundwater in the District (Fig. 2). The aquifer extends from the ground surface downward, ranging in thickness from less than 20 feet to more than 100 feet.

The formation consists of heterogeneous sequences of clay, silt, sand and gravel. These sediments are thought to have been deposited by eastward flowing aggrading streams that filled and buried valleys eroded into pre-Ogallala rocks (Ashworth and Hopkins, 1995).

Water levels in the Ogallala Aquifer are primarily influenced by the rate of recharge to and discharge from the aquifer. Recharge to the aquifer occurs primarily by infiltration of precipitation falling on the surface.

Groundwater in the aquifer generally flows from northwest to southeast, normally at right angles to water level contours. Velocities of less than one foot per day are typical, but higher velocities may occur along filled erosion valleys where coarser grained deposits have greater permeabilities.

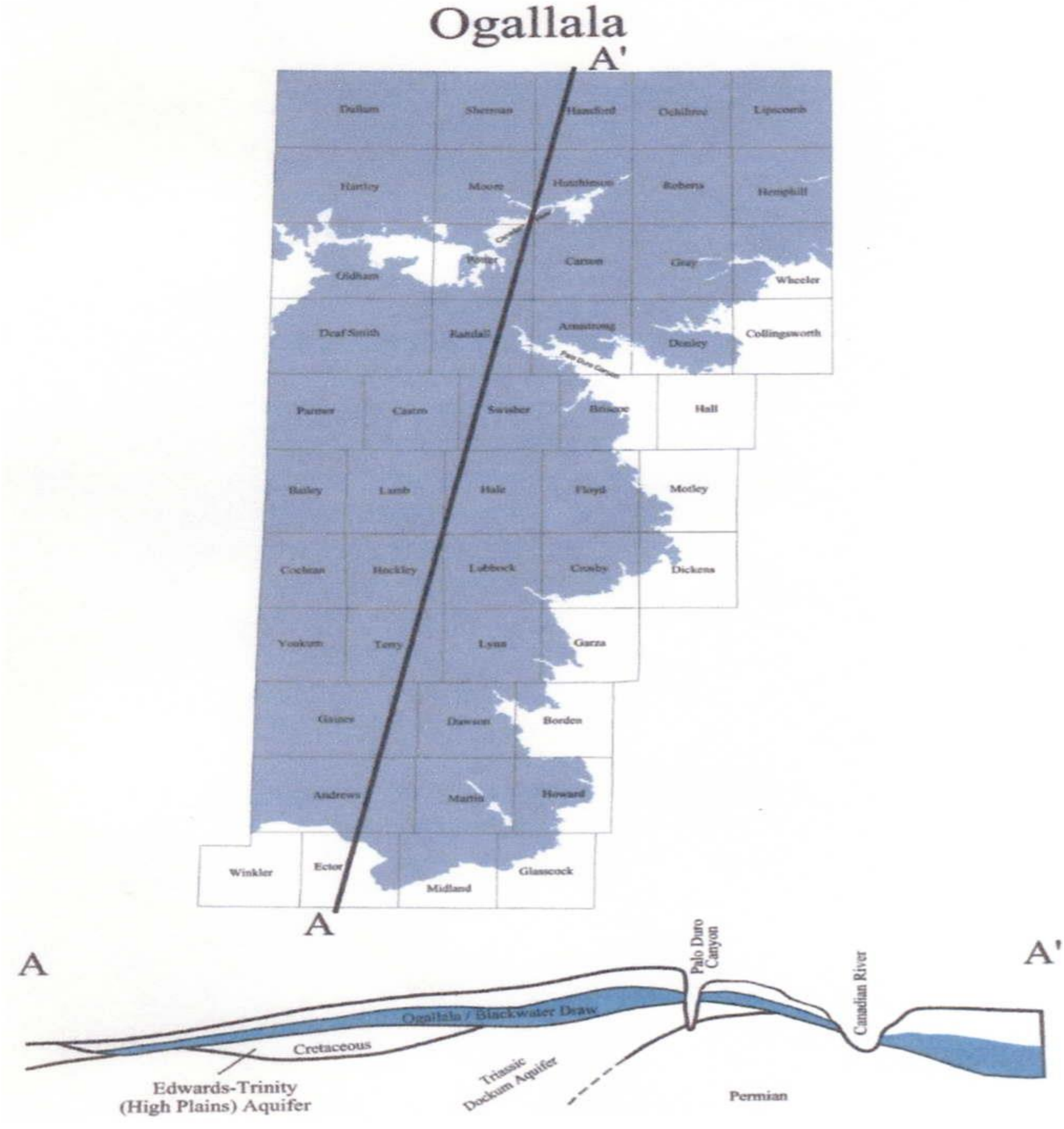
Discharge from the Ogallala aquifer within the District occurs through the pumping of wells; primarily for municipal, oil and gas production, and irrigation. Groundwater pumpage typically exceeds recharge and results in water-level declines (Ashworth and Hopkins, 1995).

The chemical quality of Ogallala groundwater varies greatly across the District. The suitability of groundwater for irrigation purposes is largely dependent on the chemical composition of the water and is determined primarily by the total concentration of soluble salts.

This district lies at the very southern end of the Ogallala. As such, the Ogallala formation here is thinning and less productive than in other areas. It is also intermingled with other formations, including the Edwards, Fredricksburg, and Antlers Sands in some places in this District.

Figure 2: Aerial extent of the Ogallala Aquifer in Texas

(Adapted from Ashworth and Hopkins 1995)



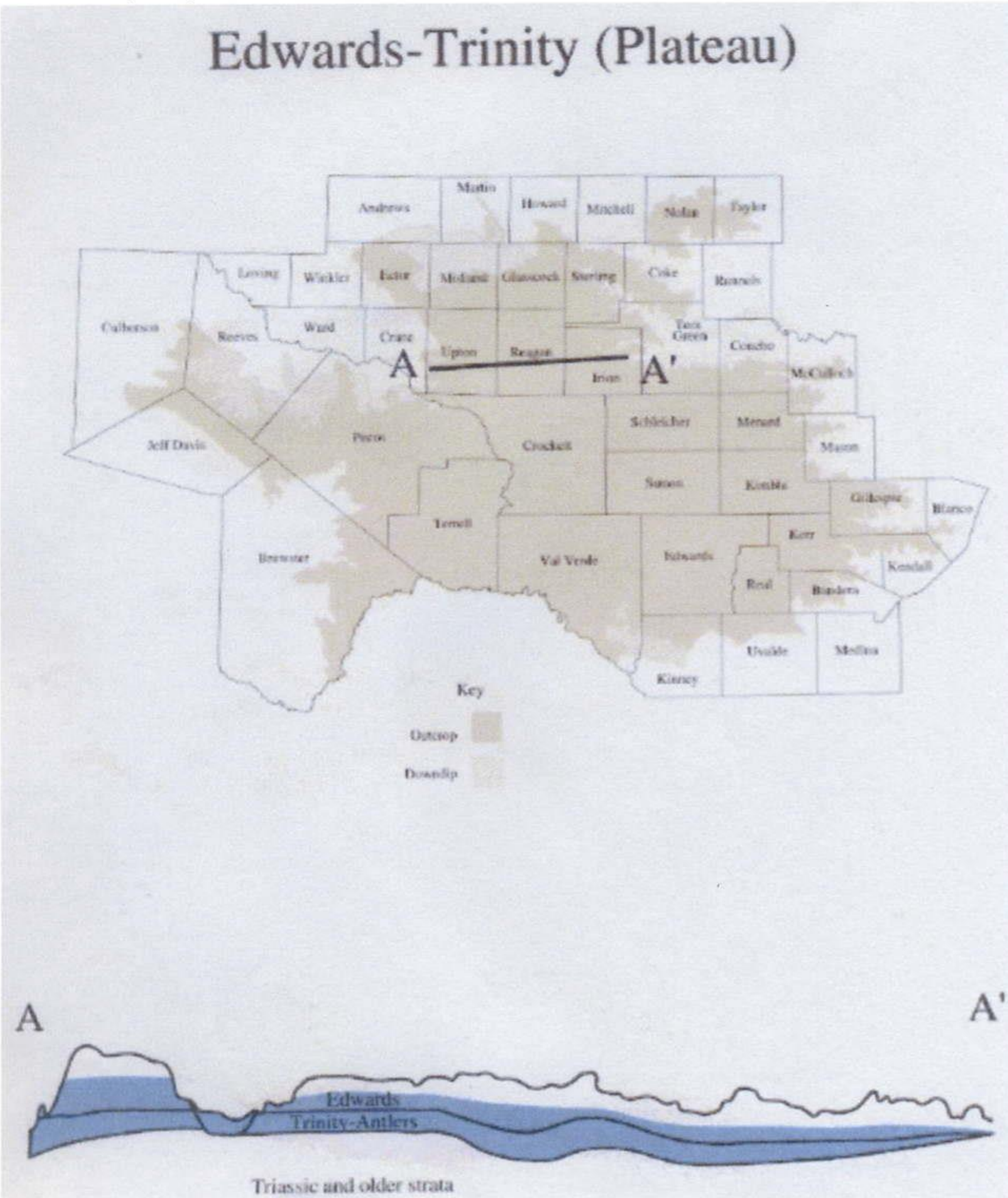
Edwards – Trinity (Plateau) Aquifer

The Edward –Trinity (Plateau) Aquifer underlies a small portion of east central and southern Martin County as well as the eastern portions of Howard County within the District (Fig. 3). The aquifer consists of saturated sediments of lower Cretaceous age Trinity Group formations and overlying limestones and dolomites of the Edwards formations.

Chemical quality of the Edwards – Trinity (Plateau) water ranges from fresh to slightly saline. The water is typically hard and may vary widely in concentrations of dissolved solids made up mostly of calcium and bicarbonate. There is little pumpage from the aquifer, and water levels remain relatively constant.

Figure 3: Aerial extent of the Edwards-Trinity (Plateau) Aquifer in Texas

(Adapted from Ashworth and Hopkins, 1995)



Modeled Available Groundwater and Desired Future Condition

The District originally adopted Desired Future Conditions (DFC) for relevant aquifers in July 2010 in accordance with Chapter 36.108 of the Texas Water Code. The aquifer conditions were reviewed in the joint planning process and new DFCs were adopted in January 2017. The relevant aquifers are the Ogallala, Edwards-Trinity (High Plains), and the Dockum Aquifers. The District Board in review of the new High Plains Aquifer System GAM Run and Scenario 16 GAM Run by Bill Hutchison developed during the joint planning process decided the Edwards Trinity (Plateau) and Pecos Valley Aquifers are not relevant aquifers for the Permian Basin UWCD at this time.

During the joint planning process, this District and six other Groundwater Conservation Districts of Groundwater Management Area 2 (GMA2) adopted DFC's for the Ogallala, Edwards-Trinity (High Plains), and the Dockum Aquifers based on the average drawdown as documented in GMA 2 Technical Memorandum 15-01 and GMA 2 Technical Memorandum 16-01. In the Permian Basin UWCD, the Ogallala and Edwards Trinity (High Plains) Aquifer cumulative drawdown is predicted to be 8 feet by 2070, so the number is -0.16 feet drawdown per year. For the Dockum Aquifer cumulative drawdown is predicted to be 5 feet by 2070, so the number is -0.1 feet drawdown per year. However the District is required to evaluate the DFCs every 5 years which will allow us to make any changes accordingly.

The Texas Water Development Board (TWDB) provided the District with the modeled available groundwater calculation based on their DFCs. It can be found in Appendix C.

Please refer to Appendix C

The District currently has Rules in effect and is considering amendments in order to better meet the adopted Desired Future Conditions.

Amount of Groundwater Being Used within the District on an Annual Basis

The Estimated Historical Water Use from the TWDB Historical Water Use Survey (WUS) are estimations of the historical quantity of groundwater used in the area served by the District. It will be used as a guide to estimate future demands on the resource in the District. It should be emphasized that the quantities shown are estimates.

Please refer to Appendix A, pg. 3 and 4

Annual Amount of Recharge From Precipitation to the Groundwater Resources within the District (GAM Run 16-013)

Please refer to Appendix B

Annual Amount of Water that Discharges from the Aquifer to Springs and any Surface Water Bodies within each aquifer of the District (GAM Run 16-013)

Please refer to Appendix B

Annual Volume of Flow into the District, out of the District, and Between Aquifers in the District (GAM Run 16-013)

Please refer to Appendix B

Surface Water Resources

The most significant surface water resource of benefit to the District is water pumped from the Colorado River Municipal Water District watershed to the City of Stanton. However, no surface water management entities exist within the District.

We will provide Colorado River Municipal Water District a copy of our Management Plan for their comments.

Projected Surface Water Supply *within the District*

Please refer to Appendix A, pg. 5

Projected Groundwater Supply and Demand

Projecting groundwater supply and demand is an arduous process. In order to make such projections, one must predict trends of groundwater use. Assumptions must be made regarding population changes, changing agricultural cropping strategies, economic development patterns, and future weather patterns. Naturally, the farther into the future one projects, the less accurate the projections become.

Projected Total Demand for Water *within the District*

Please refer to Appendix A, pg. 6

Water Supply Needs

Please refer to Appendix A, pg. 7

Water Management Strategies

Please refer to Appendix A, pgs. 8, 9, 10, and 11

Management of Groundwater Resources

The District will endeavor to manage groundwater resources, over which it has jurisdictional authority, in order to conserve the resource while seeking to maintain the economic viability of the District's constituents. A water level monitoring network has been established in order to track water level changes in aquifers each year. The District will employ all technical resources at its disposal to monitor and evaluate the groundwater resource and programs designed to encourage conservation of the same.

Method for Tracking the District's Progress in Achieving Management Goals

The District staff will prepare an annual report to the Board of Directors of the District's performance with regard to achieving management goals and objectives. The report will be maintained on file in the open records of the District.

Actions, Procedures, Performance and Avoidance for Plan Implementation as required by {TWC §36.1071(e)(2)}.

The District will implement the provisions of this plan and will utilize the provisions of this plan as a guidepost for determining the direction or priority for all District activities. All operations of the District, all agreements entered into by the District and any additional planning efforts in which the District may participate will be consistent with the provisions of this plan.

The District has rules relating to the permitting of wells. The rules adopted by the District are pursuant to TWC §36 and the provisions of this plan. All rules will be adhered to and enforced. The promulgation and enforcement of the rules will be based on the best technical evidence available. District rules are available on the District's website at www.pbuwcd.com/fies/rulespd.pdf

The District will seek the cooperation in the implementation of this plan and the management of groundwater supplies within the District. All activities of the District will be undertaken in cooperation and coordinated with the appropriate state, regional or local management entity.

Management Goals and Performance Standards

<u>Goal 1.0</u> *Providing the Most Efficient Use of Groundwater*

1.01 - ***Objective - Water Level Monitoring*** - Annually measure and record water level measurements in a water level monitoring network of the District

1.01 - Performance Standards

1.01a **-** The District will maintain a water level monitoring network, annually measure 80% of the wells in the network, and report in the annual report to the Board of Directors.

1.02 - Objective - Well Permitting and Well Completion **-** The District will issue water well drilling permits for non-exempt water wells in accordance with its' rules.

1.02 - Performance Standards

1.02a **-** The Board of Directors will vote on approval of permits at the regularly scheduled meeting after the permit has been issued and report the total annual number of issued water well drilling permits in the annual report to the Board of Directors.

<u>Goal 2.0</u> *Controlling and Preventing Waste of Groundwater*

2.01 - Objective - Laboratory Services

2.01 - Performance Standards

2.01a **-** The District will provide basic and/or coliform water quality testing upon request, communicate test results to constituents, and report the total annual number of water quality tests performed in the annual report to the Board of Directors.

2.02 - Objective - Open or Uncovered Wells

2.02** - **Performance Standards

2.02a **-** The District will inspect any open or uncovered wells found or reported each year, insure that a found or open hole is properly closed according to statute to prevent potential contamination of the aquifer, and report the total annual number of open or uncovered wells in the annual report to the Board of Directors.

2.03 - Objective - Salt Water Disposal Well Monitoring

2.03 - Performance Standards

2.03a **-** The District will inspect 80% of known salt water disposal wells for indications of pollution potential and report in the annual report to the Board of Directors.

<u>Goal 3.0</u> *Addressing Drought Conditions* **-** Drought information by the Texas Water Development Board (TWDB) is available online: http://www.twdb.state.tx.us/data/drought/

3.01** - **Objective - Drought Education

3.01** - **Performance Standards

3.01a **-** The District will monitor the drought conditions and submit a minimum of one article annually to a newspaper of general circulation within the District focused on water conservation tips and drought awareness if necessary. The annual numbers of articles submitted to the newspaper will be reported in the annual report to the Board of Directors.

<u>Goal 4.0</u> *Addressing Conservation, Recharge Enhancement, Rainwater Harvesting, Precipitation Enhancement and Brush control where appropriate and cost effective. (36.1071(a)(7))*

4.01 *-* ***Objective*** *-* ***Conservation***

4.01 - Performance Standard - Each year the District will provide a minimum of one educational material regarding water conservation to public schools within the District and report it in the annual report to the Board of Directors.

4.02 - Recharge Enhancement - A review of past work conducted by others indicates this goal is not appropriate at present; therefore this goal is not applicable.

4.03 - Objective - Rainwater Harvesting - provide and distribute literature on rainwater harvesting and promote the conservation and efficient use of water.

4.03 - Performance Standard - Each year the District staff will submit a minimum of one article on rainwater harvesting to a newspaper of general circulation located within the District and report it in the annual report to the Board of Directors.

4.04 - Precipitation Enhancement - A review of past work conducted by others indicates this goal is not appropriate at present; therefore this goal is not applicable.

4.05 - Objective - Brush Control - provide and distribute literature on brush control and promote the conservation and efficient use of water.

4.05 - Performance Standard - Each year the District staff will submit a minimum of one article on brush control to a newspaper of general circulation located within the District and report it in the annual report to the Board of Directors.

Goal 5.0 *Addressing the Desired Future Conditions adopted by the District*

5.01 *-* ***Objective -*** *Calculate Annual Drawdown*

5.01 - Performance Standards

5.01a. - The District will calculate the average annual drawdown using the results of annual water level measurements to ensure they are meeting the desired future conditions listed in the earlier section of this plan. These results will be reported in the annual report to the Board of Directors.

5.01b - The District will also submit an article detailing the average drawdown results to at least one newspaper of general circulation within the District each year.

Goals Determined not to be Applicable to the District

The following goals referenced in Chapter 36, Texas Water Code, have been determined not applicable to the District;

TWC §36.1071 (a) (3)	Controlling and preventing subsidence
TWC §36.1071 (a) (4)	Addressing conjunctive surface water management issues
TWC §36.1071 (a) (5)	Addressing natural resource issues
TWC §36.1071 (a) (7)	Addressing recharge and precipitation enhancement issues

Appendix A

Estimated Historical Groundwater Use And 2017 State Water Plan Datasets:

Permian Basin Underground Water Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
May 4, 2017

Estimated Historical Groundwater Use And 2017 State Water Plan Datasets:

Permian Basin Underground Water Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
May 4, 2017

GROUNDWATER MANAGEMENT PLAN DATA:

This package of water data reports (part 1 of a 2-part package of information) is being provided to groundwater conservation districts to help them meet the requirements for approval of their five-year groundwater management plan. Each report in the package addresses a specific numbered requirement in the Texas Water Development Board's groundwater management plan checklist. The checklist can be viewed and downloaded from this web address:

http://www.twdb.texas.gov/groundwater/docs/GCD/GMPChecklist0113.pdf

The five reports included in this part are:

1. Estimated Historical Groundwater Use (checklist item 2)

   from the TWDB Historical Water Use Survey (WUS)

2. Projected Surface Water Supplies (checklist item 6)
3. Projected Water Demands (checklist item 7)
4. Projected Water Supply Needs (checklist item 8)
5. Projected Water Management Strategies (checklist item 9)

   from the 2017 Texas State Water Plan (SWP)

Part 2 of the 2-part package is the groundwater availability model (GAM) report for the District (checklist items 3 through 5). The District should have received, or will receive, this report from the Groundwater Availability Modeling Section. Questions about the GAM can be directed to Dr. Shirley Wade, shirley.wade@twdb.texas.gov, (512) 936-0883.

DISCLAIMER:

The data presented in this report represents the most up-to-date WUS and 2017 SWP data available as of 5/4/2017. Although it does not happen frequently, either of these datasets are subject to change pending the availability of more accurate WUS data or an amendment to the 2017 SWP. District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The WUS dataset can be verified at this web address:

http://www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/

The 2017 SWP dataset can be verified by contacting Sabrina Anderson (sabrina.anderson@twdb.texas.gov or 512-936-0886).

The values presented in the data tables of this report are county-based. In cases where groundwater conservation districts cover only a portion of one or more counties the data values are modified with an apportioning multiplier to create new values that more accurately represent conditions within district boundaries. The multiplier used in the following formula is a land area ratio: (data value * (land area of district in county / land area of county)). For two of the four SWP tables (Projected Surface Water Supplies and Projected Water Demands) only the county-wide water user group (WUG) data values (county other, manufacturing, steam electric power, irrigation, mining and livestock) are modified using the multiplier. WUG values for municipalities, water supply corporations, and utility districts are not apportioned; instead, their full values are retained when they are located within the district, and eliminated when they are located outside (we ask each district to identify these entity locations).

The remaining SWP tables (Projected Water Supply Needs and Projected Water Management Strategies) are not modified because district-specific values are not statutorily required. Each district needs only "consider" the county values in these tables.

In the WUS table every category of water use (including municipal) is apportioned. Staff determined that breaking down the annual municipal values into individual WUGs was too complex.

TWDB recognizes that the apportioning formula used is not perfect but it is the best available process with respect to time and staffing constraints. If a district believes it has data that is more accurate it can add those data to the plan with an explanation of how the data were derived. Apportioning percentages that the TWDB used are listed above each applicable table.

For additional questions regarding this data, please contact Stephen Allen (stephen.allen@twdb.texas.gov or 512-463-7317) or Rima Petrossian (rima.petrossian@twdb.texas.gov or 512-936-2420).

Estimated Historical Water Use
TWDB Historical Water Use Survey (WUS) Data

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2016. TWDB staff anticipates the calculation and posting of these estimates at a later date.

HOWARD COUNTY *94.81% (multiplier)* All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2015	GW	1,100	413	1,964	221	3,509	171	7,378
	SW	4,574	1,444	0	86	0	30	6,134
2014	GW	959	671	1,430	210	5,451	171	8,892
	SW	3,937	1,071	0	94	0	30	5,132
2013	GW	2,682	749	802	0	4,733	175	9,141
	SW	2,092	1,040	0	301	0	30	3,463
2012	GW	1,963	525	758	0	6,337	168	9,751
	SW	1,342	946	0	405	0	29	2,722
2011	GW	4,556	638	455	0	9,738	210	15,597
	SW	283	1,340	145	283	0	37	2,088
2010	GW	4,561	1,666	299	0	6,372	200	13,098
	SW	283	1,231	95	367	0	35	2,011
2009	GW	4,288	457	189	0	6,447	174	11,555
	SW	278	2,176	60	433	0	31	2,978
2008	GW	4,477	2,164	79	0	4,599	188	11,507
	SW	324	1,007	24	493	0	33	1,881
2007	GW	5,498	593	3	0	5,878	255	12,227
	SW	338	2,578	0	662	0	45	3,623
2006	GW	3,578	557	4	0	2,991	174	7,304
	SW	396	1,448	0	573	0	30	2,447
2005	GW	4,660	426	3	0	2,682	160	7,931
	SW	1,995	2,647	0	679	0	28	5,349
2004	GW	4,812	394	1	0	2,628	143	7,978
	SW	337	1,702	0	509	0	36	2,584
2003	GW	5,338	451	2	0	2,252	143	8,186
	SW	340	1,614	0	963	0	35	2,952
2002	GW	6,340	601	2	0	2,903	201	10,047
	SW	361	975	0	1,520	0	50	2,906
2001	GW	6,397	393	1	0	3,102	220	10,113
	SW	331	1,444	0	1,138	0	55	2,968
2000	GW	6,363	486	0	0	4,583	237	11,669
	SW	385	1,237	0	1,214	18	59	2,913

MARTIN COUNTY *100% (multiplier)* All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2015	GW	394	0	4,545	0	35,488	59	40,486
	SW	310	0	0	0	0	25	335
2014	GW	414	0	3,317	0	37,632	58	41,421
	SW	308	0	0	0	0	25	333
2013	GW	501	0	2,094	0	41,967	67	44,629
	SW	310	0	0	0	0	28	338
2012	GW	468	0	2,527	0	31,757	76	34,828
	SW	320	0	0	0	0	33	353
2011	GW	557	0	1,587	0	34,940	111	37,195
	SW	291	0	770	0	0	47	1,108
2010	GW	344	0	497	0	36,160	103	37,104
	SW	332	0	226	0	0	44	602
2009	GW	157	0	514	0	36,970	66	37,707
	SW	294	0	234	0	0	29	557
2008	GW	88	0	531	0	28,482	72	29,173
	SW	294	0	242	0	0	31	567
2007	GW	79	0	39	0	25,872	90	26,080
	SW	294	0	0	0	0	38	332
2006	GW	86	0	53	0	15,626	90	15,855
	SW	294	0	0	0	0	39	333
2005	GW	73	0	36	0	16,152	55	16,316
	SW	297	0	0	0	0	23	320
2004	GW	73	0	24	0	14,652	81	14,830
	SW	315	0	0	0	0	20	335
2003	GW	101	0	22	0	13,176	68	13,367
	SW	220	0	0	0	0	17	237
2002	GW	103	0	18	0	16,436	147	16,704
	SW	144	0	0	0	0	37	181
2001	GW	109	0	50	0	16,381	168	16,708
	SW	129	0	0	0	0	42	171
2000	GW	107	0	41	0	14,575	544	15,267
	SW	278	0	0	0	0	136	414

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

HOWARD COUNTY

94.81% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	BIG SPRING	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM	1,960	2,695	2,442	2,189	1,974	1,786
F	COAHOMA	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM	58	80	73	65	58	53
F	LIVESTOCK, HOWARD	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	59	59	59	59	59	59
F	MANUFACTURING, HOWARD	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM	453	610	551	499	449	408
F	MINING, HOWARD	COLORADO	CRMWD DIVERTED WATER SYSTEM	0	0	0	0	0	0
	Sum of Projected Surface Water Supplies (acre-feet)			**2,530**	**3,444**	**3,125**	**2,812**	**2,540**	**2,306**

MARTIN COUNTY

100% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	LIVESTOCK, MARTIN	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	67	67	67	67	67	67
F	STANTON	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM	172	248	235	223	208	194
	Sum of Projected Surface Water Supplies (acre-feet)			**239**	**315**	**302**	**290**	**275**	**261**

Projected Water Demands
TWDB 2017 State Water Plan Data

Please note that the demand numbers presented here include the plumbing code savings found in the Regional and State Water Plans.

HOWARD COUNTY

94.81% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	BIG SPRING	COLORADO	6,149	6,288	6,299	6,248	6,238	6,237
F	COAHOMA	COLORADO	183	186	188	187	187	187
F	COUNTY-OTHER, HOWARD	COLORADO	849	847	842	840	837	837
F	IRRIGATION, HOWARD	COLORADO	6,373	6,300	6,226	6,153	6,080	6,008
F	LIVESTOCK, HOWARD	COLORADO	300	300	300	300	300	300
F	MANUFACTURING, HOWARD	COLORADO	2,605	2,723	2,839	2,936	3,119	3,314
F	MINING, HOWARD	COLORADO	2,362	2,604	1,839	1,079	451	189
		Sum of Projected Water Demands (acre-feet)	**18,821**	**19,248**	**18,533**	**17,743**	**17,212**	**17,072**

MARTIN COUNTY

100% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, MARTIN	COLORADO	342	363	376	392	406	418
F	IRRIGATION, MARTIN	COLORADO	36,322	35,674	35,026	34,381	33,746	33,123
F	LIVESTOCK, MARTIN	COLORADO	128	128	128	128	128	128
F	MANUFACTURING, MARTIN	COLORADO	41	42	43	44	47	50
F	MINING, MARTIN	COLORADO	3,527	2,998	2,251	1,441	771	413
F	STANTON	COLORADO	539	579	606	635	658	677
		Sum of Projected Water Demands (acre-feet)	**40,899**	**39,784**	**38,430**	**37,021**	**35,756**	**34,809**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

Negative values (in red) reflect a projected water supply need, positive values a surplus.

HOWARD COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	BIG SPRING	COLORADO	-2,887	-1,728	-2,115	-2,454	-2,775	-3,058
F	COAHOMA	COLORADO	-87	-50	-63	-74	-84	-92
F	COUNTY-OTHER, HOWARD	COLORADO	-449	-485	-480	-478	-475	-475
F	IRRIGATION, HOWARD	COLORADO	-3,233	-3,415	-3,337	-3,260	-3,183	-3,107
F	LIVESTOCK, HOWARD	COLORADO	-114	-129	-129	-129	-129	-129
F	MANUFACTURING, HOWARD	COLORADO	-1,319	-1,185	-1,399	-1,587	-1,859	-2,132
F	MINING, HOWARD	COLORADO	-2,328	-2,591	-1,784	-982	-320	-43
		Sum of Projected Water Supply Needs (acre-feet)	**-10,417**	**-9,583**	**-9,307**	**-8,964**	**-8,825**	**-9,036**

MARTIN COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, MARTIN	COLORADO	-211	-222	-216	-233	-239	-243
F	IRRIGATION, MARTIN	COLORADO	-25,157	-24,552	-23,084	-23,231	-22,640	-22,044
F	LIVESTOCK, MARTIN	COLORADO	-38	-37	-35	-36	-36	-35
F	MANUFACTURING, MARTIN	COLORADO	-25	-26	-25	-26	-28	-29
F	MINING, MARTIN	COLORADO	-3,039	-2,503	-1,710	-926	-249	118
F	STANTON	COLORADO	-245	-150	-193	-239	-282	-320
		Sum of Projected Water Supply Needs (acre-feet)	**-28,715**	**-27,490**	**-25,263**	**-24,691**	**-23,474**	**-22,671**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

HOWARD COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
BIG SPRING, COLORADO (F)							
ASR OF EXISTING SURFACE WATER SUPPLIES IN WARD COUNTY WELL FIELD - CRMWD	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	0	64	58	64	71	77
CRMWD - DESALINATION OF BRACKISH SURFACE WATER	CRMWD DIVERTED WATER SYSTEM [RESERVOIR]	0	0	39	43	48	52
MUNICIPAL CONSERVATION - BIG SPRING	DEMAND REDUCTION [HOWARD]	181	191	193	193	193	193
SUBORDINATION - CRMWD SYSTEM	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	2,887	1,727	2,115	2,453	2,773	3,058
WARD COUNTY WELL FIELD EXPANSION AND DEVELOPMENT OF WINKLER COUNTY WELL FIELD - CRMWD	PECOS VALLEY AQUIFER [WARD]	74	57	52	58	63	69
WARD COUNTY WELL FIELD EXPANSION AND DEVELOPMENT OF WINKLER COUNTY WELL FIELD - CRMWD	PECOS VALLEY/EDWARDS-TRINITY (PLATEAU) AQUIFER [WINKLER]	112	85	79	87	95	104
		3,254	**2,124**	**2,536**	**2,898**	**3,243**	**3,553**
COAHOMA, COLORADO (F)							
MUNICIPAL CONSERVATION - COAHOMA	DEMAND REDUCTION [HOWARD]	5	5	5	5	5	5
SUBORDINATION - CRMWD SYSTEM	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	86	51	63	73	83	92
WATER AUDITS AND LEAK - COAHOMA	DEMAND REDUCTION [HOWARD]	9	9	9	9	9	9
		100	**65**	**77**	**87**	**97**	**106**
COUNTY-OTHER, HOWARD, COLORADO (F)							
ASR OF EXISTING SURFACE WATER SUPPLIES IN WARD COUNTY WELL FIELD - CRMWD	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	0	150	123	122	121	121
CRMWD - DESALINATION OF BRACKISH SURFACE WATER	CRMWD DIVERTED WATER SYSTEM [RESERVOIR]	0	0	82	82	82	82
WARD COUNTY WELL FIELD EXPANSION AND DEVELOPMENT OF WINKLER COUNTY WELL FIELD - CRMWD	PECOS VALLEY AQUIFER [WARD]	180	134	110	110	109	109

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
WARD COUNTY WELL FIELD EXPANSION AND DEVELOPMENT OF WINKLER COUNTY WELL FIELD - CRMWD	PECOS VALLEY/EDWARDS-TRINITY (PLATEAU) AQUIFER [WINKLER]	269	201	165	164	164	164
		449	**485**	**480**	**478**	**476**	**476**
IRRIGATION, HOWARD, COLORADO (F)							
IRRIGATION CONSERVATION - HOWARD COUNTY	DEMAND REDUCTION [HOWARD]	336	665	722	722	722	722
		336	**665**	**722**	**722**	**722**	**722**
LIVESTOCK, HOWARD, COLORADO (F)							
DEVELOP ADDITIONAL DOCKUM AQUIFER SUPPLIES - HOWARD COUNTY LIVESTOCK	DOCKUM AQUIFER [HOWARD]	150	150	150	150	150	150
		150	**150**	**150**	**150**	**150**	**150**
MANUFACTURING, HOWARD, COLORADO (F)							
ASR OF EXISTING SURFACE WATER SUPPLIES IN WARD COUNTY WELL FIELD - CRMWD	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	0	239	229	255	304	357
CRMWD - DESALINATION OF BRACKISH SURFACE WATER	CRMWD DIVERTED WATER SYSTEM [RESERVOIR]	0	0	154	171	205	240
SUBORDINATION - CRMWD SYSTEM	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	705	412	504	589	668	736
WARD COUNTY WELL FIELD EXPANSION AND DEVELOPMENT OF WINKLER COUNTY WELL FIELD - CRMWD	PECOS VALLEY AQUIFER [WARD]	246	214	205	229	273	320
WARD COUNTY WELL FIELD EXPANSION AND DEVELOPMENT OF WINKLER COUNTY WELL FIELD - CRMWD	PECOS VALLEY/EDWARDS-TRINITY (PLATEAU) AQUIFER [WINKLER]	368	320	307	343	409	479
		1,319	**1,185**	**1,399**	**1,587**	**1,859**	**2,132**
MINING, HOWARD, COLORADO (F)							
DEVELOP ADDITIONAL DOCKUM AQUIFER SUPPLIES - HOWARD COUNTY MINING	DOCKUM AQUIFER [HOWARD]	274	274	274	274	274	274
DEVELOP ADDITIONAL OGALLALA AQUIFER SUPPLIES - HOWARD COUNTY MINING	OGALLALA AQUIFER [HOWARD]	20	31	31	31	3	3
MINING CONSERVATION - HOWARD COUNTY	DEMAND REDUCTION [HOWARD]	174	192	136	80	33	14

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

WUG, Basin (RWPG) — All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
SUBORDINATION - CRMWD BRACKISH WATER SYSTEM	CRMWD DIVERTED WATER SYSTEM [RESERVOIR]	1,238	1,240	1,242	982	320	43
		1,706	**1,737**	**1,683**	**1,367**	**630**	**334**
Sum of Projected Water Management Strategies (acre-feet)		**7,314**	**6,411**	**7,047**	**7,289**	**7,177**	**7,473**

MARTIN COUNTY

WUG, Basin (RWPG) — All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, MARTIN, COLORADO (F)							
DEVELOP ADDITIONAL DOCKUM AQUIFER SUPPLIES - MARTIN COUNTY OTHER	DOCKUM AQUIFER [MARTIN]	250	250	250	250	250	250
		250	**250**	**250**	**250**	**250**	**250**
IRRIGATION, MARTIN, COLORADO (F)							
IRRIGATION CONSERVATION - MARTIN COUNTY	DEMAND REDUCTION [MARTIN]	1,816	3,567	5,254	5,254	5,254	5,254
		1,816	**3,567**	**5,254**	**5,254**	**5,254**	**5,254**
LIVESTOCK, MARTIN, COLORADO (F)							
DEVELOP ADDITIONAL DOCKUM AQUIFER SUPPLIES - MARTIN COUNTY LIVESTOCK	DOCKUM AQUIFER [MARTIN]	40	40	40	40	40	40
		40	**40**	**40**	**40**	**40**	**40**
MANUFACTURING, MARTIN, COLORADO (F)							
VOLUNTARY TRANSFER FROM IRRIGATION - MARTIN COUNTY MANUFACTURING	OGALLALA AQUIFER [MARTIN]	25	26	25	26	28	29
		25	**26**	**25**	**26**	**28**	**29**
MINING, MARTIN, COLORADO (F)							
DEVELOP ADDITIONAL DOCKUM AQUIFER SUPPLIES - MARTIN COUNTY MINING	DOCKUM AQUIFER [MARTIN]	210	210	210	210	210	210
DEVELOP ADDITIONAL EDWARDS-TRINITY PLATEAU AQUIFER SUPPLIES - MARTIN COUNTY MINING	EDWARDS-TRINITY-PLATEAU AQUIFER [MARTIN]	1,500	1,500	1,000	1,000	500	500
MINING CONSERVATION - MARTIN COUNTY	DEMAND REDUCTION [MARTIN]	247	210	158	101	54	29

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

WUG, Basin (RWPG) All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
REUSE - MIDLAND DIRECT NON-POTABLE SALES TO MINING	DIRECT REUSE [MIDLAND]	1,500	1,200	600	500	0	0
		3,457	**3,120**	**1,968**	**1,811**	**764**	**739**
STANTON, COLORADO (F)							
MUNICIPAL CONSERVATION - STANTON	DEMAND REDUCTION [MARTIN]	15	17	18	19	20	20
SUBORDINATION - CRMWD SYSTEM	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	253	159	203	249	292	332
		268	**176**	**221**	**268**	**312**	**352**
Sum of Projected Water Management Strategies (acre-feet)		**5,856**	**7,179**	**7,758**	**7,649**	**6,648**	**6,664**

Appendix B

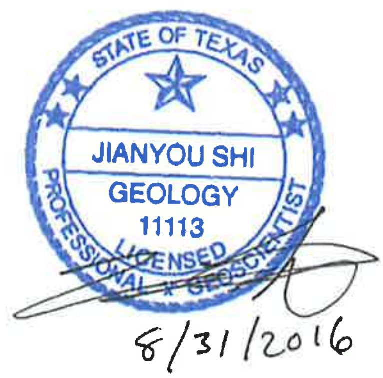
GAM Run 16-013: Permian Basin Underground Water Conservation District Management Plan

Jerry (Jianyou) Shi, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 463-5076
August 31, 2016

GAM Run 16-013: Permian Basin Underground Water Conservation District Management Plan

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

August 31, 2016



GAM Run 16-013: Permian Basin Underground Water Conservation District Management Plan

Jerry (Jianyou) Shi, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 463-5076
August 31, 2016

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2015), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator.

The TWDB provides data and information to the Permian Basin Underground Water Conservation District in two parts. Part 1 is the Estimated Historical Water Use/State Water Plan dataset report, which will be provided to you separately by the TWDB Groundwater Technical Assistance Section. Please direct questions about the water data report to Mr. Stephen Allen at (512) 463-7317 or stephen.allen@twdb.texas.gov. Part 2 is the required groundwater availability modeling information and this information includes:

1. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;

2. for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers; and

3. the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

The groundwater management plan for the Permian Basin Underground Water Conservation District should be adopted by the district on or before August 2, 2017, and submitted to the executive administrator of the TWDB on or before September 1,

2017. The current management plan for the Permian Basin Underground Water Conservation District expires on October 31, 2017.

In the Permian Basin Underground Water Conservation District, there are three aquifers identified by the TWDB: the Ogallala Aquifer, the Edwards-Trinity (Plateau) Aquifer, and the Dockum Aquifer. Two groundwater availability models were used to extract the management plan information for the aquifers within the Permian Basin Underground Water Conservation District. Information for the Ogallala and Dockum aquifers is from version 1.01 of the groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015). Information for the Edwards-Trinity (Plateau) Aquifer is from version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer (Anaya and Jones, 2009).

This report discusses the methods, assumptions, and results from the model runs for the Ogallala Aquifer, the Edwards-Trinity (Plateau) Aquifer, and the Dockum Aquifer described above. This report replaces the results of GAM Run 12-007 (Kohlrenken, 2012). GAM Run 16-013 meets current standards set after the release of GAM Run 12-007 and includes results from the recently released groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015). Tables 1 through 3 summarize the groundwater availability model data required by statute. Figures 1 through 3 show the areas of the models from which the values in Tables 1 through 3 were extracted. If after review of the figures, the Permian Basin Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability model for the High Plains Aquifer System and the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer were used to extract information for the Ogallala Aquifer, the Edwards-Trinity (Plateau) Aquifer, and the Dockum Aquifer. The water budget for the Permian Basin Underground Water Conservation District was extracted for the historical model periods (1980 through 2012 for the Ogallala and Dockum aquifers and 1981 through 2000 for the Edwards-Trinity (Plateau) Aquifer) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface-water outflow, inflow to the district, and outflow from the district for the three aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Ogallala and Dockum Aquifers

1. 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 model.

2. The model was run with MODFLOW-NWT (Niswonger and others, 2011).

3. The groundwater availability model for the High Plains Aquifer System contains four layers:

    - Layer 1—the Ogallala Aquifer and the Pecos Valley Alluvium Aquifer

    - Layer 2—the Rita Blanca Aquifer, the Edwards-Trinity (High Plains) Aquifer, the Edwards-Trinity (Plateau) Aquifer, and pass through cells of the Dockum Aquifer

    - Layer 3—the upper Dockum Group and pass through cells of the lower Dockum Group

    - Layer 4—the lower Dockum Group

4. Perennial rivers and reservoirs were simulated using MODFLOW-NWT river package. Springs, seeps, and draws were simulated using MODFLOW-NWT drain package. For this analysis, groundwater discharge to surface water includes groundwater leakage to the river and drain packages.

Edwards-Trinity (Plateau) Aquifer

1. We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer. See Anaya and Jones (2009) for assumptions and limitations of the model.

2. The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

3. The model has two active layers:

    - Layer 1—the Edwards-Trinity (Plateau) Aquifer and the Pecos Valley Alluvium Aquifer

    - Layer 2—the Edwards-Trinity (Plateau) Aquifer

4. Lakes and reservoirs were simulated using MODFLOW-2000 constant head. Springs and seeps were simulated using MODFLOW-2000 drain package. Perennial rivers were simulated using MODFLOW-2000 stream routing package. For this analysis, groundwater discharge to surface water includes groundwater leakage to the drain package because constant head and stream boundaries are not present in the Permian Basin Underground Water Conservation District.

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from two groundwater availability models for the Ogallala Aquifer, the Edwards-Trinity (Plateau) Aquifer, and the Dockum Aquifer within the district and averaged over the historical calibration periods, as shown in Tables 1 through 3.

1. Precipitation recharge—the areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.

2. Surface-water outflow—the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.

3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.

4. Flow between aquifers—the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

The information needed for the district's management plan is summarized in Tables 1 through 3. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

TABLE 1: SUMMARIZED INFORMATION FOR THE OGALLALA AQUIFER FOR THE PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST ONE ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Ogallala Aquifer	50,317
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ogallala Aquifer	11,848
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	5,218
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	3,462
Estimated net annual volume of flow between each aquifer in the district	From Dockum Aquifer to Ogallala Aquifer	13
	From Ogallala Aquifer to Edwards-Trinity (Plateau) Aquifer	253

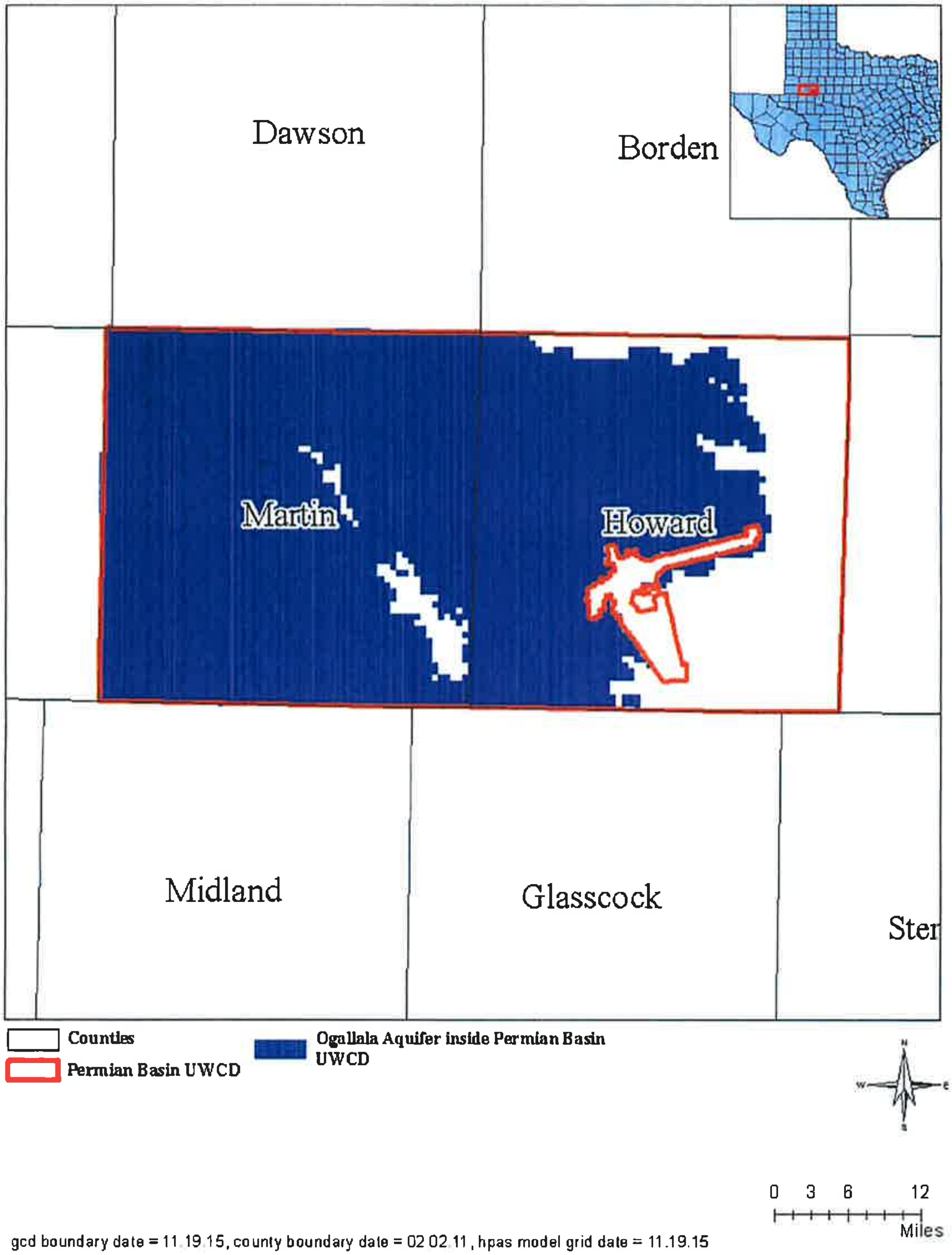


FIGURE 1: AREA OF THE OGALLALA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED FOR THE PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT (UWCD).

TABLE 2: SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FOR THE PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST ONE ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	3,884
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	124
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	2,620
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	6,167
Estimated net annual volume of flow between each aquifer in the district*	From Ogallala Aquifer to Edwards-Trinity (Plateau) Aquifer	253
	From Edwards-Trinity (Plateau) Aquifer to Dockum Aquifer	44

* Flows between each aquifer in the district were extracted from the groundwater availability model for the High Plains Aquifer System (see Tables 1 and 3).

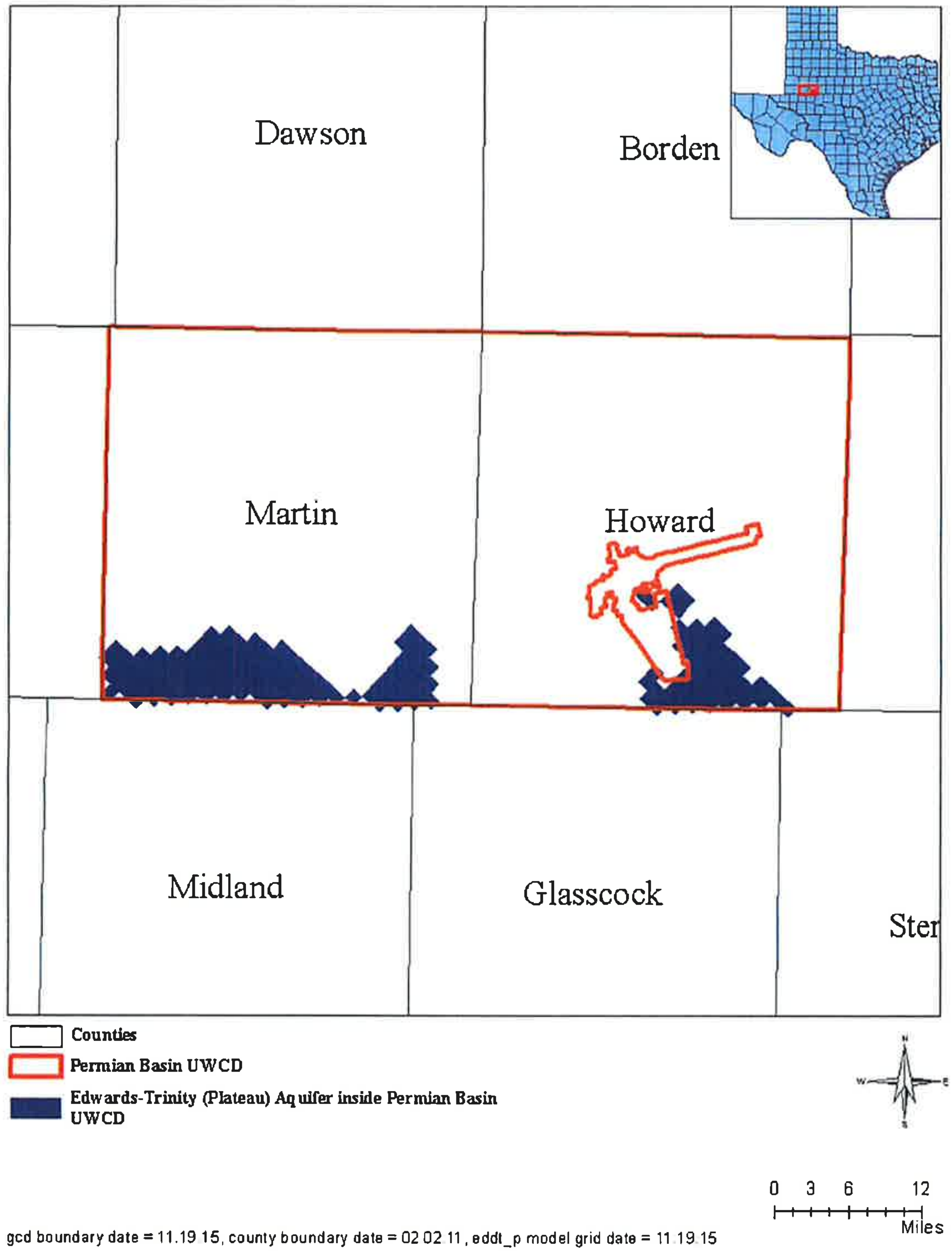


FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED FOR THE PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT (UWCD).

TABLE 3: SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER FOR THE PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST ONE ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Dockum Aquifer	4,695
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Dockum Aquifer	1,696
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	40
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	1,246
Estimated net annual volume of flow between each aquifer in the district	From Dockum Aquifer to Ogallala Aquifer	13
	From Edwards-Trinity (Plateau) Aquifer to Dockum Aquifer	44

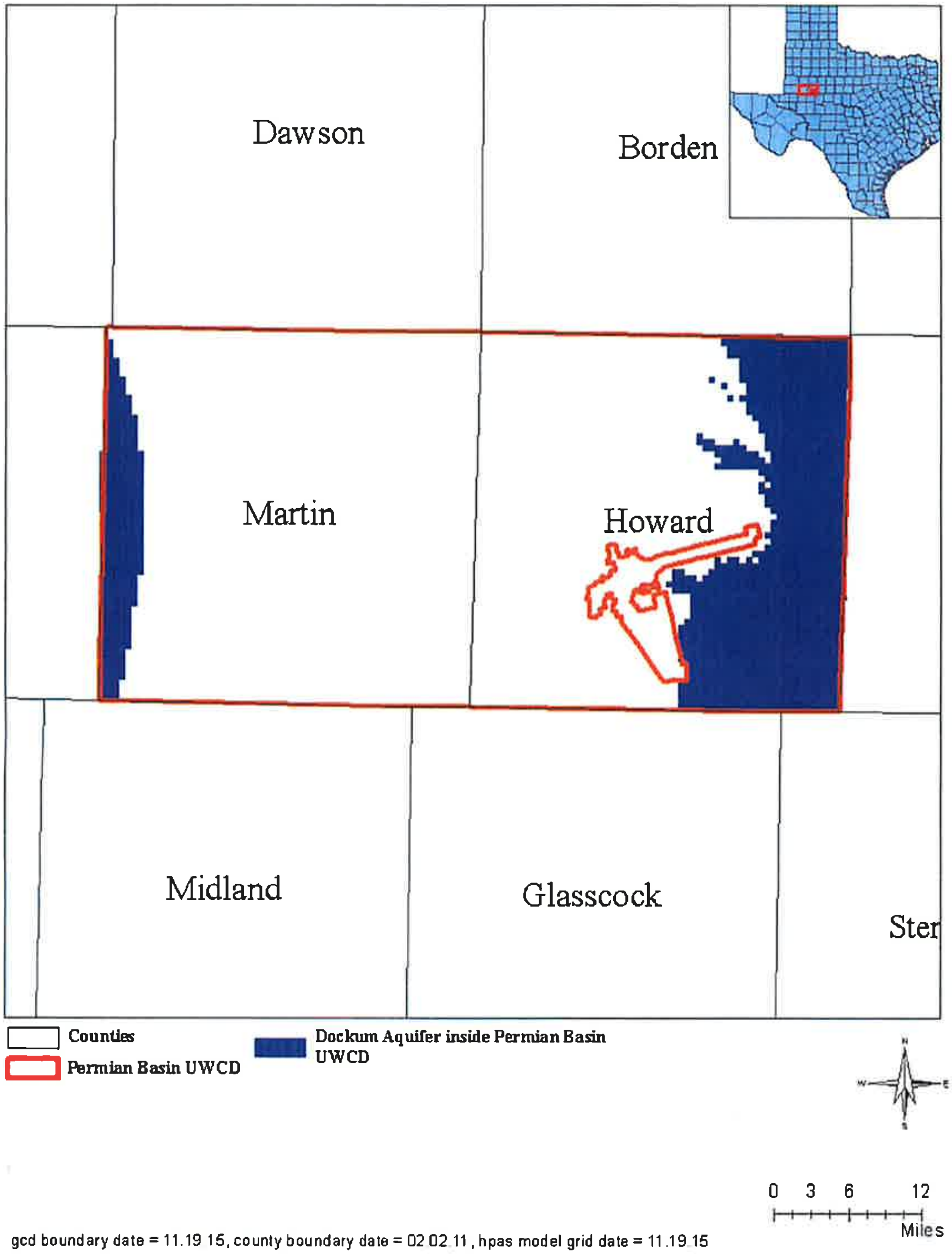


FIGURE 3: AREA OF THE DOCKUM AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED FOR THE PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT (UWCD).

LIMITATIONS:

The groundwater models used in completing this analysis are the best available scientific tools 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 interaction with streams are specific to particular historic time periods.

Because the application of the groundwater models was designed to address regional-scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations related 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 overall conditions of 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:

Anaya, R., and Jones, I., 2009, Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas. Texas Water Development Board Report 373, 113 p., http://www.twdb.texas.gov/groundwater/models/gam/eddt_p/ET-Plateau_Full.pdf

Deeds, N. and Jigmond, M., 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model (August 2015), 640 p. http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf.

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.

Harbaugh, A. W., Banta, E. R., Hill, M. C., and McDonald, M. G., 2000, MODFLOW-2000, the U.S. Geological Survey modular ground-water model -- User guide to modularization concepts and the Ground-Water Flow Process: U.S. Geological Survey Open-File Report 00-92, 121 p.

Kohlrenken, W., 2012, GAM Run 12-007: Permian Basin Underground Water Conservation District Management Plan, 15 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR12-007.pdf.

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: USGS, Techniques and Methods 6-A37, 44 p.

Texas Water Code, 2015, http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf.

Appendix C

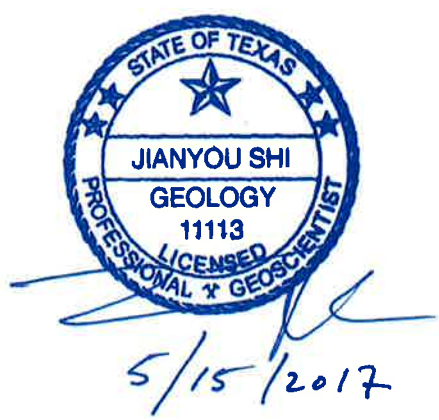
GAM Run 16-028 MAG

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

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



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

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.

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.

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.

- 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.

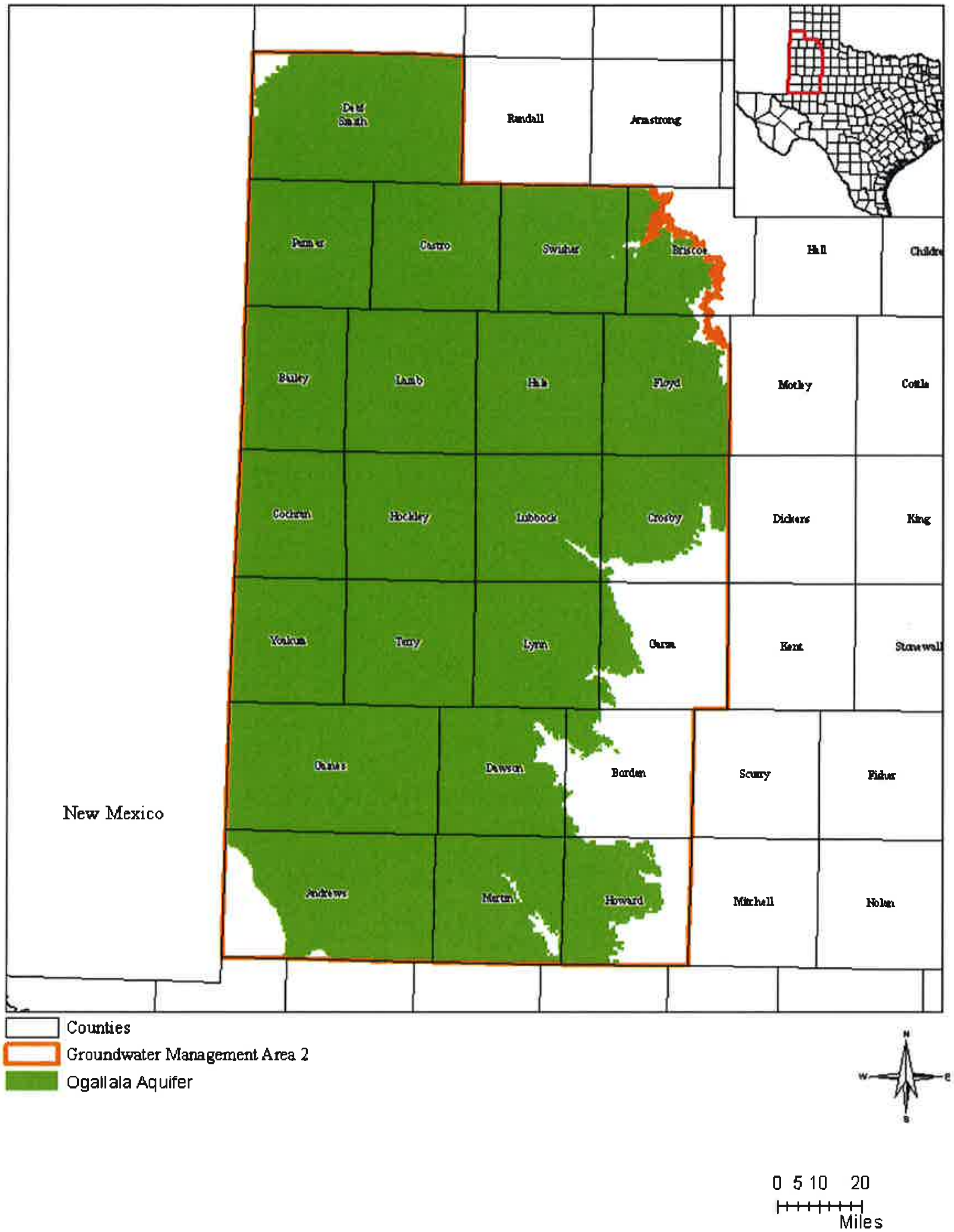


FIGURE 1. MAP SHOWING THE AREA COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE OGALLALA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2.

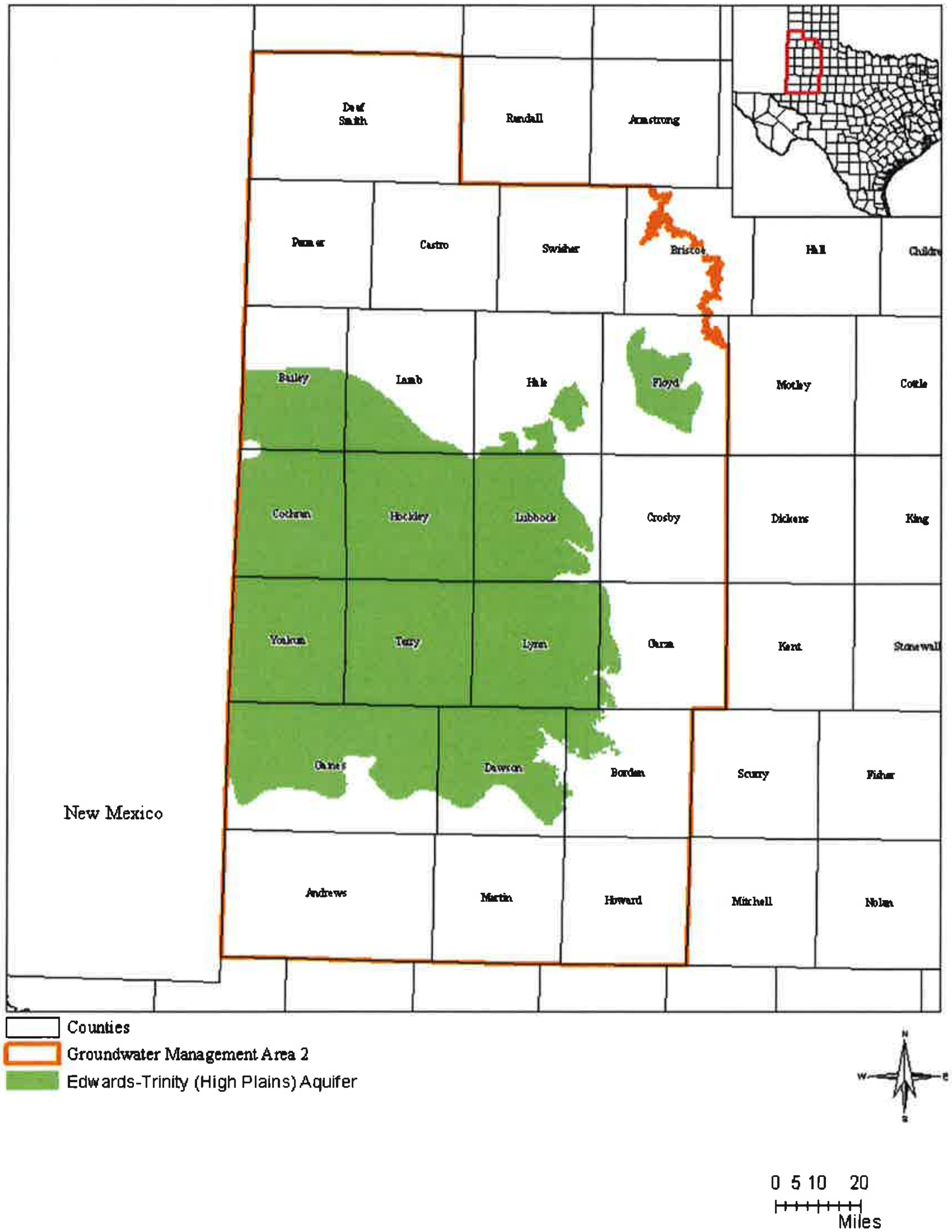


FIGURE 2. MAP SHOWING THE AREA COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2.

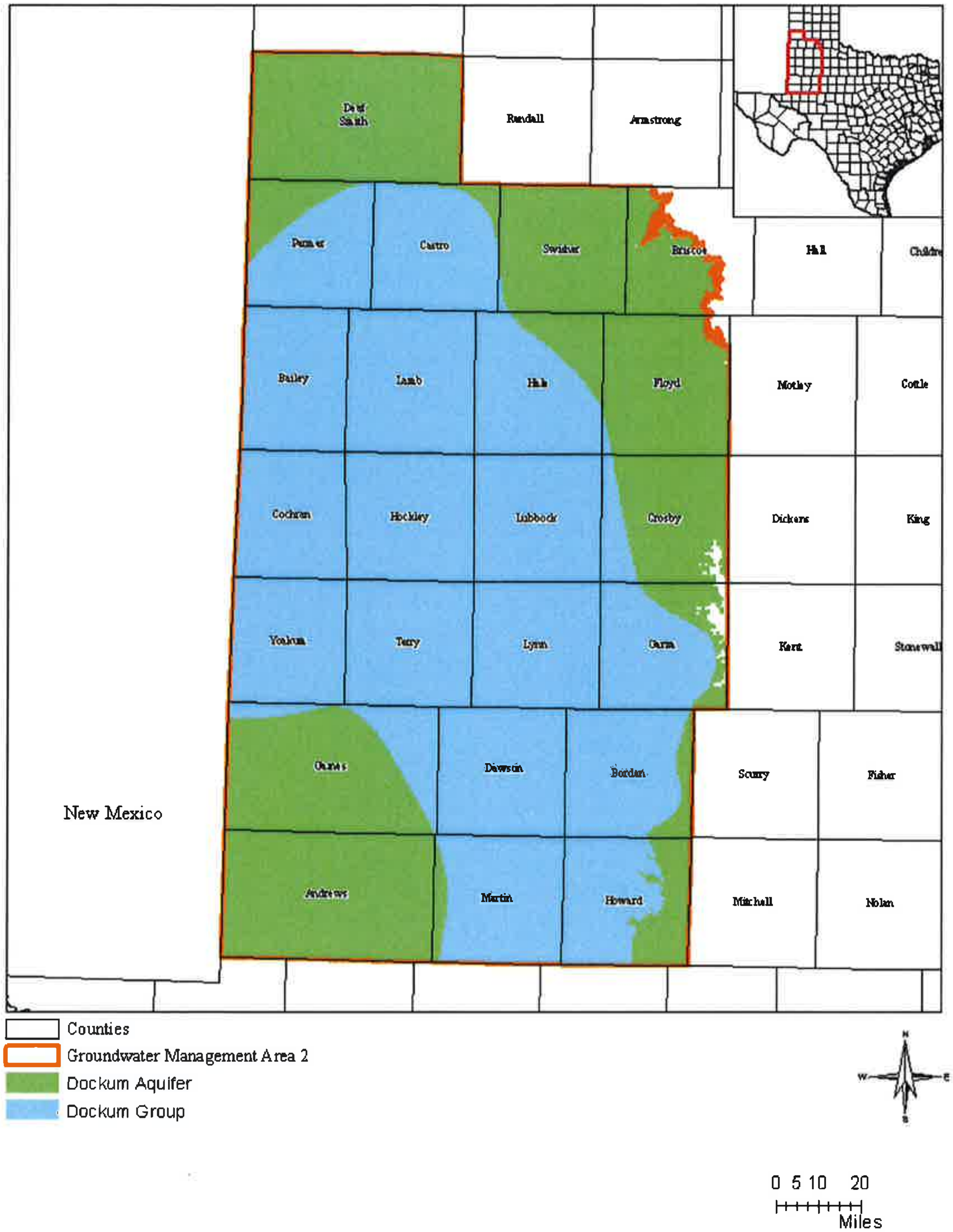


FIGURE 3. **MAP SHOWING THE AREA COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER AND DOCKUM GROUP WITHIN GROUNDWATER MANAGEMENT AREA 2.**

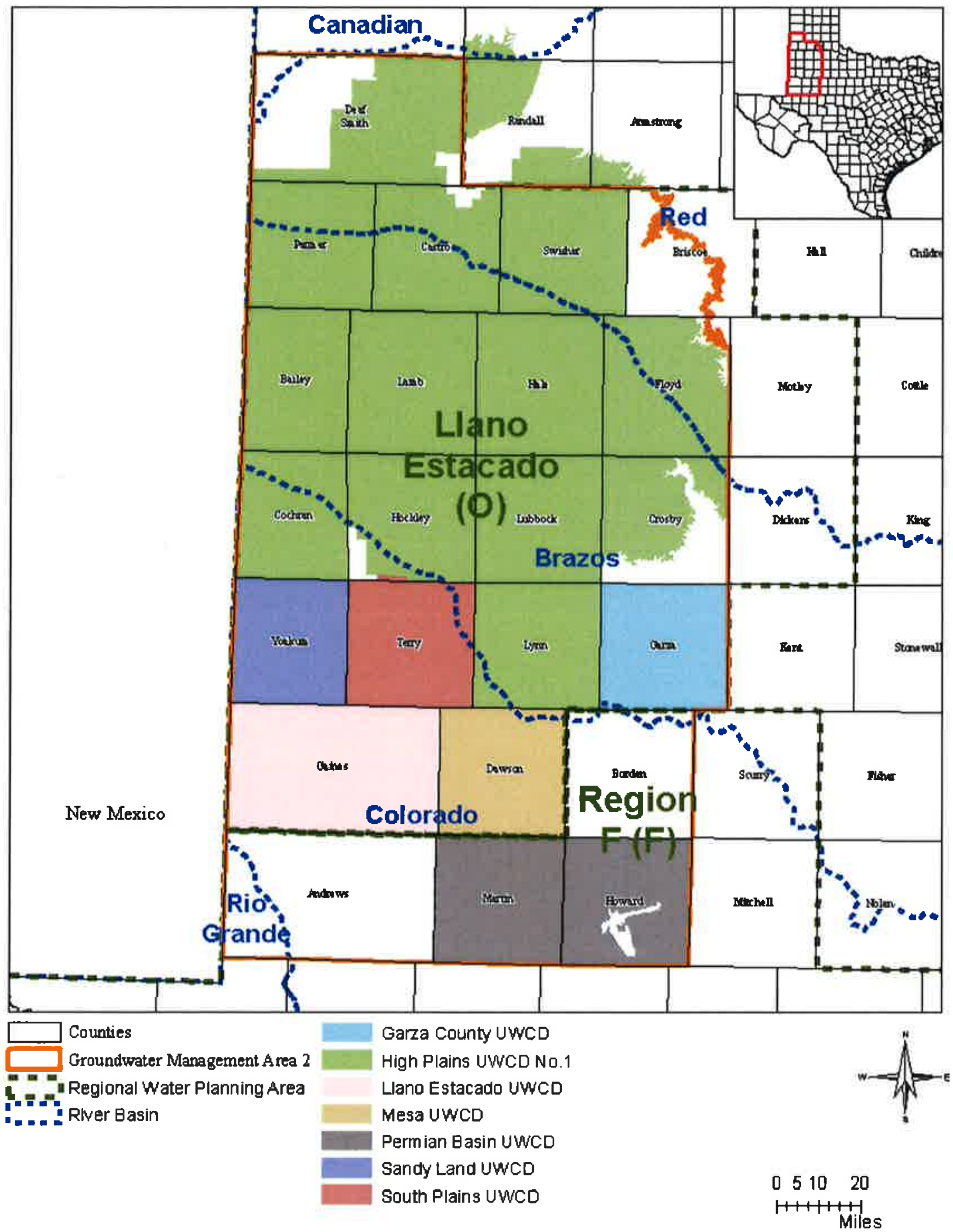


FIGURE 4. **MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS (ALSO KNOWN AS UNDERGROUND WATER CONSERVATION DISTRICT OR UWCD), COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 2.**

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**

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**

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**

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

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**

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

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**

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 .

Hutchison, William, 2016a, GMA 2 Technical Memorandum 15-01 (Final): Ogallala Aquifer.

Hutchison, William, 2016b, GMA 2 Technical Memorandum 15-02 (Final): Edwards-Trinity (High Plains) Aquifer.

Hutchison, William, 2016c, GMA 2 Technical Memorandum 15-03 (Final): Dockum Aquifer.

Hutchison, William, 2016d, GMA 2 Technical Memorandum 16-01 (Final): Predictive Simulation of the Ogallala, Edwards-Trinity (High Plains), and Dockum Aquifers (Scenario 16).

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.