# LLANO ESTACADO

# UNDERGROUND

# WATER CONSERVATION

# DISTRICT

## MANAGEMENT
## PLAN
## 2015-2020

*Effective August 13, 2015*

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## 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 August 13, 2015, upon adoption by the Board of Directors (the Board) of the District and remains in effect until a revised plan is approved or until August 13, 2020, 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. The Board has adopted the principle of "education first" and regulation as a last resort in their effort to encourage conservation of the resource. As a result, the rules of the District were designed to give all landowners a fair and equal opportunity to use the groundwater resource underlying their property for beneficial purposes. If, at the request of the constituents of the District, more stringent management strategies are needed to better manage the resource, these strategies will be put in place after an extensive educational process and with the perceived majority approval of the constituents. The District will continue to monitor groundwater quality and quantity in order to better understand the dynamics of the aquifer systems over which it has jurisdiction.

This document is intended for use as a tool to provide continuity in the management of the District. District staff will use the plan as a guide to insure that all aspects of the goals of the District are accomplished. The Board will refer to it for future planning and as a document to measure performance of the District staff on an annual basis.

Conditions can change over time that may cause the Board to modify this document. The dynamic nature of this plan shall be maintained such that the District will continue to best serve 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.

One's goals, management objectives, and performance standards must be set at an attainable level in order to be realistic and effective. Lofty ideals penned in an effort to be "all things to all people" can be the first step toward disaster. Unreasonably elevated objectives foster potentially damaging results when the objective cannot be met due to a lack of resources; fiscal or technical. One's goals can also be set too low. Simplistic ideals can foster mediocrity. In both cases, the mission of the goal setting entity is thwarted and the benefactors of the same slighted. Although well meaning, when the failure to attain a goal is realized by those measuring performance, the initial response is to assume that those setting the goals were negligent in performing their duties when, in truth, the goals were unattainable from the start.

In the opinion of the Board, the goals, management objectives, and performance standards put forth in this planning document have been set at a reasonable level considering existing and projected fiscal and technical resources.  Conditions may change which could cause change in the management objectives defined to reach the stated goals. The following guidelines will be used to ensure that the management objectives are set at a sufficient level to be realistic and effective:

- The District's constituency will determine if the District's goals are set at a level that is both meaningful and attainable; through their voting right, the public will appraise the District's overall performance in the process of electing or re-electing Board members.
- The duly elected Board will guide and direct District staff and will gauge the achievement of the goals set forth in this document.
- The interests and needs of the District's constituency shall control the direction of the management of the District.
- The Board will maintain local control 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 on May 24, 1991, when Governor Ann Richards signed HB 530, 72nd Legislature, into law.  The District was confirmed, 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 l: Board of Directors of the Llano Estacado Underground Water Conservation District**

| Office | Name | Occupation | Term Ends |
|---|---|---|---|
| President | Jud Cheuvront | Active Farmer | May 2019 |
| Vice-President | Weldon Shook | Active Farmer | May 2017 |
| Secretary | Walter Billings | Active Farmer | May 2019 |
| Member | Charles Rowland | Active Farmer | May 2017 |
| Member | Robert Warren | Active Farmer | May 2017 |

The jurisdictional extent of the District is the same as Gaines County and covers approximately 1525 square miles of the Southern High Plains of Texas. Seminole (pop. 7,027), the county seat, is the largest municipality in the District. Seagraves (pop. 2,620) 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, alfalfa, and cucumbers.

Gaines County has long been known as one of the top producers of oil and gas in the state. In 2014, companies produced over 23,000,000 barrels of crude oil in the county.

## Topography and Drainage

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

Land surface elevation drops from 3,700 feet above sea level in the northwest corner of the District to 2,935 feet above sea level in the southeast corner of the District.

Several relic drainageways cross the District from northwest to southeast. These “draws” (Sulfur, McKenzie, Wordswell, Seminole, and Monument) are shallow and usually dry, seldom carrying runoff surface 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 wet-weather lakes, are 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. 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 primarily influenced by the rate of recharge to and discharge from the aquifer. Recharge to the aquifer occurs primarily by infiltration of precipitation falling on the surface. To a lesser extent, recharge may also occur by upward leakage from underlying Cretaceous units that, in places, have a higher potentiometric surface 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.

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 permeabilities.

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

The chemical quality of Ogallala groundwater varies greatly across the District. Total Dissolved Solids (TDS) values vary from less than 600 mg/L to over 6,000 mg/L. Generally, groundwater in the eastern and southeastern parts of the District exhibit 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. In some areas of the District, the Cretaceous and Ogallala Aquifers are hydrologically connected. Groundwater in the Cretaceous is generally fresh to slightly saline. Water quality deteriorates where Cretaceous formations are overlain by saline lakes.

Recharge of the Cretaceous occurs directly from the bounding Ogallala formation. Some upward movement of groundwater from the underlying Triassic Dockum formation may occur (Ashworth and Hopkins, 1995). As mentioned earlier, in many places the potentiometric surface of groundwater in the Cretaceous Aquifer is higher than 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. 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/meter (dS/m) to over 50.0 dS/m. Even the most salt tolerant row crops grown cannot withstand such levels of salinity.

Thus, 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 pumpage pressure from the freshwater sources.

## Surface Water Resources

The only fresh surface water occurring within the District are playa lakes. The playas play an important role in aquifer recharge and support some wildlife when rainfall events are significant enough to cause runoff to accumulate 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 associated opportunistic predators.

**Groundwater Availability Modeling (GAM) Run 14-002 data**
(refer to Appendix A)

**Estimated Historical Water Use and 2012 State Water Plan data**
(refer to Appendix B)

**Modeled Available Groundwater (MAG) data**
(refer to Appendix C)

## Total Amount of Groundwater Potentially Available for Use

The Texas Water Development Board (TWDB) estimated in 2013 that the total recoverable amount of groundwater in the Ogallala and Edwards-Trinity aquifer underlying Gaines County, Texas, was approximately 14.1 million acre-feet (GAM Task 13-026, 2013). The total useable amount of groundwater underlying the county in 2013 was, of course, dependent on the category of use because of quality and pumping depths limitations. That is, several areas within the county were thought to have had groundwater quality problems severe enough to preclude its use for any purpose. However, for the purposes of this plan, to meet the requirements of 36.1072(e)(3)(A), Texas Water Code, and until more accurate data becomes available, we will assume that all of the groundwater underlying the county was useable in 2013 even though we suspect that not to be the case. Please note that the information shown should be used only as a guide, and becomes less and less representative of actual conditions the further one looks into the future.

## Management of Groundwater Resources

The District will endeavor to manage groundwater resources over which it has jurisdiction in order to conserve the resource while seeking to maintain the economic viability of the District's constituents. A water level monitoring network will be established in order to track changes in the total volume of groundwater in storage each year. Likewise, a water quality monitoring network will be established in order to track water quality changes each year. The District will employ all technical resources at its disposal to monitor and evaluate the groundwater resource. Programs to encourage conservation of groundwater will be designed and implemented as need dictates.

In October 1999, the Board, after notice and hearing, adopted the rules of the District. The rules address conservation of the groundwater resources of the District through: well permitting, well spacing, well registration, well completion, pumping limitations, open well capping, and standards for plugging wells. As conditions dictate, and with the approval of the constituents of the District, the Board will consider the modification of the rules to further the mission of the District. When considering modification or enforcement of the rules, the Board will base its decisions on the best technical evidence available. All constituents will be treated equally and fairly when applying the rules of the District. The link to the District's website is: **www.llanoestacadouwcd.org/rules.html**

## Actions, Procedures, Performance and Avoidance for Plan Implementation

The District will implement the provisions of this plan and will utilize the provisions of this plan as a guidepost for determining the direction or priority for all District activities. All operations of the District, all agreements entered into by the District and any additional planning efforts in which the District may participate will be consistent with the provisions of this plan.

The District has rules relating to the permitting of wells and the production of groundwater. The rules adopted by the District shall be pursuant to TWC § 36 and the provisions of this plan. All rules will be adhered to and enforced. The promulgation and enforcement of the rules will be based on the best technical evidence available.

The District shall treat all citizens with equality. Citizens may apply to the District for discretion in enforcement of the rules on grounds of adverse economic effect or unique local conditions. In granting of discretion to any rule, the Board shall consider the potential for adverse effect on adjacent landowners. The exercise of said discretion by the District Board shall not be construed as limiting the power of the District Board.

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

## 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 an 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 anyway 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.

## Legislative Activity

The 75th Texas Legislature officially recognized groundwater districts as the preferred method of managing groundwater resources (36.0015, Texas Water Code). Since its inception, the District has attempted to communicate with national and state lawmakers to ensure that the property rights and other groundwater related interests of its constituents are protected. The Board will continue to support the District's participation in the legislative process, to the greatest extent fiscally possible, to ensure that the interests of the District's constituency are represented. The District will attempt to keep the constituents informed of legislative activities through news releases, newsletters, and public speaking engagements.

## Weather Modification

The District participated in a weather modification program from 2002 - 2012. The District was a participant in the Southern Ogallala Aquifer Rainfall Enhancement (SOAR) program, which was administered by the Sandy Land UWCD.

The Llano Estacado UWCD Board of Directors believes that weather modification is a management tool that can help relieve some pressure from our groundwater resources. Rainfall at crucial points of the growing season may mean significantly less groundwater used for irrigation. Additionally, the Board hopes that the benefits of convective cloud seeding will contribute to enhanced recharge of the groundwater resources.
Weather modification operation were suspended in 2013 due to insufficient operational area.

## 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 of the end of each fiscal year. 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** Annually, measure the depth to water in the District's water level monitoring network; record all measurements and/or observations; enter all measurements into District's computer database; file all field notes in District's filing system; maintain a network of measurement wells.

**Performance Standards**

**1.01a** Water level monitoring wells for which measurements were recorded each year
**1.01b** Water level monitoring wells for which field notes were written describing reason for inability to attain measurements each year
**1.01c** Number of data records entered into District's data base each year
**1.01d** Number of water level measurement wells for which field notes are filed in District's filing system each year
**1.01e** Number of wells in the water level measurement network each year
**1.01f** Number of wells added to the network, if required, each year

**Management Objective-Technical Field Services**

**1.02** Provide technical field services including, but not limited to: flow testing, drawdown measurement, sprinkler pattern efficiency testing, and water management strategy consultation. Record any observations, measurements, etc. in field log. Enter recorded information in District's database.

**Performance Standards**

**1.02a** Number of field service test performed, as evidenced by field log, each year
**1.02b** Number of records entered into District's computer database each year

**Management Objective-Laboratory Services**

**1.03** Provide basic water quality testing services. Maintain a record of tests performed by entering the results in the District's database. Communicate results of analyses to well owners.

**Performance Standards**

**1.03a** Number of laboratory service tests
**1.03b** Number of records entered into District's database each year
**1.03c** Number of results communicated to well owners

**Management Objective – Irrigation Monitoring**

**1.04** Monitor seasonal irrigation applications using a network of cooperative producers. Prepare monthly reports for cooperators that include the seasonal irrigation applications. Acquire yield data and analyze crop water use efficiency.

**Performance Standards**

**1.04a** Number of irrigation systems in the cooperative program
**1.04b** Number and type of crops monitored
**1.04c** Average irrigation application by crop

**Management Objective-Center Pivot Inventories**

**1.05** Beginning in 2002, and again every five years thereafter, perform a physical inventory of the number and type of all irrigation systems in the District. Note which center pivot irrigation systems have Low Energy Precision Application (LEPA) spaced nozzles as a measure of adoption of more efficient irrigation technology. Enter data in District's database file by block and section.

**Performance Standards**

**1.05a** Number of irrigation systems recorded each documenting period
**1.05b** Percentage of center pivot irrigation systems with LEPA spaced nozzles each documenting period
**1.05c** Number of active irrigation systems by type in District's database

## 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, and well registrations for the drilling of exempt water wells. Inspect all well sites to be assured that the District's completion and spacing standards are met. Send written notification to the well owner if the well initially fails to meet standards. The Board will vote on final approval of the permit at the next regularly scheduled meeting after the well site has been inspected and District well completion standards have been met.

### Performance Standards

**2.01a** Number of water well drilling permits issued each year
**2.01b** Number of well sites inspected after well completion each year
**2.01c** Number of well sites that initially fail to meet the standards of the District each year

## 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 reports shall be filed on forms provided by the District in order to track the progress of the closure process. The District will contact the party responsible for the open, deteriorated or uncovered well within 30 days of same being reported. The site will be inspected after notification to ensure the well closure process occurs within 60 days of the initial contact with the responsible party. If the well is not closed by the end of the 60 day period, the District will pursue the available options at its disposal and remedy the well violation.

### Performance Standards

**2.02a** Number of open, deteriorated or uncovered wells
**2.02b** Number of initial inspections accomplished each year
**2.02c** Average number of days required to make initial contact with responsible party each year
**2.02d** Average number of days required to complete closure of open or uncovered wells each year
**2.02e** Number of wells remaining open or uncovered after 60 day period that are closed in accordance with District rules each year

## Management Objective-Maximum Allowable Production

**2.03** The District will investigate reports of groundwater in excess of the maximum production allowable under the District's rules. Investigation of each occurrence shall occur within 30 days of receiving the report. Each case will be remedied in accordance with District rules.

**Performance Standards**

**2.03a** Number of reports
**2.03b** Average amount of time taken to investigate reports each year
**2.03c** Number of incidences where violations occurred and violators were required to change operations to be in compliance with District rules each year

**Management Objective-Water Quality Monitoring**

**2.04** Conduct a District–wide water quality testing program. The results of the quality monitoring program will be published in map form, entered in to the District's computer database, and will be made available to the public.

**Performance Standards**

**2.04a** Number of samples collected and analyzed each year
**2.04b** Percent of previously sampled wells that were sampled in the current testing year.
**2.04c** Number of maps made available to the public each year
**2.04d** Number of analyses entered into District's computer database each year

## Goal 3.0 Addressing Drought Conditions

For educational purposes, the link to the TWDB drought page which has much useful information. That link is: **http://waterdatafortexas.org/drought/**

**Management Objective-Rain Gauges**

**3.01** Maintain a network of rain gauges in the District. Publish monthly and yearly rainfall totals on the District's web site

**Performance Standards**

**3.01a** Number of rain gauges in the network

**3.01b** Number of monthly rain gauge readings

## <u>Goal 4.0</u> Addressing Conservation

**<u>Management Objective</u> – Classroom Education**

**4.01** The District will make water conservation education curriculum available to schools within the District. Annually, the District will sponsor water conservation education book covers for public schools within the District.

**<u>Performance Standards</u>**

**4.01a** Number of schools where water conservation curriculum is made available each year
**4.01b** Number of book covers distributed to each school each year

**<u>Management Objective</u>-News Releases**

**4.02** District staff will prepare a minimum of two news releases addressing groundwater protection and / or conservation.

**<u>Performance Standard</u>**

**4.02a** Number of news releases prepared for publication in local newspapers.

**<u>Management Objective</u>-Public Speaking Engagements**

**4.03** The District staff and/or directors shall present a minimum of four programs concerning groundwater protection and / or conservation.

**<u>Performance Standard</u>**

**4.03a** Number of programs

**<u>Management Objective</u>-Printed Material Resource Center and Technical File**

**4.04** Maintain a self-service printed material resource center in the District office. Conduct an annual inventory items. Through the inventory process, determine the number and type of materials procured from the center by the public each year. Maintain a technical filing system of resource materials and annually record the number of copies procured from the technical file by the public.

**<u>Performance Standards</u>**

**4.04a** Number of items by type procured by the public from the resource center each year
**4.04b** Number of items copied and given to the public from the technical file each year

**<u>Management Objective</u>-Saturated Thickness Maps**

**4.05** Every 5 years, beginning 2005, provide saturated thickness maps that show the varying thickness of groundwater remaining in storage.

**<u>Performance Standards</u>**

**4.05a** Number of saturated thickness maps displayed and/or printed at the District office

**<u>Management Objective</u>-Conservation Literature**

**4.06** Maintain a portion of the District's material resource center devoted to water conservation. Stock this portion with conservation tips for both home water conservation and farm conservation

**<u>Performance Standards</u>**

**4.06a** Number of brochures/periodicals dedicated to conservation
**4.06b** Number of conservation brochures/periodicals obtained by the public

## <u>Goal 5.0</u> Addressing Rainwater Harvesting

**<u>Management Objective</u> – Public Awareness Program**

**5.01** The District will conduct an educational program for this conservation strategy at least once a year

**Performance Standards**

**5.01a** Document the type of program conducted (i.e. newsletter article, public presentation)

## Goal 6.0 Addressing Precipitation Enhancement

**6.01a** While the District did participate in this program for twelve years, the program has been dissolved. Therefore this goal is not applicable.

## Goal 7.0 Controlling and Preventing Subsidence

This goal is not applicable to the District because there is no surface water in our district. Referenced in Chapter 36, Texas Water Code. TWC § 36.1071 (a) (3)

## Goal 8.0 Addressing Conjunctive Surface Water Management Issues

This goal is not applicable to the District because there is no fresh surface water in our district. Referenced in Chapter 36, Texas Water Code. TWC § 36.1071 (a) (4)

## Goal 9.0 Addressing Natural Resource Issues

This goal is not applicable to the District because there is no fresh surface water in our district. Referenced in Chapter 36, Texas Water Code. TWC § 36.1071 (a) (5)

## Goal 10.0 Addressing Recharge Enhancement

**10.01** A review of past work conducted by others indicates this goal is not appropriate at present. 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 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 Desired Future Condition of the Aquifers

**Desired Future Conditions (DFCs) were adopted in August 2010.**
**The adopted values are:**

- The Ogallala/Trinity-Edwards Aquifer System: Average Drawdown less than 75 feet in 2060;
- The Dockum Aquifer: Average Drawdown less than 40 feet in 2060.

**Management Objective – Calculate Annual Drawdown**

**12.1** The District will calculate the average annual drawdown using the results of the annual water level measurement program and any well measurements made by the TWDB.

**Performance Standards**

**12.01a** Present the average annual drawdown results to the District Board in the Annual Hydrograph Report
**12.01b** Present the average annual drawdown results to the District Board in the District Annual Report

**<u>Management Objective</u> – Calculate Cumulative Drawdown**

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

**<u>Performance Standards</u>**

**12.02a** Present the cumulative drawdown results to the District Board in the Annual Hydrograph Report.
**12.01b** Present the cumulative drawdown results to the District Board in the District Annual Report.

## References


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GAM Task 13-026 TWDB Estimated Recoverable Storage for Aquifers in Groundwater Management

Area 2 September 19, 2013

Llano Estacado UWCD 2013-2014 Irrigation System Survey

# Appendix A

# GAM Run 14-002: Llano Estacado Underground Water Conservation District Management Plan

by William Kohlrenken
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June 30, 2014

*Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by William Kohlrenken under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on June 30, 2014.*

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# GAM RUN 14-002: LLANO ESTACADO UNDERGROUND WATER CONSERVATION DISTRICT MANAGEMENT PLAN

by William Kohlrenken
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Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-8279
June 30, 2014

## *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. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

- the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
- for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers; and
- the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

This report—Part 2 of a two-part package of information from the TWDB to the Llano Estacado Underground Water Conservation District—fulfills the requirements noted above. Part 1 of the two-part package is the Historical Water Use/State Water Plan data report. The District will receive this data report from the TWDB Groundwater Technical Assistance Section. Questions about the data report can be directed to Mr. Stephen Allen, stephen.allen@twdb.texas.gov, (512) 463-7317.

The groundwater management plan for the Llano Estacado Underground Water Conservation District should be adopted by the district on or before May 12, 2015 and submitted to the executive administrator of the TWDB on or before June 11, 2015. The current management plan for the Llano Estacado Underground Water Conservation District expires on August 10, 2015.

This report discusses the methods, assumptions, and results from model runs using the groundwater availability models for the Dockum Aquifer, and the Edwards-Trinity (High Plains) Aquifer and the southern portion of the Ogallala Aquifer. This model run replaces the results of GAM Run 09-18 (Oliver, 2009). GAM Run 14-002 meets current standards set after the release of GAM Run 09-18. Tables 1 through 3 summarize the groundwater availability model data required by statute, and Figures 1 through 3 show the area of the models from which the values in the 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 Dockum Aquifer and the groundwater availability model for the southern portion of the Ogallala Aquifer and Edwards-Trinity (High Plains) Aquifer were run for this analysis. Llano Estacado Underground Water Conservation District water budgets were extracted for the historical model period (1980 through 1997 for the Dockum Aquifer and 1980 through2000 for the southern portion of the Ogallala Aquifer and Edwards-Trinity (High Plains) Aquifer) 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 inter-aquifer flow (upper), and net inter-aquifer flow (lower) for the portion of the aquifer located within the district is summarized in this report.

## *PARAMETERS AND ASSUMPTIONS:*

### *Dockum Aquifer*

- We used version 1.01 of the groundwater availability model for the Dockum Aquifer. See Ewing and others (2008) for assumptions and limitations of the groundwater availability model for the Dockum Aquifer.

- This groundwater availability model includes three layers which generally represent the Ogallala, Edwards-Trinity (High Plains), Edwards-Trinity

(Plateau), Pecos Valley, and Rita Blanca aquifers (Layer 1), the upper portion of the Dockum Aquifer (Layer2), and the lower portion of the Dockum Aquifer (Layer 3 – referred to as the brackish/saline portion of the Dockum Formation in Table 1).

- The geologic units represented in Layer 1 of the groundwater availability model are only included in the model for the purpose of more accurately representing flow between these units and the Dockum Aquifer. This model is not intended to explicitly simulate flow in these overlying units (Ewing and others, 2008).
- The MODFLOW Drain package was used to simulate both evapotranspiration and springs. Only drain flow from model grid cells representing springs within the district were incorporated into the surface water outflow values shown in Table 1.
- Groundwater in the Dockum Aquifer ranges from fresh to brine in composition (Ewing and others, 2008). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh, total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish, and total dissolved solids greater than 35,000 milligrams per liter are considered brines.
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

***Southern portion of the Ogallala Aquifer and Edwards-Trinity (High Plains) Aquifer***

- Version 2.01 of the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer was used for this analysis. This model is an expansion on and update to the previously developed southern portion of the Ogallala Aquifer described in Blandford and others (2003). See Blandford and others (2008) and Blandford and others (2003) for assumptions and limitations of the model.
- The model includes four layers representing the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer. The units comprising the Edwards-Trinity (High Plains) Aquifer (primarily Edwards, Comanche Peak, and Antlers Sand formations) are separated from the overlying Ogallala Aquifer by a layer of Cretaceous shale, where present. Water budgets for the district have been determined for the Ogallala

Aquifer (Layer 1), as well as the Edwards-Trinity (High Plains) Aquifer (Layer 2 through Layer 4, collectively).

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

## *RESULTS:*

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the model results for the aquifers located within the district and averaged over the duration of the calibration and verification portion of the model run in the district, as shown in Tables 1 through 3.

- 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 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 or confining unit and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs. “Inflow” to an aquifer from an overlying or underlying aquifer will always equal the “Outflow” from the other aquifer.

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 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 | 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 | 567 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Dockum Aquifer | 370 |
| Estimated net annual volume of flow between each aquifer in the district | From the Dockum Aquifer into other overlying units | 1,251 |
| | From the brackish/ saline portions of the Dockum Formation into the Dockum Aquifer | 510 |

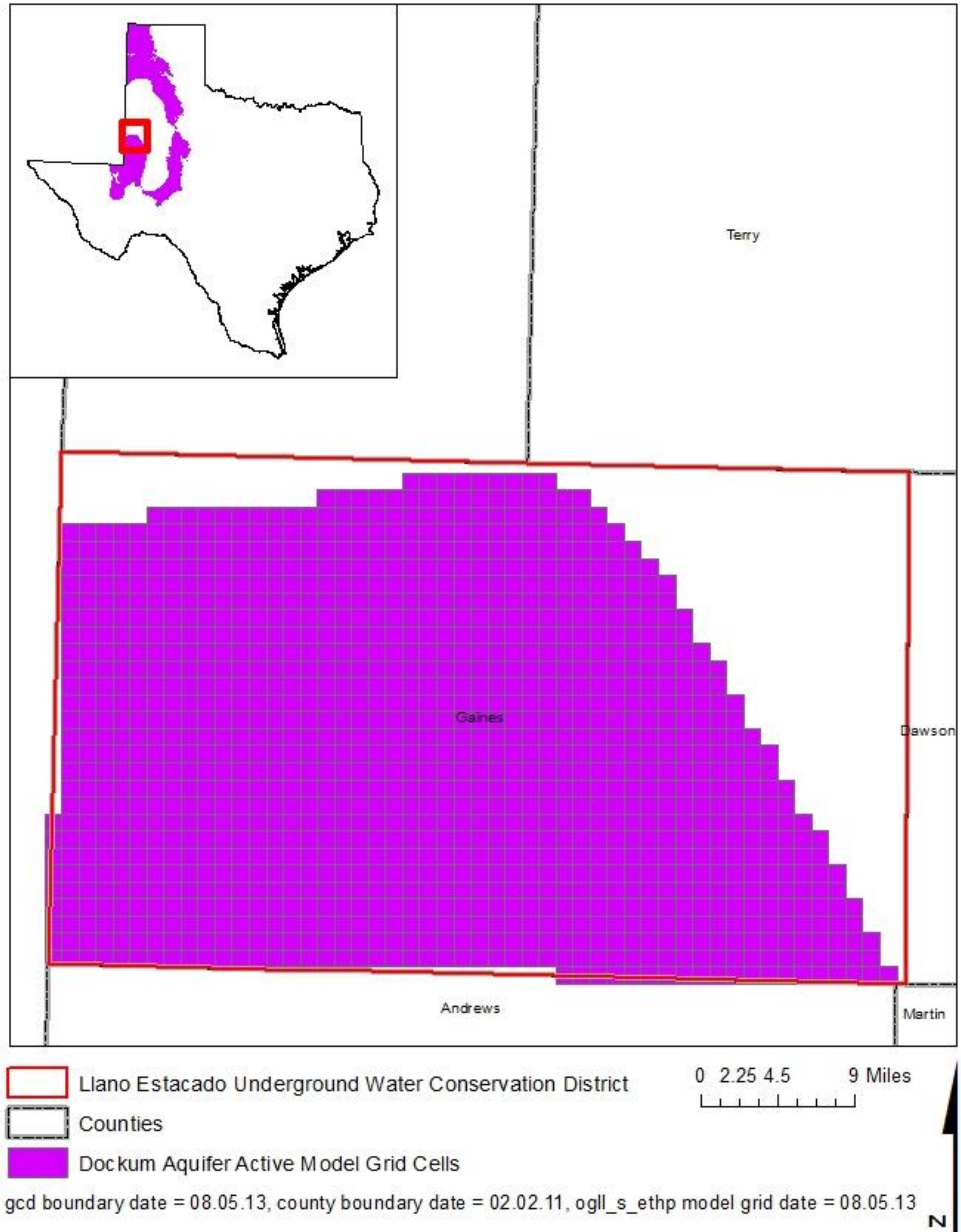


**FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE DOCKUM AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).**

**TABLE 2: SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (HIGH PLAINS) 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 | 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 | 55 |
| Estimated annual volume of flow into the district within each aquifer in the district | Edwards-Trinity (High Plains) Aquifer | 781 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Edwards-Trinity (High Plains) Aquifer | 311 |
| Estimated net annual volume of flow between each aquifer in the district | From the Ogallala Aquifer into the Edwards-Trinity (High Plains) Aquifer | 33,219 |
| | From the Edwards and Trinity Groups into the Edwards-Trinity (High Plains) Aquifer | 167 |

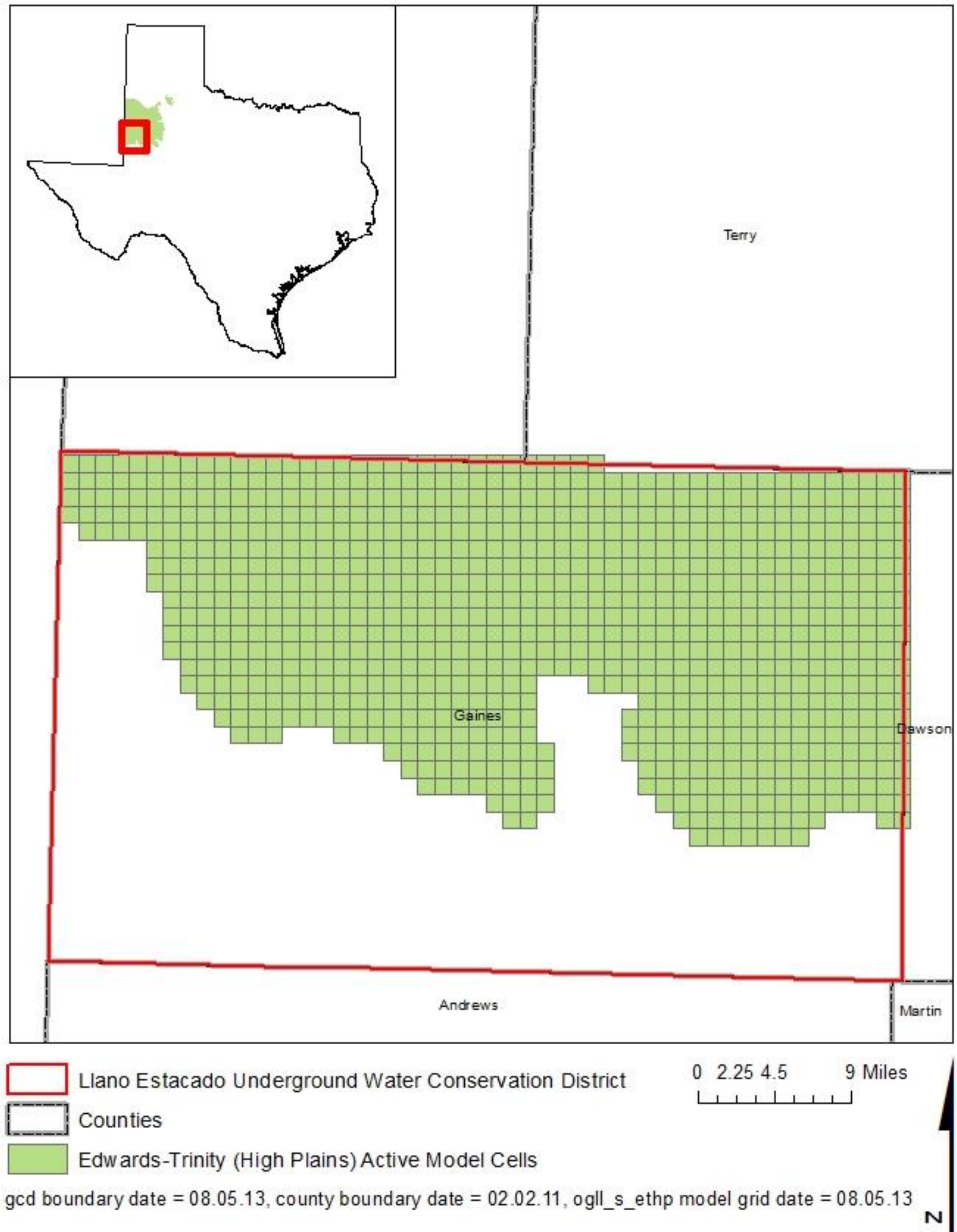


**FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).**

**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 | 93,247 |
| Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers | Ogallala Aquifer | 2,338 |
| Estimated annual volume of flow into the district within each aquifer in the district | Ogallala Aquifer | 4,638 |
| Estimated annual volume of flow out of the district within each aquifer in the district | Ogallala Aquifer | 5,969 |
| 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 | 33,497 |

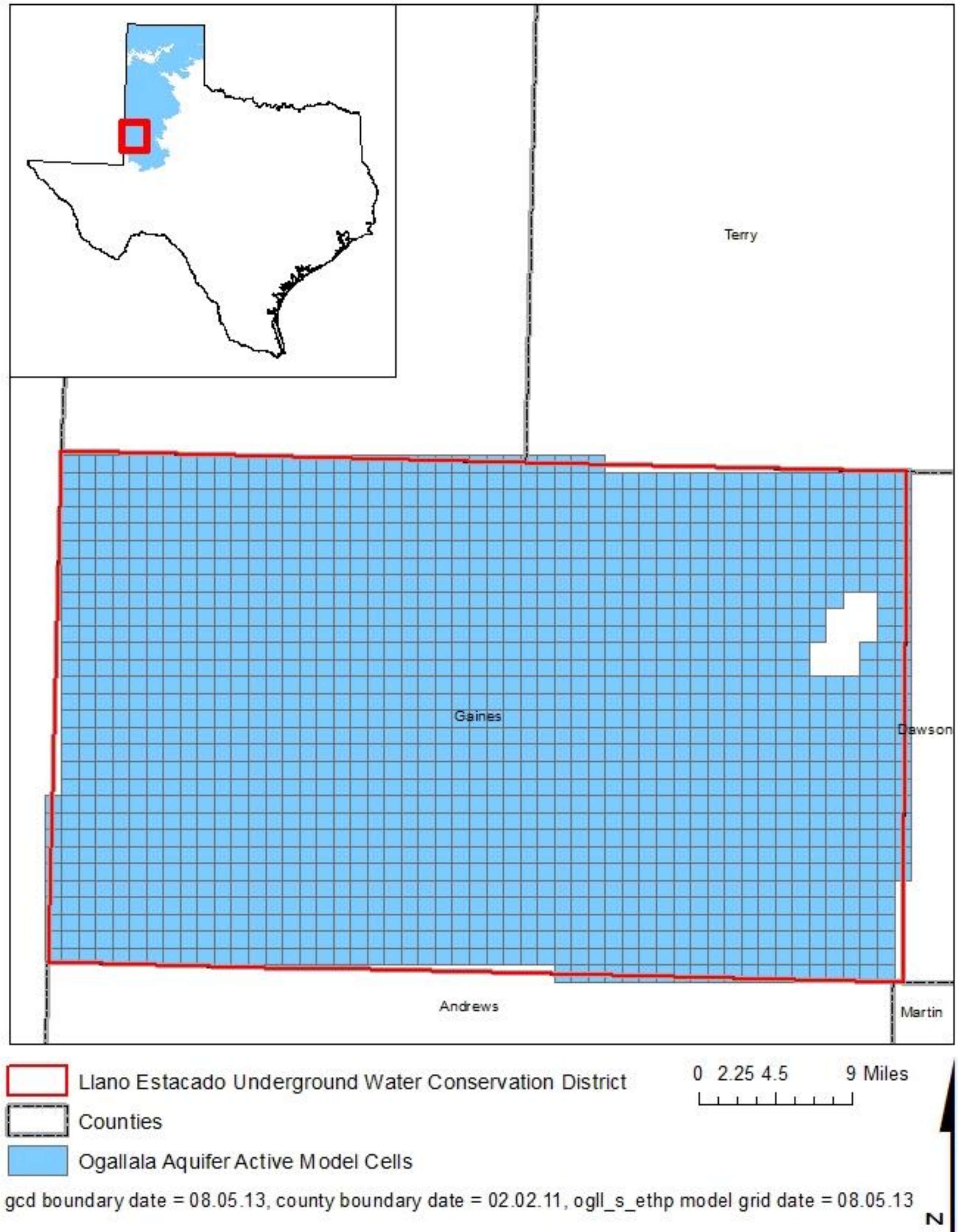


**FIGURE 3: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE OGALLALA AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE OGALLALA AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).**

## *LIMITATIONS:*

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

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

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

Blandford, T.N., Blazer, D.J., Calhoun, K.C., Dutton, A.R., Naing, T., Reedy, R.C., and Scanlon, B.R., 2003, Groundwater availability of the southern Ogallala aquifer in Texas and New Mexico—Numerical simulations through 2050: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 158 p., http://www.twdb.texas.gov/groundwater/models/gam/ogll_s/OGLL_S_Full_Report.pdf.

Blandford, T.N., Kuchanur, M., Standen, A., Ruggiero, R., Calhoun, K.C., Kirby, P., and Shah, G., 2008, Groundwater availability model of the Edwards-Trinity (High Plains) Aquifer in Texas and New Mexico: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 176 p., http://www.twdb.texas.gov/groundwater/models/gam/ethp/ETHP_Model_Report.pdf.

Ewing, J.E., Jones, T.L., Yan, T., Vreughdenhil, A.M., Fryar, D.G., Pickens, J.F., Gordon, K., Nicot, J.P., Scanlon, B.R., Ashworth, J.B., and Beach, J., 2008, Groundwater Availability Model for the Dockum Aquifer – Final Report: contract report to the Texas Water Development Board, 510 p., http://www.twdb.texas.gov/groundwater/models/gam/dckm/DCKM_Model_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.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model-User guide to modularization concepts and the ground-water flow process: U.S. Geological Survey, Open-File Report 00-92.

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., http://www.nap.edu/catalog.php?record_id=11972.

Oliver, Wade, 2009, GAM Run 09-18: Texas Water Development Board, GAM Run 09-18 Report, 7 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR09-18.pdf.

Texas Water Code, 2011, http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf

# Appendix B

# Estimated Historical Water Use And 2012 State Water Plan Datasets:

## Llano Estacado Underground Water Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Resources Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
July 14, 2015

### *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 part 1 are:

1. Estimated Historical Water Use (checklist Item 2)

   *from the TWDB Historical Water Use Survey (WUS)*

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

   *reports 2-5 are from the 2012 Texas State Water Plan (SWP)*

Part 2 of the 2-part package is the groundwater availability model (GAM) report. 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 2012 SWP data available as of 7/14/2015. Although it does not happen frequently, neither of these datasets are static so they are subject to change pending the availability of more accurate WUS data or an amendment to the 2012 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 2012 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) or Rima Petrossian (rima.petrossian@twdb.texas.gov or 512-936-2420).

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

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2014. TWDB staff anticipates the calculation and posting of these estimates at a later date.

## GAINES COUNTY

All values are in acre-fee/year

| Year | Source | Municipal | Manufacturing | Mining | Steam Electric | Irrigation | Livestock | Total |
|---|---|---|---|---|---|---|---|---|
| 2013 | GW | 3,374 | 5,134 | 630 | 0 | 360,353 | 136 | 369,627 |
| | SW | 0 | 0 | 0 | 0 | 0 | 15 | 15 |
| 2012 | GW | 3,588 | 5,192 | 602 | 0 | 424,388 | 180 | 433,950 |
| | SW | 0 | 0 | 0 | 0 | 0 | 20 | 20 |
| 2011 | GW | 3,866 | 5,456 | 567 | 0 | 404,205 | 203 | 414,297 |
| | SW | 0 | 0 | 45 | 0 | 0 | 23 | 68 |
| 2010 | GW | 3,353 | 4,801 | 1,932 | 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 |
| 2001 | GW | 3,117 | 67 | 371 | 0 | 520,267 | 639 | 524,461 |
| | SW | 0 | 0 | 0 | 0 | 0 | 160 | 160 |
| 2000 | GW | 3,237 | 67 | 1,436 | 0 | 414,772 | 629 | 420,141 |
| | SW | 0 | 0 | 0 | 0 | 0 | 157 | 157 |

# Projected Surface Water Supplies
# TWDB 2012 State Water Plan Data

## GAINES COUNTY

All values are in acre-feet/year

| RWPG | WUG | WUG Basin | Source Name | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|---|---|
| O | LIVESTOCK | COLORADO | LIVESTOCK LOCAL SUPPLY | 304 | 312 | 320 | 329 | 338 | 348 |
| | **Sum of Projected Surface Water Supplies (acre-feet/year)** | | | **304** | **312** | **320** | **329** | **338** | **348** |

# Projected Water Demands
# TWDB 2012 State Water Plan Data

Please note that the demand numbers presented here include the plumbing code savings found in the Regional and State Water Plans.

## GAINES COUNTY

All values are in acre-feet/year

| RWPG | WUG | WUG Basin | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|---|
| O | SEMINOLE | COLORADO | 2,214 | 2,401 | 2,525 | 2,605 | 2,579 | 2,544 |
| O | COUNTY-OTHER | COLORADO | 754 | 800 | 823 | 839 | 824 | 813 |
| O | MINING | COLORADO | 5,746 | 4,011 | 2,493 | 1,084 | 217 | 0 |
| O | IRRIGATION | COLORADO | 393,170 | 372,693 | 353,283 | 334,884 | 317,442 | 300,908 |
| O | LIVESTOCK | COLORADO | 913 | 995 | 1,045 | 1,099 | 1,156 | 1,216 |
| O | SEAGRAVES | COLORADO | 449 | 482 | 502 | 513 | 506 | 499 |
| | | **Sum of Projected Water Demands (acre-feet/year)** | **403,246** | **381,382** | **360,671** | **341,024** | **322,724** | **305,980** |

# Projected Water Supply Needs
# TWDB 2012 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/year

| RWPG | WUG | WUG Basin | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|---|
| O | COUNTY-OTHER | COLORADO | 0 | 0 | 0 | 0 | 0 | 0 |
| O | IRRIGATION | COLORADO | -67,285 | -105,447 | -119,451 | -127,613 | -134,285 | -139,981 |
| O | LIVESTOCK | COLORADO | 0 | 0 | 0 | 0 | 0 | 0 |
| O | MINING | COLORADO | 0 | 0 | 0 | 0 | 0 | 0 |
| O | SEAGRAVES | COLORADO | 196 | 308 | 209 | 127 | 70 | 20 |
| O | SEMINOLE | COLORADO | 0 | 0 | 0 | 0 | 0 | 0 |
| | **Sum of Projected Water Supply Needs (acre-feet/year)** | | **-67,285** | **-105,447** | **-119,451** | **-127,613** | **-134,285** | **-139,981** |

# Projected Water Management Strategies
# TWDB 2012 State Water Plan Data

## GAINES COUNTY

**WUG, Basin (RWPG)**

All values are in acre-feet/year

| Water Management Strategy | Source Name [Origin] | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|
| **IRRIGATION, COLORADO (O)** | | | | | | | |
| IRRIGATION WATER CONSERVATION | CONSERVATION [GAINES] | 10,515 | 9,463 | 8,517 | 7,665 | 6,898 | 6,209 |
| **SEMINOLE, COLORADO (O)** | | | | | | | |
| MUNICIPAL WATER CONSERVATION | CONSERVATION [GAINES] | 178 | 384 | 588 | 778 | 938 | 1,035 |
| **Sum of Projected Water Management Strategies (acre-feet/year)** | | **10,693** | **9,847** | **9,105** | **8,443** | **7,836** | **7,244** |

# Appendix C

# GAM Run 10-030 MAG

**by Mr. Wade Oliver**

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-3132
June 22, 2011

STATE OF TEXAS
CYNTHIA K RIDGEWAY
GEOLOGY
No. 471
LICENSED
PROFESSIONAL GEOSCIENTIST

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

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## EXECUTIVE SUMMARY:

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

## REQUESTOR:

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

## DESCRIPTION OF REQUEST:

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

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

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

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

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

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

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

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

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

**METHODS:**

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

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

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

## PARAMETERS AND ASSUMPTIONS:

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

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

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

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

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

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

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

### Determining Managed Available Groundwater

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

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

## RESULTS:

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

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

## LIMITATIONS:

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

The groundwater model used in developing estimates of total pumping is the best available scientific tool that can be used to estimate the pumping that will achieve the desired future condition. Although the groundwater model used in this analysis is the best available scientific tool for this purpose, it, like all models, has limitations. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

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

A key aspect of using the groundwater model to develop estimates of total pumping is the need to make assumptions about the location in the aquifer where future pumping will occur. As actual pumping changes in the future, it will be necessary to evaluate the amount of that pumping as well as its location in the context of the assumptions associated with this analysis. Evaluating the amount and location of future pumping is as important as evaluating the changes in groundwater levels, spring flows, and other metrics that describe the condition of the groundwater resources in the area that relate to the adopted desired future condition.

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

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

Given these limitations, users of this information are cautioned that the total pumping numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor future groundwater pumping as well as whether or not they are achieving their desired future conditions. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine these managed available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

**REFERENCES:**

Blandford, T.N., Blazer, D.J., Calhoun, K.C., Dutton, A.R., Naing, T., Reedy, R.C., and Scanlon, B.R., 2003, Groundwater availability of the southern Ogallala aquifer in Texas and New Mexico—Numerical simulations through 2050: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 158 p.

Blandford, T.N., Kuchanur, M., Standen, A., Ruggiero, R., Calhoun, K.C., Kirby, P., and Shah, G., 2008, Groundwater availability model of the Edwards-Trinity (High Plains) Aquifer in Texas and New Mexico: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 176 p.

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.

Oliver, W., 2010, GAM Task 10-023: Texas Water Development Board, GAM Task 10-023 Report, 27 p.

Texas Water Development Board, 2007, Water for Texas – 2007—Volumes I-III; Texas Water Development Board Document No. GP-8-1, 392 p.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

D = Estimated exempt use calculated by the district

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

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

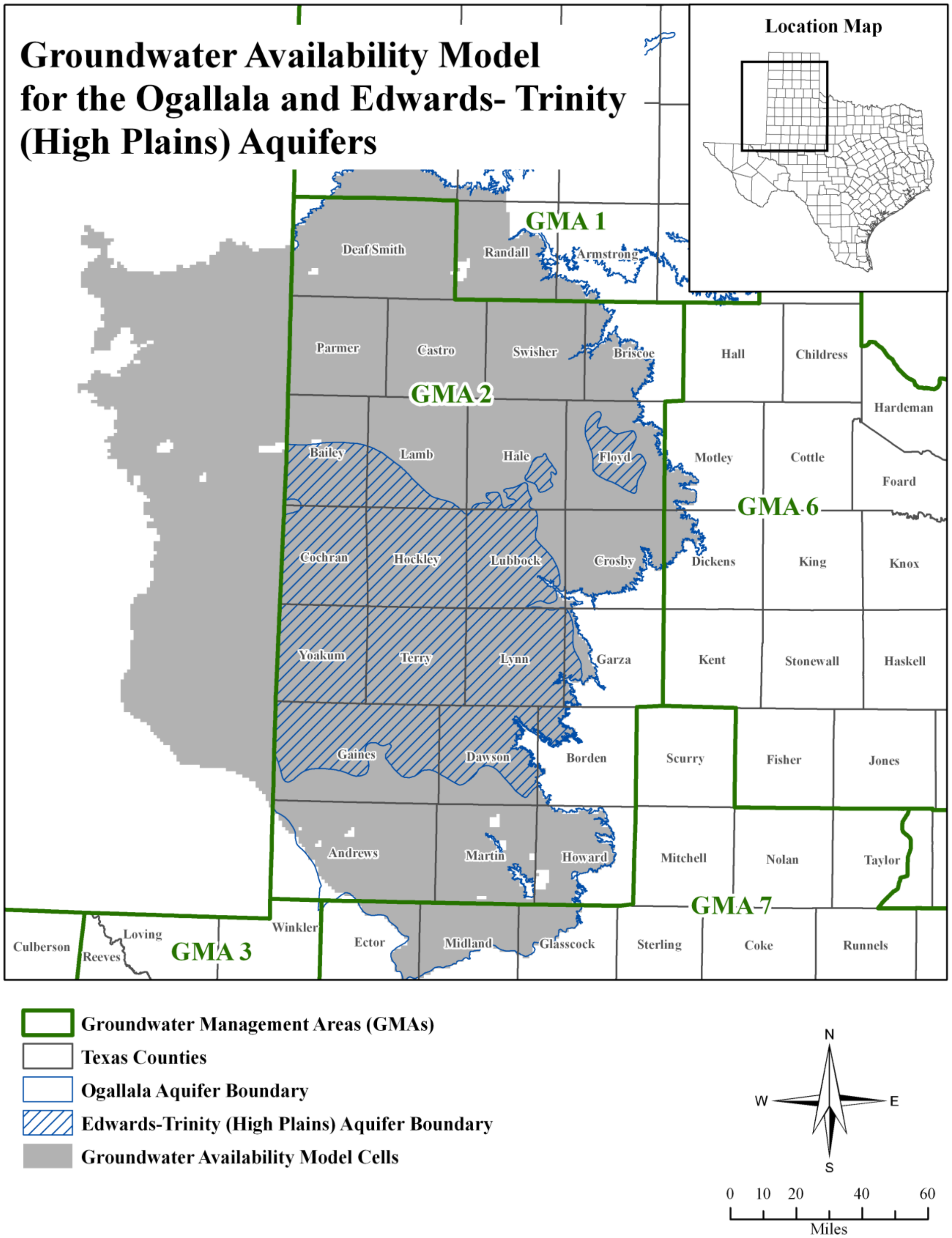


Figure 1. Map showing the areas covered by the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer.

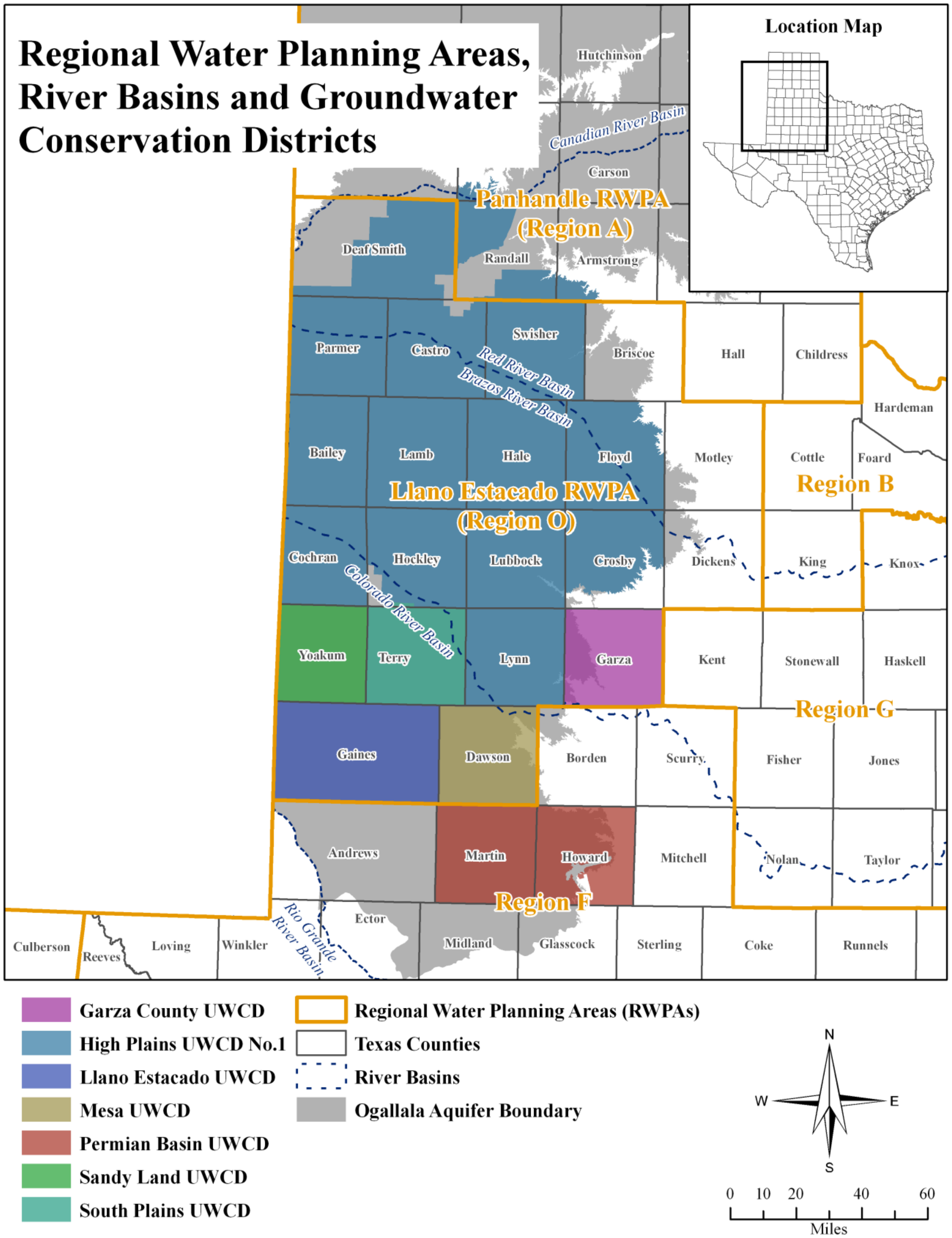


Figure 2. Map showing regional water planning areas (RWPAs), groundwater conservation districts (GCDs), counties, and river basins in Groundwater Management Area 2. UWCD refers to Underground Water Conservation District.

# GAM Run 10-035 MAG Version 3: Modeled Available Groundwater for the Dockum Aquifer

**by Mr. Wade Oliver**

Edited and finalized by Radu Boghici to reflect statutory changes effective September 1, 2011

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-2386
July 9, 2012

Cynthia K. Ridgeway, the Manager of the Groundwater Availability Modeling Section is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on July 9, 2012.

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## EXECUTIVE SUMMARY:

The modeled available groundwater from the Dockum Aquifer as a result of the desired future condition adopted by the members of Groundwater Management Area 2 is approximately 14,100 acre-feet per year. This is shown divided by county, regional water planning area, and river basin in Table 1 for use in the regional water planning process. Modeled available groundwater is summarized by county, regional water planning area, river basin, and groundwater conservation district in tables 2 through 5. The estimates were extracted from Groundwater Availability Modeling Task 10-025, which Groundwater Management Area 2 used as the basis for developing the desired future condition of an average decline of no more than 40 feet between 2010 and 2060. Earlier versions of this report showed modeled available groundwater for Dawson, Garza, Howard, Martin, Terry, and Yoakum counties based on the pumping assumed in the groundwater availability model simulation. However, Groundwater Management Area 2 declared those counties "not relevant" for joint planning purposes. Since modeled available groundwater only applies to areas with a specified desired future condition, we updated this report to depict modeled available groundwater only in counties with specified desired future conditions.

## REQUESTOR:

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

## DESCRIPTION OF REQUEST:

In a letter dated August 10, 2010 and received August 13, 2010, Mr. Jason Coleman provided the Texas Water Development Board (TWDB) with the desired future condition of the Dockum Aquifer adopted by the members of Groundwater Management Area 2. The desired future condition for the Dockum Aquifer, as described in Resolution No. 2010-01 and adopted August 5, 2010 by the groundwater conservation districts within Groundwater Management Area 2, are described below:

> [T]*he members of* [Groundwater Management Area] *#2 adopt the desired future condition of the Dockum Aquifer as described in Table A-8, GAM Task 10-025 whereby the decline in water levels averages no more than forty feet over the time period 2010-2060 and further declare that the Dockum Aquifer is not relevant for the following counties: Dawson, Garza, Howard, Martin, Terry, and Yoakum.*

In response to receiving the adopted desired future condition, the TWDB has estimated the modeled available groundwater for the above desired future condition in Groundwater Management Area 2 where the Dockum Aquifer was considered by the management area to be relevant for joint planning purposes.

## METHODS:

Groundwater Management Area 2 contains a portion of the Dockum Aquifer, a minor aquifer in Texas as defined in the 2007 State Water Plan (TWDB, 2007). The location of Groundwater Management Area 2, the Dockum Aquifer, and the groundwater model cells that represent the aquifer are shown in Figure 1. The TWDB previously completed several predictive groundwater model simulations for the Dockum Aquifer in Groundwater Management Area 2, documented in Groundwater Availability Modeling (GAM) Task 10-025 (Oliver, 2010). As described in the desired future conditions statement above, the model simulation scenario on which the desired future condition is based is shown in Table A-8 of GAM Task 10-025 (Oliver, 2010). The pumping results for Groundwater Management Area 2 presented here, taken directly from the above scenario, achieve the adopted desired future condition for the Dockum Aquifer and have been divided by county, regional water planning area, river basin, and groundwater conservation district. These areas are shown in Figure 2.

## PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the model run using the modified groundwater model for the Dockum Aquifer are described below:

- The results presented in this report are based on the "160 percent of base" scenario in GAM Task 10-025 (Oliver, 2010). This is the scenario shown in Table A-8 of Oliver (2010) and referred to in the Groundwater Management Area 2 desired future condition statement for the Dockum Aquifer. See Oliver (2010) for a full description of the methods, assumptions, and results for the groundwater availability model run.

- The modified version the groundwater model for the Dockum Aquifer described in Oliver and Hutchison (2010) was used for this analysis. This model is an update to the previously developed groundwater availability model for the Dockum Aquifer described in Ewing and others (2008) in order to more effectively simulate predictive conditions. See Oliver and Hutchison (2010) and Ewing and others (2008) for assumptions and limitations of the model.

- The model includes two active layers which represent the upper and lower portions of the Dockum Aquifer. Layer 2 represents the upper portion of the Dockum Aquifer. Layer 3 represents the lower portion of the Dockum Aquifer. Layer 1, which is active in version 1.01 of the model documented in Ewing and others (2008), was inactivated in the modified model as described in Oliver and Hutchison (2010).

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) for the lower portion of the Dockum Aquifer between 1980 and 1997 is 53 feet.

- Cells were assigned to individual counties, river basins, regional water planning areas, and groundwater conservation districts as shown in the August 3, 2010 version of file that associates the model grid to political and natural boundaries for the Dockum Aquifer.

Note that some minor adjustments were made to the file better reflect the relationship of model cells to political boundaries.

- The recharge used for the model run represents average recharge as described in Ewing and others (2008).

**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. This is distinct from "managed available groundwater," shown in version 2 of this report dated August 30, 2011, which was a permitting value and accounted for the estimated use of the aquifer exempt from permitting. This change was made to reflect changes in statute by the 82nd Texas Legislature, effective September 1, 2011.

Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits. The estimated amount of pumping exempt from permitting, which the Texas Water Development Board is now required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

## RESULTS:

The modeled available groundwater for the Dockum Aquifer in Groundwater Management Area 2 consistent with the desired future condition is approximately 14,100 acre-feet per year. This has been divided by county, regional water planning area, and river basin for each decade between 2010 and 2060 for use in the regional water planning process (Table 1).

The modeled available groundwater is also summarized by county, regional water planning area, river basin, and groundwater conservation district as shown in tables 2, 3, 4, and 5, respectively. In Table 5, note that the modeled available groundwater is also totaled for those districts that considered the Dockum Aquifer relevant for joint planning purposes: High Plains Underground Water Conservation District No. 1 and Llano Estacado Underground Water Conservation District.

## LIMITATIONS:

The groundwater model used in developing estimates of total pumping is the best available scientific tool that can be used to estimate the pumping that will achieve the desired future condition. Although the groundwater model used in this analysis is the best available scientific tool for this purpose, it, like all models, has limitations. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

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

A key aspect of using the groundwater model to develop estimates of total pumping is the need to make assumptions about the location in the aquifer where future pumping will occur. As actual pumping changes in the future, it will be necessary to evaluate the amount of that pumping as well as its location in the context of the assumptions associated with this analysis. Evaluating the amount and location of future pumping is as important as evaluating the changes in groundwater levels, spring flows, and other metrics that describe the condition of the groundwater resources in the area that relate to the adopted desired future condition(s).

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

Given these limitations, users of this information are cautioned that the total pumping numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor future groundwater pumping as well as whether or not they are achieving their desired future conditions. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine these managed available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

## REFERENCES:

Ewing, J.E., Jones, T.L., Yan, T., Vreugdenhil, A.M., Fryar, D.G., Pickens, J.F., Gordon, K., Nicot, J.P., Scanlon, B.R., Ashworth, J.B., Beach, J., 2008, Groundwater Availability Model for the Dockum Aquifer – Final Report: contract report to the Texas Water Development Board, 510 p.

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.

Oliver, W., Hutchison, W.R., 2010, Modification and recalibration of the Groundwater Availability Model of the Dockum Aquifer: Texas Water Development Board, 114 p.

Oliver, W., 2010, GAM Task 10-025: Texas Water Development Board, GAM Task 10-025 Report, 61 p.

Texas Water Development Board, 2007, Water for Texas – 2007—Volumes I-III; Texas Water Development Board Document No. GP-8-1, 392 p.

Table 1. Modeled available groundwater for the Dockum Aquifer in Groundwater Management Area 2 by county, regional water planning area, and river basin. Results are in acre-feet per year.

| County | Regional Water Planning Area | Basin | Year | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
| Andrews | F | Colorado | 715 | 715 | 715 | 715 | 715 | 715 |
| | | Rio Grande | 135 | 135 | 135 | 135 | 135 | 135 |
| Bailey | O | Brazos | 1 | 1 | 1 | 1 | 1 | 1 |
| Borden | F | Brazos | 33 | 33 | 33 | 33 | 33 | 33 |
| | | Colorado | 482 | 482 | 482 | 482 | 482 | 482 |
| Briscoe | O | Red | 231 | 231 | 231 | 231 | 231 | 231 |
| Castro | O | Brazos | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Red | 1 | 1 | 1 | 1 | 1 | 1 |
| Cochran | O | Brazos | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Colorado | 0 | 0 | 0 | 0 | 0 | 0 |
| Crosby | O | Brazos | 4,061 | 4,061 | 4,061 | 4,061 | 4,061 | 4,061 |
| | | Red | 48 | 48 | 48 | 48 | 48 | 48 |
| Deaf Smith | O | Canadian | 1,082 | 1,082 | 1,082 | 1,082 | 1,082 | 1,082 |
| | | Red | 3,630 | 3,630 | 3,630 | 3,630 | 3,630 | 3,630 |
| Floyd | O | Brazos | 745 | 745 | 745 | 745 | 745 | 745 |
| | | Red | 939 | 939 | 939 | 939 | 939 | 939 |
| Gaines | O | Colorado | 0 | 0 | 0 | 0 | 0 | 0 |
| Hale | O | Brazos | 734 | 734 | 734 | 734 | 734 | 734 |
| | | Red | 4 | 4 | 4 | 4 | 4 | 4 |
| Hockley | O | Brazos | 571 | 571 | 571 | 571 | 571 | 571 |
| | | Colorado | 0 | 0 | 0 | 0 | 0 | 0 |
| Lamb | O | Brazos | 0 | 0 | 0 | 0 | 0 | 0 |
| Lubbock | O | Brazos | 15 | 15 | 15 | 15 | 15 | 15 |
| Lynn | O | Brazos | 5 | 5 | 5 | 5 | 5 | 5 |
| | | Colorado | 0 | 0 | 0 | 0 | 0 | 0 |
| Parmer | O | Brazos | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Red | 2 | 2 | 2 | 2 | 2 | 2 |
| Swisher | O | Brazos | 83 | 83 | 83 | 83 | 83 | 83 |
| | | Red | 614 | 614 | 614 | 614 | 614 | 614 |
| **Total** | | | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** |

Table 2. Modeled available groundwater for the Dockum Aquifer summarized by county in Groundwater Management Area 2 for each decade between 2010 and 2060. Results are in acre-feet per year.

| County | Year | | | | | |
|---|---|---|---|---|---|---|
| | **2010** | **2020** | **2030** | **2040** | **2050** | **2060** |
| Andrews | 850 | 850 | 850 | 850 | 850 | 850 |
| Bailey | 1 | 1 | 1 | 1 | 1 | 1 |
| Borden | 515 | 515 | 515 | 515 | 515 | 515 |
| Briscoe | 231 | 231 | 231 | 231 | 231 | 231 |
| Castro | 1 | 1 | 1 | 1 | 1 | 1 |
| Cochran | 0 | 0 | 0 | 0 | 0 | 0 |
| Crosby | 4,109 | 4,109 | 4,109 | 4,109 | 4,109 | 4,109 |
| Deaf Smith | 4,712 | 4,712 | 4,712 | 4,712 | 4,712 | 4,712 |
| Floyd | 1,684 | 1,684 | 1,684 | 1,684 | 1,684 | 1,684 |
| Gaines | 0 | 0 | 0 | 0 | 0 | 0 |
| Hale | 738 | 738 | 738 | 738 | 738 | 738 |
| Hockley | 571 | 571 | 571 | 571 | 571 | 571 |
| Lamb | 0 | 0 | 0 | 0 | 0 | 0 |
| Lubbock | 15 | 15 | 15 | 15 | 15 | 15 |
| Lynn | 5 | 5 | 5 | 5 | 5 | 5 |
| Parmer | 2 | 2 | 2 | 2 | 2 | 2 |
| Swisher | 697 | 697 | 697 | 697 | 697 | 697 |
| **Total** | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** |

Table 3. Modeled available groundwater for the Dockum Aquifer summarized by regional water planning area in Groundwater Management Area 2 for each decade between 2010 and 2060. Results are in acre-feet per year.

| Regional Water Planning Area | Year | | | | | |
|---|---|---|---|---|---|---|
| | **2010** | **2020** | **2030** | **2040** | **2050** | **2060** |
| F | 1,365 | 1,365 | 1,365 | 1,365 | 1,365 | 1,365 |
| O | 12,766 | 12,766 | 12,766 | 12,766 | 12,766 | 12,766 |
| **Total** | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** |

Table 4. Modeled available groundwater for the Dockum Aquifer summarized by river basin in Groundwater Management Area 2 for each decade between 2010 and 2060. Results are in acre-feet per year.

| Basin | Year | | | | | |
|---|---|---|---|---|---|---|
| | **2010** | **2020** | **2030** | **2040** | **2050** | **2060** |
| Brazos | 6,248 | 6,248 | 6,248 | 6,248 | 6,248 | 6,248 |
| Canadian | 1,082 | 1,082 | 1,082 | 1,082 | 1,082 | 1,082 |
| Colorado | 1,197 | 1,197 | 1,197 | 1,197 | 1,197 | 1,197 |
| Red | 5,469 | 5,469 | 5,469 | 5,469 | 5,469 | 5,469 |
| Rio Grande | 135 | 135 | 135 | 135 | 135 | 135 |
| **Total** | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** |

Table 5. Modeled available groundwater for the Dockum Aquifer summarized by groundwater conservation district (GCD) in Groundwater Management Area 2 for each decade between 2010 and 2060. Results are in acre-feet per year. UWCD refers to Underground Water Conservation District.

| Groundwater Conservation District | Year | | | | | |
|---|---|---|---|---|---|---|
| | **2010** | **2020** | **2030** | **2040** | **2050** | **2060** |
| High Plains UWCD No. 1 | 10,092 | 10,092 | 10,092 | 10,092 | 10,092 | 10,092 |
| Llano Estacado UWCD | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total (districts where aquifer is relevant)** | **10,092** | **10,092** | **10,092** | **10,092** | **10,092** | **10,092** |
| No District | 4,039 | 4,039 | 4,039 | 4,039 | 4,039 | 4,039 |
| **Total (all areas)** | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** | **14,131** |

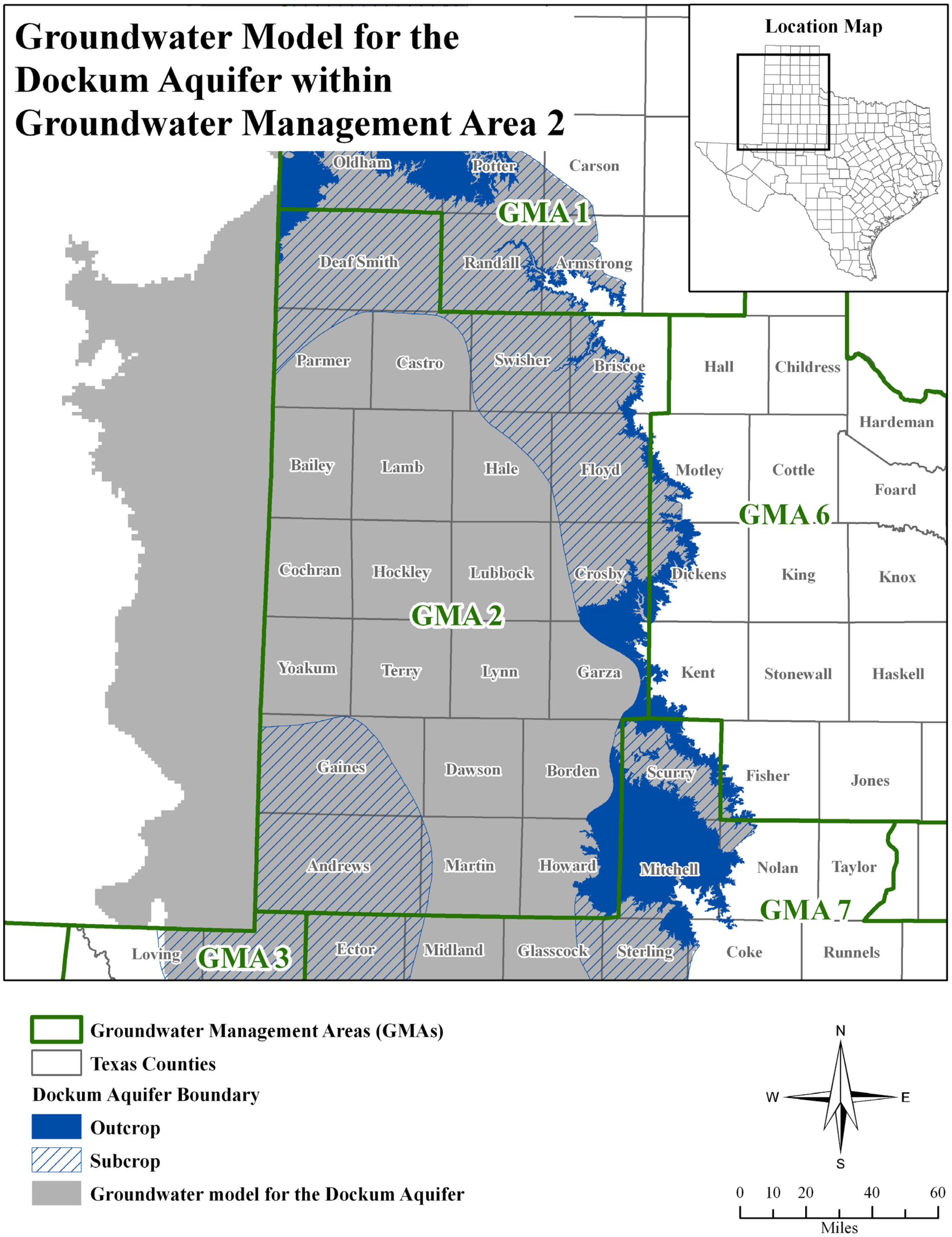


Figure 1. Map showing the areas covered by the groundwater model for the Dockum Aquifer and the boundary of Groundwater Management Area 2.

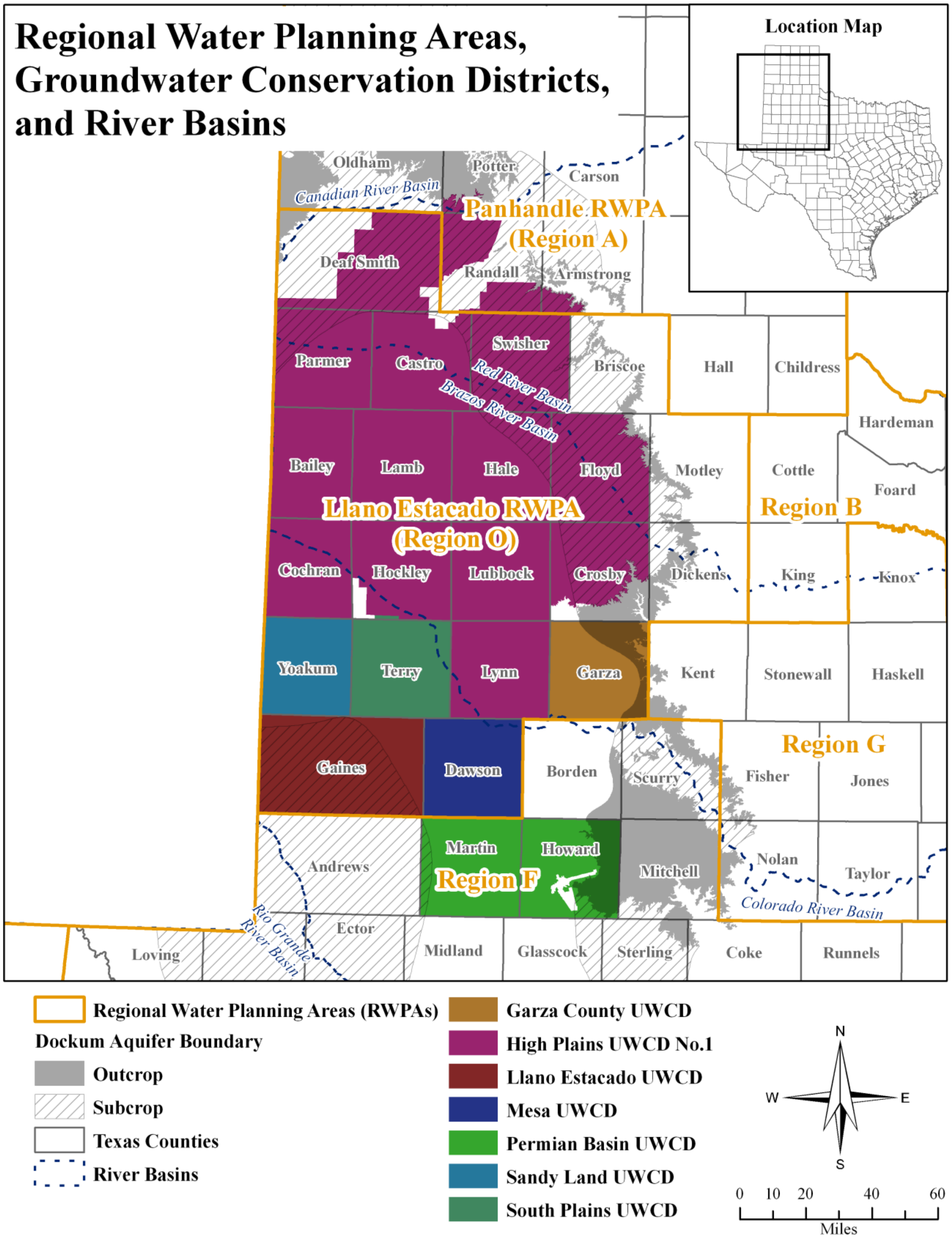


Figure 2. Map showing regional water planning areas (RWPAs), groundwater conservation districts (GCDs), counties, and river basins in and neighboring Groundwater Management Area 2. UWCD refers to Underground Water Conservation District.