PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT

MANAGEMENT PLAN 2012-2022

P.O. Box 1314
Stanton, Texas 79782

RESOLUTION OF THE PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT

ADOPTING DISTRICT MANAGEMENT PLAN 2012-2022

WHEREAS, the Permian Basin Underground Water Conservation District (the District) was created on April 25, 1985, by authority of HB 2382 of the 69th Texas Legislature; and

WHEREAS, the registered voters of the District confirmed the District's creation in September, 1985; and

WHEREAS, the District adopted a 10 year Management Plan in 1998, as required by the Texas Water Code; and

WHEREAS, SB 1, 75th Texas Legislature required the District to adopt a revised Management Plan every five years stated in Chapter 36.1071, Texas Water Code; and

WHEREAS, the revised Management Plan is required to be certified as administratively complete by the Executive Administrator of the Texas Water Development Board as stated in Chapter 36.1072, Texas Water Code; and

WHEREAS, in 1991 the District annexed the Northwest portion of Howard County; and

WHEREAS, the District annexed the remaining part of Howard County in 2001 except Big Spring and the subdivisions surrounding it; and

WHEREAS, The Board of Directors of the District have determined that a revision of the existing Management Plan is warranted; and

WHEREAS, The Board of Directors of the District have determined that the revised Management Plan adequately addresses the requirements of Chapter 36.1071, 36.1072 and 36.108 of the Texas Water Code and 31 Texas Administrative Code Chapter 356; and

WHEREAS, the revised Management Plan shall become effective on October 1, 2012, upon adoption by the Board of Directors of the District and shall remain in effect until September 30, 2022, or until a revised Plan is adopted, whichever occurs first, therefore be it

RESOLVED, that the Board of Directors of the Permian Basin Underground Water Conservation District hereby adopt the revised Management Plan; and further

RESOLVED that this revised Management Plan shall become effective on October 1, 2012

Adopted this 20th day of September, 2012 by the Board of Directors of the Permian Basin Underground Water Conservation District.

Christopher C Stone

Christopher Stone, Vice President

Raymond Straub Jr., Secretary

State of Texas
County of Martin
This instrument was acknowledged before me on the 20th day of September, 2012.

DONNA HALL SPRINGER
Notary Public, State of Texas
My Commission Expires
JULY 15, 2014

Donna Hall Springer

Notary Public, State of Texas
Notary's Name Printed:

Donna Hall Springer

Notary's Commission Expires:
July 15, 2014

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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 October 1, 2012 upon adoption by the Board of Directors (the Board) of the District and remains in effect until a revised plan is approved or until September 30, 2022, whichever is earlier.

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.

One's goals, management objectives, and performance standards must be set at an attainable level in order to be realistic and effective. Lofty ideals penned in an effort to be *"all things to all people"* can be the first step toward disaster.

Unreasonably elevated objectives foster potentially damaging results when the objective cannot be met due to a lack of resources; fiscal or technical. One's goals can also be set too low. Simplistic ideals can foster mediocrity. In both cases, the mission of the goal setting entity is thwarted and the benefactors of the same slighted. Although well meaning, when the failure to attain a goal is realized by those measuring performance, the initial response is to assume that those setting the goals were negligent in performing their duties when, in truth, the goals were unattainable from the start.

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	Martin	May 2014
Vice-President	Christopher Stone	Martin	May 2016
Secretary	Raymond Straub Jr.	Martin	May 2014
Member	Kent Robinson	Howard	May 2014
Member	Richie Tubb	Howard	May 2016

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.

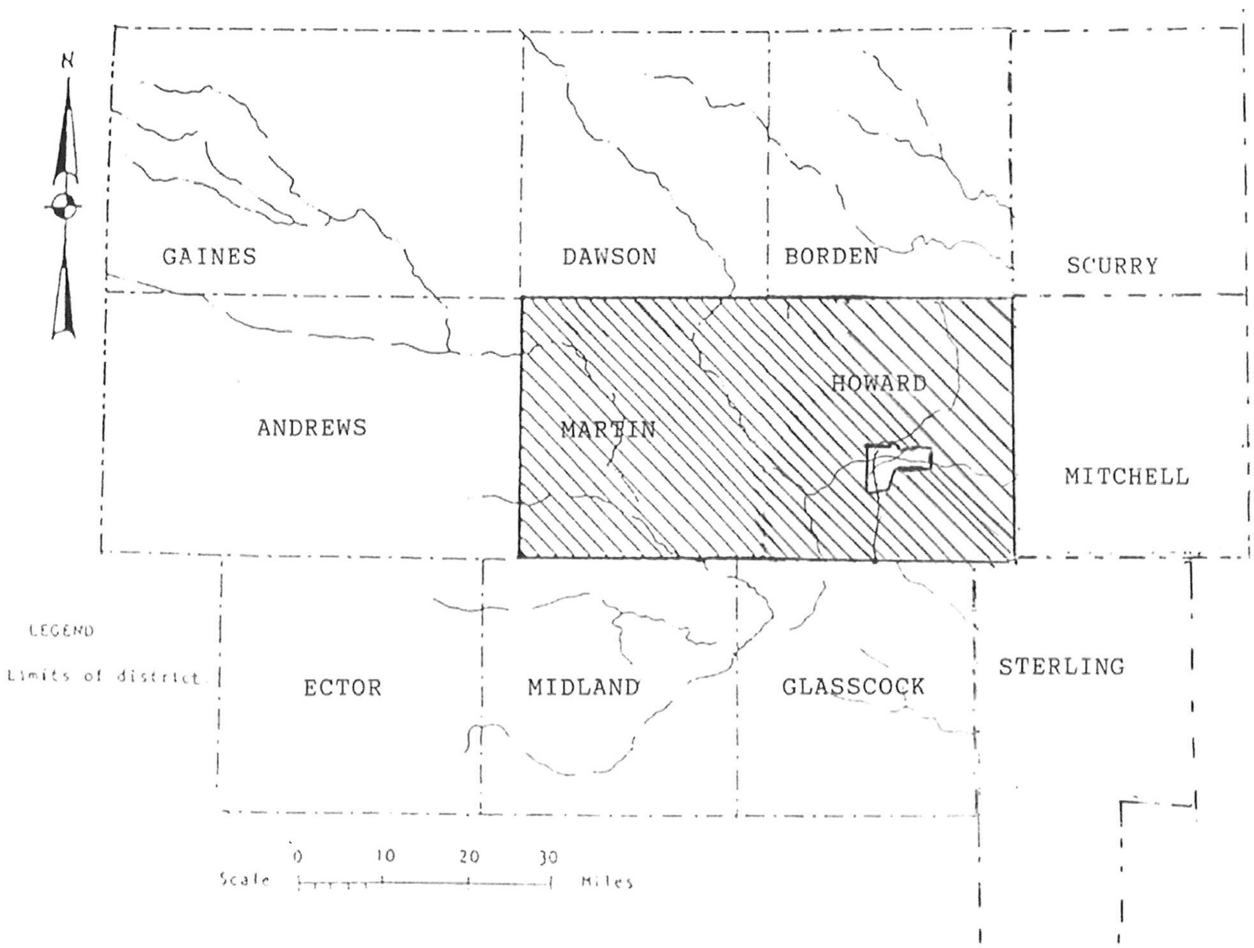
In 2001 the District annexed all of Howard County save and except City Limits of Big Spring, Texas also part of east half of Section 14 Block 33-1-South up to Rockhouse Road; thence eastward on Rockhouse Road to south Wasson Road; thence, southward along Wasson Road to Longshore Drive southward to Hwy 33, also being Garden City Highway then east along the north road of Hwy 33 to Hwy 87 thence southeasterly along south Hwy 87 to the southwest corner of Section 2 Block 32-2-South. Also the east corner of Wildfire Road. Then east along the bottom of Sections 1 and 2 Block 32-2- South to the southwest corner of Section 105 Waco & Northwest, thence along the south line of Section 105 to the eastside of Section 105, thence north to the northeast corner of Section 104, thence west along the south line of section 46 Block 32-1-South to the southeast corner of Section 45 Block 32-1-South, thence north along the section line to the northeast corner of Section 16 Block 32-1-South. Then along the north line of Section 16 Block 32-1-South to the northeast corner of Section 17 Block 32-1-South, thence south along the east line of Section 17 Block 32-1-South to the northeast corner of Section 20; thence west on Driver Road to the middle half of Section 18 Block 32-1-South; thence north westerly on Driver Road back to south Highway 87; thence north easterly back to south City Limits of Big Spring. Save and except from east City Limits of Big Spring eastward along Midway Road to Southeast corner of Section 47 Block 31-1- North; thence north to city limits of Coahoma, Texas being Section 48 Block 31-1-North. Thence the entire city limits of Coahoma, Texas. Thence west along railroad right-of-way back to the east city limits of Big Spring, Texas.

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: Location 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.

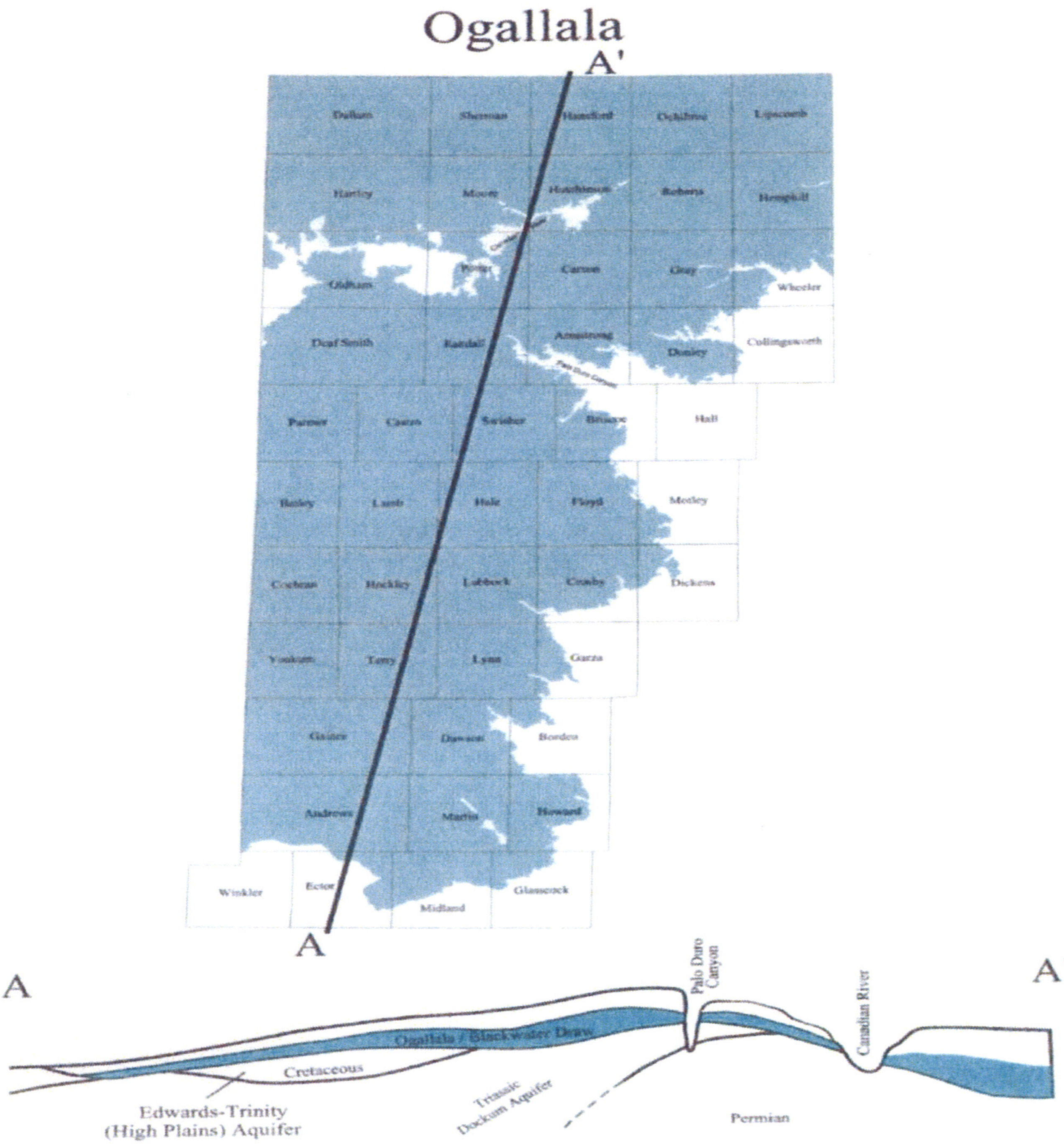
Groundwater in the aquifer generally flows from northwest to southeast, normally at right angles to water level contours. Velocities of less than one foot per day are typical, but higher velocities may occur along filled erosion valleys where coarser grained deposits have greater permeabilities.

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. Electrical conductance (EC) varies from less than 1.0 dS/m to over 4.0 dS/m. 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.

Figure 2: Aerial extent of the Ogallala Aquifer in Texas

(Adapted from Ashworth and Hopkins 1995)



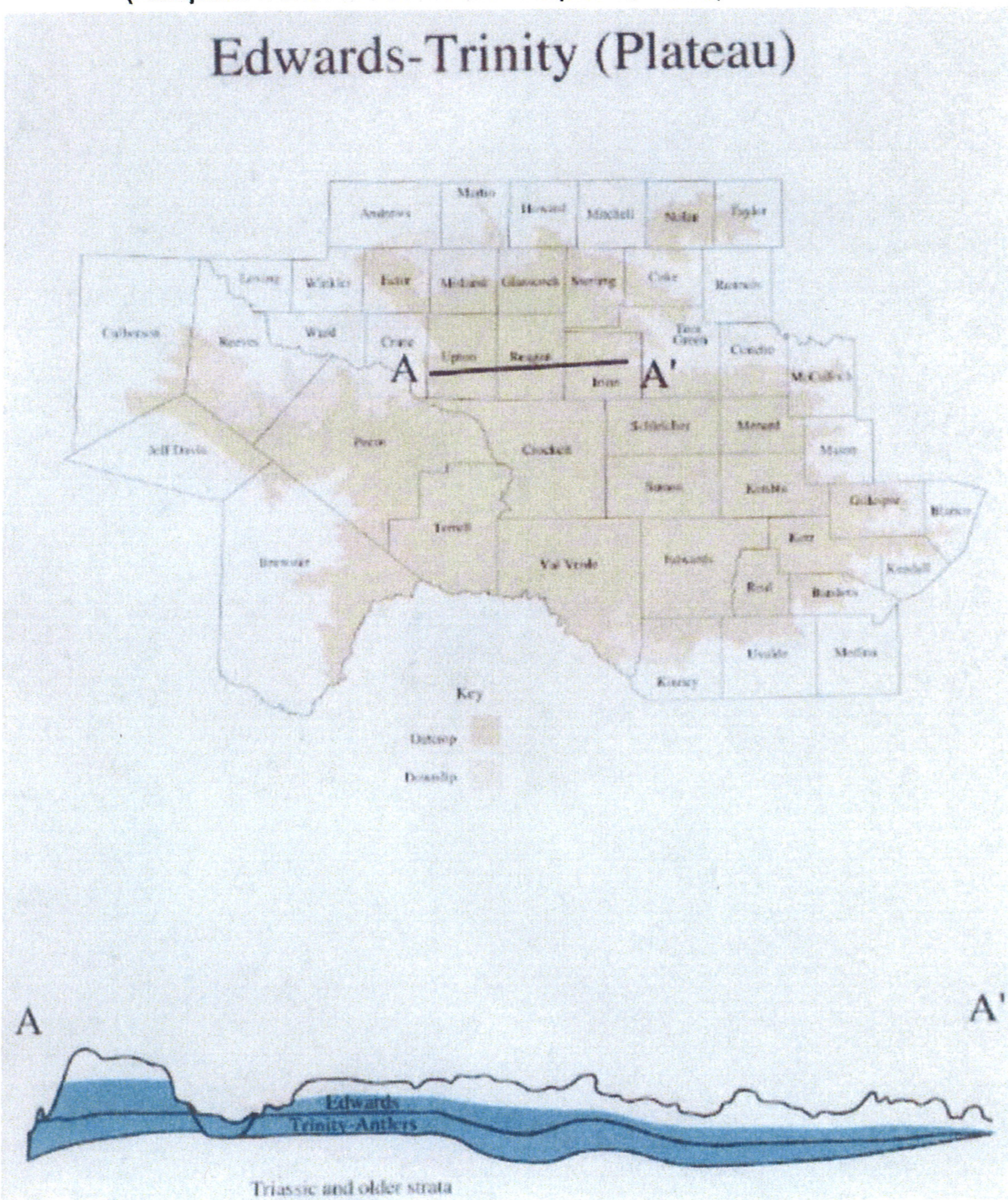
Edwards – Trinity (Plateau) Aquifer

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 adopted Desired Future Conditions (DFC) for relevant aquifers in July 2010 in accordance with Chapter 36.108 of the Texas Water Code. The relevant aquifers are the Ogallala and Edwards-Trinity (High Plains) Aquifers. The District Board in review of GAM Run 10-035 Mag Version decided the Dockum Aquifer is not a relevant aquifer for the Permian Basin UWCD at this time.

During the joint planning process, this District and five other Groundwater Conservation Districts along the southern end of Groundwater Management Area 2 (GMA2) adopted DFC's for the Ogallala and Edwards-Trinity (High Plains) Aquifers, August 2010, based on the average change during the 10 year period 1998-2007. For the Permian Basin UWCD that number is
-0.675 ft/year (GAM Run 08-85). Based on the 50 year planning horizon, the Southern Ogallala GAM predicts the cumulative drawdown to be 8 feet for the District (GAM Run 10-023 scenario 3). However, for the purposes of this management plan, the District proposes to evaluate the cumulative drawdown in 5 year increments which will gage our attainment of the DFC in shorter increments and allow us to make any changes accordingly.

The Texas Water Development Board (TWDB) provided GMA 2 with GAM Run 10-030 MAG based upon adoption of the desired future conditions for GMA 2.

Please refer to Appendix C

The District is currently considering changes to the District Rules in order to 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

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

Please refer to Appendix B

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

Please refer to Appendix B

Surface Water Resources

The only fresh surface waters occurring within the District are manmade stock tanks. The stock tanks play an important role in the watering of wildlife as well as livestock within the District.

Perhaps 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. The Colorado River Municipal Water District is under contract to provide up to 100 million gallons per year of water to the city through their extensive pipeline system.

No surface water management entities exist within the District. There are no surface water impoundments within the District except for livestock consumption. There are no surface water entities located within the District to coordinate the development of this plan.

The Colorado Municipal Water District is a surface water entity that pumps groundwater out of our District. We will provide this entity 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 and 9

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 changes in the total volume of groundwater in storage 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 will adopt rules relating to the permitting of wells and the production of groundwater. The rules adopted by the District shall be 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.

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

__*Goal 1.0*__ *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 and annually measure the wells in the network.

1.01b - The District will provide the total number of wells measured in the water level network in an annual report to the Board of Directors.

1.01c - The District will provide the total number of wells for which a measurement could not be obtained in an 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 next regularly scheduled meeting after the permit has been issued.

1.02b - The District will provide the total number of issued water well drilling permits in an annual report to the Board of Directors.

__*Goal 2.0*__ *Controlling and Preventing Waste of Groundwater*

2.01 - Objective - Laboratory Services

2.01 - Performance Standards

2.01a - The District will provide basic water quality testing to constituents.

2.01b - The District will communicate test results to constituents

2.01c - The District will provide the total number of basic water quality tests conducted for constituents in an 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.

2.02b - The District will insure that a found or open hole is properly closed according to District rules and, in so doing, prevent potential contamination of the groundwater resource.

2.02c - The District will provide the total number of open or uncovered wells in an 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 known salt water disposal wells for indications of pollution potential.

2.03b - The District will provide the total number of Salt Water Disposal Wells inspected in an annual report to the Board of Directors.

2.03c - The District will record the total number of Salt Water Disposal Wells for which inspections could not be obtained in an annual report to the Board of Directors.

Goal 3.0 *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 Palmer Drought Severity Index (PDSI) by the Texas Climatic Divisions PDSI quarterly.

3.01b - If the PDSI shows severe drought, the District will submit a press release to a newspaper of general circulation within the District. The article will stress the immediate need to reduce water use. It will provide conservation tips the public can implement in and around the home.

3.01c - The District will keep a copy of the published article from the newspaper.

<u>Goal 4.0</u> *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 book covers to public schools within the District. The book covers will have a water conservation message to provide students ideas on how to conserve water.

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.

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.

<u>Goal 5.0</u> *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.

5.01b - The District will provide the average drawdown results to the Board of Directors each year.

5.01c - The District will submit the average drawdown results to one or more newspapers of general circulation within the District each year.

5.02 - Objective - Calculate Cumulative Annual Drawdown

5.02 - Performance Standards

5.02a - The District will calculate the cumulative average annual drawdown beginning with the 2012 year. The District will calculate the remaining allowable drawdown (based on the DFC) for the remaining years of the 2012-2017 period.

5.02b - The District will provide the cumulative average annual drawdown results to the Board of Directors each year.

5.02c - The District will submit the cumulative average annual drawdown results to one or more newspapers 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

References

Ashworth, J. B. and Hopkins, J., 1995, Aquifers of Texas: Texas Water Development Board Report 345, page 69.

Wade, Shirley; Petrossian, Rima; Ridgeway, Cindy; Kohlrenken, William; and Allen, Stephen, 2012, Data supplied from the Texas Water Development Board GAMS Model.

APPENDIX A

Estimated Historical Water Use And 2012 State Water Plan Datasets:

Permian Basin Underground Water Conservation District

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

July 26, 2012

Estimated Historical Water Use And 2012 State Water Plan Datasets:

Permian Basin Underground Water Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Resources Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
July 26, 2012

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/GMPchecklist0911.pdf

The five reports included in part 1 are:

1. Estimated Historical Water 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)
   reports 2-5 are from the 2012 State Water Plan (SWP)

Part 2 of the 2-part package is the groundwater availability model (GAM) report. The District should have received this report from the Groundwater Availability Modeling Section. Questions about the GAM can be directed to Dr. Shirley Wade, shirley.wade@twdb.texas.gov, or (512) 463-0749 (to contact the Administrative Assistant).

DISCLAIMER:

The data presented in this report represents the most updated Historical Water Use and 2012 State Water Planning data available as of 7/26/2012. Although it does not happen frequently, neither of these datasets are static and are subject to change pending the availability of more accurate data (Historical Water Use data) or an amendment to the 2012 State Water Plan (2012 State Water Planning data). District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The Historical Water Use dataset can be verified at this web address:

http://www.twdb.texas.gov/wrpi/wus/summary.asp

The 2012 State Water Planning dataset can be verified by contacting Wendy Barron (wendy.barron@twdb.texas.gov or 512-936-0886).

The data values provided in the tables of this report are county-based. But, for groundwater conservation districts that cover only a portion of one or more counties, those county values have been modified using an apportioning multiplier to create new values that more accurately represent district conditions. The multiplier used within the following formula is a land area ratio: (county 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) were modified using the multiplier. WUG values for municipalities, water supply corporations, and utility districts were not apportioned. Instead, their full values were retained if they are located within the district (each district is requested to report the location of these WUGs) and eliminated if they are located outside. The two other SWP tables (Projected Water Supply Needs and Projected Water Management Strategies) were not apportioned because district-specific values are not statutorily required for those data. In the Historical Water Use 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 has the option of including those data in the plan with an explanation of how the data were derived. The apportioning multiplier used in the calculation is shown next to each county header on the applicable tables.

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 use estimates are currently unavailable for 2005, 2009 and 2010. TWDB staff anticipates the calculation and posting of such estimates during the first half of 2012.

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

Year	Source	Municipal	Manufacturing	Steam Electric	Irrigation	Mining	Livestock	Total
1974	GW	1,114	162	0	2,238	1,271	182	4,967
1980	GW	904	261	0	789	417	172	2,543
1984	GW	890	166	0	476	1,411	233	3,176
1985	GW	950	300	0	1,555	1,384	156	4,345
1986	GW	729	401	0	1,555	1,352	183	4,220
1987	GW	856	283	0	777	1,261	170	3,347
1988	GW	776	288	0	1,166	400	188	2,818
1989	GW	856	119	0	1,518	374	186	3,053
1990	GW	708	418	0	2,243	374	183	3,926
1991	GW	795	376	265	2,040	309	187	3,972
1992	GW	908	72	0	3,595	298	250	5,123
1993	GW	889	127	0	973	291	249	2,529
1994	GW	1,193	414	0	1,088	292	215	3,202
1995	GW	1,064	451	0	975	201	213	2,904
1996	GW	1,111	536	0	905	201	185	2,938
1997	GW	816	377	0	2,254	179	278	3,904
1998	GW	911	444	0	3,282	174	248	5,059
1999	GW	802	382	0	4,610	174	232	6,200
2000	GW	645	147	0	4,583	174	237	5,786
2001	GW	795	532	0	3,102	36	220	4,685
2002	GW	744	376	0	2,903	179	201	4,403
2003	GW	999	483	0	2,252	179	143	4,056
2004	GW	735	562	0	2,628	179	143	4,247
2006	GW	5,198	559	0	2,991	2	174	8,924
2007	GW	5,882	594	0	5,878	1	255	12,610
2008	GW	4,253	671	0	4,599	1	188	9,712
2009	GW	5,787	457	0	6,447	189	174	13,054

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

Groundwater use estimates are currently unavailable for 2005, 2009 and 2010. TWDB staff anticipates the calculation and posting of such estimates during the first half of 2012.

MARTIN COUNTY *100.00 % (multiplier)* All values are in acre-feet/year

Year	Source	Municipal	Manufacturing	Steam Electric	Irrigation	Mining	Livestock	Total
1974	GW	419	0	0	29,825	568	248	31,060
1980	GW	308	14	0	20,439	229	128	21,118
1984	GW	355	14	0	16,537	824	259	17,989
1985	GW	338	53	0	14,659	840	165	16,055
1986	GW	333	36	0	11,550	807	191	12,917
1987	GW	300	18	0	7,101	756	299	8,474
1988	GW	301	17	0	8,601	730	319	9,968
1989	GW	300	19	0	12,256	681	315	13,571
1990	GW	310	30	0	12,588	681	310	13,919
1991	GW	337	16	0	5,367	1,286	317	7,323
1992	GW	354	0	0	12,789	1,284	290	14,717
1993	GW	340	27	0	8,568	1,275	292	10,502
1994	GW	343	41	0	7,114	1,275	211	8,984
1995	GW	332	44	0	11,485	852	251	12,964
1996	GW	334	31	0	12,515	852	209	13,941
1997	GW	418	44	0	14,294	852	222	15,830
1998	GW	443	29	0	20,318	845	177	21,812
1999	GW	383	26	0	19,309	845	189	20,752
2000	GW	408	34	0	14,575	132	544	15,693
2001	GW	213	43	0	16,381	838	168	17,643
2002	GW	263	14	0	16,436	788	147	17,648
2003	GW	201	18	0	13,176	788	68	14,251
2004	GW	355	40	0	14,652	788	81	15,916
2006	GW	303	53	0	15,626	0	90	16,072
2007	GW	303	39	0	25,872	0	90	26,304
2008	GW	89	44	0	28,482	0	72	28,687
2009	GW	157	0	0	36,970	514	66	37,707

Projected Surface Water Supplies
TWDB 2012 State Water Plan Data

HOWARD COUNTY

94.81 % (multiplier)

All values are in acre-feet/year

RWPG	WUG	WUG Basin	Source Name	2010	2020	2030	2040	2050	2060
F	BIG SPRING	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM						
F	COAHOMA	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM						
F	IRRIGATION	COLORADO	BEALS CREEK COMBINED RUN-OF-RIVER IRRIGATION	0	0	0	0	0	0
F	LIVESTOCK	COLORADO	LIVESTOCK LOCAL SUPPLY	59	59	59	59	59	59
F	MANUFACTURING	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM	685	667	1,037	1,033	1,046	1,071
F	MINING	COLORADO	BEALS CREEK RUN-OF-RIVER CRMWD DIVERTED WATER	0	0	0	0	0	0
F	MINING	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM	1,020	998	1,525	1,474	1,444	1,384
	Sum of Projected Surface Water Supplies (acre-feet/year)			**1,764**	**1,724**	**2,621**	**2,566**	**2,549**	**2,514**

MARTIN COUNTY

100.00 % (multiplier)

All values are in acre-feet/year

RWPG	WUG	WUG Basin	Source Name	2010	2020	2030	2040	2050	2060
F	LIVESTOCK	COLORADO	LIVESTOCK LOCAL SUPPLY	67	67	67	67	67	67
F	STANTON	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM	0	0	0	0	0	0
	Sum of Projected Surface Water Supplies (acre-feet/year)			**67**	**67**	**67**	**67**	**67**	**67**

Projected Water Demands
TWDB 2012 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/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
F	BIG SPRING	COLORADO						
F	COUNTY-OTHER	COLORADO	1,051	1,052	1,035	1,010	994	994
F	MANUFACTURING	COLORADO	1,562	1,662	1,737	1,811	1,873	1,990
F	MINING	COLORADO	1,690	1,785	1,824	1,861	1,897	1,946
F	IRRIGATION	COLORADO	4,550	4,498	4,447	4,394	4,343	4,292
F	LIVESTOCK	COLORADO	347	347	347	347	347	347
F	COAHOMA	COLORADO						
	Sum of Projected Water Demands (acre-feet/year)		**9,200**	**9,344**	**9,390**	**9,423**	**9,454**	**9,569**

MARTIN COUNTY

100.00 % (multiplier)

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
F	LIVESTOCK	COLORADO	273	273	273	273	273	273
F	IRRIGATION	COLORADO	14,324	14,073	13,822	13,571	13,321	13,075
F	MINING	COLORADO	674	645	634	624	615	603
F	MANUFACTURING	COLORADO	39	41	42	43	44	47
F	COUNTY-OTHER	COLORADO	377	403	411	412	399	378
F	STANTON	COLORADO	411	440	447	448	433	411
	Sum of Projected Water Demands (acre-feet/year)		**16,098**	**15,875**	**15,629**	**15,371**	**15,085**	**14,787**

Projected Water Supply Needs
TWDB 2012 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/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
F	BIG SPRING	COLORADO	-1,345	-1,672	-24	-299	-491	-796
F	COAHOMA	COLORADO	-49	-61	-1	-11	-18	-29
F	COUNTY-OTHER	COLORADO	44	43	61	88	105	105
F	IRRIGATION	COLORADO	63	118	172	227	281	335
F	LIVESTOCK	COLORADO	0	0	0	0	0	0
F	MANUFACTURING	COLORADO	-177	-301	11	-71	-124	-220
F	MINING	COLORADO	-400	-523	-9	-101	-171	-285
	Sum of Projected Water Supply Needs (acre-feet/year)		**-1,971**	**-2,557**	**-34**	**-482**	**-804**	**-1,330**

MARTIN COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
F	COUNTY-OTHER	COLORADO	0	0	0	0	0	0
F	IRRIGATION	COLORADO	-788	-564	-322	0	0	0
F	LIVESTOCK	COLORADO	0	0	0	0	0	0
F	MANUFACTURING	COLORADO	0	0	0	0	0	0
F	MINING	COLORADO	31	60	71	81	90	102
F	STANTON	COLORADO	-392	-422	-429	-430	-415	-393
	Sum of Projected Water Supply Needs (acre-feet/year)		**-1,180**	**-986**	**-751**	**-430**	**-415**	**-393**

Projected Water Management Strategies
TWDB 2012 State Water Plan Data

HOWARD COUNTY

WUG, Basin (RWPG)

All values are in acre-feet/year

Water Management Strategy	Source Name [Origin]	2010	2020	2030	2040	2050	2060
BIG SPRING, COLORADO (F)							
MUNICIPAL CONSERVATION	CONSERVATION [HOWARD]	241	603	676	698	725	754
REUSE	DIRECT REUSE [HOWARD]	0	1,855	1,855	1,855	1,855	1,855
SUBORDINATION	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	1,345	1,672	24	299	491	796
COAHOMA, COLORADO (F)							
SUBORDINATION	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	49	61	1	11	18	29
IRRIGATION, COLORADO (F)							
IRRIGATION CONSERVATION	CONSERVATION [HOWARD]	0	327	653	653	653	653
MANUFACTURING, COLORADO (F)							
SUBORDINATION	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	267	349	5	71	124	220
MINING, COLORADO (F)							
SUBORDINATION	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	400	523	9	101	171	285
Sum of Projected Water Management Strategies (acre-feet/year)		**2,302**	**5,390**	**3,223**	**3,688**	**4,037**	**4,592**

MARTIN COUNTY

WUG, Basin (RWPG)

All values are in acre-feet/year

Water Management Strategy	Source Name [Origin]	2010	2020	2030	2040	2050	2060
IRRIGATION, COLORADO (F)							
IRRIGATION CONSERVATION	CONSERVATION [MARTIN]	0	1,751	3,502	3,502	3,502	3,502

Projected Water Management Strategies
TWDB 2012 State Water Plan Data

WUG, Basin (RWPG)							All values are in acre-feet/year
Water Management Strategy	Source Name [Origin]	2010	2020	2030	2040	2050	2060
STANTON, COLORADO (F)							
NEW/RENEW WATER SUPPLY	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	392	422	429	430	415	393
SUBORDINATION	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	0	0	0	0	0	0
Sum of Projected Water Management Strategies (acre-feet/year)		**392**	**2,173**	**3,931**	**3,932**	**3,917**	**3,895**

APPENDIX B

GAM Run 12-007

by William Kohlrenken

Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-8279

June 13, 2012

GAM RUN 12-007: PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT MANAGEMENT PLAN

by William Kohlrenken
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-8279
June 13, 2012

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by William Kohlrenken under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on June 13, 2012.

GAM Run 12-007: Permian Basin Underground Water Conservation District Management Plan

by William Kohlrenken
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-8279
June 13, 2012

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, groundwater conservation districts shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

- the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
- 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
- the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

The purpose of this report is to provide Part 2 of a two-part package of information to Permian Basin Underground Water Conservation District for its groundwater management plan. The groundwater management plan for the Permian Basin Underground Water Conservation District is due for approval by the Executive Administrator of the Texas Water Development Board before January 23, 2014.

This report discusses the method, assumptions, and results from model runs using the following three groundwater availability models: the southern portion of the Ogallala Aquifer, which includes the Edwards-Trinity (High Plains) Aquifer; the Edwards-Trinity (Plateau) Aquifer; and the Dockum Aquifer. Tables 1 through 3 summarize the groundwater availability model data required by the statute, and figures 1 through 3 show the area of each model from which the values in the respective tables 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 Texas Water Development Board immediately.

METHODS:

Groundwater availability models for the southern part of the Ogallala Aquifer, which includes the Edwards-Trinity (High Plains) Aquifer (1980 through 2000); the Edwards-Trinity (Plateau) Aquifer (1981 through 2000); and the Dockum Aquifer (1980 through 1997) were run for this analysis. Water budgets for each year of the transient model period were extracted and the average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow (upper), and net inter-aquifer flow (lower) for the portions of the aquifers located within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer

- Version 2.01 of the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer was used for this analysis. This model is an expansion on and update to the previously developed groundwater availability model for the southern portion of the Ogallala Aquifer described in Blandford and others (2003). See Blandford and others (2008) and Blandford and others (2003) for assumptions and limitations of the model.

- The model includes four layers representing the southern portion of the Ogallala (layer 1) and Edwards-Trinity (High Plains) aquifers. The units comprising the Edwards-Trinity (High Plains) Aquifer consist of primarily Duck Creek and Kiamichi Formations in Layer 2, primarily Edwards and Comanche Peaks Formations in Layer 3, and the Antlers Sand in Layer 4. The Edwards-Trinity units are separated from the overlying Ogallala Aquifer by a layer of Cretaceous shale, where present (Blandford and others, 2008). Water budgets for the district have been determined for the Ogallala Aquifer (Layer 1). Budget terms were not determined for the Edwards-

Trinity (High Plains) aquifer because it is not present in the Permian Basin UWCD.

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) for the Ogallala Aquifer in 2000 is 33 feet (Blandford and others, 2008). This represents 1.8 percent of the hydraulic head drop across the model area for the aquifer.
- Irrigation return flow was accounted for in the groundwater availability model by a direct reduction in agricultural pumping as described in Blandford and others (2003).

Edwards-Trinity (Plateau) Aquifer

- The recently modified and calibrated one-layer groundwater flow model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Hutchison and others, 2011) was used for this management plan data extraction analysis because of model calibration enhancements and to be consistent with the Managed/Modeled Available Groundwater (MAG) process. The model was calibrated based on groundwater elevation data from 1931 to 2005; however, data were extracted only for the period from 1980 to 2000 to avoid a 3.7 percent bias of the 1950's drought of record and to be more consistent with the analysis completed for previous management plans.
- The model has one layer which represents the Pecos Valley Aquifer in the northwest portion of the model area, the Edwards-Trinity (Plateau) Aquifer in the southeast portion of the model area, and a lumped representation of both aquifers in the relatively narrow area where the Pecos Valley Aquifer overlies the Edwards-Trinity (Plateau) Aquifer.
- The standard deviation of groundwater elevation residuals (a measure of the difference between simulated and actual water levels during model calibration) for the entire model domain is 70 feet and the absolute residual mean is 48 feet.
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).
- See Hutchison and Others (2011) for additional assumptions and limitations of the model.

Dockum Aquifer

- Version 1.01 of the groundwater availability model was used for the Dockum Aquifer. See Ewing and others (2008) for assumptions and limitations of the groundwater availability model.
- The model includes three layers representing the younger geologic units overlying the Dockum Aquifer (layer 1), the upper portion of the Dockum Aquifer (layer 2), and the lower portion of the Dockum Aquifer (layer 3).
- The aquifers represented in Layer 1 of the groundwater availability model are only included in the model for the purpose of more accurately representing flow between these units and the Dockum Aquifer. This model is not intended to explicitly simulate flow in these overlying units (Ewing and others, 2008).
- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 82 feet for the Upper Dockum Aquifer, and 108 feet for the Lower Dockum Aquifer for the calibration period (1980 to 1990) and 83 and 78 feet for the same aquifers, respectively, in the verification period (1991 to 1999) (Ewing and others, 2008). These root mean square errors are between two and three percent of the range of measured water levels (Ewing and others, 2008).
- The MODFLOW Drain package was used to simulate both evapotranspiration and springs. However, there were no model grid cells representing springs within the district so there was no drain flow incorporated into the surface water outflow values shown in Table 3.
- Groundwater in the Dockum Aquifer ranges from fresh to brine in composition (Ewing and others, 2008). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh, total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish, and total dissolved solids greater than 35,000 milligrams per liter are considered brines.

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 the model results for the aquifers located within the district and averaged over the duration of the calibration and verification portion of the model runs in the district, as shown in tables 1 through 3. The components of the modified budget shown in tables 1 through 3 include:

- 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.
- Surface water outflow—The total water discharging from the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).
- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent counties.
- Flow between aquifers—The vertical flow between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer or confining unit and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer.

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 district or county boundaries, 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 (see figures 1 through 3).

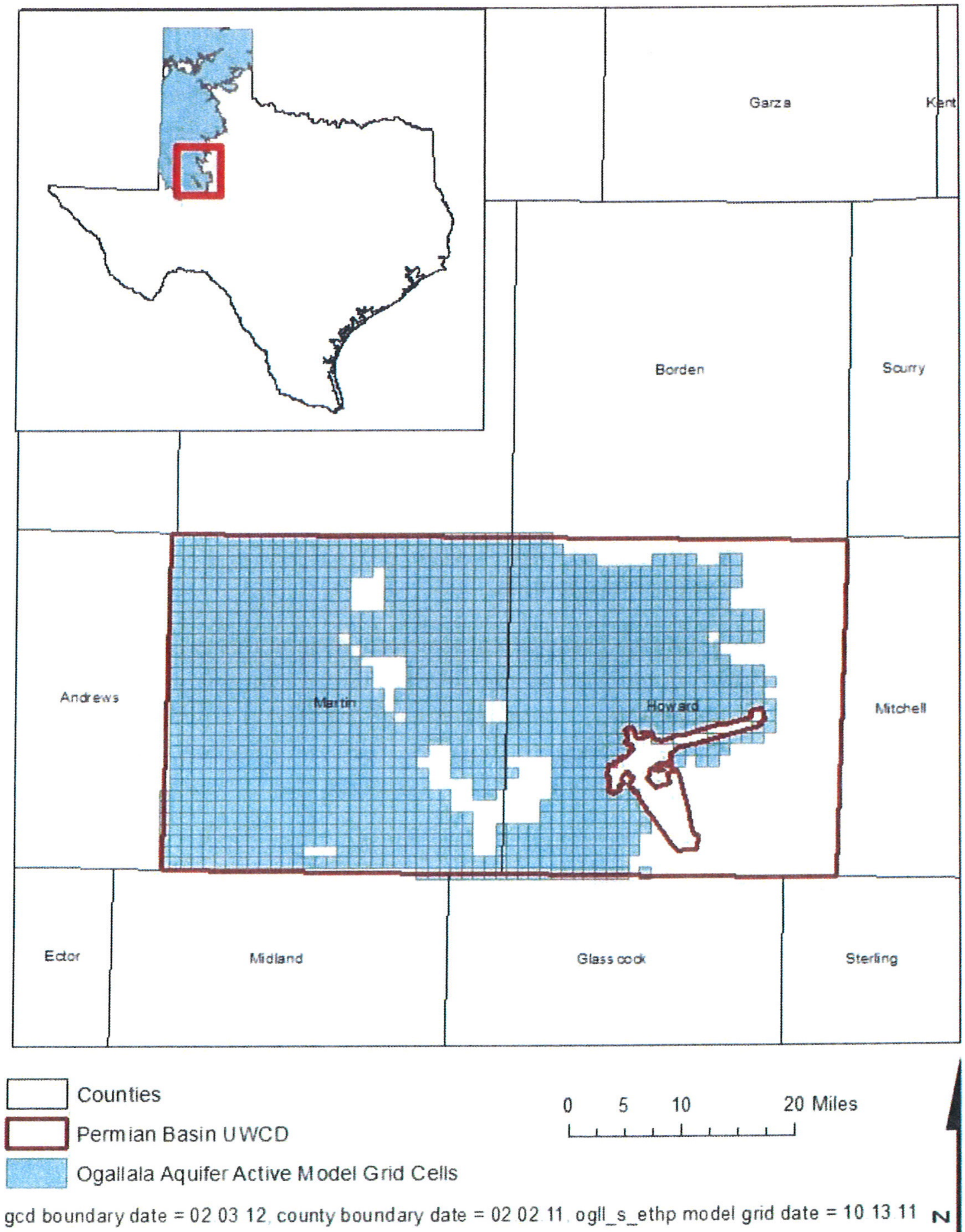


FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE SOUTHERN PORTION OF THE OGALLALA AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

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

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Ogallala Aquifer	11,927
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ogallala Aquifer	4,855
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	9,012
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	2,505
Estimated net annual volume of flow between each aquifer in the district*	From Ogallala Aquifer into the Edwards-Trinity (Plateau) Aquifer	661

*Determined from the Groundwater Availability Model for the Edwards-Trinity (Plateau)

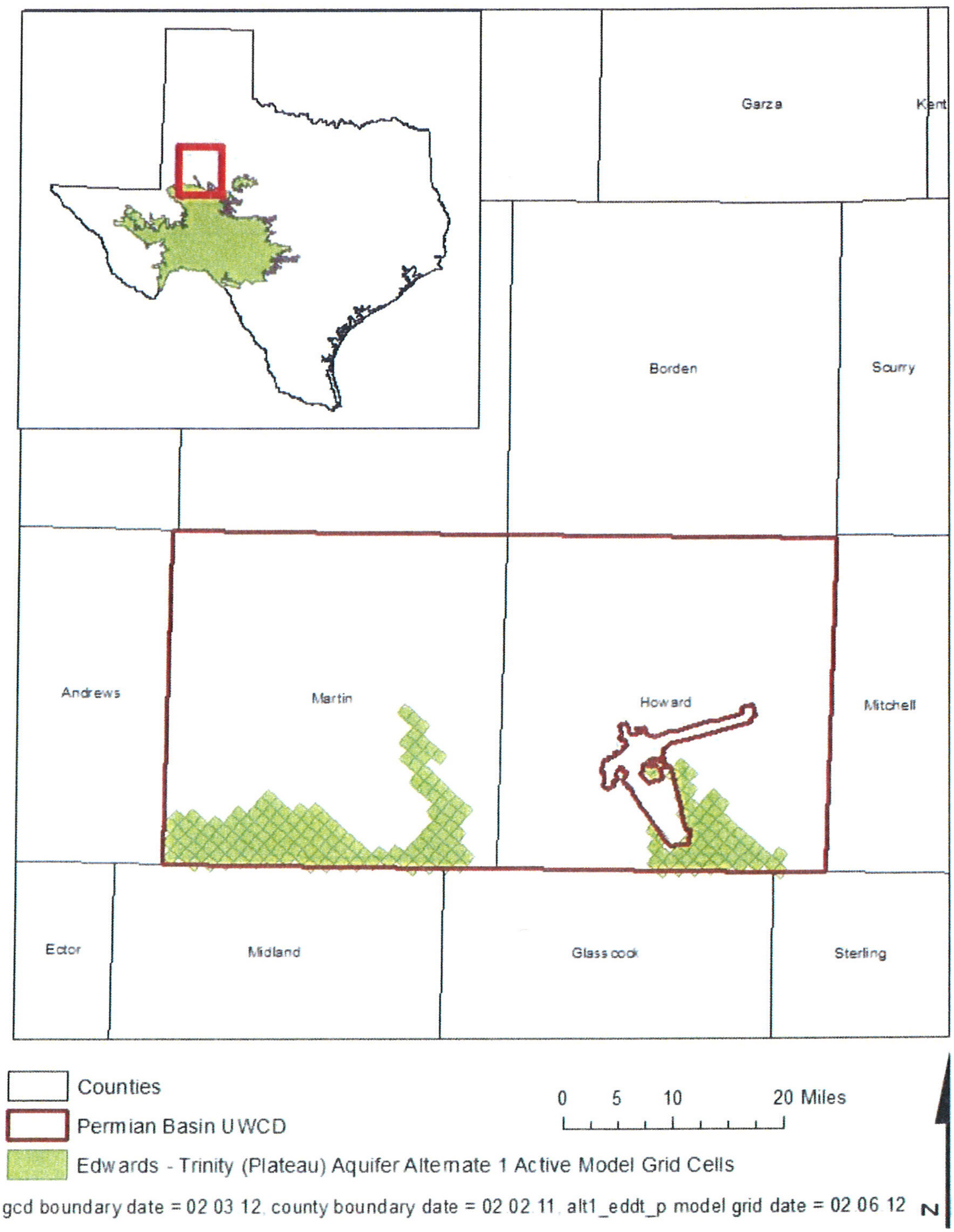


FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER THAT IS NEEDED FOR PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	*Aquifer*	*Results*
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	2,469
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	206
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	3,217
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	6,600
Estimated net annual volume of flow between each aquifer in the district	From Ogallala Aquifer into the Edwards-Trinity (Plateau) Aquifer	661

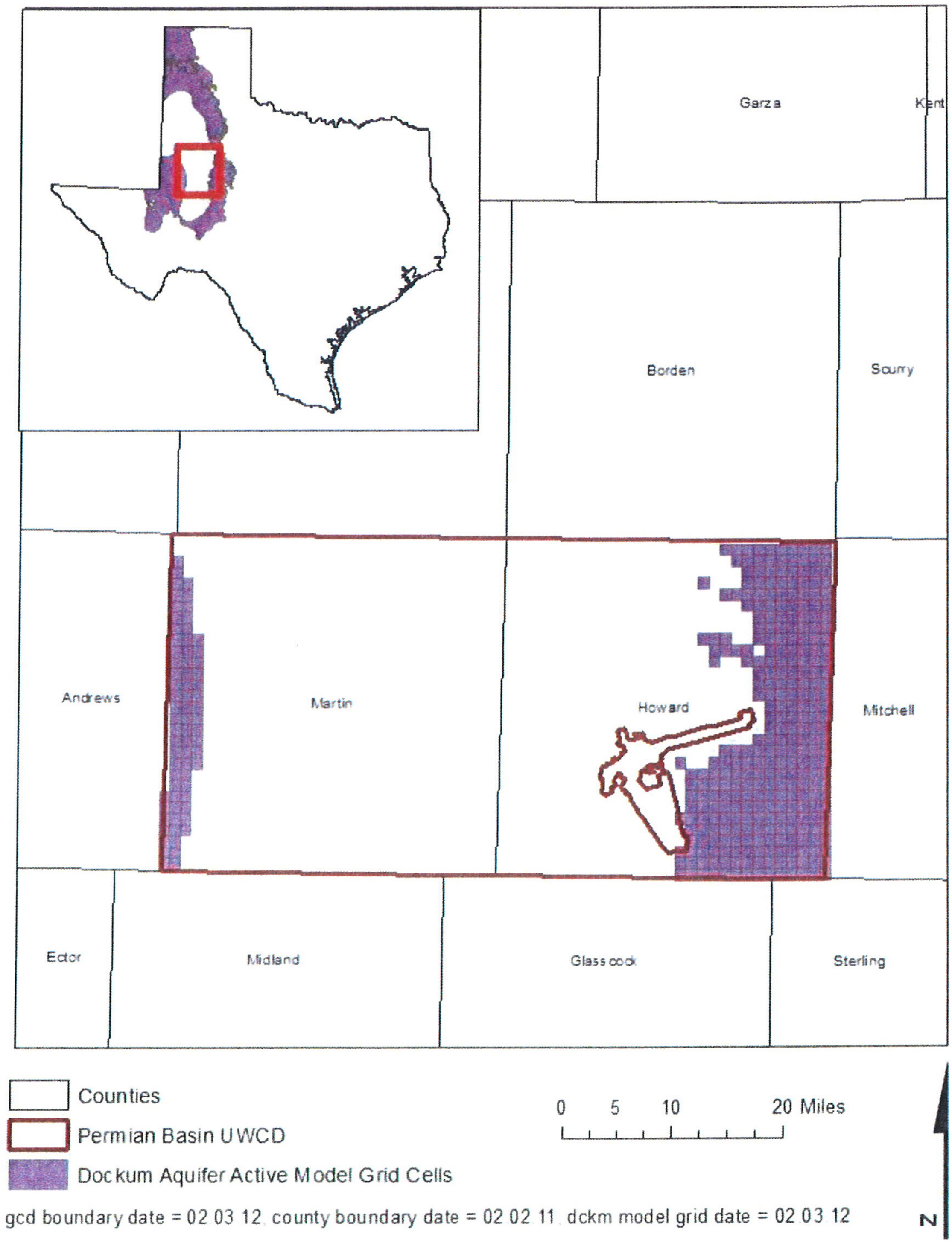


FIGURE 3: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3: SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER THAT IS NEEDED FOR PERMIAN BASIN UNDERGROUND WATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Dockum Aquifer	3,899
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	2,226
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	1,033
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	1,754
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer, Edwards-Trinity (Plateau) Aquifer, and overlying younger units into the Dockum Aquifer	39

LIMITATIONS

The groundwater model(s) used in completing this analysis is the best available scientific tool that can be used to meet the stated objective(s). 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 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.

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APPENDIX C

GAM Run 10-030 MAG

by Mr. Wade Oliver

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-3132

June 22, 2011

GAM Run 10-030 MAG

by Mr. Wade Oliver

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(512) 463-3132
June 22, 2011

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on June 22, 2011.

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EXECUTIVE SUMMARY:

The estimated total pumping from the Ogallala Aquifer that achieves the desired future conditions adopted by the members of Groundwater Management Area 2 declines from approximately 2,367,000 acre-feet per year to 1,307,000 acre-feet per year between 2010 and 2060. This is summarized by county, regional water planning area, and river basin as shown in Table 2. The corresponding total pumping from the Edwards-Trinity (High Plains) Aquifer declines from approximately 96,000 acre-feet per year to 23,000 acre-feet per year over the same time period (Table 3). The estimated managed available groundwater, the amount available for permitting, for the groundwater conservation districts within Groundwater Management Area 2 for the Ogallala and Edwards-Trinity (High Plains) aquifers declines from approximately 2,368,000 acre-feet per year to 1,266,000 acre-feet per year between 2010 and 2060 (Table 9). The pumping estimates were extracted from Groundwater Availability Modeling Task 10-023, Scenario 3, which Groundwater Management Area 2 used as the basis for developing their desired future conditions.

REQUESTOR:

Mr. Jason Coleman of South Plains Underground Water Conservation District on behalf of Groundwater Management Area 2

DESCRIPTION OF REQUEST:

In a letter dated August 10, 2010 and received August 13, 2010, Mr. Jason Coleman provided the Texas Water Development Board (TWDB) with the desired future conditions of the Ogallala and Edwards-Trinity (High Plains) aquifers adopted by the members of Groundwater Management Area 2. Below are the desired future conditions for the Ogallala and Edwards-Trinity (High Plains) aquifers in the northern portion of the management area as described in Resolution No. 2010-01 and adopted August 5, 2010:

> [T]he *members of* [Groundwater Management Area] *#2 adopt the desired future condition of 50 percent of the saturated thickness remaining after 50 years for the Northern Portion of* [Groundwater Management Area] *#2, based on GAM Run 10-023, Scenario 3...*

As described in Resolution No. 2010-01, the northern portion of Groundwater Management Area 2 consists of Bailey, Briscoe, Castro, Cochran, Crosby, Deaf Smith, Floyd, Hale, Hockley, Lamb, Lubbock, Lynn, Parmer, and Swisher counties.

For the southern portion of Groundwater Management Area 2, desired future conditions for the Ogallala and Edwards-Trinity (High Plains) aquifers were stated as average water-level declines (drawdowns) over the same time period. The average drawdowns specified as desired future conditions for the southern portion of Groundwater Management Area 2 are: Andrews–6 feet, Bordon–3 feet, Dawson–74 feet, Gaines–70 feet, Garza–40 feet, Howard–1 foot, Martin–8 feet, Terry–42 feet, and Yoakum–18 feet.

In response to receiving the adopted desired future conditions, the Texas Water Development Board has estimated the managed available groundwater for each of the groundwater conservation districts within Groundwater Management Area 2 for the Ogallala and Edwards-Trinity (High Plains) aquifers.

Although not explicitly stated in the adopted desired future conditions statement, drawdown estimates for the Edwards-Trinity (High Plains) Aquifer associated with Scenario 3 of GAM Task 10-023 are shown in Table 1 below.

Table 1. Average drawdown in feet in the Edwards-Trinity (High Plains) Aquifer by county in Scenario 3 of GAM Task 10-023.

County	Average drawdown (feet)					
	2010	2020	2030	2040	2050	2060
Bailey	0	1	2	4	4	5
Borden	0	1	1	2	3	4
Cochran	-1	0	3	6	9	11
Dawson	3	21	37	50	60	67
Floyd	3	16	29	41	52	61
Gaines	6	28	42	53	61	67
Garza	2	10	18	26	33	40
Hale	1	8	15	22	29	36
Hockley	1	7	13	19	24	28
Lamb	0	1	1	2	3	3
Lubbock	1	8	14	20	25	29
Lynn	0	7	14	21	27	32
Terry	2	14	25	32	37	40
Yoakum	1	6	10	13	15	17

For purposes of developing total pumping and managed available groundwater numbers, it was assumed that by referencing Scenario 3 of GAM Task 10-023, the groundwater conservation districts in Groundwater Management Area 2 intended to fully incorporate the drawdown and pumping estimates of the Edwards-Trinity (High Plains) Aquifer. Thus, this analysis included those pumping numbers.

METHODS:

Groundwater Management Area 2, located in the Texas Panhandle, contains a portion of the Ogallala Aquifer and the entire Edwards-Trinity (High Plains) Aquifer. The location of Groundwater Management Area 2, the Ogallala and Edwards-Trinity (High Plains) aquifers, and the groundwater availability model cells that represent the aquifers are shown in Figure 1.

The Texas Water Development Board previously completed several predictive groundwater availability model simulations of the Ogallala and Edwards-Trinity (High Plains) aquifers to assist the members of Groundwater Management Area 2 in developing desired future conditions.

As stated in Resolution No. 2010-01 and the narrative of the methods used for developing desired future conditions provided by Groundwater Management Area 2, the simulation on which the desired future conditions above are based is Scenario 3 of GAM Task 10-023 (Oliver, 2010). The estimated pumping for Groundwater Management Area 2 presented here, taken directly from the above scenario, has been divided by county, regional water planning area, river basin, and groundwater conservation district. These areas are shown in Figure 2.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the model run using the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer are described below:

- The results presented in this report are based on "Scenario 3" in GAM Task 10-023 (Oliver, 2010). See GAM Task 10-023 for a full description of the methods, assumptions, and results for the groundwater availability model run.

- Version 2.01 of the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer (Blandford and others, 2008) was used for this analysis. This model is an expansion on and update to the previously developed groundwater availability model for the southern portion of the Ogallala Aquifer described in Blandford and others (2003). See Blandford and others (2008) and Blandford and others (2003) for assumptions and limitations of the groundwater availability model.

- The model includes four layers representing the southern portion of the Ogallala and Edwards-Trinity (High Plains) aquifers. The units comprising the Edwards-Trinity (High Plains) Aquifer (primarily Edwards, Comanche Peak, and Antlers Sand formations) are separated from the overlying Ogallala Aquifer by a layer of Cretaceous shale, where present.

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) for the Ogallala Aquifer in 2000 is 33 feet. The mean absolute error for the Edwards-Trinity (High Plains) Aquifer in 1997 is 25 feet (Blandford and others, 2008).

- Cells were assigned to individual counties, river basins, regional water planning areas, and groundwater conservation districts as shown in the August 3, 2010 version of the file that associates the model grid to political and natural boundaries for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer. Note that some minor corrections were made to the file to better reflect the relationship of model cells to political boundaries.

- The recharge used for the model run represents average recharge as described in Blandford and others (2003).

Determining Managed Available Groundwater

As defined in Chapter 36 of the Texas Water Code, "managed available groundwater" is the amount of water that may be permitted. The pumping output from groundwater availability models, however, represents the total amount of pumping from the aquifer. The total pumping includes uses of water both subject to permitting and exempt from permitting. Examples of exempt uses include domestic, livestock, and oil and gas exploration. Each district may also exempt additional uses as defined by its rules or enabling legislation.

Since exempt uses are not available for permitting, it is necessary to account for them when determining managed available groundwater. To do this, the Texas Water Development Board developed a standardized method for estimating exempt use for domestic and livestock purposes based on projected changes in population and the distribution of domestic and livestock wells in the area. Because other exempt uses can vary significantly from district to district, and there is much higher uncertainty associated with estimating use due to oil and gas exploration, estimates of exempt pumping outside domestic and livestock uses have not been included. The districts were also encouraged to evaluate the estimates of exempt pumping and, if desired, provide updated estimates. Once established, the estimates of exempt pumping were subtracted from the total pumping output from the groundwater availability model to yield the estimated managed available groundwater for permitting purposes.

RESULTS:

The estimated total pumping from the Ogallala Aquifer in Groundwater Management Area 2 that achieves the above desired future conditions declines from approximately 2,367,000 acre-feet per year in 2010 to 1,307,000 acre-feet per year in 2060. This pumping has been divided by county, regional water planning area, and river basin for each decade between 2010 and 2060 for use in the regional water planning process (Table 2). The corresponding estimated total pumping from the Edwards-Trinity (High Plains) Aquifer declines from approximately 96,000 acre-feet per year to 23,000 acre-feet per year over the same time period (Table 3).

The total pumping estimates for the combined Ogallala and Edwards-Trinity (High Plains) aquifers are also summarized by county, regional water planning area, river basin, and groundwater conservation district as shown in tables 4, 5, 6, and 7, respectively. In Table 7, the total pumping both excluding and including areas outside of a groundwater conservation district is shown. Table 8 contains the estimates of exempt pumping for the Ogallala and Edwards-Trinity (High Plains) aquifers by groundwater conservation district. The managed available groundwater, the difference between the total pumping in the districts (Table 7, excluding areas outside of a district) and the estimated exempt use (Table 8) is shown in Table 9. The total managed available groundwater for the Ogallala and Edwards-Trinity (High Plains) aquifers in Groundwater Management Area 2 declines from approximately 2,368,000 acre-feet per year to 1,266,000 acre-feet per year between 2010 and 2060.

LIMITATIONS:

Managed available groundwater numbers included in this report are the result of subtracting the estimated future exempt use from the estimated total pumping that would achieve the desired future condition adopted by the groundwater conservation districts in the groundwater management area. These numbers, therefore, are the result of (1) running the groundwater model to estimate the total pumping required to achieve the desired future condition and (2) estimating the future exempt use in the area.

The groundwater model used in developing estimates of total pumping is the best available scientific tool that can be used to estimate the pumping that will achieve the desired future condition. Although the groundwater model used in this analysis is the best available scientific tool for this purpose, it, like all models, has limitations. 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 develop estimates of total pumping is the need to make assumptions about the location in the aquifer where future pumping will occur. As actual pumping changes in the future, it will be necessary to evaluate the amount of that pumping as well as its location in the context of the assumptions associated with this analysis. Evaluating the amount and location of future pumping is as important as evaluating the changes in groundwater levels, spring flows, and other metrics that describe the condition of the groundwater resources in the area that relate to the adopted desired future condition.

In addition, certain assumptions have been made regarding future precipitation, recharge, and streamflow in developing these total pumping estimates. Those assumptions also need to be considered and compared to actual future data when evaluating compliance with the desired future condition.

In the case of TWDB's estimates of future exempt use, key assumptions were made as to the pattern of population growth relative to the need for domestic wells or supplied water, per capita use from domestic wells, and livestock uses of water. In the case of district estimates of future exempt use, including exempt use associated with the exploration of oil and gas, the assumptions are specific to that district. In either case, these assumptions need to be considered when reviewing future data related to exempt use.

Given these limitations, users of this information are cautioned that the total pumping numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. 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 future groundwater pumping as well as whether or not they are achieving their desired future conditions. 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 these managed available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

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Table 2. Estimated total annual pumping for the Ogallala Aquifer in Groundwater Management Area 2. Results are in acre-feet per year and are divided by county, regional water planning area, and river basin.

County	Region	Basin	Year					
			2010	2020	2030	2040	2050	2060
Andrews	F	Colorado	17,584	15,085	13,678	12,014	10,016	7,377
		Rio Grande	54	50	41	41	41	41
Bailey	O	Brazos	62,538	41,283	34,907	30,064	24,021	21,429
Borden	F	Brazos	292	292	292	292	292	292
		Colorado	107	107	107	107	107	107
Briscoe	O	Red	33,622	26,457	19,722	14,220	13,037	11,933
Castro	O	Brazos	90,367	90,367	90,367	90,367	88,630	84,458
		Red	37,055	36,936	36,141	35,449	34,650	33,540
Cochran	O	Brazos	16,324	7,707	6,556	4,770	4,410	4,179
		Colorado	32,021	28,501	27,085	25,926	23,674	21,192
Crosby	O	Brazos	133,239	133,058	133,058	133,058	133,058	133,058
		Red	1,624	1,624	1,624	1,624	1,624	1,624
Dawson	O	Brazos	5,350	5,350	5,350	5,138	4,075	1,099
		Colorado	196,260	192,758	180,531	156,477	131,379	92,681
Deaf Smith	O	Red	129,167	118,166	106,868	97,057	80,382	65,931
Floyd	O	Brazos	95,488	93,749	92,041	90,930	86,458	84,300
		Red	59,482	55,617	53,320	47,453	43,351	40,061
Gaines	O	Colorado	350,369	240,110	175,175	130,951	97,498	71,544
Garza	O	Brazos	19,203	19,073	18,942	18,812	18,032	17,121
Hale	O	Brazos	130,097	129,291	127,492	125,488	119,612	111,734
		Red	525	525	525	525	525	525
Hockley	O	Brazos	87,712	84,378	80,285	76,847	69,445	60,771
		Colorado	8,256	8,004	8,004	7,571	7,324	7,009
Howard	F	Colorado	3,075	3,075	2,731	2,731	2,731	2,703
Lamb	O	Brazos	147,368	137,304	125,466	111,509	95,696	85,190
Lubbock	O	Brazos	124,519	120,044	115,348	108,699	100,762	91,073
Lynn	O	Brazos	98,003	97,740	96,954	94,600	86,945	78,543
		Colorado	6,020	6,020	6,020	6,020	6,020	5,925
Martin	F	Colorado	13,570	13,570	13,570	13,140	12,299	12,277
Parmer	O	Brazos	50,258	45,572	39,624	35,624	29,978	27,692
		Red	18,436	17,493	16,960	16,525	15,642	13,289
Swisher	O	Brazos	28,248	28,248	26,603	19,889	14,084	8,304
		Red	82,677	79,158	74,399	64,929	59,764	55,994
Terry	O	Brazos	13,342	13,342	13,342	9,793	5,348	4,092
		Colorado	192,317	182,880	121,267	77,305	48,557	29,555
Yoakum	O	Colorado	82,297	59,745	43,575	33,882	26,717	20,040
Total			**2,366,866**	**2,132,679**	**1,907,970**	**1,699,827**	**1,496,184**	**1,306,683**

Table 3. Estimated total annual pumping for the Edwards-Trinity (High Plains) Aquifer in Groundwater Management Area 2. Results are in acre-feet per year and are divided by county, regional water planning area, and river basin.

County	Region	Basin	Year					
			2010	2020	2030	2040	2050	2060
Bailey	O	Brazos	279	279	279	279	279	279
Borden	F	Brazos	65	65	65	65	65	65
		Colorado	41	41	41	41	41	41
Cochran	O	Brazos	137	137	137	137	137	137
		Colorado	127	127	127	127	127	127
Dawson	O	Brazos	0	0	0	0	0	0
		Colorado	1,103	1,103	1,103	1,103	1,103	1,103
Floyd	O	Brazos	521	521	521	518	505	499
		Red	695	695	695	695	695	683
Gaines	O	Colorado	85,058	46,202	30,316	22,997	16,523	12,904
Garza	O	Brazos	18	18	18	18	18	18
		Colorado	0	0	0	0	0	0
Hale	O	Brazos	3,523	3,523	3,523	3,523	3,523	3,419
Hockley	O	Brazos	96	96	96	96	96	96
		Colorado	0	0	0	0	0	0
Lamb	O	Brazos	164	164	164	164	164	164
Lubbock	O	Brazos	690	690	690	690	690	690
Lynn	O	Brazos	221	221	221	221	221	221
		Colorado	9	9	9	9	9	9
Terry	O	Brazos	23	23	23	23	23	23
		Colorado	959	959	922	922	922	922
Yoakum	O	Colorado	2,532	1,893	1,757	1,642	1,642	1,524
Total			**96,261**	**56,766**	**40,707**	**33,270**	**26,783**	**22,924**

Table 4. Estimated total annual pumping for the Ogallala and Edwards-Trinity (High Plains) aquifers summarized by county in Groundwater Management Area 2 for each decade between 2010 and 2060. Results are in acre-feet per year.

County	Year					
	2010	2020	2030	2040	2050	2060
Andrews	17,638	15,135	13,719	12,055	10,057	7,418
Bailey	62,817	41,562	35,186	30,343	24,300	21,708
Borden	505	505	505	505	505	505
Briscoe	33,622	26,457	19,722	14,220	13,037	11,933
Castro	127,422	127,303	126,508	125,816	123,280	117,998
Cochran	48,609	36,472	33,905	30,960	28,348	25,635
Crosby	134,863	134,682	134,682	134,682	134,682	134,682
Dawson	202,713	199,211	186,984	162,718	136,557	94,883
Deaf Smith	129,167	118,166	106,868	97,057	80,382	65,931
Floyd	156,186	150,582	146,577	139,596	131,009	125,543
Gaines	435,427	286,312	205,491	153,948	114,021	84,448
Garza	19,221	19,091	18,960	18,830	18,050	17,139
Hale	134,145	133,339	131,540	129,536	123,660	115,678
Hockley	96,064	92,478	88,385	84,514	76,865	67,876
Howard	3,075	3,075	2,731	2,731	2,731	2,703
Lamb	147,532	137,468	125,630	111,673	95,860	85,354
Lubbock	125,209	120,734	116,038	109,389	101,452	91,763
Lynn	104,253	103,990	103,204	100,850	93,195	84,698
Martin	13,570	13,570	13,570	13,140	12,299	12,277
Parmer	68,694	63,065	56,584	52,149	45,620	40,981
Swisher	110,925	107,406	101,002	84,818	73,848	64,298
Terry	206,641	197,204	135,554	88,043	54,850	34,592
Yoakum	84,829	61,638	45,332	35,524	28,359	21,564
Total	**2,463,127**	**2,189,445**	**1,948,677**	**1,733,097**	**1,522,967**	**1,329,607**

Table 5. Estimated total annual pumping for the Ogallala and Edwards-Trinity (High Plains) aquifers summarized by regional water planning area in Groundwater Management Area 2 for each decade between 2010 and 2060. Results are in acre-feet per year.

Regional Water Planning Area	Year					
	2010	2020	2030	2040	2050	2060
F	34,788	32,285	30,525	28,431	25,592	22,903
O	2,428,339	2,157,160	1,918,152	1,704,666	1,497,375	1,306,704
Total	**2,463,127**	**2,189,445**	**1,948,677**	**1,733,097**	**1,522,967**	**1,329,607**

Table 6. Estimated total annual pumping for the Ogallala and Edwards-Trinity (High Plains) aquifers summarized by river basin in Groundwater Management Area 2 for each decade between 2010 and 2060. Results are in acre-feet per year.

Basin	Year					
	2010	2020	2030	2040	2050	2060
Brazos	1,108,085	1,052,535	1,012,364	961,614	886,567	818,946
Colorado	991,705	800,189	626,018	492,965	386,689	287,040
Red	363,283	336,671	310,254	278,477	249,670	223,580
Rio Grande	54	50	41	41	41	41
Total	**2,463,127**	**2,189,445**	**1,948,677**	**1,733,097**	**1,522,967**	**1,329,607**

Table 7. Estimated total annual pumping for the Ogallala and Edwards-Trinity (High Plains) aquifers summarized by groundwater conservation district (GCD) in Groundwater Management Area 2 for each decade between 2010 and 2060. Results are in acre-feet per year. UWCD refers to Underground Water Conservation District.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Garza County UWCD	19,221	19,091	18,960	18,830	18,050	17,139
High Plains UWCD No. 1	1,421,975	1,343,554	1,282,656	1,208,126	1,109,582	1,019,597
Llano Estacado UWCD	435,427	286,312	205,491	153,948	114,021	84,448
Mesa UWCD	202,713	199,211	186,984	162,718	136,557	94,883
Permian Basin UWCD	16,403	16,403	16,099	15,669	14,828	14,795
Sandy Land UWCD	84,829	61,638	45,332	35,524	28,359	21,564
South Plains UWCD	207,257	197,820	136,170	88,659	55,466	35,208
Total (excluding non-district areas)	**2,387,825**	**2,124,029**	**1,891,692**	**1,683,474**	**1,476,863**	**1,287,634**
No District	75,302	65,416	56,985	49,623	46,104	41,973
Total (including non-district areas)	**2,463,127**	**2,189,445**	**1,948,677**	**1,733,097**	**1,522,967**	**1,329,607**

Table 8. Estimates of annual exempt use for the Ogallala and Edwards-Trinity (High Plains) aquifers in Groundwater Management Area 2 by groundwater conservation district (GCD) for each decade between 2010 and 2060. Results are in acre-feet per year. UWCD refers to Underground Water Conservation District.

Groundwater Conservation District	Source	Year					
		2010	2020	2030	2040	2050	2060
Garza County UWCD	TA	68	71	69	67	64	59
High Plains UWCD No. 1	D	15,482	16,253	16,712	16,925	17,087	17,043
Llano Estacado UWCD	D	2,242	2,332	2,397	2,443	2,435	2,420
Mesa UWCD	TA	542	558	573	582	566	545
Permian Basin UWCD	TA	575	596	605	608	605	599
Sandy Land UWCD	TA	366	402	424	448	436	422
South Plains UWCD	TA	502	537	569	601	603	599
Total		**19,777**	**20,749**	**21,349**	**21,674**	**21,796**	**21,687**

TA = Estimated exempt use calculated by TWDB and accepted by the district

D = Estimated exempt use calculated by the district

Table 9. Estimates of managed available groundwater for the Ogallala and Edwards-Trinity (High Plains) aquifers in Groundwater Management Area 2 by groundwater conservation district (GCD) for each decade between 2010 and 2060. Results are in acre-feet per year. UWCD refers to Underground Water Conservation District.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Garza County UWCD	19,153	19,020	18,891	18,763	17,986	17,080
High Plains UWCD No. 1	1,406,493	1,327,301	1,265,944	1,191,201	1,092,495	1,002,554
Llano Estacado UWCD	433,185	283,980	203,094	151,505	111,586	82,028
Mesa UWCD	202,171	198,653	186,411	162,136	135,991	94,338
Permian Basin UWCD	15,828	15,807	15,494	15,061	14,223	14,196
Sandy Land UWCD	84,463	61,236	44,908	35,076	27,923	21,142
South Plains UWCD	206,755	197,283	135,601	88,058	54,863	34,609
Total	**2,368,048**	**2,103,280**	**1,870,343**	**1,661,800**	**1,455,067**	**1,265,947**

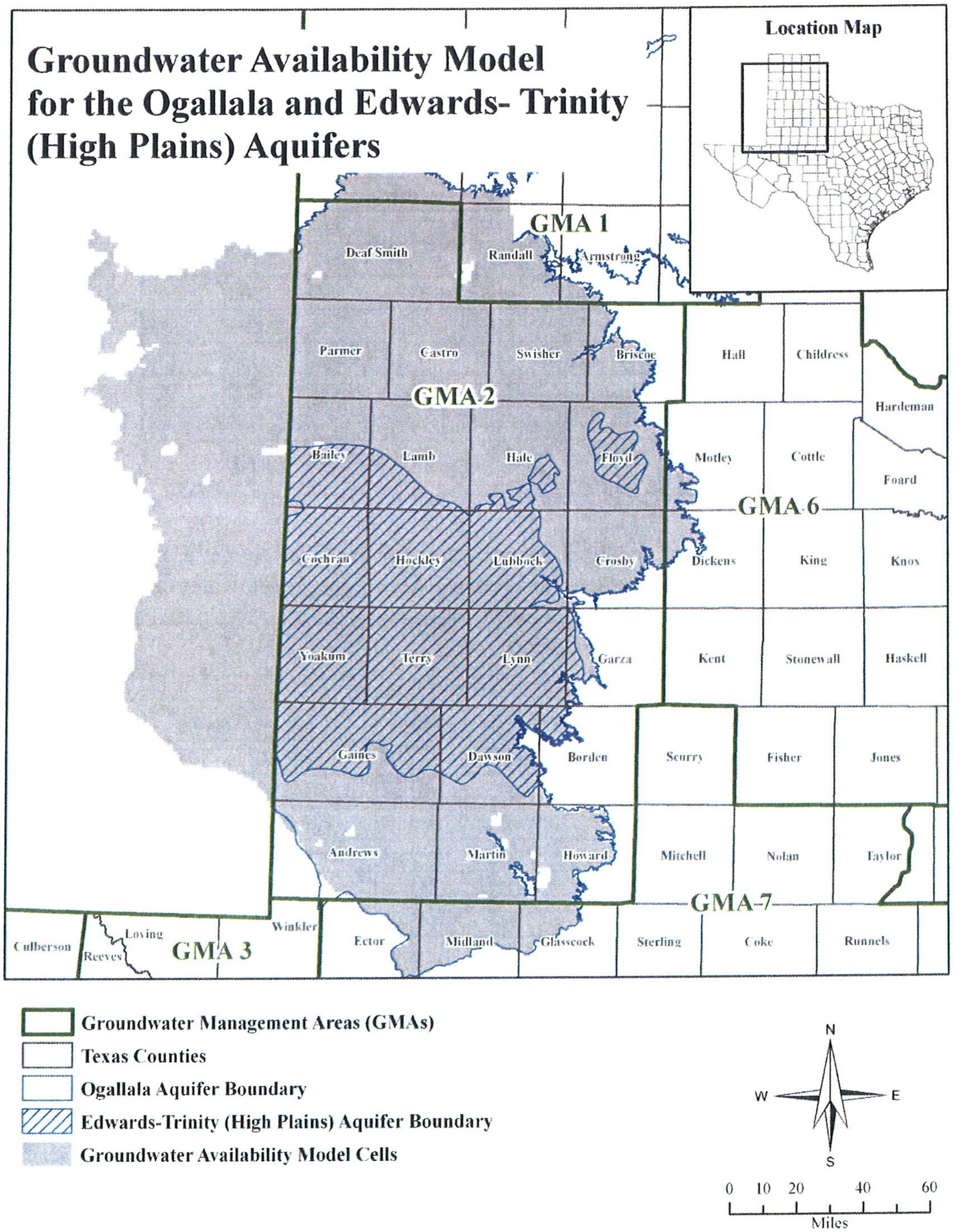

Figure 1. Map showing the areas covered by the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer.

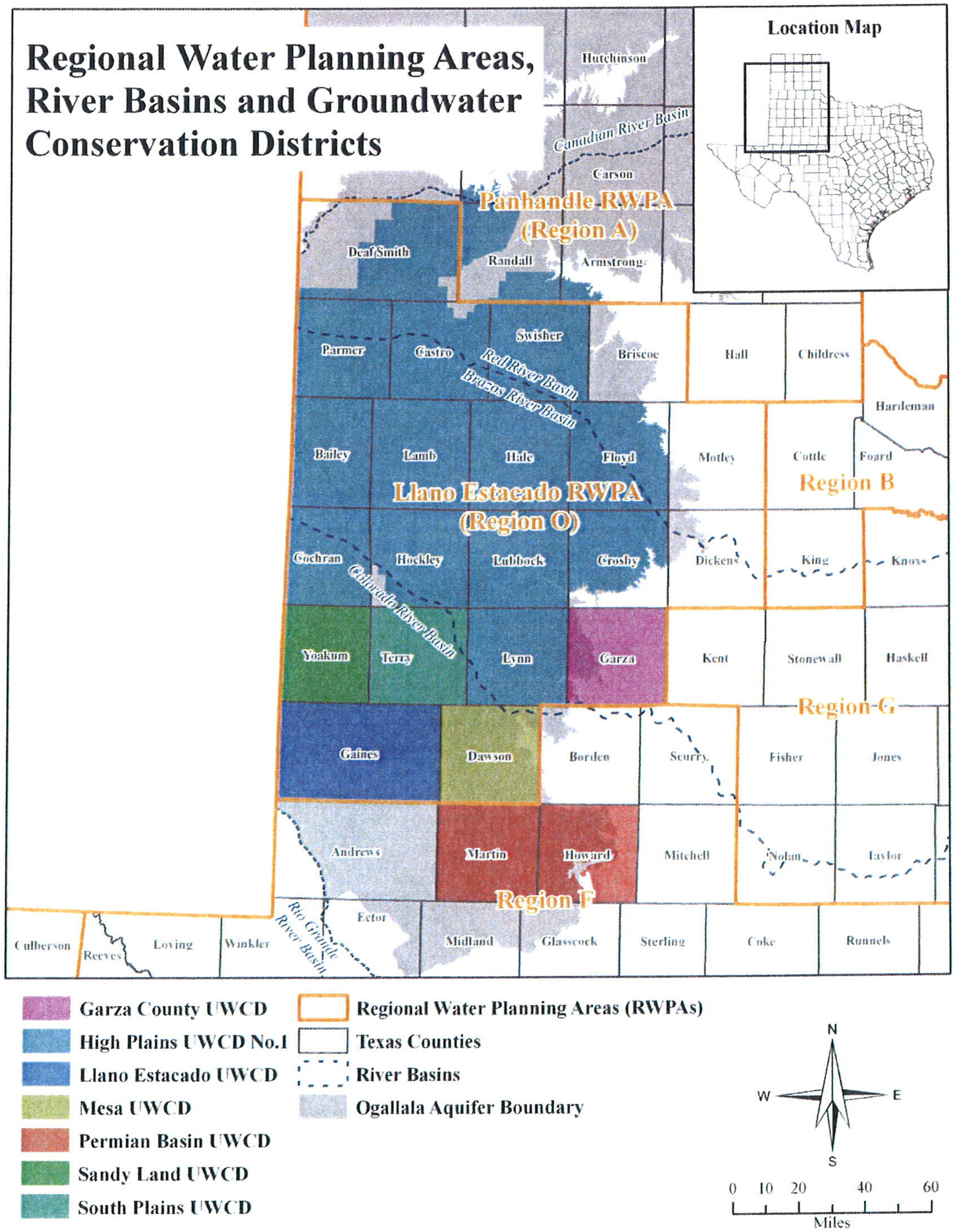

Figure 2. Map showing regional water planning areas (RWPAs), groundwater conservation districts (GCDs), counties, and river basins in Groundwater Management Area 2. UWCD refers to Underground Water Conservation District.