LLANO ESTACADO
UNDERGROUND
WATER CONSERVATION DISTRICT

"GROUNDWATER MANAGEMENT PLAN"
2020-2025
Effective October 8, 2020
Revised September 14, 2023

Table of Contents

District Mission Statement ---------- 3
Time Period for this Plan ---------- 3
Guiding Principles ---------- 3
General Description, Location and Extent ---------- 4
Topography and Drainage ---------- 5
Groundwater Resources ---------- 5
Ogallala Aquifer ---------- 5
Cretaceous Aquifer ---------- 6
Dockum Aquifer ---------- 7
Surface Water Resources ---------- 7
1. Estimates of Modeled Available Groundwater ---------- 7
2. Estimates of Historic Groundwater Usage ---------- 8
3. Estimates of Annual Groundwater Recharge from Precipitation ---------- 8
4. Estimates of Annual Groundwater Discharge to Springs/Surface Water Bodies ---------- 8
5. Estimates of Annual Groundwater Flow Into/Out of the District for the Ogallala: Estimates of Annual Groundwater Flow between Aquifers in the District ---------- 8
6. Estimates of Projected Total Demand for Water, and Projected Total Surface Water Supplies in the District ---------- 8
7. Water Supply Needs and Water Management Strategies ---------- 8
Actions, Procedures, Performance and Avoidance for Plan Implementation and Details of How the District will Manage Groundwater Supplies ---------- 9
Drought Contingency Plan ---------- 9
Regional Water Planning ---------- 10
Goals, Management Objectives and Performance Standards ---------- 10
Method for Tracking the District's Progress in Achieving Management Goals ---------- 10
Goals ---------- 11
References ---------- 17

List of Tables

Table 1 Board of Directors of the Llano Estacado Underground Water Conservation District ---------- 4
Appendix A
Modeled Availability Groundwater GAM Run 21-008 MAG Addendum
Appendix B
Estimated Historical Water Use and 2017 State Water Plan Datasets
Appendix C
Groundwater Availability Modeling (GAM) Run 19-017

District Mission Statement

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

Time Period for this Plan

This plan becomes effective October 8, 2020, upon adoption by the Board of Directors (the Board) of the District and remains in effect until a revised plan is approved or until October 8, 2025, whichever is earlier.

Guiding Principles

The District was formed, and has been operated from its inception, with the guiding belief that the ownership and production of groundwater is a private property right. It is understood that, without the District, there is no protection of private property rights. The methods of protecting private property rights in groundwater are implemented using the policies adopted by the locally elected board members.

The Board understands the responsibilities of the District and creates programs necessary for meeting them. The Board believes that the District should be more knowledgeable of its groundwater resources than any other entity.

Additionally, the Board realizes that the aquifer extends beyond the District's boundaries, and the sharing of information, programs and ideas with neighboring districts is important. As a result, the District will consider the joint administration of certain programs when practical.

This management plan is a tool which provides continuity in the management of the District. The District staff uses this guide to ensure that the goals of the District are met. The Board uses it for planning, as well as measuring the performance of the staff.

Conditions change over time which requires that the Board modify this document. The dynamic nature of this plan shall be maintained such that the District continues serving the needs of the constituents. At the very least, the Board will review and readopt this plan every five years, or as specified by Chapter 36, Texas Water Code.

In the opinion of the Board, the goals, management objectives, and performance standards in this planning document have been set at a reasonable level considering existing and future fiscal and technical resources. Evolving conditions may change the management objectives defined to reach the stated goals. Whatever the future holds, the following guidelines are used to ensure the management objectives are set at a realistic and effective level:

•The District's constituency will determine if the District's goals are set at a level that is both meaningful and attainable; through their voting right, the public will appraise the District's overall performance in the process of electing or re-electing Board members.

•The duly elected Board will guide and direct the District staff and will gauge the achievement of the goals set forth in this document.
•The interests and needs of the District's constituents shall control the direction of the management of the District.
•The Board will maintain local management of the privately-owned resource over which the District has jurisdictional authority, as provided by Chapter 36, Texas Water Code.
•The Board will evaluate District activities on a fiscal year basis. That is, the District budgets operations on a October 1 - September 30 fiscal year. When considering stated goals, management objectives, and performance standards, any reference to the terms annual, annually, or yearly will refer to the fiscal year of the District.

General Description, Location and Extent

The District was created by HB 530 (72nd Legislature) during 1991. The District was confirmed by voter approval, the initial Board elected, and an ad valorem tax rate cap of $0.02/$100 valuation was set in an election held in November 1998. Table 1 lists the current Board of Directors, office held, occupation, and term.

Table I: Board of Directors of the Llano Estacado Underground Water Conservation District

Office	Name	Occupation	Term Ends
President	Weldon Shook	Active Farmer	May 2023
Vice-President	Charles Rowland	Active Farmer	May 2021
Secretary	Walter Billings	Active Farmer	May 2023
Member	Larry Day	Active Farmer	May 2021
Member	Robert Warren	Active Farmer	May 2021

Originally, the jurisdictional extent of the District is the same as Gaines County, Texas. The District covers approximately 1525 square miles of the Southern High Plains of Texas. Seminole (pop. 7,629), the county seat, is the largest municipality in the District. Seagraves (pop. 2,846) and Loop (pop. 225) are the other incorporated communities in the District.

The District is bordered on the north by the Sandy Land UWCD (Yoakum County) and South Plains UWCD (Terry and Hockley Counties), on the east by Mesa UWCD (Dawson County), on the south by Andrews County, and on the west by the State of New Mexico.

The economy of the District is supported predominately by row crop agriculture and oil and gas production. The 317,000 plus acres of irrigated cropland affords economic stability to the area. The major crops cultivated within the District include: cotton, peanuts, grain sorghum, wheat and corn; and, to a lesser extent, watermelons, sunflowers, hay, and cucumbers.

Gaines County has long been known as one of the top producers of oil and gas in the state. In 2019, companies produced over 1.6M BBLs of crude oil in the county. A significant portion of the District's tax-based revenues are generated by mineral valuation. Fluctuating oil prices are a challenge to the budgeting process.

Topography and Drainage

The land surface in the District is a nearly level to very gently undulating constructional plain that has little dissection. Deep, moderately permeable, sandy soils predominate the region.

The elevation ranges from about 3,700 feet above sea level in the northwest part of the District to 2,935 feet above sea level in the southeast corner of the District.

Several relict drainage ways cross the District from northwest to southeast. These "draws" (Sulfur, McKenzie, Wordswell, Seminole, and Monument) are shallow and usually dry; they seldom carry runoff water.

Cedar Lake and McKenzie Lake are the largest salt lakes in the District. In periods of normal rainfall, McKenzie Lake occupies approximately 1,500 acres, and Cedar Lake, approximately 3,500 acres. The lakes are bordered by calcareous soils that support various salt – tolerant sedges and grasses. The soils around the lakes and in the lake bottoms are strongly affected by alkali and are not conducive to agricultural activities.

Playas, or shallow lakes, are more common in areas where fine sandy loam and sandy clay loam soil types prevail. Playas range in size from 2 to 10 acres and are important vectors for local aquifer recharge.

Groundwater Resources

The District has jurisdiction over all groundwater that lies within the District's boundaries. Three aquifers, the Ogallala, the Cretaceous, and the Dockum occur within the District. The following is a description of geological formations that may be beneficial to District constituents by providing useable quantities of groundwater.

Ogallala Aquifer

The Ogallala Aquifer is the primary source of groundwater in the District (Figure 1) (Appendix A). Saturated sections range from less than 10 feet to more than 180 feet in the area covered by the District.

The formation consists of heterogeneous sequences of clay, silt, sand and gravel. These sediments are thought to have been deposited by eastward-flowing, aggrading streams that filled and buried valleys eroded into pre-Ogallala rocks. A resistant layer of calcium carbonate-cemented caliche known locally as the "caprock" occurs near the surface of much of the area (Ashworth and Hopkins, 1995).

Water levels in the Ogallala Aquifer are influenced by the rate of recharge and discharge. Recharge occurs primarily by infiltration of precipitation. GAM studies show that recharge is greater beneath irrigated lands. To a lesser extent, recharge may also occur by upward leakage from underlying Cretaceous units that, in places, have a higher water table elevation than the Ogallala. Generally, only a small percentage of water from precipitation actually reaches the water table due to a combination of limited annual precipitation (15.8 inches per year), high evaporation rate (60 – 70 inches per year), and slow infiltration rate. However, where deep sands are prevalent, and the water table is shallow, precipitation may affect recharge rather quickly.

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

Discharge from the Ogallala Aquifer within the District primarily occurs through the pumping of irrigation wells. Groundwater usage typically exceeds recharge and results in water-level declines (Ashworth and Hopkins, 1995).

The chemical quality of Ogallala groundwater varies greatly across the District. Total Dissolved Solids (TDS) values varies from less than 600 mg/L to over 6,000 mg/L. Generally, groundwater in the eastern and southeastern parts of the District exhibits the highest TDS. Isolated occurrence of high TDS concentrations elsewhere in the District may be due to pollution through oil field salt water disposal pits or upward leakage and mixing from the underlying Cretaceous Aquifer.

The suitability of groundwater for irrigation purposes is largely dependent on the chemical composition of the water and is determined primarily by the total concentration of soluble salts. Some farm acreage in the District is already limited to certain varieties of salt tolerant crops due to limiting or damaging total salt levels.

Cretaceous Aquifer

The Edwards-Trinity (High Plains) Aquifer, commonly referred to as the Cretaceous Aquifer, underlies the Ogallala Aquifer in the northern half of the District (Figure 2) (Appendix A). In some areas of the District, the Cretaceous and Ogallala aquifers may be hydrologically connected. Groundwater in the Cretaceous is generally fresh to slightly saline. Water quality deteriorates where Cretaceous formations are overlain by saline lakes.

Studies performed by the District suggest that water quality in Cretaceous units is generally similar to that of the Ogallala. However, there are some instances where it has been discovered that lower Cretaceous units have poor quality water. This work is a continual investigation and limited by the sparse locations of Cretaceous water wells. Further work should provide additional understanding of this issue.

As Ogallala water levels decline, it is expected that there will be greater interest in this minor aquifer. The District is implementing a water level measurement program for this minor aquifer and is committing additional resources to the study of Cretaceous units.

Recharge of the Cretaceous occurs directly from the bounding Ogallala Formation. Some upward movement of groundwater from the underlying Triassic Dockum formation may also occur, affecting recharge of the Cretaceous (Ashworth and Hopkins, 1995). As mentioned earlier, in some places the potentiometric surface elevation of the Cretaceous Aquifer is higher than the water table elevation of the Ogallala Aquifer, resulting in the upward leakage from the Cretaceous Aquifer. Movement of water in the Cretaceous is generally east to southeast.

Dockum Aquifer

The Dockum Aquifer underlies the Cretaceous and Ogallala formations throughout the District (Figure 3) (Appendix A). The primary water-bearing zone in the Dockum Group, commonly called the "Santa Rosa", consists of up to 700 feet of sand and conglomerate interbedded with layers of silt and shale (Ashworth and Hopkins, 1995). Aquifer permeability is typically low and well yields normally do not exceed 300 gal/min.

Water quality in the Dockum is the main limiting factor when considering its use within the District (Ashworth and Hopkins, 1995). Electrical Conductance (EC) values for Dockum groundwater range from 15.0 deciSiemens per meter (dS/m) to over 50.0 dS/m. Even the most salt tolerant row crops grown cannot withstand such levels of salinity.

Currently, it seems the only practical use of Dockum groundwater may be for make-up water in secondary recovery operations of crude oil. By using water from this aquifer, oil companies could reduce their use of Ogallala and/or Cretaceous groundwater, thereby relieving some pressure from the freshwater sources.

At some point, it may be feasible to treat Dockum water for use as municipal supply. As desalination technology evolves, this process might be feasible for meeting some needs within the District. However, due to the limited productivity of this aquifer, it is likely best suited (using this scenario) for stock or municipal supply. These uses permit a storage system for water that is not available for agricultural irrigation usage.

Surface Water Resources

The only fresh surface water in the District are playa lakes. The playas play an important role in aquifer recharge and support some wildlife when rainfall accumulates in these naturally occurring depressions. Playas are rarely, if ever, used to support irrigation activities.

As previously mentioned, Cedar Lake and McKenzie Lake are naturally occurring salt lakes within the District. Each of these naturally occurring impoundments support limited wildlife populations, primarily migratory waterfowl and opportunistic predators.

1. Estimates of Modeled Available Groundwater

GMA 2 adopted Desired Future Conditions (DFC) for relevant aquifers in August 17, 2021. The relevant aquifers are the Ogallala, Edwards-Trinity (High Plains) and Dockum aquifers. The DFC for the Ogallala and Edwards-Trinity (High Plains) aquifers is average drawdown of 28 feet for all of GMA 2. The DFC for the Dockum Aquifer is an average drawdown of 31 feet for all of GMA 2. The drawdowns are calculated from the end of 2012 conditions to the year 2080. These DFC's and associated MAG's are documented in GMA 2 Technical Memorandum 20-01, and the TWDB GAM Run 21-008 MAG Addendum report which is in appendix A of this groundwater management plan. The 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 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 Llano Estacado UWCD, refer to the *GMA 2 MAG report table from the TWDB* GAM Run 21-008 MAG Addendum *Report, Appendix A*.

2. Estimates of Historical Groundwater Usage

The estimated historical water use from the TWDB Estimated Historical Water Use Survey (WUS) are estimations of the historical quantity of groundwater used in 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 the TWDB Estimated Historical Groundwater Use and 2017 State Water Plan Data Sets,
Appendix B

3. Estimates of Annual Groundwater Recharge from Precipitation

Refer to GAM Run 19-017, Appendix C

4. Estimates of Annual Groundwater Discharge to Springs/Surface Water Bodies

Refer to GAM Run 19-017, Appendix C

5. 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 GAM Run 19-017, Appendix C

6. Estimates of Projected Total Demand for Water, and Projected Total Surface Water Supplies in the District

Projecting water demand is a challenging task. Some user group projections are more accurate than others. This is an inherent part of the process. Of particular difficulty is the projection of irrigation water demand. Rainfall, commodity prices, water level changes, and federal farm policy are a few of the factors that complicate the mater. There are no projected surface water supplies in the district.

Refer to the TWDB Estimated Historical Groundwater use and 2017 State Water Plan Data Sets, Appendix B

7. 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 2017 State Water Plan (TWC 36.1071(e)(4).

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

The 2015 Region O Regional Water Plan shows unmet demands in Gaines County in the irrigation, municipal, and county other categories. The strategies that will be used to meet these needs are conservation, development of new supplies, new groundwater supply and brackish water desalination. The majority of the unmet needs are in the irrigation category, and will be met by the producers adjusting their farming practices to meet the available water. This falls under the conservation strategy, which will meet nearly all of the county's needs in the future. It is possible municipal needs may also be met by developing new supplies or new groundwater supplies from currently owned land purchased for that purpose.

Actions, Procedures, Performance and Avoidance for Plan Implementation and Details of How the District will Manage Groundwater Supplies

The District currently employs a set of rules governing the spacing and production of wells, as well as production limits based on tract size. It is expected that this approach will remain the foundation of the Board's strategies for groundwater management. As conditions dictate, and as the DFC process is completed, it may require that the specific provisions within the existing rules be modified. The District's Board of Directors is responsible for that determination. The District's rules are available on the District web site: http://www.llanoestacadouwcd.org/rules.html
Additional water management strategies the District may consider, when applicable, are listed below.

A. Conversion to Dryland Farming – As water supplies decline, there are some landowners that may exercise this option. There are incentive payments available through the USDA NRCS for those interested in this option. The District supports the use of these incentive payments to help those landowners interested in this program.
B. Increased study of Minor Aquifers – Some future needs may be addressed using the two minor aquifers, the Cretaceous (Edwards – Trinity High Plains) and the Dockum, within the District. At this time, it is uncertain what additional amount of water may be available from minor aquifers. The District supports the continued and further investigation of these resources and is committed to the monitoring and study of them.
C. Conservation Programs – The implementation of educational programs and resources regarding conservation remains top priority for the District. The Board supports the expansion of resources pertaining to those programs, which include, but are not limited to: maximizing crop water use efficiency, minimizing irrigation water evaporative losses, rainwater harvesting, use of water wise plants and drought tolerant landscaping, wise water use, and device giveaways.

Drought Contingency Plan

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. Drought is also a temporary aberration, and differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate ("What is Drought?" National Drought Mitigation Center). The Llano Estacado Underground Water Conservation District is in a semi-arid region that also experiences drought. However, even in the midst of a drought, rainfall at crucial times of the growing season may significantly reduce irrigation water demand.

Drought response conservation measures typically used in other regions of Texas (i.e. rationing) cannot and are not used in this region due to extreme economic impact potential. In the District, groundwater conservation is stressed at all times. The Board recognizes that irrigated agriculture provides the economic stability to the communities within the District. Therefore, through the notice and hearing provisions required in the development and adoption of this management plan, the Board adopts the official position that, in times of precipitation shortage, irrigated agricultural producers will not be limited to any less usage of groundwater than is provided for by District rules.
In order to treat all other groundwater user groups fairly and equally, the District will encourage more stringent conservation measures, where practical, but likewise, will not limit groundwater use in any way not already provided for by District rules.

Regional Water Planning

The Board of Directors recognizes the regional water plan requirements listed in Ch. 36, TWC, §36.1071. Namely, the District's management plan must be forwarded to the regional water planning group for their consideration in their planning process, and the plan must address water supply needs such that there is no conflict with the approved regional water plan. It is the Board's belief that no such conflict exists.

The Board agrees that the regional water plan should include the District's best data. The Board also recognizes that the regional water planning process provides a necessary overview of the region's water supply and needs. However, the Board also believes it is the duty of the District to develop the best and most accurate information concerning groundwater within the District.

Goals, Management Objectives and Performance Standards

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

The District Manager will prepare an annual report of the District's performance 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 within 60 days after September 30. The report will be maintained on file in the open records of the District.

The District will actively enforce all rules of the District in order to conserve, preserve, protect and prevent the waste of the groundwater resources over which the District has jurisdictional authority. The Board will periodically review the District's rules, and may modify the rules, with public approval, to better manage the groundwater resources within the District and to carry out the duties prescribed in Chapter 36, Texas Water Code.

Goal 1.0 Providing the Most Efficient Use of Groundwater

Management Objective-Water Level Monitoring

1.01 Measure the depth to water in the District's water level monitoring well Network and record measured levels in a database to support tracking of DFC attainment.

Performance Standards

1.01a Report the number of wells measured in the annual report to the Board.
1.01b Report the number of wells added to the network, if required, each year in the annual report to the Board.

Management Objective-Technical Field Services

1.02 Provide technical field services including flow testing and drawdown measurement for wells and irrigation systems.

Performance Standards

1.02a Report the number of field service tests performed each year in the annual report to the Board.

Management Objective-Laboratory Services

1.02 Provide basic water quality testing services. Maintain a record of tests performed by entering the results in the District's database.

Performance Standards

1.03a Report the number of laboratory service tests in the annual report to the Board.
1.03b Report the number of records entered into District's computer database each year in the annual report to the Board.

Management Objective – Water Use Monitoring

1.04 Monitor seasonal irrigation applications using a network of cooperative producers.

Performance Standards

1.04a Report the number of irrigation systems in the cooperative program in the annual report to the Board.
1.04b Report the number and type of crops monitored in the annual report to the Board.
1.04c Report the average irrigation application by crop in the annual report to the Board.

Management Objective-Irrigation System Inventory

1.05 Every five years perform a physical inventory of irrigation systems in the District. Enter data in District's data base file by block and section.

Performance Standards

1.05a Report the number of irrigation systems recorded each documenting period in the annual report to the Board.
1.05b Report the number of active irrigation systems by type in District's database in the annual report to the Board.

Goal 2.0 Controlling and Preventing Waste of Groundwater

Management Objective-Well Permitting and Well Completion
2.01 Issue temporary water well drilling permits for the drilling and completion of non-exempt water wells. Inspect all well sites to be assured that the District's completion and spacing standards are met.

Performance Standards
2.01a Report the number of water well drilling permits issued each year in the annual report to the Board.
2.01b Report the number of well sites inspected after well completion each year in the annual report to the Board.

Management Objective-Open, Deteriorated or Uncovered Wells
2.02 If an open, deteriorated or uncovered well is found, the District will insure that the open hole is properly closed according to District rules and, in so doing, prevent potential contamination of the groundwater resource. The District will contact the party responsible for the open, deteriorated or uncovered. The site will be inspected after notification to ensure the well closure process occurs.

Performance Standards
2.02a Report the number of open, deteriorated or uncovered wells in the annual report to the Board.
2.02b Report the number of initial inspections accomplished each year in the annual report to the Board.

Management Objective-Maximum Allowable Production
2.03 The District will investigate reports of usage of groundwater in excess of the maximum production allowable under the District's rules.

Performance Standards
2.03a Report the number of reports in the annual report to the Board.

Management Objective-Water Quality Monitoring
2.04 Conduct a District–wide water quality testing program. The results will be entered in to the District's computer database, and will be made available to the public.

Performance Standards
2.04a Report the number of samples collected and analyzed each year in the annual report to the Board.

Goal 3.0 Controlling and Preventing Subsidence

The TWDB subsidence risk report figure 4.32 indicated less than 100' of clay in Gaines County. Examination of Ogallala well logs in the county showed a range of 0 to 40 feet of clay, and an average of approximately 12 feet. Wells completed in the Edwards

Trinity (Plateau) reported slightly more, averaging 21 feet of clay. In the TWDB report figure 4.33, a general statewide subsidence risk map, Gaines County appears to be shown as a medium subsidence risk area.

The District used the TWDB Subsidence Model 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: http://www.twdb.texas.gov/groundwater/models/research/subsidence/subsidence.asp to check estimated subsidence risk values in selected new wells. New wells were selected since current practice is to complete wells into the Edwards-Trinity aquifer as well as the overlying Ogallala aquifer. Predicted risk factors calculated ranged from 2.8 to 4.4 for the wells checked. According to the model results, this corresponds to a low-to-medium risk.

The District measures water levels, collects water quality samples, monitors meter readings, and collects rainfall data, countywide, year around. Limited subsidence has been observed in 2 instances immediately adjacent to older existing irrigation wells. No other types of subsidence have been observed to date. The District continues to observe well conditions during routine operations, but declares this goal not applicable.

Goal 4.0 Addressing Conjunctive Surface Water Management Issues

Not applicable because there are no surface water resources in the District for use in conjunctive management.

Goal 5.0 Addressing Natural Resource Issues

Management Objective

5.01 The District will investigate, or refer to the proper agency, any Citizen's or District Initiated complaint related to surface water, groundwater, or any natural resource within the District.

Performance Standards

5.01a The District will record all complaints and report these annually to the District Board of Directors

Management Objective

5.02 The District will attend at least one Region O meeting at which natural resource issues are discussed.

Performance Standards

5.02a Report the number of Region O meetings attended by a District Representative in the annual report to the Board.

Management Objective

5.03 The District will track the number of wells being permitted and drilled to support oil and gas drilling and production operations.

Performance Standards
5.03a The District will track the number of wells being permitting and drilled to support oil and gas drilling and production operations and will report that in the annual report to the Board.

Goal 6.0 Addressing Drought Conditions

Management Objective-Rain Gauges
6.01 Maintain a network of rain gauges in the District. Publish rainfall data on the District's web site.

Performance Standards
6.01a Report the number of rain gauges in the network in the annual report to the Board.

6.02 The TWDB drought link, which has much useful drought information, and web site links. https://www.waterdatafortexas.org/drought

Goal 7.0 Addressing Conservation

Management Objective – Classroom Education
7.01 The District will promote water conservation through presentations given at schools within the District.

Performance Standards
7.01a Report the number of classroom presentations in the annual report to the Board.

Management Objective-News Releases
7.02 District staff will prepare news releases addressing groundwater Conservation groundwater quality and District activities.

Performance Standard
7.02a Report the number of news releases prepared for publication in local newspapers in the annual report to the Board.

Management Objective-Public Speaking Engagements
7.03 The District staff and/or directors shall present programs addressing groundwater conservation, groundwater quality and District information or activities.

Performance Standard
7.03a Report the number of programs presented in the annual report to the Board.

Management Objective-Printed Material Resource Center
7.04 Maintain a self-service printed material resource center in the District office. Conduct an annual inventory of these items. Through the inventory process, determine the number and type of materials obtained by the public each year.

Performance Standards
7.04a Report the number of items by type procured by the public from the resource center in the annual report to the Board.

Management Objective-**Saturated Thickness Maps**
7.05a Every 5 years, provide a saturated thickness map to show the varying thickness of groundwater remaining in storage. The most recent saturated thickness map will be available at the District office and on District web site.

Performance Standards
7.06a Report the most recent saturated thickness map available at the District office and on District web site in the annual report to the Board.

Goal 8.0 Addressing Recharge Enhancement

8.01 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 – **Public Awareness Program**
9.01a The District will conduct an educational program for this conservation strategy at least once a year.

Performance Standards
9.01a Report the type of program conducted (i.e. newspaper article, public presentation) in the annual report to the Board.

Goal 10.0 Addressing Precipitation Enhancement

10.01 While the District did participate in this program for eleven years, the Board has since determined it is not cost-effective. Therefore, this goal is not applicable.

Goal 11.0 Addressing Brush Control

11.01 Existing programs administered by the USDA – NRCS are sufficient for addressing his 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 Desired Future Condition of the Aquifers

Management Objective – Calculate Annual Drawdown

12.01 Each year the District will measure water levels in the District's water level monitoring well network. These measurements are stored in a database, graphs for each well are prepared, and long term trends calculated.

Performance Standards

12.01a Annually calculate and compare the composite long term water level trends to the District and GMA 2 DFC. This analysis will be presented to the Board annually and recorded in the annual report.

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TWDB Estimated Historical Water Use and 2017 State Water Plan Datasets for Llano Estacado UWCD, April, 2020

Appendix

A

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

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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

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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.

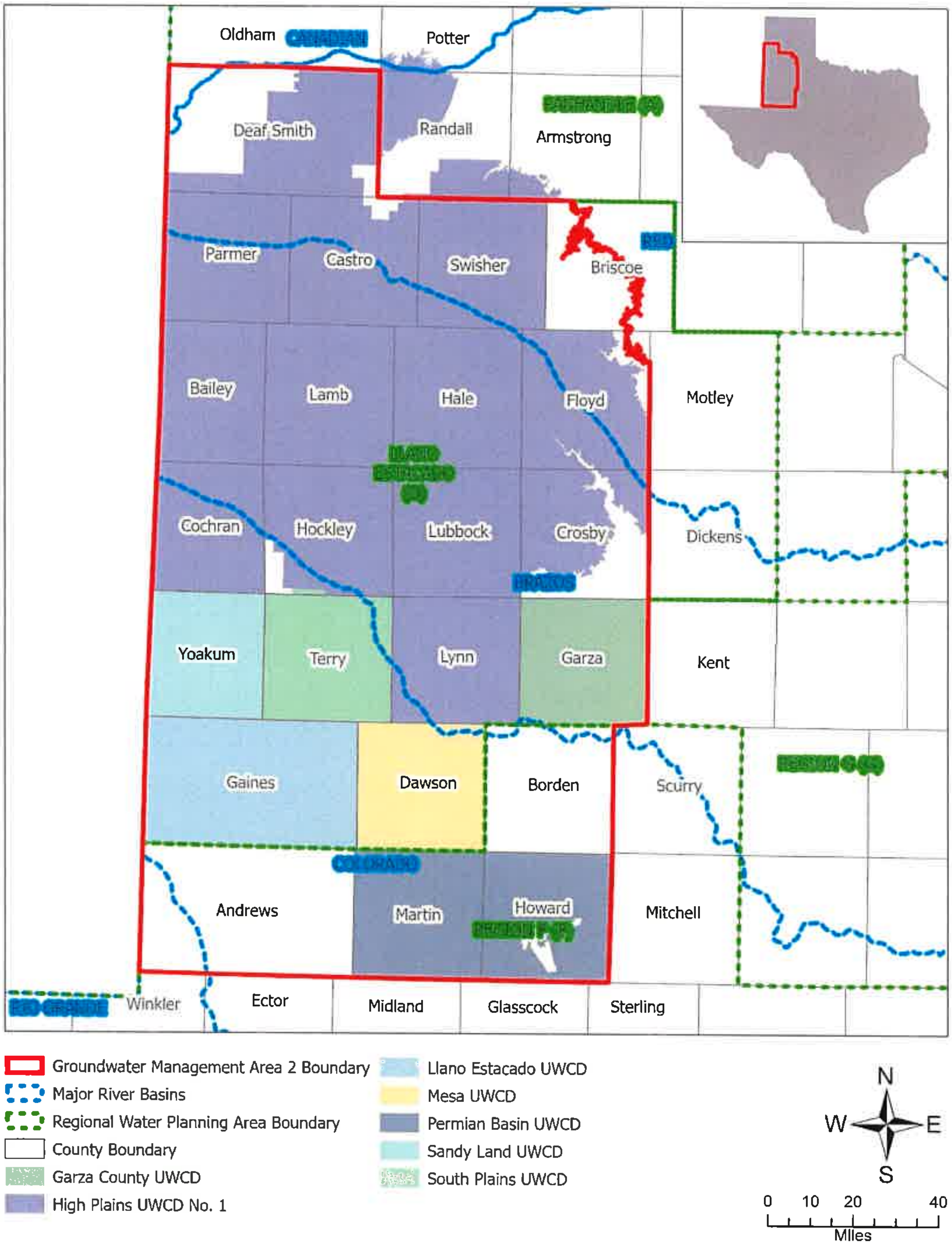

FIGURE 1. MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS (ALSO KNOWN AS UNDERGROUND WATER CONSERVATION DISTRICT OR UWCD), COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 2

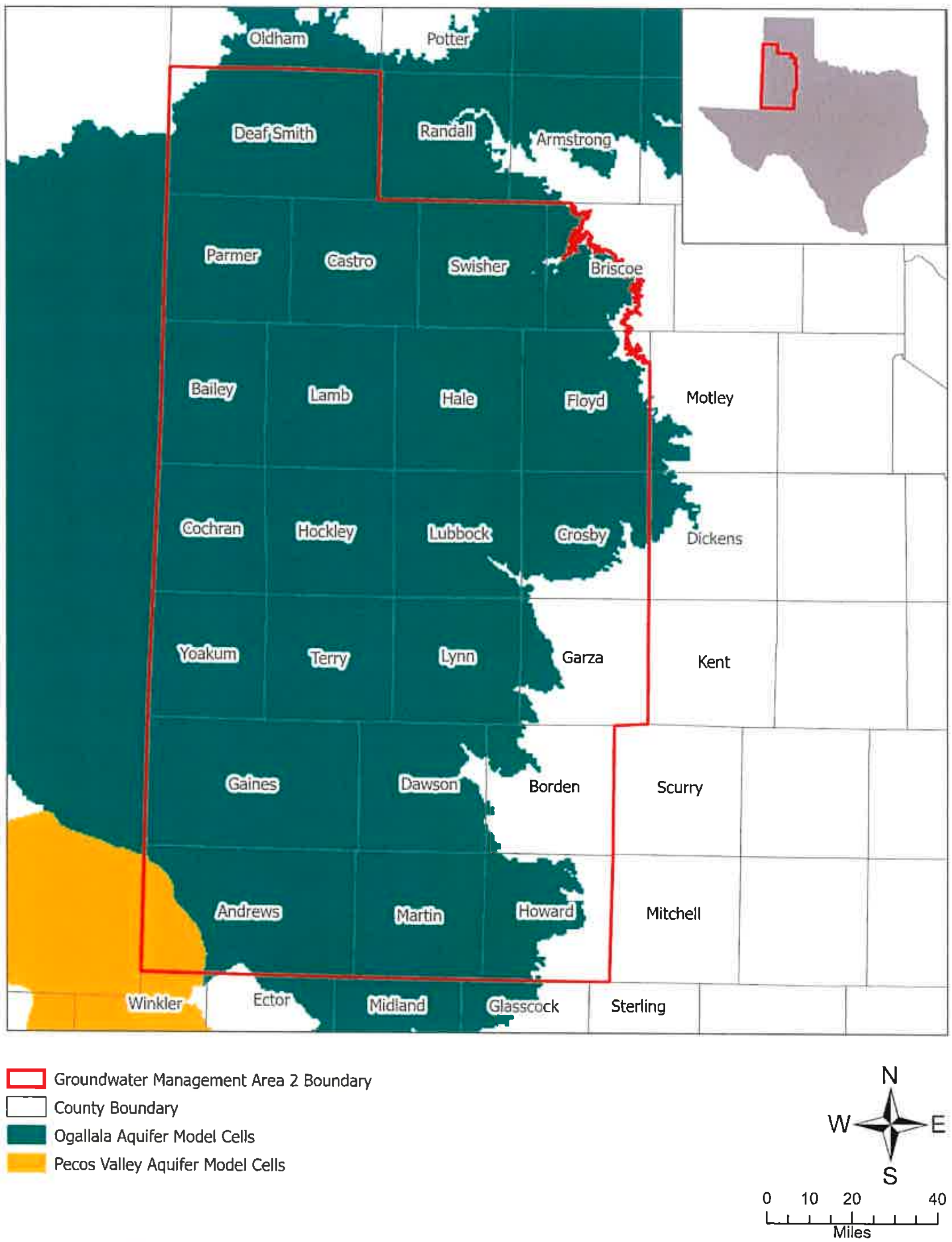

FIGURE 2. MAP SHOWING THE ACTIVE MODEL CELLS REPRESENTING THE OGALLALA AQUIFER AND THE PECOS VALLEY AQUIFER IN LAYER 1 OF THE HIGH PLAINS AQUIFER SYSTEM GROUNDWATER AVAILABILITY MODEL

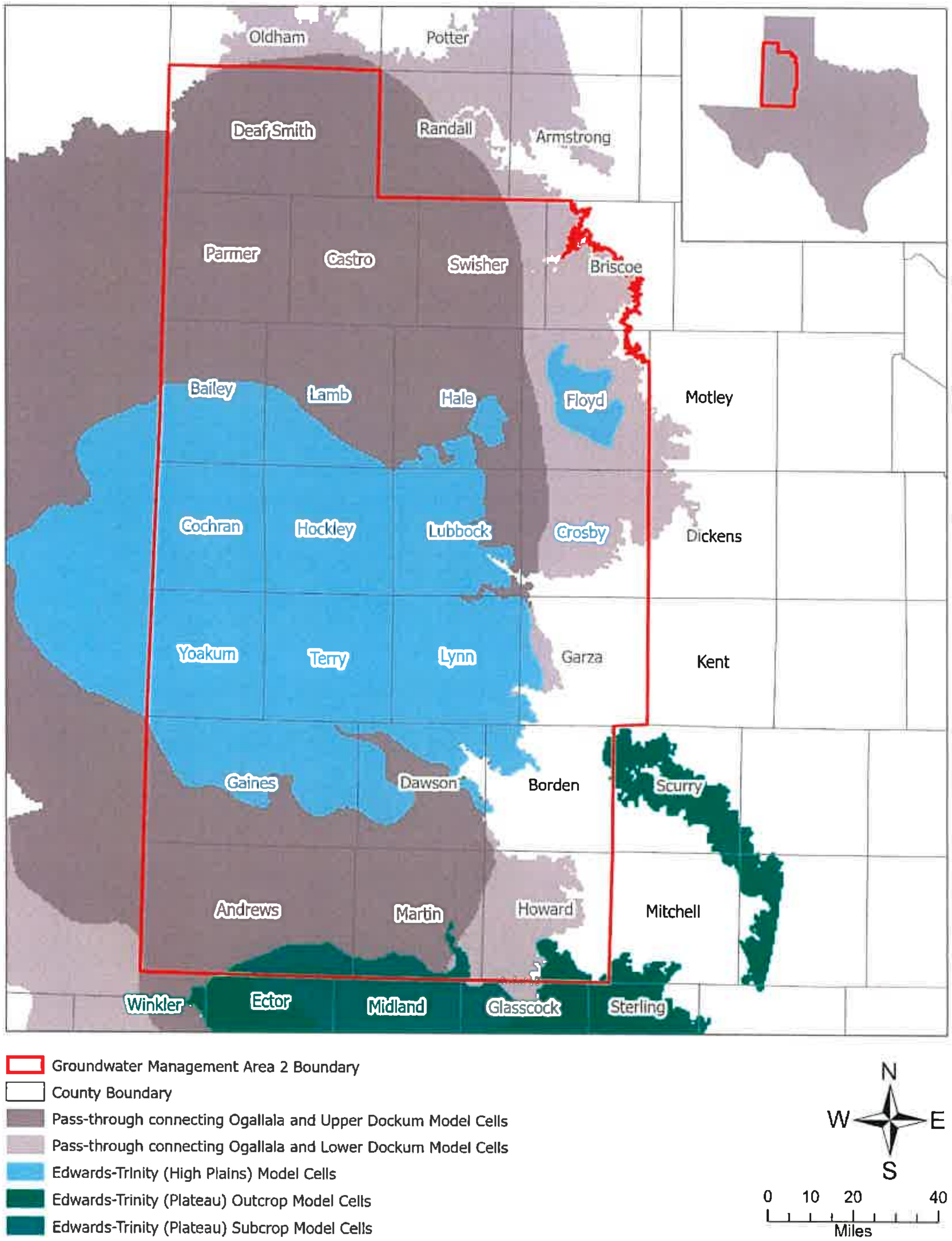

FIGURE 3. MAP SHOWING THE ACTIVE MODEL CELLS REPRESENTING THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER, THE EDWARDS-TRINITY (PLATEAU) AQUIFER, AND PASS-THROUGH CELLS IN LAYER 2 OF THE HIGH PLAINS AQUIFER SYSTEM GROUNDWATER AVAILABILITY MODEL

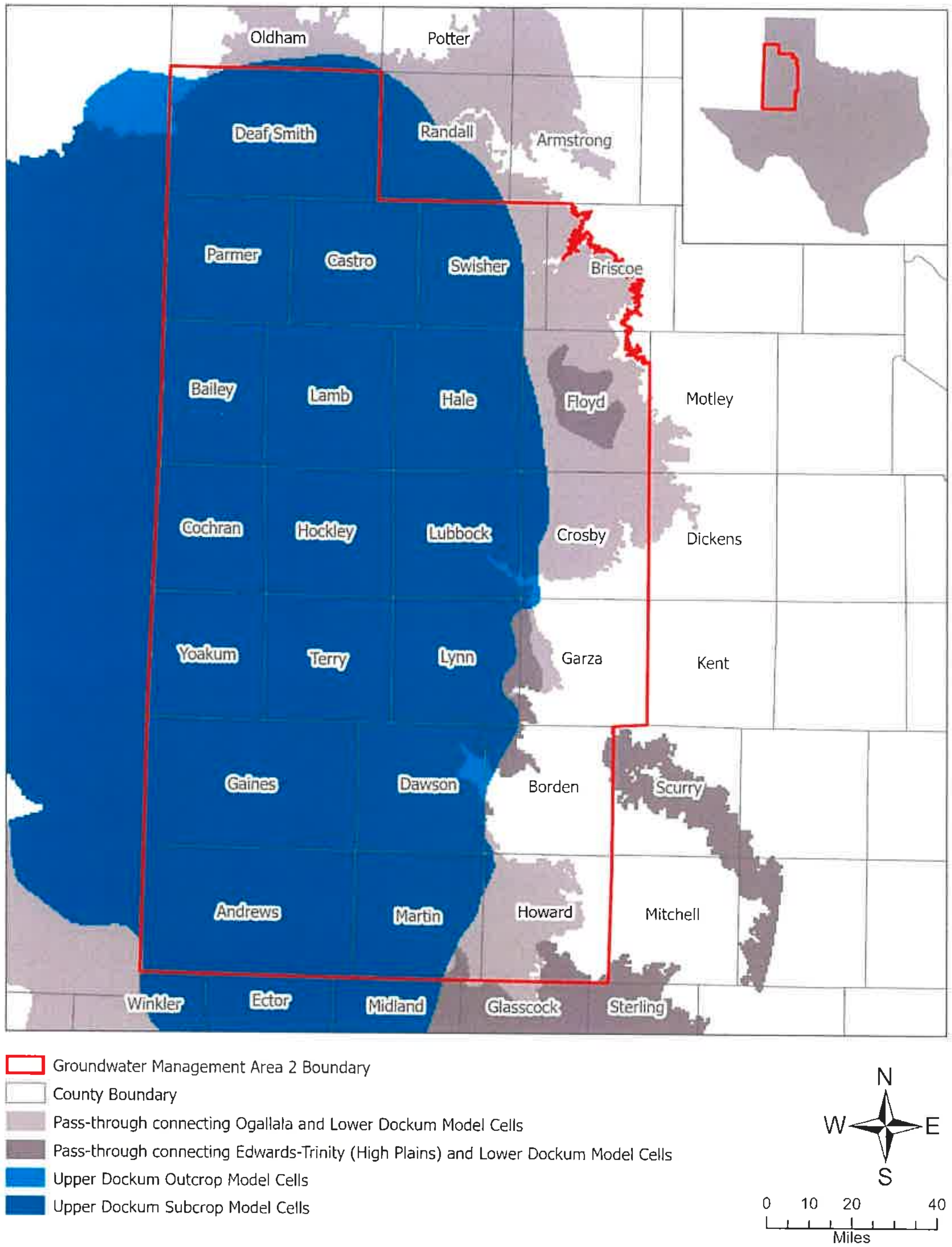

FIGURE 4. MAP SHOWING THE ACTIVE MODEL CELLS REPRESENTING THE UPPER PORTION OF THE DOCKUM AQUIFER AND PASS-THROUGH CELLS IN LAYER 3 OF THE HIGH PLAINS AQUIFER SYSTEM GROUNDWATER AVAILABILITY MODEL

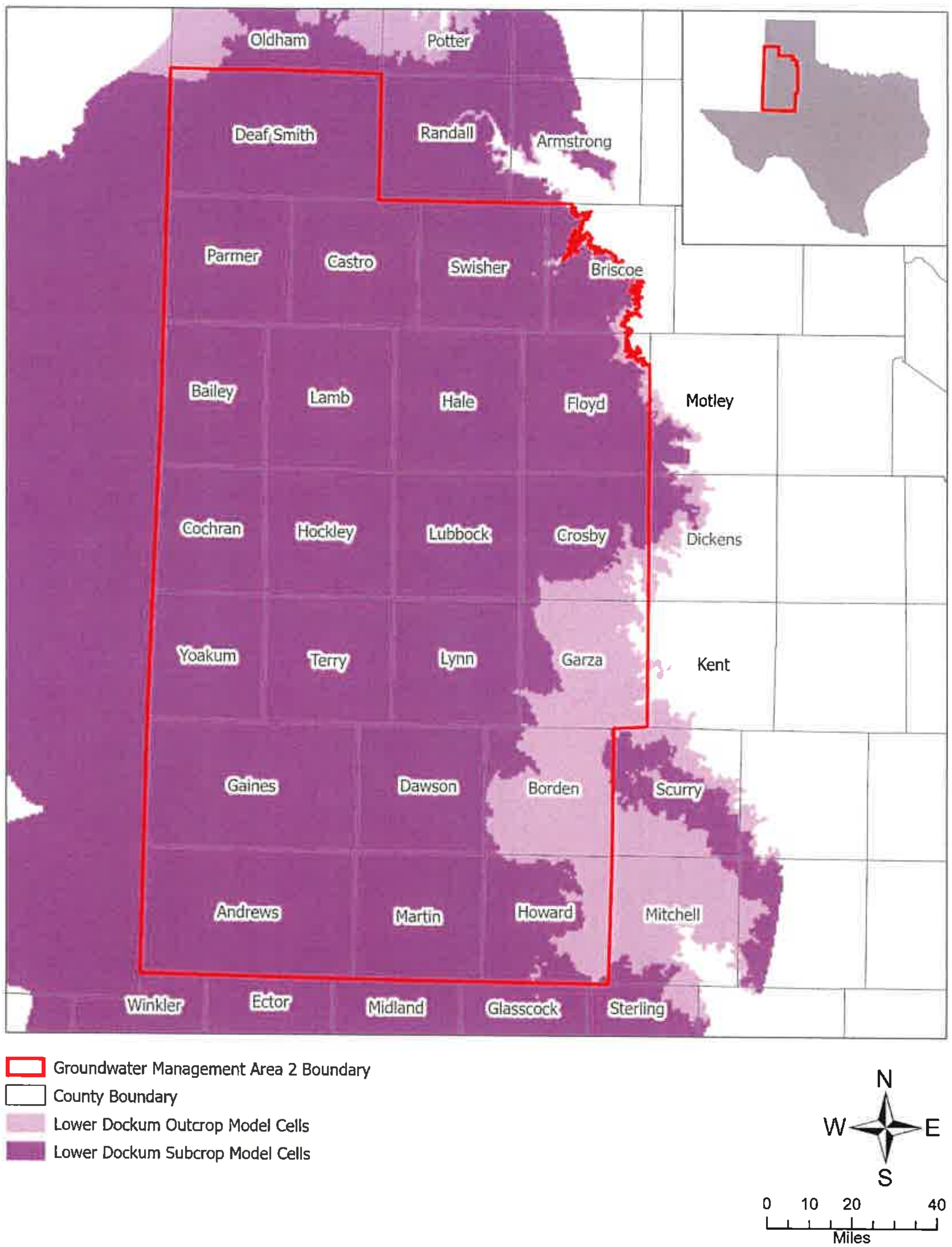

FIGURE 5. MAP SHOWING ACTIVE MODEL CELLS REPRESENTING THE LOWER PORTION OF THE DOCKUM AQUIFER IN LAYER 4 OF THE HIGH PLAINS AQUIFER SYSTEM GROUNDWATER AVAILABILITY MODEL

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.

REFERENCES:

Deeds, Neil E. and Jigmond, Marius, 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model: Prepared for Texas Water Development Board, 640 p., http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf .

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Appendix

B

Estimated Historical Water Use And 2017 State Water Plan Datasets:

Llano Estacado 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

April 12, 2020

GROUNDWATER MANAGEMENT PLAN DATA:

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

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

The five reports included in this part are:

1. Estimated Historical 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 4/12/2020. Although it does not happen frequently, either of these datasets are subject to change pending the availability of more accurate WUS data or an amendment to the 2017 SWP. District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The WUS dataset can be verified at this web address:

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

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

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

Estimated Historical Water Use

TWDB Historical Water Use Survey (WUS) Data

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

GAINES COUNTY

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2017	GW	2,921	337	6,178	0	305,058	289	314,783
	SW	0	0	0	0	0	32	32
2016	GW	2,683	336	5,124	0	325,473	129	333,745
	SW	0	0	0	0	0	14	14
2015	GW	2,722	363	4,851	0	312,119	128	320,183
	SW	0	0	0	0	0	14	14
2014	GW	3,165	513	5,056	0	304,582	139	313,455
	SW	0	0	0	0	0	15	15
2013	GW	3,374	655	5,109	0	360,353	137	369,628
	SW	0	0	0	0	0	15	15
2012	GW	3,588	517	5,166	0	424,388	180	433,839
	SW	0	0	0	0	0	20	20
2011	GW	3,866	522	5,378	0	404,205	203	414,174
	SW	0	0	0	0	0	23	23
2010	GW	3,353	1,512	5,221	0	318,882	194	329,162
	SW	0	0	160	0	0	22	182
2009	GW	3,159	5,027	1,806	0	344,607	187	354,786
	SW	0	0	451	0	0	21	472
2008	GW	3,014	4,364	2,770	0	496,890	203	507,241
	SW	0	0	742	0	0	23	765
2007	GW	2,773	77	1,406	0	381,479	113	385,848

	SW	0	0	0	0	0	13	13
2006	GW	3,106	60	1,537	0	385,340	369	390,412
	SW	0	0	0	0	0	41	41
2005	GW	3,001	65	1,537	0	394,580	506	399,689
	SW	0	0	0	0	0	56	56
2004	GW	2,893	56	1,559	0	413,261	419	418,188
	SW	0	0	0	0	0	104	104
2003	GW	3,190	88	1,453	0	391,496	539	396,766
	SW	0	0	0	0	0	135	135
2002	GW	3,089	78	1,512	0	470,616	617	475,912
	SW	0	0	0	0	0	154	154

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

GAINES COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
O	LIVESTOCK, GAINES	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.

GAINES COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
O	COUNTY-OTHER, GAINES	COLORADO	1,403	1,763	2,205	2,692	3,152	3,633
O	IRRIGATION, GAINES	COLORADO	379,779	360,000	341,251	323,477	306,629	292,238
O	LIVESTOCK, GAINES	COLORADO	238	250	262	276	289	304
O	MANUFACTURING, GAINES	COLORADO	2,278	2,386	2,489	2,578	2,722	2,874
O	MINING, GAINES	COLORADO	1,829	2,400	2,071	1,527	1,051	776
O	SEAGRAVES	COLORADO	419	430	447	470	485	502
O	SEMINOLE	COLORADO	2,348	2,571	2,847	3,160	3,411	3,675
	Sum of Projected Water Demands (acre-feet)		**388,294**	**369,800**	**351,572**	**334,180**	**317,739**	**304,002**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

GAINES COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
O	COUNTY-OTHER, GAINES	COLORADO	-253	-563	-1,155	-1,492	-1,952	-1,613
O	IRRIGATION, GAINES	COLORADO	-148,524	-193,401	-218,191	-233,497	-242,333	-266,837
O	LIVESTOCK, GAINES	COLORADO	2	0	3	4	1	-146
O	MANUFACTURING, GAINES	COLORADO	-310	-686	-1,007	-1,295	-1,604	-2,380
O	MINING, GAINES	COLORADO	-202	-604	-777	-692	-531	-463
O	SEAGRAVES	COLORADO	1	0	3	0	-15	-32
O	SEMINOLE	COLORADO	-548	-1,071	-1,347	-1,560	-1,611	-1,675
	Sum of Projected Water Supply Needs (acre-feet)		**-149,837**	**-196,325**	**-222,477**	**-238,536**	**-248,046**	**-273,146**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

GAINES COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, GAINES, COLORADO (O)							
GAINES COUNTY-OTHER LOCAL GROUNDWATER DEVELOPMENT	EDWARDS-TRINITY-HIGH PLAINS AQUIFER [GAINES]	600	600	1,500	1,500	2,000	1,622
		600	**600**	**1,500**	**1,500**	**2,000**	**1,622**
IRRIGATION, GAINES, COLORADO (O)							
GAINES COUNTY IRRIGATION WATER CONSERVATION	DEMAND REDUCTION [GAINES]	11,563	11,563	12,306	12,306	9,644	9,644
		11,563	**11,563**	**12,306**	**12,306**	**9,644**	**9,644**
SEAGRAVES, COLORADO (O)							
GAINES COUNTY - SEAGRAVES LOCAL GROUNDWATER DEVELOPMENT	EDWARDS-TRINITY-HIGH PLAINS AQUIFER [GAINES]	0	0	0	50	50	50
GAINES COUNTY - SEAGRAVES MUNICIPAL WATER CONSERVATION	DEMAND REDUCTION [GAINES]	20	9	0	0	0	0
		20	**9**	**0**	**50**	**50**	**50**
SEMINOLE, COLORADO (O)							
GAINES COUNTY - SEMINOLE GROUNDWATER DESALINATION	DOCKUM AQUIFER [GAINES]	500	500	500	500	500	500
GAINES COUNTY - SEMINOLE LOCAL GROUNDWATER DEVELOPMENT	EDWARDS-TRINITY-PLATEAU AQUIFER [ANDREWS]	0	1,000	1,000	1,000	1,000	1,000
GAINES COUNTY - SEMINOLE MUNICIPAL WATER CONSERVATION	DEMAND REDUCTION [GAINES]	117	129	142	158	171	184
		617	**1,629**	**1,642**	**1,658**	**1,671**	**1,684**
Sum of Projected Water Management Strategies (acre-feet)		**12,800**	**13,801**	**15,448**	**15,514**	**13,365**	**13,000**

Appendix C

GAM Run 19-017: Llano Estacado Underground Water Conservation District Groundwater Management Plan

Andrew Denham and Shirley Wade, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
(512) 936-0883
July 19, 2019

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Department and is responsible for oversight of work performed by Andrew Denham under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on July 19, 2019.

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GAM Run 19-017: Llano Estacado Underground Water Conservation District Groundwater Management Plan

Andrew Denham and Shirley Wade, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
(512) 936-0883
July 19, 2019

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2011), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator.

The TWDB provides data and information to the Llano Estacado 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 Llano Estacado Underground Water Conservation District should be adopted by the district on or before June 17, 2020 and submitted to the executive administrator of the TWDB on or before July 17, 2020. The current management plan for the Llano Estacado Underground Water Conservation District expires on September 15, 2020.

Information for the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers located within the Llano Estacado Underground Water Conservation District is from version 1.01 of the groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015).

This report replaces the results of GAM Run 14-002 (Kohlrenken, 2014), as GAM Run 19-017 includes results from the groundwater availability model for the High Plains Aquifer System (Deeds and Jigmond, 2015), which was released after GAM Run 14-002. Tables 1, 2, and 3 summarize the groundwater availability model data required by statute, and Figures 1, 2, and 3 show the area of the model from which the values in the table were extracted. If, after review of the figures, the Llano Estacado Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB immediately.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability model for the High Plains Aquifer System was used to estimate information for the Llano Estacado Underground Water Conservation District groundwater management plan. Water budgets were extracted and averaged for the historical model periods (1980 to 2012) for the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers. We used ZONEBUDGET Version 3.01 (Harbaugh, 2009) to extract water budgets from the model results. 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 represent the Ogallala Aquifer (Layer 1), the Edwards-Trinity (High Plains) Aquifer (Layer 2), and the Dockum Units (Layers 3 and 4). We lumped layers 3 and 4 for calculating water budgets in the Dockum Aquifer within the district.
- Water budgets for the aquifers within the district were averaged over the historical calibration period (1980 to 2012).
- 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. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers located within Llano Estacado Underground Water Conservation District and averaged over the historical calibration periods, as shown in Tables 1 through 3.

1. Precipitation recharge—the areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.
2. Surface water outflow—the total water discharging from the aquifer (outflow) to surface water features such as streams, reservoirs, and springs.
3. Flow into and out of district—the lateral flow within the aquifer between the district and adjacent counties.
4. Flow between aquifers—the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

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

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

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Dockum Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	3
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	8
Estimated net annual volume of flow between each aquifer in the district	From the Dockum Aquifer into other overlying units	1,889
	From the brackish[1] portions of the Dockum Group into the Dockum Aquifer	15

[1] The Dockum Aquifer extent is delineated where groundwater contains less than 5,000 mg/l total dissolved solids (Ashworth and Hopkins, 1995).

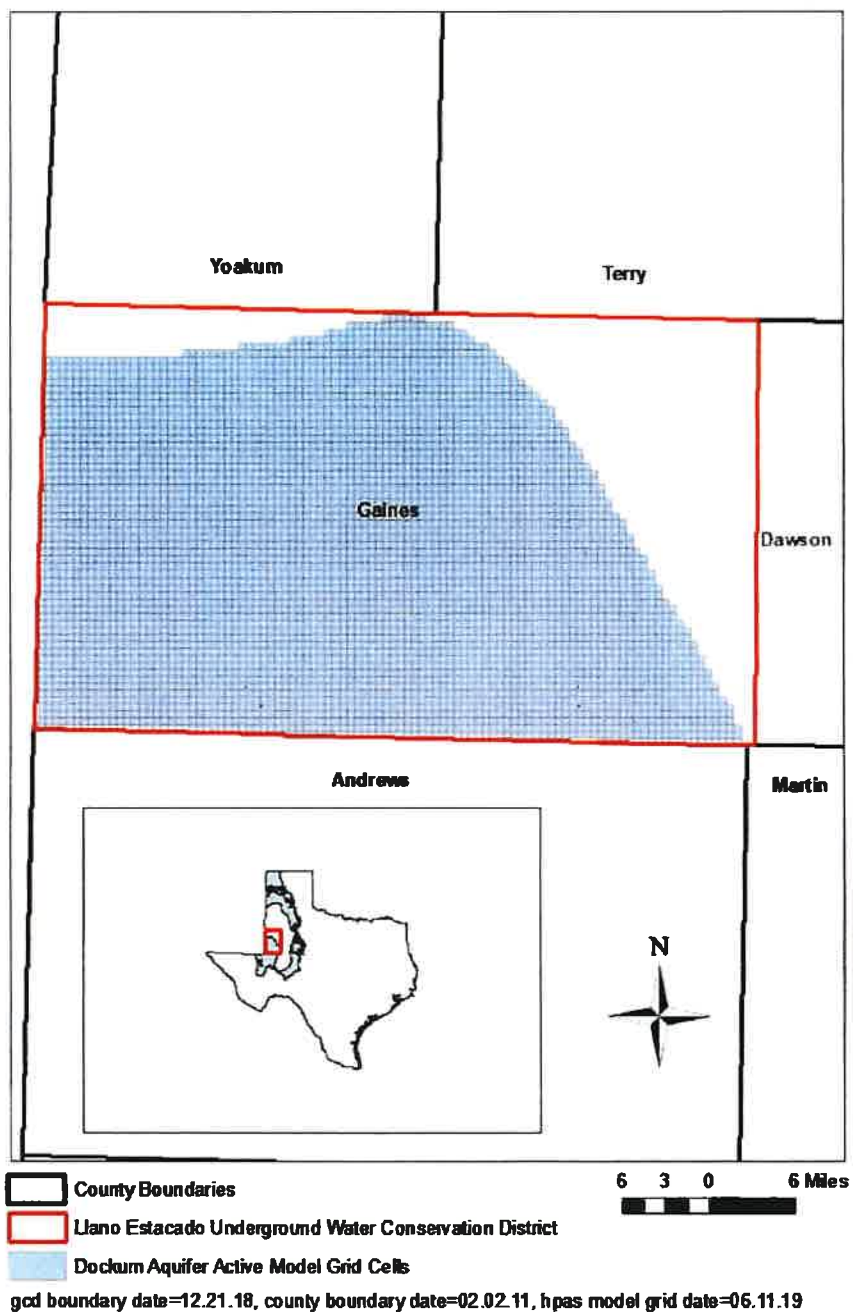

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER FOR LLANO ESTACADO 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	6,524
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (High Plains) Aquifer	389
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer into the Edwards-Trinity (High Plains) Aquifer	3,789
	From the Edwards-Trinity (High Plains) Aquifer into the Trinity and Fredericksburg Groups	996

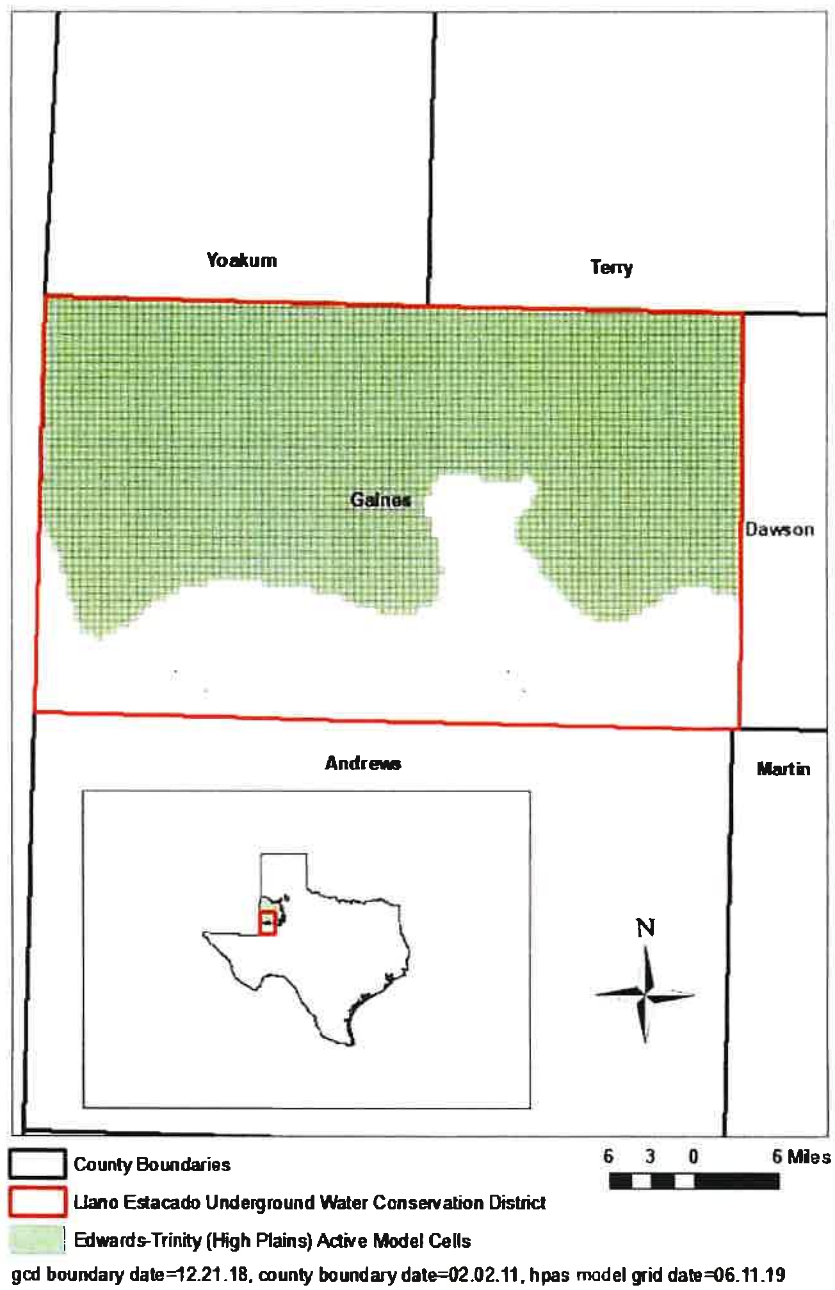

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE OGALLALA AQUIFER THAT IS NEEDED FOR THE LLANO ESTACADO 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	64,814
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ogallala Aquifer	2,304
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	10,299
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	3,120
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer into the Edwards-Trinity (High Plains) Aquifer and other underlying formations	2,174

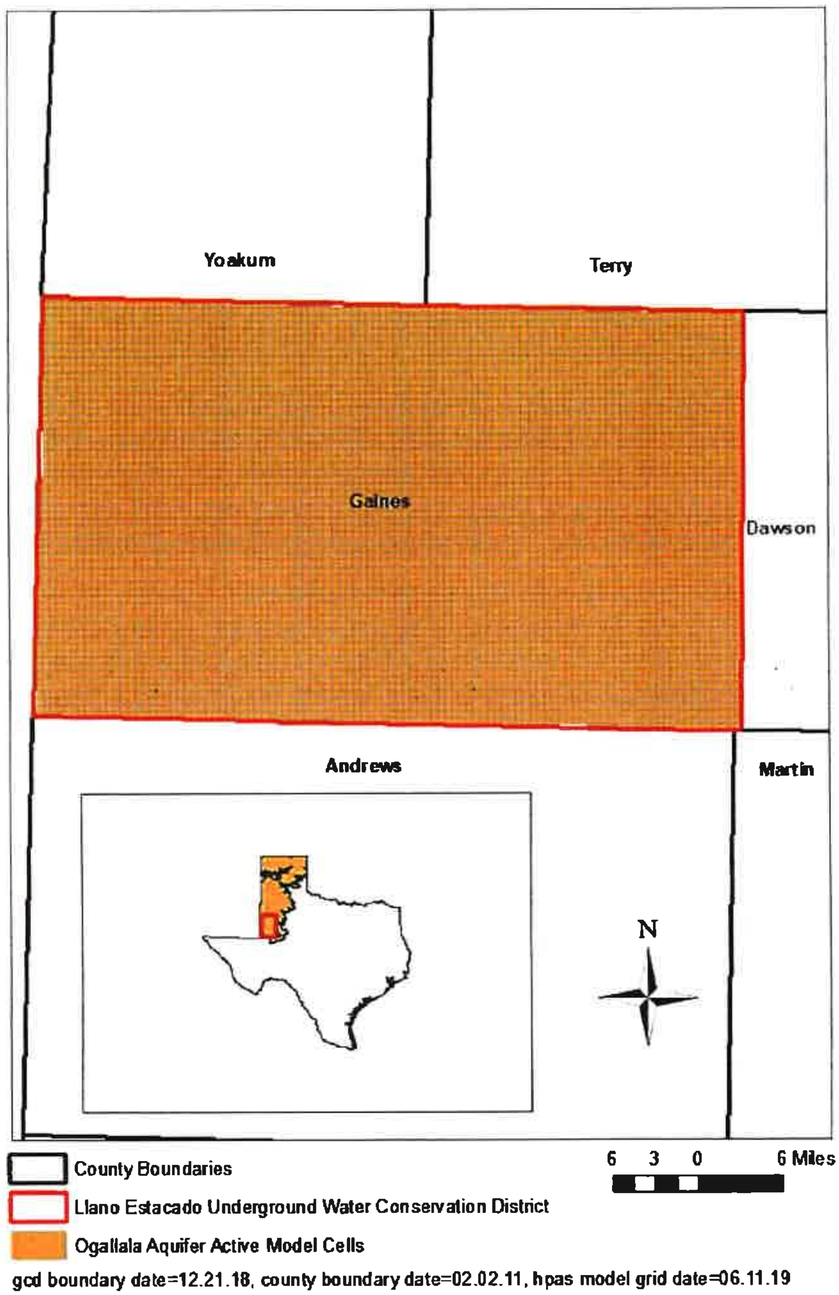

FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE OGALLALA AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS:

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

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

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

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

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

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