Sandy Land Underground Water Conservation District

Groundwater Management Plan 2024-2029

Effective June 2024

Sandy Land Underground Water Conservation District

Groundwater Management Plan

Adopted 1998
Amended 2003
Amended 2009
Amended 2014
Amended 2019
Amended 2024

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 2029) 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 affected 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)*

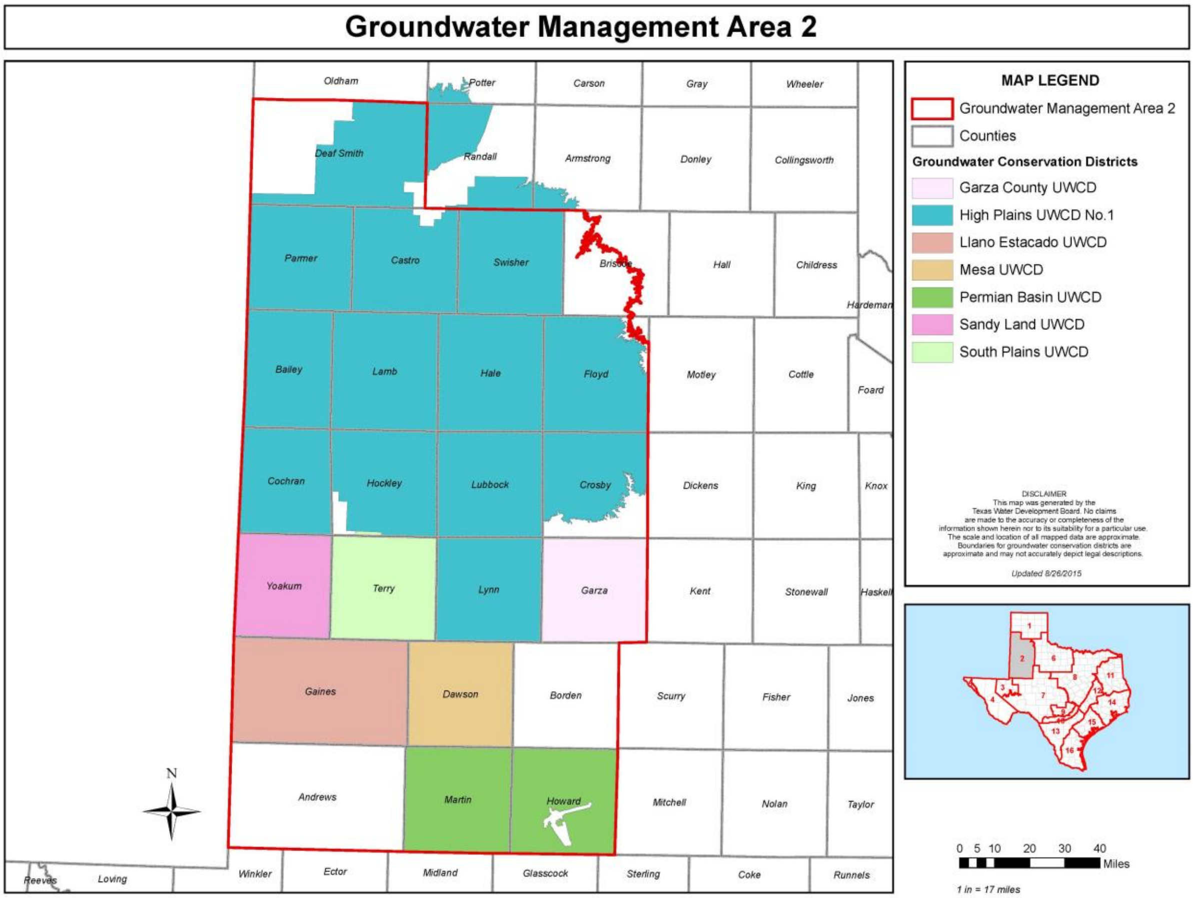


Figure 1. Location of Sandy Land Underground Water Conservation District

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 underwater 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.

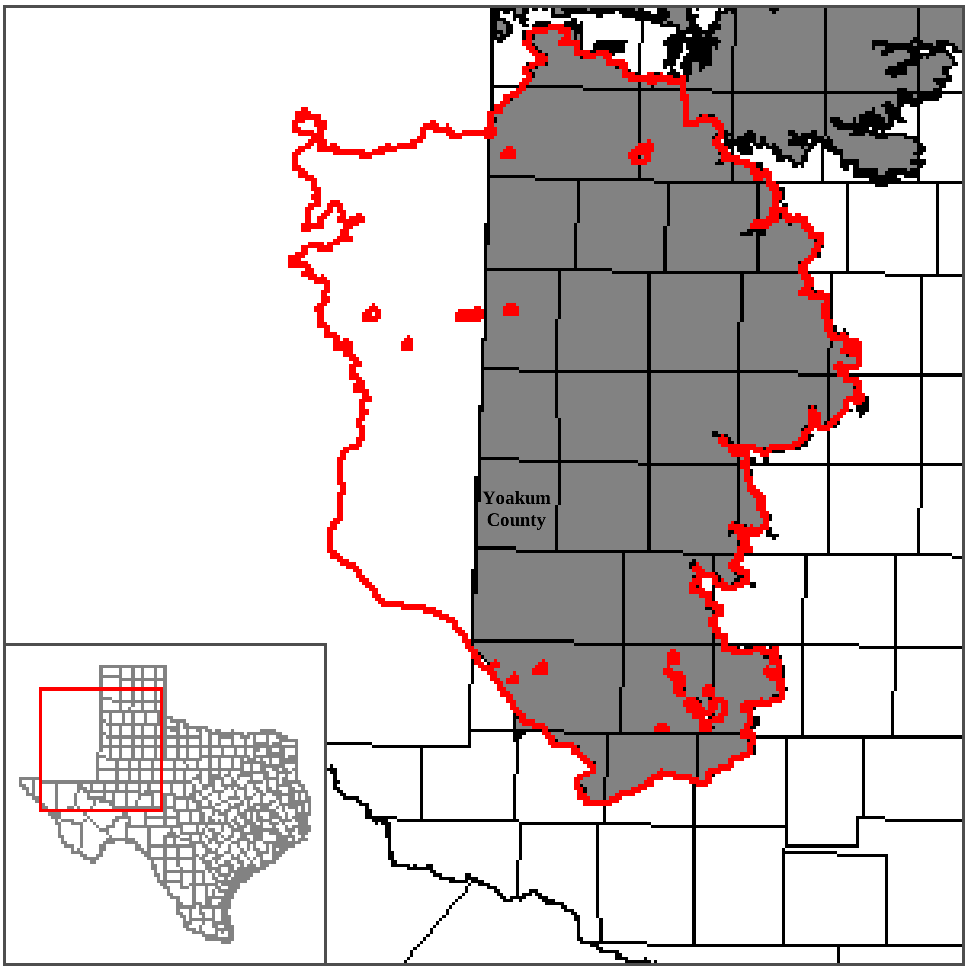


Figure 2. Map of Ogallala Aquifer

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 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.

Estimates of Modeled Available Groundwater

GMA 2 adopted Desired Future Conditions for relevant aquifers in March 2021.

The desired future condition for the Ogallala and Edwards-Trinity (High Plains) aquifers is a GMA 2-wide average drawdown of 28 feet between 2013 and 2080. A GMA 2-wide average drawdown of 31 feet between 2013 and 2080 was adopted for the Dockum Aquifer.

As documented in GMA 2 Technical Memorandum 20-01, the average drawdown calculations involve summing the drawdowns in all cells in an identified unit (e.g. county or GCD) and dividing the sum by the number of cells in the unit. Calculated average drawdowns based on the active cells in the model can be different than the calculated average drawdown based on the official aquifer boundary cells, which are often limited to groundwater less than 3,000 mg/l total dissolved solids. Because the GCDs in GMA 2 are actively managing groundwater with total dissolved solids greater than 3,000 mg/l, GMA 2 decided to express the average drawdown desired future conditions based on the active model cell average, not the official aquifer boundary average. Thus, modeled available groundwater values should also include active model area pumping totals, not the official aquifer boundary totals. For Estimated Modeled Available Groundwater for the Sandy Land UWCD, refer to the GMA MAG Report table from TWDB GAM Run 21-008 MAG Addendum Report, Appendix C.

Estimated Historical Annual Groundwater Usage

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 Report, Appendix B, estimated Historical Water Use and 2022 State Water Plan Datasets.

Estimates of Annual Groundwater Recharge from Precipitation

Refer to Report, Appendix A, GAM 23-024

Estimates of Annual Groundwater Discharge to Springs/Surface Water Bodies

Refer to Report, Appendix A, GAM 23-024

Estimates of Annual Groundwater Flow Into/Out of the District for the Ogallala; Estimates of Annual Groundwater Flow between Aquifers in the District

Refer to Report, Appendix A, GAM 23-024

Estimates of Projected Surface Water Supplies

Refer to Report, Appendix A, GAM 23-024

Estimates of Projected Total Demand for Water in the District

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 Report, Appendix B, estimated Historical Water Use and 2022 State Water Plan Datasets.

Consideration of Water Supply Needs and Water Management Strategies

It is required that the District Management Plan consider the water supply needs and water management strategies included in the 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. For needs refer to Report, Appendix B, Estimated Historical Water Use and 2022 State Water Plan Datasets.

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. For strategies refer to Report, Appendix B, Estimated Historical Water Use and 2022 State Water Plan Datasets.

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: https://www.sandylandwater.com/resources/

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

As noted in *Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping* – TWDB Contract Number 1648302062, by LRE Water, (https://www.twdb.texas.gov/groundwater/models/research/subsidence/Final_Subsidence_Vulnerability_Report_final.pdf) results of the subsidence vulnerability study on the Ogallala Aquifer suggest that the northern part of the Ogallala has the greatest risk for future subsidence due to pumping. Data from wells in the central and southern portions of the aquifer, the location of the District is at lower risk with a medium subsidence risk.

The District measures water levels, collects water quality samples and collects rainfall data countywide, year round. Limited subsidence has been observed. The District will continue to observe well conditions during routine operations but declares that this goal is not applicable.

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

Management Objective

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

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

Performance Standard

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

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. To review current state of drought, please refer to the US Drought Monitor: https://waterdatafortexas.org/drought/drought-monitor?period=2024-08-20&areaType=state&areaName=tx

Management Objective

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

Performance Standard

(a1) Maintain a network of rain gauges 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.

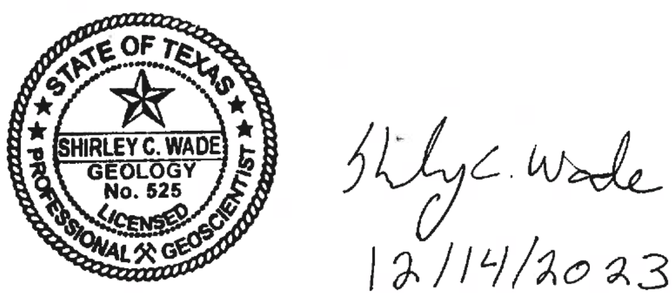
Sandy Land UWCD

Groundwater Management Plan

Appendix A:
GAM Run Report

GAM RUN 23-024: SANDY LAND UNDERGROUND WATER CONSERVATION DISTRICT MANAGEMENT PLAN

Saheli Majumdar, Ph.D. and Shirley Wade, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512-936-6079
December 14, 2023



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GAM RUN 23-024: SANDY LAND UNDERGROUND WATER CONSERVATION DISTRICT MANAGEMENT PLAN

Saheli Majumdar, Ph.D. and Shirley Wade, Ph.D., P.G.
Texas Water Development Board
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Groundwater Modeling Department
512-936-6079
December 14, 2023

EXECUTIVE SUMMARY:

Texas Water Code § 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, which includes:

1. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;
2. the annual volume of water that discharges from the aquifer to springs and any surface-water bodies, including lakes, streams, and rivers for each aquifer within the district; 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 February 15, 2024, and submitted to the executive administrator of the TWDB on or before March 16, 2024. The current management plan for the Sandy Land Underground Water Conservation District expires on May 15, 2024.

The management plan information for the aquifers within Sandy Land Underground Water Conservation District was extracted from the groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015).

This report replaces the results of GAM Run 18-014 (Boghici, 2019). Values may differ from the previous report as a result of routine updates to the spatial grid file used to define county, groundwater conservation district, and aquifer boundaries, which can impact the calculated water budget values. Additionally, the approach used for analyzing model results is reviewed during each update and may have been refined to delineate groundwater flows better. Tables 1 and 2 summarize the groundwater availability model data required by statute. Figures 1 and 3 show the area of the model from which the values in Tables 1 and 2 were extracted. Figures 2 and 4 provide a generalized diagram of the groundwater flow components provided in Tables 1 and 2. If the Sandy Land Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions after reviewing the figures, please notify the TWDB Groundwater Modeling Department at your earliest convenience.

The flow components presented in this report do not represent the full groundwater budget. If additional inflow and outflow information would be helpful for planning purposes, the district may submit a request in writing to the TWDB Groundwater Modeling Department for the full groundwater budget.

METHODS:

In accordance with the provisions of the Texas Water Code § 36.1071(h), the groundwater availability model mentioned above was used to estimate information for the Sandy Land Underground Water Conservation District management plan. The water budget for the High Plains Aquifer System groundwater availability model was extracted using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net cross-formation flow between aquifers, and net flow between aquifer and its equivalent portion located within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Groundwater availability model for the High Plains Aquifer System

- We used version 1.01 of the groundwater availability model for the High Plains Aquifer System to analyze the Ogallala and Edwards-Trinity (High Plains) aquifers. See Deeds and Jigmond (2015) for assumptions and limitations of the groundwater availability model.
- The groundwater availability model for the High Plains Aquifer System contains the following four layers:
    - Layer 1 represents the Ogallala and Pecos Valley aquifers
    - Layer 2 represents the Rita Blanca, Edwards-Trinity (High Plains), and Edwards-Trinity (Plateau) aquifers
    - Layer 3 represents the upper portion of the Dockum Aquifer and equivalent units
    - Layer 4 represents the lower portion of the Dockum Aquifer and equivalent units
- The model was run with MODFLOW-NWT (Niswonger and others, 2011).
- Water budgets for the district were determined for the Ogallala Aquifer (Layer 1) and the Edwards-Trinity [High Plains] (Layer 2).
- Water budget terms were averaged for the period 1980-2012.

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the aquifers located within the Sandy Land Underground Water Conservation District and averaged over the historical calibration period, as shown in Tables 1 and 2.

- Precipitation recharge—the areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.
- Surface-water outflow—the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.
- Flow into and out of the district—the lateral flow within the aquifer between the district and adjacent counties.
- 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 and 2. Figures 1 and 3 show the area of the model from which the values in Tables 1 and 2 were extracted. Figures 2 and 4 provide a generalized diagram of the groundwater flow components provided in Tables 1 and 2. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

Table 1: Summarized information for the Ogallala Aquifer that is needed for the 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	Results
Estimated annual amount of recharge from precipitation to the district	Ogallala Aquifer	19,654
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	1,208
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	1,887
Estimated net annual volume of flow between each aquifer in the district	From Ogallala Aquifer to Edwards-Trinity (High Plains) Aquifer	1,561
	To Ogallala Aquifer from equivalent units in New Mexico	1,069

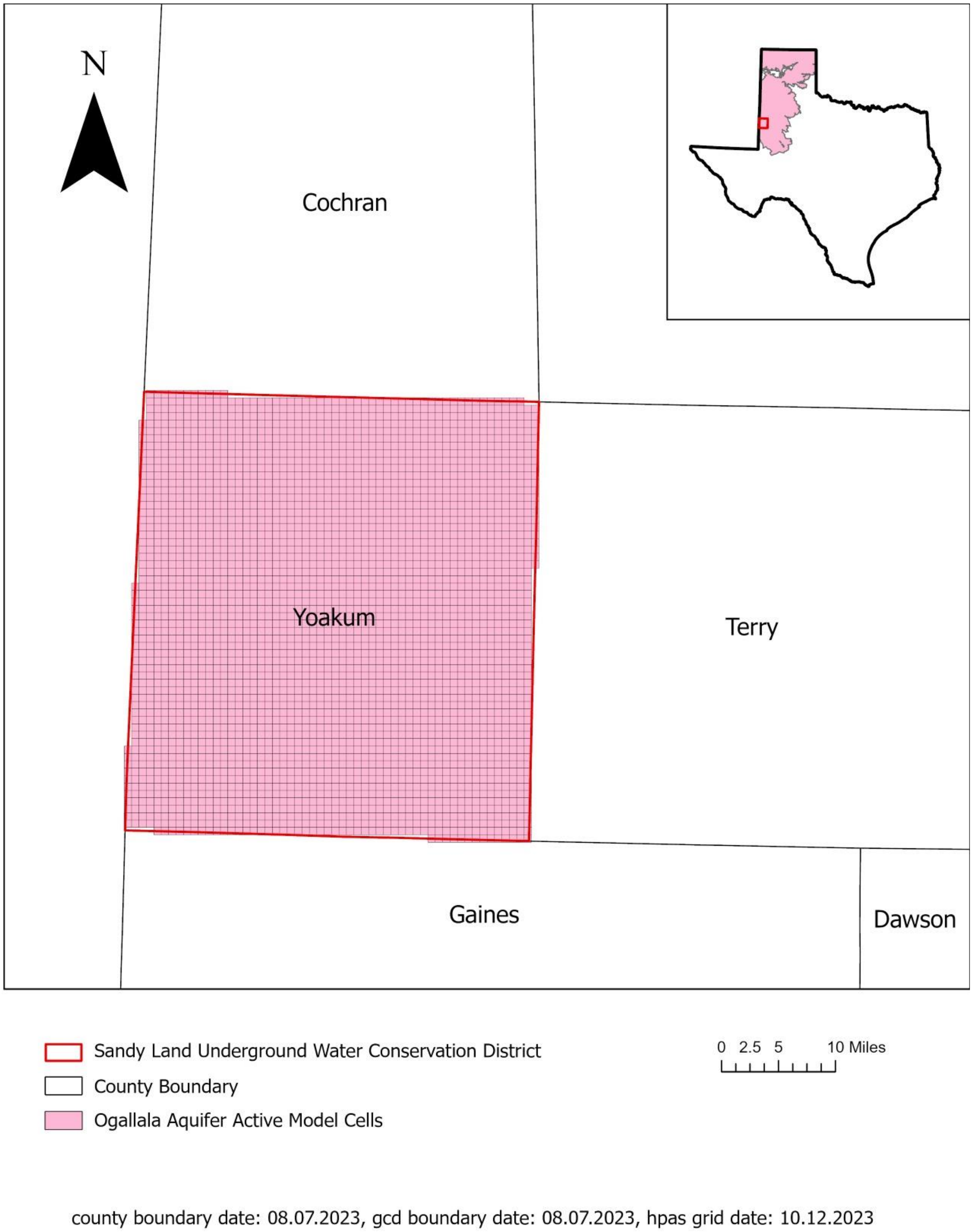


Figure 1: Area of the High Plains Aquifer System groundwater availability model from which the information in Table 1 was extracted (the Ogallala Aquifer extent within the district boundary).

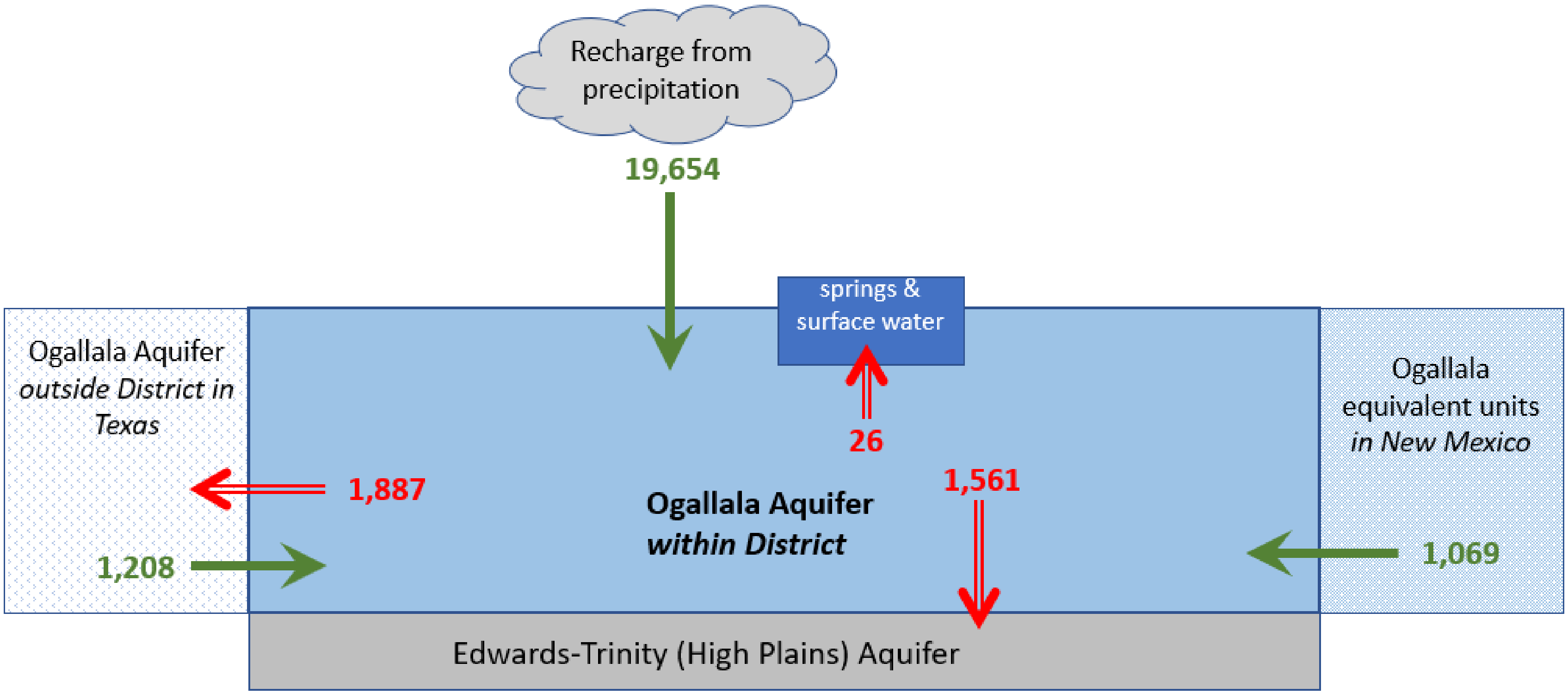


Figure 2: Generalized Diagram of the summarized budget information from Table 1, representing directions of flow for the Ogallala Aquifer within Sandy Land Underground Water Conservation District. Flow values expressed in acre-feet per year.

Table 2: Summarized information for the Edwards-Trinity (High Plains) Aquifer that is needed for the 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	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	1,452
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (High Plains) Aquifer	7,079
Estimated net annual volume of flow between each aquifer in the district	To Edwards-Trinity (High Plains) Aquifer from Ogallala Aquifer	1,561
	To Edwards-Trinity (High Plains) Aquifer from Dockum equivalent units	350
	To Edwards-Trinity (High Plains) Aquifer from equivalent units in New Mexico	2,693

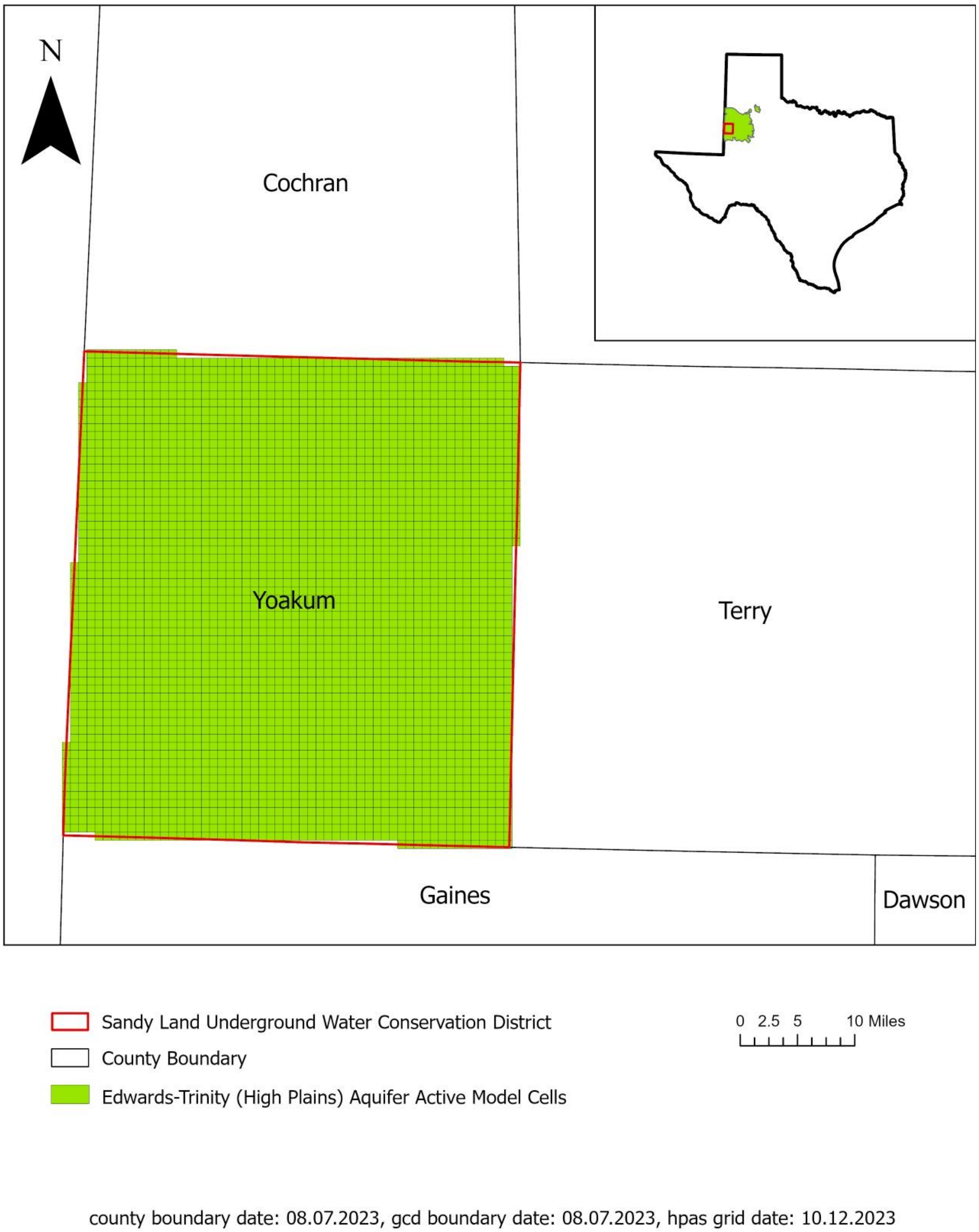


Figure 3: Area of the groundwater availability model for the High Plains Aquifer System from which the information in Table 2 was extracted (the Edwards-Trinity [High Plains] Aquifer extent within the district boundary).

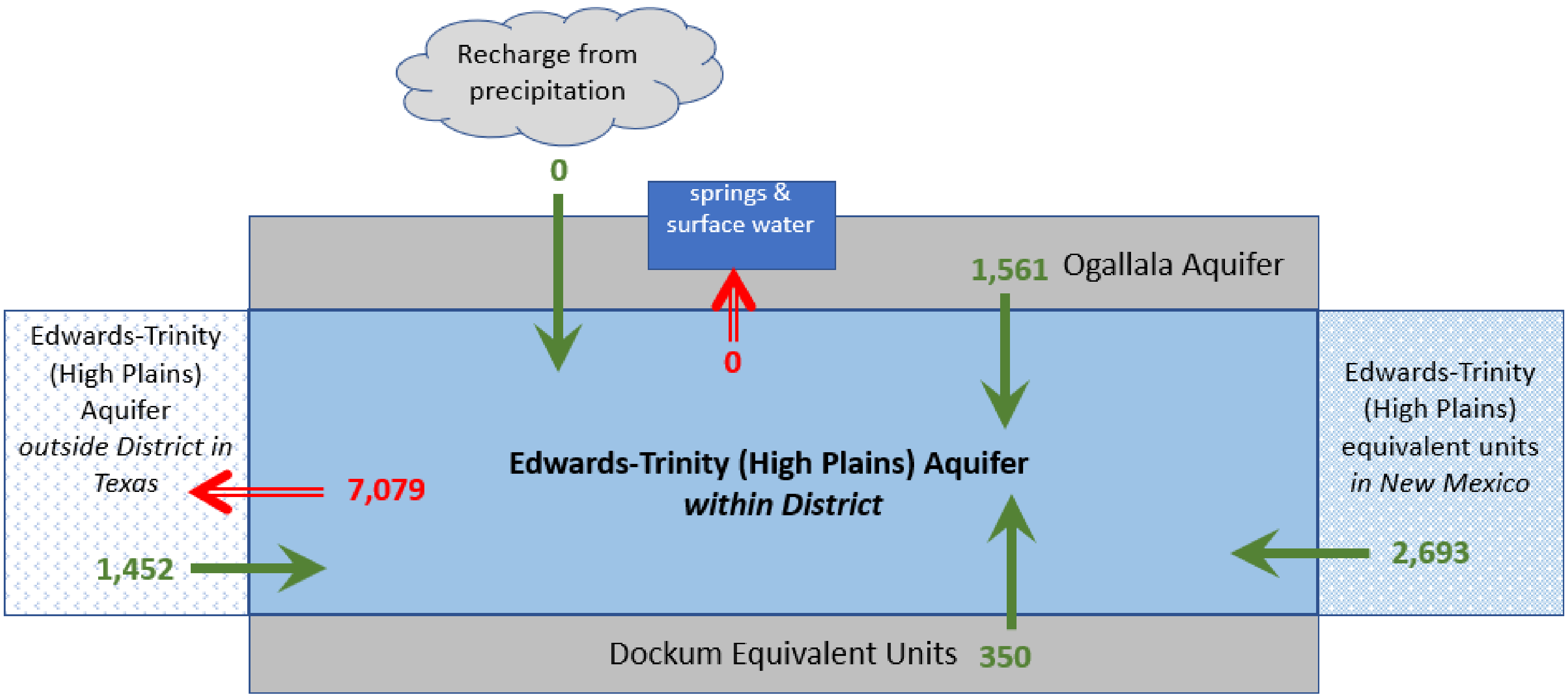


Figure 4: Generalized Diagram of the summarized budget information from Table 2, representing directions of flow for the Edwards-Trinity (High Plains) Aquifer within Sandy Land Underground Water Conservation District. Flow values expressed in acre-feet per year.

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 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 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:

Boghici, R., 2019, GAM Run 18-014: Sandy Land Underground Water Conservation District Groundwater Management Plan, 11 p., www.twdb.texas.gov/groundwater/docs/GAMruns/GR18-014.pdf

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

Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models, U.S. Geological Survey Groundwater Software. https://water.usgs.gov/water-resources/software/ZONEBUDGET/zonbud3.pdf

National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p. https://nap.nationalacademies.org/catalog/11972/models-in-environmental-regulatory-decision-making

Niswonger, R. G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, A Newton formulation for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6-A37, 44 p., https://doi.org/10.3133/tm6A37

Texas Water Code § 36.1071

Sandy Land UWCD

Groundwater Management Plan

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

Estimated Historical Groundwater Use And 2022 State Water Plan Datasets:

Sandy Land Underground Water Conservation District

Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
August 7, 2024

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 2022 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 Modeling Department. Questions about the GAM can be directed to Grayson Dowlearn, Grayson.dowlearn@twdb.texas.gov, (512) 475-1552.

DISCLAIMER:

The data presented in this report represents the most up to date WUS and 2022 SWP data available as of 08/07/2024. 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 2022 SWP. District personnel must review these datasets and correct any discrepancies 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 2022 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 districts to identify these entities).

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 2020. TWDB staff anticipates the calculation and posting of these estimates at a later date.

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

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2019	GW	1,512	0	309	1,596	126,241	158	129,816
	SW	0	0	0	0	0	8	8
2018	GW	1,566	0	328	1,592	114,075	158	117,719
	SW	0	0	0	0	0	8	8
2017	GW	1,513	0	275	1,110	129,484	151	132,533
	SW	0	0	0	0	0	8	8
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	20	0	173,237	154	175,233
	SW	0	0	0	0	0	8	8
2011	GW	2,003	0	9	0	157,147	168	159,327
	SW	0	0	0	0	0	9	9
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

Projected Surface Water Supplies
TWDB 2022 State Water Plan Data

Projected Water Demands
TWDB 2022 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

100% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
O	County-Other, Yoakum	Colorado	263	287	310	336	368	398
O	Denver City	Colorado	1,423	1,579	1,720	1,888	2,066	2,236
O	Irrigation, Yoakum	Colorado	161,693	161,693	138,141	127,049	121,210	117,681
O	Livestock, Yoakum	Colorado	91	96	101	106	111	113
O	Mining, Yoakum	Colorado	1,300	1,334	1,147	957	783	641
O	Plains	Colorado	438	486	529	578	632	685
O	Steam-Electric Power, Yoakum	Colorado	1,910	1,910	1,910	1,910	1,910	1,910
		Sum of Projected Water Demands (acre-feet)	**167,118**	**167,385**	**143,858**	**132,824**	**127,080**	**123,664**

Projected Water Supply Needs
TWDB 2022 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	136	112	89	63	31	1
O	Denver City	Colorado	3,890	3,734	3,593	3,425	3,247	3,077
O	Irrigation, Yoakum	Colorado	-33,198	-79,186	-79,186	-79,186	-79,186	-79,186
O	Livestock, Yoakum	Colorado	100	95	90	85	80	78
O	Mining, Yoakum	Colorado	-536	-570	-383	-193	-19	123
O	Plains	Colorado	700	652	609	560	506	453
O	Steam-Electric Power, Yoakum	Colorado	90	90	90	90	90	90
	Sum of Projected Water Supply Needs (acre-feet)		**-33,734**	**-79,756**	**-79,569**	**-79,379**	**-79,205**	**-79,186**

Projected Water Management Strategies
TWDB 2022 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 Municipal Water Conservation	DEMAND REDUCTION [Yoakum]	62	47	39	49	62	77
		62	**47**	**39**	**49**	**62**	**77**
Irrigation, Yoakum, Colorado (O)							
Yoakum County Irrigation Water Conservation	DEMAND REDUCTION [Yoakum]	4,851	8,085	9,670	8,893	8,485	8,238
		4,851	**8,085**	**9,670**	**8,893**	**8,485**	**8,238**
Mining, Yoakum, Colorado (O)							
Yoakum County - Mining Additional Groundwater Development	Ogallala and Edwards-Trinity-High Plains Aquifers [Yoakum]	640	640	640	640	640	640
Yoakum County - Mining Water Conservation	DEMAND REDUCTION [Yoakum]	13	40	57	48	39	32
		653	**680**	**697**	**688**	**679**	**672**
Plains, Colorado (O)							
Yoakum County - Plains Municipal Water Conservation	DEMAND REDUCTION [Yoakum]	18	13	10	10	13	18
		18	**13**	**10**	**10**	**13**	**18**
Sum of Projected Water Management Strategies (acre-feet)		**5,584**	**8,825**	**10,416**	**9,640**	**9,239**	**9,005**

Sandy Land UWCD

Groundwater Management Plan

Appendix C:
GMA2 GAM Run MAG

GAM RUN 21-008 ADDENDUM: MODELED AVAILABLE GROUNDWATER FOR THE HIGH PLAINS AQUIFER SYSTEM (OGALLALA, EDWARDS-TRINITY (HIGH PLAINS), AND DOCKUM AQUIFERS) IN GROUNDWATER MANAGEMENT AREA 2

Grayson Dowlearn, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Modeling Department
512 475-1552
June 3, 2022

ADDENDUM SUMMARY:

Modeled available groundwater for the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers in Groundwater Management Area 2 was provided on May 2, 2022 in GAM Run 22-008 (Bond and Dowlearn, 2022). However, after the report was released, errors were identified in Tables 1 and 2. The identified errors are listed below:

1) Tables 1 and 2 were missing a column with the modeled available groundwater for the year 2020, and

2) Table 2 incorrectly included Gaines County and its modeled available groundwater values within the High Plains UWCD No. 1 modeled available groundwater totals.

The errors were addressed with the following corrections:

1) A column with modeled available groundwater values for the year 2020 was added to Tables 1 and 2,

2) Gaines County was removed from the High Plains UWCD No. 1 and the modeled available groundwater values were subtracted from the total for the High Plains UWCD No. 1, and

3) Llano Estacado UWCD, which coincides with Gaines County, was added as a separate groundwater conservation district to Table 2.

This addendum contains the corrected Tables 1 and 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 2080. VALUES ARE IN ACRE-FEET PER YEAR. (UWCD = UNDERGROUND WATER CONSERVATION DISTRICT)

Groundwater Conservation District	County	2020	2030	2040	2050	2060	2070	2080
Garza County UWCD Total	**Garza**	**15,519**	**13,508**	**12,402**	**11,717**	**11,263**	**10,948**	**10,721**
High Plains UWCD No.1	Bailey	88,271	65,138	50,725	42,532	37,743	34,724	32,675
	Castro	228,996	176,186	116,578	68,325	42,856	30,477	23,914
	Cochran	87,584	73,991	62,095	54,265	48,561	43,632	40,036
	Crosby	145,637	105,559	73,026	51,628	39,354	32,169	27,680
	Deaf Smith	162,070	117,359	80,488	56,872	43,574	35,948	31,405
	Floyd	157,164	93,953	65,087	52,305	44,155	39,232	35,987
	Hale	217,265	116,615	75,108	53,298	41,142	34,308	30,298
	Hockley	141,111	96,747	73,687	62,502	56,622	53,198	51,064
	Lamb	204,808	120,172	77,677	60,088	52,063	47,868	45,425
	Lubbock	135,045	110,472	100,950	95,478	91,655	88,877	86,735
	Lynn	99,629	88,768	82,064	77,033	73,324	70,707	68,886
	Parmer	144,423	92,025	63,568	46,835	37,743	32,290	28,757
	Swisher	119,920	73,407	48,754	35,887	28,541	23,972	20,935
High Plains UWCD No.1 Total		**1,931,923**	**1,330,392**	**969,807**	**757,048**	**637,333**	**567,402**	**523,797**
Llano Estacado UWCD Total	**Gaines**	**254,329**	**205,486**	**177,777**	**159,523**	**147,028**	**138,157**	**131,974**
Mesa UWCD Total	**Dawson**	**156,735**	**121,336**	**98,590**	**84,192**	**75,448**	**70,262**	**66,945**

TABLE 1 (CONTINUED): 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 2080. VALUES ARE IN ACRE-FEET PER YEAR. (UWCD = UNDERGROUND WATER CONSERVATION DISTRICT)

Groundwater Conservation District	County	2020	2030	2040	2050	2060	2070	2080
No District County	Andrews	22,379	19,391	17,897	16,937	16,260	15,764	15,378
	Borden	5,448	4,432	3,893	3,591	3,393	3,227	3,072
	Briscoe	26,813	17,859	12,598	9,600	7,844	6,743	6,016
	Castro	4,726	3,742	2,496	1,874	1,475	1,214	1,039
	Crosby	2,529	2,506	2,276	1,897	1,685	1,562	1,479
	Deaf Smith	20,853	18,024	15,387	13,553	12,267	11,301	10,556
	Floyd	0	0	0	0	0	0	0
	Hockley	15,302	12,402	7,093	3,411	2,028	1,419	1,102
	Howard	483	471	474	483	494	504	513
No District County Total		**98,533**	**78,827**	**62,114**	**51,346**	**45,446**	**41,734**	**39,155**
Permian Basin UWCD	Howard	16,677	15,160	14,344	13,882	13,596	13,411	13,287
	Martin	55,313	48,293	43,032	39,019	36,358	34,521	33,171
Permian Basin UWCD Total		**71,990**	**63,453**	**57,376**	**52,901**	**49,954**	**47,932**	**46,458**
Sandy Land UWCD Total	**Yoakum**	**128,498**	**90,983**	**70,810**	**59,346**	**53,002**	**49,187**	**46,687**
South Plains UWCD	Hockley	4,157	2,638	1,005	493	331	265	234
	Terry	180,555	134,878	108,182	96,190	89,977	86,343	84,043
South Plains UWCD Total		**184,712**	**137,516**	**109,187**	**96,683**	**90,308**	**86,608**	**84,277**
Groundwater Management Area 2 Total		**2,842,239**	**2,041,501**	**1,558,063**	**1,272,756**	**1,109,782**	**1,012,230**	**950,014**

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 2080. VALUES ARE IN ACRE-FEET PER YEAR. (UWCD = UNDERGROUND WATER CONSERVATION DISTRICT)

Groundwater Conservation District	County	2020	2030	2040	2050	2060	2070	2080
Garza County UWCD Total	**Garza**	**1,038**	**1,038**	**1,038**	**1,038**	**1,038**	**1,038**	**1,038**
High Plains UWCD No.1	Bailey	949	949	949	949	949	949	949
	Castro	484	484	484	484	484	484	484
	Cochran	1,106	1,106	1,106	1,106	1,106	1,106	1,106
	Crosby	4,312	4,312	4,312	4,312	4,312	4,312	4,312
	Deaf Smith	5,006	5,006	5,006	5,006	5,006	5,006	5,006
	Floyd	3,674	3,674	3,674	3,674	3,674	3,674	3,674
	Hale	1,277	1,277	1,277	1,277	1,277	1,277	1,277
	Hockley	1,109	1,109	1,109	1,109	1,109	1,109	1,109
	Lamb	1,051	1,051	1,051	1,051	1,051	1,051	1,051
	Lubbock	1,236	1,236	1,236	1,236	1,236	1,236	1,236
	Lynn	1,039	1,039	1,039	1,039	1,039	1,039	1,039
	Parmer	6,207	6,207	6,207	6,207	5,202	5,188	5,182
	Swisher	1,796	1,796	1,796	1,796	1,796	1,796	1,796
High Plains UWCD No.1 Total		**29,246**	**29,246**	**29,246**	**29,246**	**28,241**	**28,227**	**28,221**
Llano Estacado UWCD	**Gaines**	**880**	**880**	**880**	**880**	**880**	**880**	**880**
Mesa UWCD Total	**Dawson**	**640**	**640**	**640**	**640**	**640**	**640**	**640**

TABLE 2 (CONTINUED): 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 2080. VALUES ARE IN ACRE-FEET PER YEAR. (UWCD = UNDERGROUND WATER CONSERVATION DISTRICT)

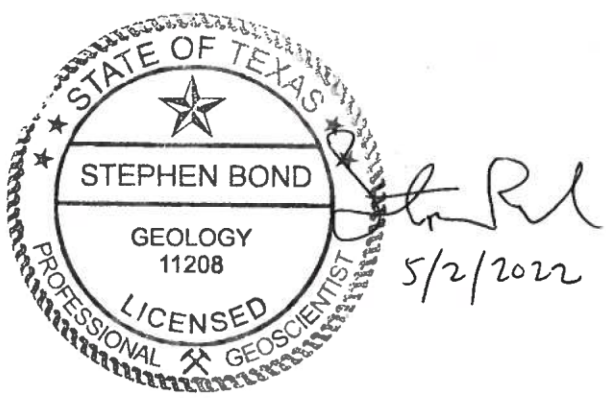
Groundwater Conservation District	County	2020	2030	2040	2050	2060	2070	2080
No District County	Andrews	1,503	1,503	1,503	1,503	1,503	1,503	1,503
	Borden	1,026	1,026	1,026	1,026	1,026	1,026	1,026
	Briscoe	0	0	0	0	0	0	0
	Castro	0	0	0	0	0	0	0
	Crosby	81	81	81	81	81	81	81
	Deaf Smith	7	7	7	7	7	7	7
	Floyd	0	0	0	0	0	0	0
	Hockley	95	95	95	95	95	95	95
	Howard	134	134	134	134	134	134	134
No District County Total		**2,846**	**2,846**	**2,846**	**2,846**	**2,846**	**2,846**	**2,846**
Permian Basin UWCD	Howard	6,636	6,636	6,636	6,636	6,636	6,636	6,636
	Martin	11,449	11,449	11,449	11,449	11,449	11,449	11,449
Permian Basin UWCD Total		**18,085**	**18,085**	**18,085**	**18,085**	**18,085**	**18,085**	**18,085**
Sandy Land UWCD Total	**Yoakum**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
South Plains UWCD	Hockley	0	0	0	0	0	0	0
	Terry	0	0	0	0	0	0	0
South Plains UWCD Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**
Groundwater Management Area 2 Total		**52,735**	**52,735**	**52,735**	**52,735**	**51,730**	**51,716**	**51,710**

REFERENCES:

Bond, S. and Dowlearn, R. G., 2022, GAM Run 22-008: Modeled Available Groundwater for the High Plains Aquifer System (Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers) in Groundwater Management Area 2, GAM Run Report, 23 p. http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR21-008_MAG.pdf

GAM Run 21-008 MAG: Modeled Available Groundwater for the High Plains Aquifer System (Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers) in Groundwater Management Area 2

Stephen Bond, P.G. and Grayson Dowlearn
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 475-1552
May 2, 2022



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GAM RUN 21-008 MAG: MODELED AVAILABLE GROUNDWATER FOR THE HIGH PLAINS AQUIFER SYSTEM (OGALLALA, EDWARDS-TRINITY (HIGH PLAINS), AND DOCKUM AQUIFERS) IN GROUNDWATER MANAGEMENT AREA 2

Stephen Bond, P.G. and Grayson Dowlearn
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 475-1552
May 2, 2022

EXECUTIVE SUMMARY:

Modeled available groundwater for the Ogallala and Edwards-Trinity (High Plains) aquifers in Groundwater Management Area 2 decreases from 2,041,501 acre-feet per year in 2030 to 950,014 acre-feet per year in 2080. Modeled available groundwater for the Dockum Aquifer decreases from 52,735 acre-feet per year in 2030 to 51,710 acre-feet per year in 2080. 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 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 August 17, 2021. 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 February 25, 2022.

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 an email dated August 26, 2021, Dr. William Hutchison, on behalf of Groundwater Management Area (GMA) 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 several predictive groundwater flow simulations (Hutchison, 2021a). The predictive simulations were developed from the groundwater availability model for the High Plains Aquifer System (Version 1.01; Deeds and Jigmond, 2015) from 2013 through 2080 under different pumping scenarios, with an initial water level equal to that of the model's last stress period (i.e., year 2012). The drawdown was calculated as the water level difference between 2012 and 2080.

The desired future conditions for the High Plains Aquifer System, as described in Resolution No. 21-01, were adopted on August 17, 2021 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

- An average drawdown of 28 feet for all of GMA 2 between the years 2013 and 2080.

Dockum Aquifer

- An average drawdown of 31 feet for all of GMA 2 between the years 2013 and 2080.

After review of the submittal, TWDB sent an email on November 16, 2021 to Mr. Jason Coleman, Coordinator of Groundwater Management Area 2, to clarify if Groundwater Management Area 2 accepted the tolerance of three (3) feet and assumptions used to calculate average drawdown. On November 19, 2021 TWDB received the final clarification email from Mr. Jason Coleman confirming the three (3) feet of tolerance and drawdown calculation assumptions, specified in the Methods and Parameters and Assumptions sections below, can be used. TWDB then proceeded with 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 19 (Hutchison, 2021a). TWDB reviewed the submitted model files and attempted to replicate the adopted desired future conditions using these files. Since groundwater conservation districts in GMA 2 manage groundwater with total dissolved solids concentrations above 3,000 mg/L (Hutchison, 2021b), active model cells, rather than official aquifer boundaries, were used for the basis of the average drawdown calculations. Cell-by-cell drawdowns were calculated based on the difference between modeled head values at the end of 2012 and model heads extracted for the year 2080. Average heads were calculated by summing cell-by-cell heads and dividing by the total number of cells in each aquifer or set of aquifers considered.

Average drawdown results matched the adopted desired future conditions precisely if all active cells were included in the calculations. Excluding cells that went dry during the model run, or cells that were part of the Pecos Alluvium or Edwards-Trinity (Plateau) aquifers changed the results by less than half a foot. Excluding pass-through cells, modeled cells which are not representative of a rock unit but hydraulically connect two model layers when one or more layers between the two is no longer present (for example, the Lower Dockum is connected to the Ogallala Aquifer through two layers of pass-through cells where the Upper Dockum and Edwards-Trinity (High Plains) aquifers are absent) reduced average drawdown for the Ogallala and Edwards-Trinity (High Plains) aquifers from 28 feet to 25 feet.

Modeled available groundwater values were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Annual pumping rates were then divided by county, river basin, regional water planning area, and groundwater conservation district within Groundwater Management Area 2 (Figure 5 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 to manage groundwater production to achieve the desired future condition(s). The districts must also consider 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 (2021b) 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). The Pecos Valley Alluvium and Edwards-Trinity (Plateau) aquifers were declared not relevant for the purpose of joint planning and were excluded from the modeled available groundwater calculation. Model layers are shown in Figures 1 through 4.

- Where the Upper Dockum and Edwards-Trinity (High Plains) aquifers are absent in layers 3 and 2, respectively, pass-through cells hydraulically connect the Ogallala Aquifer to the Upper or Lower Dockum, or connect the Edwards-Trinity (High Plains) Aquifer to the Lower Dockum. These pass-through cells contain no pumping and were excluded from the drawdown 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, some model cells within Groundwater Management Area 2 went dry in each model layer by the end of the simulation in the year 2080.

- Drawdown averages and modeled available groundwater volumes were calculated based on the extent of the model area. The most recent available model grid file (dated January 6,2020) was used to determine which model cells were assigned to specific county, groundwater management area, groundwater conservation district, river basin, or regional water planning area.

- A tolerance of three feet was assumed when comparing desired future conditions to modeled drawdown results.

- 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 nearest 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 2,041,501 to 950,014 acre-feet per year between 2030 and 2080. 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 from 52,735 to 51,710 acre-feet per year between 2030 and 2080. 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.

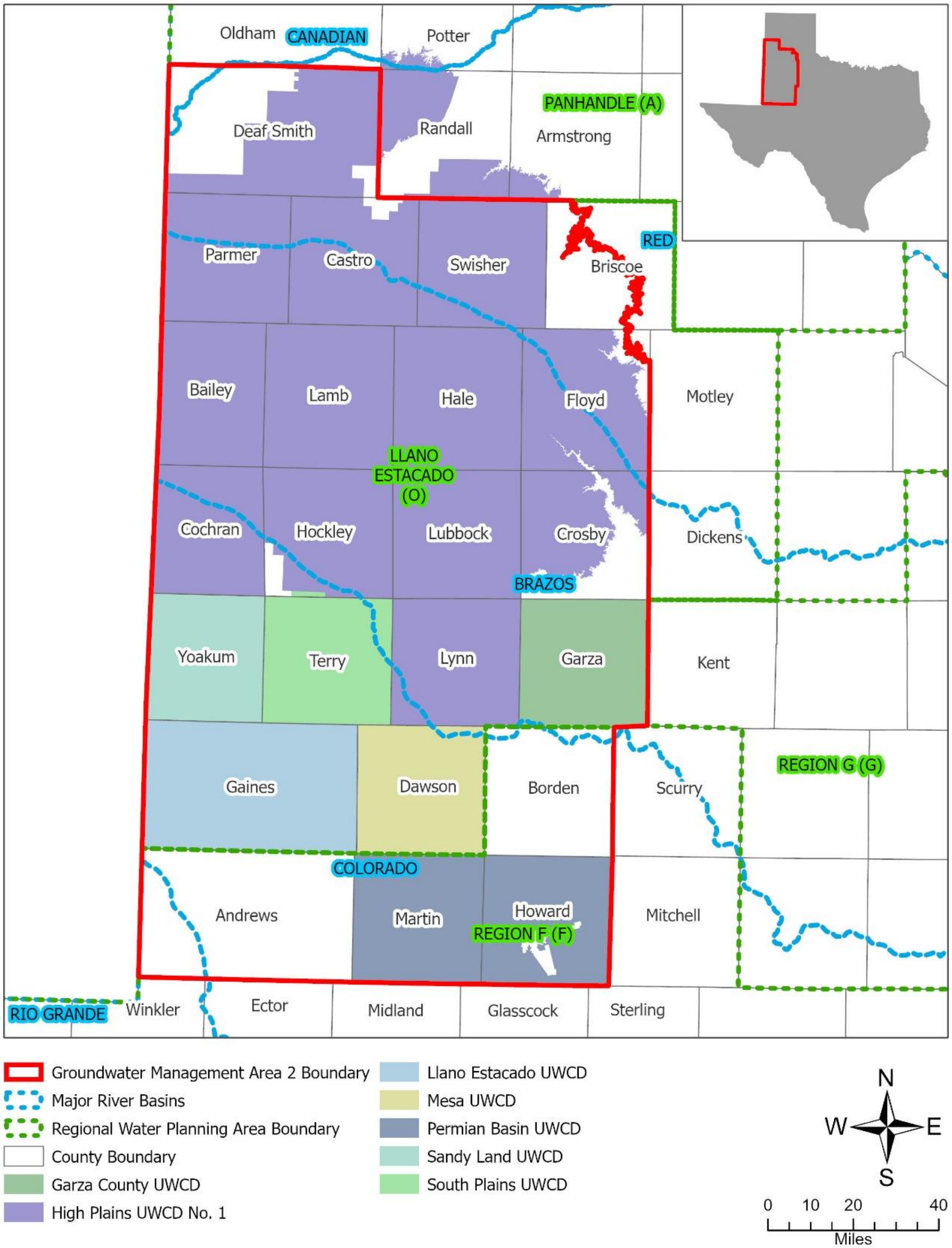

FIGURE 1. MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS (ALSO KNOWN AS UNDERGROUND WATER CONSERVATION DISTRICT OR UWCD), COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 2

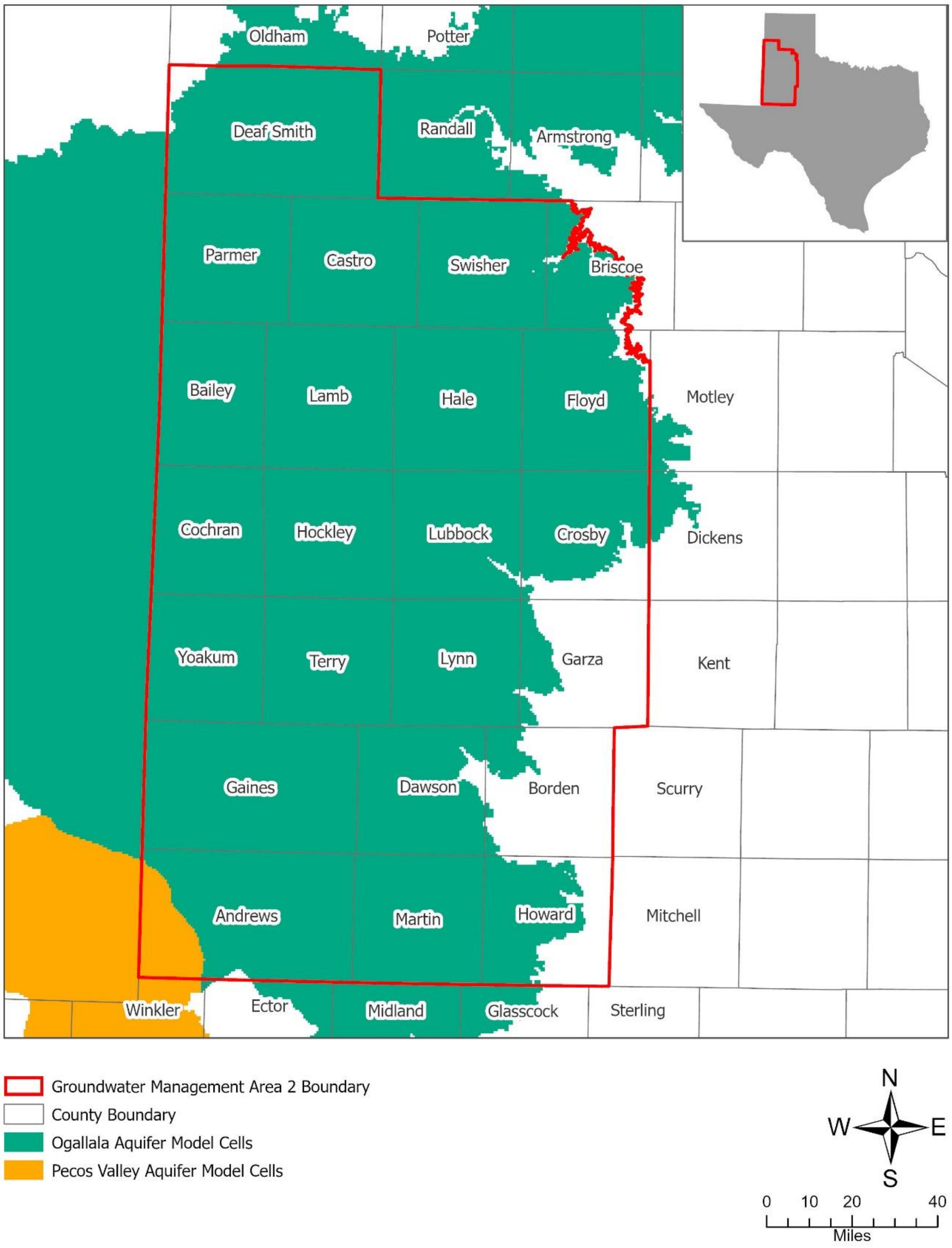

FIGURE 2. MAP SHOWING THE ACTIVE MODEL CELLS REPRESENTING THE OGALLALA AQUIFER AND THE PECOS VALLEY AQUIFER IN LAYER 1 OF THE HIGH PLAINS AQUIFER SYSTEM GROUNDWATER AVAILABILITY MODEL

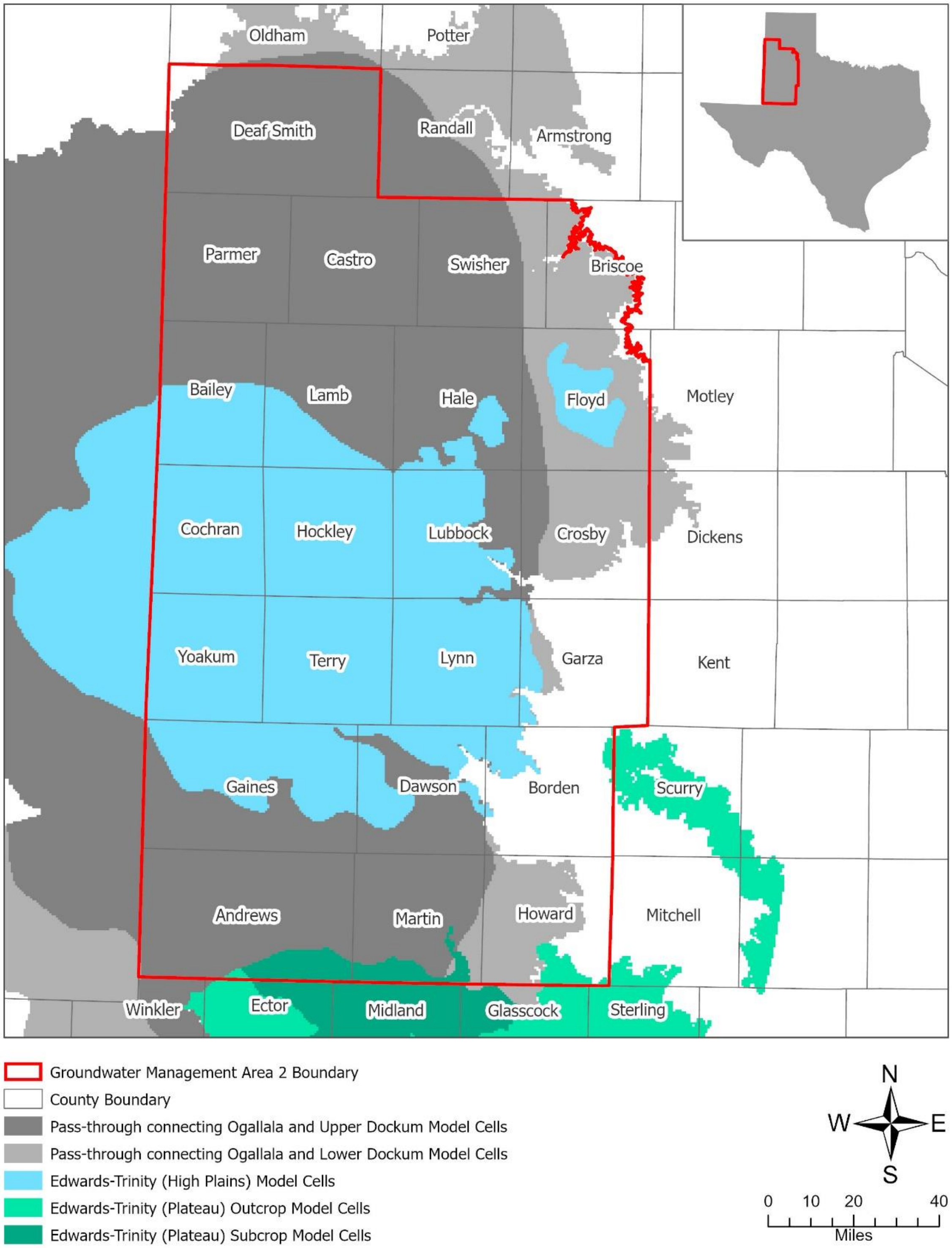

FIGURE 3. MAP SHOWING THE ACTIVE MODEL CELLS REPRESENTING THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER, THE EDWARDS-TRINITY (PLATEAU) AQUIFER, AND PASS-THROUGH CELLS IN LAYER 2 OF THE HIGH PLAINS AQUIFER SYSTEM GROUNDWATER AVAILABILITY MODEL

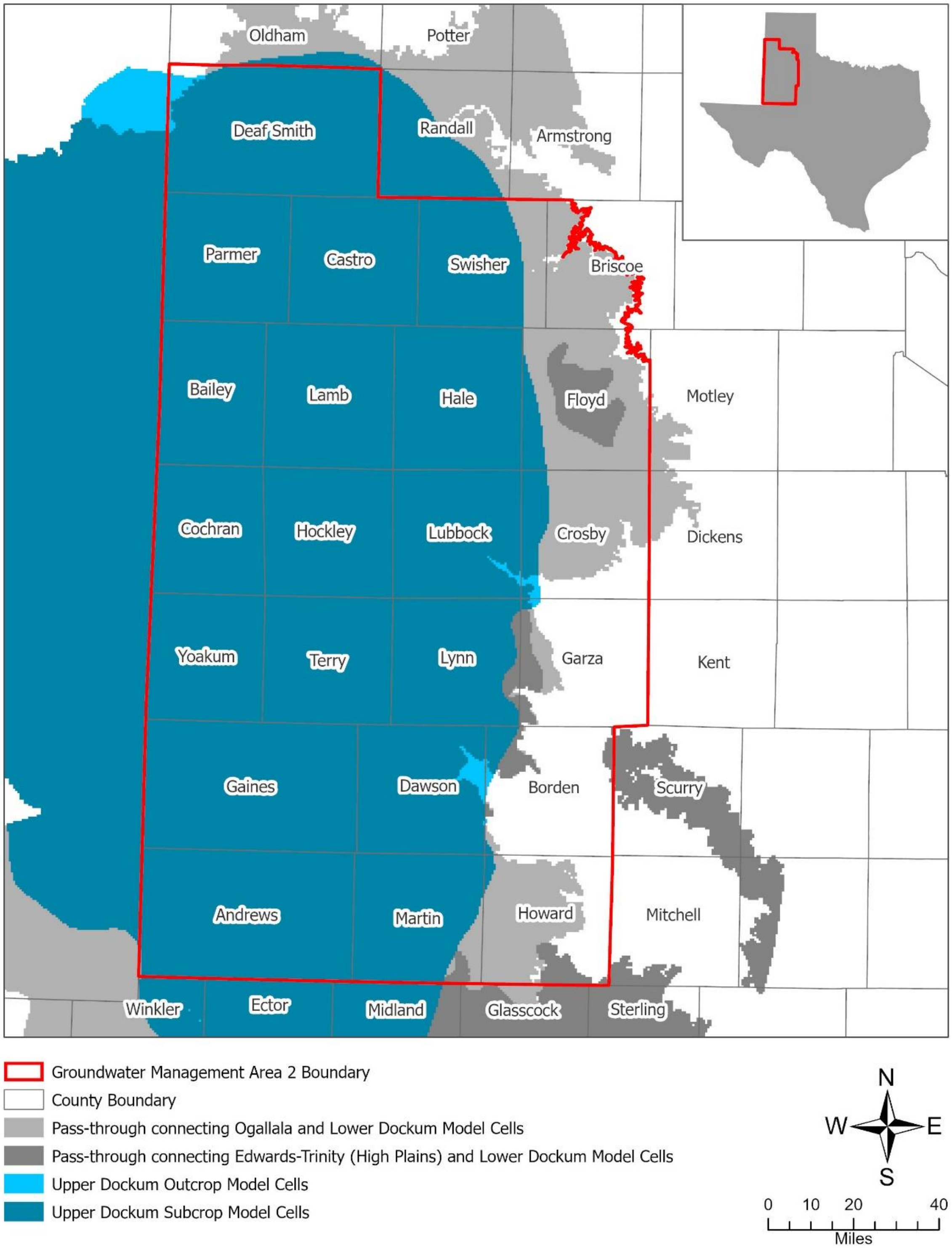

FIGURE 4. MAP SHOWING THE ACTIVE MODEL CELLS REPRESENTING THE UPPER PORTION OF THE DOCKUM AQUIFER AND PASS-THROUGH CELLS IN LAYER 3 OF THE HIGH PLAINS AQUIFER SYSTEM GROUNDWATER AVAILABILITY MODEL

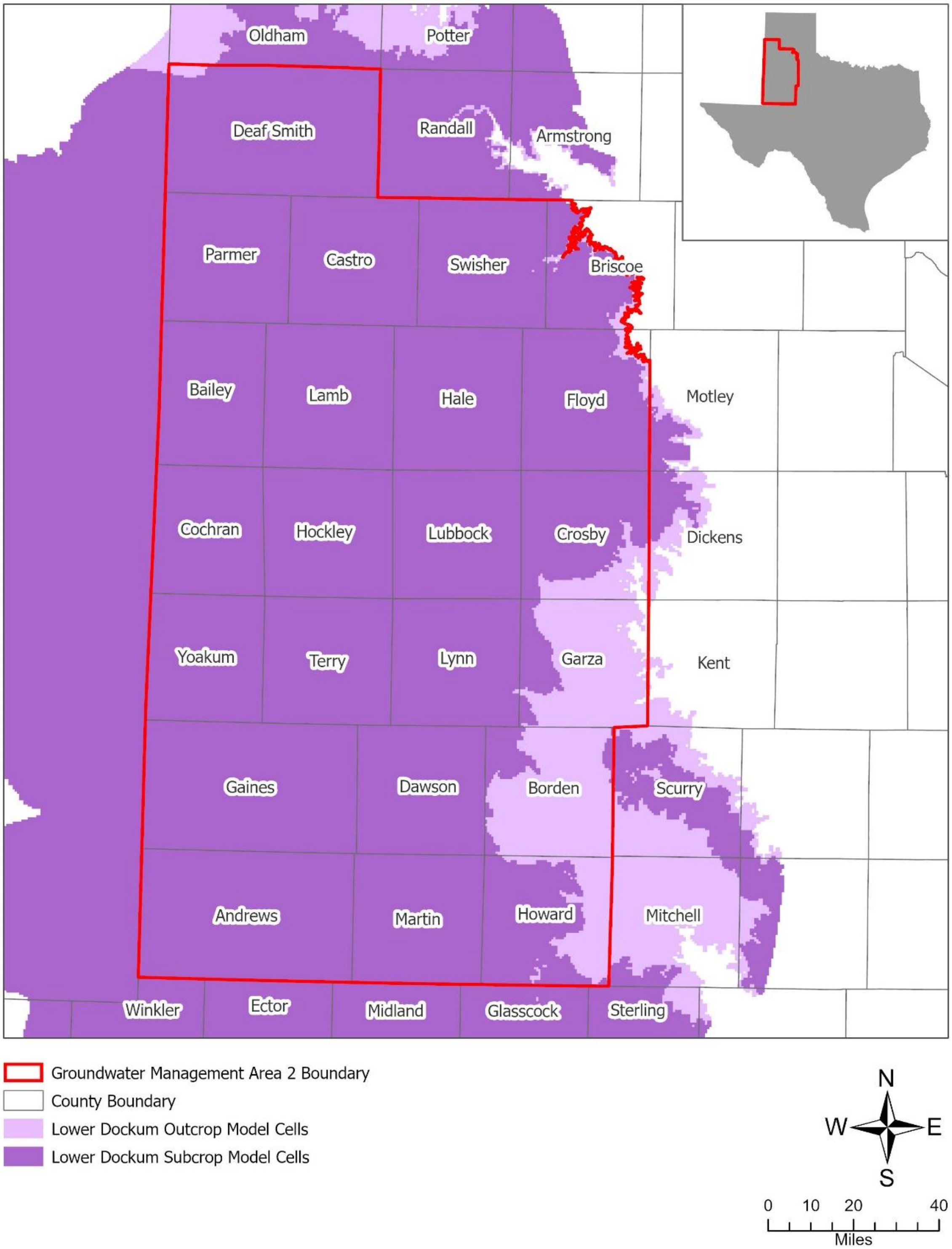

FIGURE 5. MAP SHOWING ACTIVE MODEL CELLS REPRESENTING THE LOWER PORTION OF THE DOCKUM AQUIFER IN LAYER 4 OF THE HIGH PLAINS AQUIFER SYSTEM GROUNDWATER AVAILABILITY MODEL

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 2030 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR. (UWCD = UNDERGROUND WATER CONSERVATION DISTRICT)

Groundwater Conservation District	County	2030	2040	2050	2060	2070	2080
Garza County UWCD Total	**Garza**	**13,508**	**12,402**	**11,717**	**11,263**	**10,948**	**10,721**
High Plains UWCD No.1	Bailey	65,138	50,725	42,532	37,743	34,724	32,675
	Castro	176,186	116,578	68,325	42,856	30,477	23,914
	Cochran	73,991	62,095	54,265	48,561	43,632	40,036
	Crosby	105,559	73,026	51,628	39,354	32,169	27,680
	Deaf Smith	117,359	80,488	56,872	43,574	35,948	31,405
	Floyd	93,953	65,087	52,305	44,155	39,232	35,987
	Hale	116,615	75,108	53,298	41,142	34,308	30,298
	Hockley	96,747	73,687	62,502	56,622	53,198	51,064
	Lamb	120,172	77,677	60,088	52,063	47,868	45,425
	Lubbock	110,472	100,950	95,478	91,655	88,877	86,735
	Lynn	88,768	82,064	77,033	73,324	70,707	68,886
	Parmer	92,025	63,568	46,835	37,743	32,290	28,757
	Swisher	73,407	48,754	35,887	28,541	23,972	20,935
High Plains UWCD No.1 Total		**1,330,392**	**969,807**	**757,048**	**637,333**	**567,402**	**523,797**
Llano Estacado UWCD Total	**Gaines**	**205,486**	**177,777**	**159,523**	**147,028**	**138,157**	**131,974**
Mesa UWCD Total	**Dawson**	**121,336**	**98,590**	**84,192**	**75,448**	**70,262**	**66,945**

Groundwater Conservation District	County	2030	2040	2050	2060	2070	2080
No District County	Andrews	19,391	17,897	16,937	16,260	15,764	15,378
	Borden	4,432	3,893	3,591	3,393	3,227	3,072
	Briscoe	17,859	12,598	9,600	7,844	6,743	6,016
	Castro	3,742	2,496	1,874	1,475	1,214	1,039
	Crosby	2,506	2,276	1,897	1,685	1,562	1,479
	Deaf Smith	18,024	15,387	13,553	12,267	11,301	10,556
	Floyd	0	0	0	0	0	0
	Hockley	12,402	7,093	3,411	2,028	1,419	1,102
	Howard	471	474	483	494	504	513
No District County Total		**78,827**	**62,114**	**51,346**	**45,446**	**41,734**	**39,155**
Permian Basin UWCD	Howard	15,160	14,344	13,882	13,596	13,411	13,287
	Martin	48,293	43,032	39,019	36,358	34,521	33,171
Permian Basin UWCD Total		**63,453**	**57,376**	**52,901**	**49,954**	**47,932**	**46,458**
Sandy Land UWCD Total	**Yoakum**	**90,983**	**70,810**	**59,346**	**53,002**	**49,187**	**46,687**
South Plains UWCD	Hockley	2,638	1,005	493	331	265	234
	Terry	134,878	108,182	96,190	89,977	86,343	84,043
South Plains UWCD Total		**137,516**	**109,187**	**96,683**	**90,308**	**86,608**	**84,277**
Groundwater Management Area 2 Total		**2,041,501**	**1,558,063**	**1,272,756**	**1,109,782**	**1,012,230**	**950,014**

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 2030 AND 2080. VALUES ARE IN ACRE-FEET PER YEAR. (UWCD = UNDERGROUND WATER CONSERVATION DISTRICT)

Groundwater Conservation District	County	2030	2040	2050	2060	2070	2080
Garza County UWCD Total	**Garza**	**1,038**	**1,038**	**1,038**	**1,038**	**1,038**	**1,038**
High Plains UWCD No.1	Bailey	949	949	949	949	949	949
	Castro	484	484	484	484	484	484
	Cochran	1,106	1,106	1,106	1,106	1,106	1,106
	Crosby	4,312	4,312	4,312	4,312	4,312	4,312
	Deaf Smith	5,006	5,006	5,006	5,006	5,006	5,006
	Floyd	3,674	3,674	3,674	3,674	3,674	3,674
	Hale	1,277	1,277	1,277	1,277	1,277	1,277
	Hockley	1,109	1,109	1,109	1,109	1,109	1,109
	Lamb	1,051	1,051	1,051	1,051	1,051	1,051
	Lubbock	1,236	1,236	1,236	1,236	1,236	1,236
	Lynn	1,039	1,039	1,039	1,039	1,039	1,039
	Parmer	6,207	6,207	6,207	5,202	5,188	5,182
	Swisher	1,796	1,796	1,796	1,796	1,796	1,796
	Gaines	880	880	880	880	880	880
High Plains UWCD No.1 Total		**30,126**	**30,126**	**30,126**	**29,121**	**29,107**	**29,101**
Mesa UWCD Total	**Dawson**	**640**	**640**	**640**	**640**	**640**	**640**

Groundwater Conservation District	County	2030	2040	2050	2060	2070	2080
No District County	Andrews	1,503	1,503	1,503	1,503	1,503	1,503
	Borden	1,026	1,026	1,026	1,026	1,026	1,026
	Briscoe	0	0	0	0	0	0
	Castro	0	0	0	0	0	0
	Crosby	81	81	81	81	81	81
	Deaf Smith	7	7	7	7	7	7
	Floyd	0	0	0	0	0	0
	Hockley	95	95	95	95	95	95
	Howard	134	134	134	134	134	134
No District County Total		**2,846**	**2,846**	**2,846**	**2,846**	**2,846**	**2,846**
Permian Basin UWCD	Howard	6,636	6,636	6,636	6,636	6,636	6,636
	Martin	11,449	11,449	11,449	11,449	11,449	11,449
Permian Basin UWCD Total		**18,085**	**18,085**	**18,085**	**18,085**	**18,085**	**18,085**
Sandy Land UWCD Total	**Yoakum**	**0**	**0**	**0**	**0**	**0**	**0**
South Plains UWCD	Hockley	0	0	0	0	0	0
	Terry	0	0	0	0	0	0
South Plains UWCD Total		**0**	**0**	**0**	**0**	**0**	**0**
Groundwater Management Area 2 Total		**52,735**	**52,735**	**52,735**	**51,730**	**51,716**	**51,710**

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	2030	2040	2050	2060	2070	2080
Andrews	Region F	Colorado	19,391	17,897	16,937	16,260	15,764	15,378
Andrews	Region F	Rio Grande	0	0	0	0	0	0
Bailey	Llano Estacado	Brazos	65,138	50,725	42,532	37,743	34,724	32,675
Borden	Region F	Brazos	673	615	581	559	543	532
Borden	Region F	Colorado	3,759	3,278	3,010	2,834	2,684	2,540
Briscoe	Llano Estacado	Red	17,859	12,598	9,600	7,844	6,743	6,016
Castro	Llano Estacado	Brazos	106,971	71,565	40,493	24,591	17,282	13,530
Castro	Llano Estacado	Red	72,957	47,509	29,706	19,740	14,409	11,423
Cochran	Llano Estacado	Brazos	20,220	18,297	17,034	16,204	15,655	15,283
Cochran	Llano Estacado	Colorado	53,771	43,798	37,231	32,357	27,977	24,753
Crosby	Llano Estacado	Brazos	105,148	72,526	50,976	38,890	31,952	27,655
Crosby	Llano Estacado	Red	2,917	2,776	2,549	2,149	1,779	1,504
Dawson	Llano Estacado	Brazos	1,390	1,294	1,230	1,187	1,156	1,134
Dawson	Llano Estacado	Colorado	119,946	97,296	82,962	74,261	69,106	65,811
Deaf Smith	Llano Estacado	Canadian	0	0	0	0	0	0
Deaf Smith	Llano Estacado	Red	135,383	95,875	70,425	55,841	47,249	41,961

County	RWPA	River Basin	2030	2040	2050	2060	2070	2080
Floyd	Llano Estacado	Brazos	73,465	45,024	32,571	24,708	20,244	17,492
Floyd	Llano Estacado	Red	20,488	20,063	19,734	19,447	18,988	18,495
Gaines	Llano Estacado	Colorado	205,486	177,777	159,523	147,028	138,157	131,974
Garza	Llano Estacado	Brazos	13,508	12,402	11,717	11,263	10,948	10,721
Garza	Llano Estacado	Colorado	0	0	0	0	0	0
Hale	Llano Estacado	Brazos	116,240	74,782	53,039	40,940	34,150	30,172
Hale	Llano Estacado	Red	375	326	259	202	158	126
Hockley	Llano Estacado	Brazos	84,987	67,316	58,259	53,255	50,258	48,358
Hockley	Llano Estacado	Colorado	26,800	14,469	8,147	5,726	4,624	4,042
Howard	Region F	Colorado	15,631	14,818	14,365	14,090	13,915	13,800
Lamb	Llano Estacado	Brazos	120,172	77,677	60,088	52,063	47,868	45,425
Lubbock	Llano Estacado	Brazos	110,472	100,950	95,478	91,655	88,877	86,735
Lynn	Llano Estacado	Brazos	82,425	76,194	71,817	68,689	66,499	64,962
Lynn	Llano Estacado	Colorado	6,343	5,870	5,216	4,635	4,208	3,924
Martin	Region F	Colorado	48,293	43,032	39,019	36,358	34,521	33,171
Parmer	Llano Estacado	Brazos	51,129	37,132	28,030	22,549	19,129	16,878

County	RWPA	River Basin	2030	2040	2050	2060	2070	2080
Parmer	Llano Estacado	Red	40,896	26,436	18,805	15,194	13,161	11,879
Swisher	Llano Estacado	Brazos	11,508	6,845	4,598	3,421	2,759	2,360
Swisher	Llano Estacado	Red	61,899	41,909	31,289	25,120	21,213	18,575
Terry	Llano Estacado	Brazos	6,825	6,322	5,998	5,776	5,612	5,487
Terry	Llano Estacado	Colorado	128,053	101,860	90,192	84,201	80,731	78,556
Yoakum	Llano Estacado	Colorado	90,983	70,810	59,346	53,002	49,187	46,687
Groundwater Management Area 2 Total			**2,041,501**	**1,558,063**	**1,272,756**	**1,109,782**	**1,012,230**	**950,014**

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	2030	2040	2050	2060	2070	2080
Andrews	Region F	Colorado	1,503	1,503	1,503	1,503	1,503	1,503
Andrews	Region F	Rio Grande	0	0	0	0	0	0
Bailey	Llano Estacado	Brazos	949	949	949	949	949	949
Borden	Region F	Brazos	323	323	323	323	323	323
Borden	Region F	Colorado	703	703	703	703	703	703
Briscoe	Llano Estacado	Red	0	0	0	0	0	0
Castro	Llano Estacado	Brazos	0	0	0	0	0	0
Castro	Llano Estacado	Red	484	484	484	484	484	484
Cochran	Llano Estacado	Brazos	118	118	118	118	118	118
Cochran	Llano Estacado	Colorado	988	988	988	988	988	988
Crosby	Llano Estacado	Brazos	4,393	4,393	4,393	4,393	4,393	4,393
Crosby	Llano Estacado	Red	0	0	0	0	0	0
Dawson	Llano Estacado	Brazos	0	0	0	0	0	0
Dawson	Llano Estacado	Colorado	640	640	640	640	640	640
Deaf Smith	Llano Estacado	Canadian	0	0	0	0	0	0
Deaf Smith	Llano Estacado	Red	5,013	5,013	5,013	5,013	5,013	5,013
Floyd	Llano Estacado	Brazos	3,389	3,389	3,389	3,389	3,389	3,389
Floyd	Llano Estacado	Red	285	285	285	285	285	285
Gaines	Llano Estacado	Colorado	880	880	880	880	880	880
Garza	Llano Estacado	Brazos	1,038	1,038	1,038	1,038	1,038	1,038
Garza	Llano Estacado	Colorado	0	0	0	0	0	0
Hale	Llano Estacado	Brazos	1,244	1,244	1,244	1,244	1,244	1,244
Hale	Llano Estacado	Red	33	33	33	33	33	33
Hockley	Llano Estacado	Brazos	1,013	1,013	1,013	1,013	1,013	1,013
Hockley	Llano Estacado	Colorado	191	191	191	191	191	191

County	RWPA	River Basin	2030	2040	2050	2060	2070	2080
Howard	Region F	Colorado	6,770	6,770	6,770	6,770	6,770	6,770
Lamb	Llano Estacado	Brazos	1,051	1,051	1,051	1,051	1,051	1,051
Lubbock	Llano Estacado	Brazos	1,236	1,236	1,236	1,236	1,236	1,236
Lynn	Llano Estacado	Brazos	901	901	901	901	901	901
Lynn	Llano Estacado	Colorado	138	138	138	138	138	138
Martin	Region F	Colorado	11,449	11,449	11,449	11,449	11,449	11,449
Parmer	Llano Estacado	Brazos	3,590	3,590	3,590	2,585	2,571	2,565
Parmer	Llano Estacado	Red	2,617	2,617	2,617	2,617	2,617	2,617
Swisher	Llano Estacado	Brazos	29	29	29	29	29	29
Swisher	Llano Estacado	Red	1,767	1,767	1,767	1,767	1,767	1,767
Terry	Llano Estacado	Brazos	0	0	0	0	0	0
Terry	Llano Estacado	Colorado	0	0	0	0	0	0
Yoakum	Llano Estacado	Colorado	0	0	0	0	0	0
Groundwater Management Area 2 Total			**52,735**	**52,735**	**52,735**	**51,730**	**51,716**	**51,710**

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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