Hickory Underground Water Conservation District No. 1

Groundwater Management Plan

2019-2024

District Mission

The Hickory Underground Water Conservation District No. 1 ("District") strives to conserve, preserve, prevent waste, protect, and recharge the underground waters of all aquifers within its legal boundaries, as far as practicable, to minimize the draw-down of the water table and the reduction of artesian pressure within the District Boundaries.

Time Period

This amended plan becomes effective upon approval by the Board of Directors and remains in effect until an amended plan is approved or December 1, 2023, whichever is later. The plan may be revised at anytime, or after five years when the plan will be reviewed, revised or amended and is approved as administratively complete by the Texas Water Development Board.

History

At the request of area citizens, the Texas Water Development Board entered an order on December 29, 1975, delineating a subdivision of the Hickory Aquifer Underground Water Reservoir in Concho, Kimble, Llano, Mason, McCulloch, Menard and San Saba Counties. In November 1981, a petition was submitted to the Texas Water Commission calling for the creation of the Hickory Underground Water Conservation District No. 1 (District). At a hearing on June 9, 1982, before the Texas Water Commission the petition was granted and the District thus created.

The confirmation election required by state statute was held on August 14, 1982; the District was officially established with a 94% approval of voters in those areas of Concho, Kimble, Mason, McCulloch, Menard and San Saba within the District boundaries.

On August 12, 1999 the petition of creation was amended by the TNRCC (now Texas Commission on Environmental Quality) to include all aquifers within the legal boundaries and management jurisdiction of the District.

On January 11, 2003, landowners of Mason County petitioned the District to annex the remainder of Mason County not currently in the District, and on May 03, 2003, in a special election held at the Mason County Courthouse the remainder of Mason County was annexed into the District with approval of 88% of the voters.

Regional Cooperation and Coordination

Regional Water Planning Groups

In 1998 the District was apportioned into two Regional Water Planning Groups established pursuant to § 16.053 of the Texas Water Code–Concho, Kimble, Mason, McCulloch and Menard are located in Region F and San Saba County is in the Lower Colorado Regional Water Planning Group (Region

K). The District's Regional planning responsibilities are within a 46-county area, stretching from Matagorda Bay to the Pecos River in West Texas.

Groundwater Management Area 7

In 2003 the Texas Water Development Board designated the boundaries of 16 groundwater management areas in Texas. The District lies entirely within Groundwater Management Area 7, which encompasses 34 counties and 20 groundwater conservation districts within an area of approximately 42,000 square miles. The groundwater management area was designated for the Edwards-Trinity aquifer, but also includes all or portions of the minor Lipan-Kickapoo, Hickory, Ellenburger-San Saba, and Dockum aquifers, as well as a small portion of the Ogallala aquifer,

The District participates in the mandatory joint planning process mandated by 36.108 of the Texas Water Code and is actively working with the other 19 GMA 7districts to develop Desired Future Conditions for the Edwards-Trinity aquifer. Since the adoption of the most recent Management Plan in 2014 the District has met with relevant GMA 7 districts and worked with the Texas Water Development Board to develop a Groundwater Availability Model to assist in establishing Desired Future Conditions and the calculation of Managed Available Groundwater for the Hickory and Ellenburger-San Saba aquifers.

West Texas Regional Groundwater Alliance

The District is a member of the West Texas Regional Groundwater Alliance. The regional alliance consists of seventeen (17) locally created and locally funded districts that encompass almost 8.75 million acres or 13,000 square miles of West Texas. This West Texas region is as diverse as the State of Texas, making it necessary for each member district to develop its own unique priority management goals and rules to best serve the needs of its constituents.
In 1988, four (4) groundwater districts; Coke County UWCD, Glasscock GCD, Irion County WCD, and Sterling County UWCD signed the original Cooperative Agreement. Since then the number of groundwater conservation districts in the area has more than quadrupled. The current member districts are:

Coke County UWCD	Crockett County GCD	Glasscock GCD
Hickory UWCD	Irion County WCD	Lipan-Kickapoo WCD
Plateau UWC & SD	Santa Rita UWCD	Sterling County UWCD
Sutton County UWCD	Menard County UWD	Lone Wolf GCD
Hill Country UWCD	Jeff Davis County UWCD	Middle Pecos GCD
Permian Basin UWCD	Wes-Tex GCD	

The Alliance was created to implement common objectives of coordinating and facilitating the conservation, preservation, and beneficial use of water and related sources. Local districts monitor the water-related activities of the farming and ranching, oil and gas, industrial entities and municipalities

District Location and Extent

The Hickory Underground Water Conservation District No. 1 is located near the geographical center of Texas and is comprised of approximately 1,683,080 acres, including portions of McCulloch, Menard, Kimble, San Saba, Concho counties and the entirety of Mason County. In 2003 the District gained approximately 433,000 acres with the annexation of the remainder of Mason County that had not been included when the District was initially created.

Principal industries of the District are listed in the table below. The District's economy is based to a large degree on agriculture; 12% of the acreage in the District is cropland. Principal municipalities in or near the district boundaries are Brady, San Saba, Mason and Eden.

Topography

The District is within the Colorado River basin and is bisected by the Llano and San Saba Rivers, as well as numerous other creeks. Drainage is typically from west to east.
There are two major geologic features within the District. The Llano Uplift (Central Basin) is in the eastern and southern portions of the District. This feature is made up of ancient Cambrian Age rocks ranging in age from 1.0 to 1.2 billion years old and comprises granite and older metamorphic rocks. The northern and western parts of the District are in the Edwards Plateau region and are made up of Cretaceous Age limestone, dolomite, and marble.
The District elevation ranges from 1,100 to 2,300 feet above sea level.

Economic Enterprise in the Hickory District[1]

County	Economy
Concho	Livestock production, tourism, hunting, fishing
Kimble	Livestock production, tourism, hunting, fishing
McCulloch	Agribusiness, tourism, manufacturing, silica sand
Mason	Ranching, hunting, tourism
Menard	Agribusiness, hunting and tourism, minor oil and gas production
San Saba	Gov/Services, retail pecan industry, tourism, hunting

Statement of Guiding Principles

The Hickory Underground Water Conservation District No. 1 (District) is created and organized under the terms and provisions of Article XVI, Section 59, of the Constitution of Texas and Chapter 36 (formerly Chapter 52) of the Texas Water Code, Vernon's Texas Civil Statutes, and the District's actions are authorized by, and consistent with this constitutional and statutory provision, including all amendments and additions. The District is created for the purpose of conserving, preserving, recharging, controlling subsidence, protecting and preventing waste and as far as practicable to minimize the drawdown of the water table and the reduction of artesian pressure in all aquifers within the district boundaries. In order to carry out its constitutional and statutory purposes, the District has all the powers authorized by Article XVI, Section 59, of the Texas Constitution, and Chapter 36 of the Texas Water Code, Vernon's Texas Civil Statutes, together with all amendments and additions.

The District's purposes and powers are implemented through promulgation and enforcement of the District's rules which are adopted and revised under the authority of Subchapter E, Chapter 36, Texas Water Code, and are incorporated herein as a part of the District's management plan. A copy of the District Rules is available on the District website at http://www.hickoryuwcd.org/HickoryRules.htm

GROUNDWATER RESOURCES OF THE DISTRICT

Hickory Aquifer[2]

The Hickory Aquifer is the primary source of the District's groundwater, which is used for irrigation, public water supply, industrial, stock, and the domestic needs of the people and entities served.

The Hickory Aquifer occurs in parts of the counties in the Llano uplift region of Central Texas. Discontinuous outcrops of the Hickory Sandstone overlie or flank exposed Precambrian rocks that form the central core of the uplift. The down dip artesian portion of the aquifer encircles the uplift and extends to maximum depths approaching 4000 ft. Most of the water pumped from the aquifer is used for irrigation. The largest capacity wells, however, have been completed for municipal water supply and industrial purposes in the Mason, Eden and Brady area.

The Hickory Sandstone Member of the Cambrian Riley Formation is composed of some of the oldest sedimentary rocks found in Texas. In most of the northern and western portions of the aquifer, the Hickory can be differentiated into lower, middle, and upper units, which reach a maximum thickness of 480 feet in southwestern McCulloch County. In the southern and eastern extent of the aquifer, the Hickory consists of only two units. Extensive block faulting has compartmentalized the Hickory Aquifer, thus restricting hydrologic connection from one area to another.

Edwards-Trinity Aquifer[3]

The Edwards-Trinity Plateau Aquifer underlies the Edwards Plateau east of the Pecos River and the Stockton Plateau west of the Pecos River, supplying water to all or parts of 38 counties.

The aquifer consists of saturated sediments of lower Cretaceous age Trinity Group formations. Natural chemical quality of water ranges from fresh to slightly saline. The water is typically hard and may vary widely in concentrations of dissolved solids and bicarbonate. The salinity of the groundwater tends to increase toward the west.

Well yields are typically low in the eastern portion of the Edwards-Trinity, consequently there is little pumpage from the aquifer within the District. Nevertheless, in some instances water levels have declined as a result of pumpage. Historical declines have occurred in the northwestern part of the District.

Ellenburger-San Saba Aquifer[4]

The Ellenburger-San Saba Aquifer underlies 4,000 square miles in parts of 15 counties in the Llano Uplift area of Central Texas. Discontinuous outcrops of the aquifer generally encircle older rocks in the core of the Uplift. The remaining down-dip portion contains fresh to slightly saline water to depths of approximately 3,000 feet below land and surface.
Water produced from the aquifer has a range in dissolved solids between 200 and 3,000 mg/l, but usually less than 1,000 mg/l. The quality of water deteriorates rapidly away from the outcrop areas. Approximately, 20 miles of more down-dip from the outcrop, water is typically unsuitable for most uses.
Most of the deep municipal wells, which supply the City of Brady, produce an unknown amount of water from the Ellenburger-San Saba sequence of rocks. A large portion of the water supply for the City of San Saba is believed to be from the Ellenberger-San Saba and Marble Falls Aquifer.

Marble Falls Aquifer[5]

The Marble Falls Aquifer occurs primarily in the portions of McCulloch and San Saba counties within the District. Smaller amounts of water are also used for rural domestic supplies, watering of livestock and irrigation. Only small portions of Mason and Kimble counties are affected by this aquifer.
The Marble Falls Aquifer occurs in several outcrops, primarily along the northern and eastern flanks of the Llano Uplift Region of Central Texas. Groundwater occurs in fractures, solution cavities, and channels in the limestone of the Marble Falls Formation of the Pennsylvanian Bend Group. Maximum thickness of the formation is 600 feet. Numerous large springs issue from the aquifer and provide a significant part of the base-flow to the San Saba River in McCulloch and San Saba counties and to the Colorado River in San Saba and Lampasas counties.

Existing data for the Marble Falls aquifer show that it contains mostly fresh water in outcrop areas and becomes mineralized a short distance down-dip from the outcrop areas. However, very few data exist to evaluate the brackish water that is present.

Most wells producing from the Marble Falls aquifer produce fresh groundwater on the outcrop, while groundwater becomes highly mineralized within a relatively short distance of the down-dip. However, because the areal extent of the Marble Falls aquifer is relatively limited, and because much of the existing data indicate that the aquifer has limited groundwater availability, the Marble Falls aquifer must be considered a very limited source of brackish groundwater. Due to the presumed deep nature where brackish groundwater would be located, and the low productivity of the aquifer, relative costs are expected to be moderate to high.

MODELED AVAILABLE GROUNDWATER IN DISTRICT AQUIFERS

The District actively participates in joint planning with 19 other groundwater conservation districts (GCDs) in Groundwater Management Area (GMA) 7 pursuant to Section 36.108 of the Texas Water Code. The estimates of Modeled Available Groundwater (MAG) for each GCD in GMA 7 are based on the Desired Future Conditions adopted by GMA 7's member districts on September 22, 2016 and March 22, 2017.

The models used in determining the MAGS and the parameters and assumptions relied upon for the aquifers of the Hickory district are more fully described in pages 17-18 and page 20 of *GAM Run16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers of Groundwater Management Area 7*, Texas Water Development Board, September 21, 2018, attached hereto as Appendix "A".

Edwards-Trinity Plateau Aquifer

There are very limited supplies of groundwater from the Edwards-Trinity (Plateau) Aquifer within the boundaries of the District; those are used almost exclusively for domestic and livestock purposes. Therefore GMA 7 districts declared that the Edwards-Trinity (Plateau) aquifer is not relevant for joint planning purposes in the District and did not adopt Desired Future Conditions for the 2010-2070 planning period. Consequently MAGs are not estimated for the aquifer within the District.

A map showing the area of the aquifer is on page 28 of the above-referenced Appendix B, *GAM Run 16-026 MAG Version 2.*

Ellenburger-San Saba Aquifer

Total Modeled Available Groundwater (MAG) for the Ellenburger-San Saba Aquifer within the District is 12,887 acre-feet/year for each decade of the 2011-2070 period.

See page 38 Appendix B, *GAM Run16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers of Groundwater Management Area 7* Texas Water Development Board, September 21, 2018, attached hereto as Appendix "A", for total Modeled Available Groundwater and the MAGs for the Ellenburger-San Saba Aquifer located in each county, or portion thereof, within the District.

A map showing the area of the aquifer is on page 37 of Appendix B, *GAM Run 16-026 MAG Version 2.*

Hickory Aquifer

Total Modeled Available Groundwater for the Hickory Aquifer is 44,843 acre-feet/year for each decade of the 2011-2070 period.

See page 41 of Appendix B, *GAM Run16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers of Groundwater Management Area 7*, Texas Water Development Board, September 21, 2018, for total Modeled Available Groundwater and the MAGs for the aquifer in each county, or portion thereof, located within the District.

A map of the area of the Hickory Aquifer is on page 40 of *GAM Run 16-026 MAG Version 2.*

Marble Falls Aquifer

The Marble Falls Aquifer was declared irrelevant for joint planning purposes within the boundaries of GMA 7. No Desired Future Conditions were adopted for this aquifer, nor MAGs calculated.

Methodology for Calculating District Water Usage, Supply and Demand

Irrigation and Livestock: Irrigation and livestock numbers for counties are allocated to the District in proportion to the percentage of the area of the respective counties within the District as follows: Concho, 11.43%; Kimble, 2.55%; Mason, 100%; McCulloch 72.92%; Menard, 13.51%; San Saba, 55.88%.

Mining, Electric Generation and Manufacturing: No mining, electric generation or manufacturing takes place within the District in Concho, Kimble and Menard Counties. All mining in Mason, McCulloch and San Saba counties takes place within District boundaries. Electric generation estimates for Mason, McCulloch and San Saba Counties are included within District boundaries, but all estimates are zero. All manufacturing in Mason, McCulloch and San Saba counties takes place within the District.

Municipal and County Other: The municipalities of Brady (McCulloch County), Eden (Concho County), Mason (Mason County), and San Saba (San Saba County), and the Millersview-Doole WSC (Concho and McCulloch Counties) and Richland SUD (San Saba and McCulloch Counties) are within District boundaries and are included in the respective data tables. The municipalities of Junction (Kimble County) and Menard (Menard County) are outside of District boundaries and are excluded from the data tables. The county data for the County Other Water user Group is apportioned in all counties based upon the percentage of county area located within the District. See the Irrigation and Livestock methodology discussion for the respective percentage values.

District totals within tables may vary by an acre-foot due to rounding of numbers.

TABLE 1.

Summary of Historical Groundwater Use Within the District

(See the Methodology section for data apportionment criteria.)
(Source: Appendix A, *Estimated Historical Groundwater Use and 2017 State Water Plan Dataset, Hickory Underground Water Conservation District No. 1*, Texas Water Development Board, July 30, 2018
(All values are in acre-feet)

CONCHO COUNTY
(11.44% of land area is within the District)

Year	Municipal	Manufacturing	Electric	Irrigation	Mining	Livestock	Total
2016	56	0	0	504	0	19	579
2015	58	0	0	473	0	19	550
2014	51	0	0	509	0	19	579
2013	53	0	0	564	0	18	635
2012	46	0	0	539	0	22	607

KIMBLE COUNTY
(2.55% of land area is within the District)

Year	Municipal	Manufacturing	Electric	Irrigation	Mining	Livestock	Total
2016	1	0	0	9	0	4	14
2015	3	0	0	3	0	4	10
2014	4	0	0	8	0	4	16
2013	6	0	0	5	5	4	20
2012	6	0	0	10	0	5	21

MASON COUNTY
(100% of land area is within District)

Year	Municipal	Manufacturing	Electric	Irrigation	Mining	Livestock	Total
2016	639	0	0	4,791	187	509	6,126
2015	670	0	0	4,888	116	499	6,173
2014	737	0	0	5,126	266	489	6,618
2013	776	0	0	4,695	311	474	6,256
2012	777	0	0	5,203	313	608	6,901

MCCULLOCH COUNTY
(79.92% of land area is in District)

Year	Municipal	Manufacturing	Electric	Irrigation	Mining	Livestock	Total
2016	1,111	53	0	637	3,681	283	5,765
2015	1,034	28	0	1,475	3,128	281	5,946
2014	1,113	28	0	1,456	2,772	273	5,642
2013	1,101	29	0	1,331	2,045	267	4,773
2012	1,187	53	0	1,504	2,230	308	5,282

MENARD COUNTY
(13.51% of land area is in District)

Year	Municipal	Manufacturing	Electric	Irrigation*	Mining	Livestock	Total
2016	4	0	0	52	0	34	90
2015	6	0	0	69	0	34	109
2014	10	0	0	54	0	33	97
2013	12	0	0	63	0	33	108
2012	13	0	0	136	0	30	179

SAN SABA COUNTY
(55.88% of land area is in District)

Year	Municipal	Manufacturing	Electric	Irrigation	Mining	Livestock	Total
2016	849	2	0	1,297	0	168	2,316
2015	873	2	0	1,798	0	164	2,837
2014	785	2	0	2,248	0	161	3,196
2013	957	2	0	1,617	0	157	2,733
2012	1,228	5	0	2,012	6	165	3,416

TABLE 2.

Estimates of Recharge from Precipitation, Discharges to Surface Water Bodies, and Flows Into, Out of and Between Aquifers in the Edwards-Trinity Aquifer within District Boundaries
(acre-feet/year. All numbers rounded to nearest acre-foot)

Management Plan Requirement	Aquifer or Confining Unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	12,278
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams and rivers	Edwards-Trinity (Plateau) Aquifer	15,069
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	6,885
Estimated annual volume of flow out of the district within each aquifer in the District	Edwards-Trinity (Plateau) Aquifer	3,857
Estimated net annual volume of flow between each aquifer in the district	To the Edwards-Trinity (Plateau Aquifer from the Hickory Aquifer	31

Estimated net annual volume of flow between each aquifer in the district	To the Edwards-Trinity (Plateau) Aquifer from the Ellenburger-San Saba Aquifer	367
	To the Edwards-Trinity (Plateau) Aquifer from the Marble Falls Aquifer	7

(Source: Appendix C, *GAM Run 18-007*, TWDB, July 12, 2018)

TABLE 3.

Estimates of Recharge from Precipitation, Discharges to Surface Water Bodies, and Flows Into, Out of and Between Aquifers in the Ellenburger-San Saba Aquifer within District Boundaries

(acre-feet/year. All numbers rounded to nearest acre-foot)

Management Plan Requirement	Aquifer or Confining Unit	Results
Estimated annual amount of recharge from precipitation to the district	Ellenburger-San Saba Aquifer	56,007
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams and rivers	Ellenburger-San Saba Aquifer	176,861
Estimated annual volume of flow into the District within the Ellenburger-San Saba aquifer	Ellenburger-San Saba Aquifer	11,160
Estimated annual volume of flow out of the district within the Ellenburger-San Saba aquifer	Ellenburger-San Saba Aquifer	31,784
Estimated net annual volume of flow between each aquifers in the district	From Ellenburger-San Saba Aquifer to Edwards-Trinity (Plateau) Aquifer	409
	From Ellenburger-San Saba Aquifer to Marble Falls Aquifer	1,840
	To Ellenburger-San Saba Aquifer from Ellenburger-San Saba brackish zone	11,084
	From Ellenburger-San Saba Aquifer to Hickory Aquifer	3,315

Source: Appendix C, *GAM Run 18-007*: *HCUWD No. 1 Groundwater Management Plan*, TWDB, July 12, 2018

TABLE 4.
Estimates of Recharge from Precipitation, Discharges to Surface Water Bodies, and Flows Into, Out of and Between Aquifers in the Hickory Aquifer within District Boundaries

(acre-feet/year. All numbers rounded to nearest acre-foot)

Management Plan Requirement	Aquifer or Confining Unit	Results
Estimated annual amount of recharge from precipitation	Hickory Aquifer	9,994
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams and rivers	Hickory Aquifer	17,286
Estimated annual volume of flow into the District within the Hickory aquifer	Hickory Aquifer	21,475
Estimated annual volume of flow out of the District within the Hickory aquifer	Hickory Aquifer	15,310
Estimated net annual volume of flow between aquifers in the District	From Hickory Aquifer to Edwards-Trinity (Plateau) Aquifer	31
	Between Hickory Aquifer and Marble Falls Aquifer	0
	To Hickory Aquifer from Ellenburger-San Saba Aquifer	3,332
	From Hickory Aquifer to Hickory brackish zone	1,039

(Source: Appendix C, *GAM Run 18-007: HCUWD No. 1 Groundwater Management Plan*, TWDB, July 12, 2018

TABLE 5.
Estimates of Recharge from Precipitation, Discharges to Surface Water Bodies, and Flows Into, Out of and Between Aquifers in the Marble Falls Aquifer within District Boundaries
(acre-feet/year. All numbers rounded to nearest acre-foot)

Management Plan Requirement	Aquifer or Confining Unit	Results
Estimated annual amount of recharge from precipitation	Marble Falls Aquifer	7,895
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams and rivers	Marble Falls Aquifer	20,108
Estimated annual volume of flow into the District within the Hickory aquifer	Marble Falls Aquifer	76
Estimated annual volume of flow out of the District within the Marble Falls aquifer	Marble Falls Aquifer	0
Estimated net annual volume of flow between aquifers in the District	From Marble Falls Aquifer to Edwards-Trinity (Plateau) Aquifer	7
	From Marble Falls Aquifer to Marble Falls subcrop equivalent formation	2,242
	To Marble Falls Aquifer from Ellenburger-San Saba Aquifer	1,838
	Between Marble Falls Aquifer and Hickory Aquifer	0

(Source: Appendix C, *GAM Run 18-007: HCUWD No. 1 Groundwater Management Plan*, TWDB, July 12, 2018

TABLE 6.

PROJECTED WATER DEMANDS
2017 ADOPTED STATE WATER PLAN
(See the Methodology section for data apportionment criteria.)

Total projected water demands for the 2020-2070 planning period are as follows:
(all values in acre-feet)

County	2020	2030	2040	2050	2060	2070
CONCHO	1,837	1,828	1,808	1,792	1,781	1,772

KIMBLE	**737**	**727**	**716**	**709**	**707**	**706**
MASON	**11,493**	**11,274**	**10,907**	**10,640**	**10,412**	**10,207**
MCCULLOCH	**11,794**	**11,403**	**10,128**	**9,388**	**8,618**	**8,368**
MENARD	**903**	**891**	**868**	**848**	**832**	**818**
SAN SABA	**5,856**	**5,806**	**5,615**	**5,464**	**5,386**	**5,323**
DISTRICT Total	**32,620**	**31,929**	**30,042**	**28,841**	**27,736**	**27,194**

Source: The projected water demands for each water user group in the respective counties for each decade of the planning period are detailed in pages 12-14 of Appendix A, *Estimated Historical Groundwater Use and 2017 State Water Plan Data Set,*
The largest increases in demand over the fifty-year planning period will be in municipal use and the largest decreases will be in irrigation use.

Surface Water Resources of the Hickory UWCD No. 1

The only surface water impoundment used for purposes other than livestock consumption is Brady Lake. The normal pool capacity is 30,000 acre-feet with a calculated annual firm yield of 2,252[8] acre-feet. Currently the City of Brady is not utilizing this water; however the city will construct a 3mgd R.O. Treatment Plant to provide the City of Brady adequate water supplies to blend with the Hickory Aquifer wells in order to maintain a Radium 226/228 level below state and federal standards. Current Brady Lake pumpage is approximately 9 acre-feet annually for domestic purposes.

The San Saba and Llano Rivers bisect the District; however, only a small amount is used for other than livestock and domestic purposes.

TABLE 7.

PROJECTED SURFACE WATER SUPPLIES

(See the Methodology section for data apportionment criteria.)
(all values in acre-feet)

	2020	2030	2040	2050	2060	2070
DISTRICT TOTAL	**2,978**	**3,023**	**3,006**	**2,990**	**2,976**	**2,965**

Source: Projected surface water supplies, and their source, for each water user group in each county located in the district are detailed in pages 9-11 of Appendix A, *Estimated Historical Groundwater Use and 2017 State Water Plan Data Set, TWDB, July 30, 2018*

TABLE 8.

PROJECTED WATER SUPPLY NEEDS

(See the Methodology section for data apportionment criteria.)
(all values in acre-feet)

	2020	2030	2040	2050	2060	2070
DISTRICT TOTAL	17,174	16,523	14,644	13,449	12,847	12,740

Source: Projected Water Supply needs for each water user group in the respective counties for each decade of the planning period are detailed in pages 15-16 of Appendix B, *Estimated Historical Groundwater Use and 2017 State Water Plan Data Set.*

PROJECTED WATER MANAGEMENT STRATEGIES IN THE 2017 ADOPTED STATE WATER PLAN

(See the Methodology section for data apportionment criteria.)

Projected Water Management Strategies in the 2017 Adopted State Water Plan for each water user group in each county within the District for each decade of the planning period are detailed in pages 18-22 of Appendix A, *Estimated Historical Groundwater Use and 2017 State Water Plan Data Set.* Conservation through reduction in demand is the primary water management strategy for irrigation, as it is for municipal and mining use. Other strategies include reuse for municipal supplies and development of additional Hickory aquifer water supply for the City of Menard. Recent closings of several frac sand plants in McCulloch County indicate that the demand for supply for mining may decline faster than is projected in the 2017 Texas State Water Plan.

PROJECTED WATER SUPPLY NEEDS IN THE ADOPTED 2007 STATE WATER PLAN

(See the Methodology section for data apportionment criteria.)

Projected Water Supply Needs included in the 2017 Adopted State Water Plan for each water user group in each county within the District for each decade of the planning period are detailed in pages 15-16 of Appendix A, *Estimated Historical Groundwater Use and 2017 State Water Plan Data Set.* Irrigation will be the largest water supply need in the District over the 50-year planning period, followed by municipal water supply needs for the cities of Brady, Mason Junction, Menard, and San Saba. Mining in McCulloch County is another major water supply need for the period 2020-2040.

In the year 2070 the total projected water demands of the District are estimated at 27,194 acre-feet. While this number appears to be well within available supplies, Federal Drinking Water Standards relating to the levels of radionuclides in much of the Hickory water supply will significantly diminish the availability of groundwater for public water supply purposes. According to the Texas Commission on Environmental Quality, public water supplies in Mason County do not exceed the Federal radionuclide standards. However, the cities of Brady and Eden, as well as other municipal systems, may be impacted by the Federal standards.

The City of San Angelo well field is permitted for production of 12,000 acre-feet from the Hickory aquifer. The wellfield has not been developed, so permitted supplies are not yet being conveyed to and used by the City. However, levels of radionuclides exceeding Federal drinking water standards in the San Angelo well field will render the supply unusable without treatment or blending with water from other sources.

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 District operations and activities. Operations of the District, all agreements entered into by the District and any additional planning efforts in which the District may participate will be consistent with the provisions of this plan.

The District has adopted rules relating to the permitting of wells and the production of groundwater and continues to review and revise those rules in accordance with the best scientific evidence available and pursuant to changes in state laws and regulations. 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 indiscriminately. 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 of Directors 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 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."

TRACKING METHODOLOGY

The District manager will provide a report of staff activities to the Board of Directors at quarterly board meetings to insure management objectives and goals are being achieved.

MANAGEMENT GOALS, OBJECTIVES AND PERFORMANCE STANDARDS

Goal 1.0 To provide the most efficient use of groundwater

Management Objective
1.1 Annually the district will provide educational materials identifying conservation measures for the efficient use of water. Annually, two (2) District newsletter issues will be published that contain water conservation information. Handout packets with conservation literature will be provided at the annual McCulloch County Soil and Water Conservation 5th Grade Field Day or one other water-related function.

Performance Standard
1.1a Number of newsletters published annually containing water conservation information.
1.1b Number of events annually where conservation material was provided.

Management Objective
1.2 To monitor groundwater availability over the five-year management period; the District will identify and monitor 50 wells for water levels and obtain quarterly water levels on the monitored wells.

Performance Standards
1.2 Number of monitor wells measured quarterly.

Goal 2.0 To control and prevent the waste of groundwater.

Management Objective
2.1 Once each year the District will lend flow meters to assist at least one irrigating farmer within the District to evaluate irrigation systems and reduce waste.

Performance Standard
2.1 The number of District farmers who receive loans of flow-meters to assist in evaluating their irrigation systems.

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Goal 3.0 Addressing natural resource issues that impact the use and availability of groundwater and are impacted by the use of groundwater

Management Objective

3.1 The District will identify at least twenty (20) wells to be used as water quality monitoring wells that will be sampled annually.

Performance Standard

3.1 Number of monitor wells sampled annually for water quality.

Goal 4.0 Addressing conjunctive surface water management issues.

Management Objective

4.1 Meet at least once annually with City of Brady to discuss and review potential use of surface water resources in the area.

Performance Standard
4.1 Number of meetings with City representatives annually.

Management Objective

4.2 Meet at least once annually with a Lower Colorado River Authority staff member to review potential conjunctive groundwater/surface water resources in the area.

Performance Standard
4.2 Number of meetings with LCRA staff annually.

Goal 5.0 Addressing Drought Conditions

Management Objective

5.1a Annually monitor the Palmer Drought Severity Index (PDSI), notifying all District public water suppliers of severe drought conditions when they occur.

5.1b Notify area residents, in the District newsletter, of severe drought conditions when they occur and advise them that they may find useful information on the current drought status at the TWDB Water Data for Texas drought link at https://waterdatafortexas.org/drought .

Performance Standards

5.1a Report the current drought status of the District to the Board of Directors at quarterly meetings.

5. 1b Annually report to the Board of Directors the number of times area residents are notified of severe drought conditions in the District newsletter and the number of times that letters are sent to public water suppliers warning of severe drought conditions.

Goal 6.0 (a) Addressing Conservation

Management Objectives

6.a)1. At least once annually the District will provide educational literature promoting water conservation in a public educational presentation.

Performance Standard

6.a)1. Report to Board of Directors annually number of times water conservation information was distributed to area residents or in public informational or educational meetings.

Goal 6.0 (b) Addressing rainwater harvesting

Management Objective

6.b)1 The District will display rainwater harvesting manuals publicly at the district office and at least once annually provide notice in the District newsletter that manuals on rainwater harvesting are available to residents in the District office.

Performance Standards

6.b)1 Report to the Board of Directors annually on the number of times notice was published in the District newsletter about the availability of Rainwater Harvesting manuals in the District office.

Management Objective

6.b)2 Include information on rainwater harvesting in one public education presentation annually

Performance Standards

6.b)2 Report to Board of Directors annually the number of educational presentations that included rainwater harvesting information.

Goal 6.0 (c) Addressing brush control

Management Objective

6.c)1 Meet once annually with NRCS to discuss prioritizing brush control for EQIP funds or other federal conservation funding.

Performance Standards

6.c)1 Report to Board of Directors annually on the number of meetings held with NRCS officials regarding priority conservation funding for brush control.

Goal 7.0 Addressing the Desired Future Conditions of the District aquifers.

Management Objective

7.1 Monitor three (3) well levels annually in the Hickory aquifer outcrop area and one (1) well level annually in the Ellenburger-San Saba outcrop area of the district to determine whether the drawdown objectives of the District's DFCs are being met.

Performance Standard

7.1. Annual report to Board of Director on monitor wells measured annually to determine whether drawdown objectives are being met.

36.1071 (a) Management Goals Not Applicable to the District

Goal 1.0 Controlling and Preventing Subsidence

Following District review of the TWDB report **Identification of the Vulnerability of the Major and Minor Aquifers of Texas with Subsidence with Regard to Groundwater Pumping** the District concluded that this goal is not applicable to the operation of the District. The report may be accessed at https://www.twdb.texas.gov/groundwater/models/research/subsidence/subsidence.asp

Goal 2.0 Addressing recharge enhancement

The Texas Water Development Board, at the request of the District, completed a study of an area within the District to evaluate the possibility of beneficial artificial recharge of this area of the Hickory Aquifer. Evaluation of the Hickory Aquifer and Its Relationship to Katemcy Creek and Its Major Tributaries for Beneficial Recharge, McCulloch and Mason Counties, Texas, is available in the District Office. This study, along with subsequent studies, does not support an economically feasible recharge program.

Goal 3.0 Addressing precipitation enhancement

The District has investigated participation in the West Texas Weather Modification program which performs cloud-seeding operations out of San Angelo, Texas, but had determined that it is not economically feasible.

Statement of Commitment by Hickory Underground Water Conservation District No. 1, to Effectuation of the District Groundwater Management Plan.

The District will implement the provisions of this plan and/or future amendments and will utilize the provisions of this plan, or amended plan, as guidance for implementation of District goals, in promulgating District Rules and selecting, evaluating, and carrying our district programs, activities and hydrogeologic studies.

Bibliography

1 Texas Almanac 2002-2003, 2000 Census Data, The Dallas Morning News
2 "Hickory Water Data" prepared for Hickory UWCD No. 1 by Harden and Associates, August 1986, and aquifer maps obtained from Water for Texas, 1997, TWDB
3 Edwards-Trinity Aquifer information obtained from TWDB website: http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/Brackish%20GW%20Manual/08-Edwards-Trinity(Plateau).pdf Report by LBG-Guyton Associates
4 Aquifer maps obtained from Water for Texas, 1997, TWDB
5 Ellenburger-San Saba Aquifer information obtained from TWDB website: http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/Brackish%20GW%20Manual/26-Ellenburger-SanSaba.pdf Report by LBG-Guyton Associates

6 Marble Falls Aquifer information obtained from TWDB website:
http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/Brackish%20GW%20Manual/27-MarbleFalls.pdf Report by LBG-Guyton Associate
7 Table 3.1-1, Region F Regional Water Plan, TWDB, January 2006
8 Table 3.2-2 Region F Regional Water Plan, January 2006

APPENDIX "A"

Estimated Historical Groundwater Use And 2017 State Water Plan Datasets:

Hickory Underground Water Conservation District # 1

by Stephen Allen
Texas Water Development Board
Groundwater Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
July 30, 2018

GROUNDWATER MANAGEMENT PLAN DATA:

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

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

The five reports included in this part are:

1. Estimated Historical Groundwater Use (checklist item 2)

   from the TWDB Historical Water Use Survey (WUS)

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

   from the 2017 Texas State Water Plan (SWP)

Part 2 of the 2-part package is the groundwater availability model (GAM) report for the District (checklist items 3 through 5). The District should have received, or will receive, this report from the Groundwater Availability Modeling Section. Questions about the GAM can be directed to Dr. Shirley Wade, shirley.wade@twdb.texas.gov, (512) 936-0883.

DISCLAIMER:

The data presented in this report represents the most up-to-date WUS and 2017 SWP data available as of 7/30/2018. Although it does not happen frequently, either of these datasets are subject to change pending the availability of more accurate WUS data or an amendment to the 2017 SWP. District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The WUS dataset can be verified at this web address:

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

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

The values presented in the data tables of this report are county-based. In cases where groundwater conservation districts cover only a portion of one or more counties the data values are modified with an apportioning multiplier to create new values that more accurately represent conditions within district boundaries. The multiplier used in the following formula is a land area ratio: (data value * (land area of district in county / land area of county)). For two of the four SWP tables (Projected Surface Water Supplies and Projected Water Demands) only the county-wide water user group (WUG) data values (county other, manufacturing, steam electric power, irrigation, mining and livestock) are modified using the multiplier. WUG values for municipalities, water supply corporations, and utility districts are not apportioned; instead, their full values are retained when they are located within the district, and eliminated when they are located outside (we ask each district to identify these entity locations).

The remaining SWP tables (Projected Water Supply Needs and Projected Water Management Strategies) are not modified because district-specific values are not statutorily required. Each district needs only "consider" the county values in these tables.

In the WUS table every category of water use (including municipal) is apportioned. Staff determined that breaking down the annual municipal values into individual WUGs was too complex.

TWDB recognizes that the apportioning formula used is not perfect but it is the best available process with respect to time and staffing constraints. If a district believes it has data that is more accurate it can add those data to the plan with an explanation of how the data were derived. Apportioning percentages that the TWDB used are listed above each applicable table.

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

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

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2017. TWDB staff anticipates the calculation and posting of these estimates at a later date.

CONCHO COUNTY *11.44% (multiplier)* All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2016	GW	56	0	0	0	504	19	579
	SW	5	0	0	0	25	19	49
2015	GW	58	0	0	0	473	19	550
	SW	2	0	0	0	41	19	62
2014	GW	51	0	0	0	509	19	579
	SW	3	0	0	0	36	19	58
2013	GW	53	0	0	0	564	18	635
	SW	5	0	0	0	28	18	51
2012	GW	46	0	0	0	539	22	607
	SW	2	0	0	0	21	22	45
2011	GW	63	0	31	0	264	25	383
	SW	11	0	5	0	23	25	64
2010	GW	45	0	12	0	738	26	821
	SW	11	0	2	0	82	26	121
2009	GW	45	0	9	0	138	28	220
	SW	11	0	1	0	160	28	200
2008	GW	52	0	5	0	1,106	28	1,191
	SW	4	0	1	0	12	28	45
2007	GW	57	0	0	0	585	40	682
	SW	8	0	0	0	14	40	62
2006	GW	73	0	0	0	873	33	979
	SW	8	0	0	0	11	33	52
2005	GW	82	0	0	0	337	27	446
	SW	11	0	0	0	70	27	108
2004	GW	61	0	0	0	208	41	310
	SW	11	0	0	0	143	10	164
2003	GW	64	0	0	0	171	40	275
	SW	9	0	0	0	137	10	156
2002	GW	70	0	0	0	397	50	517
	SW	9	0	0	0	25	12	46
2001	GW	61	0	0	0	225	49	335
	SW	8	0	0	0	14	12	34

KIMBLE COUNTY 2.55% *(multiplier)* All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2016	GW	1	0	0	0	9	4	14
	SW	13	14	0	0	52	2	81
2015	GW	3	0	0	0	3	4	10
	SW	13	16	0	0	58	2	89
2014	GW	4	0	0	0	8	4	16
	SW	13	14	0	0	55	2	84
2013	GW	6	0	5	0	5	4	20
	SW	13	15	1	0	58	2	89
2012	GW	6	0	0	0	10	5	21
	SW	15	15	0	0	58	2	90
2011	GW	7	0	0	0	8	8	23
	SW	16	15	0	0	61	4	96
2010	GW	6	0	0	0	14	8	28
	SW	16	13	0	0	62	3	94
2009	GW	6	0	0	0	20	6	32
	SW	16	12	0	0	57	3	88
2008	GW	6	0	0	0	5	6	17
	SW	15	0	0	0	70	3	88
2007	GW	5	0	0	0	12	7	24
	SW	15	0	0	0	28	3	46
2006	GW	6	0	0	0	1	7	14
	SW	16	2	0	0	77	3	98
2005	GW	6	0	0	0	4	7	17
	SW	16	2	0	0	60	3	81
2004	GW	5	0	0	0	2	8	15
	SW	16	2	0	0	56	2	76
2003	GW	5	0	0	0	1	7	13
	SW	17	0	0	0	67	2	86
2002	GW	5	0	0	0	1	8	14
	SW	18	1	0	0	15	2	36
2001	GW	5	0	0	0	1	9	15
	SW	20	0	0	0	15	2	37

MASON COUNTY

100% (multiplier)

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2016	GW	639	0	187	0	4,791	509	6,126
	SW	0	0	0	0	103	170	273
2015	GW	670	0	116	0	4,888	499	6,173
	SW	0	0	0	0	83	166	249
2014	GW	737	0	266	0	5,126	489	6,618
	SW	0	0	0	0	99	163	262
2013	GW	776	0	311	0	4,695	474	6,256
	SW	0	0	0	0	69	158	227
2012	GW	777	0	313	0	5,203	608	6,901
	SW	0	0	0	0	70	203	273
2011	GW	952	0	275	0	5,644	680	7,551
	SW	0	0	285	0	2	227	514
2010	GW	814	0	275	0	3,853	426	5,368
	SW	0	0	285	0	69	142	496
2009	GW	812	0	275	0	6,725	650	8,462
	SW	0	0	285	0	69	216	570
2008	GW	748	0	275	0	5,445	738	7,206
	SW	0	0	285	0	74	246	605
2007	GW	583	0	0	0	3,311	742	4,636
	SW	0	0	0	0	0	248	248
2006	GW	825	0	0	0	6,775	936	8,536
	SW	0	0	0	0	55	312	367
2005	GW	704	0	0	0	8,375	756	9,835
	SW	0	0	0	0	38	252	290
2004	GW	573	0	0	0	9,562	524	10,659
	SW	0	0	0	0	115	524	639
2003	GW	655	0	0	0	9,276	515	10,446
	SW	0	0	0	0	36	515	551
2002	GW	811	0	0	0	9,866	327	11,004
	SW	0	0	0	0	0	327	327
2001	GW	748	0	0	0	9,499	396	10,643
	SW	0	0	0	0	0	396	396

MCCULLOCH COUNTY

72.92% (multiplier)

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2016	GW	1,111	53	3,681	0	637	283	5,765
	SW	13	0	0	0	215	71	299
2015	GW	1,034	28	3,128	0	1,475	281	5,946
	SW	8	0	0	0	136	70	214
2014	GW	1,113	28	2,772	0	1,456	273	5,642
	SW	6	0	0	0	171	69	246
2013	GW	1,101	29	2,045	0	1,331	267	4,773
	SW	9	0	0	0	154	67	230
2012	GW	1,187	53	2,230	0	1,504	308	5,282
	SW	9	0	0	0	116	77	202
2011	GW	1,329	1	3,957	0	1,781	365	7,433
	SW	21	0	1,989	0	95	91	2,196
2010	GW	745	1	3,709	0	1,770	686	6,911
	SW	436	0	2,015	0	95	171	2,717
2009	GW	747	1	2,510	0	2,451	416	6,125
	SW	428	0	1,999	0	163	104	2,694
2008	GW	754	1	3,572	0	560	384	5,271
	SW	591	0	1,983	0	0	96	2,670
2007	GW	1,461	20	1,654	0	1,308	376	4,819
	SW	26	0	0	0	61	94	181
2006	GW	1,517	25	1,779	0	2,146	359	5,826
	SW	28	0	0	0	389	90	507
2005	GW	1,482	25	542	0	2,297	398	4,744
	SW	22	0	0	0	349	100	471
2004	GW	1,442	28	535	0	2,297	363	4,665
	SW	23	0	0	0	364	90	477
2003	GW	1,458	36	514	0	2,527	363	4,898
	SW	8	0	0	0	526	90	624
2002	GW	1,367	32	357	0	1,516	478	3,750
	SW	2	0	0	0	31	120	153
2001	GW	1,339	61	489	0	1,487	395	3,771
	SW	2	0	0	0	31	98	131

MENARD COUNTY

13.51% (multiplier)

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2016	GW	4	0	0	0	52	34	90
	SW	34	0	0	0	453	6	493
2015	GW	6	0	0	0	69	34	109
	SW	32	0	0	0	496	6	534
2014	GW	10	0	0	0	54	33	97
	SW	34	0	0	0	553	6	593
2013	GW	12	0	0	0	63	33	108
	SW	35	0	0	0	638	6	679
2012	GW	13	0	0	0	136	30	179
	SW	39	0	0	0	131	5	175
2011	GW	14	0	77	0	45	35	171
	SW	49	0	20	0	574	6	649
2010	GW	12	0	28	0	115	37	192
	SW	40	0	7	0	165	6	218
2009	GW	47	0	14	0	110	45	216
	SW	0	0	4	0	106	8	118
2008	GW	41	0	0	0	0	40	81
	SW	0	0	0	0	138	7	145
2007	GW	34	0	0	0	143	47	224
	SW	0	0	0	0	141	8	149
2006	GW	39	0	0	0	211	46	296
	SW	0	0	0	0	132	8	140
2005	GW	35	0	0	0	29	44	108
	SW	0	0	0	0	190	8	198
2004	GW	35	0	0	0	19	43	97
	SW	0	0	0	0	153	11	164
2003	GW	43	0	0	0	25	43	111
	SW	0	0	0	0	206	11	217
2002	GW	45	0	0	0	57	40	142
	SW	0	0	0	0	416	10	426
2001	GW	46	0	0	0	57	45	148
	SW	0	0	0	0	416	11	427

SAN SABA COUNTY

55.88% (multiplier)

All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2016	GW	849	2	0	0	1,297	168	2,316
	SW	83	1	0	0	3,022	251	3,357
2015	GW	873	2	0	0	1,798	164	2,837
	SW	75	1	0	0	2,120	246	2,442
2014	GW	785	2	0	0	2,248	161	3,196
	SW	137	1	0	0	2,208	243	2,589
2013	GW	957	2	0	0	1,617	157	2,733
	SW	78	1	0	0	2,258	235	2,572
2012	GW	1,228	5	6	0	2,012	165	3,416
	SW	0	1	1	0	2,176	248	2,426
2011	GW	1,149	3	213	0	1,703	193	3,261
	SW	0	0	221	0	2,711	290	3,222
2010	GW	748	3	224	0	800	193	1,968
	SW	0	0	231	0	2,380	291	2,902
2009	GW	741	1	221	0	1,748	205	2,916
	SW	0	0	226	0	2,425	307	2,958
2008	GW	734	1	218	0	139	205	1,297
	SW	0	0	221	0	2,264	307	2,792
2007	GW	656	1	0	0	801	284	1,742
	SW	0	0	0	0	1,789	425	2,214
2006	GW	742	1	0	0	500	205	1,448
	SW	0	0	0	0	2,891	307	3,198
2005	GW	677	1	1	0	597	235	1,511
	SW	0	0	0	0	2,806	353	3,159
2004	GW	3,292	1	4	0	607	496	4,400
	SW	0	0	0	0	2,236	124	2,360
2003	GW	658	1	4	0	420	484	1,567
	SW	53	0	0	0	2,611	121	2,785
2002	GW	664	0	13	0	206	490	1,373
	SW	32	0	0	0	1,262	122	1,416
2001	GW	739	0	13	0	198	490	1,440
	SW	8	0	0	0	1,214	122	1,344

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

CONCHO COUNTY

11.44% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, CONCHO	COLORADO	COLORADO RUN-OF-RIVER	4	4	4	4	4	4
F	COUNTY-OTHER, CONCHO	COLORADO	MOUNTAIN CREEK LAKE/RESERVOIR	0	0	0	0	0	0
F	COUNTY-OTHER, CONCHO	COLORADO	SAN ANGELO LAKES LAKE/RESERVOIR SYSTEM	0	0	0	0	0	0
F	LIVESTOCK, CONCHO	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	14	14	14	14	14	14
F	MILLERSVIEW-DOOLE WSC	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM	49	65	59	52	47	43
	Sum of Projected Surface Water Supplies (acre-feet)			**67**	**83**	**77**	**70**	**65**	**61**

KIMBLE COUNTY

2.55% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, KIMBLE	COLORADO	COLORADO RUN-OF-RIVER	0	0	0	0	0	0
F	IRRIGATION, KIMBLE	COLORADO	COLORADO RUN-OF-RIVER	29	29	29	29	29	29
F	JUNCTION	COLORADO	COLORADO RUN-OF-RIVER	0	0	0	0	0	0
F	LIVESTOCK, KIMBLE	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	2	2	2	2	2	2
F	MANUFACTURING, KIMBLE	COLORADO	COLORADO RUN-OF-RIVER	0	0	0	0	0	0
F	MINING, KIMBLE	COLORADO	COLORADO RUN-OF-RIVER	0	0	0	0	0	0
	Sum of Projected Surface Water Supplies (acre-feet)			**31**	**31**	**31**	**31**	**31**	**31**

MASON COUNTY

100% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	IRRIGATION, MASON	COLORADO	HIGHLAND LAKES LAKE/RESERVOIR SYSTEM	59	59	59	59	59	59

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	LIVESTOCK, MASON	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	498	498	498	498	498	498
F	MINING, MASON	COLORADO	HIGHLAND LAKES LAKE/RESERVOIR SYSTEM	2	2	2	2	2	2
	Sum of Projected Surface Water Supplies (acre-feet)			**559**	**559**	**559**	**559**	**559**	**559**

MCCULLOCH COUNTY

72.92% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	BRADY	COLORADO	BRADY CREEK LAKE/RESERVOIR	0	0	0	0	0	0
F	IRRIGATION, MCCULLOCH	COLORADO	COLORADO RUN-OF-RIVER	50	50	50	50	50	50
F	LIVESTOCK, MCCULLOCH	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	120	120	120	120	120	120
F	MILLERSVIEW-DOOLE WSC	COLORADO	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM	77	106	95	86	77	70
	Sum of Projected Surface Water Supplies (acre-feet)			**247**	**276**	**265**	**256**	**247**	**240**

MENARD COUNTY

13.51% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
F	IRRIGATION, MENARD	COLORADO	COLORADO RUN-OF-RIVER	284	284	284	284	284	284
F	LIVESTOCK, MENARD	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	12	12	12	12	12	12
F	MANUFACTURING, MENARD	COLORADO	COLORADO RUN-OF-RIVER	0	0	0	0	0	0
F	MENARD	COLORADO	COLORADO RUN-OF-RIVER	136	136	136	136	136	136
	Sum of Projected Surface Water Supplies (acre-feet)			**432**	**432**	**432**	**432**	**432**	**432**

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

SAN SABA COUNTY *55.88% (multiplier)* All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
K	COUNTY-OTHER, SAN SABA	COLORADO	HIGHLAND LAKES LAKE/RESERVOIR SYSTEM	11	11	11	11	11	11
K	IRRIGATION, SAN SABA	COLORADO	COLORADO RUN-OF-RIVER	1,118	1,118	1,118	1,118	1,118	1,118
K	LIVESTOCK, SAN SABA	COLORADO	COLORADO LIVESTOCK LOCAL SUPPLY	503	503	503	503	503	503
K	SAN SABA	COLORADO	COLORADO RUN-OF-RIVER	10	10	10	10	10	10
	Sum of Projected Surface Water Supplies (acre-feet)			**1,642**	**1,642**	**1,642**	**1,642**	**1,642**	**1,642**

Projected Water Demands
TWDB 2017 State Water Plan Data

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

CONCHO COUNTY

11.44% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, CONCHO	COLORADO	11	11	11	10	10	10
F	EDEN	COLORADO	480	478	471	467	466	466
F	IRRIGATION, CONCHO	COLORADO	1,114	1,109	1,104	1,100	1,096	1,092
F	LIVESTOCK, CONCHO	COLORADO	80	80	80	80	80	80
F	MILLERSVIEW-DOOLE WSC	COLORADO	97	96	94	93	92	92
F	MINING, CONCHO	COLORADO	55	54	48	42	37	32
		Sum of Projected Water Demands (acre-feet)	**1,837**	**1,828**	**1,808**	**1,792**	**1,781**	**1,772**

KIMBLE COUNTY

2.55% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, KIMBLE	COLORADO	7	6	6	6	6	6
F	IRRIGATION, KIMBLE	COLORADO	75	72	69	66	64	61
F	JUNCTION	COLORADO	627	620	610	605	604	604
F	LIVESTOCK, KIMBLE	COLORADO	10	10	10	10	10	10
F	MANUFACTURING, KIMBLE	COLORADO	18	19	21	22	23	25
F	MINING, KIMBLE	COLORADO	0	0	0	0	0	0
		Sum of Projected Water Demands (acre-feet)	**737**	**727**	**716**	**709**	**707**	**706**

MASON COUNTY

100% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, MASON	COLORADO	234	227	221	218	217	217
F	IRRIGATION, MASON	COLORADO	8,294	8,174	8,054	7,935	7,816	7,699
F	LIVESTOCK, MASON	COLORADO	1,248	1,248	1,248	1,248	1,248	1,248
F	MASON	COLORADO	694	684	676	671	671	671
F	MINING, MASON	COLORADO	1,023	941	708	568	460	372
		Sum of Projected Water Demands (acre-feet)	**11,493**	**11,274**	**10,907**	**10,640**	**10,412**	**10,207**

Projected Water Demands
TWDB 2017 State Water Plan Data

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

MCCULLOCH COUNTY

72.92% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	BRADY	COLORADO	1,389	1,418	1,399	1,408	1,410	1,412
F	COUNTY-OTHER, MCCULLOCH	COLORADO	67	69	69	69	69	69
F	IRRIGATION, MCCULLOCH	COLORADO	2,613	2,581	2,547	2,514	2,482	2,451
F	LIVESTOCK, MCCULLOCH	COLORADO	521	521	521	521	521	521
F	MANUFACTURING, MCCULLOCH	COLORADO	365	394	421	446	483	524
F	MILLERSVIEW-DOOLE WSC	COLORADO	153	155	152	151	151	152
F	MINING, MCCULLOCH	COLORADO	6,510	6,087	4,843	4,103	3,526	3,063
F	RICHLAND SUD	COLORADO	176	178	176	176	176	176
		Sum of Projected Water Demands (acre-feet)	**11,794**	**11,403**	**10,128**	**9,388**	**8,818**	**8,368**

MENARD COUNTY

13.51% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, MENARD	COLORADO	13	12	12	12	12	12
F	IRRIGATION, MENARD	COLORADO	342	341	340	338	337	336
F	LIVESTOCK, MENARD	COLORADO	55	55	55	55	55	55
F	MANUFACTURING, MENARD	COLORADO	0	0	0	0	0	0
F	MENARD	COLORADO	346	338	332	331	331	331
F	MINING, MENARD	COLORADO	147	145	129	112	97	84
		Sum of Projected Water Demands (acre-feet)	**903**	**891**	**868**	**848**	**832**	**818**

SAN SABA COUNTY

55.88% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
K	COUNTY-OTHER, SAN SABA	COLORADO	177	179	175	173	176	180
K	IRRIGATION, SAN SABA	COLORADO	3,095	2,996	2,899	2,804	2,714	2,631
K	LIVESTOCK, SAN SABA	COLORADO	666	666	666	666	666	666
K	MANUFACTURING, SAN SABA	COLORADO	4	4	4	4	4	4
K	MINING, SAN SABA	COLORADO	608	611	528	503	483	468
K	RICHLAND SUD	COLORADO	168	172	169	165	168	172

Projected Water Demands
TWDB 2017 State Water Plan Data

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

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
K	SAN SABA	COLORADO	1,138	1,178	1,174	1,149	1,175	1,202
		Sum of Projected Water Demands (acre-feet)	**5,856**	**5,806**	**5,615**	**5,464**	**5,386**	**5,323**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

CONCHO COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, CONCHO	COLORADO	0	0	0	0	0	0
F	EDEN	COLORADO	0	0	0	0	0	0
F	IRRIGATION, CONCHO	COLORADO	-5,249	-5,208	-5,169	-5,133	-5,097	-5,061
F	LIVESTOCK, CONCHO	COLORADO	0	0	0	0	0	0
F	MILLERSVIEW-DOOLE WSC	COLORADO	15	30	25	18	13	8
F	MINING, CONCHO	COLORADO	-212	-206	-154	-99	-52	-11
	Sum of Projected Water Supply Needs (acre-feet)		**-5,461**	**-5,414**	**-5,323**	**-5,232**	**-5,149**	**-5,072**

KIMBLE COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, KIMBLE	COLORADO	-13	-12	-12	-12	-12	-12
F	IRRIGATION, KIMBLE	COLORADO	-1,496	-1,387	-1,275	-1,163	-1,058	-957
F	JUNCTION	COLORADO	-627	-620	-610	-605	-604	-604
F	LIVESTOCK, KIMBLE	COLORADO	0	0	0	0	0	0
F	MANUFACTURING, KIMBLE	COLORADO	-699	-750	-802	-850	-914	-983
F	MINING, KIMBLE	COLORADO	0	0	0	0	0	0
	Sum of Projected Water Supply Needs (acre-feet)		**-2,835**	**-2,769**	**-2,699**	**-2,630**	**-2,588**	**-2,556**

MASON COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, MASON	COLORADO	-9	-9	-9	-9	-9	-9
F	IRRIGATION, MASON	COLORADO	59	59	59	59	59	59
F	LIVESTOCK, MASON	COLORADO	0	0	0	0	0	0
F	MASON	COLORADO	-694	-684	-676	-671	-671	-671
F	MINING, MASON	COLORADO	2	2	2	2	2	2
	Sum of Projected Water Supply Needs (acre-feet)		**-703**	**-693**	**-685**	**-680**	**-680**	**-680**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

MCCULLOCH COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	BRADY	COLORADO	-1,389	-1,418	-1,399	-1,408	-1,410	-1,412
F	COUNTY-OTHER, MCCULLOCH	COLORADO	-35	-36	-35	-36	-36	-36
F	IRRIGATION, MCCULLOCH	COLORADO	-2,184	-2,138	-2,081	-2,031	-1,986	-1,944
F	LIVESTOCK, MCCULLOCH	COLORADO	-24	-24	-24	-24	-24	-24
F	MANUFACTURING, MCCULLOCH	COLORADO	-201	-217	-230	-241	-261	-284
F	MILLERSVIEW-DOOLE WSC	COLORADO	21	49	40	31	21	12
F	MINING, MCCULLOCH	COLORADO	-3,618	-3,066	-1,438	-472	0	0
F	RICHLAND SUD	COLORADO	137	133	136	140	137	134
	Sum of Projected Water Supply Needs (acre-feet)		**-7,451**	**-6,899**	**-5,207**	**-4,212**	**-3,717**	**-3,700**

MENARD COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
F	COUNTY-OTHER, MENARD	COLORADO	0	0	0	0	0	0
F	IRRIGATION, MENARD	COLORADO	-426	-418	-410	-401	-393	-385
F	LIVESTOCK, MENARD	COLORADO	18	18	18	18	18	18
F	MANUFACTURING, MENARD	COLORADO	0	0	0	0	0	0
F	MENARD	COLORADO	-210	-202	-196	-195	-195	-195
F	MINING, MENARD	COLORADO	0	0	0	0	0	0
	Sum of Projected Water Supply Needs (acre-feet)		**-636**	**-620**	**-606**	**-596**	**-588**	**-580**

SAN SABA COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
K	COUNTY-OTHER, SAN SABA	COLORADO	215	211	217	222	216	209
K	IRRIGATION, SAN SABA	COLORADO	461	639	812	982	1,144	1,291
K	LIVESTOCK, SAN SABA	COLORADO	27	27	27	27	27	27
K	MANUFACTURING, SAN SABA	COLORADO	0	0	0	0	0	0
K	MINING, SAN SABA	COLORADO	451	446	595	639	675	701
K	RICHLAND SUD	COLORADO	131	129	131	131	131	130
K	SAN SABA	COLORADO	-88	-128	-124	-99	-125	-152
	Sum of Projected Water Supply Needs (acre-feet)		**-88**	**-128**	**-124**	**-99**	**-125**	**-152**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

CONCHO COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
EDEN, COLORADO (F)							
MUNICIPAL CONSERVATION - EDEN	DEMAND REDUCTION [CONCHO]	16	16	16	16	16	16
REUSE - EDEN, DIRECT NON-POTABLE	DIRECT REUSE [CONCHO]	50	50	50	50	50	50
		66	**66**	**66**	**66**	**66**	**66**
IRRIGATION, CONCHO, COLORADO (F)							
IRRIGATION CONSERVATION - CONCHO COUNTY	DEMAND REDUCTION [CONCHO]	487	969	1,062	1,062	1,062	1,062
		487	**969**	**1,062**	**1,062**	**1,062**	**1,062**
MILLERSVIEW-DOOLE WSC, COLORADO (F)							
MUNICIPAL CONSERVATION - MILLERSVIEW-DOOLE WSC	DEMAND REDUCTION [CONCHO]	4	4	4	4	4	4
SUBORDINATION - CRMWD SYSTEM	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	38	20	24	29	33	36
		42	**24**	**28**	**33**	**37**	**40**
MINING, CONCHO, COLORADO (F)							
DEVELOP ADDITIONAL HICKORY AQUIFER SUPPLIES - CONCHO COUNTY MINING	HICKORY AQUIFER [CONCHO]	200	200	200	200	200	200
MINING CONSERVATION - CONCHO COUNTY	DEMAND REDUCTION [CONCHO]	34	33	30	26	22	20
		234	**233**	**230**	**226**	**222**	**220**
Sum of Projected Water Management Strategies (acre-feet)		**829**	**1,292**	**1,386**	**1,387**	**1,387**	**1,388**

KIMBLE COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, KIMBLE, COLORADO (F)							
DEVELOP ADDITIONAL EDWARDS-TRINITY PLATEAU AQUIFER SUPPLIES - JUNCTION	EDWARDS-TRINITY-PLATEAU AQUIFER [KIMBLE]	13	12	12	12	12	12
		13	**12**	**12**	**12**	**12**	**12**
IRRIGATION, KIMBLE, COLORADO (F)							
IRRIGATION CONSERVATION - KIMBLE COUNTY	DEMAND REDUCTION [KIMBLE]	147	283	326	326	326	326

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

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

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
		147	**283**	**326**	**326**	**326**	**326**
JUNCTION, COLORADO (F)							
DEVELOP ADDITIONAL EDWARDS-TRINITY PLATEAU AQUIFER SUPPLIES - JUNCTION	EDWARDS-TRINITY-PLATEAU AQUIFER [KIMBLE]	203	208	208	208	208	208
MUNICIPAL CONSERVATION - JUNCTION	DEMAND REDUCTION [KIMBLE]	14	15	15	15	15	15
SUBORDINATION - KIMBLE COUNTY ROR	COLORADO RUN-OF-RIVER [KIMBLE]	412	412	412	412	412	412
WATER AUDITS AND LEAK - JUNCTION	DEMAND REDUCTION [KIMBLE]	31	31	31	30	30	30
		660	**666**	**666**	**665**	**665**	**665**
MANUFACTURING, KIMBLE, COLORADO (F)							
DEVELOP ADDITIONAL EDWARDS-TRINITY PLATEAU AQUIFER SUPPLIES - KIMBLE COUNTY MANUFACTURING	EDWARDS-TRINITY-PLATEAU AQUIFER [KIMBLE]	300	300	300	300	300	300
		300	**300**	**300**	**300**	**300**	**300**
MINING, KIMBLE, COLORADO (F)							
MINING CONSERVATION - KIMBLE COUNTY	DEMAND REDUCTION [KIMBLE]	1	1	1	1	1	1
		1	**1**	**1**	**1**	**1**	**1**
Sum of Projected Water Management Strategies (acre-feet)		**1,121**	**1,262**	**1,305**	**1,304**	**1,304**	**1,304**

MASON COUNTY

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

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, MASON, COLORADO (F)							
ADDITIONAL WATER TREATMENT - MASON	HICKORY AQUIFER [MASON]	9	9	9	9	9	9
		9	**9**	**9**	**9**	**9**	**9**
IRRIGATION, MASON, COLORADO (F)							
IRRIGATION CONSERVATION - MASON COUNTY	DEMAND REDUCTION [MASON]	415	817	1,208	1,208	1,208	1,208
		415	**817**	**1,208**	**1,208**	**1,208**	**1,208**
MASON, COLORADO (F)							
ADDITIONAL WATER TREATMENT - MASON	HICKORY AQUIFER [MASON]	694	684	676	671	671	671
MUNICIPAL CONSERVATION - MASON	DEMAND REDUCTION [MASON]	12	12	12	12	12	12

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

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

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
WATER AUDITS AND LEAK - MASON	DEMAND REDUCTION [MASON]	26	26	26	25	25	25
		732	**722**	**714**	**708**	**708**	**708**
MINING, MASON, COLORADO (F)							
MINING CONSERVATION - MASON COUNTY	DEMAND REDUCTION [MASON]	72	66	50	40	32	26
		72	**66**	**50**	**40**	**32**	**26**
Sum of Projected Water Management Strategies (acre-feet)		**1,228**	**1,614**	**1,981**	**1,965**	**1,957**	**1,951**

MCCULLOCH COUNTY

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

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
BRADY, COLORADO (F)							
ADVANCED GROUNDWATER TREATMENT - BRADY	HICKORY AQUIFER [MCCULLOCH]	400	385	377	368	349	325
MUNICIPAL CONSERVATION - BRADY	DEMAND REDUCTION [MCCULLOCH]	32	33	33	33	33	33
SUBORDINATION - BRADY CREEK RESERVOIR	BRADY CREEK LAKE/RESERVOIR [RESERVOIR]	1,892	1,854	1,816	1,778	1,740	1,700
		2,324	**2,272**	**2,226**	**2,179**	**2,122**	**2,058**
COUNTY-OTHER, MCCULLOCH, COLORADO (F)							
MUNICIPAL CONSERVATION - MCCULLOCH COUNTY OTHER	DEMAND REDUCTION [MCCULLOCH]	3	3	3	3	3	3
VOLUNTARY TRANSFER FROM MILLERSVIEW DOOLE - MCCULLOCH COUNTY-OTHER	HICKORY AQUIFER [MCCULLOCH]	35	35	35	35	35	35
		38	**38**	**38**	**38**	**38**	**38**
IRRIGATION, MCCULLOCH, COLORADO (F)							
IRRIGATION CONSERVATION - MCCULLOCH COUNTY	DEMAND REDUCTION [MCCULLOCH]	179	354	524	524	524	524
		179	**354**	**524**	**524**	**524**	**524**
LIVESTOCK, MCCULLOCH, COLORADO (F)							
DEVELOP ADDITIONAL EDWARDS-TRINITY PLATEAU AQUIFER SUPPLIES - MCCULLOCH COUNTY LIVESTOCK	EDWARDS-TRINITY-PLATEAU AQUIFER [MCCULLOCH]	30	30	30	30	30	30
		30	**30**	**30**	**30**	**30**	**30**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
MANUFACTURING, MCCULLOCH, COLORADO (F)							
ADVANCED GROUNDWATER TREATMENT - BRADY	HICKORY AQUIFER [MCCULLOCH]	201	217	230	241	261	284
		201	**217**	**230**	**241**	**261**	**284**
MILLERSVIEW-DOOLE WSC, COLORADO (F)							
MUNICIPAL CONSERVATION - MILLERSVIEW-DOOLE WSC	DEMAND REDUCTION [MCCULLOCH]	6	6	6	6	6	6
SUBORDINATION - CRMWD SYSTEM	COLORADO RIVER MWD LAKE/RESERVOIR SYSTEM [RESERVOIR]	60	32	40	47	54	60
		66	**38**	**46**	**53**	**60**	**66**
MINING, MCCULLOCH, COLORADO (F)							
MINING CONSERVATION - MCCULLOCH COUNTY	DEMAND REDUCTION [MCCULLOCH]	625	584	465	394	339	294
		625	**584**	**465**	**394**	**339**	**294**
RICHLAND SUD, COLORADO (F)							
MUNICIPAL CONSERVATION - RICHLAND SUD	DEMAND REDUCTION [MCCULLOCH]	13	14	14	14	14	14
		13	**14**	**14**	**14**	**14**	**14**
Sum of Projected Water Management Strategies (acre-feet)		**3,476**	**3,547**	**3,573**	**3,473**	**3,388**	**3,308**

MENARD COUNTY

WUG, Basin (RWPG)

All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
IRRIGATION, MENARD, COLORADO (F)							
IRRIGATION CONSERVATION - MENARD COUNTY	DEMAND REDUCTION [MENARD]	127	252	377	377	377	377
		127	**252**	**377**	**377**	**377**	**377**
MENARD, COLORADO (F)							
DEVELOP ADDITIONAL HICKORY AQUIFER SUPPLIES - MENARD	HICKORY AQUIFER [MENARD]	500	500	500	500	500	500
MUNICIPAL CONSERVATION - MENARD	DEMAND REDUCTION [MENARD]	8	8	8	8	8	8
REUSE - MENARD, DIRECT NON-POTABLE	DIRECT REUSE [MENARD]	67	67	67	67	67	67

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

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

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
WATER AUDITS AND LEAK - MENARD	DEMAND REDUCTION [MENARD]	17	17	17	16	16	16
		592	**592**	**592**	**591**	**591**	**591**
MINING, MENARD, COLORADO (F)							
MINING CONSERVATION - MENARD COUNTY	DEMAND REDUCTION [MENARD]	76	75	67	58	50	44
		76	**75**	**67**	**58**	**50**	**44**
Sum of Projected Water Management Strategies (acre-feet)		**795**	**919**	**1,036**	**1,026**	**1,018**	**1,012**

SAN SABA COUNTY

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

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
COUNTY-OTHER, SAN SABA, COLORADO (K)							
BRUSH CONTROL	COLORADO RUN-OF-RIVER [SAN SABA]	425	425	425	425	425	425
DROUGHT MANAGEMENT	DEMAND REDUCTION [SAN SABA]	47	48	47	46	47	48
		472	**473**	**472**	**471**	**472**	**473**
RICHLAND SUD, COLORADO (K)							
DROUGHT MANAGEMENT	DEMAND REDUCTION [SAN SABA]	25	26	25	25	25	26
		25	**26**	**25**	**25**	**25**	**26**
SAN SABA, COLORADO (K)							
DROUGHT MANAGEMENT	DEMAND REDUCTION [SAN SABA]	228	236	235	230	235	240
MUNICIPAL CONSERVATION - SAN SABA	DEMAND REDUCTION [SAN SABA]	114	211	302	377	463	510
		342	**447**	**537**	**607**	**698**	**750**
Sum of Projected Water Management Strategies (acre-feet)		**839**	**946**	**1,034**	**1,103**	**1,195**	**1,249**

APPENDIX "B"

GAM Run 16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7

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

STATE OF TEXAS
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GEOLOGY
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PROFESSIONAL GEOSCIENTIST

9/24/2018

GAM Run 16-026 MAG Version 2: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 7

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EXECUTIVE SUMMARY:

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

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

The modeled available groundwater values are summarized by decade for the groundwater conservation districts (Tables 1, 3, 5, 7, 9, 11, 13) and for use in the regional water planning process (Tables 2, 4, 6, 8, 10, 12, 14). The modeled available groundwater estimates are 26,164 acre-feet per year in the Capitan Reef Complex Aquifer; 2,324 acre-feet per year in the Dockum Aquifer; 474,464 acre-feet per year in the undifferentiated Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers; 22,616 acre-feet per year in the Ellenburger-San Saba Aquifer; 49,936 acre-feet per year in the Hickory Aquifer; 6,570 to 8,019 acre-feet per year in the Ogallala Aquifer; and 7,040 acre-feet per year in the Rustler Aquifer. The modeled available groundwater estimates were extracted from results of model runs using

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the groundwater availability models for the Capitan Reef Complex Aquifer (Jones, 2016); the High Plains Aquifer System (Deeds and Jigmond, 2015); the minor aquifers of the Llano Uplift Area (Shi and others, 2016), and the Rustler Aquifer (Ewing and others, 2012). In addition, the alternative 1-layer model for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers (Hutchison and others, 2011) was used for the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers, except for Kinney and Val Verde counties. In these two counties, the alternative Kinney County model (Hutchison and others, 2011) and the model associated with a hydrogeological study for Val Verde County and the City of Del Rio (EcoKai Environmental, Inc. and Hutchison, 2014), respectively, were used to estimate modeled available groundwater. The Val Verde County/Del Rio model covers Val Verde County. This model was used to simulate multiple pumping scenarios indicating the effects of a proposed wellfield. The model indicated the effects of varied pumping rates and wellfield locations. These model runs were used by Groundwater Management Area 7 as the basis for the desired future conditions for Val Verde County.

REQUESTOR:

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

DESCRIPTION OF REQUEST:

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

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

Capitan Reef [Complex] Aquifer

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

Dockum Aquifer

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

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

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

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

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

Taylor	0
Terrell	2
Upton	20
Uvalde	2

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

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

Minor Aquifers of the Llano Uplift Area

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

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

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

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

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

Ogallala Aquifer

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

Rustler Aquifer

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

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

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

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

Capitan Reef Complex Aquifer

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

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

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

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

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

Kinney County

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

Val Verde County

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

Minor Aquifers of the Llano Uplift Area

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

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

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

Dockum Aquifer

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

Modeled available groundwater analysis excludes pass-through cells.

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

Ogallala Aquifer

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

Modeled available groundwater analysis excludes pass-through cells.

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

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

Rustler Aquifer

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

Use 2008 recharge conditions throughout the predictive period.

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

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

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

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

METHODS:

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

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

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

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

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

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

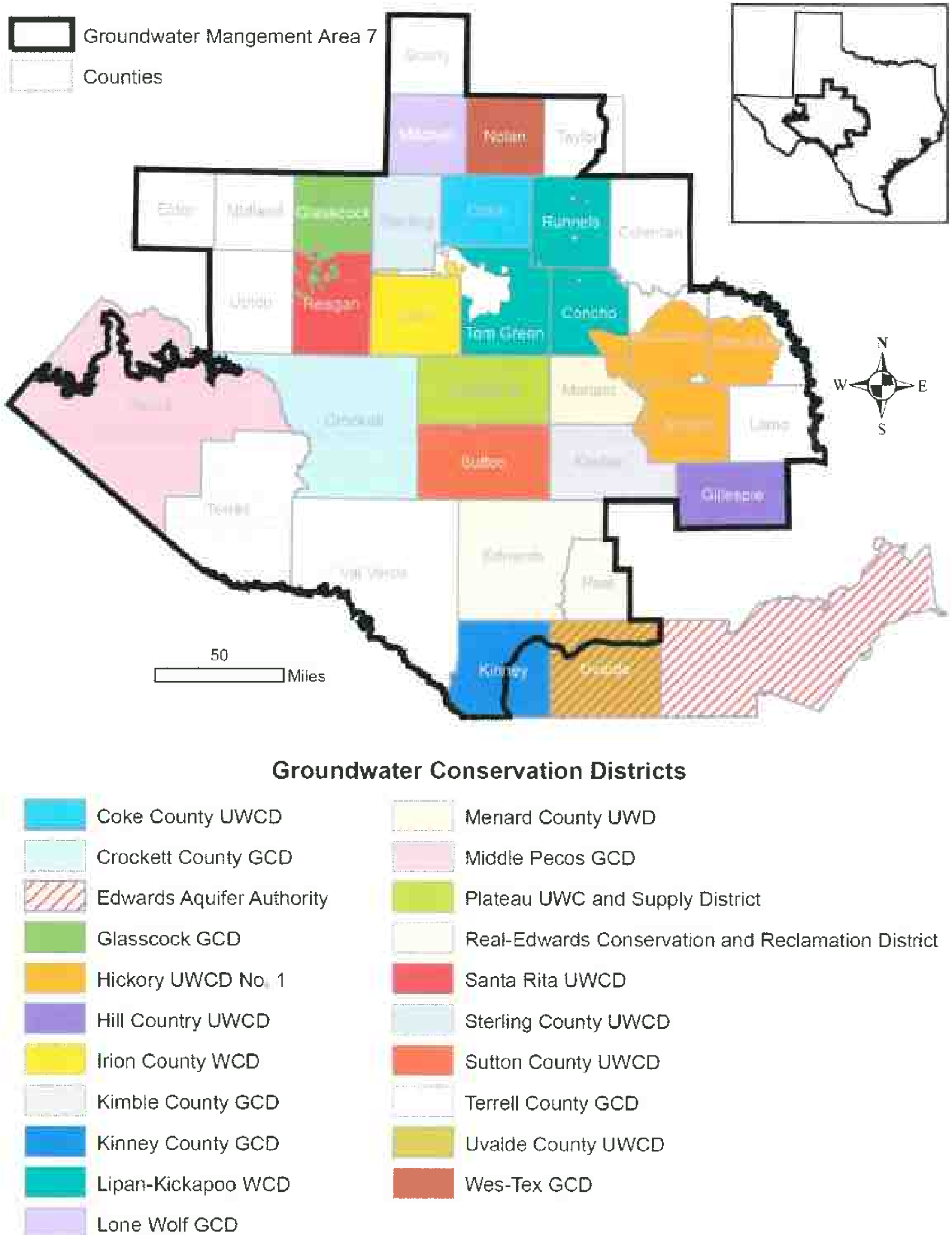

FIGURE 1. **MAP SHOWING THE GROUNDWATER CONSERVATION DISTRICTS (GCD) IN GROUNDWATER MANAGEMENT AREA 7. NOTE: THE BOUNDARIES OF THE EDWARDS AQUIFER AUTHORITY OVERLAP WITH THE UVALDE COUNTY UNDERGROUND WATER CONSERVATION DISTRICT (UWCD).**

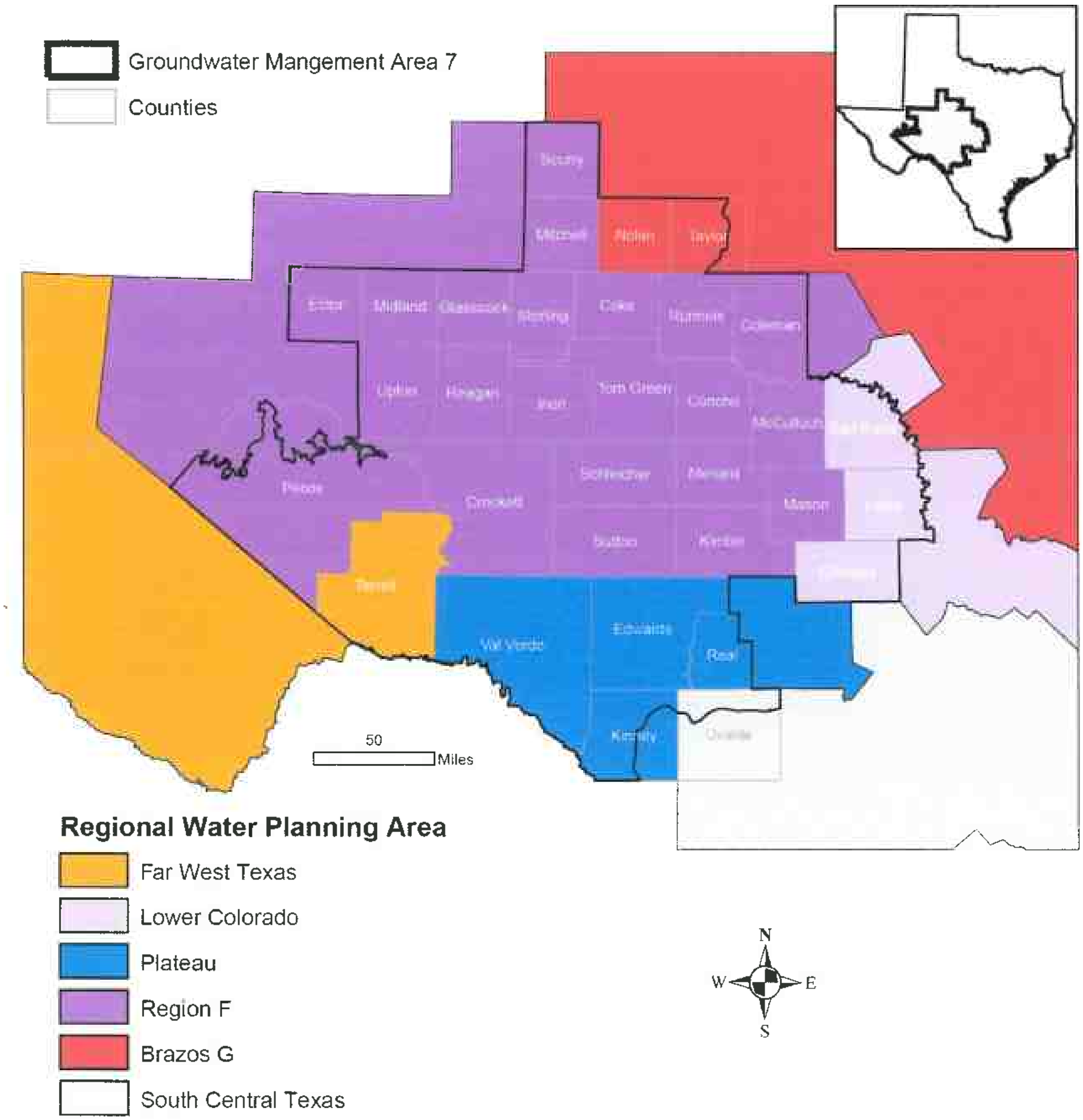

FIGURE 2. **MAP SHOWING REGIONAL WATER PLANNING AREAS IN GROUNDWATER MANAGEMENT AREA 7.**

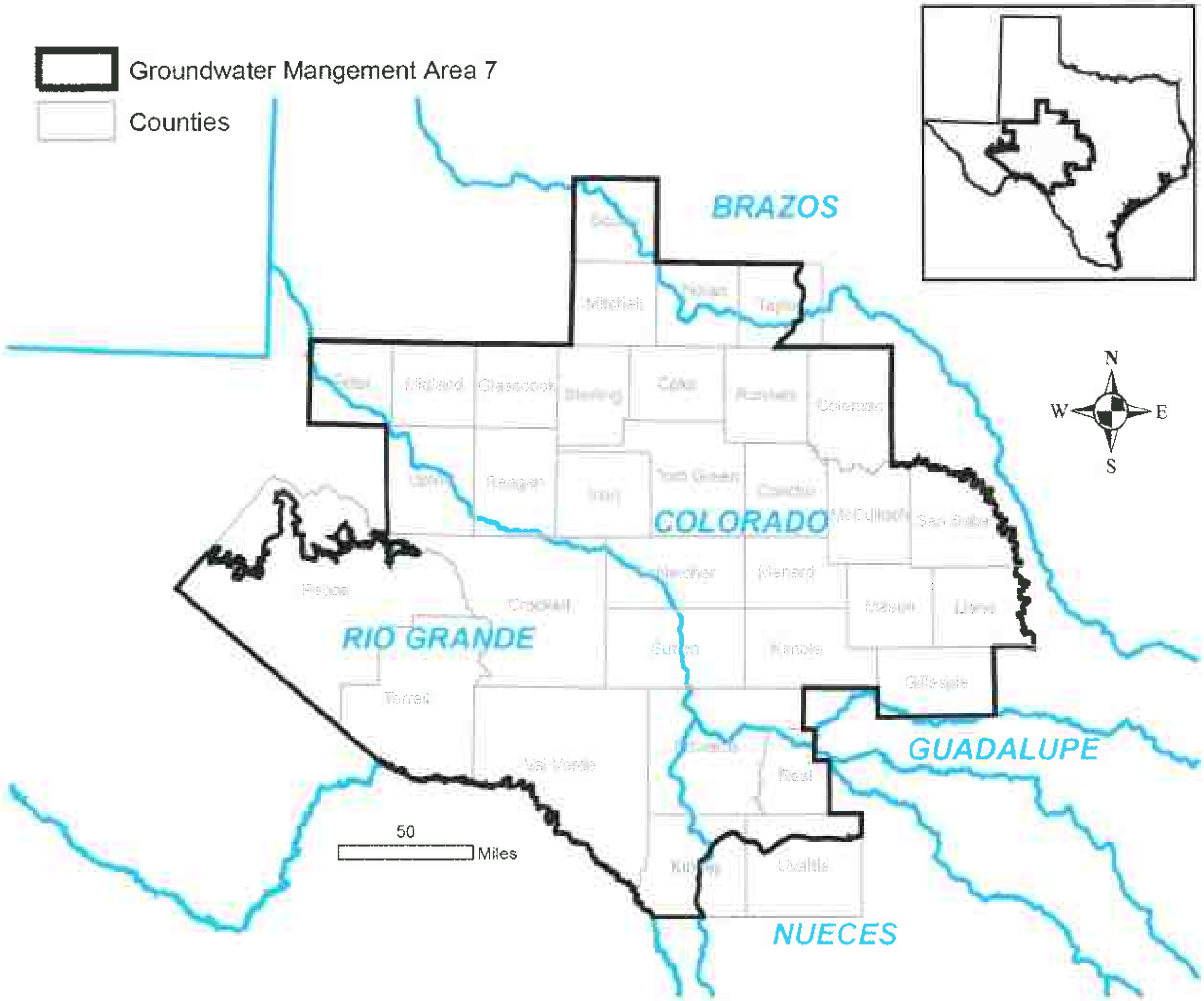

FIGURE 3. **MAP SHOWING RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 7. THESE INCLUDE PARTS OF THE BRAZOS, COLORADO, GUADALUPE, NUECES, AND RIO GRANDE RIVER BASINS.**

PARAMETERS AND ASSUMPTIONS:

Capitan Reef Complex Aquifer

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

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

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

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

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

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

Dockum and Ogallala Aquifers

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

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

The model was run with MODFLOW-NWT (Niswonger and others, 2011). The model uses the Newton formulation and the upstream weighting package, which automatically reduces pumping as heads drop in a particular cell, as defined by the user. This feature may simulate the declining production of a well as saturated thickness decreases. Deeds and Jigmond (2015) modified the MODFLOW-NWT code to use a saturated thickness of 30 feet as the threshold—instead of percent of the saturated thickness—when pumping reductions occur during a simulation. It is important for groundwater management areas to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

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

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

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

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

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

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

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

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

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

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

Edwards-Trinity (Plateau) Aquifer of Kinney County

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

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

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

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

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

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

Edwards-Trinity (Plateau) Aquifer of Val Verde County

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

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

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

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

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

Rustler Aquifer

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

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

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

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

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

Minor aquifers of the Llano Uplift Area

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

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

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

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

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

RESULTS:

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

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

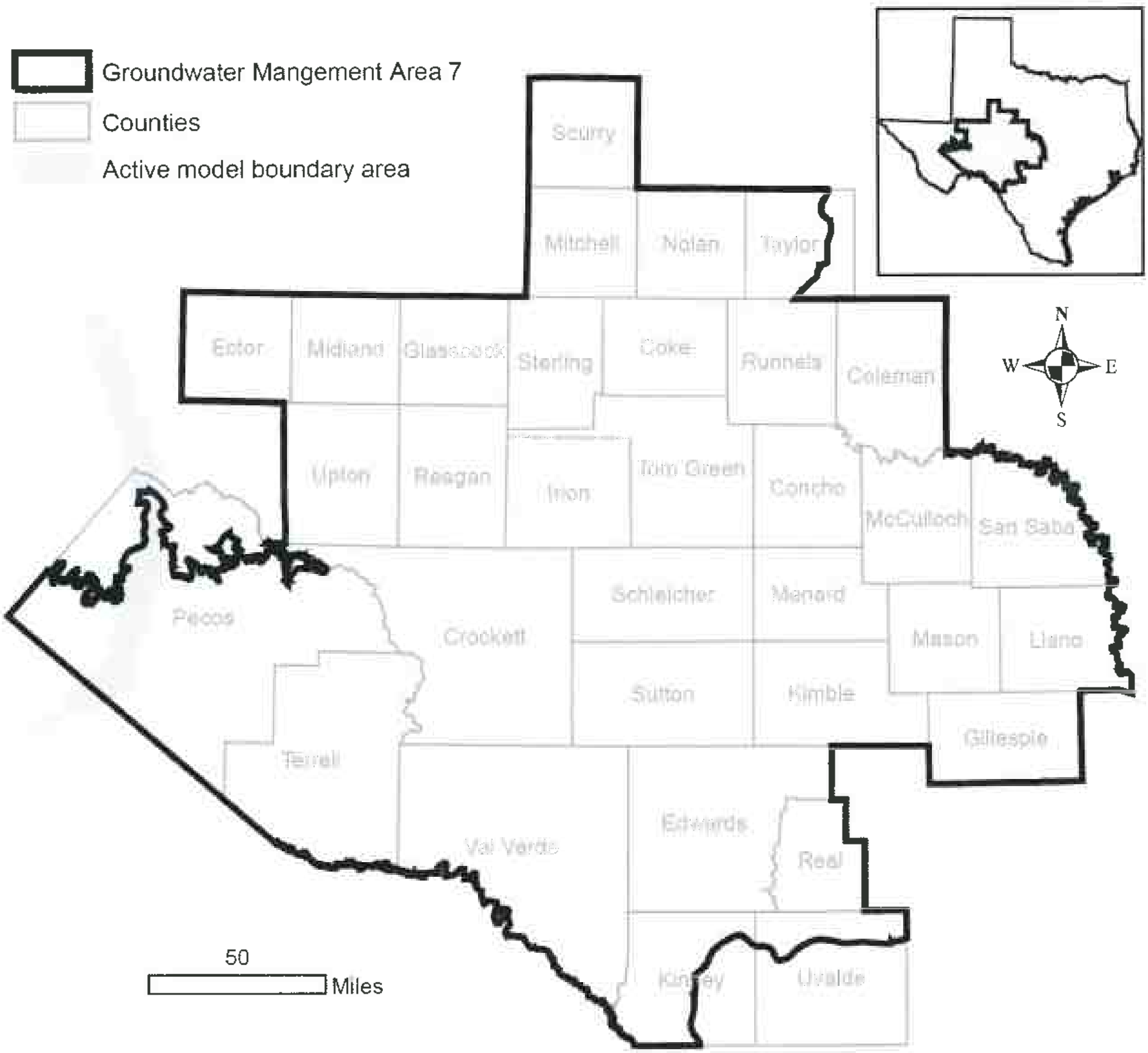

FIGURE 4. MAP SHOWING THE AREAS COVERED BY THE CAPITAN REEF COMPLEX AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EASTERN ARM OF THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

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

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

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

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

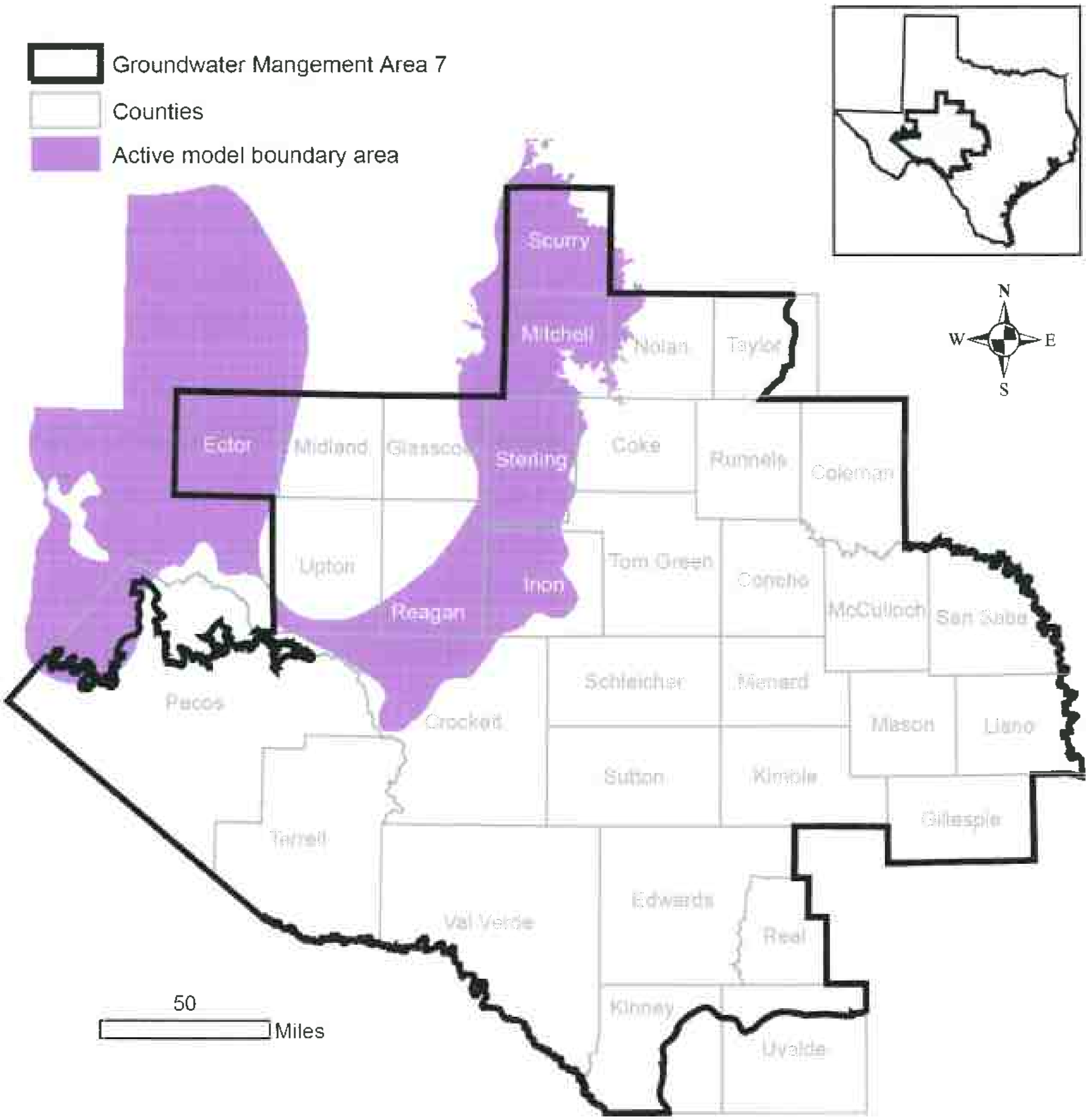

FIGURE 5. **MAP SHOWING AREAS COVERED BY THE DOCKUM AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.**

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

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

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

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

County	RWPA	River Basin	Year					
			2020	2030	2040	2050	2060	2070
Pecos	F	Rio Grande	2,022	2,022	2,022	2,022	2,022	2,022
		Total	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**	**2,022**
Reagan	F	Colorado	302	302	302	302	302	302
		Rio Grande	0	0	0	0	0	0
		Total	**962**	**962**	**962**	**962**	**962**	**962**
GMA 7			**2,324**	**2,324**	**2,324**	**2,324**	**2,324**	**2,324**

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

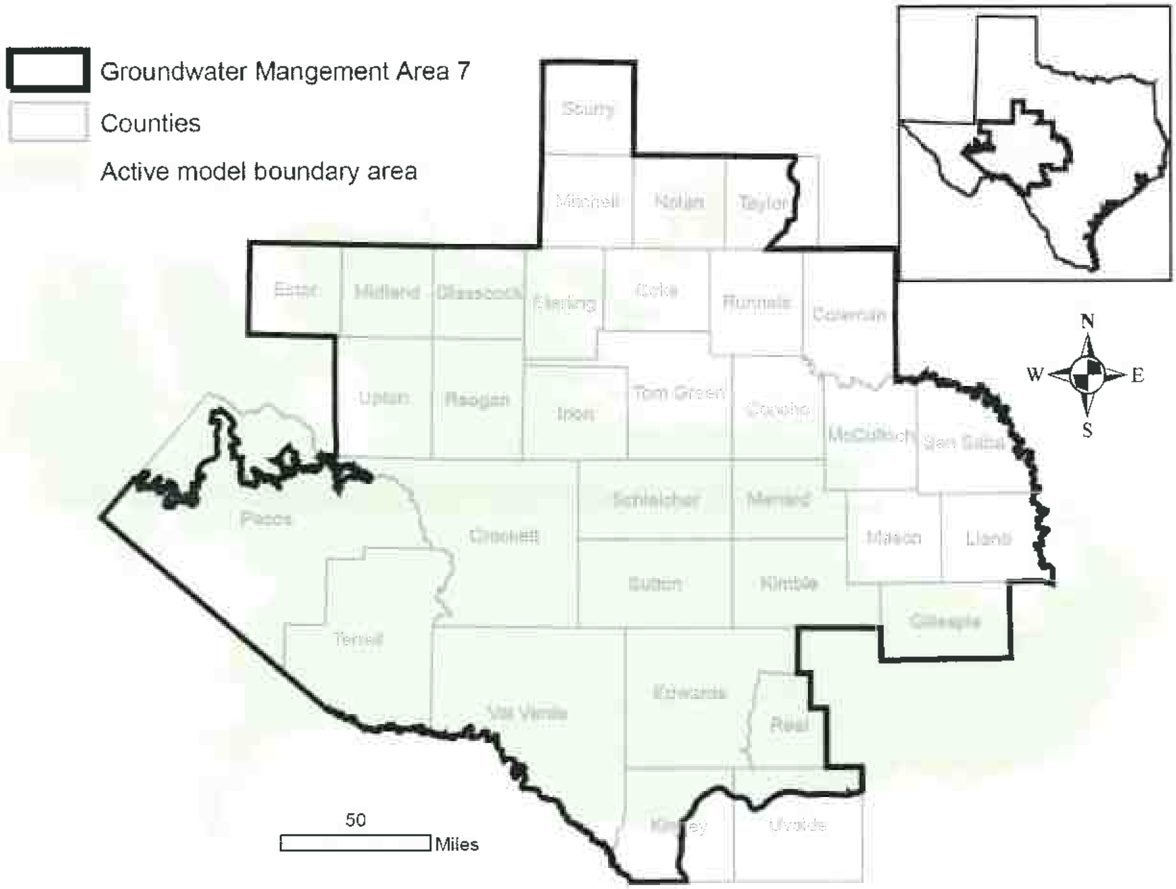

FIGURE 6. MAP SHOWING THE AREAS COVERED BY THE UNDIFFERENTIATED EDWARDS-TRINITY (PLATEAU), PECOS VALLEY, AND TRINITY AQUIFERS IN THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS IN GROUNDWATER MANAGEMENT AREA 7.

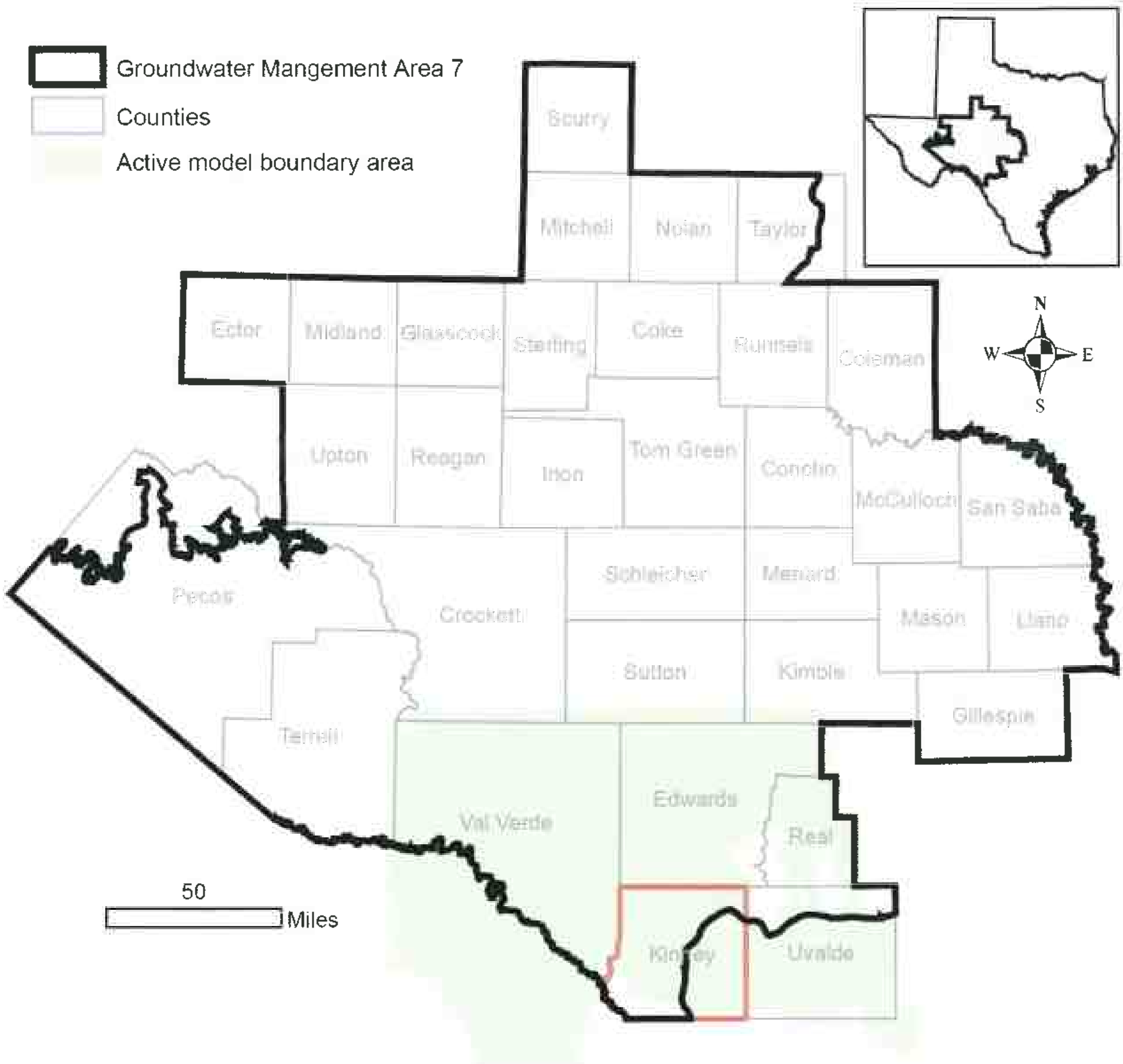

FIGURE 7. **MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE ALTERNATIVE MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN KINNEY COUNTY.**

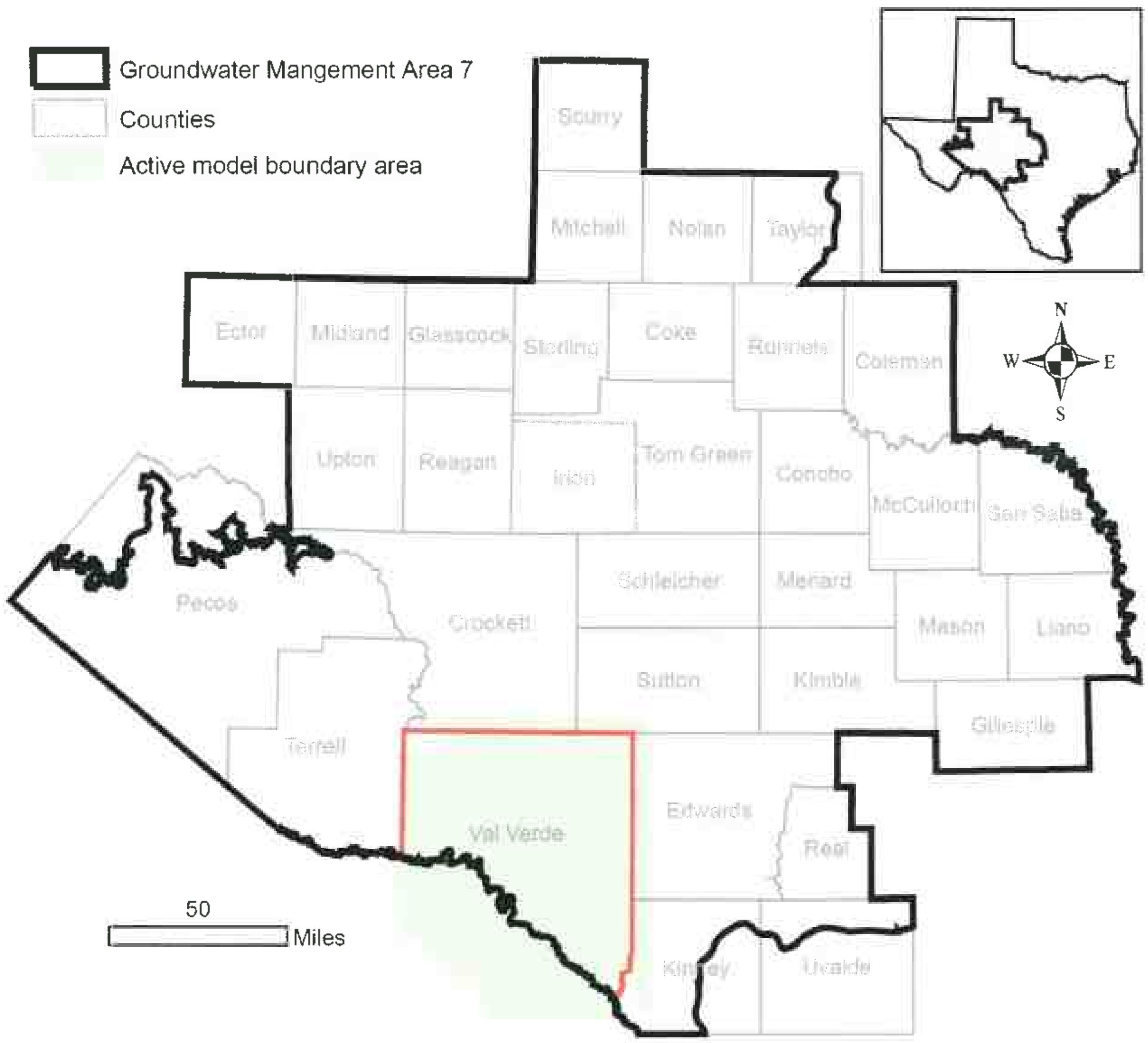

FIGURE 8. **MAP SHOWING THE AREAS COVERED BY THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN THE GROUNDWATER FLOW MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN VAL VERDE COUNTY.**

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

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

TABLE 5. (CONTINUED).

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

TABLE 5. (CONTINUED).

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

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

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

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

TABLE 6. (CONTINUED).

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

TABLE 6. (CONTINUED).

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

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

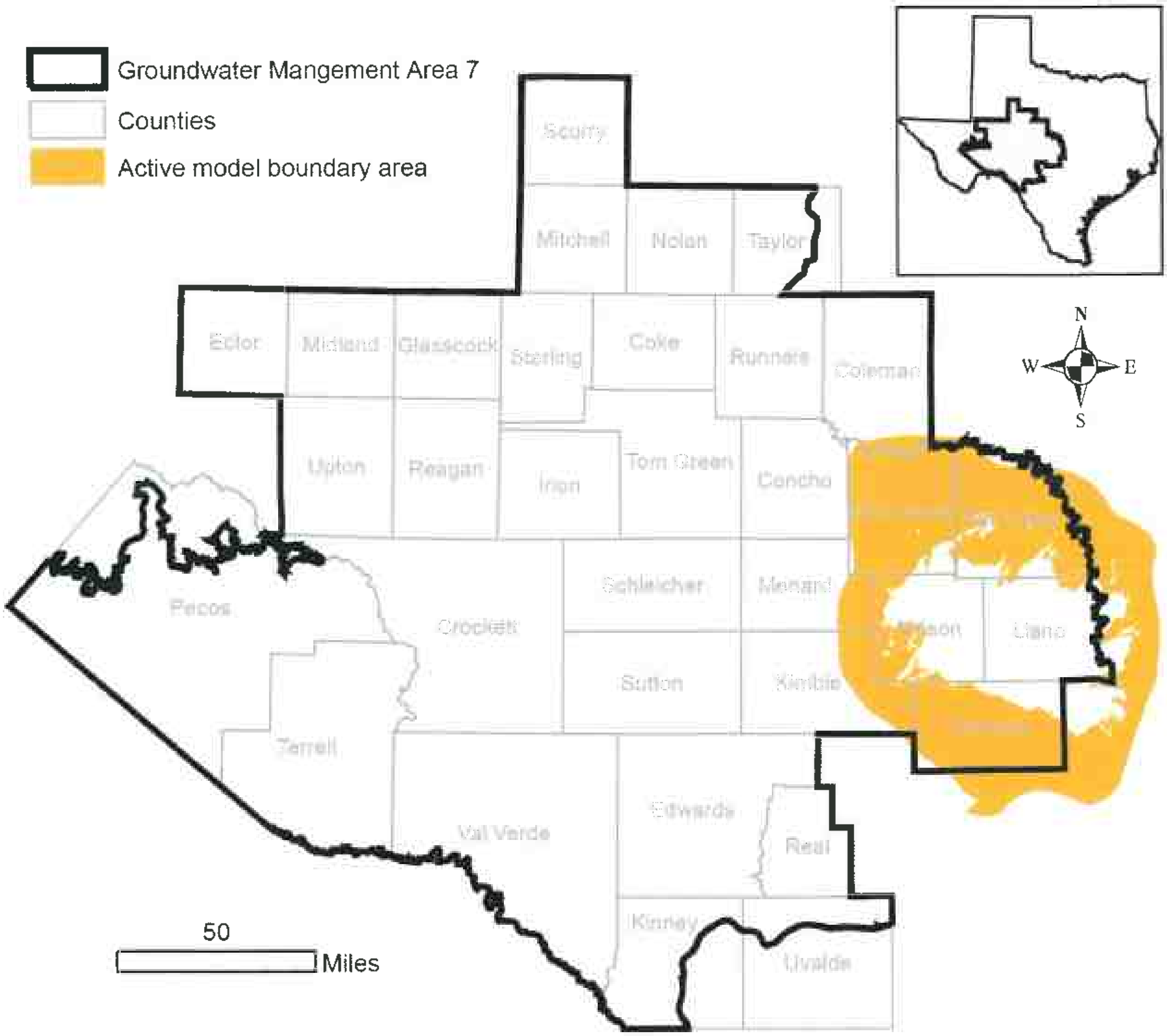

FIGURE 9. **MAP SHOWING THE AREAS COVERED BY THE ELLENBURGER-SAN SABA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.**

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

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

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

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

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

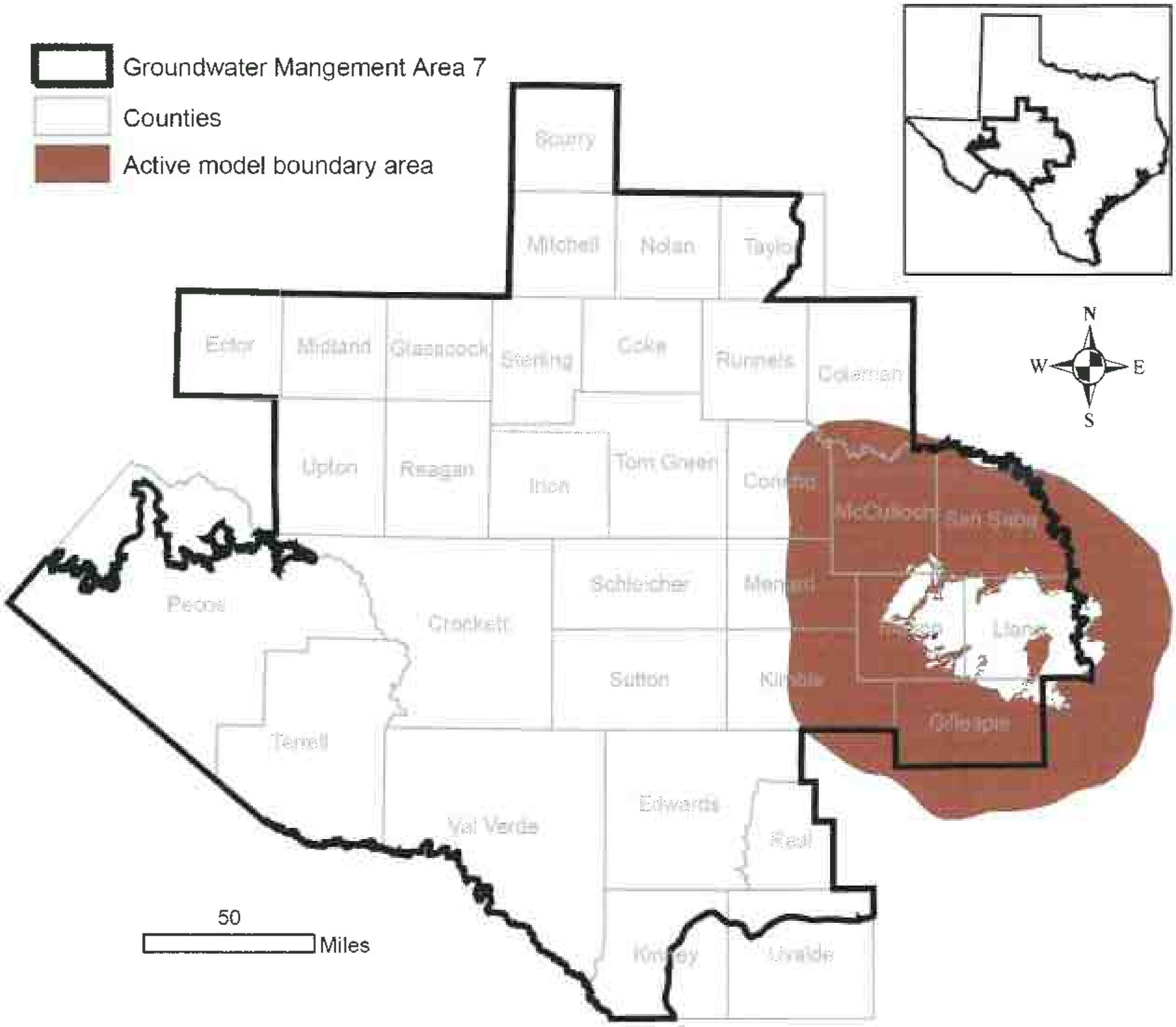

FIGURE 10. **MAP SHOWING AREAS COVERED BY THE HICKORY AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE MINOR AQUIFERS OF THE LLANO UPLIFT AREA IN GROUNDWATER MANAGEMENT AREA 7.**

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

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

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

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

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

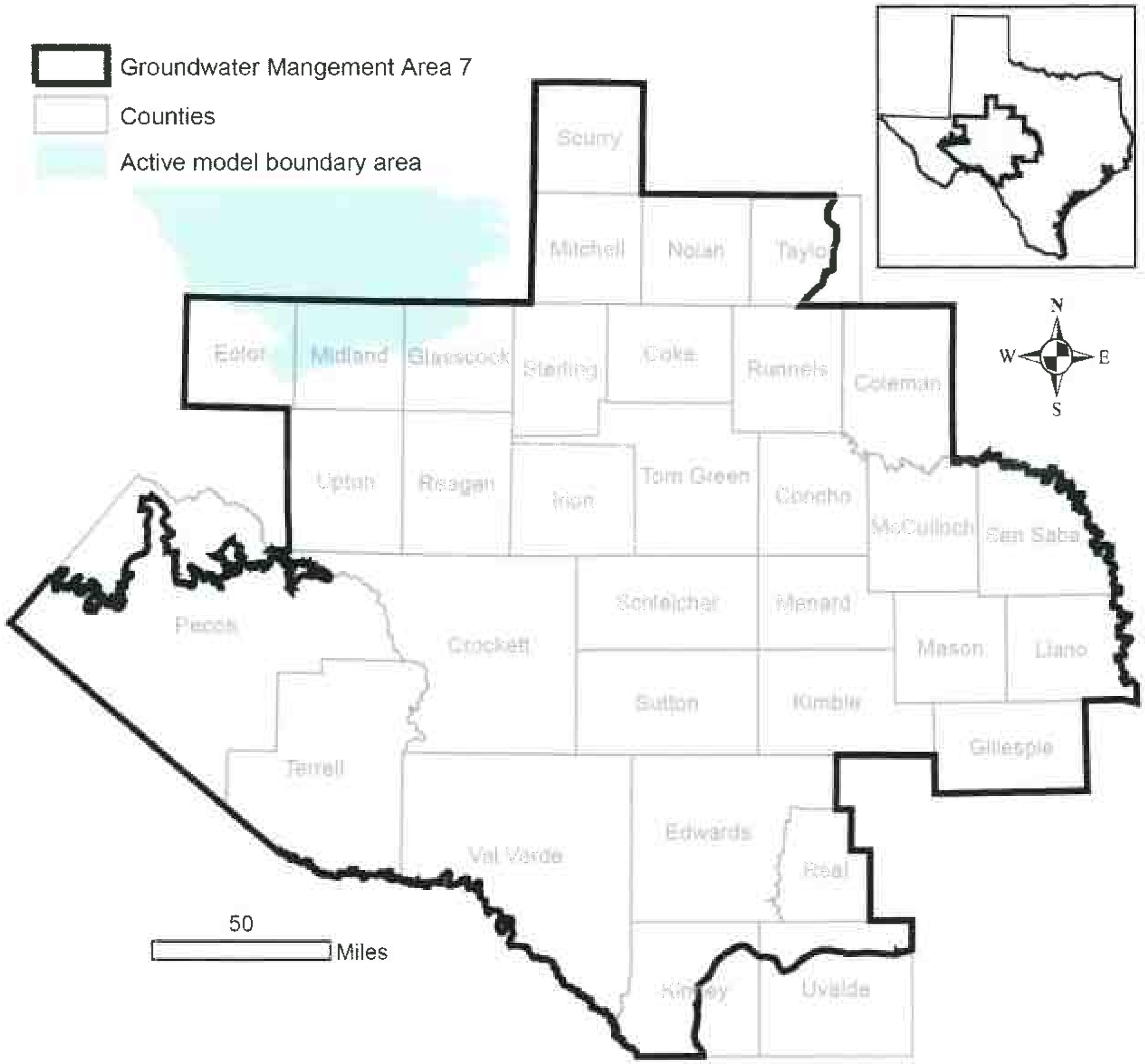

FIGURE 11. **MAP SHOWING THE AREAS COVERED BY THE OGALLALA AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE HIGH PLAINS AQUIFER SYSTEM IN GROUNDWATER MANAGEMENT AREA 7.**

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

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

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

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

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

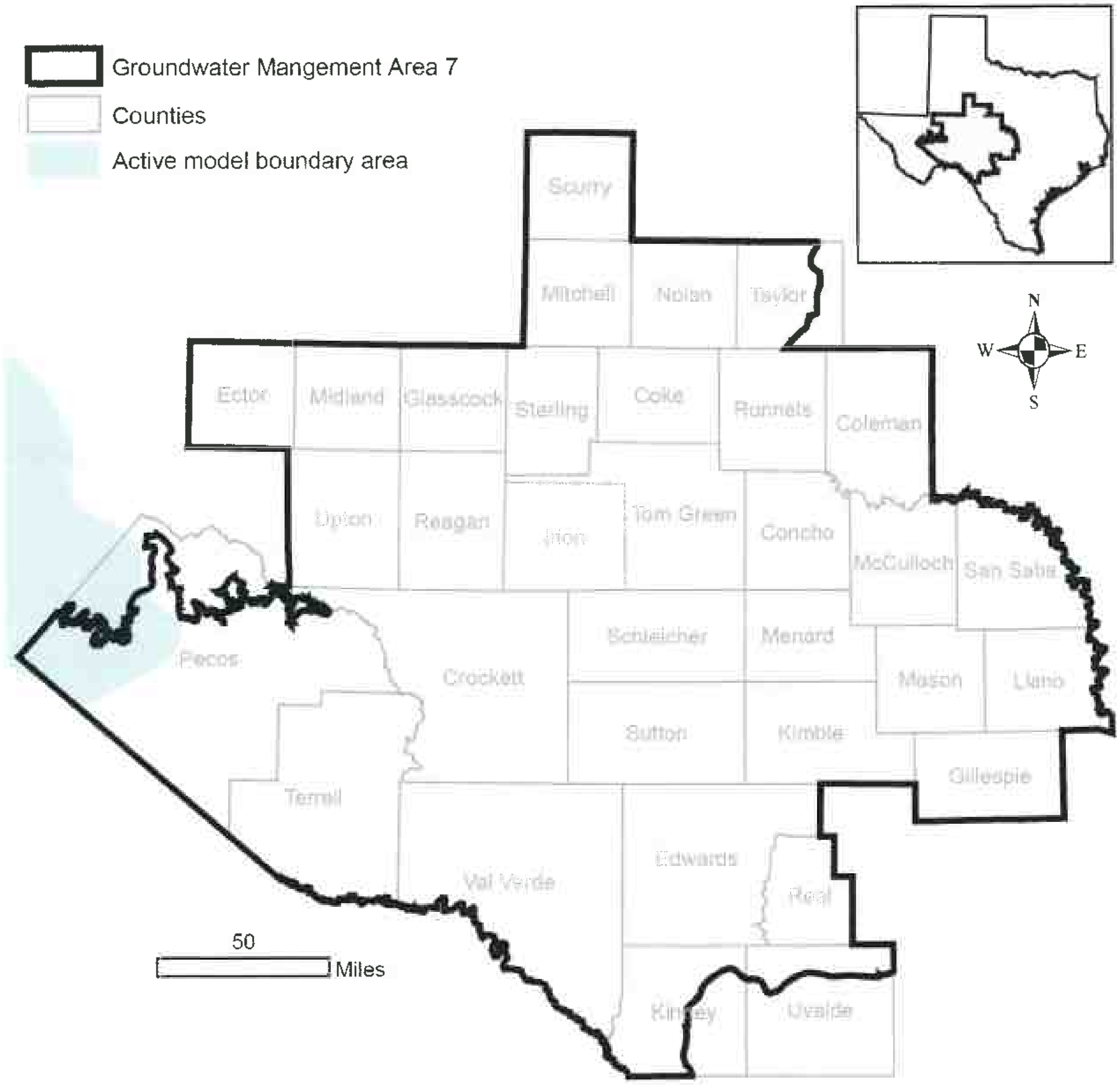

FIGURE 12. MAP SHOWING AREAS COVERED BY THE RUSTLER AQUIFER IN THE GROUNDWATER AVAILABILITY MODEL FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 7.

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

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

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

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

LIMITATIONS:

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

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

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

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

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

Model "Dry" Cells

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

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APPENDIX "C"

GAM Run 18-007: Hickory Underground Water Conservation District No. 1 Groundwater Management Plan

Roberto Anaya, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
(512) 463-6115
July 12, 2018

STATE OF TEXAS
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7/12/18

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GAM RUN 18-007: HICKORY UNDERGROUND WATER CONSERVATION DISTRICT NO. 1 GROUNDWATER MANAGEMENT PLAN

Roberto Anaya, P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
(512) 463-6115
July 12, 2018

EXECUTIVE SUMMARY:

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

The TWDB provides data and information to the Hickory Underground Water Conservation District No. 1 in two parts. Part 1 is the Estimated Historical Water Use/State Water Plan dataset report, which will be provided to you separately by the TWDB Groundwater Technical Assistance Department. Please direct questions about the water data report to Mr. Stephen Allen at (512) 463-7317 or stephen.allen@twdb.texas.gov. Part 2 is the required groundwater availability modeling information and this information includes:

1. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;

2. for each aquifer within the district, the annual volume of water that discharges from the aquifer to any surface-water bodies, including lakes, streams, rivers, and springs; and

3. the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

The groundwater management plan for the Hickory Underground Water Conservation District No. 1 should be adopted by the district on or before November 29, 2018, and submitted to the Executive Administrator of the TWDB on or before December 29, 2018.

The current management plan for the Hickory Underground Water Conservation District No. 1 expires on February 27, 2019.

We used the groundwater availability models for the Llano Uplift Aquifer System (Shi and others, 2016) and for the Edwards-Trinity (Plateau) Aquifer (Anaya and Jones, 2009) to estimate the management plan information for the aquifers within Hickory Underground Water Conservation District No. 1. This report replaces the results of GAM Run 13-010 (Wade, 2013). GAM Run 18-007 meets current standards set after GAM Run 13-010 was released and includes results from the recently released groundwater availability model for the Llano Uplift Aquifer System. Tables 1 through 4 summarize the groundwater availability model data required by statute and Figures 1 through 4 show the area of the models from which the values in the tables were extracted. If after review of the figures, the Hickory Underground Water Conservation District No. 1 determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas Water Code, Section 36.1071, Subsection (h), groundwater availability models for the Llano Uplift Aquifer System (1980 through 2010) and the Edwards-Trinity (Plateau) and Pecos Valley aquifers (1981 through 2000) were run for this analysis. Water budgets for each year of the transient model periods were extracted using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface-water outflow, inflow to the district, and outflow from the district for the aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Hickory, Ellenburger-San Saba, and Marble Falls aquifers of the Llano Uplift Aquifer System

- We used version 1.01 of the groundwater availability model for the Llano Uplift Aquifer System to analyze the Hickory, Ellenburger-San Saba, and Marble Falls aquifers. See Shi and others (2016) for assumptions and limitations of the model.

- The groundwater availability model for the Llano Uplift Aquifer System contains eight active layers:

- Layer 1 — the Trinity Aquifer, Edwards-Trinity (Plateau) Aquifer, and younger alluvium deposits
- Layer 2 — Permian and Pennsylvanian age confining units
- Layer 3 — the Marble Falls Aquifer and equivalent
- Layer 4 — Mississippian age confining units
- Layer 5 — the Ellenburger-San Saba Aquifer and equivalent
- Layer 6 — Cambrian age confining units
- Layer 7 — the Hickory Aquifer and equivalent
- Layer 8 — Precambrian age confining units

- Perennial rivers and reservoirs were simulated using the MODFLOW-USG river package. Springs were simulated using the MODFLOW-USG drain package. For this management plan, groundwater discharge to surface water includes groundwater leakage to the river and drain boundaries.
- The model was run with MODFLOW-USG (Panday and others, 2013).

Edwards-Trinity (Plateau) Aquifer

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers. See Anaya and Jones (2009) for assumptions and limitations of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers. The Pecos Valley Aquifer does not occur within Hickory Underground Conservation Water District No. 1 and therefore no groundwater budget values are included for it in this report.

- The groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers contains two active layers:
    - Layer 1 — Edwards sub-aquifer unit of the Edwards-Trinity (Plateau) Aquifer
    - Layer 2 — Trinity sub-aquifer unit of the Edwards-Trinity (Plateau) Aquifer
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

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 portion of the model runs in the district. The components of the modified budget shown in tables 1 through 3 include:

- 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 and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

The information needed for the district's management plan is summarized in Tables 1 through 4. 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 district or county boundaries, 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 (Figures 1 through 4).

TABLE 1. SUMMARIZED INFORMATION FOR THE HICKORY AQUIFER FOR HICKORY UNDERGROUND WATER CONSERVATION DISTRICT NO. 1 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	Hickory Aquifer	9,994
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Hickory Aquifer	17,286
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	21,475
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	15,310
Estimated net annual volume of flow between each aquifer in the district	From Hickory Aquifer to Edwards-Trinity (Plateau) Aquifer	31
	Between Hickory Aquifer and Marble Falls Aquifer	0
	To Hickory Aquifer from Ellenburger-San Saba Aquifer	3,332
	From Hickory Aquifer to Hickory brackish zone	1,039

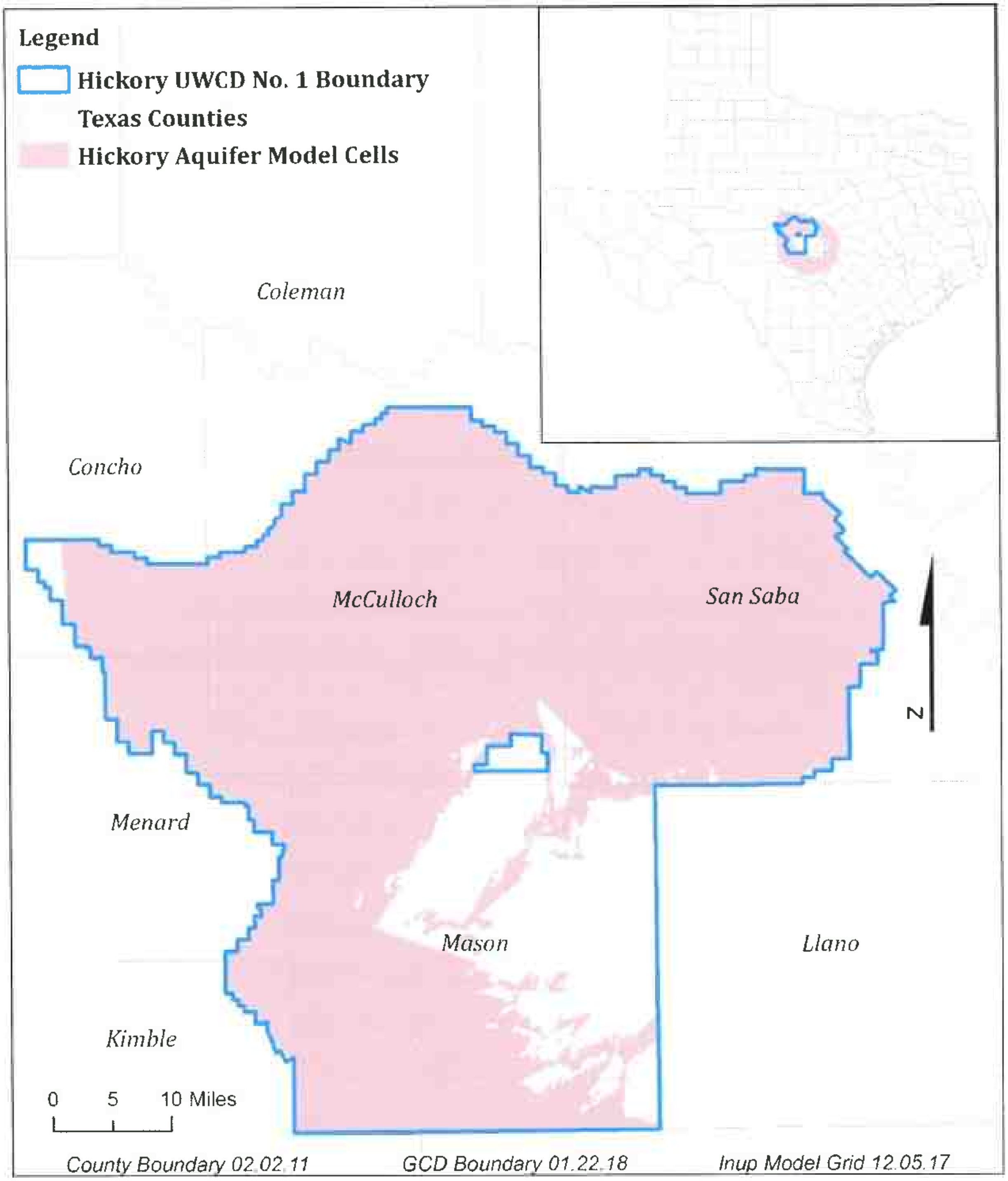

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE LLANO UPLIFT AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE HICKORY AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE ELLENBURGER-SAN SABA AQUIFER FOR HICKORY UNDERGROUND WATER CONSERVATION DISTRICT NO. 1 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	Ellenburger-San Saba Aquifer	56,007
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ellenburger-San Saba Aquifer	176,861
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	11,160
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	31,784
Estimated net annual volume of flow between each aquifer in the district	From Ellenburger-San Saba Aquifer to Edwards-Trinity (Plateau) Aquifer	409
	From Ellenburger-San Saba Aquifer to Marble Falls Aquifer	1,840
	To Ellenburger-San Saba Aquifer from Ellenburger-San Saba brackish zone	11,084
	From Ellenburger-San Saba Aquifer to Hickory Aquifer	3,315

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE LLANO UPLIFT AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE ELLENBURGER-SAN SABA AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE MARBLE FALLS AQUIFER FOR HICKORY UNDERGROUND WATER CONSERVATION DISTRICT NO. 1 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	Marble Falls Aquifer	7,895
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Marble Falls Aquifer	20,108
Estimated annual volume of flow into the district within each aquifer in the district	Marble Falls Aquifer	76
Estimated annual volume of flow out of the district within each aquifer in the district	Marble Falls Aquifer	0
Estimated net annual volume of flow between each aquifer in the district	From Marble Falls Aquifer to Edwards-Trinity (Plateau) Aquifer	7
	From Marble Falls Aquifer to Marble Falls subcrop equivalent formation	2,242
	To Marble Falls Aquifer from Ellenburger-San Saba Aquifer	1,838
	Between Marble Falls Aquifer and Hickory Aquifer	0

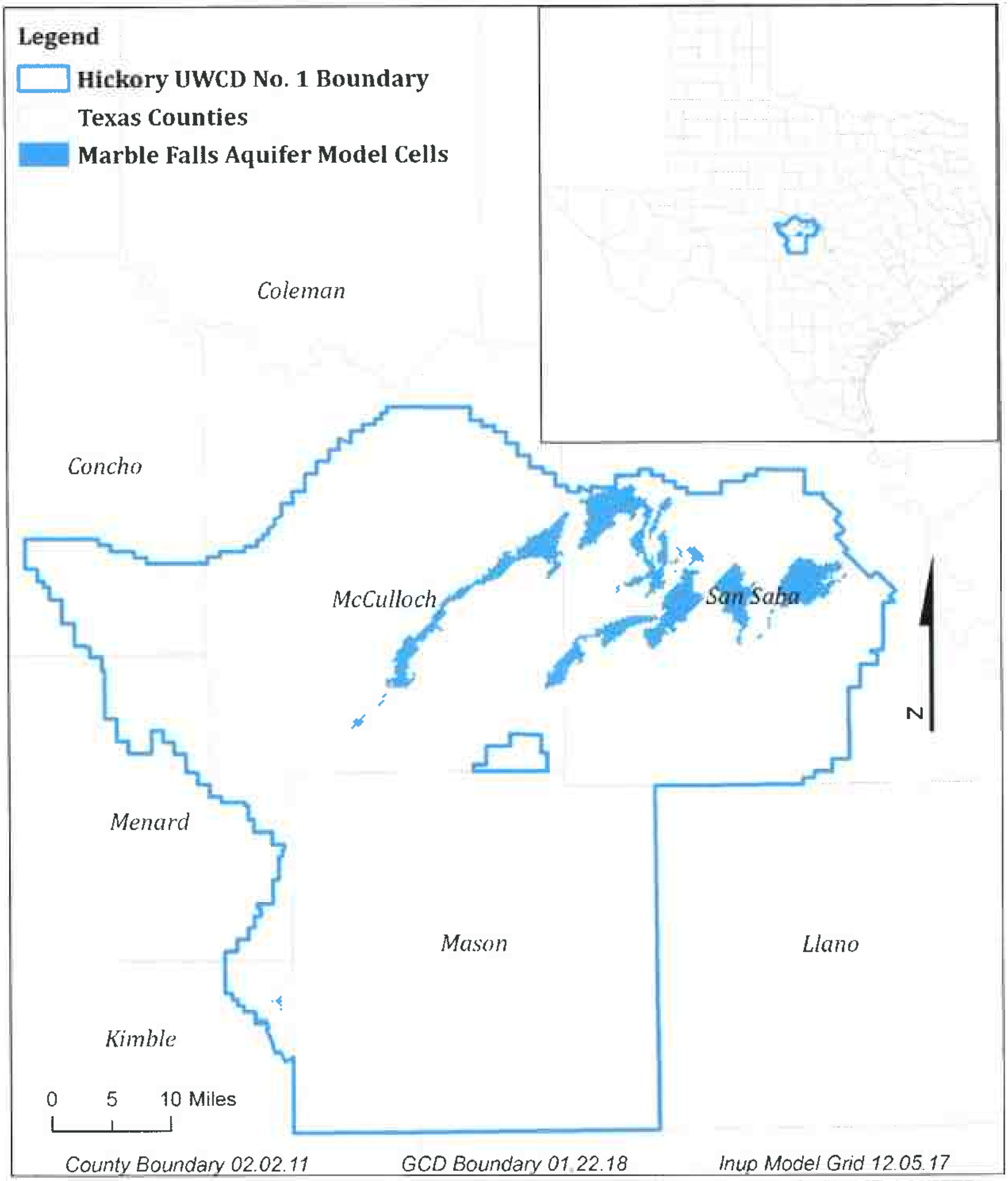

FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE LLANO UPLIFT AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE MARBLE FALLS AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 4: SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER THAT IS NEEDED FOR HICKORY UNDERGROUND WATER CONSERVATION DISTRICT NO. 1'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	12,278
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	15,069
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	6,885
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	3,857
Estimated net annual volume of flow between each aquifer in the district	To the Edwards-Trinity (Plateau) Aquifer from Hickory Aquifer	31*
	To the Edwards-Trinity (Plateau) Aquifer from Ellenburger-San Saba Aquifer	367*
	To the Edwards-Trinity (Plateau) Aquifer from Marble Falls Aquifer	7*

* Groundwater budget values calculated from the Llano Uplift Aquifer System GAM version 1.01 are more accurately calibrated flow between the Edwards-Trinity (Plateau) Aquifer and the underlying minor aquifers.

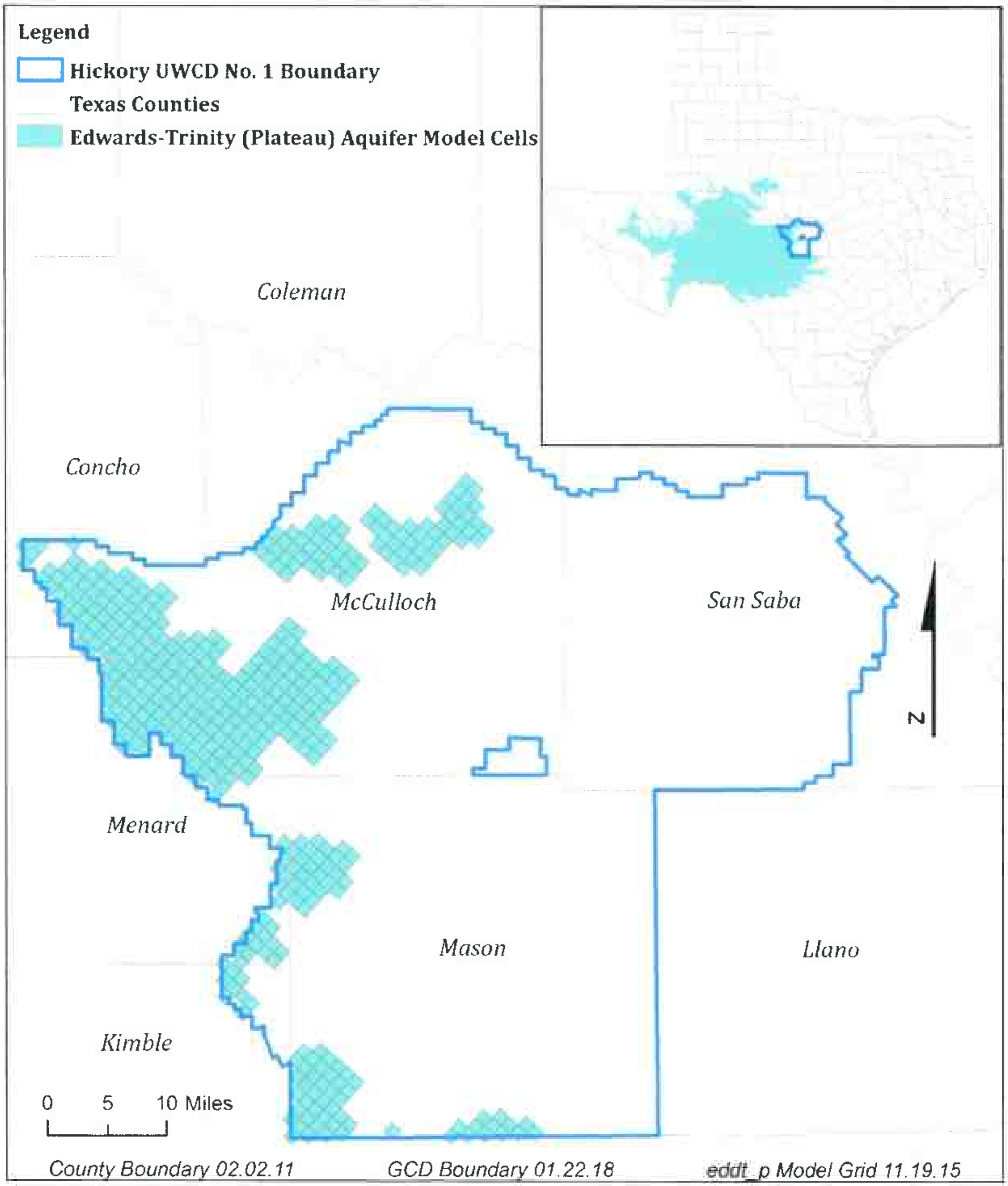

FIGURE 4: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED (THE EDWARDS-TRINITY (PLATEAU) AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS:

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

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

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

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

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

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