Sandy Land Underground Water Conservation District

Groundwater Management Plan 2019-2024

Effective June 2019

Sandy Land Underground Water Conservation District

Groundwater Management Plan

Adopted 1998
Amended 2003
Amended 2009
Amended 2014
Amended 2019

Sandy Land UWCD Management Plan

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Sandy Land Underground Water Conservation District
Groundwater Management Plan

District Mission

Sandy Land Underground Water Conservation District will provide technical assistance and develop, promote and implement management strategies to provide for the conservation, preservation, protection, recharging and prevention of waste of the groundwater reservoir, thereby extending the quantity and quality of the Ogallala and the Edwards-Trinity (High Plains) aquifers in Yoakum County.

Time Period of This Plan

This plan will become effective upon adoption by the Sandy Land Underground Water Conservation District Board of Directors and once approved as administratively complete by the Texas Water Development Board. The plan will remain in effect for five years from the date of approval (on or around June 2024) or until a revised plan is adopted and approved.

Statement of Guiding Principles

Sandy Land Underground Water Conservation District recognizes that the groundwater resources of the region are of vital importance to the continued vitality of the citizens, economy and environment within the District. The preservation of the groundwater resources can be managed in the most prudent and cost-effective manner through the regulation of production as effected by the District's production limits, well permitting, and well spacing rules. This management plan is intended as a tool to focus the thoughts and actions of those individuals charged with the responsibility for the execution of District activities.

General Description

Sandy Land Underground Water Conservation District (The District) was created in November 1989 by authority of SB 1777 of the 71st Texas Legislature. The District has the same areal extent as Yoakum County, Texas and contains 510,540 upland acres. The District is bounded on the west by the State of New Mexico and by Cochran, Terry and Gaines Counties on the north, east and south, respectively. *(Figure 1)*

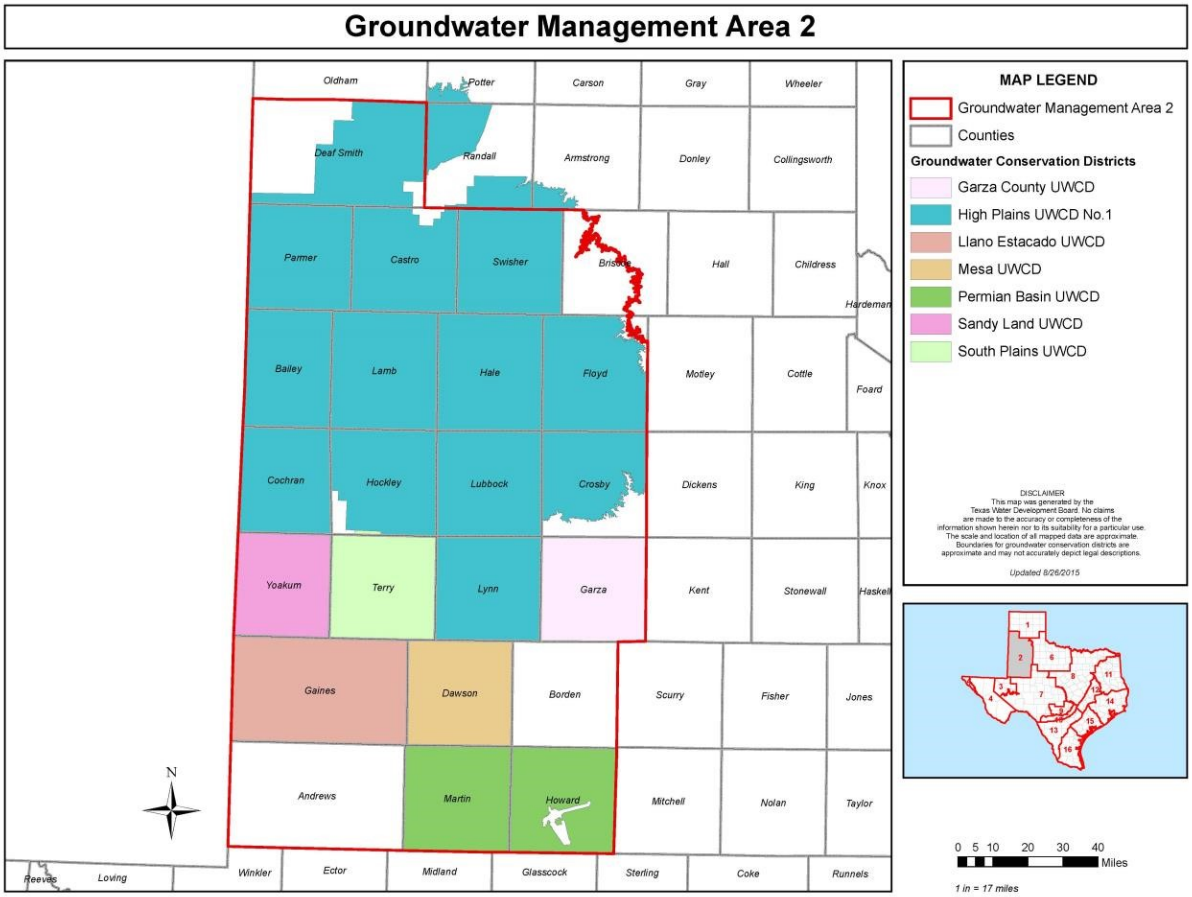


Figure 1. Location of Sandy Land Underground Water Conservation District

The economy of Yoakum County is primarily driven by two different industries; oil production and agriculture. The dominant crops produced in the District are irrigated cotton and peanuts. Additionally, grapes, watermelons, grain sorghum, sunflowers, soybeans, corn and hay are all grown both on irrigated and dry land acres.

Groundwater Resources

The District has jurisdictional authority over all groundwater that lies within the District's boundaries.

The Ogallala Aquifer is the primary source of water for Yoakum County, *(Figure 2).* The Ogallala Aquifer yields water from interfingered sands, gravels and silts of the Ogallala Formation from the Pliocene Epoch. These sediments represent deposits eroded from the ancestral Rocky Mountains to the west. Within the District, groundwater in the Ogallala Aquifer is under water table or unconfined conditions. In this portion of the Southern High Plains, the Ogallala Formation is predominantly covered by dune sands of the Quaternary Period.

Underlying the Ogallala Aquifer are sandstones and limestones of the Edwards-Trinity (High Plains) Aquifer. These sediments were deposited during the Cretaceous Period upon an eroded surface and were in turn eroded before being covered by deposition of Ogallala Formation. The result is that the Edwards-Trinity Aquifer within the District is highly variable in thickness and depth, and represents a minor source of groundwater in the District.

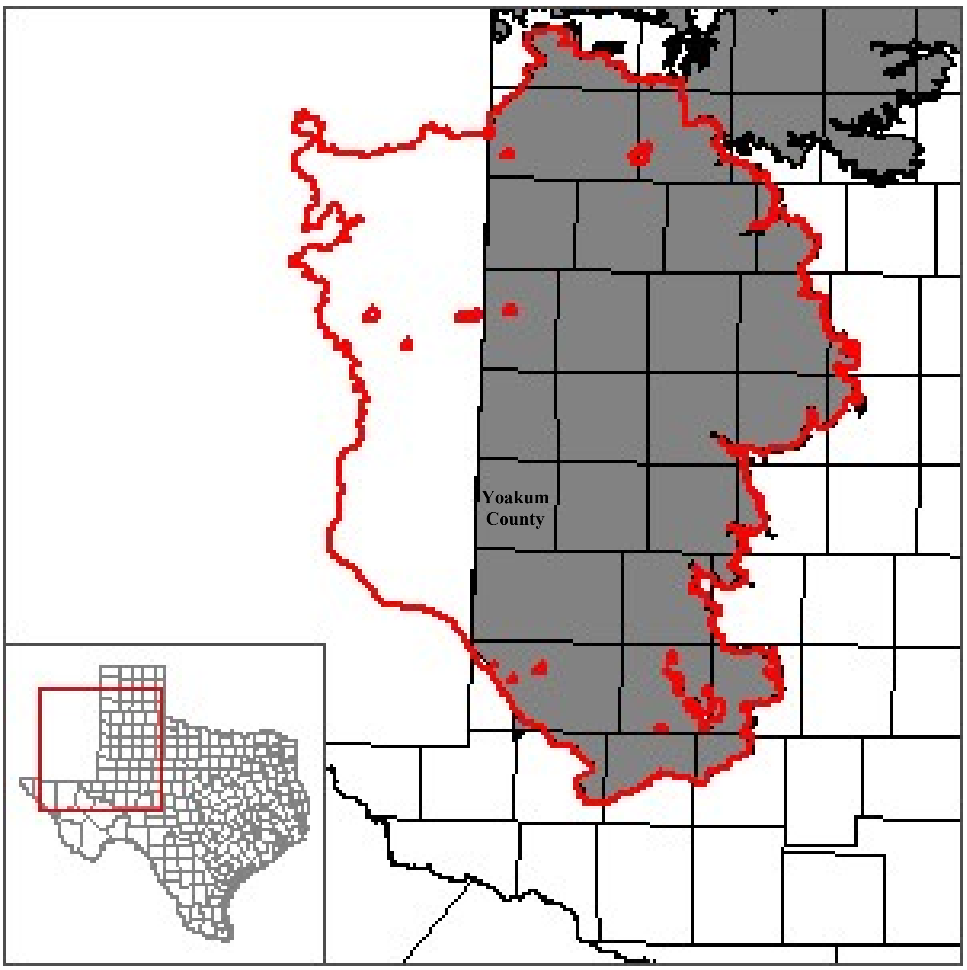


Figure 2. Map of Ogallala Aquifer

The Dockum Formation underlies the Edwards –Trinity (High Plains) and Ogallala Formations in Yoakum County. The Dockum Formation is divided into an upper, or younger Group and a lower, older Group. Water bearing zones are found in both the upper and lower Groups. The younger, shallower zone is found from about 470 to as much as 980 feet below ground surface. The average zone is about 35 feet thick with ranges from 20 to 50 feet of saturated thickness.

The older, lower zone produces water from depths of 1,500 to 1,900 feet below ground surface. Saturated material thickness varies from 30 to over 260 feet. Reported water production is approximately 100 to 150 gallons per minute, or about 4,000 barrels of water per day. The water produced is currently used for secondary oil recovery operations. Limited water quality data indicated a moderately saline water, with total dissolved solids (TDS) concentrations approaching 10,000 mg/L. The TDS values correspond to high reported concentrations of chlorides, sodium and sulfates. Until economical treatment techniques become available, the primary use of Dockum Formation water in Yoakum County is expected to continue to be limited to the various petroleum production related operations.

Natural recharge in the District is mostly through direct infiltration of precipitation into the coarse, wind-blown, sandy and silty surficial sediments. This is different from the more northern portions of the Southern High Plains where natural recharge is focused through the floors of the thousands of playas.

One activity that, while not technically meeting the definition of natural or enhanced recharge, which may significantly impact the overall supply of groundwater in the District is that of circulating irrigation water. Clearly not all irrigation water applied in the District is lost to evapotranspiration; rather some as yet unquantified volume of groundwater produced actually infiltrates back to the Ogallala Aquifer and is thus available for pumping again.

<u>Estimates of Modeled Available Groundwater</u>

GMA 2 adopted Desired Future Conditions for relevant aquifers in October 2016.

The desired future condition for the Ogallala and Edwards-Trinity (High Plains) aquifers is average drawdown of between 23 and 27 feet for all of GMA 2. The drawdown is calculated from the end of 2012 conditions to the year 2070. The drawdown is expressed as a range due to the link between future pumping and future rainfall. As documented in GMA 2 Technical Memorandum 15-01 and GMA 2 Technical Memorandum 16-01, historic pumping is higher in dry years than in wet years. Since most of the water use in GMA 2 from the Ogallala Aquifer is for irrigation, producers pump more groundwater in dry years than in normal or wet years. The simulations assumed that initial pumping rates in the future would be between 100-percent and 150-percent of 2012 pumping rates. Essentially, in average or wet years, initial annual pumping would be approximately the same as 2012 pumping rates. In dry years, initial annual pumping rates could be as high as 150-percent of 2012 pumping rates based on the variation of pumping rates in the recent past. For Estimated Modeled Available Groundwater for the Sandy Land UWCD, refer to the GMA 2 MAG Report table from the TWDB GAM Run 16-028 MAG Report, Appendix C.

<u>Estimated Historical Annual Groundwater Usage</u>

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

Refer to Estimated Historical Groundwater Use and 2017 State Water Plan Data Sets, Appendix B.

<u>Estimates of Annual Groundwater Recharge from Precipitation</u>
Refer to GAM Run 18-014 Report, Appendix A

<u>Estimates of Annual Groundwater Discharge to Springs/Surface Water Bodies</u>
Refer to GAM Run 18-014 Report, Appendix A

<u>Estimates of Annual Groundwater Flow Into/Out of the District for the Ogallala; Estimates of Annual Groundwater Flow between Aquifers in the District</u>
Refer to GAM Run 18-014 Report, Appendix A

<u>Estimates of Projected Surface Water Supplies</u>
Refer to Estimated Historical Groundwater Use and 2017 State Water Plan Data Sets, Appendix B.

<u>Estimates of Projected Total Demand for Water in the District</u>
Projecting water demand is a laborious process. In order to make such projections, one must predict the trends of groundwater use. Assumptions must be made regarding population changes, economic development patterns and future weather patterns. Of particular difficulty is that of projecting the demand of irrigation water; rainfall, commodity prices, water level changes and federal farm policy which are a few of the factors that complicate this matter.

Refer to Estimated Historical Groundwater Use and 2017 State Water Plan Data Sets, Appendix B.

<u>Consideration of Water Supply Needs and Water Management Strategies</u>
It is required that the District Management Plan consider the water supply needs and water management strategies included in the 2017 State Water Plan (TWC 36.1071(e)(4)).

The water supply needs in Yoakum County are identified when the projected water demand of a Water User Group (WUG) exceeds the projected water supplies of the WUG. See Appendix B, Page 7.

Water Management Strategies recommended for the area covered by Sandy Land UWCD are municipal and irrigation water conservation, and local water development in both Denver City and Plains. See Appendix B, Page 8.

Now, it seems necessary that the issue of irrigation needs be discussed. While the District understands that there is need for more irrigation supply than is currently available, the demand figures are not indicative of the average usage. The producers in the District, as previously stated, have been educated by the aquifer and make the necessary changes in their practices to adjust to irrigation demands.

Management of Groundwater Resources

The District will 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 identify and engage in such activities and practices that, if implemented, would result in a reduction of groundwater use. A monitor well observation network shall be established and maintained in order to evaluate changing conditions of groundwater supplies (water in storage) within the District. The District will make a regular assessment of water supply and groundwater storage conditions and will report those conditions to the Board and to the public.

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 will adopt rules relating to the permitting of wells and the production of groundwater. The rules adopted by the District shall be pursuant to TWC Chapter 36 and the provisions of this plan. A copy of the District's rules is available on the District web site: http://www.sandylandwater.com/documents.html .

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

Drought Contingency Plan

There essentially can be no drought contingency plan for Sandy Land Underground Water Conservation District (Yoakum County) because under any standards drought is a constant. Rainfall averages for the year may seem somewhat adequate, but the need, during the growing season, is only a fraction of the total yearly rainfall. Irrigation wells cannot be turned off, or the amount of water pumped by them reduced, because of the crops that are growing.

What we have seen in many cases are half circles being irrigated instead of full circles. Those that pump the most, agricultural users have been educated by the aquifer itself and the regulation it bestows on all users.

It is our belief that we will not make any more groundwater. We have no surface water available to those located in Yoakum County and therefore our reliance on rainfall becomes even greater in the years ahead.

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

The District Manager will prepare and present an annual report to the Board of Directors on District performance in regard to achieving management goals and objectives. The report will be prepared in a format that will be reflective of the performance standards listed following each management objective. The report will be presented to the Board of Directors within 60 days of the end of each fiscal year. The Board will maintain the report on file, for public inspection at the District's offices upon adoption. This methodology will apply to all management goals contained within this plan.

The District will actively enforce all rules and regulations necessary for conserving, preserving, protecting, recharging and prevention of waste of water from the aquifers in Yoakum County. To accomplish this goal, the District will continue to develop and enforce rules and regulations, and modify as necessary, to carry out the duties as provided by Chapter 36 of the Texas Water code to effectively manage the aquifers of the District.

Goals, Management Objectives and Performance Standards

Goal 1.0:
Providing the most efficient use of groundwater within the District

Management Objective

(a) Annually conduct irrigation well efficiency tests for 100 percent of requests within 10 days of the property owner request.

Performance Standard

(a1) Percentage of irrigation well efficiency test requests conducted annually within 10 days of request.

Management Objective

(b) There are currently 93 water wells in the District's water level monitoring network. The objective is to annually measure water levels in a majority of the District's monitor well network and replace wells as needed.

Performance Standard

(b1) Percentage of monitor wells in monitor well network in which water levels were measured.

Goal 2.0:
Controlling and preventing waste of groundwater within the District

Management Objective

(a) Each year, the District will sample the water quality in selected well(s) in order to monitor water quality trends and prevent the waste of groundwater by contamination. The District will also sample for water quality analysis on 100 percent of other wells which the owner requests to be sampled each year.

Performance Standard

(a1) Number of wells sampled for water quality analysis by the District to monitor water quality trends each year.

Performance Standard

(a2) Percent of wells sampled for water quality analysis by the District upon request each year.

Management Objective

(b) Each year, the District will enforce District spacing and production limitation rules requiring the permitting of all new wells to prevent the waste of groundwater. The District will issue temporary permits for 100 percent of the application requests that meet the District's rigorous rules for spacing within 30 days of the receipt of the application.

Performance Standard
(b1) Number of temporary permits issued by the District for new wells in compliance with spacing and production limits each year.

(b2) Percent of temporary permits issued to applications that meet the District's rigorous rules for spacing within 30 days of receipt of application.

Management Objective
(c) The District will publish articles on the district's activities and water conservation to encourage a reduction of water use. This information may be made available by direct mail, website or local newspaper.

Performance Standard
(c1) Number of articles on water conservation presented by the District each year.

Goal 3.0:

Controlling and Preventing Subsidence

The goal of controlling and preventing subsidence is not applicable to the District.

Goal 4.0:

Addressing Conjunctive Surface Water Management Issues

The goal for addressing conjunctive surface water management issues is not applicable to the District due to the absence of any surface water features and hence, any surface water management issues.

Goal 5.0:

Addressing Natural Resource Issues

The goal for addressing natural resource issues that impact the use and availability of groundwater or are impacted by the use of groundwater within the District is not applicable.

Goal 6.0:

Addressing Drought Conditions

As previously stated in the Drought Contingency Plan section on page 9, the District is in a constant state of drought and recognizes the importance of rainfall.

Management Objective
(a) The District will maintain a Rain Gauge Network across the county

Performance Standard

(a1) Maintain a network of rain gages in the District. Publish rainfall data on the District's web site as collected.

Goal 7.0:

Addressing Conservation of Groundwater within the District

Management Objective

(a) As long as funding is available from TWDB, the District will participate in the TWDB Agricultural Conservation Loan program as a lender district and make loans available to all qualified applicants for the purchase of water conserving irrigation apparatus, up to the maximum amount of the loan commitment made to the District by TWDB.

Performance Standard

(a1) Number of Agricultural Conservation loan applications received by the District from qualified applicants each year.

(a2) Number of Agricultural Conservation loans made by the District to qualified applicants each year.

Management Objective

(b) Each year, the District will award scholarships to at least four (4) high school students graduating from a high school within the District to facilitate study of water conservation topics.

Performance Standard

(b1) Number of scholarships awarded to students graduating high school within the District to facilitate study of water conservation topics, each year.

Management Objective

(c) Each year, the District will provide Educational material to specific teachers at each school within the district.

Performance Standard

(c1) Number of Teachers who were provided educational materials.

Management Objective

(d) Each year the District will promote water conservation through presentations given within the District.

Performance Standard

(d1) Number of presentations given during the fiscal year

Goal 8.0:

Addressing Recharge Enhancement

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

Goal 9.0:

Addressing Rainwater Harvesting

Management Objective

(a) The District will conduct an educational program for this conservation strategy at least once a year.

Performance Standard

(a1) Number of educational programs given on rainwater harvesting

Goal 10.0:

Addressing Precipitation Enhancement

While the District did participate in this program previously, in 2015 the Board determined that it is not cost effective. Therefore, this goal is not applicable.

Goal 11.0:

Addressing Brush Control

Existing programs administered by the USDA-NRCS are sufficient for addressing this goal. The Board does not believe that this activity is cost-effective and applicable for the District at this time; therefore, this goal is not applicable.

Goal 12.0:

Addressing the Desired Future Conditions (DFC)

For the purposes of this management plan, the District proposes to evaluate the cumulative drawdown in 5-year increments, which will gage our attainment of the DFC in shorter increments and allow us to make changes accordingly.

Management Objective

(a) The District will calculate the average annual drawdown using the results of annual water level measurements each winter.

Performance Standard

(a1) Present the average drawdown results to the Board of Directors each year.
(a2) The average drawdown results will be made available to the public each year.

Management Objective

(a) The District will calculate the average cumulative drawdown in 5-year increments.

Performance Standard

(a1) Present the cumulative average drawdown results to the Board of Directors each year.

(a2) The cumulative average drawdown results will be made available to the public each year.

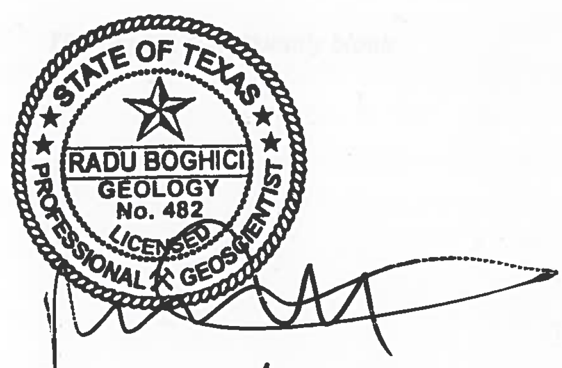
Sandy Land UWCD

Groundwater Management Plan

Appendix A:
GAM Run 18-014 Report

GAM Run 18-014: Sandy Land Underground Water Conservation District Groundwater Management Plan

Radu Boghici, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-463-5808
January 15, 2019



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GAM RUN 18-014: SANDY LAND UNDERGROUND WATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Radu Boghici, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-463-5808
January 15, 2019

EXECUTIVE SUMMARY:

Texas Water Code, Section 36.1071(h), 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 Sandy Land Underground Water Conservation District in two parts. Part 1 is the Estimated Historical Water Use/State Water Plan dataset report, which will be provided to you separately by the TWDB Groundwater Technical Assistance 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 Sandy Land Underground Water Conservation District should be adopted by the district on or before March 8, 2019, and submitted to the Executive Administrator of the TWDB on or before April 7, 2019. The current management plan for the Sandy Land Underground Water Conservation District expires on June 6, 2019.

This report replaces the results of GAM Run 13-022 (Kohlrenken, 2013). GAM Run 18-014 includes results from the groundwater availability model of the High Plains Aquifer System (Deeds and Jigmond, 2015). Tables 1 and 2 summarize the groundwater availability model data required by statute, and Figures 1 and 2 show the area of the models from which the values in the tables were extracted. If, after review of the figures, the Sandy Land Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas Water Code, Section 36.1071(h), the groundwater availability model of the High Plains Aquifer System was used to estimate information for the Sandy Land Underground Water Conservation District management plan. Water budgets were extracted for the historical model period (1980 through 2012) 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

- We used version 1.01 of the groundwater availability model for the High Plains Aquifer System for this analysis. See Deeds and Jigmond (2015) for assumptions and limitations of the model.
- The model has four layers which, in the area under the Sandy Land Underground Water Conservation District, represent the Ogallala Aquifer (Layer 1), the Edwards-Trinity (High Plains) Aquifer (Layer 2), and the Dockum Units (Layers 3 and 4). Within the South Plain Underground Water Conservation District the Dockum units are not designated as part of the Dockum Aquifer.
- Water budgets for the district were determined for the Ogallala Aquifer (Layer 1) and the Edwards-Trinity (High Plains) Aquifer.
- The model was run with MODFLOW-NWT (Niswonger and others, 2011).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. The groundwater budget components listed below and reported in Tables 1 and 2 were extracted from the groundwater availability model results for the Ogallala and Edwards-Trinity (High Plains) aquifers located within Sandy Land Underground Water Conservation District and averaged over the historical calibration periods.

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.

Water budgets are estimates because of the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

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

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ogallala Aquifer	19,587
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ogallala Aquifer	26
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	2,253
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	2,310
Estimated net annual volume of flow between each aquifer in the district	Net flow from Ogallala Aquifer to underlying Edwards-Trinity (High Plains) Aquifer	1,575

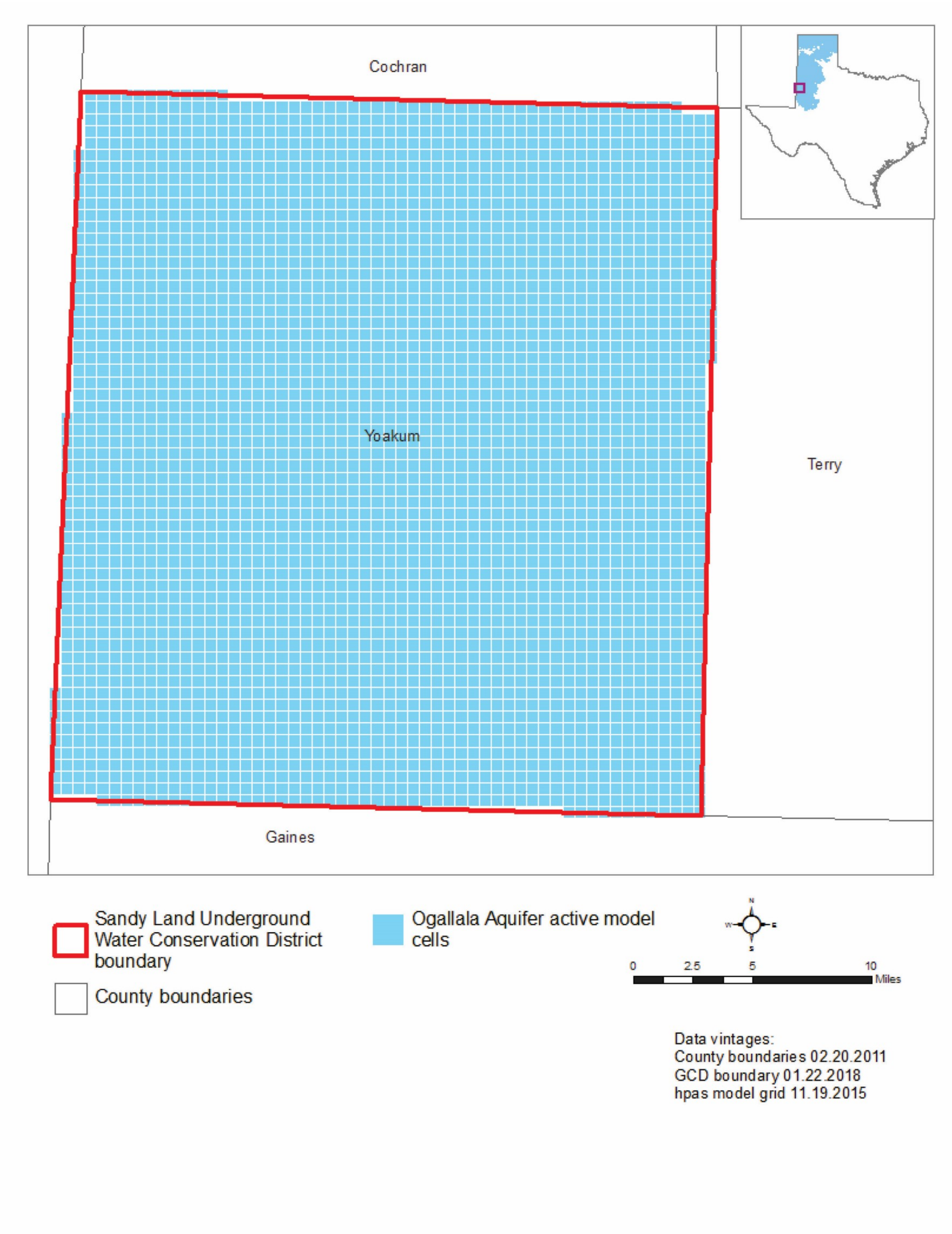

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE OGALLALA AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER FOR SANDY LAND UNDERGROUND WATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (High Plains) Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Edwards-Trinity (High Plains) Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (High Plains) Aquifer	4,130
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (High Plains) Aquifer	7,075
Estimated net annual volume of flow between each aquifer in the district	Net flow from Ogallala Aquifer to underlying Edwards-Trinity (High Plains) Aquifer	1,575
Estimated net annual volume of flow between each aquifer in the district	Net flow from underlying Dockum Group to Edwards-Trinity (High Plains) Aquifer	348

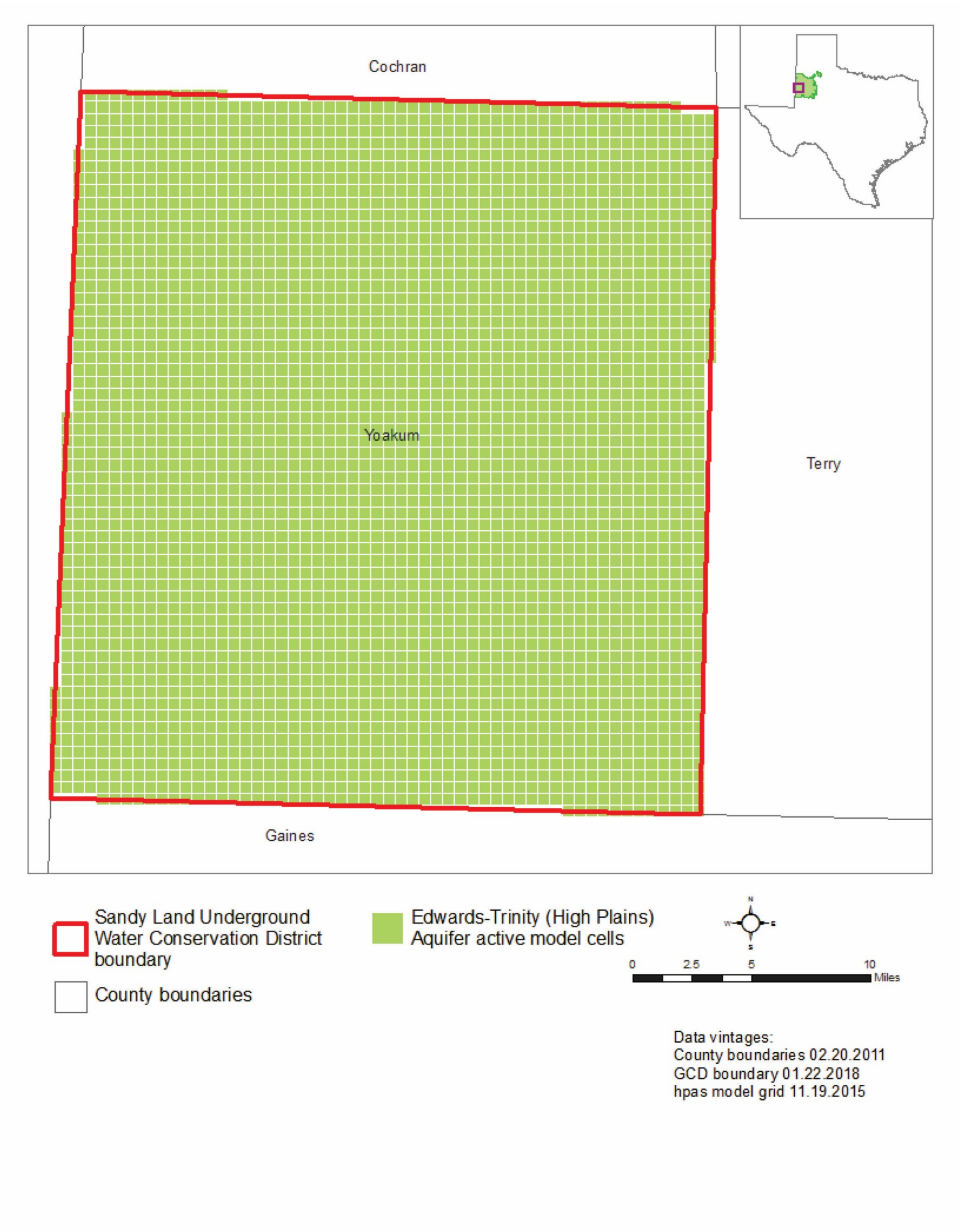

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

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 historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and interaction with streams are specific to particular historic time periods.

Because the application of the groundwater models was designed to address regional-scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations related to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

REFERENCES:

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

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Niswonger, R. G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, A Newtonian formulation for MODFLOW-2005: U.S. Geological Survey Survey Techniques and Methods 6-A37, 44 p.

Kohlrenken, W., 2013, GAM Run 13-022: Sandy Land Underground Water Conservation District Management Plan, 12 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR13-022.pdf

Sandy Land UWCD

Groundwater Management Plan

Appendix B:
Estimated Historical Groundwater Use and 2017 State Water Plan Data Sets

Estimated Historical Water Use And 2017 State Water Plan Datasets:

Sandy Land Underground Water Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
February 14, 2019

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 Water Use (checklist item 2)

   from the TWDB Historical Water Use Survey (WUS)

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

   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 2/14/2019. 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).

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 2017. TWDB staff anticipates the calculation and posting of these estimates at a later date.

YOAKUM COUNTY

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2016	GW	1,476	0	215	1,302	118,714	80	121,787
	SW	0	0	0	0	0	4	4
2015	GW	1,391	0	44	0	93,728	79	95,242
	SW	0	0	0	0	0	4	4
2014	GW	1,588	0	70	0	126,634	79	128,371
	SW	0	0	0	0	0	4	4
2013	GW	1,715	0	63	0	151,408	85	153,271
	SW	0	0	0	0	0	4	4
2012	GW	1,822	0	116	0	173,237	154	175,329
	SW	0	0	0	0	0	8	8
2011	GW	2,003	0	525	0	157,147	168	159,843
	SW	0	0	124	0	0	9	133
2010	GW	1,680	0	253	0	199,437	165	201,535
	SW	0	0	60	0	0	9	69
2009	GW	1,556	0	509	0	186,461	174	188,700
	SW	0	0	121	0	0	9	130
2008	GW	1,474	0	764	0	172,445	191	174,874
	SW	0	0	182	0	0	10	192
2007	GW	1,330	0	0	0	155,776	143	157,249
	SW	0	0	0	0	0	7	7
2006	GW	1,558	0	0	0	123,394	302	125,254
	SW	0	0	0	0	0	16	16
2005	GW	1,402	0	0	0	127,747	254	129,403
	SW	0	0	0	0	0	13	13
2004	GW	1,371	0	0	0	126,533	195	128,099
	SW	0	0	0	0	0	48	48
2003	GW	1,594	0	0	0	132,391	209	134,194
	SW	0	0	0	0	0	52	52
2002	GW	1,400	0	0	0	144,251	208	145,859
	SW	0	0	0	0	0	52	52
2001	GW	1,504	0	0	0	118,305	123	119,932
	SW	0	0	0	0	0	31	31

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

YOAKUM COUNTY All values are in acre-feet

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

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.

YOAKUM COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
O	COUNTY-OTHER, YOAKUM	COLORADO	267	291	314	341	372	403
O	DENVER CITY	COLORADO	1,423	1,579	1,721	1,889	2,066	2,237
O	IRRIGATION, YOAKUM	COLORADO	146,083	139,091	132,435	126,095	120,060	114,838
O	LIVESTOCK, YOAKUM	COLORADO	281	286	290	296	301	322
O	MINING, YOAKUM	COLORADO	1,300	1,334	1,147	957	783	641
O	PLAINS	COLORADO	432	480	522	570	624	675
O	STEAM ELECTRIC POWER, YOAKUM	COLORADO	3,718	4,346	5,113	6,047	7,186	8,540
		Sum of Projected Water Demands (acre-feet)	**153,504**	**147,407**	**141,542**	**136,195**	**131,392**	**127,656**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

YOAKUM COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
O	COUNTY-OTHER, YOAKUM	COLORADO	3	4	1	4	3	2
O	DENVER CITY	COLORADO	-759	-769	-771	-789	-866	-1,037
O	IRRIGATION, YOAKUM	COLORADO	-90,656	-99,143	-101,954	-102,808	-103,413	-109,358
O	LIVESTOCK, YOAKUM	COLORADO	-281	-286	-290	-296	-301	-322
O	MINING, YOAKUM	COLORADO	-386	-1,006	-1,070	-940	-783	-641
O	PLAINS	COLORADO	-194	-306	-387	-464	-518	-525
O	STEAM ELECTRIC POWER, YOAKUM	COLORADO	-1,486	-2,326	-3,189	-4,185	-5,474	-7,864
		Sum of Projected Water Supply Needs (acre-feet)	**-93,762**	**-103,836**	**-107,661**	**-109,482**	**-111,355**	**-119,747**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

YOAKUM COUNTY

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

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
DENVER CITY, COLORADO (O)							
YOAKUM COUNTY - DENVER CITY LOCAL GROUNDWATER DEVELOPMENT	EDWARDS-TRINITY-HIGH PLAINS AQUIFER [YOAKUM]	925	925	925	925	925	925
YOAKUM COUNTY - DENVER CITY MUNICIPAL WATER CONSERVATION	DEMAND REDUCTION [YOAKUM]	71	79	86	94	103	112
		996	**1,004**	**1,011**	**1,019**	**1,028**	**1,037**
IRRIGATION, YOAKUM, COLORADO (O)							
YOAKUM COUNTY IRRIGATION WATER CONSERVATION	DEMAND REDUCTION [YOAKUM]	2,771	2,771	3,048	3,048	2,497	2,497
		2,771	**2,771**	**3,048**	**3,048**	**2,497**	**2,497**
PLAINS, COLORADO (O)							
YOAKUM COUNTY - PLAINS LOCAL GROUNDWATER DEVELOPMENT	EDWARDS-TRINITY-HIGH PLAINS AQUIFER [YOAKUM]	500	500	500	500	500	500
YOAKUM COUNTY - PLAINS MUNICIPAL WATER CONSERVATION	DEMAND REDUCTION [YOAKUM]	22	24	26	28	31	34
		522	**524**	**526**	**528**	**531**	**534**
Sum of Projected Water Management Strategies (acre-feet)		**4,289**	**4,299**	**4,585**	**4,595**	**4,056**	**4,068**

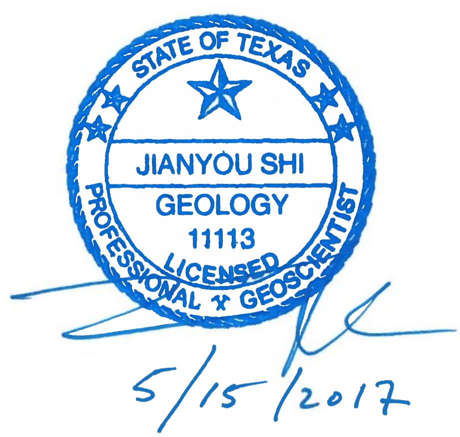
Sandy Land UWCD

Groundwater Management Plan

Appendix C:
GMA2 GAM Run 16-028 MAG

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

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



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

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

EXECUTIVE SUMMARY:

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

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

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

REQUESTOR:

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

DESCRIPTION OF REQUEST:

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

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

Ogallala and Edwards-Trinity (High Plains) Aquifers

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

Dockum Aquifer

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

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

METHODS:

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

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

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

Modeled Available Groundwater and Permitting

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

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the groundwater availability are described below:

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

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

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

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

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

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

RESULTS:

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

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

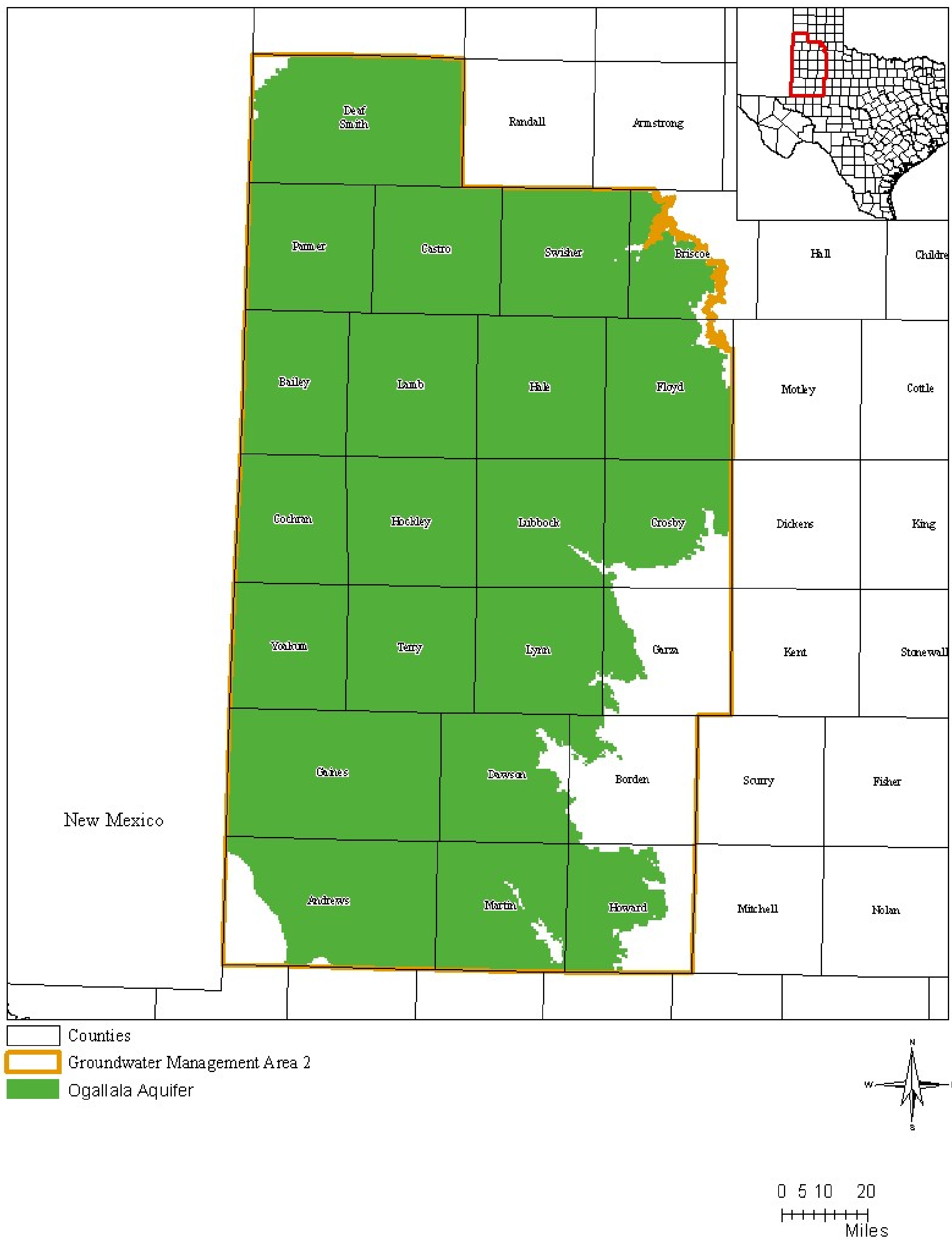

FIGURE 1. MAP SHOWING THE AREA COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE OGALLALA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2.

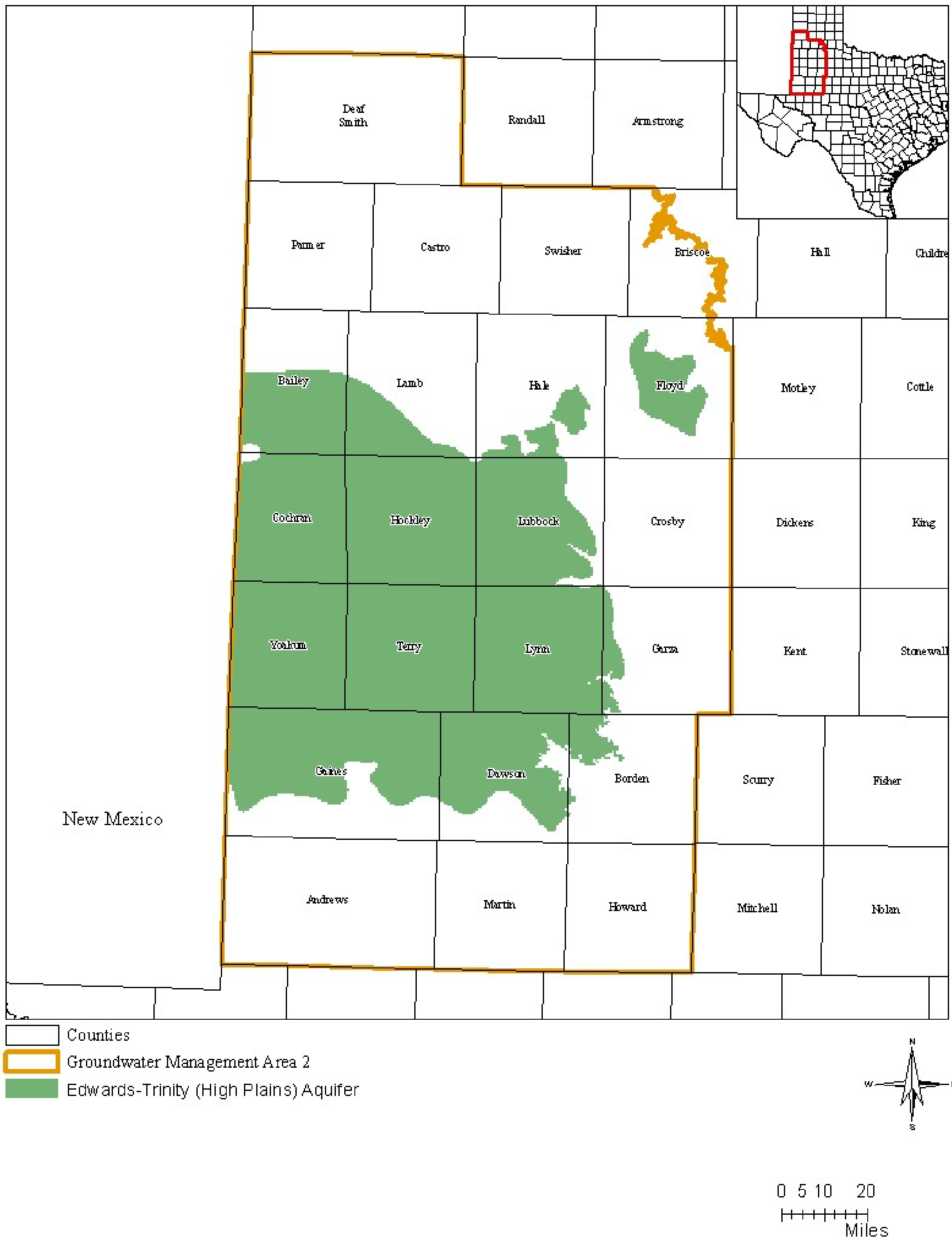

FIGURE 2. MAP SHOWING THE AREA COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2.

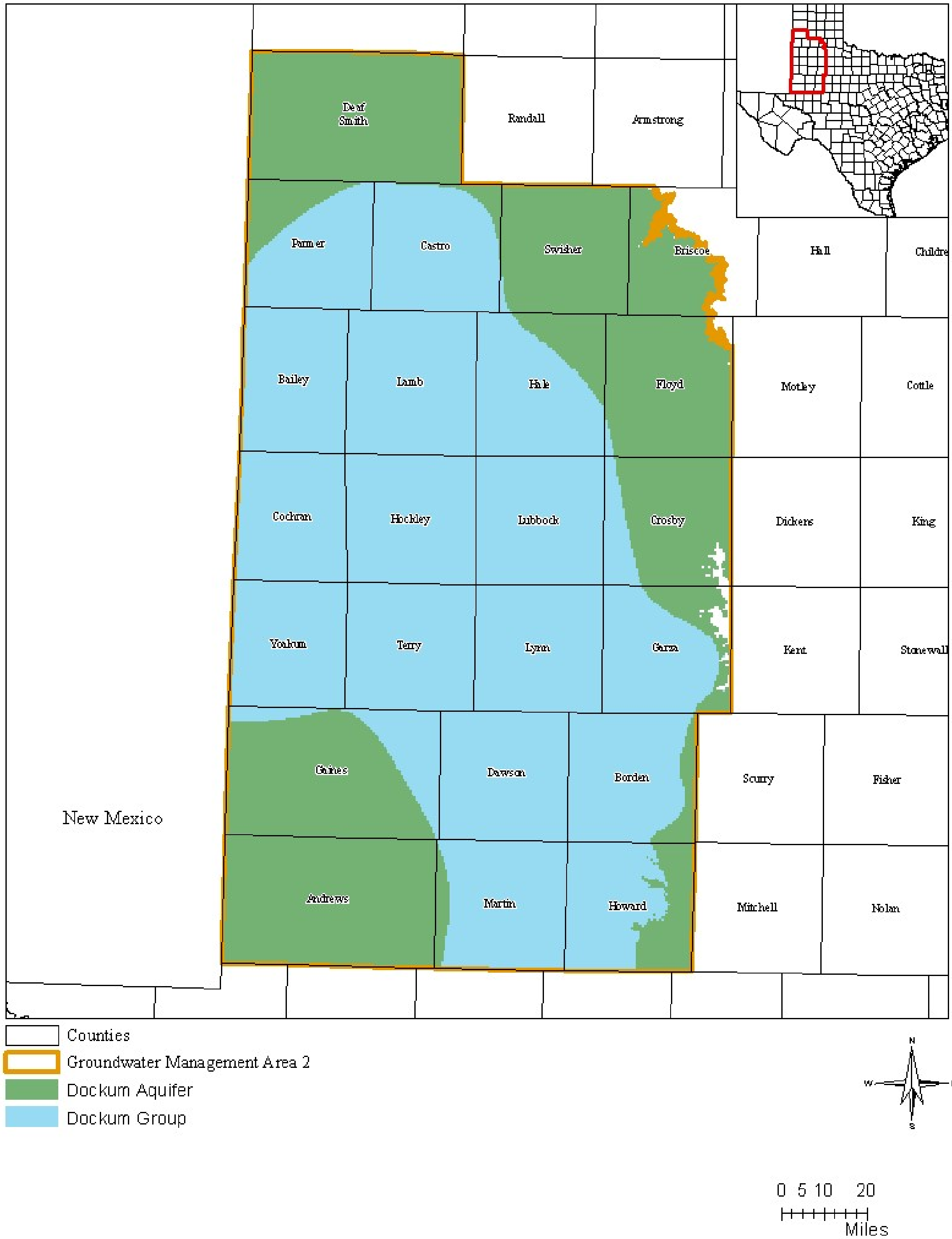

FIGURE 3. **MAP SHOWING THE AREA COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER AND DOCKUM GROUP WITHIN GROUNDWATER MANAGEMENT AREA 2.**

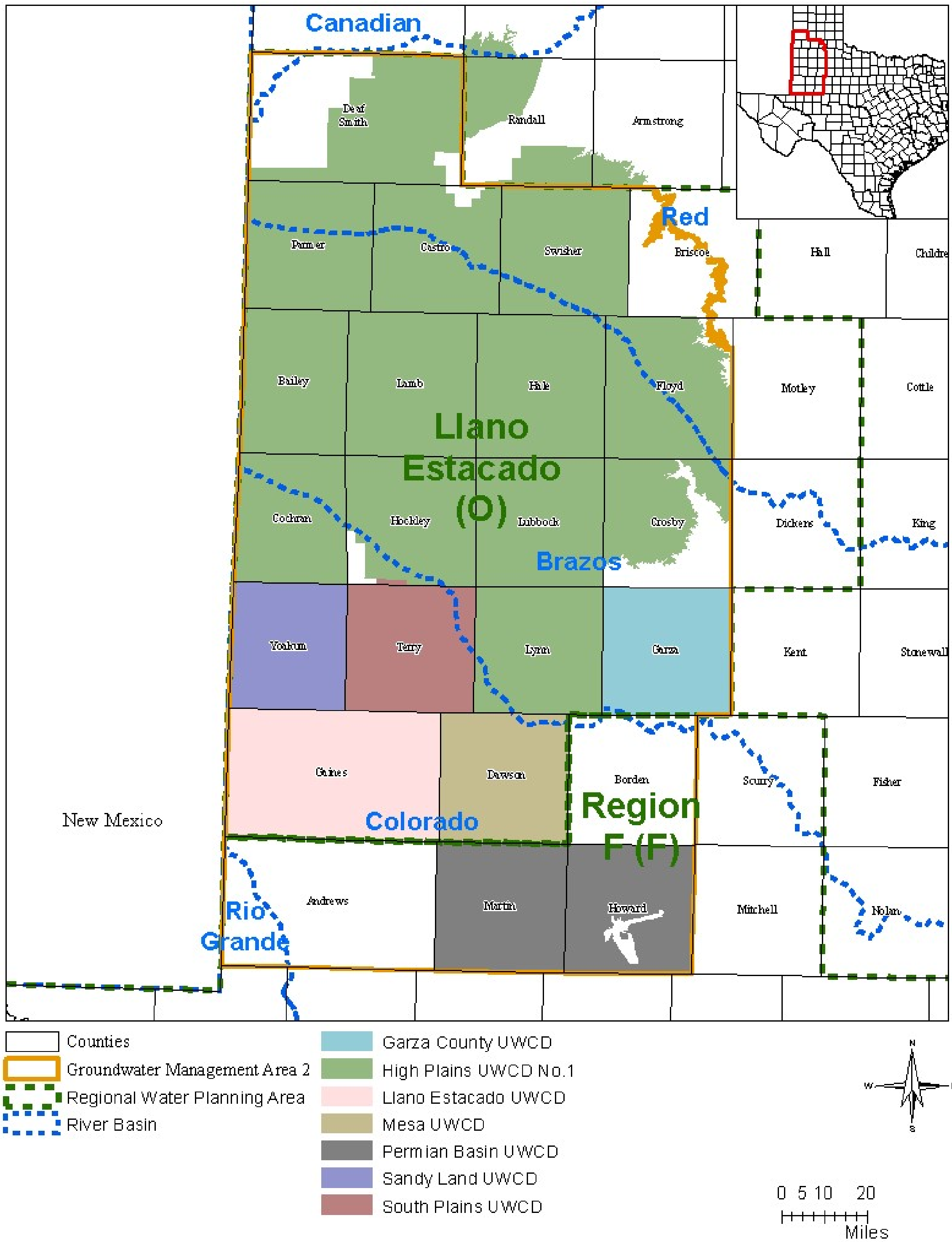

FIGURE 4. MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS (ALSO KNOWN AS UNDERGROUND WATER CONSERVATION DISTRICT OR UWCD), COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 2.

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

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

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

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

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

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

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

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

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

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

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

LIMITATIONS:

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> *"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."*

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and streamflow are specific to a particular historic time period.

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and groundwater levels in the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

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