GLASSCOCK GROUNDWATER CONSERVATION DISTRICT

GROUNDWATER MANAGEMENT PLAN

2019-2024

Adopted February 18, 2020

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TABLE OF CONTENTS

DISTRICT MISSION

The Glasscock Groundwater Conservation District strives to bring about conservation, preservation, and the efficient, beneficial and wise use of water for the benefit of the citizens and economy of the District through monitoring and protecting the quality of the groundwater.

TIME PERIOD FOR THIS PLAN

This plan becomes effective upon adoption by the District Board of Directors and approval by the Texas Water Development Board (TWDB) affirming the plan is administratively complete. This plan replaces the existing plan adopted by the District Board of Directors on September 23, 2014. The current District management plan will remain in effect until a revised plan is approved or October 1, 2019, whichever is earlier.

STATEMENT OF GUIDING PRINCIPLES

The primary concern of the residents of this area of the State regarding groundwater is the potential contamination of the groundwater from the vast amount of oil and gas production and the activities involved in the production of oil and gas. For this reason, the residents asked Representative Tom Craddick to introduce legislation to create this groundwater conservation district. The District recognizes that the groundwater resources of this region are of vital importance to the residents and that this resource must be managed and protected from contamination. The greatest threat to prevent the District from achieving the stated mission is from state mandates and agency bureaucrats who have no understanding of local conditions. A basic understanding of the aquifers and their hydrogeologic properties, as well as a quantification of resources is the foundation from which to build prudent planning measures. This management plan is intended as a tool to focus the thoughts and actions of those given the responsibility for the execution of District activities.

General Description

The Glasscock Groundwater Conservation District (GCD) was created by Acts of the 67th Legislature (1981). In August 1981, the residents confirmed the District and voted to fund the district operations through local property taxes. It became an active District in August 1981. On April 15, 1986, the District adopted Rules and By-Laws which became effective immediately and on February 21, 1989 the District adopted a management plan. With the adoption of these rules, the District implemented a well permitting and registration program. The District rules were amended on June 20, 2000. The current members of the Board of Directors are: Galen Schwartz; President, Allan Fuchs; Vice President, Wayne Hirt; Secretary, Bart Belew; Member and Russell Halfmann; Member. The District General Manager is Rhetta Yanez and Rocio De Luna is the Secretary. The Glasscock GCD covers all of Glasscock County and a portion of

Northwest Reagan County. The District's economy is based primarily on agriculture, and oil and gas production. The agricultural income is derived primarily from cotton, grain sorghum, wheat, alfalfa, pecans, as well as sheep, goats, and beef cattle production. Recreational hunting leases also contribute to the income of the area.

Location and Extent

The Glasscock GCD has an aerial extent of approximately 900 square miles or approximately 571,499 acres of land in Glasscock County and 65,350 acres in Northwest Reagan County. The total population of the District is approximately 1,400 people. There are no incorporated cities within the District boundaries. The two communities within the District are Garden City and St. Lawrence. Land use in the District is for agricultural purposes of which 151,000 acres is crop or farmland, 85,009 acres is improved pasture, and the balance of 400,840 acres is rangeland. The majority of the District is over the Edwards-Trinity (Plateau) Aquifer with exception of the northwest part of Glasscock County which is over the Ogallala Aquifer. The cropland is located primarily in the southern and northwest portions of the District, with the balance being in pasture and rangeland. Irrigation covers approximately 36,529 acres of the District's cropland. Of these acres, 26,529 are located in Glasscock County and 10,000 acres are located in Reagan County. Historically, the principal method of irrigation had been furrow irrigation. However, within recent years there has been a gradual trend to change to more highly efficient subsurface drip irrigation and low energy precision application (LEPA) center pivots. There are currently, approximately 28,400 acres of subsurface drip irrigation and 5,129 acres of LEPA center pivots within the District. The remaining 3,000 acres is furrow irrigation.

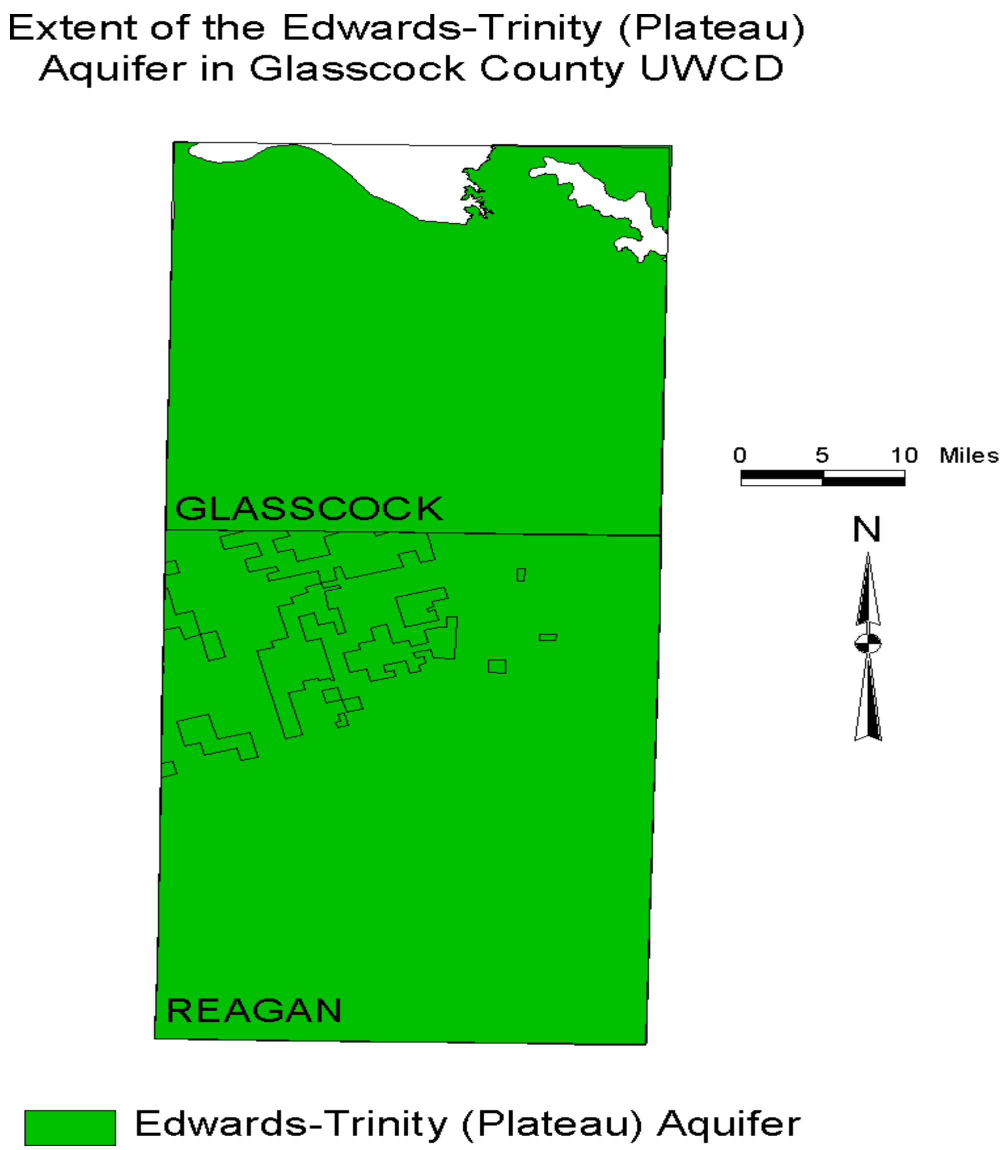
Topography and Drainage

The District is within what is known as the Permian Basin of Texas. Topographically, the area within the District is generally a nearly level to undulating plain that slopes upward from the east to the west. The altitude of the land surface ranges from 2,300 feet above sea level in the eastern part of the District to about 2,750 feet above sea level in the western part of the District.

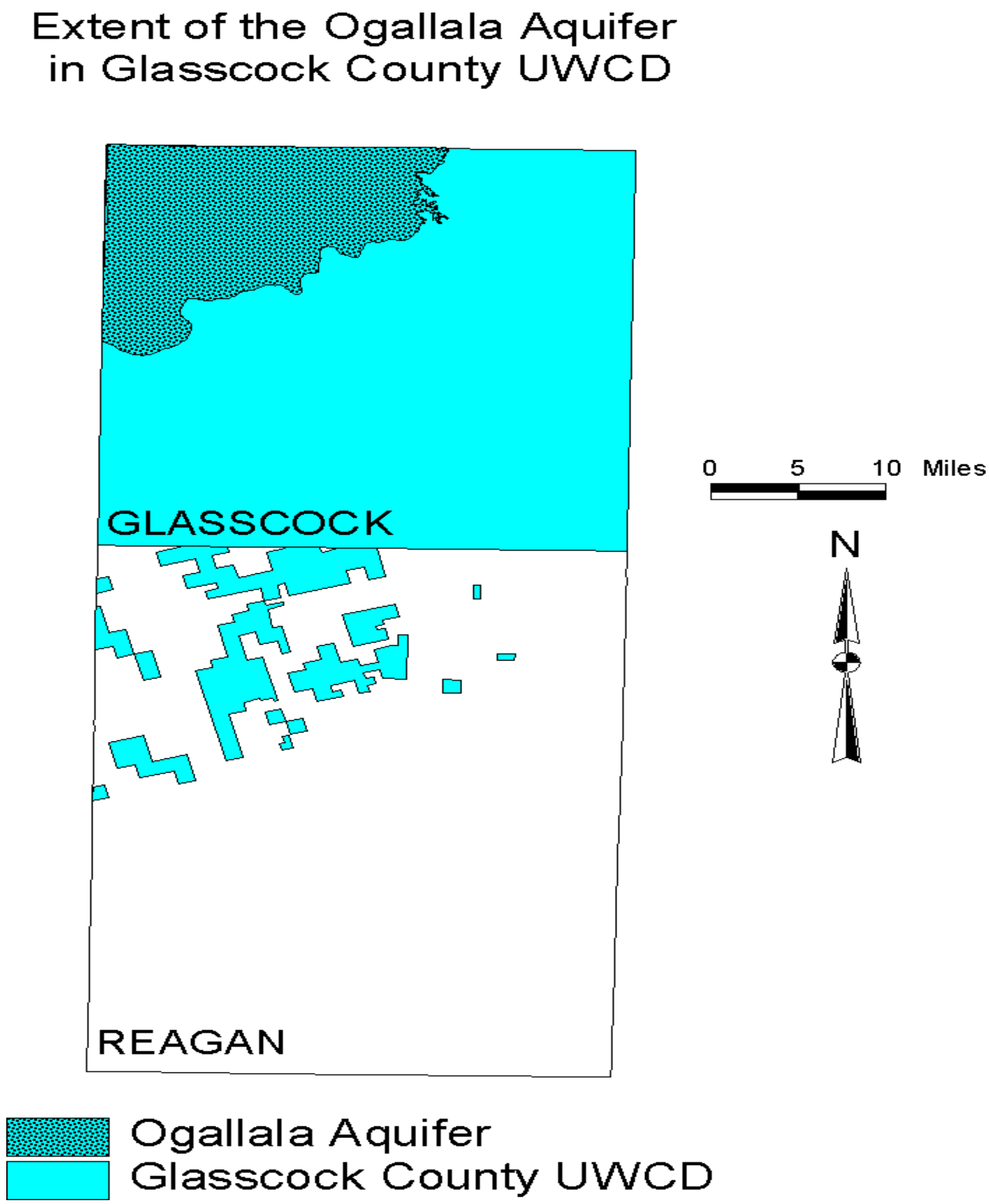
The Glasscock GCD lies within the Colorado River Basin. The North Concho River is a tributary of the Colorado River and is located in the northeast part of the District.

Groundwater Resources

The Edwards-Trinity (Plateau) Aquifer underlies the entire District except in the northwest portion of Glasscock County. Water from this aquifer is principally used for irrigation, rural domestic, and livestock needs. This aquifer consists of saturated sediments of lower Cretaceous Epoch Trinity Group formations and overlying limestones and dolomite of the Comanche Peak, Edwards, and Georgetown formations. The Glen Rose Limestone is the primary unit of the Trinity Group in the southern part of the plateau and is replaced by the Antlers Sand north of the Glen Rose pinch out. Reported well yields range from 20 gal/min, where saturated thickness is thin, to more than 300 gal/min, within the District. Chemical quality of 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. The salinity of the groundwater tends to increase toward the west. Certain areas have unacceptable levels of fluoride. Water levels have declined as a result of increased pumpage and the increase of harmful vegetation such as mesquite and prickly pear. The average decline has been approximately 20 feet since 1980. (See map on next page)

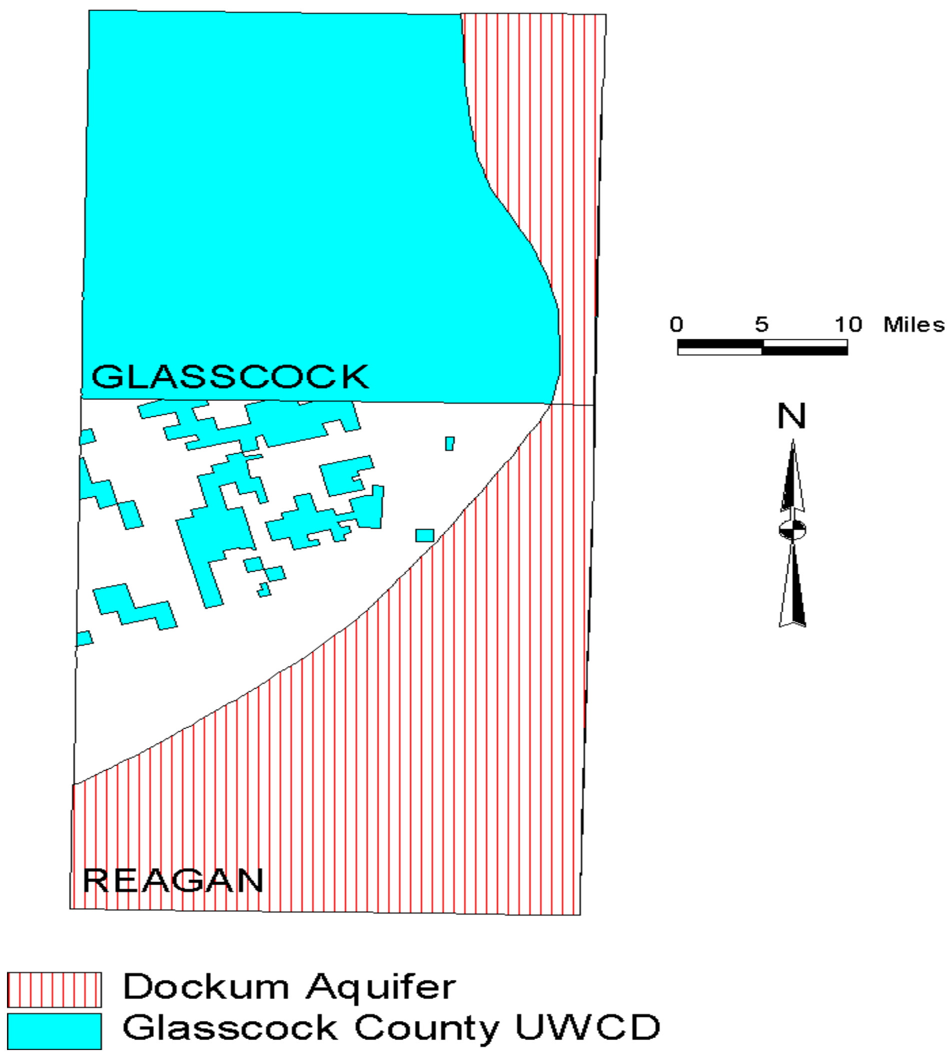

Extent of the Edwards-Trinity (Plateau)
Aquifer in Glasscock County UWCD
GLASSCOCK
REAGAN
0
5
10
Miles
N
Edwards-Trinity (Plateau) Aquifer

The Ogallala Aquifer is located in northwest Glasscock County. It is composed primarily of sand, gravel, clay and silts deposited during the Tertiary Period. Water from this aquifer is principally used for irrigation, rural domestic, and livestock needs. Water yields from this aquifer are generally greater than 150 gal/min. The chemical quality of the water in the aquifer is generally fresh; however, higher levels of dissolved-solids and chloride concentrations can be found within the District. Water levels have fluctuated in this area due to several acres participating in the USDA Conservation Reserve Program being removed and put back into production. (See map below)



The Dockum Group of the Triassic Period is located in the extreme eastern portion of the District. This aquifer is used principally for livestock needs. (See map below)

Extent of the Dockum Aquifer
in Glasscock County UWCD



The aquifer explanations above were taken from Texas Water Development Board's Report 380, July 2011, "Aquifers of Texas".

Currently the District is using the 2017 State Water Plan Projected Water Availability as well as estimates of recharge and availability rates. The data sets describe the saturated thickness and yield, which the product describes as water in storage. When combined with recharge and production values, these estimates can be used by the District to derive goals for future estimates of available groundwater. Currently within the District, there is an estimated 23,637 acre-feet of recoverable water in storage in the Edwards-Trinity (Plateau) Aquifer, 3,928 acre-feet in the Ogallala Aquifer, and 145 acre-feet in the Dockum Aquifer. There is an estimated 42 acre-feet in surface water from private stock tanks. The existing total usable amount of groundwater in the District is 27,752 acre-feet on an annual basis.

Groundwater Availability Model (GAM RUN 18-022)
Please refer to Appendix A

Surface Water Resources
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.

Estimated Historical Groundwater Use
Please refer to Appendix B.

Projected Surface Water Supply
Please refer to Appendix B.

Projected Total Demand for Water
Please refer to Appendix B

Water Supply Needs

Based on supply and demand calculations and projections it is obvious that there will be times that demands exceed supply. In this area of the State and with the type of aquifer that serves the area, this is a normal occurrence that is recognized by the local residents. This information can be found in Appendix B from the 2017 State Water Plan.

The residents of the District understand that groundwater supplies are limited and have modified farming and ranching techniques to match the availability of water. There are currently, approximately 28,400 acres of subsurface drip irrigation and 5,129 acres of LEPA center pivots within the District, with more acres going in every year. Efforts are being made by the residents

of the District to use the available groundwater resources with maximum efficiency, while monitoring the quality of the groundwater to protect this resource for the years to come.
The District has no identified water needs in the Region F Plan.

Water Management Strategies
The District continues to encourage conservation and reuse to meet the projected strategies in the Texas Water Development Board 2017 State Water Plan. The water management plan strategies for the District include irrigation conservation, mining conservation, municipal conservation.
Please refer to Appendix B.

Management of Groundwater Supplies

Since 1981, the District has and will continue to manage the supply of groundwater within the District, in order to conserve the resource while seeking to maintain the economic viability of all resource user groups, public and private. In consideration of the economic and cultural activities occurring within the District, the District will continue to identify and engage in such activities and practices, that if implemented, would result in preservation and protection of the groundwater. The observation network will continue to be reviewed and maintained in order to monitor changing conditions of groundwater within the District. The District will undertake investigations of the groundwater resources within the District and will make the results of investigations available to the public.

The District has, or will amend as necessary, rules to regulate groundwater withdrawals by means of spacing and/or production limits. The relevant factors to be considered in making the determination to grant a permit or limit groundwater withdrawal will include:

1. The purpose of the District and its rules;
2. The equitable conservation and preservation of the resource; and
3. The economic hardship resulting from granting or denying a permit or the terms prescribed by the rules.

In pursuit of the District's mission of preserving and protecting the resource, the District will enforce the terms and conditions of permits and the rules of the District by enjoining the permit holder in a court of competent jurisdiction, as provided for in TWC Chapter 36.102, if necessary.

Actions, Procedures, Performance, and Avoidance for Plan Implementation

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 adopted and will amend, as necessary, rules relating to the implementation of this plan. The rules adopted by the District shall be pursuant to TWC Chapter 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 shall treat all citizens with equality. Citizens may apply to the District for discretion in enforcement of the rules on grounds of adverse economic effect or unique local characteristics. In granting of discretion to any rule, the Board shall consider the potential for adverse effect on adjacent owners and aquifer conditions. The exercise of said discretion by the Board shall not be construed as limiting the power of the Board.

District rules can be viewed at http://glasscock-groundwater.org/rules_by-laws

Modeled Available Groundwater
Refer to Appendix C (GAM Run 16-026 MAG v. 2)

GOALS, MANAGEMENT OBJECTIVES
and PERFORMANCE STANDARDS

Methodology
The methodology that the District will use to trace its progress on an annual basis in achieving all of its management goals will be as follows: The District manager will prepare and present an annual report to the Board of Directors on District performance in regards to achieving management goals and objectives (during the first monthly Board of Directors meeting each fiscal year, beginning December 31, 2000). The report will include the number of instances each activity was engaged in during the year. The annual report will be maintained on file at the District office.

Goal 1.0 Controlling and Preventing Waste of Groundwater
<u>Management Objective</u>

1.1 Each month, the District will investigate all identified wasteful practices within two (2) working days of identification or complaint received.

<u>Performance Standard</u>

1.1a Number of wasteful practices identified and the average number of days District personnel took to respond or investigate after identification or complaint received, during the month.

Goal 2.0 Providing the Most Efficient Use of Groundwater

<u>Management Objective</u>

2.1 Each year, the District will provide laser plane leveling equipment (based upon availability) to producers for better irrigation planning and contour farming.

<u>Performance Standard</u>

2.1a Annual report to the Board of Directors the number of times District's leveling equipment was loaned to producers.

Goal 3.0 Addressing Drought Conditions
<u>Management Objective</u>

3.1 The District will monitor the Palmer Drought Severity Index (PDSI) by Texas Climatic Divisions. https://www.waterdatafortexas.org/drought

<u>Performance Standard</u>

3.1a The District staff will report the PDSI findings and actions to the Board of Directors at least quarterly.

Goal 4.0 Addressing Conservation, Recharge Enhancement, Precipitation Enhancement, Rainwater Harvesting, and Brush Control where appropriate and cost effective. (36.1071(a)(7)

Management Objective: Conservation

4.1 Provide information to area residents about water conservation. http://www.savetexaswater.org

Performance Standard: Conservation

4.1a The District staff will provide information to the local newsletter at least once a year.

Management Objective: Recharge Enhancement

4.2 Provide and distribute literature on recharge enhancement to area residents.

Performance Standards: Recharge Enhancement

4.2a The District staff will provide information to the local newsletter at least once a year.

Management Objective: Rainwater Harvesting

4.3 Provide and distribute literature on rainwater harvesting to area residents.

Performance Standards: Rainwater Harvesting

4.3a The District staff will provide information to the local newsletter at least once a year.

Management Objective: Brush Control

4.4 Provide and distribute literature on brush control to area residents.

Performance Standards: Brush Control

4.4a The District staff will provide information to area residents about brush control.

4.4b Annual report to the Board of Directors listing the number of times brush control information was distributed at least once a year

Goal 5.0 Addressing Desired Future Conditions (DFCs) adopted by GMA 7

Management Objective

5.1 The District will monitor water levels and evaluate whether the average change in water well levels is in conformance with the Desired Future Conditions adopted by the District. The District will estimate total annual groundwater production for each aquifer based on water use reports, estimated exempt use and other relevant information and compare these production estimates to the MAGs. The DFCs for GMA 7 can be seen here:
http://www.twdb.texas.gov/groundwater/dfc/docs/summary/GMA7_DFC_2016.pdf?d=25484.0043

Performance Standards

5.1a Record the water level data and average annual change in water levels for each

aquifer and compare to the DFCs. Include this information in the District's Annual Report.
5.1b Record the total estimated annual productions for each aquifer and compare these amounts to the MAG. Include this information in the District's Annual Report.

Goal 6.0 Addressing Natural Resource Issues. Gather and maintain groundwater data to improve the understanding of the aquifers and their hydrogeologic properties. This data will help in determining groundwater availability and future planning. (36.1071(a) (5))

<u>Management Objective</u>

6.1 The District will submit all requested water quality samples within 7 business days from receipt.

<u>Performance Standards</u>

6.1a The number of results will be presented to the Board in the District's annual report.

<u>Management Objective</u>

6.2 This District will inspect any abandoned wells discovered by District staff or reported to the District and send a letter to the landowner requiring the well be covered or plugged in accordance with state laws.

<u>Performance Standards</u>

6.2a the number of abandoned well enforcement letters will be reported to the Board in the District's annual report.

<u>Management Objective</u>

6.3 The District will require all wells drilled for oil and gas operations be permitted or registered, including meeting the spacing standards if applicable.

<u>Performance Standards</u>

6.3a The number of wells drilled for this purpose will be reported to the board in the District's annual report.

MANAGEMENT GOALS DETERMINED NOT APPLICABLE

Goal 7.0 Addressing Precipitation Enhancement

The Board of Directors has determined precipitation enhancement not to be cost-effective for the District. Therefore, this goal is not applicable.

Goal 8.0 Controlling and preventing subsidence

The rigid geologic framework of the region precludes significant subsidence from occurring. Upon examining the major aquifer subsidence risk map on page 1.7 and the minor aquifer subsidence risk map on page 1.8 of the TWDB subsidence risk report, District staff was able to see the risk for subsidence was very low in our District. Therefore, no immediate actions on our part is indicated. This goal is not applicable to the operations of the District.

Goal 9.0 Addressing Conjunctive surface water management issues

No surface water management entities exist within the District. There are no surface water impoundments within the District except for livestock consumption. The Glasscock GCD has no jurisdiction over surface water. The groundwater within the district is used primarily for irrigated agriculture, rural domestic, livestock and petroleum drilling and exploration needs. This goal is not applicable to the operations of the District.

Summary Definitions.

"Abandoned Well" - shall mean:
1) A well or borehole the condition of which is causing or is likely to cause pollution of groundwater in the District. A well is considered to be in use in the following cases:

(A) A well which contains the casing, pump, and pump column in good condition; or

(B) A well in good condition which has been capped.

2) a well or borehole which is not in compliance with applicable law, including the Rules and Regulations of the District, the Texas Water Well Drillers' Act, Texas Natural Resource Conservation Commission, or any other state or federal agency or political subdivision having jurisdiction, if presumed to be an abandoned or deteriorated well.

"Board" - the Board of Directors of the Glasscock Groundwater Conservation District.

"District" - the Glasscock Groundwater Conservation District.

"TCEQ" - Texas Commission on Environmental Quality.

"TWDB" - Texas Water Development Board.

"Waste" - as defined by Chapter 36 of the Texas Water Code means any one or more of the following:

(1) withdrawal of groundwater from a groundwater reservoir at a rate and in an amount that causes or threatens to cause intrusion into the reservoir of water unsuitable for agricultural, gardening, domestic, or stock raising purposes;

(2) The flowing or producing of wells from a groundwater reservoir if the water produced is not used for a beneficial purpose;

(3) escape of groundwater from a groundwater reservoir to any other reservoir or geologic strata that do not contain groundwater;

(4) Pollution or harmful alteration of groundwater in a groundwater reservoir by saltwater or by other deleterious matter admitted from another stratum or from the surface of the ground;

(5) willfully or negligently causing, suffering, or allowing groundwater to escape into any river, creek, natural watercourse, depression, lake, reservoir, drain, sewer, street, highway, road, or road ditch, or onto any land other than that of the owner of the well unless such discharge is authorized by permit, rule, or order issued by the commission under Chapter 26;

(6) groundwater pumped for irrigation that escapes as irrigation tail water onto land other than that of the owner of the well unless permission has been granted by the occupant of the land receiving the discharge; or

(7) For water produced from an artesian well, "waste" has the meaning assigned by Section 11.205.

Appendix A

GAM RUN 18-022: GLASSCOCK GROUNDWATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Shirley C. Wade, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-936-0883
February 11, 2019

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2011), 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 Glasscock Groundwater 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 Department. 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 Glasscock Groundwater Conservation District should be adopted by the district on or before October 17, 2019 and submitted to the

Executive Administrator of the TWDB on or before November 16, 2019. The current management plan for the Glasscock Groundwater Conservation District expires on January 15, 2020.

We used two groundwater availability models to estimate the management plan information for the aquifers within the Glasscock Groundwater Conservation District. Information for the Dockum and Ogallala 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 the alternative groundwater model for the Edwards-Trinity (Plateau) Aquifer (Hutchison and others, 2011).

This report replaces the results of GAM Run 12-020 (Wade, 2012). GAM Run 18-022 includes results from the groundwater availability model for the High Plains Aquifer System released in 2015 (Deeds and Jigmond, 2015). Tables 1 through 3 summarize the groundwater availability model data required by statute and Figures 1 through 3 show the area of the models from which the values in the tables were extracted. If, after review of the figures, Glasscock Groundwater 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 two groundwater availability models mentioned above were used to estimate information for the Glasscock Groundwater Conservation District management plan. Water budgets were extracted for the historical model periods for the Dockum and Ogallala aquifers (1980 through 2012) and Edwards-Trinity (Plateau) Aquifer (1980 through 2005) 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 aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

High Plains Aquifer System (Dockum and Ogallala aquifers)

- We used version 1.01 of the groundwater availability model for the High Plains Aquifer System. See Deeds and Jigmond (2015) for assumptions and limitations of the model.

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

- 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

- Perennial rivers and reservoirs were simulated using MODFLOW-NWT river package. Springs, seeps, and draws were simulated using MODFLOW-NWT drain package.

Edwards-Trinity (Plateau) Aquifer

- The one-layer alternative groundwater flow model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Hutchison and others, 2011) was used for these simulations. The modified model version was developed to more effectively simulate groundwater conditions. The model was calibrated based on groundwater elevation data from 1930 to 2005.

- 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 middle, and the Hill Country portion of the Trinity Aquifer in the southeast portion of the model area. A lumped representation of both the Pecos Valley and Edwards-Trinity (Plateau) aquifers was used in the relatively narrow area where the Pecos Valley

Aquifer overlies the Edwards-Trinity (Plateau) Aquifer. Only the Edwards-Trinity (Plateau) Aquifer underlies the district.

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

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Dockum, Ogallala, and Edwards-Trinity (Plateau) aquifers 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 DOCKUM AQUIFER FOR GLASSCOCK GROUNDWATER 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	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Dockum Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	2
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	67
Estimated net annual volume of flow between each aquifer in the district	Into the Dockum Aquifer from the Edwards-Trinity (Plateau) Aquifer and other overlying units	1
	From the saline portions of the Dockum Group into the Dockum Aquifer	44

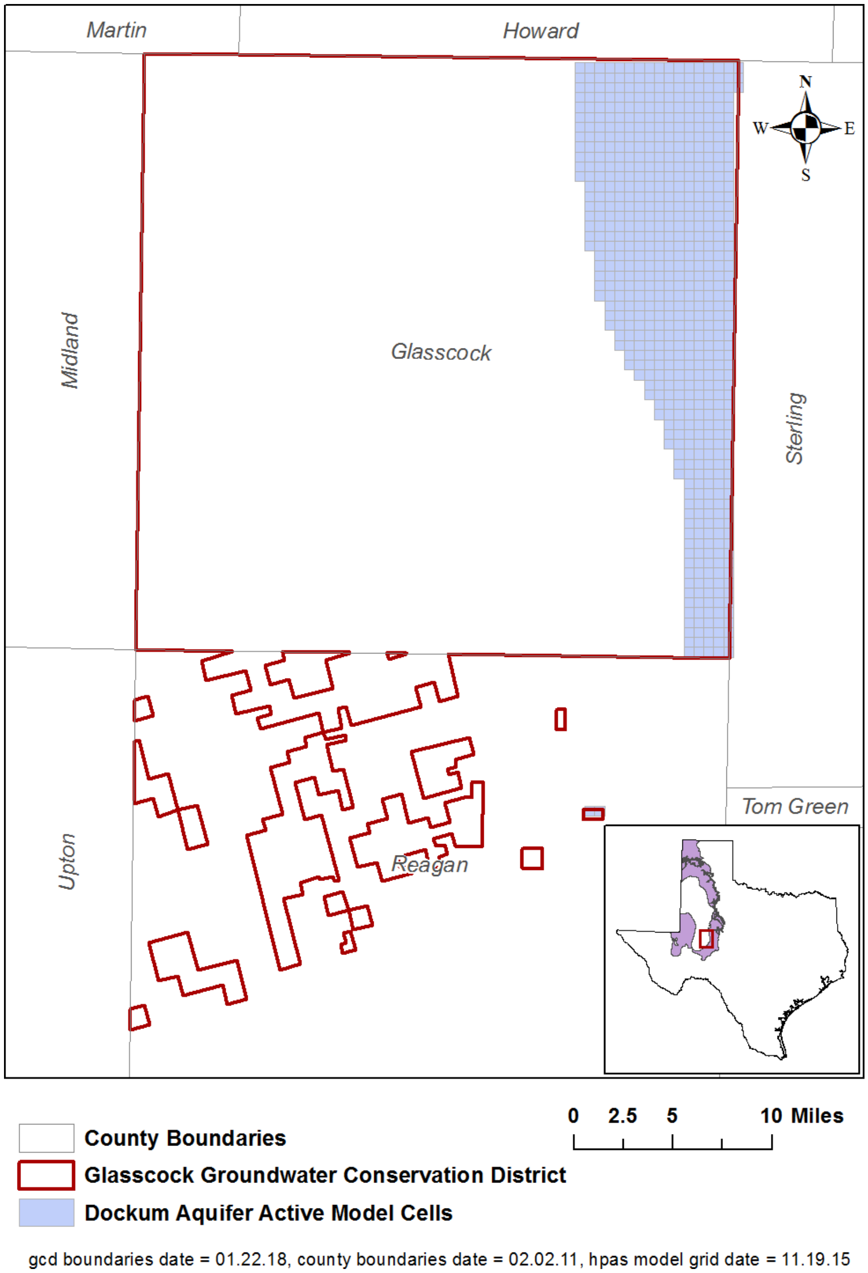


FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE OGALLALA AQUIFER FOR GLASSCOCK GROUNDWATER 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	3,186
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ogallala Aquifer	951
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	751
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	420
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer into the Edwards-Trinity (Plateau) Aquifer	5,412[1]

[1] This value was extracted from the alternative groundwater model for the Edwards-Trinity (Plateau) Aquifer. The groundwater availability model for the High Plains Aquifer System indicates 445 acre-feet per year flows into the Ogallala Aquifer from the Edwards-Trinity (Plateau) Aquifer; however, the Edwards-Trinity (Plateau) is included mainly as a boundary condition for the High Plains Aquifer System model.

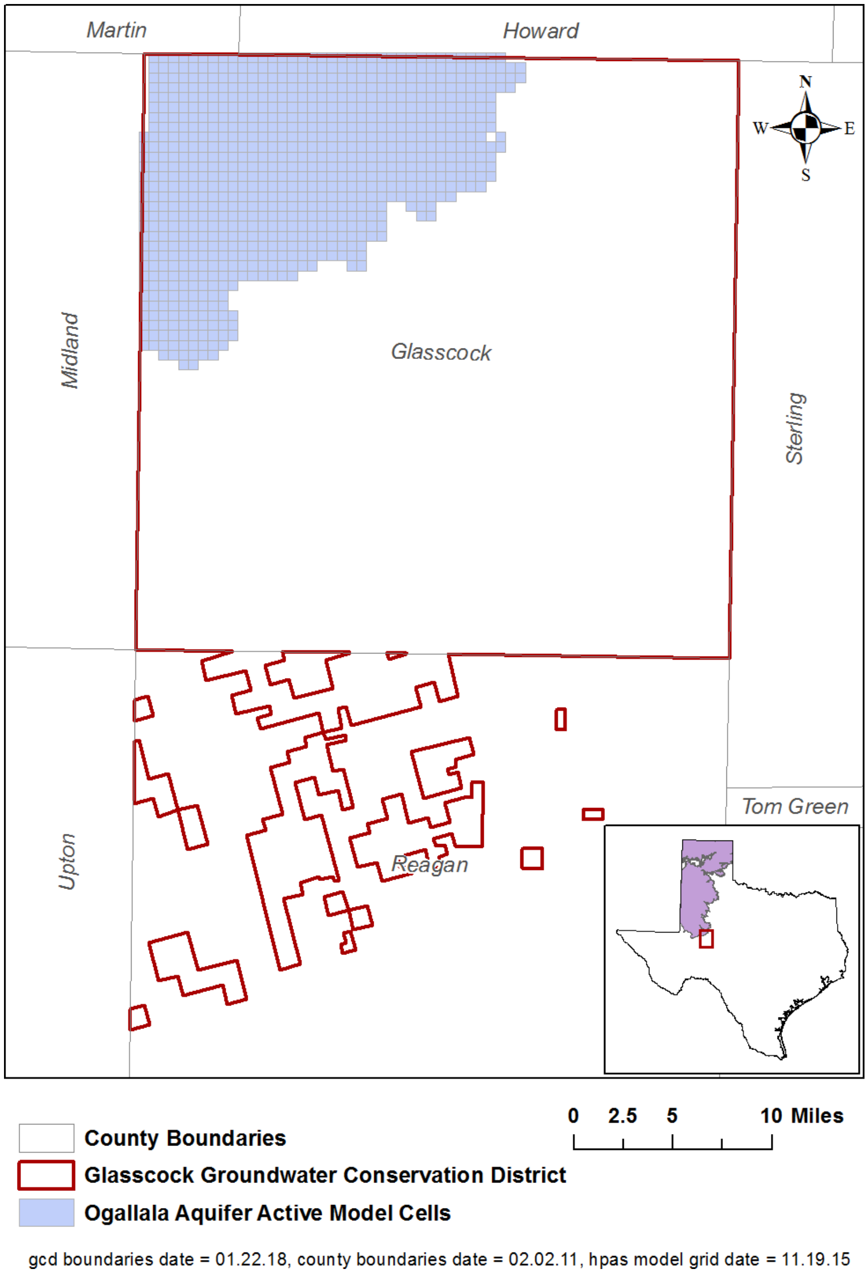


FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE OGALLALA AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FOR GLASSCOCK GROUNDWATER 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	Edwards-Trinity (Plateau) Aquifer	23,079
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	431
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	50,475
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	51,411
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer into the Edwards-Trinity (Plateau) Aquifer	5,412

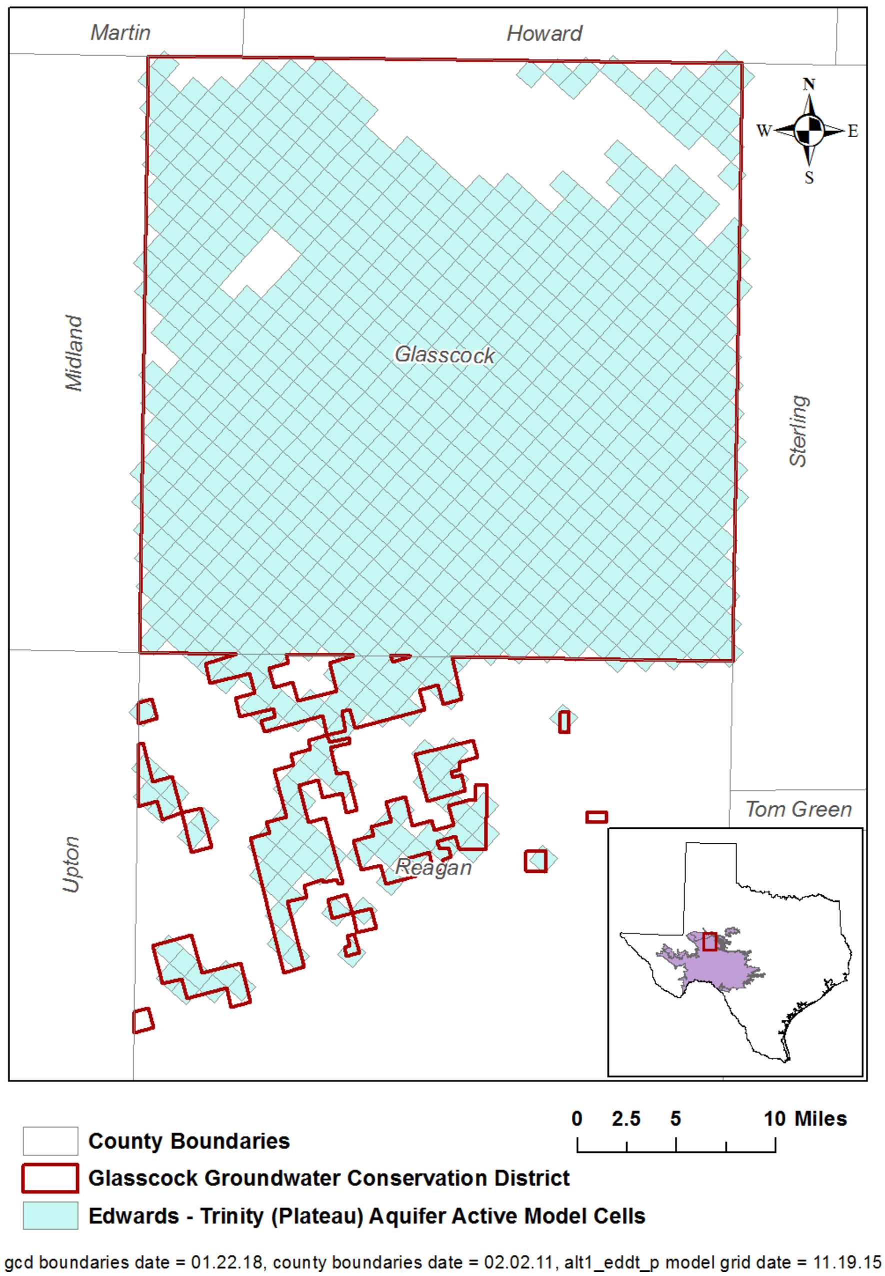


FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

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 historical groundwater flow conditions includes the assumptions about the location in the aquifer where historical pumping was placed. Understanding the amount and location of historical 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 historical 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. Historical 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 B

Estimated Historical Groundwater Use And 2017 State Water Plan Datasets:

Glasscock Groundwater Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
January 13, 2020

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 1/13/2020. 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).

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

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2018. TWDB staff anticipates the calculation and posting of these estimates at a later date.

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

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2017	GW	124	25	6,536	0	39,419	92	46,196
	SW	0	0	0	0	0	23	23
2016	GW	122	35	2,619	0	37,376	89	40,241
	SW	0	0	0	0	0	22	22
2015	GW	118	38	3,127	0	25,274	88	28,645
	SW	0	0	0	0	0	22	22
2014	GW	128	25	3,596	0	51,077	88	54,914
	SW	0	0	0	0	0	22	22
2013	GW	143	3	2,485	0	49,582	99	52,312
	SW	0	0	0	0	0	25	25
2012	GW	153	3	1,840	0	45,197	108	47,301
	SW	0	0	0	0	0	27	27
2011	GW	164	3	562	0	53,250	153	54,132
	SW	0	0	0	0	0	38	38
2010	GW	144	3	510	0	57,164	138	57,959
	SW	0	0	322	0	0	35	357
2009	GW	142	3	446	0	45,852	115	46,558
	SW	0	0	281	0	0	29	310
2008	GW	140	0	381	0	42,879	108	43,508
	SW	0	0	240	0	0	27	267
2007	GW	124	1	0	0	37,816	210	38,151
	SW	0	0	0	0	0	52	52
2006	GW	153	0	0	0	46,579	154	46,886
	SW	0	0	0	0	0	39	39
2005	GW	147	0	0	0	44,231	141	44,519
	SW	0	0	0	0	0	35	35
2004	GW	126	0	0	0	44,305	111	44,542
	SW	0	0	0	0	0	28	28
2003	GW	148	0	0	0	45,092	112	45,352
	SW	0	0	0	0	0	28	28
2002	GW	150	0	0	0	26,398	143	26,691
	SW	0	0	0	0	0	36	36

REAGAN COUNTY *8.22% (multiplier)* All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2017	GW	59	0	743	0	1,820	28	2,650
	SW	0	0	0	0	0	3	3
2016	GW	51	0	300	0	1,664	11	2,026
	SW	0	0	0	0	0	1	1
2015	GW	68	0	400	0	1,655	10	2,133
	SW	0	0	0	0	0	1	1
2014	GW	66	0	496	0	2,004	10	2,576
	SW	0	0	0	0	0	1	1
2013	GW	61	0	266	0	1,660	10	1,997
	SW	0	0	0	0	0	1	1
2012	GW	53	0	23	0	1,630	14	1,720
	SW	0	0	0	0	0	1	1
2011	GW	63	0	116	0	2,167	16	2,362
	SW	0	0	0	0	0	2	2
2010	GW	49	0	47	0	1,593	16	1,705
	SW	0	0	18	0	0	2	20
2009	GW	62	0	41	0	1,373	19	1,495
	SW	0	0	16	0	0	2	18
2008	GW	61	0	34	0	1,599	19	1,713
	SW	0	0	14	0	0	2	16
2007	GW	61	0	0	0	1,397	11	1,469
	SW	0	0	0	0	0	1	1
2006	GW	115	0	0	0	1,541	10	1,666
	SW	0	0	0	0	0	1	1
2005	GW	114	0	0	0	1,008	13	1,135
	SW	0	0	0	0	0	1	1
2004	GW	114	0	0	0	853	7	974
	SW	0	0	0	0	0	3	3
2003	GW	114	0	0	0	822	7	943
	SW	0	0	0	0	0	3	3
2002	GW	61	0	0	0	1,223	12	1,296
	SW	0	0	0	0	0	5	5

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

GLASSCOCK COUNTY

100% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	LIVESTOCK, GLASSCOCK	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	40	40	40	40	40	40
	Sum of Projected Surface Water Supplies (acre-feet)			**40**	**40**	**40**	**40**	**40**	**40**

REAGAN COUNTY

8.22% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	LIVESTOCK, REAGAN	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	3	3	3	3	3	3
F	LIVESTOCK, REAGAN	RIO GRANDE	RIO GRANDE LIVESTOCK LOCAL SUPPLY	0	0	0	0	0	0
	Sum of Projected Surface Water Supplies (acre-feet)			**3**	**3**	**3**	**3**	**3**	**3**

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.

GLASSCOCK COUNTY

100% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, GLASSCOCK	COLORADO	162	165	161	160	160	160
F	IRRIGATION, GLASSCOCK	COLORADO	56,707	56,252	55,796	55,339	54,887	54,439
F	LIVESTOCK, GLASSCOCK	COLORADO	262	262	262	262	262	262
F	MINING, GLASSCOCK	COLORADO	3,423	3,101	2,384	1,679	1,100	798
		Sum of Projected Water Demands (acre-feet)	**60,554**	**59,780**	**58,603**	**57,440**	**56,409**	**55,659**

REAGAN COUNTY

8.22% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	BIG LAKE	COLORADO	731	796	835	878	907	929
F	COUNTY-OTHER, REAGAN	COLORADO	6	6	6	7	7	7
F	IRRIGATION, REAGAN	COLORADO	1,572	1,546	1,520	1,493	1,467	1,442
F	LIVESTOCK, REAGAN	COLORADO	20	20	20	20	20	20
F	LIVESTOCK, REAGAN	RIO GRANDE	1	1	1	1	1	1
F	MINING, REAGAN	COLORADO	322	260	188	108	40	15
F	MINING, REAGAN	RIO GRANDE	24	20	14	8	3	1
		Sum of Projected Water Demands (acre-feet)	**2,676**	**2,649**	**2,584**	**2,515**	**2,445**	**2,415**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

GLASSCOCK COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, GLASSCOCK	COLORADO	0	0	0	0	0	0
F	IRRIGATION, GLASSCOCK	COLORADO	0	0	0	0	0	0
F	LIVESTOCK, GLASSCOCK	COLORADO	0	0	0	0	0	0
F	MINING, GLASSCOCK	COLORADO	0	0	0	0	0	0
	Sum of Projected Water Supply Needs (acre-feet)		**0**	**0**	**0**	**0**	**0**	**0**

REAGAN COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	BIG LAKE	COLORADO	0	0	0	0	0	0
F	COUNTY-OTHER, REAGAN	COLORADO	0	0	0	0	0	0
F	IRRIGATION, REAGAN	COLORADO	0	0	0	0	0	0
F	LIVESTOCK, REAGAN	COLORADO	11	11	11	11	11	11
F	LIVESTOCK, REAGAN	RIO GRANDE	0	0	0	0	0	0
F	MINING, REAGAN	COLORADO	0	0	0	0	0	0
F	MINING, REAGAN	RIO GRANDE	15	15	15	15	15	15
	Sum of Projected Water Supply Needs (acre-feet)		**0**	**0**	**0**	**0**	**0**	**0**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

GLASSCOCK COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
IRRIGATION, GLASSCOCK, COLORADO (F)							
IRRIGATION CONSERVATION - GLASSCOCK COUNTY	DEMAND REDUCTION [GLASSCOCK]	2,268	2,250	2,232	2,232	2,232	2,232
		2,268	**2,250**	**2,232**	**2,232**	**2,232**	**2,232**
MINING, GLASSCOCK, COLORADO (F)							
MINING CONSERVATION - GLASSCOCK COUNTY	DEMAND REDUCTION [GLASSCOCK]	240	217	167	118	77	56
		240	**217**	**167**	**118**	**77**	**56**
Sum of Projected Water Management Strategies (acre-feet)		**2,508**	**2,467**	**2,399**	**2,350**	**2,309**	**2,288**

REAGAN COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
BIG LAKE, COLORADO (F)							
MUNICIPAL CONSERVATION - BIG LAKE	DEMAND REDUCTION [REAGAN]	18	21	22	23	24	24
WATER AUDITS AND LEAK - BIG LAKE	DEMAND REDUCTION [REAGAN]	29	32	33	35	36	37
		47	**53**	**55**	**58**	**60**	**61**
IRRIGATION, REAGAN, COLORADO (F)							
IRRIGATION CONSERVATION - REAGAN COUNTY	DEMAND REDUCTION [REAGAN]	957	1,881	2,773	2,773	2,773	2,773
WEATHER MODIFICATION	WEATHER MODIFICATION [ATMOSPHERE]	1,469	1,469	1,469	1,469	1,469	1,469
		2,426	**3,350**	**4,242**	**4,242**	**4,242**	**4,242**
MINING, REAGAN, COLORADO (F)							
MINING CONSERVATION - REAGAN COUNTY	DEMAND REDUCTION [REAGAN]	274	221	160	91	34	13
		274	**221**	**160**	**91**	**34**	**13**
MINING, REAGAN, RIO GRANDE (F)							
MINING CONSERVATION - REAGAN COUNTY	DEMAND REDUCTION [REAGAN]	21	17	12	7	3	1
		21	**17**	**12**	**7**	**3**	**1**
Sum of Projected Water Management Strategies (acre-feet)		**2,768**	**3,641**	**4,469**	**4,398**	**4,339**	**4,317**

Appendix C

GAM RUN 18-022: GLASSCOCK GROUNDWATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Shirley C. Wade, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-936-0883
February 11, 2019

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GAM RUN 18-022: GLASSCOCK GROUNDWATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Shirley C. Wade, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-936-0883
February 11, 2019

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2011), 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 Glasscock Groundwater 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 Department. 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:

4. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;
5. 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
6. 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 Glasscock Groundwater Conservation District should be adopted by the district on or before October 17, 2019 and submitted to the

Executive Administrator of the TWDB on or before November 16, 2019. The current management plan for the Glasscock Groundwater Conservation District expires on January 15, 2020.

We used two groundwater availability models to estimate the management plan information for the aquifers within the Glasscock Groundwater Conservation District. Information for the Dockum and Ogallala 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 the alternative groundwater model for the Edwards-Trinity (Plateau) Aquifer (Hutchison and others, 2011).

This report replaces the results of GAM Run 12-020 (Wade, 2012). GAM Run 18-022 includes results from the groundwater availability model for the High Plains Aquifer System released in 2015 (Deeds and Jigmond, 2015). Tables 1 through 3 summarize the groundwater availability model data required by statute and Figures 1 through 3 show the area of the models from which the values in the tables were extracted. If, after review of the figures, Glasscock Groundwater 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 two groundwater availability models mentioned above were used to estimate information for the Glasscock Groundwater Conservation District management plan. Water budgets were extracted for the historical model periods for the Dockum and Ogallala aquifers (1980 through 2012) and Edwards-Trinity (Plateau) Aquifer (1980 through 2005) 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 aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

High Plains Aquifer System (Dockum and Ogallala aquifers)

- We used version 1.01 of the groundwater availability model for the High Plains Aquifer System. See Deeds and Jigmond (2015) for assumptions and limitations of the model.
- The model was run with MODFLOW-NWT (Niswonger and others, 2011).
- 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
- Perennial rivers and reservoirs were simulated using MODFLOW-NWT river package. Springs, seeps, and draws were simulated using MODFLOW-NWT drain package.

Edwards-Trinity (Plateau) Aquifer

- The one-layer alternative groundwater flow model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Hutchison and others, 2011) was used for these simulations. The modified model version was developed to more effectively simulate groundwater conditions. The model was calibrated based on groundwater elevation data from 1930 to 2005.
- 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 middle, and the Hill Country portion of the Trinity Aquifer in the southeast portion of the model area. A lumped representation of both the Pecos Valley and Edwards-Trinity (Plateau) aquifers was used in the relatively narrow area where the Pecos Valley

Aquifer overlies the Edwards-Trinity (Plateau) Aquifer. Only the Edwards-Trinity (Plateau) Aquifer underlies the district.

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

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Dockum, Ogallala, and Edwards-Trinity (Plateau) aquifers 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 DOCKUM AQUIFER FOR GLASSCOCK GROUNDWATER 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	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Dockum Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	2
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	67
Estimated net annual volume of flow between each aquifer in the district	Into the Dockum Aquifer from the Edwards-Trinity (Plateau) Aquifer and other overlying units	1
	From the saline portions of the Dockum Group into the Dockum Aquifer	44

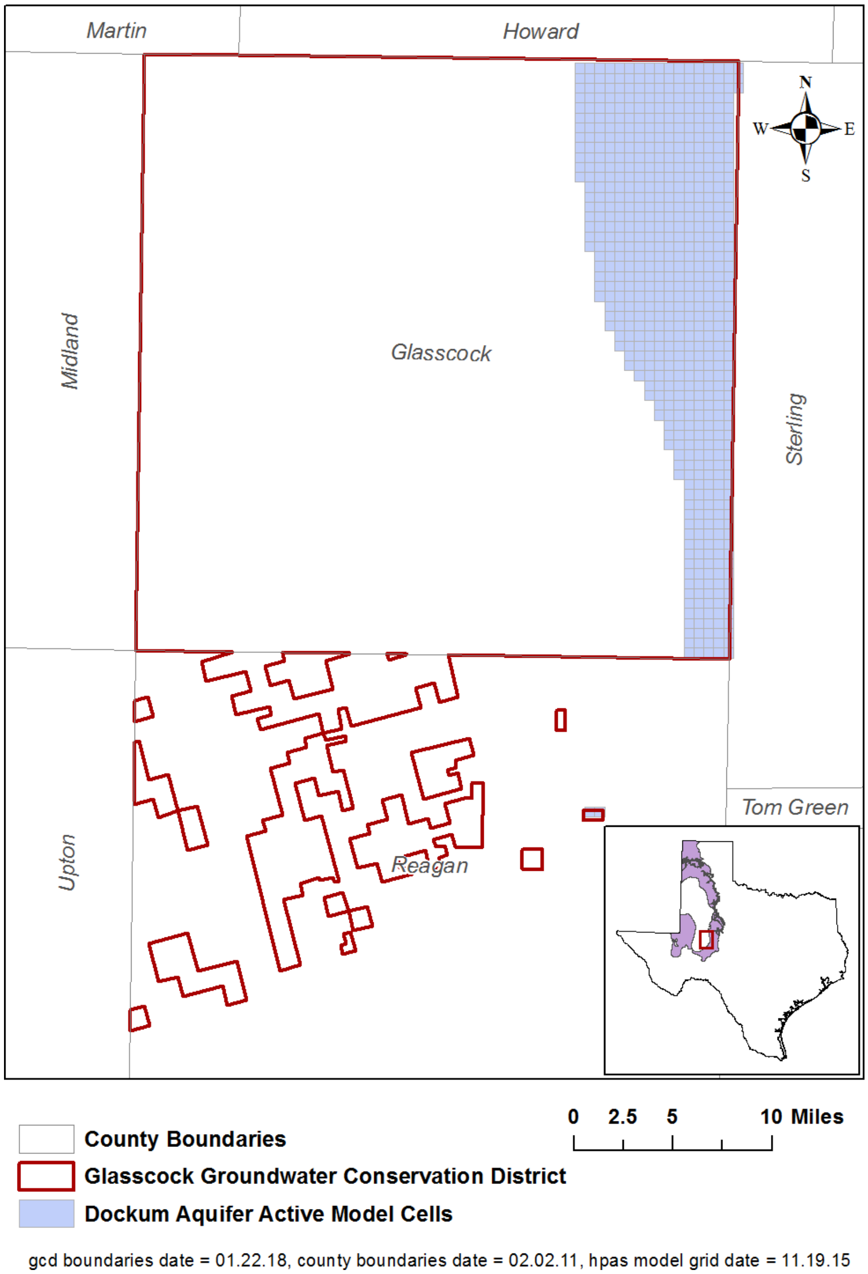

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE OGALLALA AQUIFER FOR GLASSCOCK GROUNDWATER 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	3,186
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ogallala Aquifer	951
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	751
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	420
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer into the Edwards-Trinity (Plateau) Aquifer	5,412[1]

[1] This value was extracted from the alternative groundwater model for the Edwards-Trinity (Plateau) Aquifer. The groundwater availability model for the High Plains Aquifer System indicates 445 acre-feet per year flows into the Ogallala Aquifer from the Edwards-Trinity (Plateau) Aquifer; however, the Edwards-Trinity (Plateau) is included mainly as a boundary condition for the High Plains Aquifer System model.

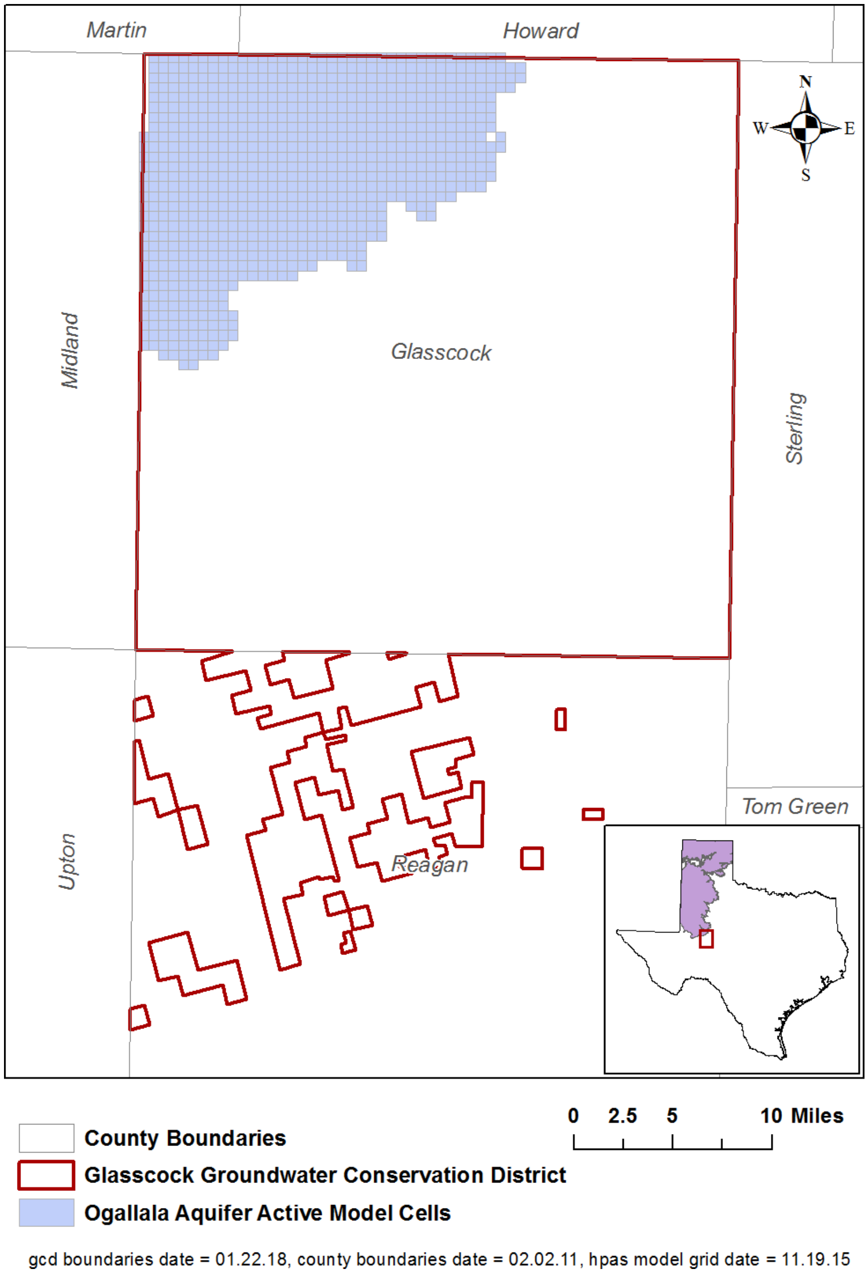

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE OGALLALA AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FOR GLASSCOCK GROUNDWATER 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	Edwards-Trinity (Plateau) Aquifer	23,079
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	431
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	50,475
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	51,411
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer into the Edwards-Trinity (Plateau) Aquifer	5,412

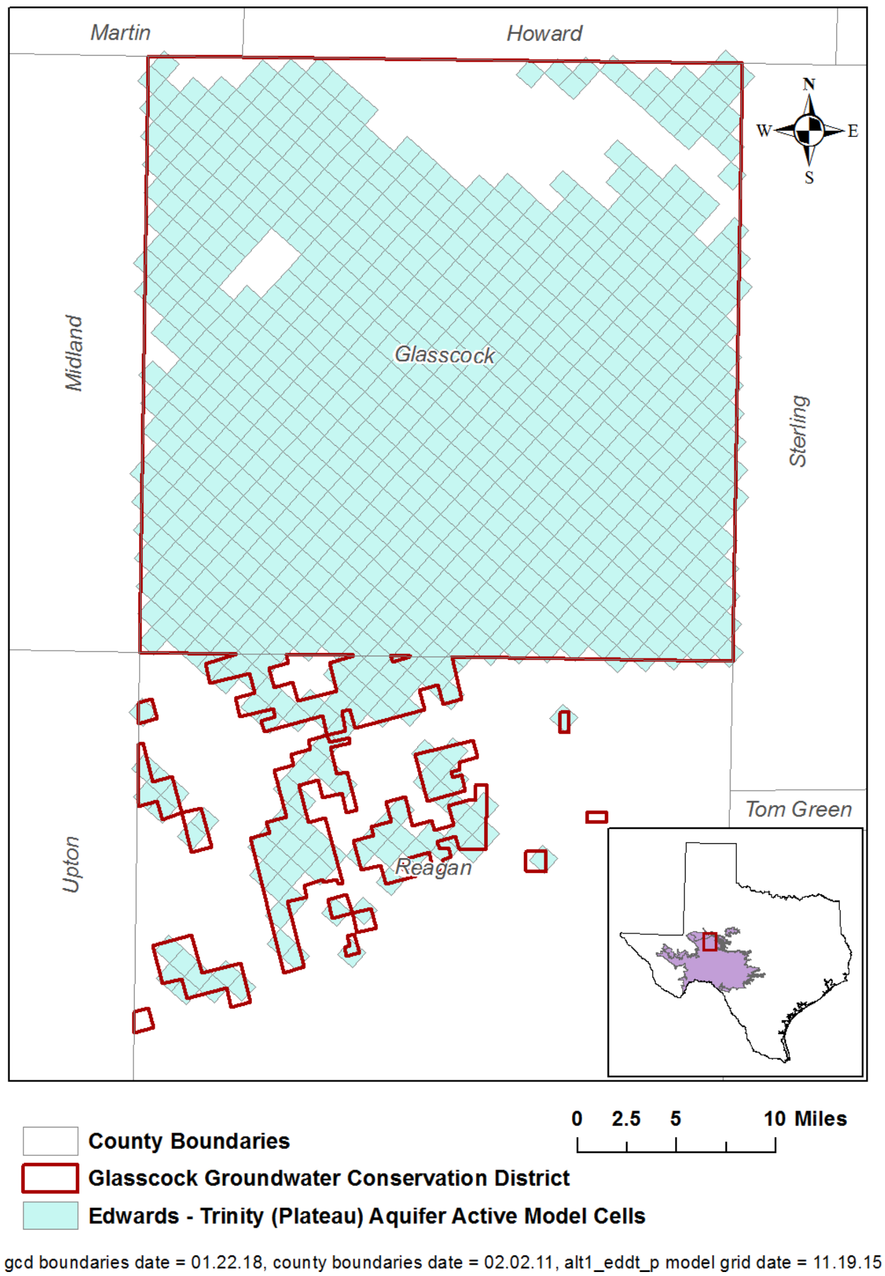

FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

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 historical groundwater flow conditions includes the assumptions about the location in the aquifer where historical pumping was placed. Understanding the amount and location of historical 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 historical 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. Historical 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 D

GAM RUN 16-026 MAG VERSION 2: MODELED AVAILABLE GROUNDWATER FOR THE AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7

Ian C. Jones, Ph.D., P.G. Texas Water Development Board
Groundwater Division Groundwater Availability Modeling Department
(512) 463-6641
September 21, 2018

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9/24/2018

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GAM RUN 16-026 MAG VERSION 2: MODELED AVAILABLE GROUNDWATER FOR THE AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7

Ian C. Jones, Ph.D., P.G. Texas Water Development Board
Groundwater Division Groundwater Availability Modeling Department
(512) 463-6641
September 21, 2018

EXECUTIVE SUMMARY:

We have prepared estimates of the modeled available groundwater for the relevant aquifers of Groundwater Management Area 7—the Capitan Reef Complex, Dockum, Edwards-Trinity (Plateau), Ellenburger-San Saba, Hickory, Ogallala, Pecos Valley, Rustler, and Trinity aquifers. The estimates are based on the desired future conditions for these aquifers adopted by the groundwater conservation districts in Groundwater Management Area 7 on September 22, 2016 and March 22, 2018. The explanatory reports and other materials submitted to the Texas Water Development Board (TWDB) were determined to be administratively complete on June 22, 2018.

The original version of GAM Run 16-026 MAG inadvertently included modeled available groundwater estimates for areas declared not relevant by the groundwater management area and areas that had no desired future conditions for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers. GAM Run 16-026 MAG Version 2 (this report) contains updates to reported total modeled available groundwater estimates and to Tables 5 and 6 that reflect only relevant portions of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers.

The modeled available groundwater values are summarized by decade for the groundwater conservation districts (Tables 1, 3, 5, 7, 9, 11, 13) and for use in the regional water planning process (Tables 2, 4, 6, 8, 10, 12, 14). The modeled available groundwater estimates are 26,164 acre-feet per year in the Capitan Reef Complex Aquifer; 2,324 acre-feet per year in the Dockum Aquifer; 474,464 acre-feet per year in the undifferentiated Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers; 22,616 acre-feet per year in the Ellenburger-San Saba Aquifer; 49,936 acre-feet per year in the Hickory Aquifer; 6,570 to 8,019 acre-feet per year in the Ogallala Aquifer; and 7,040 acre-feet per year in the Rustler Aquifer. The modeled available groundwater estimates were extracted from results of model runs using the groundwater availability models for the Capitan Reef Complex Aquifer (Jones, 2016); the High Plains Aquifer System (Deeds and Jigmond, 2015); the minor aquifers of the Llano Uplift Area (Shi and others, 2016), and the Rustler Aquifer (Ewing and others, 2012). In addition, the alternative 1-layer model for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers (Hutchison and others, 2011) was used for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers, except for Kinney and Val Verde counties. In these two counties, the alternative Kinney County model (Hutchison and others, 2011) and the model associated with a hydrogeological study for Val Verde County and the City of Del Rio (EcoKai Environmental, Inc. and Hutchison, 2014), respectively, were used to estimate modeled available groundwater. The Val Verde County/Del Rio model covers Val Verde County. This model was used to simulate multiple pumping scenarios indicating the effects of a proposed wellfield. The model indicated the effects of varied pumping rates and wellfield locations. These model runs were used by Groundwater Management Area 7 as the basis for the desired future conditions for Val Verde County.

REQUESTOR:

Mr. Joel Pigg, chair of Groundwater Management Area 7 districts.

DESCRIPTION OF REQUEST:

In letters dated November 22, 2016 and March 26, 2018, Dr. William Hutchison on behalf of Groundwater Management Area 7 provided the TWDB with the desired future conditions for the Capitan, Dockum, Edwards-Trinity (Plateau), Ellenburger-San Saba, Hickory, Ogallala, Pecos Valley, Rustler, and Trinity aquifers in Groundwater Management Area 7. Groundwater Management Area 7 provided additional clarifications through emails to the TWDB on March 23, 2018 and June 12, 2018 for the use of model extents (Dockum, Ellenburger-San Saba, Hickory, Ogallala, Rustler aquifers), the use of aquifer extents (Capitan Reef Complex, Edwards-Trinity [Plateau], Pecos Valley, and Trinity aquifers), and desired future conditions for the Edwards-Trinity (Plateau) Aquifer of Kinney and Val Verde counties.

The final adopted desired future conditions as stated in signed resolutions for the aquifers in Groundwater Management Area 7 are reproduced below:

Capitan Reef [Complex] Aquifer

Total net drawdown of the Capitan Reef [Complex] Aquifer not to exceed 56 feet in Pecos County (Middle Pecos [Groundwater Conservation District]) in 2070 as compared with 2006 aquifer levels (Reference: Scenario 4, GMA 7 Technical Memorandum 15-06, 4-8-2015).

Dockum Aquifer

Total net drawdown of the Dockum Aquifer not to exceed 14 feet in Reagan County (Santa Rita [Groundwater Conservation District]) in 2070, as compared with 2012 aquifer levels.

Total net drawdown of the Dockum Aquifer not to exceed 52 feet in Pecos County (Middle Pecos [Groundwater Conservation District]) in 2070, as compared with 2012 aquifer levels.

Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers

Average drawdown for [the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers] in the following [Groundwater Management Area] 7 counties not to exceed drawdowns from 2010 to 2070 […].

County	[…] Average Drawdowns from 2010 to 2070 [feet]
Coke	0
Crockett	10
Ector	4
Edwards	2
Gillespie	5
Glasscock	42
Irion	10
Kimble	1
Menard	1
Midland	12
Pecos	14
Reagan	42
Real	4
Schleicher	8
Sterling	7
Sutton	6

Taylor	0
Terrell	2
Upton	20
Uvalde	2

Total net drawdown *[of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers]* in Kinney County in 2070, as compared with 2010 aquifer levels, shall be consistent with maintenance of an annual average flow of 23.9 [cubic feet per second] and an annual median flow of 23.9 [cubic feet per second] at Las Moras Springs […].

Total net drawdown [of the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers] in Val Verde County in 2070, as compared with 2010 aquifer levels, shall be consistent with maintenance of an average annual flow of 73-75 [million gallons per day] at San Felipe Springs.

Minor Aquifers of the Llano Uplift Area

Total net drawdowns of [Ellenburger-San Saba Aquifer] levels in 2070, as compared with 2010 aquifer levels, shall not exceed the number of feet set forth below, respectively, for the following counties and districts:

County	[Groundwater Conservation District]	Drawdown in 2070 (feet)
Gillespie	Hill Country [Underground Water Conservation District]	8
Mason	Hickory [Underground Water Conservation District] no. 1	14
McCulloch	Hickory [Underground Water Conservation District] no. 1	29
Menard	Menard County [Underground Water District] and Hickory [Underground Water Conservation District] no. 1	46
Kimble	Kimble County [Groundwater Conservation District] and Hickory	18

	[Underground Water Conservation District] no. 1	
San Saba	Hickory [Underground Water Conservation District] no. 1	5

Total net drawdown of [Hickory Aquifer] levels in 2070, as compared with 2010 aquifer levels, shall not exceed the number of feet set forth below, respectively, for the following counties and districts:

County	[Groundwater Conservation District]	Drawdown in 2070 (feet)
Concho	Hickory [Underground Water Conservation District No. 1]	53
Gillespie	Hill Country UWCD	9
Mason	Hickory [Underground Water Conservation District No. 1]	17
McCulloch	Hickory [Underground Water Conservation District No. 1]	29
Menard	Menard UWD and Hickory [Underground Water Conservation District No. 1]	46
Kimble	Kimble County [Groundwater Conservation District] and Hickory [Underground Water Conservation District No. 1]	18
San Saba	Hickory [Underground Water Conservation District No. 1]	6

Ogallala Aquifer

Total net [drawdown] of the Ogallala Aquifer in Glasscock County (Glasscock [Groundwater Conservation District]) in 2070, as compared with 2012 aquifer levels, not to exceed 6 feet […].

Rustler Aquifer

Total net drawdown of the Rustler Aquifer in Pecos County (Middle Pecos GCD) in 2070 not to exceed 94 feet as compared with 2009 aquifer levels.

Additionally, districts in Groundwater Management Area 7 voted to declare that the following aquifers or parts of aquifers are non-relevant for the purposes of joint planning:

- The Blaine, Igneous, Lipan, Marble Falls, and Seymour aquifers.
- The Edwards-Trinity (Plateau) Aquifer in Hickory Underground Water Conservation District No. 1, the Lipan-Kickapoo Water Conservation District, Lone Wolf Groundwater Conservation District, and Wes-Tex Groundwater Conservation District.
- The Ellenburger-San Saba Aquifer in Llano County.
- The Hickory Aquifer in Llano County.
- The Dockum Aquifer outside of Santa Rita Groundwater Conservation District and Middle Pecos Groundwater Conservation District.
- The Ogallala Aquifer outside of Glasscock County.

In response to a several requests for clarifications from the TWDB in 2017 and 2018, the Groundwater Management Area 7 Chair, Mr. Joel Pigg, and Groundwater Management Area 7 consultant, Dr. William R. Hutchison, indicated the following preferences for verifying the desired future condition of the aquifers and calculating modeled available groundwater volumes in Groundwater Management Area 7:

Capitan Reef Complex Aquifer

Calculate modeled available groundwater values based on the official aquifer boundaries.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers

Calculate modeled available groundwater values based on the official aquifer boundaries.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Kinney County

Use the modeled available groundwater values and model assumptions from GAM Run 10-043 MAG Version 2 (Shi, 2012) to maintain annual average springflow of 23.9 cubic feet per second and a median flow of 24.4 cubic feet per second at Las Moras Springs from 2010 to 2060.

Val Verde County

There is no associated drawdown as a desired future condition. The desired future condition is based solely on simulated springflow conditions at San Felipe Spring of 73 to 75 million gallons per day. Pumping scenarios—50,000 acre-feet per year—in three well field locations, and monthly hydrologic conditions for the historic period 1969 to 2012 meet the desired future conditions set by Groundwater Management Area 7 (EcoKai and Hutchison, 2014; Hutchison 2018b).

Minor Aquifers of the Llano Uplift Area

Calculate modeled available groundwater values based on the spatial extent of the Ellenburger-San Saba and Hickory aquifers in the groundwater availability model for the aquifers of the Llano Uplift Area and use the same model assumptions used in Groundwater Management Area 7 Technical Memorandum 16-02 (Hutchison 2016g).

Drawdown calculations do not take into consideration the occurrence of dry cells where water levels are below the base of the aquifer.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Dockum Aquifer

Calculate modeled available groundwater values based on the spatial extent of the groundwater availability model for the Dockum Aquifer.

Modeled available groundwater analysis excludes pass-through cells.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Ogallala Aquifer

Calculate modeled available groundwater values based on the official aquifer boundary and use the same model assumptions used in Groundwater Management Area Technical Memorandum 16-01 (Hutchison, 2016f).

Modeled available groundwater analysis excludes pass-through cells.

Well pumpage decreases as the saturated thickness of the aquifer decreases below a 30- foot threshold.

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

Rustler Aquifer

Use 2008 as the baseline year and run the model from 2009 through 2070 (end of 2008/beginning of 2009 as initial conditions), as used in the submitted predictive model run.

Use 2008 recharge conditions throughout the predictive period.

Calculate modeled available groundwater values based on the spatial extent of the groundwater availability model for the Rustler Aquifer.

General-head boundary heads decline at a rate of 1.5 feet per year.

Use the same model assumptions used in Groundwater Management Area 7 Technical Memorandum 15-05 (Hutchison, 2016d).

Assume that modeled drawdown verifications within 1 foot achieve the desired future conditions.

METHODS:

As defined in Chapter 36 of the Texas Water Code (TWC, 2011), “modeled available groundwater” is the estimated average amount of water that may be produced annually to achieve a desired future condition. Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits.

For relevant aquifers with desired future conditions based on water-level drawdown, water levels simulated at the end of the predictive simulations were compared to specified baseline water levels. In the case of the High Plains Aquifer System (Dockum and Ogallala aquifers) and the minor aquifers of the Llano Uplift area (Ellenburger-San Saba and Hickory aquifers), baseline water levels represent water levels at the end of the calibrated transient model are the initial water level conditions in the predictive simulation—water levels at the end of the preceding year. In the case of the Capitan Reef Complex, Edwards- Trinity (Plateau), Pecos Valley, and Trinity, and Rustler aquifers, the baseline water levels may occur in a specified year, early in the predictive simulation. These baseline years are 2006 in the groundwater availability model for the Capitan Reef Complex Aquifer, 2010 in the alternative model for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers, 2012 in the groundwater availability model for the High Plains Aquifer System, 2010 in the groundwater availability model for the minor aquifers of the Llano Uplift area, and 2009 in the groundwater availability model for the Rustler Aquifer. The predictive model runs used average pumping rates from the historical period for the respective model except in the aquifer or area of interest. In those areas, pumping rates are varied until they produce drawdowns consistent with the adopted desired future conditions. Pumping rates or modeled available groundwater are reported in 10-year intervals.

Water-level drawdown averages were calculated for the relevant portions of each aquifer. Drawdown for model cells that became dry during the simulation—when the water level dropped below the base of the cell—were excluded from the averaging. In Groundwater Management Area 7, dry cells only occur during the predictive period in the Ogallala Aquifer of Glasscock County. Consequently, estimates of modeled available groundwater decrease over time as continued simulated pumping predicts the development of increasing numbers of dry model cells in areas of the Ogallala Aquifer in Glasscock County. The calculated water-level drawdown averages were compared with the desired future conditions to verify that the pumping scenario achieved the desired future conditions.

In Kinney and Val Verde counties, the desired future conditions are based on discharge from selected springs. In these cases, spring discharge is estimated based on simulated average spring discharge over a historical period maintaining all historical hydrologic conditions—such as recharge and river stage—except pumping. In other words, we assume that past average hydrologic conditions—the range of fluctuation—will continue in the future. In the cases of Kinney and Val Verde counties, simulated spring discharge is based on hydrologic variations that took place over the periods 1950 through 2005 and 1968 through 2013, respectively. The desired future condition for the Edwards-Trinity (Plateau) Aquifer in Kinney County is similar to the one adopted in 2010 and the associated modeled available groundwater is based on a specific model run—GAM Run 10-043 (Shi, 2012).

Modeled available groundwater values for the Ellenburger-San Saba and Hickory aquifers were determined by extracting pumping rates by decade from the model results using

ZONBUDUSG Version 1.01 (Panday and others, 2013). For the remaining relevant aquifers in Groundwater Management Area 7 modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Decadal modeled available groundwater for the relevant aquifers are reported by groundwater conservation district and county (Figure 1; Tables 1, 3, 5, 7, 9, 11, 13), and by county, regional water planning area, and river basin
(Figures 2 and 3; Tables 2, 4, 6, 8, 10, 12, 14).

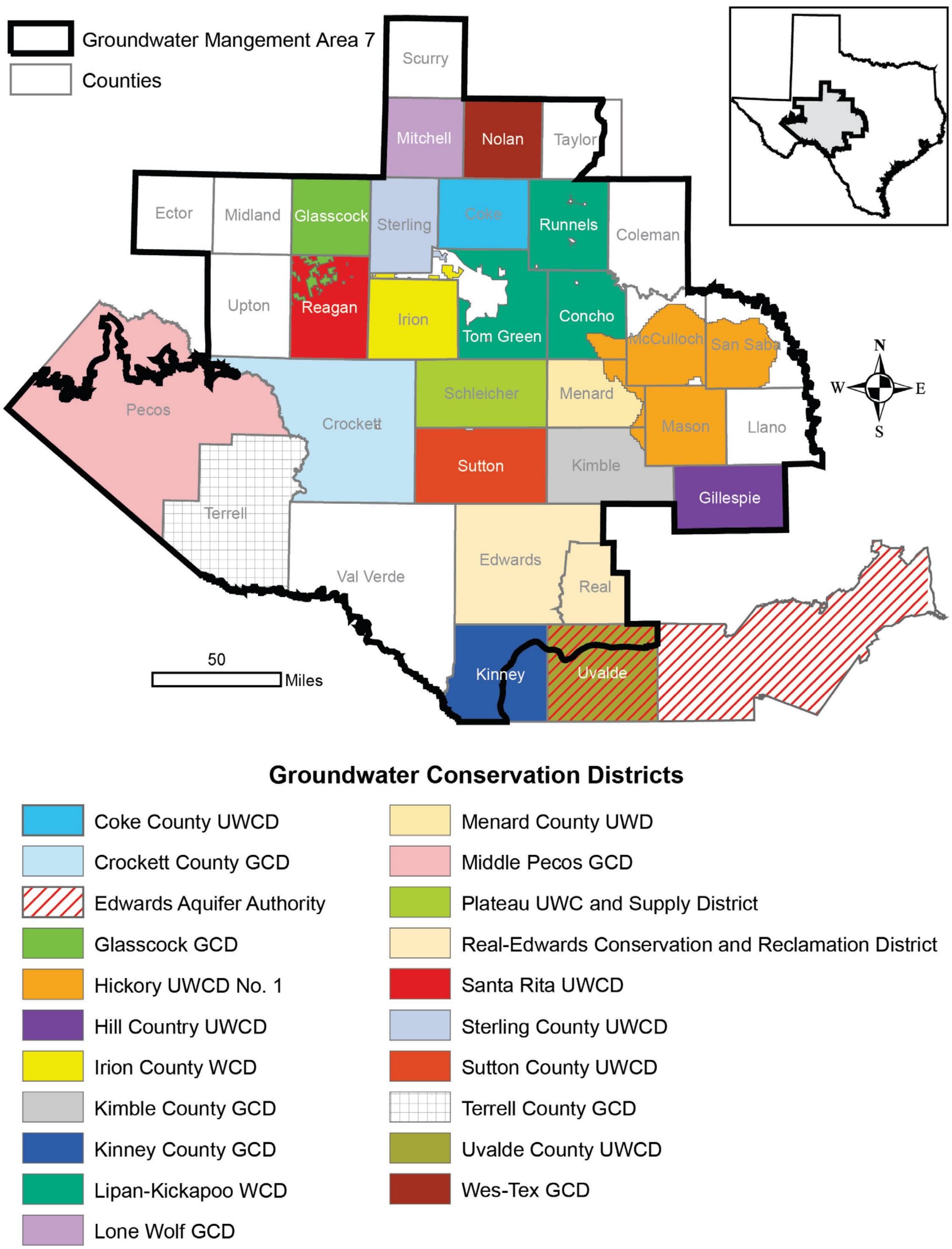

FIGURE 1. MAP SHOWING THE GROUNDWATER CONSERVATION DISTRICTS (GCD) IN GROUNDWATER MANAGEMENT AREA 7. NOTE: THE BOUNDARIES OF THE EDWARDS AQUIFER AUTHORITY OVERLAP WITH THE UVALDE COUNTY UNDERGROUNDWATER CONSERVATION DISTRICT (UWCD).

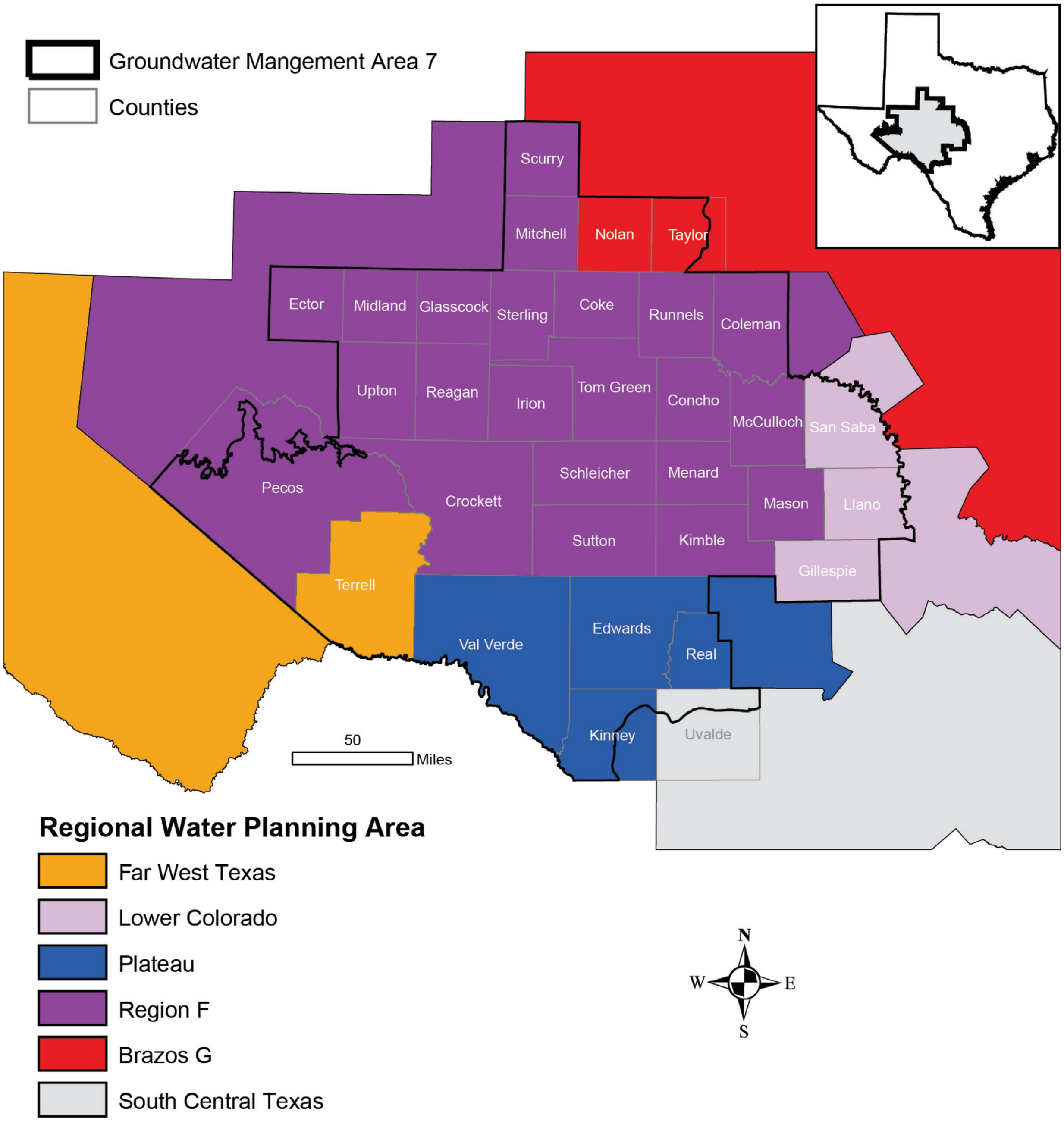

FIGURE 2. MAP SHOWING REGIONAL WATER PLANNING AREAS IN GROUNDWATER MANAGEMENT AREA 7.

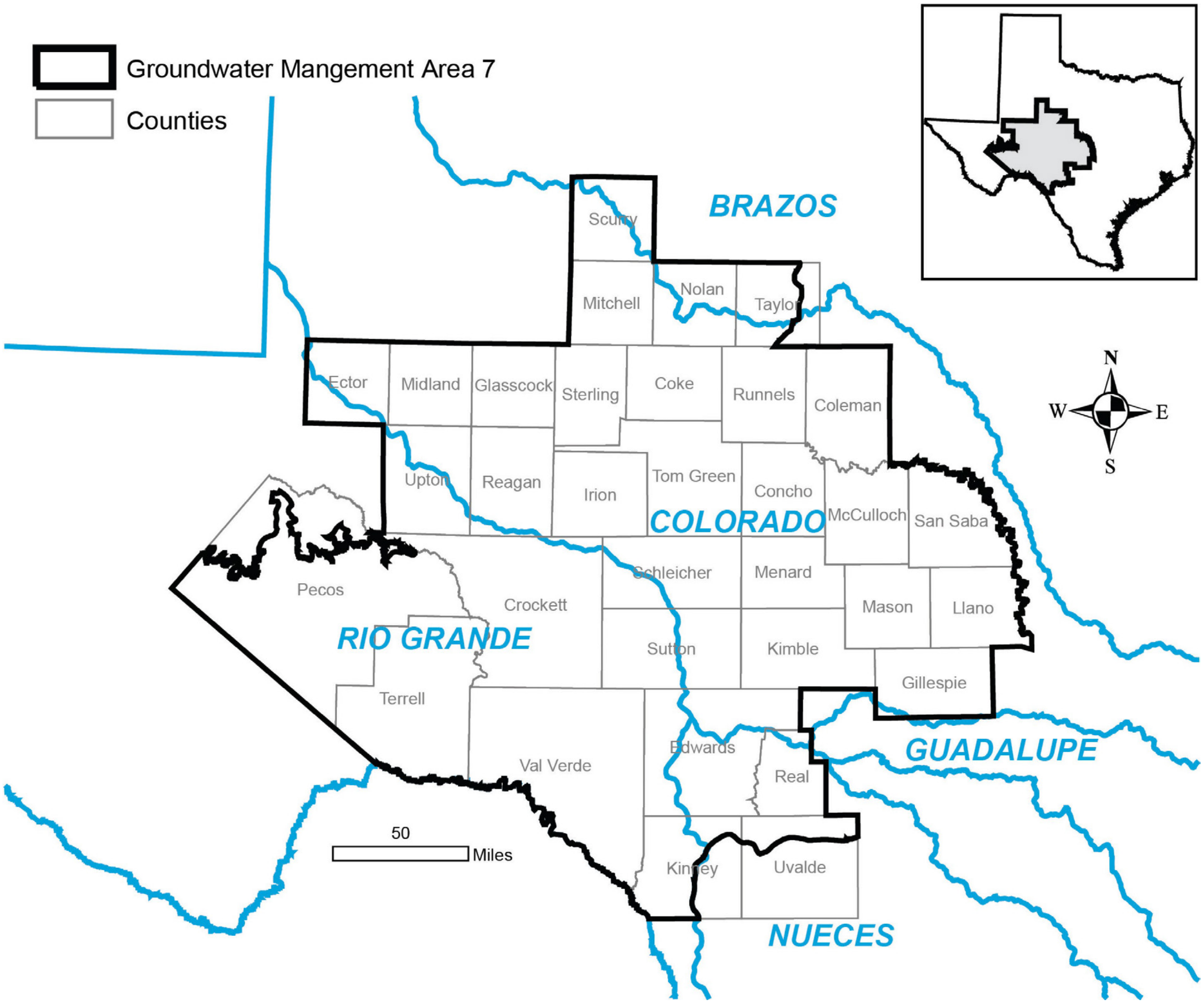

FIGURE 3. MAP SHOWING RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 7. THESE INCLUDE PARTS OF THE BRAZOS, COLORADO, GUADALUPE, NUECES, AND RIO GRANDE RIVER BASINS.

PARAMETERS AND ASSUMPTIONS:

Capitan Reef Complex Aquifer

Version 1.01 of the groundwater availability model of the eastern arm of the Capitan Reef Complex Aquifer was used. See Jones (2016) for assumptions and limitations of the groundwater availability model. See Hutchison (2016h) for details on the assumptions used for predictive simulations.

The model has five layers: Layer 1, the Edwards-Trinity (Plateau) and Pecos Valley aquifers; Layer 2, the Dockum Aquifer and the Dewey Lake Formation; Layer 3, the Rustler Aquifer; Layer 4, a confining unit made up of the Salado and Castile formations, and the overlying portion of the Artesia Group; and Layer 5, the Capitan Reef Complex Aquifer, part of the Artesia Group, and the Delaware Mountain Group. Layers 1 through 4 are intended to act solely as boundary conditions facilitating groundwater inflow and outflow relative to the Capitan Reef Complex Aquifer (Layer 5).

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

The model was run for the interval 2006 through 2070 for a 64-year predictive simulation. Drawdowns were calculated by subtracting 2006 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7.

During predictive simulations, there were no cells where water levels were below the base elevation of the cell (“dry” cells). Therefore, all drawdowns were included in the averaging.

Drawdown averages and modeled available groundwater volumes are based on the official aquifer boundary within Groundwater Management Area 7.

Dockum and Ogallala Aquifers

Version 1.01 of the groundwater availability model for the High Plains Aquifer System by Deeds and Jigmond (2015) was used to construct the predictive model simulation for this analysis. See Hutchison (2016f) 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 calculations of drawdowns and modeled available groundwater.

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. It is important for groundwater management areas 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.

The model was run for the interval 2013 through 2070 for a 58-year predictive simulation. Drawdowns were calculated by subtracting 2012 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7.

During predictive simulations, there were no cells where water levels were below the base elevation of the cell ("dry" cells). Therefore, all drawdowns were included in the averaging. Modeled available groundwater analysis excludes pass-through cells.

Drawdown averages and modeled available groundwater volumes are based on the model boundaries within Groundwater Management Area 7 for the Dockum Aquifer and official aquifer boundaries for the Ogallala Aquifer.

Pecos Valley, Edwards-Trinity (Plateau) and Trinity Aquifers

The single-layer alternative groundwater flow model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers used for this analysis. This model is an update to the previously developed groundwater availability model documented in Anaya and Jones (2009). See Hutchison and others (2011a) and Anaya and Jones (2009) for assumptions and limitations of the model. See Hutchison (2016e; 2018c) for details on the assumptions used for predictive simulations.

The groundwater model has one layer representing the Pecos Valley Aquifer and the Edwards-Trinity (Plateau) Aquifer. In the relatively narrow area where both aquifers are present, the model is a lumped representation of both aquifers.

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

The model was run for the interval 2006 through 2070 for a 65-year predictive simulation. Drawdowns were calculated by subtracting 2010 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7. Comparison of 2010 simulated and measured water levels indicate a root mean squared error of 84 feet or 3 percent of the range in water-level elevations.

Drawdowns for cells with water levels below the base elevation of the cell ("dry" cells) were included in the averaging.

Drawdown averages and modeled available groundwater volumes are based on the official aquifer boundaries within Groundwater Management Area 7.

Edwards-Trinity (Plateau) Aquifer of Kinney County

All parameters and assumptions for the Edwards-Trinity (Plateau) Aquifer of Kinney County in Groundwater Management Area 7 are described in GAM Run 10-043 MAG Version 2 (Shi, 2012). This report assumes a planning period from 2010 to 2070.

The Kinney County Groundwater Conservation District model developed by Hutchison and others (2011b) was used for this analysis. The model was calibrated to water level and spring flux collected from 1950 to 2005.

The model has four layers representing the following hydrogeologic units (from top to bottom): Carrizo-Wilcox Aquifer (layer 1), Upper Cretaceous Unit (layer 2), Edwards (Balcones Fault Zone) Aquifer/Edwards portion of the Edwards-Trinity (Plateau) Aquifer (layer 3), and Trinity portion of the Edwards-Trinity (Plateau) Aquifer (layer 4).

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

The model was run for the interval 2006 through 2070 for a 65-year predictive simulation. Drawdowns were calculated by subtracting 2010 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7.

Modeled available groundwater volumes are based on the official aquifer boundaries within Groundwater Management Area 7 in Kinney County.

Edwards-Trinity (Plateau) Aquifer of Val Verde County

The single-layer numerical groundwater flow model for the Edwards-Trinity (Plateau) Aquifer of Val Verde County was used for this analysis. This model is based on the previously developed alternative groundwater model of the Kinney County area documented in Hutchison and others (2011b). See EcoKai (2014) for assumptions and limitations of the model. See Hutchison (2016e; 2018b) for details on the assumptions used for predictive simulations, including recharge and pumping assumptions.

The groundwater model has one layer representing the Edwards-Trinity (Plateau) Aquifer of Val Verde County.

The model was run with MODFLOW-2005 (Harbaugh, 2005).

The model was run for a 45-year predictive simulation representing hydrologic conditions of the interval 1968 through 2013. Simulated spring discharge from San Felipe Springs was then averaged over duration of the simulation. The resultant pumping rate that met the desired future conditions was applied to the predictive period—2010 through 2070—based on the assumption that average conditions over the predictive period are the same as those over the historic period represented by the model run.

Modeled available groundwater volumes are based on the official aquifer boundaries within Groundwater Management Area 7 in Val Verde County.

Rustler Aquifer

Version 1.01 of the groundwater availability model for the Rustler Aquifer by Ewing and others (2012) was used to construct the predictive model simulation for this analysis. See Hutchison (2016d) for details of the initial assumptions, including recharge conditions.

The model has two layers, the top one representing the Rustler Aquifer, and the other representing the Dewey Lake Formation and the Dockum Aquifer.

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

The model was run for the interval 2009 through 2070 for a 61-year predictive simulation. Drawdowns were calculated by subtracting 2009 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7. During predictive simulations, there were no cells where water levels were below the base elevation of the cell (“dry” cells).
Therefore, all drawdowns were included in the averaging.

Drawdown averages and modeled available groundwater volumes are based on the model boundaries within Groundwater Management Area 7.

Minor aquifers of the Llano Uplift Area

We used version 1.01 of the groundwater availability model for the minor aquifers in the Llano Uplift Area. See Shi and others (2016) for assumptions and limitations of the model. See Hutchison (2016g) for details of the initial assumptions.

The model contains eight layers: Trinity Aquifer, Edwards-Trinity (Plateau) Aquifer, and younger alluvium deposits (Layer 1), confining units (Layer 2), Marble Falls Aquifer and equivalent units (Layer 3), confining units (Layer 4), Ellenburger-San Saba Aquifer and equivalent units (Layer 5), confining units (Layer 6), Hickory Aquifer and equivalent units (Layer 7), and Precambrian units (Layer 8).

The model was run with MODFLOW-USG beta (development) version (Panday and others, 2013). Perennial rivers and reservoirs were simulated using the MODFLOW- USG river package. Springs were simulated using the MODFLOW-USG drain package.

Drawdown averages and modeled available groundwater volumes are based on the model boundaries within Groundwater Management Area 7.

The model was run for the interval 2011 through 2070 for a 60-year predictive simulation. Drawdowns were calculated by subtracting 2010 simulated water levels from 2070 simulated water levels, which were then averaged over the portion of the aquifer in Groundwater Management Area 7. During predictive simulations, there were no cells where water levels were below the base elevation of the cell ("dry" cells).
Therefore, all drawdowns were included in the averaging.

RESULTS:

The modeled available groundwater estimates are 26,164 acre-feet per year in the Capitan Reef Complex Aquifer, 474,464 acre-feet per year in the undifferentiated Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers, 22,616 acre-feet per year in the Ellenburger-San Saba Aquifer, 49,936 acre-feet per year in the Hickory Aquifer, 6,570 to 7,925 acre-feet per year in the Ogallala Aquifer, 2,324 acre-feet per year in the Dockum Aquifer, and 7,040 acre-feet per year in the Rustler Aquifer.

The modeled available groundwater for the respective aquifers has been summarized by aquifer, county, and groundwater conservation district (Tables 1, 3, 5, 7, 9, 11, and 13). The modeled available groundwater is also summarized by county, regional water planning area, river basin, and aquifer for use in the regional water planning process (Tables 2, 4, 6, 8, 10, 12, and 14). The modeled available groundwater for the Ogallala Aquifer that achieves the desired future conditions adopted by districts in Groundwater Management Area 7 decreases from 7,925 to 6,570 acre-feet per year between 2020 and 2070 (Tables 9 and 10). This decline is attributable to the occurrence of increasing numbers of cells where water levels were below the base elevation of the cell ("dry" cells) in parts of Glasscock County. Please note that MODFLOW-NWT automatically reduces pumping as water levels decline.

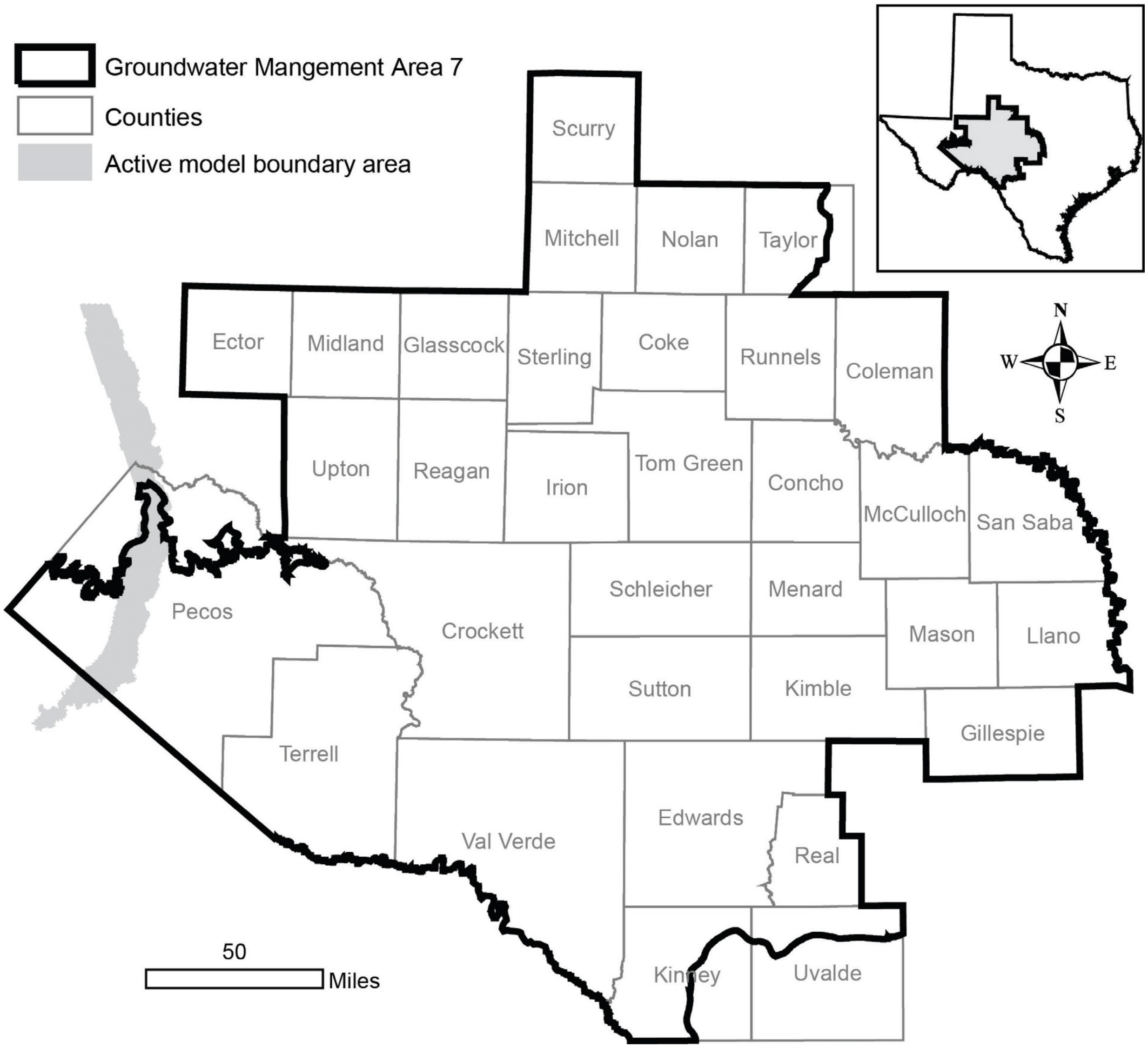

FIGURE 4. MAP SHOWING THE AREAS COVERED BY THE CAPITAN REEF COMPLEX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EASTERN ARM OF THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2006 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. GCD IS THE ABBREVIATION FOR GROUNDWATER CONSERVATION DISTRICT.

District	County	Year							
		2006	2010	2020	2030	2040	2050	2060	2070
Middle Pecos GCD	Pecos	26,164	26,164	26,164	26,164	26,164	26,164	26,164	26,164
	Total	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**
GMA 7		**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOREACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	**2030**	**2040**	**2050**	**2060**	**2070**
Pecos	F	Rio Grande	26,164	26,164	26,164	26,164	26,164	26,164
		Total	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**
GMA 7			**26,164**	**26,164**	**26,164**	**26,164**	**26,164**	**26,164**

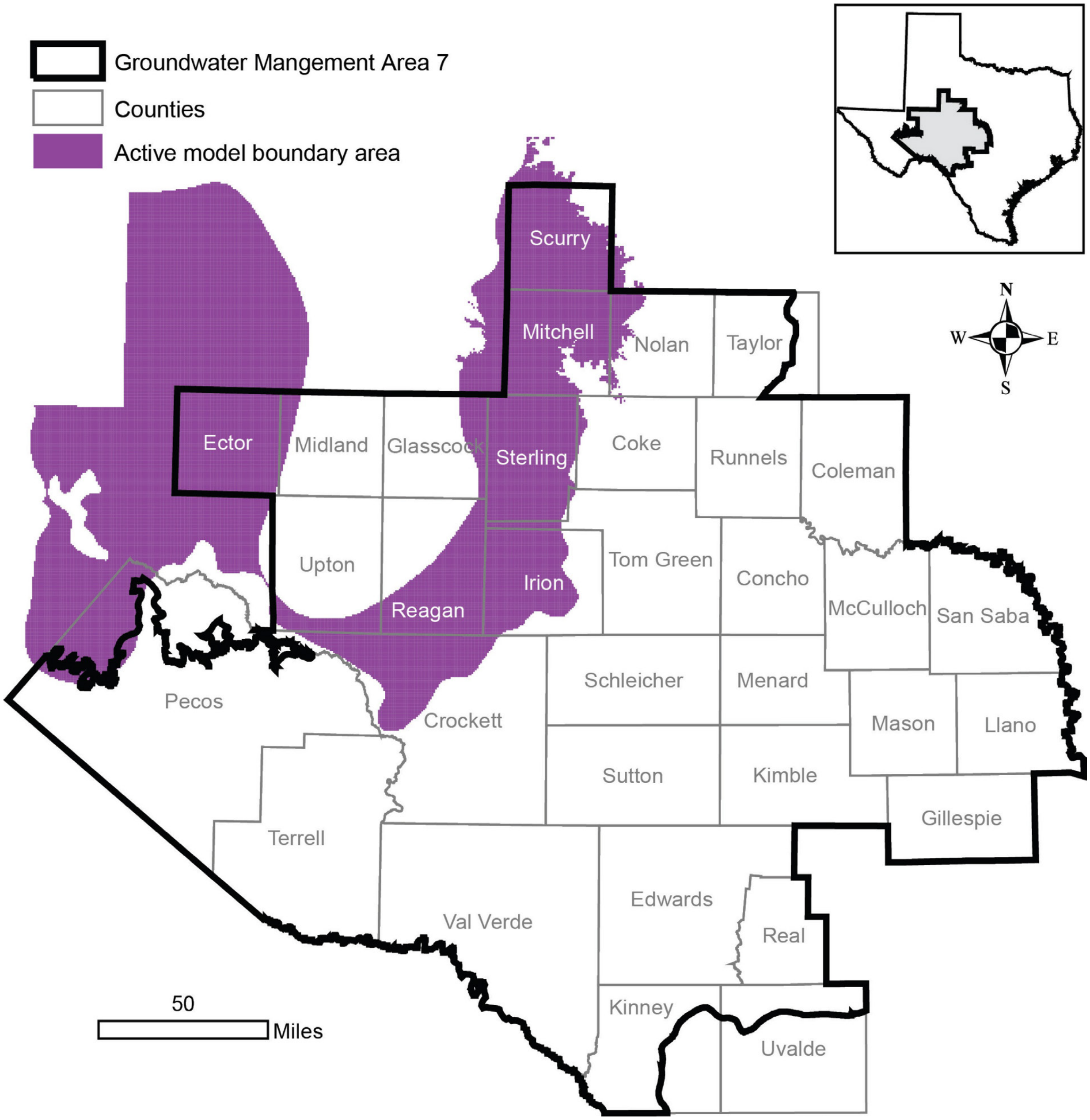

FIGURE 5. MAP SHOWING AREAS COVERED BY THE DOCKUM AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 3. MODELED AVAILABLE GROUNDWATER FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2013 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. GCD AND UWCD ARE THE ABBREVIATIONS FOR GROUNDWATER CONSERVATION DISTRICT AND UNDERGROUND WATER CONSERVATION DISTRICT, RESPECTIVELY.

District	County	Year						
		2013	2020	2030	2040	2050	2060	2070
Middle Pecos GCD	Pecos	2,022	2,022	2,022	2,022	2,022	2,022	2,022
	Total	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**
Santa Rita UWCD	Reagan	302	302	302	302	302	302	302
	Total	**302**	**302**	**302**	**302**	**302**	**302**	**302**
GMA 7		**2324**	**2,324**	**2,324**	**2,324**	**2,324**	**2,324**	**2,324**

Note: The modeled available groundwater for Santa Rita Underground Water Conservation District excludes parts of Reagan County that fall within Glasscock Groundwater Conservation District. The year 2013 is used because the 2012 desired future condition baseline year for the Dockum Aquifer is an initial condition in the predictive model run.

TABLE 4. MODELED AVAILABLE GROUNDWATER FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Pecos	F	Rio Grande	2,022	2,022	2,022	2,022	2,022	2,022
		Total	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**
Reagan	F	Colorado	302	302	302	302	302	302
		Rio Grande	0	0	0	0	0	0
		Total	**302**	**302**	**302**	**302**	**302**	**302**
GMA 7			**2,324**	**2,324**	**2,324**	**2,324**	**2,324**	**2,324**

Note: The modeled available groundwater for Reagan County excludes parts of Reagan County that fall outside of Santa Rita Underground Water Conservation District.

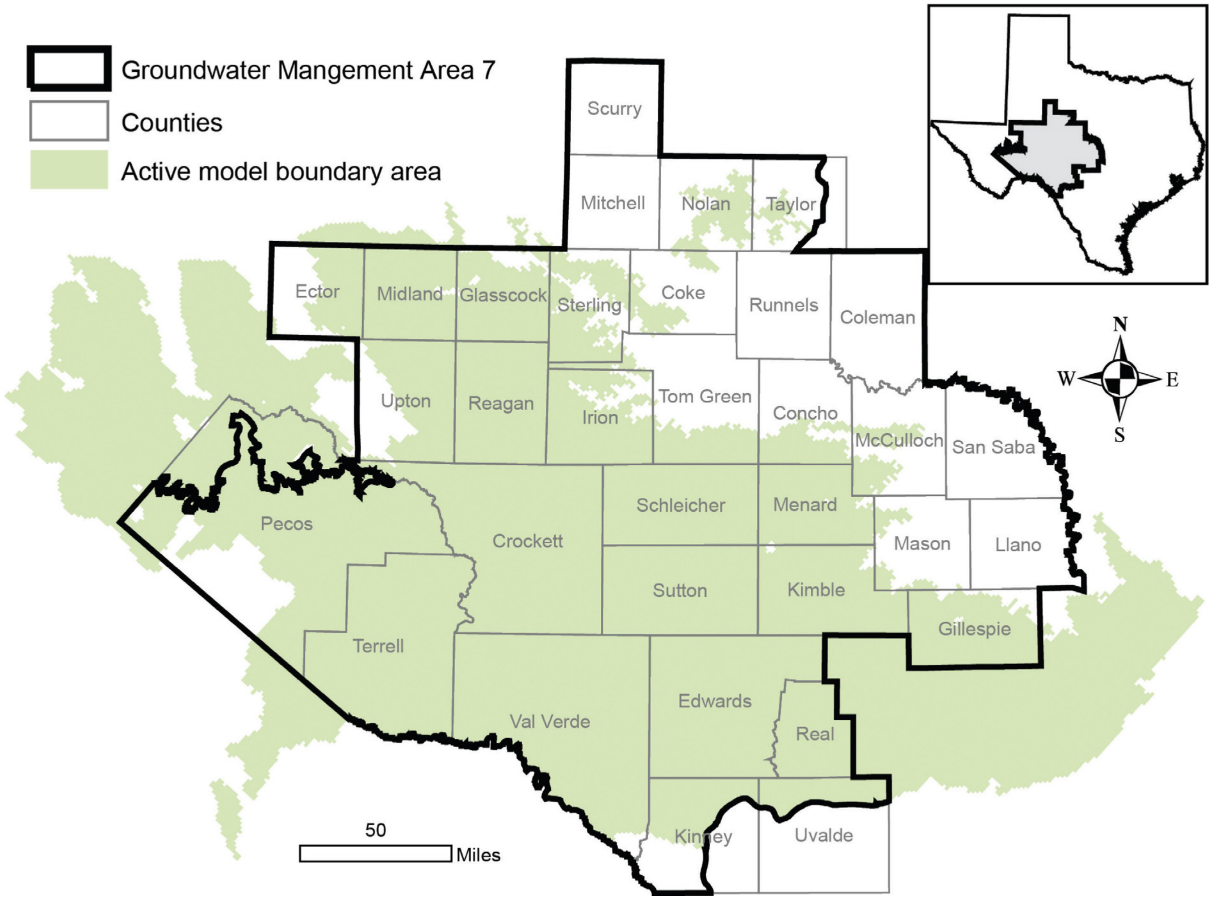

FIGURE 6. MAP SHOWING THE AREAS COVERED BY THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7.

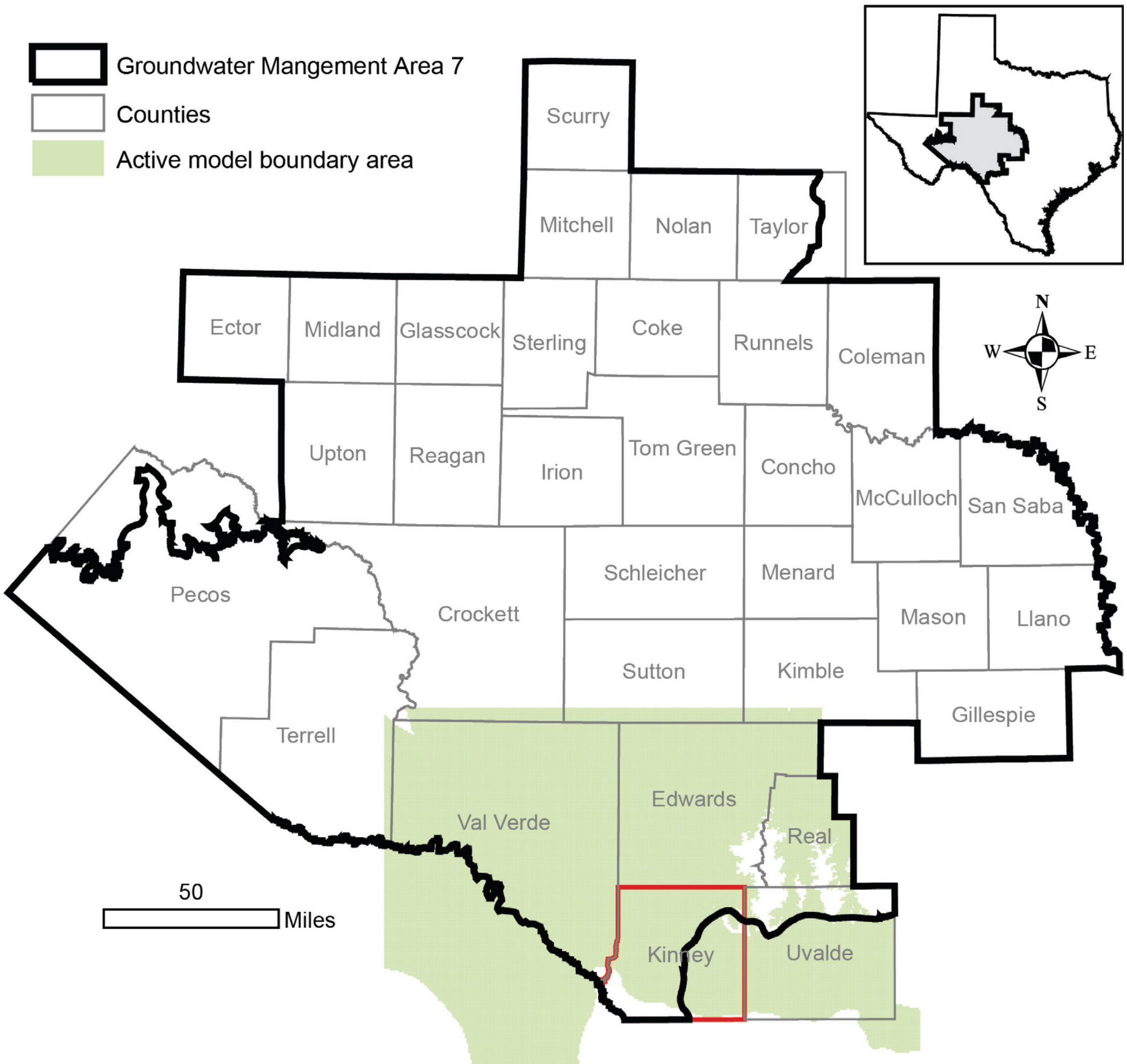

FIGURE 7. MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE ALTERNATIVE MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN KINNEY COUNTY.

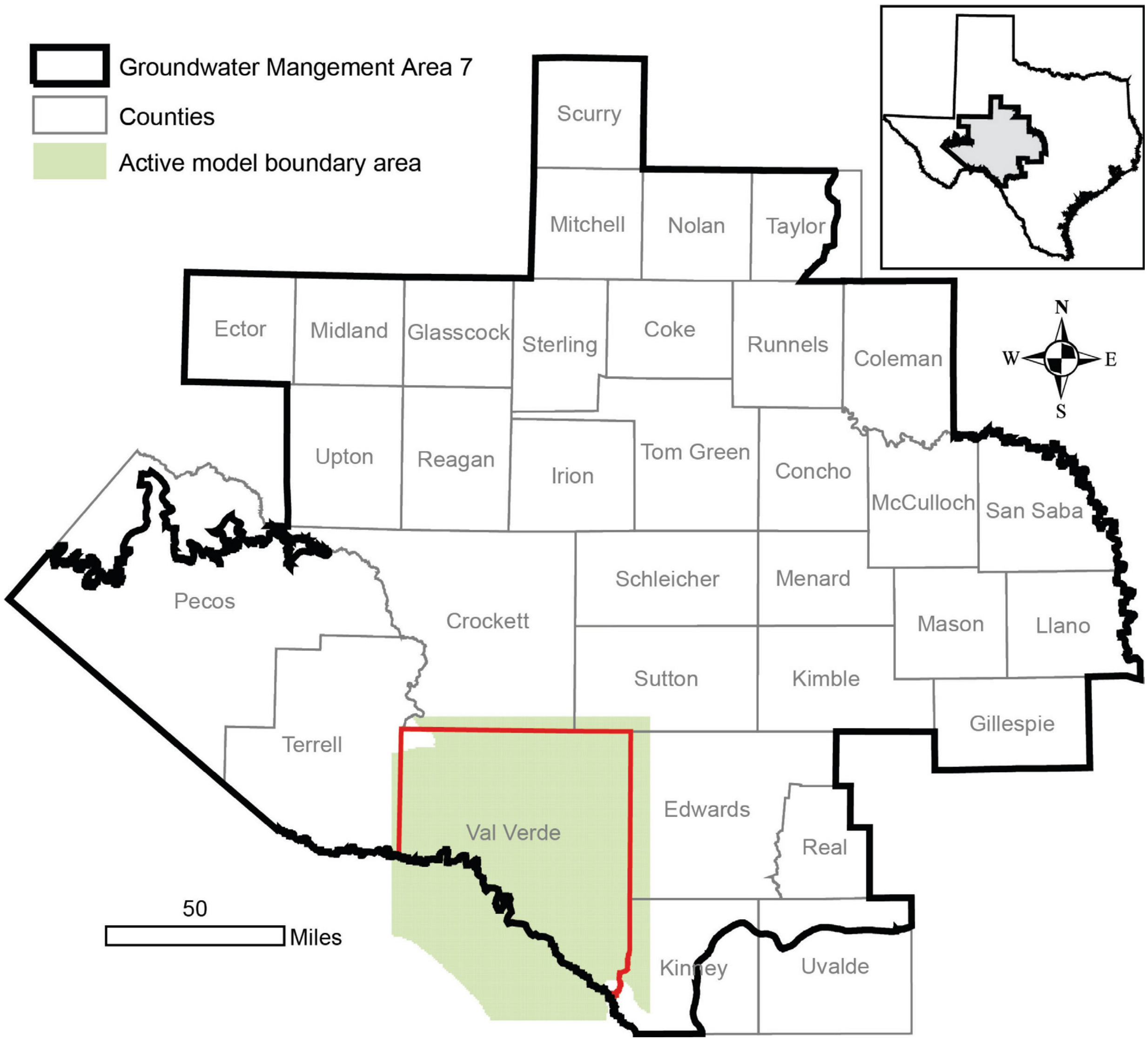

FIGURE 8. MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE GROUNDWATER FLOW MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN VAL VERDE COUNTY.

TABLE 5. MODELED AVAILABLE GROUNDWATER FOR THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY, FOR EACH DECADE BETWEEN 2006 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. UWCD IS ABBREVIATION FOR UNDERGROUND WATER CONSERVATION DISTRICT, WCD IS WATER CONSERVATION DISTRICT, UWD IS UNDERGROUND WATER DISTRICT, UWC IS UNDERGROUND WATER CONSERVATION, AND C AND R DISTRICT IS CONSERVATION AND RECLAMATION DISTRICT.

District	County	Year						
		2010	2020	2030	2040	2050	2060	2070
Coke County UWCD	Coke	997	997	997	997	997	997	997
	Total	**997**	**997**	**997**	**997**	**997**	**997**	**997**
Crockett County GCD	Crockett	4,675	4,675	4,675	4,675	4,675	4,675	4,675
	Total	**4,675**	**4,675**	**4,675**	**4,675**	**4,675**	**4,675**	**4,675**
Glasscock GCD	Glasscock	65,186	65,186	65,186	65,186	65,186	65,186	65,186
	Reagan	40,835	40,835	40,835	40,835	40,835	40,835	40,835
	Total	**106,021**	**106,021**	**106,021**	**106,021**	**106,021**	**106,021**	**106,021**
Hill Country UWCD	Gillespie	4,979	4,979	4,979	4,979	4,979	4,979	4,979
	Total	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**
Irion County WCD*	Irion	3,289	3,289	3,289	3,289	3,289	3,289	3,289
	Total	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**
Kimble County GCD	Kimble	1,282	1,282	1,282	1,282	1,282	1,282	1,282
	Total	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**
Kinney County GCD	Kinney	70,341	70,341	70,341	70,341	70,341	70,341	70,341
	Total	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**

TABLE 5. (CONTINUED).

District	County	Year						
		2010	2020	2030	2040	2050	2060	2070
Menard County UWD	Menard	2,217	2,217	2,217	2,217	2,217	2,217	2,217
	Total	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**
Middle Pecos GCD	Pecos	117,309	117,309	117,309	117,309	117,309	117,309	117,309
	Total	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**
Plateau UWC and Supply District	Schleicher	8,034	8,034	8,034	8,034	8,034	8,034	8,034
	Total	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**
Real-Edwards C and R District	Edwards	5,676	5,676	5,676	5,676	5,676	5,676	5,676
	Real	7,523	7,523	7,523	7,523	7,523	7,523	7,523
	Total	**13,199**	**13,199**	**13,199**	**13,199**	**13,199**	**13,199**	**13,199**
Santa Rita UWCD	Reagan	27,398	27,398	27,398	27,398	27,398	27,398	27,398
	Total	**27,398**	**27,398**	**27,398**	**27,398**	**27,398**	**27,398**	**27,398**
Sterling County UWCD	Sterling	2,495	2,495	2,495	2,495	2,495	2,495	2,495
	Total	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**
Sutton County UWCD	Sutton	6,400	6,400	6,400	6,400	6,400	6,400	6,400
	Total	**6,400**	**6,400**	**6,400**	**6,400**	**6,400**	**6,400**	**6,400**
Terrell County GCD	Terrell	1,420	1,420	1,420	1,420	1,420	1,420	1,420
	Total	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**
Uvalde County UWCD	Uvalde	1,993	1,993	1,993	1,993	1,993	1,993	1,993
	Total	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**

TABLE 5. (CONTINUED).

District	County	Year						
		2010	2020	2030	2040	2050	2060	2070
No district		102,415	102,415	102,415	102,415	102,415	102,415	102,415
GMA 7		**474,464**	**474,464**	**474,464**	**474,464**	**474,464**	**474,464**	**474,464**

*The modeled available groundwater for Irion County WCD only includes the portion of the district that falls within Irion County.

TABLE 6. MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Coke	F	Colorado	997	997	997	997	997	997
		Total	**997**	**997**	**997**	**997**	**997**	**997**
Crockett	F	Colorado	20	20	20	20	20	20
		Rio Grande	5,427	5,427	5,427	5,427	5,427	5,427
		Total	**5,447**	**5,447**	**5,447**	**5,447**	**5,447**	**5,447**
Ector	F	Colorado	4,925	4,925	4,925	4,925	4,925	4,925
		Rio Grande	617	617	617	617	617	617
		Total	**5,542**	**5,542**	**5,542**	**5,542**	**5,542**	**5,542**
Edwards	J	Colorado	2,305	2,305	2,305	2,305	2,305	2,305
		Nueces	1,631	1,631	1,631	1,631	1,631	1,631
		Rio Grande	1,740	1,740	1,740	1,740	1,740	1,740
		Total	**5,676**	**5,676**	**5,676**	**5,676**	**5,676**	**5,676**
Gillespie	K	Colorado	4,843	4,843	4,843	4,843	4,843	4,843
		Guadalupe	136	136	136	136	136	136
		Total	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**	**4,979**
Glasscock	F	Colorado	65,186	65,186	65,186	65,186	65,186	65,186
		Total	**65,186**	**65,186**	**65,186**	**65,186**	**65,186**	**65,186**

TABLE 6. (CONTINUED).

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Irion	F	Colorado	3,289	3,289	3,289	3,289	3,289	3,289
		Total	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**	**3,289**
Kimble*	F	Colorado	1,282	1,282	1,282	1,282	1,282	1,282
		Total	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**	**1,282**
Kinney	J	Nueces	12	12	12	12	12	12
		Rio Grande	70,329	70,329	70,329	70,329	70,329	70,329
		Total	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**	**70,341**
Menard*	F	Colorado	2,217	2,217	2,217	2,217	2,217	2,217
		Total	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**	**2,217**
Midland	F	Colorado	23,233	23,233	23,233	23,233	23,233	23,233
		Total	**23,233**	**23,233**	**23,233**	**23,233**	**23,233**	**23,233**
Pecos	F	Rio Grande	117,309	117,309	117,309	117,309	117,309	117,309
		Total	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**	**117,309**
Reagan	F	Colorado	68,205	68,205	68,205	68,205	68,205	68,205
		Rio Grande	28	28	28	28	28	28
		Total	**68,233**	**68,233**	**68,233**	**68,233**	**68,233**	**68,233**
Real	J	Colorado	277	277	277	277	277	277
		Guadalupe	3	3	3	3	3	3
		Nueces	7,243	7,243	7,243	7,243	7,243	7,243
		Total	**7,523**	**7,523**	**7,523**	**7,523**	**7,523**	**7,523**

TABLE 6. (CONTINUED).

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Schleicher	F	Colorado	6,403	6,403	6,403	6,403	6,403	6,403
		Rio Grande	1,631	1,631	1,631	1,631	1,631	1,631
		Total	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**	**8,034**
Sterling	F	Colorado	2,495	2,495	2,495	2,495	2,495	2,495
		Total	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**	**2,495**
Sutton	F	Colorado	388	388	388	388	388	388
		Rio Grande	6,022	6,022	6,022	6,022	6,022	6,022
		Total	**6,410**	**6,410**	**6,410**	**6,410**	**6,410**	**6,410**
Taylor	G	Brazos	331	331	331	331	331	331
		Colorado	158	158	158	158	158	158
		Total	**489**	**489**	**489**	**489**	**489**	**489**
Terrell	E	Rio Grande	1,420	1,420	1,420	1,420	1,420	1,420
		Total	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**	**1,420**
Upton	F	Colorado	21,243	21,243	21,243	21,243	21,243	21,243
		Rio Grande	1,126	1,126	1,126	1,126	1,126	1,126
		Total	**22,369**	**22,369**	**22,369**	**22,369**	**22,369**	**22,369**
Uvalde	L	Nueces	1,993	1,993	1,993	1,993	1,993	1,993
		Total	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**	**1,993**
Val Verde	J	Rio Grande	50,000	50,000	50,000	50,000	50,000	50,000
		Total	**50,000**	**50,000**	**50,000**	**50,000**	**50,000**	**50,000**
GMA 7			**474,464**	**474,464**	**474,464**	**474,464**	**474,464**	**474,464**

*The modeled available groundwater for Kimble and Menard counties excludes the parts of the counties that fall within Hickory Underground Water Conservation District No. 1.

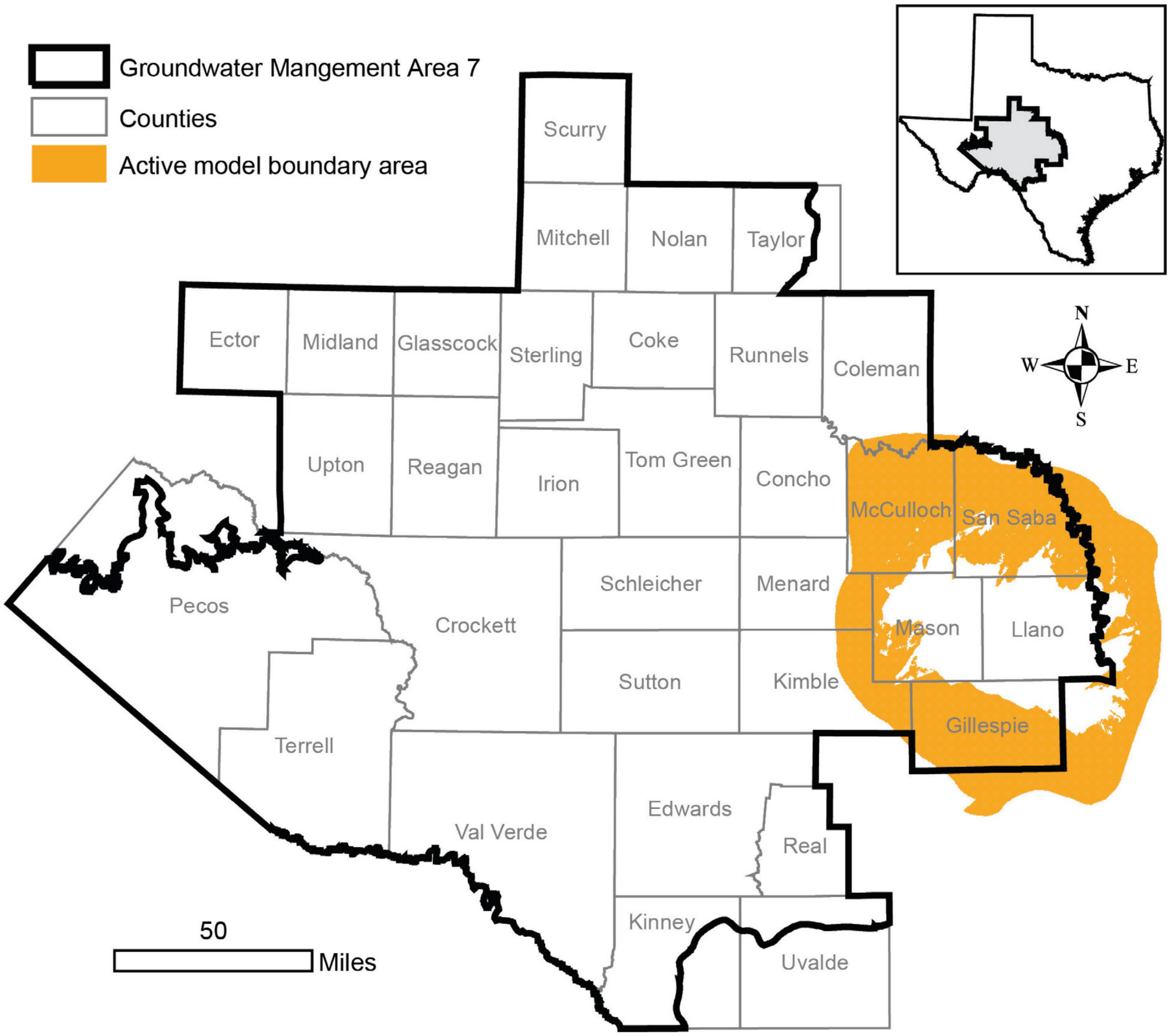

FIGURE 9. MAP SHOWING THE AREAS COVERED BY THE ELLENBURGER-SAN SABA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 7. MODELED AVAILABLE GROUNDWATER FOR THE ELLENBURGER-SAN SABA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2011 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. UWCD IS THE ABBREVIATION FOR UNDERGROUND WATER CONSERVATION DISTRICT AND UWD IS UNDERGROUND WATER DISTRICT.

District	County	Year						
		2011	2020	2030	2040	2050	2060	2070
Hickory UWCD No. 1	Kimble	344	344	344	344	344	344	344
	Mason	3,237	3,237	3,237	3,237	3,237	3,237	3,237
	McCulloch	3,466	3,466	3,466	3,466	3,466	3,466	3,466
	Menard	282	282	282	282	282	282	282
	San Saba	5,559	5,559	5,559	5,559	5,559	5,559	5,559
	Total	**12,887**	**12,887**	**12,887**	**12,887**	**12,887**	**12,887**	**12,887**
Hill Country UWCD	Gillespie	6,294	6,294	6,294	6,294	6,294	6,294	6,294
	Total	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**
Kimble County GCD	Kimble	178	178	178	178	178	178	178
	Total	**178**	**178**	**178**	**178**	**178**	**178**	**178**
Menard County UWD	Menard	27	27	27	27	27	27	27
	Total	**27**	**27**	**27**	**27**	**27**	**27**	**27**
No District	McCulloch	898	898	898	898	898	898	898
	San Saba	2,331	2,331	2,331	2,331	2,331	2,331	2,331
	Total	**3,229**	**3,229**	**3,229**	**3,229**	**3,229**	**3,229**	**3,229**
GMA 7		**22,616**	**22,616**	**22,616**	**22,616**	**22,616**	**22,616**	**22,616**

Note: The year 2011 is used because the 2010 desired future condition baseline year for the Ellenburger-San Saba Aquifer is an initial condition in the predictive model run.

TABLE 8. MODELED AVAILABLE GROUNDWATER FOR THE ELLENBURGER-SAN SABA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADEBETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Gillespie	K	Colorado	6,294	6,294	6,294	6,294	6,294	6,294
		Total	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**	**6,294**
Kimble	F	Colorado	521	521	521	521	521	521
		Total	**521**	**521**	**521**	**521**	**521**	**521**
Mason	F	Colorado	3,237	3,237	3,237	3,237	3,237	3,237
		Total	**3,237**	**3,237**	**3,237**	**3,237**	**3,237**	**3,237**
McCulloch	F	Colorado	4,364	4,364	4,364	4,364	4,364	4,364
		Total	**4,364**	**4,364**	**4,364**	**4,364**	**4,364**	**4,364**
Menard	F	Colorado	309	309	309	309	309	309
		Total	**309**	**309**	**309**	**309**	**309**	**309**
San Saba	K	Colorado	7,890	7,890	7,890	7,890	7,890	7,890
		Total	**7,890**	**7,890**	**7,890**	**7,890**	**7,890**	**7,890**
GMA 7			**22,616**	**22,616**	**22,616**	**22,616**	**22,616**	**22,616**

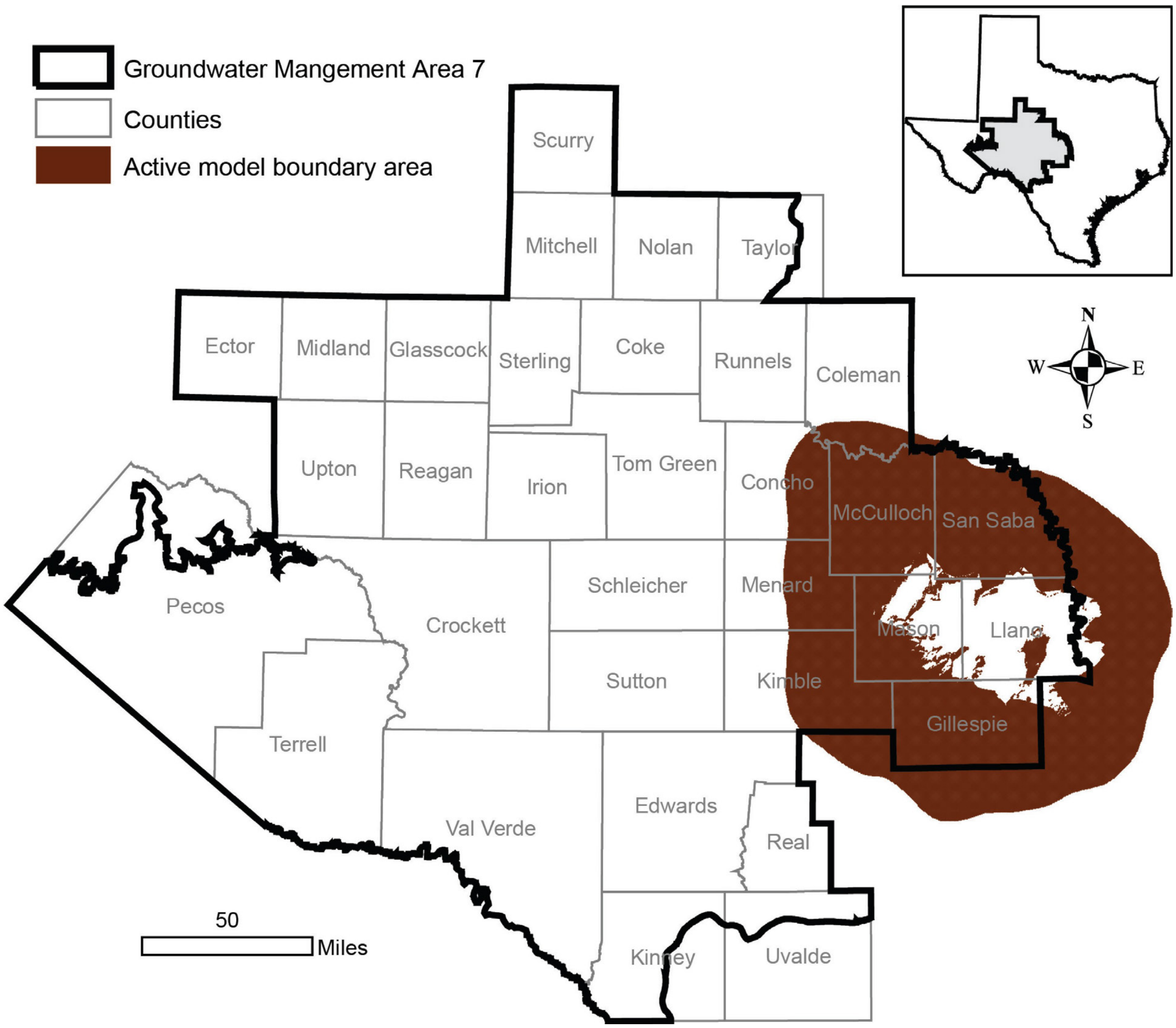

FIGURE 10. MAP SHOWING AREAS COVERED BY THE HICKORY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 9. MODELED AVAILABLE GROUNDWATER FOR THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2011 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR. UWCD IS THE ABBREVIATION FOR UNDERGROUND WATER CONSERVATION DISTRICT AND UWD IS UNDERGROUND WATER DISTRICT.

District	County	Year						
		2011	2020	2030	2040	2050	2060	2070
Hickory UWCD No. 1	Concho	13	13	13	13	13	13	13
	Kimble	42	42	42	42	42	42	42
	Mason	13,212	13,212	13,212	13,212	13,212	13,212	13,212
	McCulloch	21,950	21,950	21,950	21,950	21,950	21,950	21,950
	Menard	2,600	2,600	2,600	2,600	2,600	2,600	2,600
	San Saba	7,027	7,027	7,027	7,027	7,027	7,027	7,027
	Total	**44,843**	**44,843**	**44,843**	**44,843**	**44,843**	**44,843**	**44,843**
Hill Country UWCD	Gillespie	1,751	1,751	1,751	1,751	1,751	1,751	1,751
	Total	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**
Kimble County GCD	Kimble	123	123	123	123	123	123	123
	Total	**123**	**123**	**123**	**123**	**123**	**123**	**123**
Lipan-Kickapoo WCD	Concho	13	13	13	13	13	13	13
	Total	**13**	**13**	**13**	**13**	**13**	**13**	**13**
Menard County UWD	Menard	126	126	126	126	126	126	126
	Total	**126**	**126**	**126**	**126**	**126**	**126**	**126**
No District	McCulloch	2,427	2,427	2,427	2,427	2,427	2,427	2,427
	San Saba	652	652	652	652	652	652	652
	Total	**3,080**	**3,080**	**3,080**	**3,080**	**3,080**	**3,080**	**3,080**
GMA 7		**49,936**	**49,936**	**49,936**	**49,936**	**49,936**	**49,936**	**49,936**

Note: The year 2011 is used because the 2010 desired future condition baseline year for the Hickory Aquifer is an initial condition in the predictive model run.

TABLE 10. MODELED AVAILABLE GROUNDWATER FOR THE HICKORY AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Concho	F	Colorado	27	27	27	27	27	27
		Total	**27**	**27**	**27**	**27**	**27**	**27**
Gillespie	K	Colorado	1,751	1,751	1,751	1,751	1,751	1,751
		Total	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**	**1,751**
Kimble	F	Colorado	165	165	165	165	165	165
		Total	**165**	**165**	**165**	**165**	**165**	**165**
Mason	F	Colorado	13,212	13,212	13,212	13,212	13,212	13,212
		Total	**13,212**	**13,212**	**13,212**	**13,212**	**13,212**	**13,212**
McCulloch	F	Colorado	24,377	24,377	24,377	24,377	24,377	24,377
		Total	**24,377**	**24,377**	**24,377**	**24,377**	**24,377**	**24,377**
Menard	F	Colorado	2,725	2,725	2,725	2,725	2,725	2,725
		Total	**2,725**	**2,725**	**2,725**	**2,725**	**2,725**	**2,725**
San Saba	K	Colorado	7,680	7,680	7,680	7,680	7,680	7,680
		Total	**7,680**	**7,680**	**7,680**	**7,680**	**7,680**	**7,680**
GMA 7			**49,936**	**49,936**	**49,936**	**49,936**	**49,936**	**49,936**

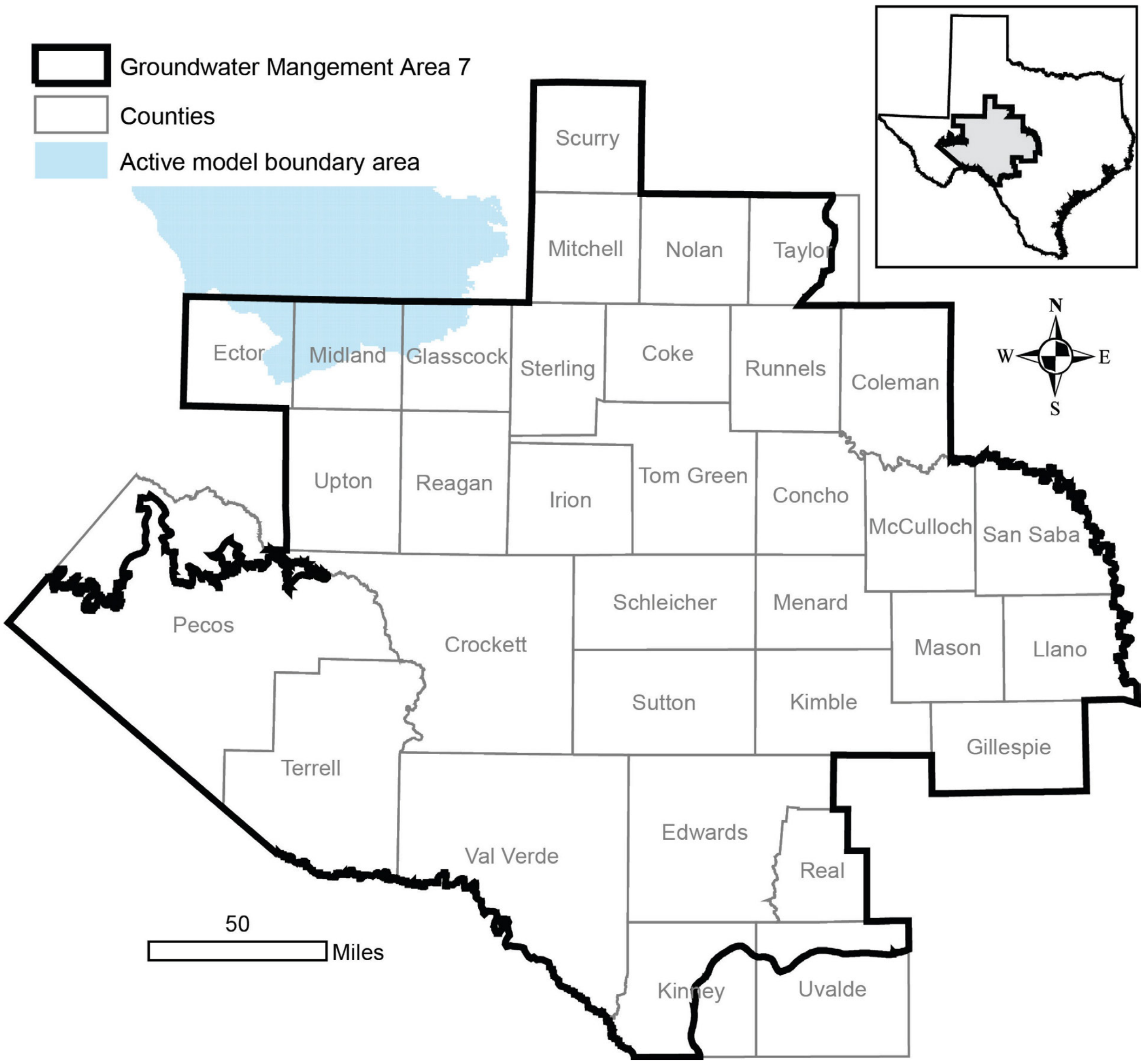

FIGURE 11. MAP SHOWING THE AREAS COVERED BY THE OGALLALA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 11. MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2013 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

District	County	Year						
		2013	2020	2030	2040	2050	2060	2070
Glasscock GCD	Glasscock	8,019	7,925	7,673	7,372	7,058	6,803	6,570
	Total	**8,019**	**7,925**	**7,673**	**7,372**	**7,058**	**6,803**	**6,570**
GMA 7		**8,019**	**7,925**	**7,673**	**7,372**	**7,058**	**6,803**	**6,570**

Note: The year 2013 is used because the 2012 desired future condition baseline year for the Ogallala Aquifer is an initial condition in the predictive model run.

TABLE 12. MODELED AVAILABLE GROUNDWATER FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Glasscock	F	Colorado	7,925	7,673	7,372	7,058	6,803	6,570
		Total	**7,925**	**7,673**	**7,372**	**7,058**	**6,803**	**6,570**
GMA 7			**7,925**	**7,673**	**7,372**	**7,058**	**6,803**	**6,570**

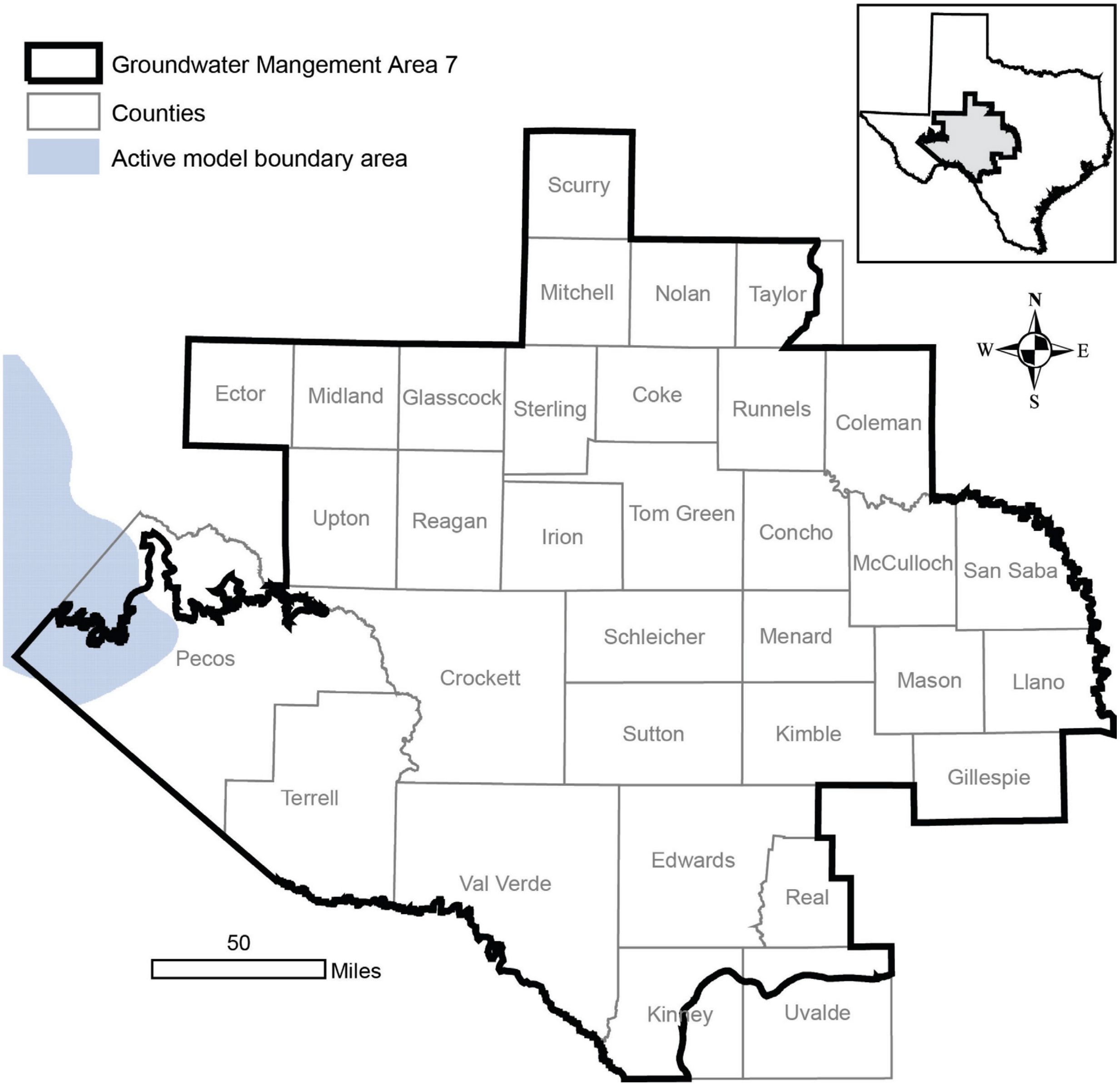

FIGURE 12. MAP SHOWING AREAS COVERED BY THE RUSTLER AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

TABLE 13. MODELED AVAILABLE GROUNDWATER FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY DISTRICT AND COUNTY FOR EACH DECADE BETWEEN 2009 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

District	County	Year							
		2009	2010	2020	2030	2040	2050	2060	2070
Middle Pecos GCD	Pecos	7,040	7,040	7,040	7,040	7,040	7,040	7,040	7,040
	Total	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**

TABLE 14. MODELED AVAILABLE GROUNDWATER FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. RESULTS ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Pecos	F	Rio Grande	7,040	7,040	7,040	7,040	7,040	7,040
		Rio Grande	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**	**7,040**

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 historical groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historical 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 historical 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.

Model "Dry" Cells

The predictive model run for this analysis results in water levels in some model cells dropping below the base elevation of the cell during the simulation. In terms of water level, the cells have gone dry. However, as noted in the model assumptions the transmissivity of the cell remains constant and will produce water.

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