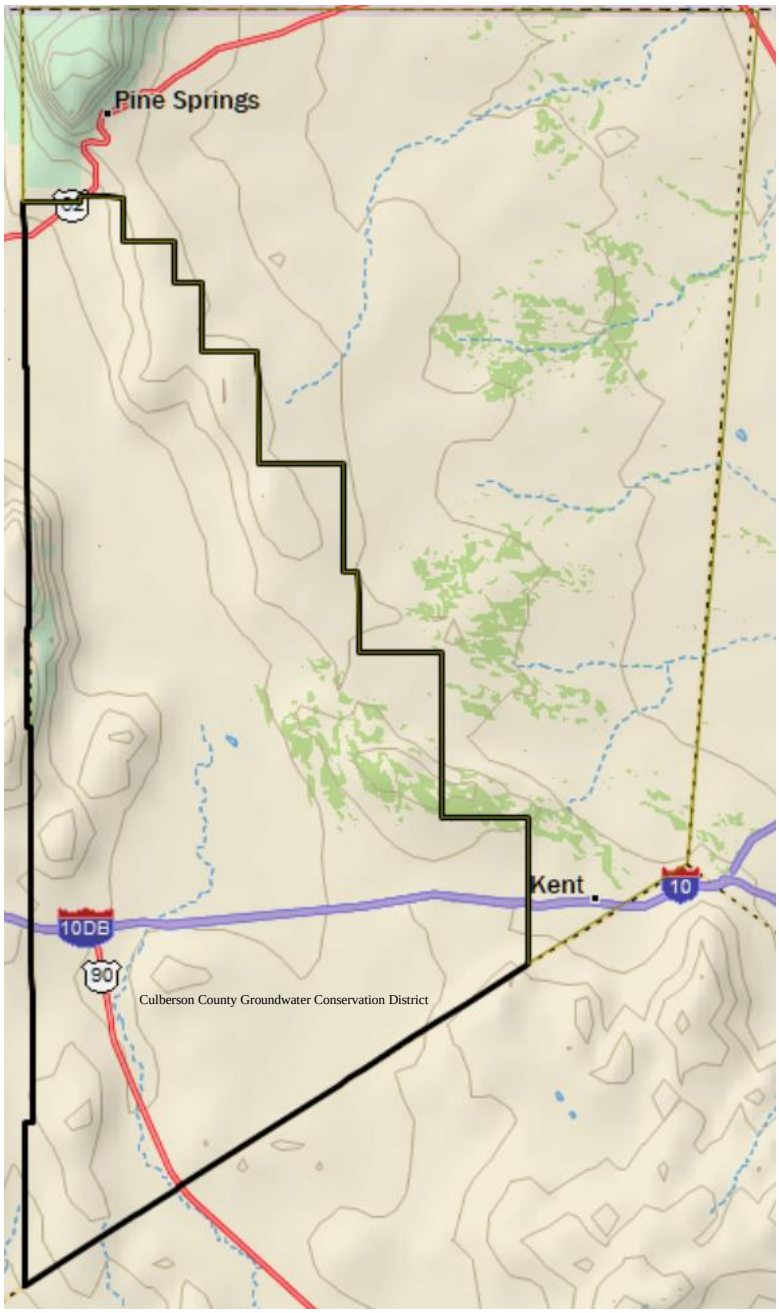
Culberson County Groundwater Conservation District Groundwater Management Plan



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Appendices

A – TWDB GAM Run 16-030 MAG ADDENDUM

B – 2015 Irrigated Land Study of Culberson County & Analysis of Rain/Fall Runoff Volumes for Wild Horse Arroyo, Lobo Road, Culberson County, Texas

C – Copy of Notice for Management Plan Hearing

D – Estimated Historical Groundwater Use And 2017 State Water Plan Datasets for CCGCD

E – TWDB GAM Run 11-018

F – Copy of Resolution Adopting Management Plan

G – Agenda for Management Plan Hearing 1/13/2021

H – Minutes from Management Plan Adoption Meeting 3/10/2021

1. Introduction

This Management Plan was prepared in accordance with the requirements of Chapter 36 of the Texas Water Code and Title 31, Chapter 356, of the Texas Administrative Code, and was made available for public comment prior to adoption by the Board of Directors of the Culberson County Groundwater Conservation District (the District).

The purpose of the District is to provide a locally controlled groundwater district to conserve and preserve groundwater, protect groundwater users, protect groundwater, prevent pollution or waste of groundwater within the boundaries of the District, and regulate the transport of water out of the boundaries of the District. The District has adopted rules to regulate groundwater withdrawals based on historic and non-historic use and to achieve the desired future conditions (DFCs) for the groundwater resources within the District, as those DFCs are agreed upon by Groundwater Management Area 4 (GMA 4).

The District shall partition the portion of the West Texas Bolson aquifers that are within the District's boundaries into two management zones consisting of the Lobo Flat area and the Wildhorse area. The District shall maintain and enforce rules that provide for, but are not limited to, the following requirements:

1. spacing requirements for groundwater wells;
2. permits limiting the annual amount of groundwater that can be produced from non-exempt wells;
3. a limit on the maximum amount of groundwater permitted for withdrawal from the Wildhorse Management Area (includes former Michigan Flat Management Area);
4. a limit on the maximum amount of groundwater permitted for withdrawal from the Lobo Flat Management Area; and
5. regulating well drilling and plugging and groundwater withdrawals in areas within and outside of the currently identified management areas to protect groundwater and groundwater users within the District.

This plan provides guidelines for the operation of the Culberson County Groundwater Conservation District.

2. Management Goals, Objectives, and Performance Standards

2.1. Estimate of Modeled Available Groundwater

TWDB GAM Run 16-030 MAG and TWDB GAM Run 16-030 MAG ADDENDUM (Appendix A) summarized the Modeled Available Groundwater for Culberson County for the year 2020 as 7,580 acre-feet per year for the Capitan Reef Complex Aquifer, 99 acre-feet per year for the Igneous Aquifer, and 35,749 acre-feet per year in the West Texas Bolsons. These values may

vary slightly for each decennial period between 2020 and 2070 (Appendix A). The entire portion of the Igneous and West Texas Bolsons aquifer that is within the county is also within the District, and the large majority of the portion of the Capitan Reef Complex that is within the county is also within the District.

The Modeled Available Groundwater was calculated by the TWDB using the established Desired Future Conditions (see TWDB GAM Run 16-030 MAG (Boghici and Bradley, 2018) presented as Appendix A). A summary of the Desired Future Conditions and Modeled Available Groundwater for each TWDB classified aquifer in the District. The District recognizes there is no Groundwater Availability Model for the CRCX aquifer in Culberson County and the Modeled Available Groundwater is based on pumping estimates from Armstrong Farms as detailed in TWDB AA 09-08 (Wuerch and Others, 2011), which may, due to the lack of data, underestimate the available groundwater for other stakeholders in the District. A study for the District by JSAI (2002) calculated 20,000 acre-feet per year of recharge to the CRCX aquifer within the District, which should be factored into the MAG.

2.2. Amount of Groundwater Being Used 2013 through 2019

Irrigation water use makes up the large majority of the water use in the District. The District requires by rule that all groundwater pumped under production permits must be metered. The District has issued approximately 24 Historic Use Production Permits (HUPP), all for irrigation purposes, approximately five Non-Historic Use Production Permits (NHUPP), mostly for industrial purposes, and one export permit for industrial use. These production permits identify approximately 127 wells from which groundwater can be pumped for non- exempt purposes. All pumping wells must be equipped with meters approved by the district and pumping data is gathered at least quarterly by a field technician employed by the District. All groundwater use data referenced to TWDB was obtained from TWDB Estimated Historical Groundwater Use And 2017 State Water Plan Datasets report (Appendix D).

Table 1 shows the estimated annual amount of groundwater pumping within the District, and uses a combination of crop water use estimates and crop acreage records from LANDSAT 8 images and meter readings. A continued effort is made to ensure that all wells are metered properly, and a matching grant from the TWDB has been used to purchase 57 new meters to replace meters needing replacement in the District.

The total amount of irrigated land in Culberson County for 2015 was estimated from LANDSAT 8 images as 9,558 acres with 32,786 acre-feet of groundwater production or 3.4 acre-feet per acre (Appendix B).

Table 1: Groundwater use within the District in acre-feet/year (based on TWDB and District numbers)

Year	Municipal[1]	Mining[2]	Irrigation[3]	Livestock[4]
2019	939	79	23,593	**125**
2018	943	57	**28,190**	**125**
2017	977	65	32,786	**125**
2016	752	**156**	35,374	**127**
2015	714	**194**	45,680	**125**
2014	655	**89**	29,301	**122**
2013	580	**44**	26,664	**125**

1: The City of Van Horn is located within the District and accounts for 100% of Municipal Use

2: Mining use based on meter readings for 2017 through 2019

3: 100% of irrigated land is within the District

4: Livestock use estimate based ratio of land within District to County (45.45%)

Values in **Bold** font were estimated

2.3. Amount of Recharge from Precipitation

The TWDB GAM Run 11-018 (Appendix E) estimate of the annual amount of recharge from precipitation to the portion of the West Texas Bolson within the District is 2,107 acre-feet per year, and 671 acre-feet of recharge to the portion of the Igneous Aquifer within the District.

2.4. Amount of Water that Discharges to Springs

The TWDB GAM Run 11-018 (Appendix E) estimate of the annual amount of water discharged to springs from the portion of the West Texas Bolson within the District is 494 acre-feet. The location of the springs is not provided in the report and currently, there are no known springs discharging from the portion of the West Texas Bolson within the District.

2.5. Groundwater Inflow and Outflow of District

The values for groundwater flow into and out of the District are shown in Tables 2 and 3 (all values are in acre-feet per year). These tables were obtained from the January 23, 2019 TWDB publication GAM Run 11-018 (Appendix E).

Table 2: TWDB GAM Run 11-018 Recharge, Inflows and Outflows–West Texas Bolson
(all values in acre-feet per year)

Management Plan requirement		
Estimated annual amount of recharge from precipitation to the district	West Texas Bolsons Aquifer	2,107
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	West Texas Bolsons Aquifer	494
Estimated annual volume of flow into the district within each aquifer in the district	West Texas Bolsons Aquifer	7,453
Estimated annual volume of flow out of the district within each aquifer in the district	West Texas Bolsons Aquifer	629
Estimated net annual volume of flow between each aquifer in the district	From the Igneous Aquifer and other underlying units into the West Texas Bolsons Aquifer	5,238*

Table 3:TWDB GAM Run 11-018 Recharge, Inflows and Outflows–Igneous Aquifer
(all values in acre-feet per year)

Management Plan requirement		
Estimated annual amount of recharge from precipitation to the district	Igneous Aquifer	671
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Igneous Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Igneous Aquifer	1,037
Estimated annual volume of flow out of the district within each aquifer in the district	Igneous Aquifer	463
Estimated net annual volume of flow between each aquifer in the district	From the Igneous Aquifer into the West Texas Bolsons Aquifer	1,562*

2.6. Projected Surface Water Supply

There are no significant sources of surface water (such as the Rio Grande) within the boundaries of the District. The primary drainage way (Wild Horse Arroyo) is an ephemeral stream with no flow except during rainfall/runoff storm events. (see Appendix D). Table 4 (Appendix D) shows the projected surface supplies included surface water from the Rio Grande of 42 acres-feet per year. No portion of the Rio Grande is located within Culberson County or the District.

Table 4: Projected Surface Water Supplies

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

CULBERSON COUNTY *45.35% (multiplier)* All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
E	LIVESTOCK, CULBERSON	RIO GRANDE	RIO GRANDE LIVESTOCK LOCAL SUPPLY	7	7	7	7	7	7
E	MINING, CULBERSON	RIO GRANDE	RIO GRANDE OTHER LOCAL SUPPLY	35	35	35	35	35	35
	Sum of Projected Surface Water Supplies (acre-feet)			**42**	**42**	**42**	**42**	**42**	**42**

2.7. Projected Total Demand for Water

Appendix D contains the "Estimated Historical Groundwater Use and 2017 State Water Plan Datasets" provided by the TWDB. Because the District comprises approximately 45% of the land area of Culberson County, the "county total" number provided by TWDB has been multiplied by 0.45 (reduced by 55%). This "prorated" reduction by area results in a significant underestimation of groundwater use in the District.

The District contains 100% of the commercial irrigated agriculture and municipal use (City of Van Horn) within the county. The 55% of the county that is outside of the District primarily uses water for oil and gas development, domestic, and livestock use. A small amount of water is used for staff and visitors to the Guadalupe National Park. Table 1 shows the amounts of measured groundwater use with the District. Flow meters are required on all active non-exempt wells and permitted wells within the District. Table 5 shows the Project Water Demands from the TWDB 2017 State Water Plan Data for Culberson County.

Table 5: TWDB State Water Plan Data – Projected Water Demand

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.

CULBERSON COUNTY *45.35% (multiplier)* All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
E	COUNTY-OTHER, CULBERSON	RIO GRANDE	29	32	32	33	34	34
E	IRRIGATION, CULBERSON	RIO GRANDE	18,107	17,720	17,341	16,970	16,607	16,251
E	LIVESTOCK, CULBERSON	RIO GRANDE	136	136	136	136	136	136
E	MINING, CULBERSON	RIO GRANDE	229	562	632	503	382	290
E	VAN HORN	RIO GRANDE	662	711	737	761	775	784
	Sum of Projected Water Demands (acre-feet)		**19,163**	**19,161**	**18,878**	**18,403**	**17,934**	**17,495**

2.8. Projected Water Supply Needs

Table 6 (Appendix D) shows the projected water supply needs for Culberson County based on the 2017 State Water Plan. All categories except "mining" show surplus supply. The 2020 projected water supply need for mining is 229 acre-feet. No information was provided by TWDB as to the location within Culberson County of a mining operation needing water. Within the District, all mining demands are being supplied with groundwater and there is no shortage of water available for mining.

Table 6: TWDB State Water Plan Data – Project Water Supply Needs

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

CULBERSON COUNTY All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
E	COUNTY-OTHER, CULBERSON	RIO GRANDE	75	70	69	67	66	65
E	IRRIGATION, CULBERSON	RIO GRANDE	57	911	1,747	2,565	3,366	4,150
E	LIVESTOCK, CULBERSON	RIO GRANDE	0	0	0	0	0	0
E	MINING, CULBERSON	RIO GRANDE	-291	-1,025	-1,178	-895	-628	-425
E	VAN HORN	RIO GRANDE	689	640	614	590	576	567
	Sum of Projected Water Supply Needs (acre-feet)		**-291**	**-1,025**	**-1,178**	**-895**	**-628**	**-425**

2.9. Projected Water Management Strategies

Table 7 shows the water management strategies for developing or conserving water in Culberson County. The Rustler Aquifer is outside of the District's boundaries.

Table 7: TWDB State Water Plan Data – Project Water Management Strategies

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

CULBERSON COUNTY

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

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
MINING, CULBERSON, RIO GRANDE (E)							
CULBERSON COUNTY - ADDITIONAL GROUNDWATER WELLS - RUSTLER AQUIFER	RUSTLER AQUIFER [CULBERSON]	590	590	590	590	590	590
CULBERSON COUNTY MINING - ADDITIONAL GROUNDWATER WELL - WEST TEXAS BOLSONS AQUIFER	WEST TEXAS BOLSONS AQUIFER [CULBERSON]	590	590	590	590	590	590
		1,180	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**
VAN HORN, RIO GRANDE (E)							
CITY OF VAN HORN - WATER LOSS AUDIT AND MAIN-LINE REPAIR	DEMAND REDUCTION [CULBERSON]	30	30	30	30	30	30
		30	**30**	**30**	**30**	**30**	**30**
Sum of Projected Water Management Strategies (acre-feet)		**1,210**	**1,210**	**1,210**	**1,210**	**1,210**	**1,210**

2.10. Management of Groundwater Supplies

The District will manage the production of groundwater from the West Texas Bolsons aquifer within the District in a sustainable manner and in two management areas (Wildhorse and Lobo Flat). The Wildhorse Management Area includes irrigated land within the District. The District will identify and engage in practices that, if implemented, would result in more efficient use of groundwater. The amount of groundwater withdrawals permitted by the District shall be tied to the long-term sustainable amount of recharge to the portions of the West Texas Bolson aquifers within the District. The groundwater elevations measured in the District's monitoring wells are used to monitor the District's Desired Future Conditions, in accordance with the District's rules, and to protect the historic and existing uses of groundwater.

The District shall report annually to the Board on the amount of groundwater being withdrawn through non-exempt wells located within the District, measured through the District's flow metering program, for the quantification of existing and historic use of groundwater within the District's boundaries, and for the issuing of production permits for all non-exempt wells in operation. The District shall prepare an annual report summarizing District activities to be approved by the Board of Directors during the first quarter of each year. This annual report will be posted on the District's web site.

2.11. District Rules: Actions, Procedures, Performance, and Avoidance Necessary to Effectuate the Management Plan

The District's Rules contain the necessary procedures and required actions that the District must perform and avoid that are necessary to effectuate this management plan. A copy of the District's current rules can be download from: https://www.ccgwcd.org/rules-management-plan/.

To meet the requirements of Texas Water Code §36.1071 (e)(2), the District will act on the goals and directives established in this District Management Plan. The District will incorporate District's Management Plan into the District Rules. The District will amend rules in accordance with Chapter 36 of the Texas Water Code. The District rules and actions will be in compliance with all application sections of Chapter 36 of the Texas Water Code and Chapter 8816 of the Special District Local Laws Code. Meetings of the District's Board of Directors will be noticed (announced) and conducted in accordance with the Texas Open Meetings Act. The District will also make available for public inspection all official documents, reports, records, and minutes of the District pursuant with the Texas Public Information Act.

2.12. Notice of Hearing and Resolution Adopting 2021 Management Plan

A hearing notice was published in the Van Horn Advocate, a newspaper of general circulation in Culberson County, Texas, on December 17, 2020, and a copy of the published notice is attached

as Appendix C. A copy of the District Resolution adopting this Management Plan is attached as Appendix F.

2.13. Coordination of Management Plan with Regional Surface Water Entities

There are no surface water entities identified in the 2017 State Water Plan that are located within the District's boundaries. A copy of the adopted Culberson County Groundwater Conservation District Management Plan was sent to the Chair of the Far West Regional Water Planning Group.

2.14. Site-Specific Information

Section 4 lists references for technical publication describing the characteristics of the groundwater resources with the District.

3. Management Goals

The methodology that the District will use to track its progress on an annual basis in achieving all of its management goals will be as follows: The District manger will prepare and present an annual report to the Board of Directors on District performance in regards to achieving management goals and objectives (during the first quarterly Board of Directors meeting each fiscal year). The report will be maintained on file at the District office.

3.1. Providing the Most Efficient Use of Groundwater

Management Objective: Each year the District will provide information to the general public regarding the amount of use and depth to water change of the groundwater in the District.

Performance Standard: The District's annual newsletter that will be posted on the District's webs site and will include information on the status of groundwater in the District.

3.2. Controlling and Preventing Waste of Groundwater

Management Objective: Each year, the District will inform District water users about the efficient use of water and methods to prevent waste.

Performance Standard: The District's website will be updated at least once a year to include information on conservation methods.

3.3. Controlling and Preventing Subsidence

There is no known subsidence (as defined in Chapter 36 of the Texas Water Code) within the District caused by groundwater withdrawals, the geologic formation of the aquifers within the District precludes significant subsidence from occurring due to groundwater pumping, and this management item is not applicable to the District's current Management Plan. The District has reviewed the TWDB subsidence risk report "Identification of the Vulnerability of the Major and

Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping" (http://www.twdb.texas.gov/groundwater/models/research/subsidence/subsidence.asp) for applicability. Figures 4.74., 4.101, and 4.140 of the report show low risk for all aquifers within the District. The District will continue to watch for subsidence risk and review reports to monitor if it could be a problem in the future.

3.4. Addressing Conjunctive Surface Water Management Issues

There are no known conjunctive surface water management issues within the District, and this management item is not applicable to the District's Management Plan.

3.5. Addressing Natural Resource Issues that Impact the Use and Availability of Groundwater and Which are Impacted by the Use of Groundwater

On page 40 of the 1975 TWDB Report 189 "Major Springs of Texas" lists five springs in Culberson County (Bone, Pine, Independence, Delaware, and Rattlesnake). Only Rattlesnake Springs is within the District boundaries and its source of water is from the mountain front recharge area of Victorio Peak. The district reviewed the Texas and Wildlife endangered species list for Culberson County (https://tpwd.texas.gov/gis/rtest/) and found no species that would be affected by the District's groundwater management plan or rules.

Management Objective: The General Manager will report to the Board of Directors, upon observance, of any contamination or pollution of the aquifers from other natural resources being produced within the District.

Performance Standard: The General Manager will report to Board regarding observing any contamination or pollution of the aquifers, if any, at each regular board meeting.

Management Objective: The District will encourage the collection and testing of groundwater quality samples by well owner from newly-drilled wells and existing wells.

Performance Standard: The District will work with the Culberson County Extension Agent to bring in outside testing facilitators and water quality programs.

Management Objective: The District may inspect suspended and abandoned wells to ensure proper closing of wells in accordance to rules set forth by the District. Notices will be sent and fines may be assessed against well owners whose wells do not adhere to District rules.

Performance Standard: The following will be the expected key metrics used to measure progress of management objectives: The number of notices sent out and possible fines assessed to well owners or operators concerning violations of District rules and the number of wells plugged each year.

Management Objective: Identify and address legislative policies that might affect groundwater resources.

Performance Standard: The CCGCD staff regularly uses TAGD as a means to monitor Texas State Legislative and judicial activity regarding groundwater issues. Staff will present to the Board annually while the Texas Legislature is in session, updates on legislative and judicial activities that may impact CCGCD constituents.

3.6. Addressing Drought Conditions

Management Objective: The annual amount of groundwater permitted by the District for withdrawal from the portion of the West Texas Bolsons aquifer located within the District may be curtailed during periods of extreme drought in the recharge zone of the aquifer or because of other conditions that cause significant declines in groundwater surface elevations. Such curtailment may be triggered by the District's Board based on the groundwater elevation measured in the District's monitoring well(s).

Performance Standard: The District's annual report will include a report on the District's monitoring well groundwater elevation based on at least one measurement per year and a report on whether the permitted withdrawals were curtailed at any time during the year because of drought conditions. The District will also include the link https://www.waterdatafortexas.org /drought for the TWDB drought information on our website.

3.7. Addressing Conservation, Recharge Enhancement, Rainwater Harvesting, Precipitation Enhancement, and Brush Control

Management Objective: The District shall promote the efficient application of irrigation water to field crops.

Performance Standard: The District shall assist in organizing the field demonstration of irrigation water conservation technology during one day every other year.

Management Objective: The District shall promote rainwater harvesting, precipitation enhancement, and brush control.

Performance Standard: The District shall include articles annually on rainwater harvesting, precipitation enhancement, and brush control in its annual newsletter.

Management Objective: The District shall study the recharge process and find possible recharge zones in the management areas.

Performance Standard: The District shall include articles annually on recharge on its website, and monitor wells thought to be in recharge zones, as well as measuring the amount of stormwater runoff flowing in the culvert crossing Wildhorse Draw at Lobos Road in Lobos Flat.

3.8. Addressing Desired Future Conditions

The GMA 4 on September 8, 2017 adopted the following Desired Future Condition for Culberson County Groundwater Conservation District for total drawdown from the period 2010

to 2060 of 50 feet for Capitan Reef Complex, 78 feet for the West Texas Bolsons, and 66 feet for the Igneous. The following objectives and performance standards will be used to address the District's Desired Future Conditions.

Management Objective: The District will continuously measure the water levels in at least one monitoring well and will manually measure water levels each year in at least five monitoring wells within the District and will determine the average groundwater levels annually. The District will compare the water level averages to the corresponding years' increment of its DFCs in order to track its progress in achieving the DFCs.

Performance Standard: The District's Annual Report will include the water level measurements taken each year for the purpose of measuring water levels to assess the District's progress towards achieving its DFCs. The District will include a discussion of its comparison of water level averages to the corresponding years' increments of its DFCs in order to track its progress in achieving its DFCs.

Management Objective: The District will review and calculate its total amount of groundwater pumped within the District and assess whether the District is on target to meet the DFC estimates submitted to the TWDB.

Performance Standard: The District's Annual Report will include a discussion of the amount of water pumped each year within the District and will evaluate the District's progress in achieving the DFCs of the groundwater resources within the boundaries of the District and whether the District is on track to maintain the DFC estimates over the fifty- year planning period.

4. References

1975 TWDB Report 189 Major and Historical Springs of Texas

1990 Hydrogeology of Trans-Pecos Texas, Kreitler & Sharp, UT Bureau of Economic Geology

2001 Mace, Robert, et al (2001), Aquifers of West Texas, Texas Water Development Board Report No. 356, Austin, Texas, pg.135-152.

2012 TWDB GAM Run 11-018: Culberson County Groundwater Conservation District Management Plan

2016 Far West Texas Regional Water Plan, 2016, Rio Grande Council of Governments, http://www.riocog.org/EnvSvcs/FWTWPG/publishe.htm

2017 TWDB Contract Report LRE Water, LLC, "Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping" http://www.twdb.texas.gov/groundwater/models/research/subsidence/subsidence.asp

2017 TWDB GAM Run 16-030 MAG

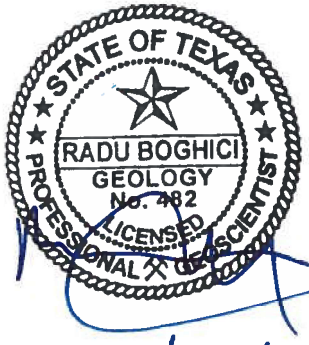
2017 Blair, A.W., Culberson County Agricultural Irrigation Water Use – 2015.

2019 TWDB (2019) Estimated Historical Groundwater Use and 2017 State Water Plan Datasets.

Appendix A – TWDB GAM Run 16-030 MAG & TWDB GAM Run 16-030 MAG Amended

GAM RUN 16-030 MAG: MODELED AVAILABLE GROUNDWATER FOR THE AQUIFERS IN GROUNDWATER MANAGEMENT AREA 4

Radu Boghici, P.G. and Robert G. Bradley, P.G.
Texas Water Development Board
Groundwater Division
(512) 463-5808
February 28, 2018



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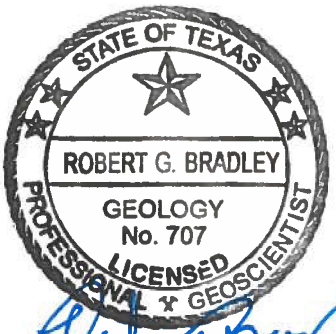

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GAM RUN 16-030 MAG: MODELED AVAILABLE GROUNDWATER FOR THE AQUIFERS IN GROUNDWATER MANAGEMENT AREA 4

Radu Boghici, P.G. and Robert G. Bradley, P.G.
Texas Water Development Board
Groundwater Division
(512) 463-5808
February 28, 2018

EXECUTIVE SUMMARY:

The modeled available groundwater for the relevant aquifers of Groundwater Management Area 4—the Bone Spring-Victorio Peak, Capitan Reef Complex, Edwards-Trinity (Plateau), Igneous, Marathon, and West Texas Bolsons aquifers—are summarized by decade for use in the regional water planning process (Tables 2, 4, 6, 8, 10, and 12) and for the groundwater conservation districts (Tables 1, 3, 5, 7, 9, and 11). The modeled available groundwater estimates are 101,400 acre-feet per year in the Bone Spring-Victorio Peak Aquifer, 8,163 acre-feet per year in the Capitan Reef Complex Aquifer, 1,394 acre-feet per year in the Edwards-Trinity (Plateau) Aquifer, range from 11,333 to 11,329 acre-feet per year in the Igneous Aquifer, 7,327 acre-feet per year in the Marathon Aquifer, and range from 58,577 to 57,881 acre-feet per year in the West Texas Bolsons Aquifer (Salt Basin and Presidio and Redford Bolsons combined). The modeled available groundwater estimates were extracted from results of model runs using the following groundwater availability models and alternative models: Bone Spring-Victorio Peak, Eastern Arm of the Capitan Reef Complex, Edwards-Trinity (Plateau), Igneous and West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat, and Lobo Flat), and West Texas Bolsons (Presidio and Redford) aquifers. Analytical methods were used to calculate the modeled available groundwater for the Capitan Reef Complex Aquifer in Culberson County and for the Marathon Aquifer. The explanatory report and other materials submitted to the Texas Water Development Board (TWDB) were determined to be administratively complete on October 9, 2017.

Groundwater Management Area 4 responded to a request for clarifications by the TWDB in December 2017 (see the "Description of Request" section below for details).

REQUESTOR:

Ms. Janet Adams, Chair of Groundwater Management Area 4.

DESCRIPTION OF REQUEST:

In a letter dated September 26, 2017, Ms. Janet Adams provided the TWDB with the desired future conditions of the relevant aquifers in Groundwater Management Area 4. The desired future conditions, adopted September 20, 2017 by the groundwater conservation districts within Groundwater Management Area 4, are reproduced below:

Brewster County GCD [Groundwater Conservation District]: for the period from 2010-2060

- 3 feet drawdown for the Edwards-Trinity (Plateau) Aquifer.
- 10 feet drawdown for the Igneous Aquifer.
- 0-foot drawdown for the Marathon Aquifer.
- 0-foot drawdown for the Capitan Reef Complex Aquifer.

Culberson County GCD [Groundwater Conservation District]: for the period from 2010-2060

- 50 feet drawdown for the Capitan Reef Complex Aquifer.
- 78 feet drawdown for the [Salt Basin portion of the] West Texas Bolsons Aquifer.
- 66 feet drawdown for the Igneous Aquifer.

Hudspeth County UWCD [Underground Water Conservation District] No.1

- 0-foot drawdown for the period from 2010 until 2060 for the Bone Spring-Victorio Peak Aquifer, averaged across the portion of the aquifer within the boundaries of the District.

Jeff Davis County UWCD [Underground Water Conservation District]: for the period from 2010-2060

- 20 feet drawdown for the Igneous Aquifer.
- 72 feet drawdown for the [Salt Basin portion of the] West Texas Bolsons Aquifer.

Presidio County UWCD [Underground Water Conservation District]: for the period from 2010-2060

- 14 feet drawdown for the Igneous Aquifer.
- 72 feet drawdown for the [Salt Basin portion of the] West Texas Bolsons Aquifer.
- 72 feet drawdown for the Presidio-Redford Bolson [portion of the West Texas Bolsons].

In response to requests for clarifications from the TWDB on December 5, 2017, December 8, 2017, and February 5, 2018 the Groundwater Management Area 4 Chair, Ms. Janet Adams, indicated the following preferences for calculating modeled available groundwater volumes in Groundwater Management Area 4:

- For the Bone Spring-Victorio Peak Aquifer (Hudspeth County), the TWDB will use the results reported in GAM Run 10-061 and the assumptions described in GAM Task 10-006;
- For the Capitan Reef Complex Aquifer (Brewster and Culberson counties), the TWDB will use the Capitan Reef Complex Aquifer (Eastern Arm) groundwater availability model for Brewster County and the analytical approach (AA 09-08) for Culberson County. For Brewster County we will use 2005 as the baseline year and for Culberson County we will use the assumptions described in AA 09-08. The TWDB will assume the desired future condition in Brewster County is met if the average simulated drawdown value is within 3 feet.
- For the Edwards-Trinity (Plateau) Aquifer (Brewster County), the TWDB will use the single layer groundwater flow model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers, with 2005 as the baseline year and the assumptions described in GR 10-048.
- For the Igneous Aquifer and Salt Basin Portion of the West Texas Bolsons Aquifer (Brewster, Culberson, Jeff Davis, and Presidio counties), the TWDB will use the Igneous and West Texas Bolsons aquifers groundwater availability model, with 2000 as the baseline year and the assumptions described in report GR 10-037 MAG.
- For Presidio and Redford Bolsons portion of the West Texas Bolsons Aquifer, the TWDB will use the West Texas Bolsons Aquifer (Presidio and Redford Bolsons) groundwater availability model, with 2007 as the baseline year.
- The Red Light Draw, Green River Valley, and Eagle Flat portions of the West Texas Bolsons Aquifer are considered non-relevant for the purposes of joint planning because there are no groundwater conservation districts with jurisdiction over this portion of the minor aquifer.

METHODS:

The desired future conditions for the Bone Spring-Victorio Peak, Capitan Reef Complex (Culberson County only), Marathon, Igneous, Edwards-Trinity (Plateau), and West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat, and Lobo Flat) aquifers are identical to the ones adopted in 2011, and the applicable groundwater availability models and

analytical methodology to calculate modeled available groundwater are unchanged. Therefore, the modeled available groundwater volumes presented for those aquifers are the same as those shown in the previous analytical assessments and model runs—GAM Task 10-061 (Oliver, 2011c), AA 09-08 (Wuerch and Davidson, 2010), AA 09-09 (Thorkildsen and Backhouse, 2010), GAM Run 10-048 (Oliver, 2012), and GAM Run 10-037 (Oliver, 2011a), and GAM Run 10-036 (Oliver, 2011b). The TWDB ran two new groundwater availability models, not previously available, for the Capitan Reef Complex (Eastern Arm) and West Texas Bolsons (Presidio and Redford Bolsons) aquifers. The modeled available groundwater volumes for these aquifers differ from the modeled available groundwater volumes previously calculated using analytical assessments.

Where analytical aquifer assessments were used, modeled available groundwater volumes were determined by summing estimates of effective recharge and the change in aquifer storage. See Freeze and Cherry (1979, p.365) for details regarding this analytical method.

Where groundwater availability models were used, the TWDB identified groundwater pumping scenarios that could achieve the adopted desired future conditions in Groundwater Management Area 4. The TWDB extracted simulated water levels for baseline years (see Parameters and Assumptions section for more information) and subsequent decades. The simulated drawdowns in all active model cells were averaged by aquifer for each county and groundwater conservation district. If water levels dropped below the base of the model cells during the predictive simulations, these cells became "dry cells". In some instances, dry cells were included in drawdown averages; in other instances they were not. See the "Parameters and Assumptions" section for more details on the treatment of dry cells in each of the model runs.

The calculated drawdown averages compared well with the desired future conditions and verified that the desired future conditions adopted by the districts can be achieved—within the assumptions and limitations associated with each groundwater availability model. Modeled available groundwater volumes were determined by extracting pumping rates by decade from the model results using ZONEBUDGET Version 3.01 (Harbaugh, 2009). Annual pumping rates were divided by county, river basin, regional water planning area, and groundwater conservation district within Groundwater Management Area 4 (Figures 1 through 13 and Tables 1 through 12).

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other

factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits.

PARAMETERS AND ASSUMPTIONS:

Bone Spring-Victorio Peak Aquifer

- The previous modeled available groundwater (Oliver, 2011c) was calculated using three separate flow models run under a variety of climatic and pumping scenarios. See Hutchison (2008) for assumptions and limitations of the three groundwater flow models.
- The models have one layer representing the Bone Spring-Victorio Peak Aquifer, a portion of the Capitan Reef Complex Aquifer, and the Diablo Plateau.
- Hutchison (2008) ran all three models using pumping ranging from 0 to 125,000 acre-feet per year and climatic information from tree ring data ranging from 1000 to 1988.
- The results of the 144 simulations were plotted to establish a relationship between pumping and drawdown (Hutchison, 2010). Modeled available groundwater was the sum of net pumping and the estimated irrigation return flow (approximately 30 percent of the net pumping, according to the Hudspeth County Underground Water Conservation District No. 1) for each desired future condition. Additional information on the application of irrigation return flow is described in GAM Run 10-061 MAG (Oliver, 2011c).
- Because the analysis used was statistically based, the starting and ending period can apply for any 50-year planning horizon. Therefore, we applied the values to 2020 to 2070.

Capitan Reef Complex Aquifer (Brewster County only)

- Version 1.01 of the groundwater availability model of the Eastern Arm of the Capitan Reef Complex Aquifer was used, with a baseline year of 2005. See Jones (2016) for assumptions and limitations of the groundwater availability model. A new model run simulation was completed to determine modeled available groundwater that achieved the desired future condition.
- 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 recharge used for the model simulation represents average recharge from 1931 through 2005 (last year of model calibration).
- Available water-level data from 2005 to 2010 for the Capitan Reef Complex Aquifer indicates that water level changes have been minimal. Therefore, applying the clarifications received from the Groundwater Management Area 4 on December 7, 2017, we concluded that a 2005-to-2055 predictive simulation is equivalent to a 2010-to-2060 predictive simulation.
- Drawdowns were then averaged in Groundwater Management Area 4 based on the official aquifer boundaries. We assumed the desired future condition was met if the average drawdown value was within 3 feet.

Capitan Reef Complex Aquifer (Culberson County only)

- There is no groundwater availability model for the Capitan Reef Complex Aquifer in Culberson County.
- The annual total pumping estimates were calculated as the sum of the annual effective recharge amount and the annual volume of water depleted from the aquifer based on the desired future condition.
- Recharge was assumed to be evenly distributed across the outcrop of the aquifer.
- Effective recharge estimates were based on springflow and surface hydrology, groundwater pumpage and water-level changes, and precipitation estimates.
- Annual volumes of water taken from storage were calculated by dividing the total volume of depletion, based on the draft desired future condition, by 50 years. For this report, we assumed the 50 years was 2010 to 2060.
- Calculated water-level declines were assumed to be uniform across the aquifer within its footprint area, and these calculated water-level declines did not exceed aquifer thickness.
- A detailed description of all parameters and assumptions is available in AA 09-08 (Wuerch and others, 2011).

Edwards-Trinity (Plateau) Aquifer (Brewster County)

- The alternate groundwater flow model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers was used with a baseline year of 2005. This model is an update to the previously developed groundwater availability model documented in Anaya and Jones (2009). See Hutchison and others (2011) and Anaya and Jones (2009) for assumptions and limitations of the model.
- 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 recharge used for the model simulation represents average recharge as described in Hutchison and others (2011).
- Drawdowns were calculated by subtracting 2005 simulated water levels from 2060 simulated water levels, which were then averaged based on the official aquifer boundaries in Groundwater Management Area 4. Drawdowns for cells with water levels below the base elevation of the cell (dry cells) were excluded from the averaging.
- A detailed description of all parameters and assumptions is available in GAM Run 10-048 (Oliver, 2012).

Igneous Aquifer

- Version 1.01 of the groundwater availability flow model for the Igneous and parts of the West Texas Bolson aquifers was used for this analysis with year 2000 as baseline. See Beach and others (2004) for assumptions and limitations of the model.
- The model includes three layers representing the Wild Horse Flat, Michigan Flat, Ryan Flat, and Lobo Flat portions of the West Texas Bolsons Aquifer (Layer 1), the Igneous Aquifer (Layer 2), and the underlying Cretaceous and Permian units (Layer3). Some areas of Layer 2 outside the boundary of the Igneous Aquifer are active in order to allow flow between Layer 1 and Layer 3.
- The averaging of drawdowns and modeled available groundwater calculations were based on model extent as opposed to the official aquifer footprint. The Igneous Aquifer model extent is a smoothed and somewhat smaller version of the official footprint of the Igneous Aquifer. A comparison of these two areas is shown in Figure 8.
- The predictive run was set up using average recharge as described in Beach and others (2004) and was run from 2000 to 2050.

- Cells were assigned to individual counties, river basins, regional water planning areas, and groundwater conservation districts as shown in the August 3, 2010, version of the file that associates the model grid to political and natural boundaries for the Igneous Aquifer. Note that some minor adjustments were made to the file to better reflect the relationship of model cells to political boundaries.
- See GAM Task 10-028 (Oliver, 2010) for a full description of the methods and assumptions used in the groundwater availability model simulations. The predictive model run for this analysis resulted in water levels in some model cells dropping below the base elevation of the cell during the simulation. These cells were excluded from the averaging of drawdowns, which in turn resulted in progressively lower pumping values through time. This is illustrated by the decline in modeled available groundwater (see Tables 7 and 8).

Marathon Aquifer

- The annual total pumping estimates was calculated as the sum of the annual effective recharge amount and the annual volume of water depleted from the aquifer based on the desired future condition.
- Recharge was assumed to occur evenly across the aerial extent of the aquifer.
- Average annual precipitation (1971 through 2000) from the Climatic Atlas of Texas (Larkin and Bomar, 1983) was used to calculate annual effective recharge volumes.
- The draft annual total pumping estimates are the sum of the annual effective recharge amount and the annual volume of water depleted from the aquifer based on the draft desired future condition. Annual volumes were calculated by dividing the total volume by 50 years. For this report, we assumed the 50 years was 2010 to 2060.
- Calculated water level declines were estimated uniformly across the aquifer.
- A detailed description of all parameters and assumptions is available in AA 09-09 (Thorkildsen and Backhouse, 2010).

[Salt Basin portion of the] West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat, and Lobo Flat) Aquifer

- Version 1.01 of the groundwater availability flow model for the Igneous and parts of the West Texas Bolson aquifers was used for this analysis with year 2000 as baseline. See Beach and others (2004) for assumptions and limitations of the model.

- The model includes three layers representing the Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat portions of the West Texas Bolsons Aquifer (Layer 1), the Igneous Aquifer (Layer 2), and the underlying Cretaceous and Permian units (Layer 3).
- The simulation was set up using average recharge as described in Beach and others (2004) and was run from 2000 to 2050.
- Cells were assigned to individual counties, river basins, regional water planning areas, and groundwater conservation districts as shown in the August 3, 2010, version of the file that associates the model grid to political and natural boundaries for the Igneous and West Texas Bolson Aquifers. Note that some minor adjustments were made to the file to better reflect the relationship of model cells to political boundaries.
- See GAM Task 10-028 (Oliver, 2010) for a full description of the methods and assumptions used in the groundwater availability model simulations. The predictive model run for this analysis resulted in water levels in some model cells dropping below the base elevation of the cell during the simulation. These cells have been excluded from the averaging of drawdowns, which in turn resulted in progressively lower pumping values through time. This is illustrated by the decline in modeled available groundwater (see Tables 11 and 12).

West Texas Bolsons (Presidio and Redford) Aquifer

- Version 1.01 of the groundwater availability model of the Presidio and Redford bolsons of the West Texas Bolsons Aquifer was used with a baseline year of 2007. A new model run simulation was completed to determine the modeled available groundwater that achieved the desired future condition.
- See Wade and Jigmond (2013) for assumptions and limitations of the groundwater availability model.
- The model includes three layers representing the Rio Grande Alluvium (Layer 1), West Texas Bolsons (Presidio and Redford) Aquifer (Layer 2), and Tertiary and Cretaceous units (Layer 3).
- The recharge used for the simulation represents average recharge from 1948 through 2007 (end year of model calibration). Pumping was scaled by an equal factor and simultaneously on both the United States and the Mexico sides of the aquifer during the predictive run simulations.
- An analysis of the Presidio and Redford bolsons indicate that the changes in water levels in the few wells with available data from 2007 through 2010 have

been minimal. Therefore, in observance of the clarifications received from the Groundwater Management Area 4 on December 7, 2017, we assumed that a 2007-to-2057 predictive simulation is equivalent to a 2010-to-2060 predictive simulation.

- Drawdowns were calculated by subtracting 2007 simulated water levels from 2057 simulated water levels which were then averaged for all active model cells within the official aquifer boundary in Presidio County. Drawdowns in model cells located in Mexico were excluded from averaging. We assumed the desired future condition was met if the average drawdown value was within 1 foot.

RESULTS:

The results for the groundwater conservation districts (Tables 1, 3, 5, 7, 9, and 11), reflects the ending year discussed in the Parameters and Assumption Section of this report. For planning purposes (Tables 2, 4, 6, 8, 10, and 12), the values may have been populated past the dates noted in Parameters and Assumption Section using the trend of results. Tables 1 through 12 show the combination of modeled available groundwater summarized (1) by groundwater conservation district and county; and (2) by county, river basin, and regional water planning area for use in the regional water planning process.

The modeled available groundwater for the Bone Spring-Victorio Peak Aquifer that achieves the desired future conditions adopted by Groundwater Management Area 4 is 101,400 acre-feet per year from 2020 to 2070 (Tables 1 and 2). These volumes represent total pumping, defined as the sum of net pumping and the irrigation return flow. Hudspeth County Underground Water Conservation District No. 1 estimates that irrigation return flow is about 30 percent of net pumping.

The modeled available groundwater for the Capitan Reef Complex Aquifer that achieves the desired future conditions adopted by Groundwater Management Area 4 is 8,163 acre-feet per year from 2020 to 2060/2070 (Tables 3 and 4). This value includes 583 acre-feet per year in Brewster County; 7,580 acre-feet per year in Culberson County.

The modeled available groundwater for the Edwards-Trinity (Plateau) Aquifer that achieves the desired future conditions adopted by Groundwater Management Area 4 is 1,394 acre-feet per year from 2020 to 2060/2070 (Tables 5 and 6).

The modeled available groundwater for the Igneous Aquifer that achieves the desired future conditions adopted by Groundwater Management Area 4 decreases from 11,333 to 11,329 acre-feet per year between 2020 and 2050 (Tables 7 and 8). In the counties comprising Groundwater Management Area 4, the modeled available groundwater from 2020 to 2060 is as follows: a decline from 2,586 to 2,583 acre-feet per year in Brewster

County; 99 acre-feet per year in Culberson County; 4,584 acre-feet per year in Jeff Davis County; 4,063 acre-feet per year in Presidio County.

The modeled available groundwater for the Marathon Aquifer that achieves the desired future conditions adopted by Groundwater Management Area 4 is 7,327 acre-feet per year from 2020 to 2060/2070 (Tables 9 and 10).

The modeled available groundwater for the West Texas Bolsons (including the Salt Bolson and Presidio and Redford Bolsons) that achieves the desired future conditions adopted by Groundwater Management Area 4 decreases from 58,577 acre-feet per year to 57,881 acre-feet per year between 2020 and 2050 (Tables 11 and 12).

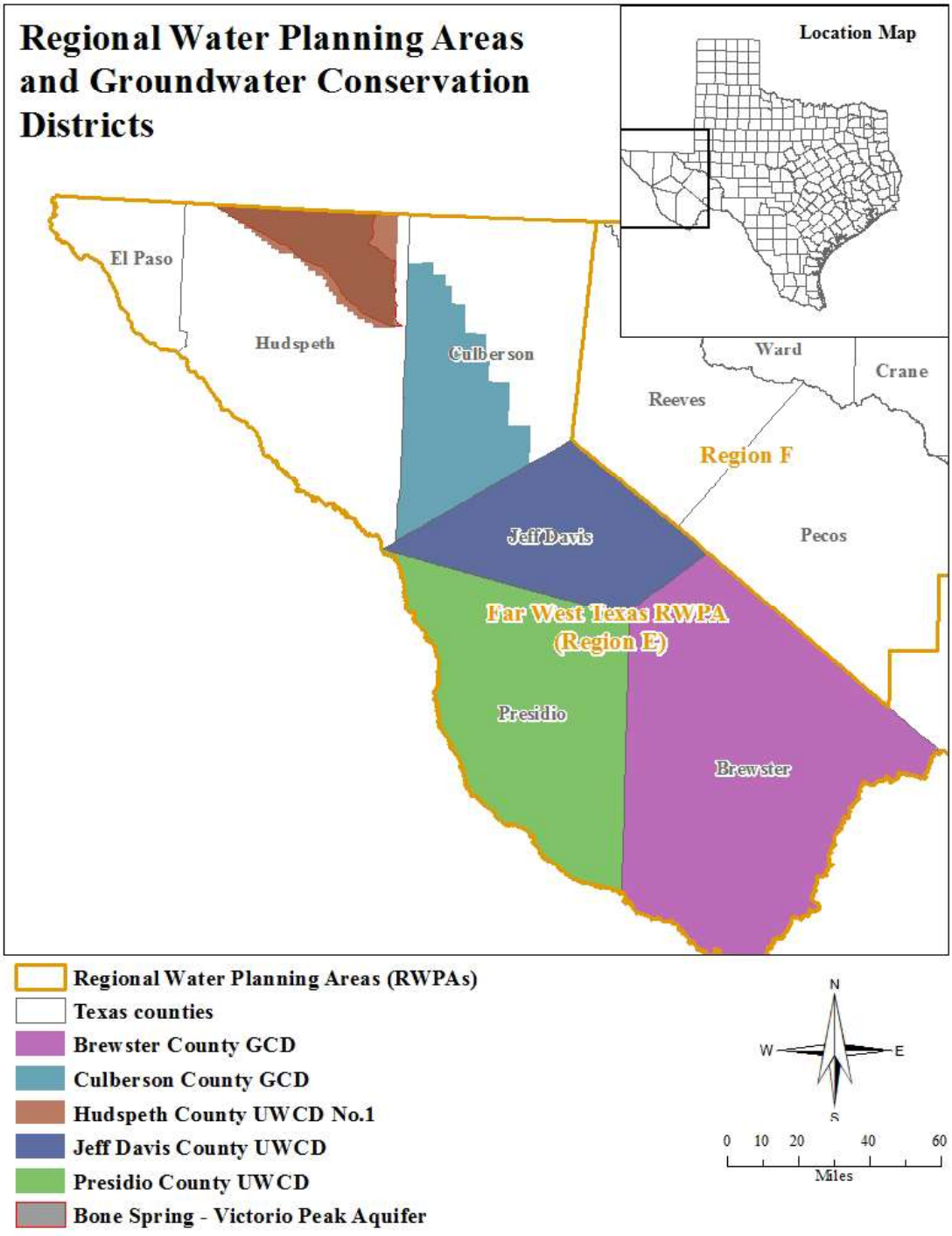

FIGURE 1. MAP SHOWING REGIONAL WATER PLANNING AREAS (RWPAS), GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES IN THE VICINITY OF THE BONE SPRING–VICTORIO PEAK AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

FIGURE 2. MAP SHOWING THE AREAS COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE BONE SPRING-VICTORIO PEAK AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

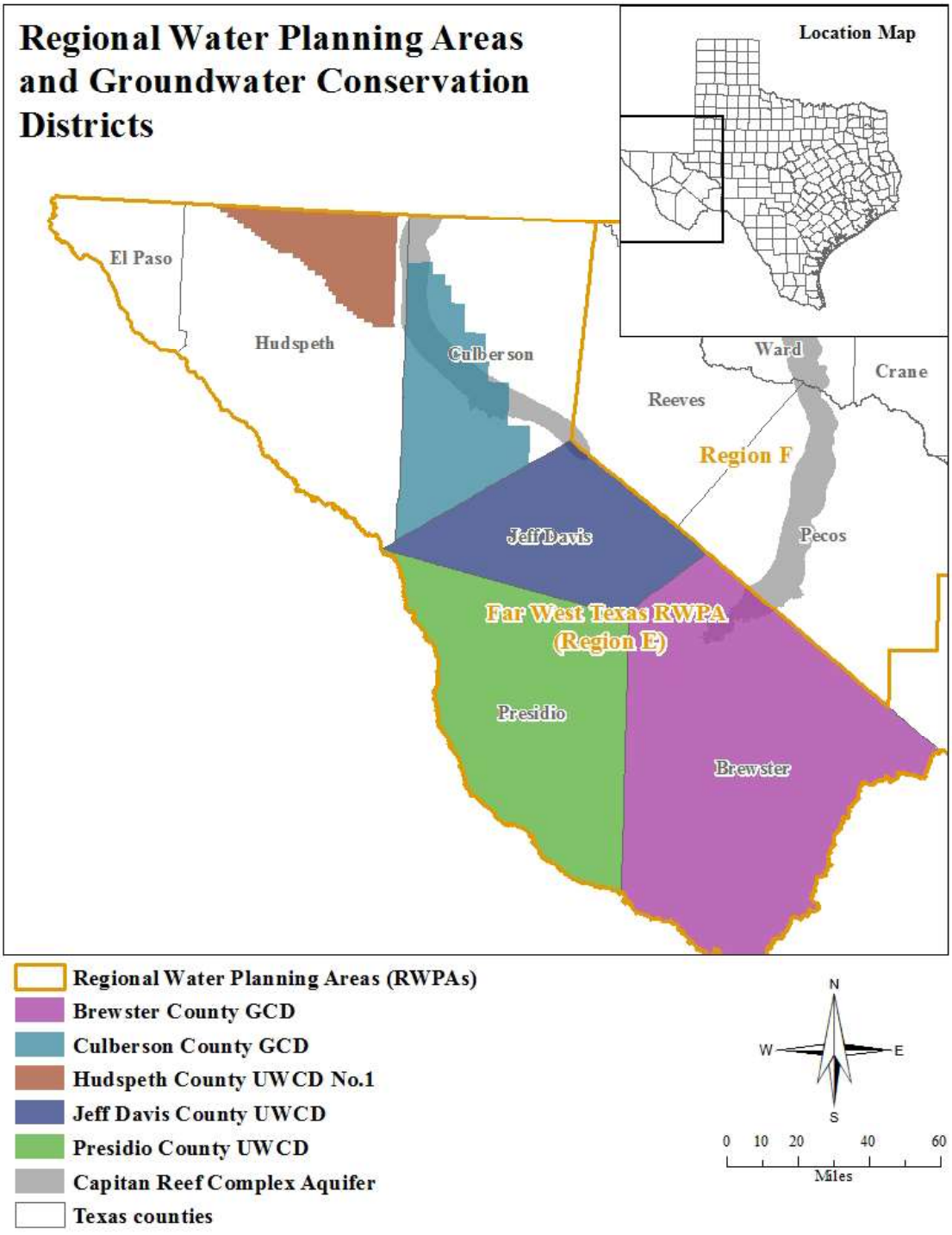

FIGURE 3. MAP SHOWING REGIONAL WATER PLANNING AREAS (RWPAS), GROUNDWATER CONSERVATIONDISTRICTS (GCDS), AND COUNTIES IN THE VICINITY OF THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

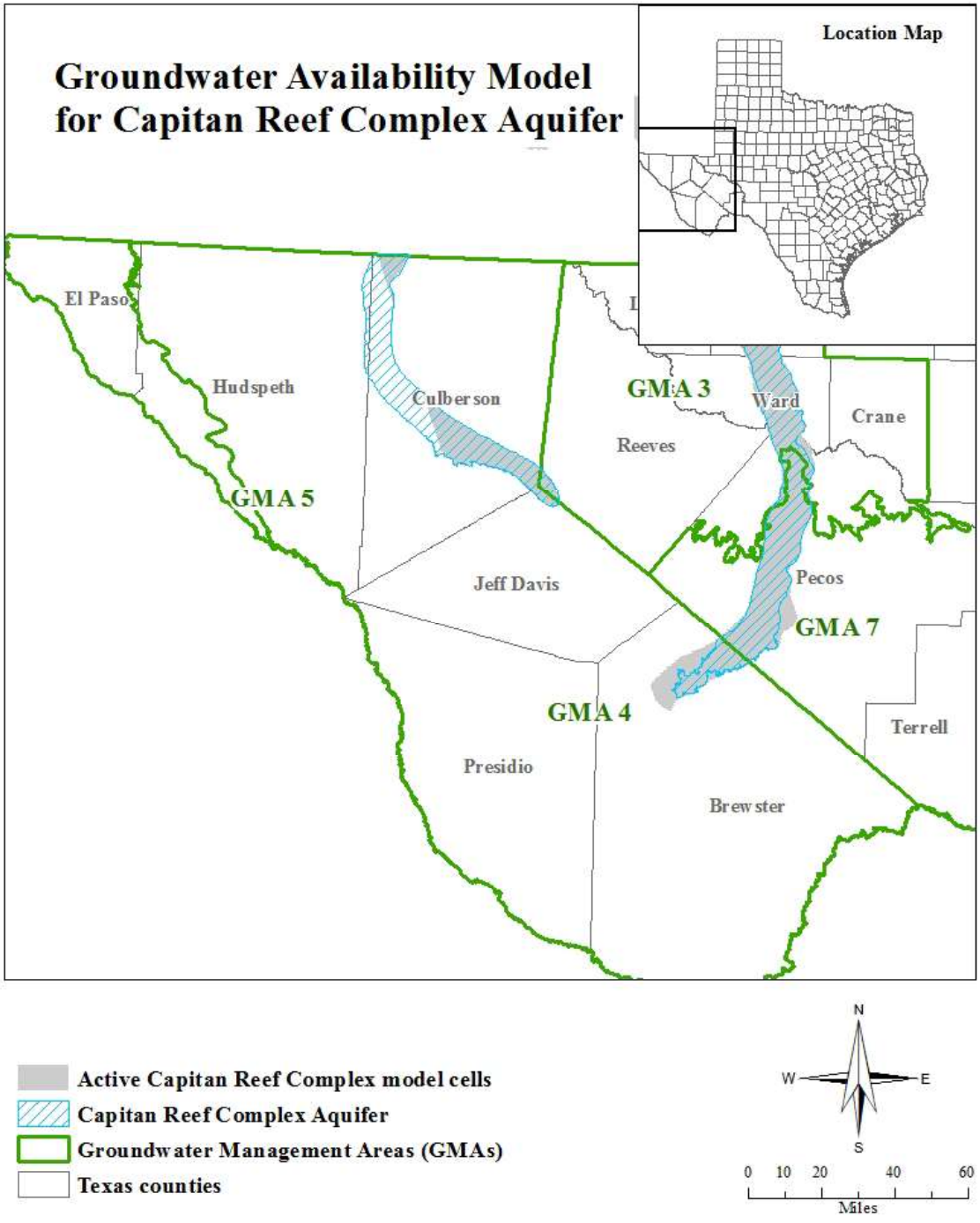

FIGURE 4. MAP SHOWING THE AREAS COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

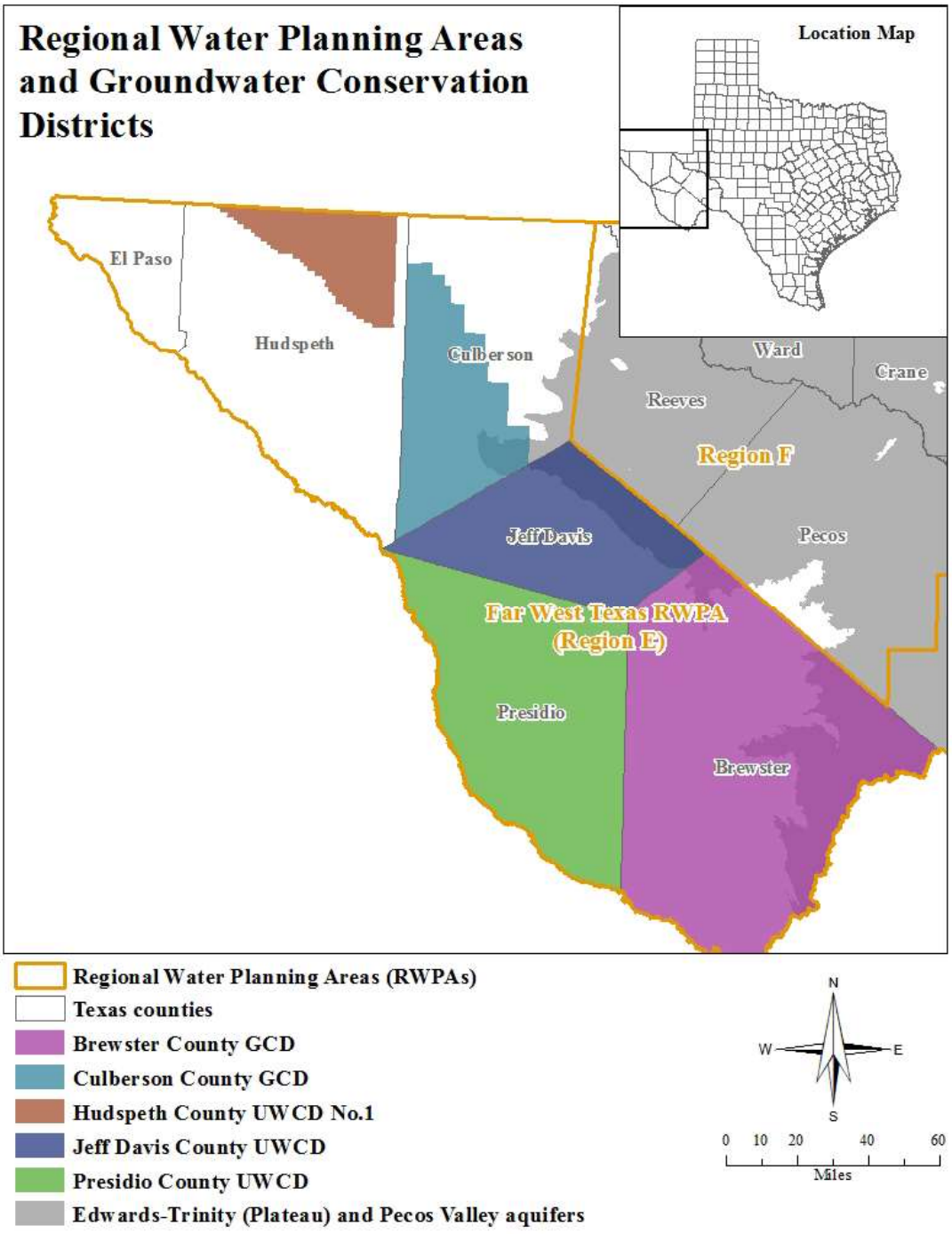

FIGURE 5. MAP SHOWING REGIONAL WATER PLANNING AREAS (RWPAS), GROUNDWATER CONSERVATIONDISTRICTS (GCDS), AND COUNTIES IN THE VICINITY OF THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

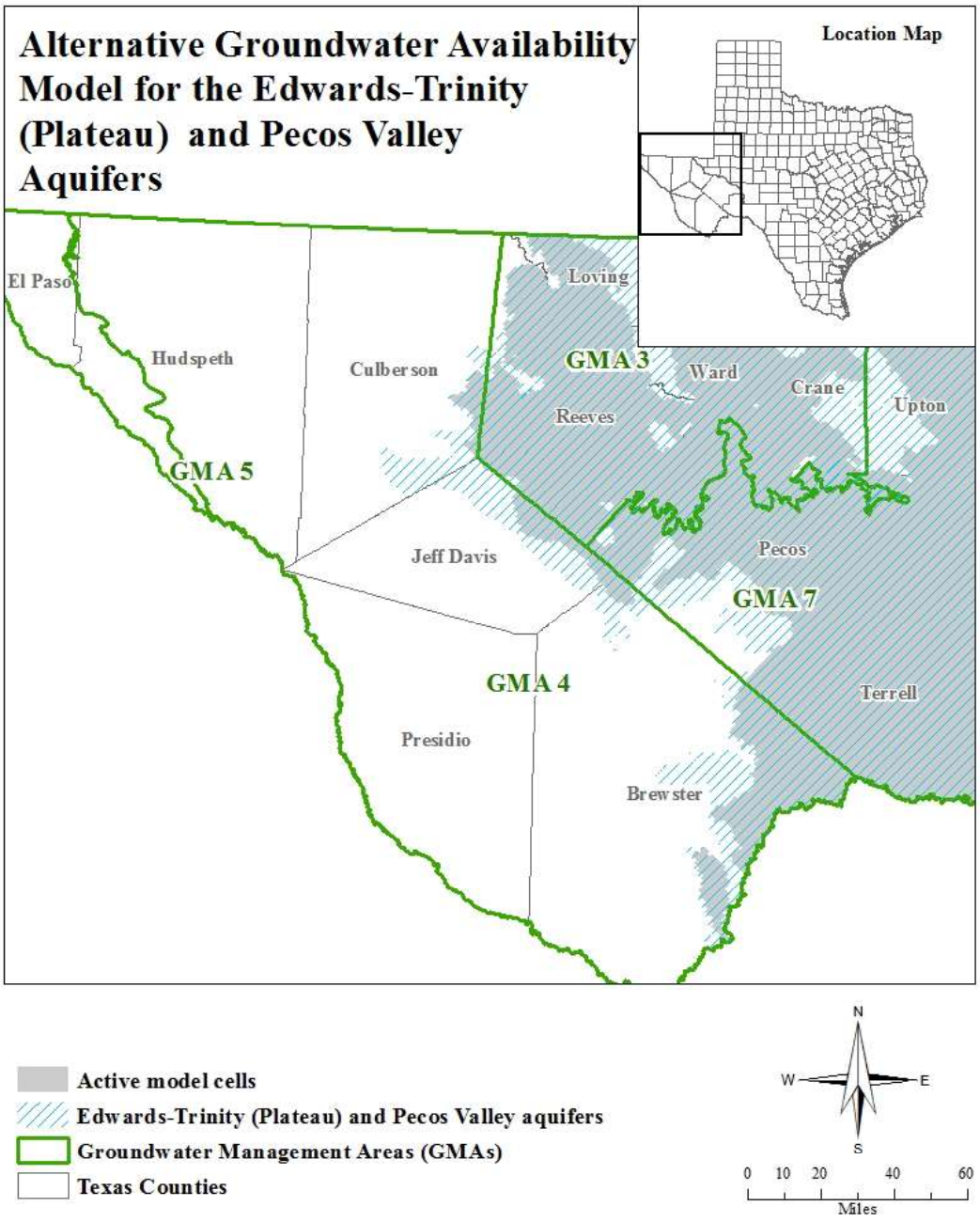

FIGURE 6. MAP SHOWING THE AREAS COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

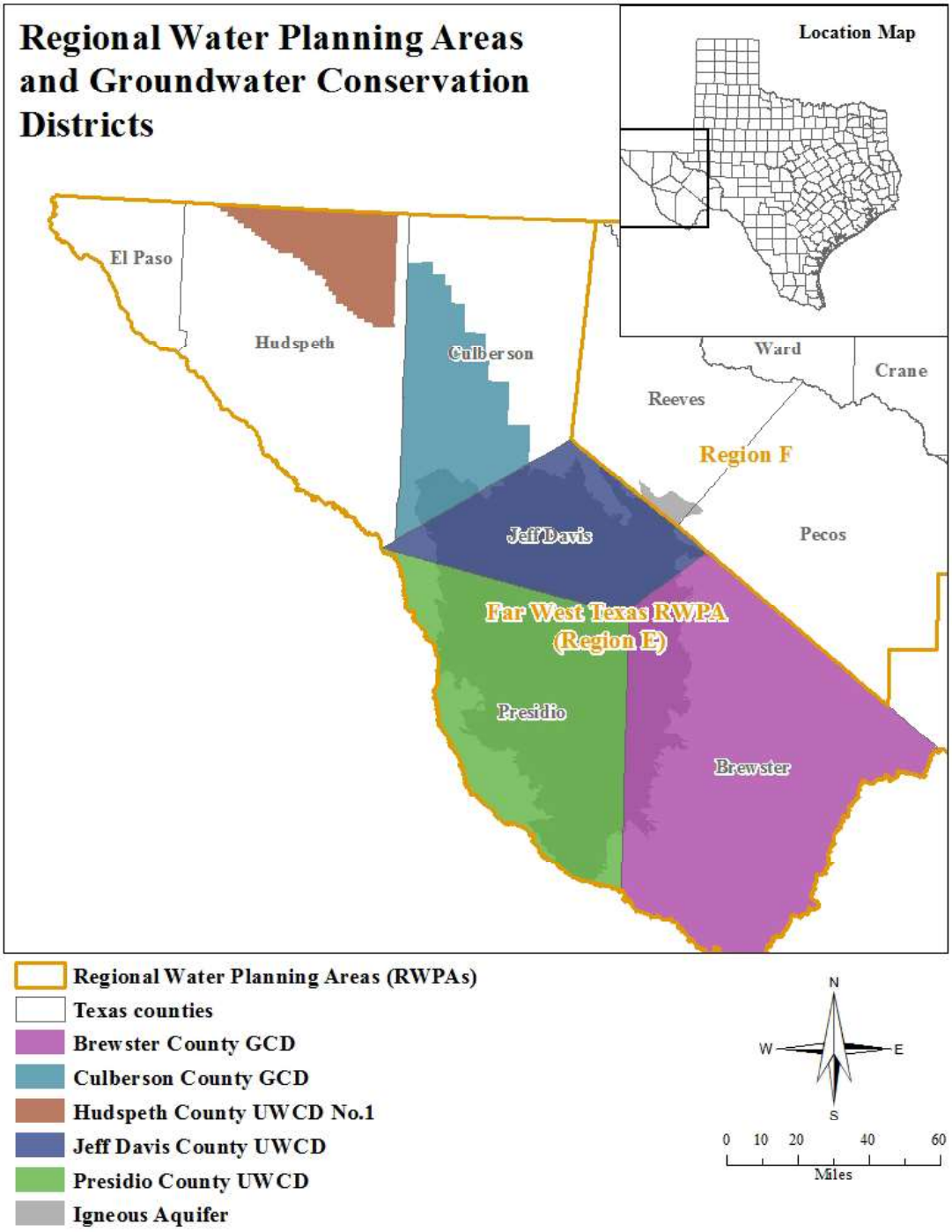

FIGURE 7. MAP SHOWING REGIONAL WATER PLANNING AREAS (RWPAS), GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES IN THE VICINITY OF THE IGNEOUS AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

FIGURE 8. MAP SHOWING THE AREAS COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE IGNEOUS AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

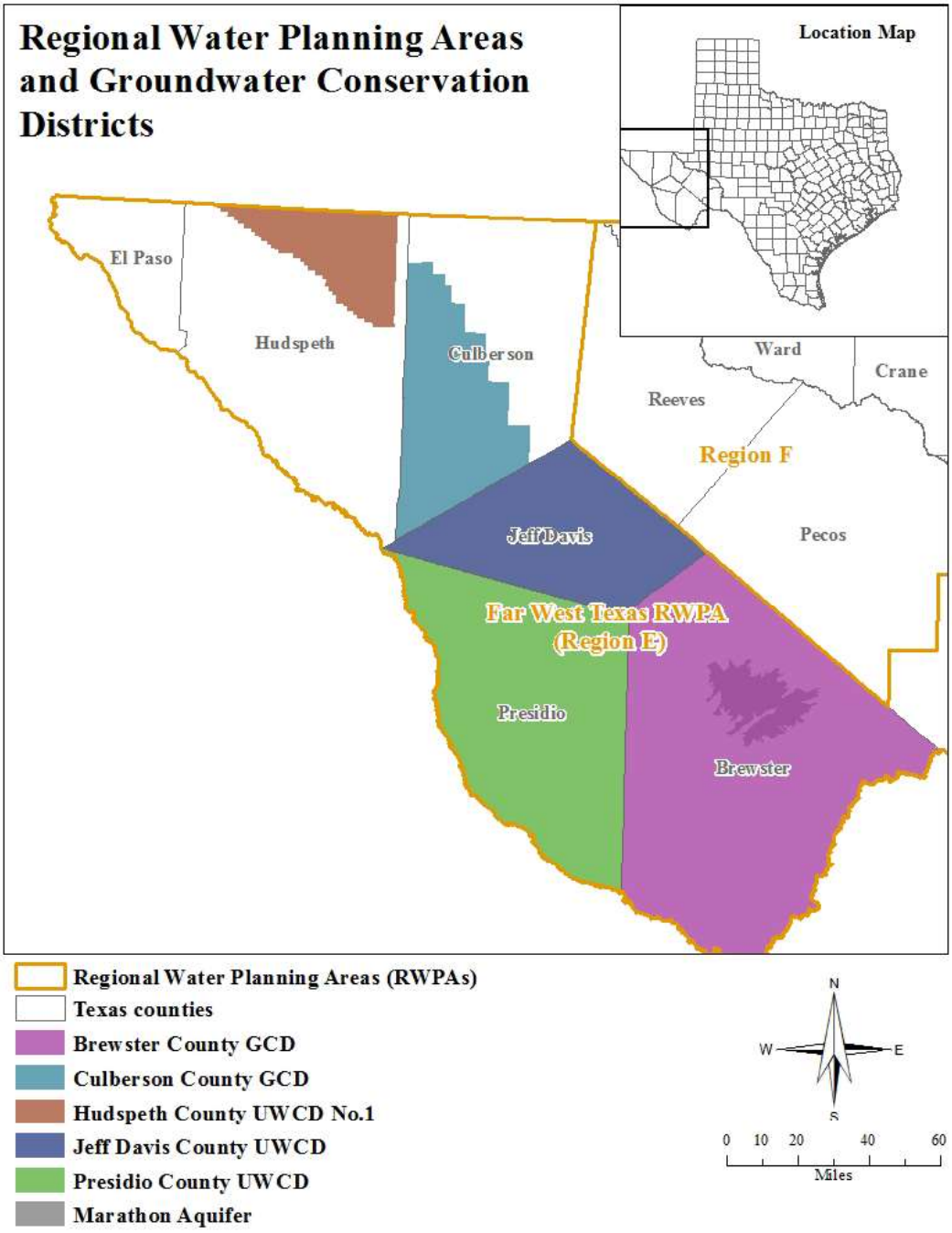

FIGURE 9. MAP SHOWING REGIONAL WATER PLANNING AREAS (RWPAS), GROUNDWATER CONSERVATION DISTRICTS (GCDS), AND COUNTIES IN THE VICINITY OF THE MARATHON AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

FIGURE 10. MAP SHOWING GROUNDWATER MANAGEMENT AREAS (GMAS) AND COUNTIES IN THE VICINITY OF THE MARATHON AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

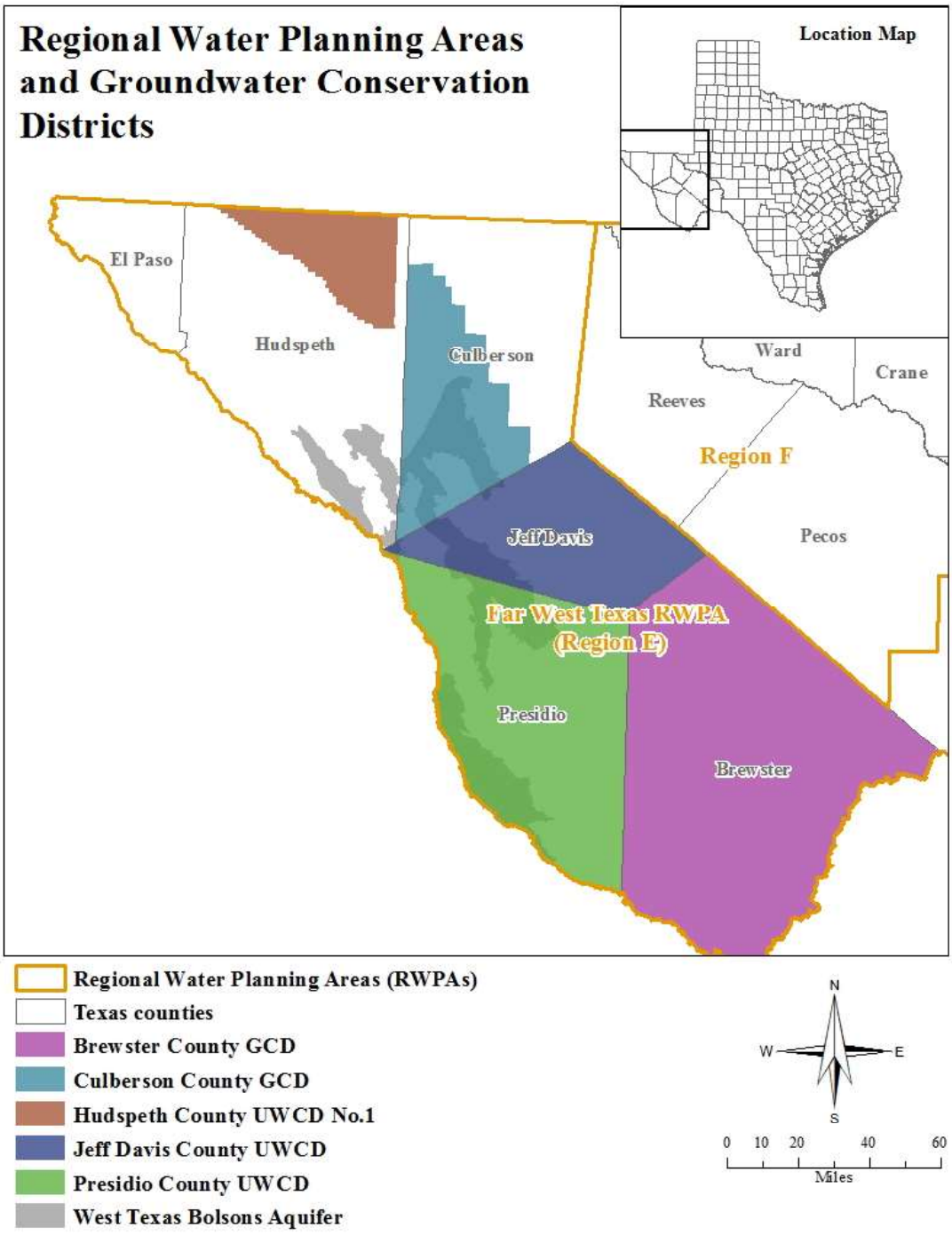

FIGURE 11. MAP SHOWING REGIONAL WATER PLANNING AREAS (RWPAS), GROUNDWATER CONSERVATIONDISTRICTS (GCDS), AND COUNTIES IN THE VICINITY OF THE WEST TEXAS BOLSONS AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

FIGURE 12. MAP SHOWING THE AREAS COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR PORTIONS OF THE WEST TEXAS BOLSONS AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

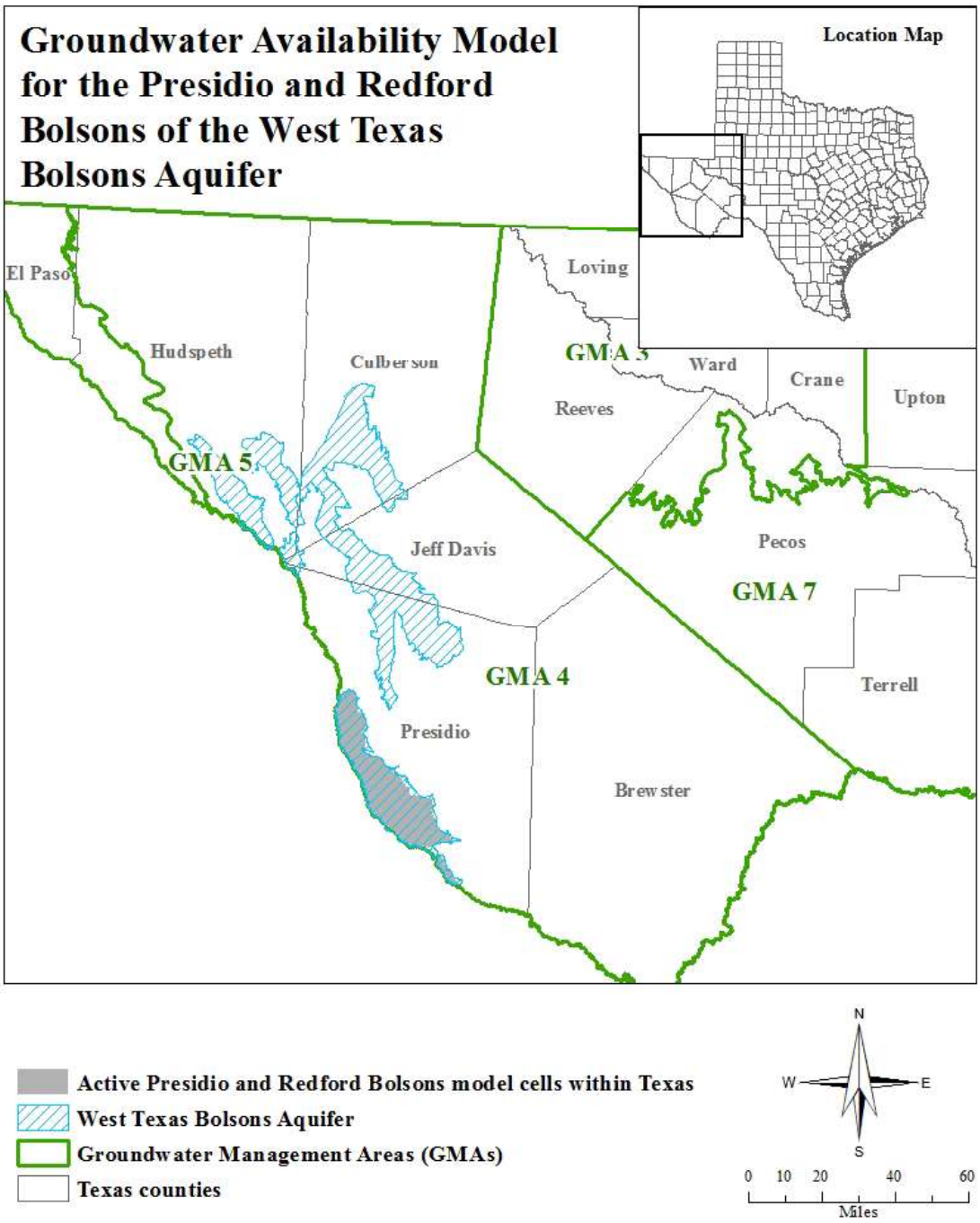

FIGURE 13. MAP SHOWING THE AREAS COVERED BY THE GROUNDWATER AVAILABILITY MODEL FOR THE PRESIDIO AND REDFORD PORTIONS OF THE WEST TEXAS BOLSON AQUIFER IN GROUNDWATER MANAGEMENT AREA 4.

TABLE 1. MODELED AVAILABLE GROUNDWATER FOR THE BONE SPRING-VICTORIO PEAK AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (UWCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	2020	2030	2040	2050	2060	2070
Hudspeth County UWCD	Hudspeth	101,400	101,400	101,400	101,400	101,400	101,400
No district-County	Hudspeth	0	0	0	0	0	0
Total		**101,400**	**101,400**	**101,400**	**101,400**	**101,400**	**101,400**

TABLE 2. MODELED AVAILABLE GROUNDWATER FOR THE BONE SPRING-VICTORIO PEAK AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Hudspeth	E	Rio Grande	101,400	101,400	101,400	101,400	101,400	**101,400**
Total			**101,400**	**101,400**	**101,400**	**101,400**	**101,400**	**101,400**

TABLE 3. MODELED AVAILABLE GROUNDWATER FOR THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2060. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	2020	2030	2040	2050	2060
Brewster County GCD	Brewster	583	583	583	583	583
Culberson County GCD	Culberson	7,580	7,580	7,580	7,580	7,580
Total		**8,163**	**8,163**	**8,163**	**8,163**	**8,163**

TABLE 4. MODELED AVAILABLE GROUNDWATER FOR THE CAPITAN REEF COMPLEX AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR. NOTE: THE VALUES LISTED IN THIS TABLE HAVE BEEN POPULATED PAST THE DATES NOTED IN PARAMETERS AND ASSUMPTIONS SECTION (SEE TABLE 3) USING THE TREND OF RESULTS.

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Brewster	E	Rio Grande	583	583	583	583	583	583
Culberson	E	Rio Grande	7,580	7,580	7,580	7,580	7,580	7,580
Total			**8,163**	**8,163**	**8,163**	**8,163**	**8,163**	**8,163**

TABLE 5. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2060. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	2020	2030	2040	2050	2060
Brewster County GCD	Brewster	1,394	1,394	1,394	1,394	1,394
Total		**1,394**	**1,394**	**1,394**	**1,394**	**1,394**

TABLE 6. MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR. NOTE: THE VALUES LISTED IN THIS TABLE HAVE BEEN POPULATED PAST THE DATES NOTED IN PARAMETERS AND ASSUMPTIONS SECTION (SEE TABLE 5) USING THE TREND OF RESULTS.

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Brewster	E	Rio Grande	1,394	1,394	1,394	1,394	1,394	1,394
Total			**1,394**	**1,394**	**1,394**	**1,394**	**1,394**	**1,394**

TABLE 7. MODELED AVAILABLE GROUNDWATER FOR THE IGNEOUS AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD, UWCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2050. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	2020	2030	2040	2050
Brewster County GCD	Brewster	2,586	2,586	2,585	2,583
Culberson County GCD	Culberson	99	99	99	99
Jeff Davis County UWCD	Jeff Davis	4,584	4,584	4,584	4,584
Presidio County UWCD	Presidio	4,064	4,064	4,064	4,063
Total		**11,333**	**11,333**	**11,332**	**11,329**

TABLE 8. MODELED AVAILABLE GROUNDWATER FOR THE IGNEOUS AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR. NOTE: THE VALUES LISTED IN THIS TABLE HAVE BEEN POPULATED PAST THE DATES NOTED IN PARAMETERS AND ASSUMPTIONS SECTION (SEE TABLE 7) USING THE TREND OF RESULTS.

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Brewster	E	Rio Grande	2,586	2,586	2,585	2,583	2,583	2,582
Culberson	E	Rio Grande	99	99	99	99	99	99
Jeff Davis	E	Rio Grande	4,584	4,584	4,584	4,584	4,584	4,584
Presidio	E	Rio Grande	4,064	4,064	4,064	4,063	4,063	4,063
Total			**11,333**	**11,333**	**11,332**	**11,329**	**11,329**	**11,327**

TABLE 9. MODELED AVAILABLE GROUNDWATER FOR THE MARATHON AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) AND COUNTY FOR EACH DECADE BETWEEN 2020 AND 2060. VALUES ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	County	2020	2030	2040	2050	2060
Brewster County GCD	Brewster	7,327	7,327	7,327	7,327	7,327
Total		**7,327**	**7,327**	**7,327**	**7,327**	**7,327**

TABLE 10. MODELED AVAILABLE GROUNDWATER FOR THE MARATHON AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), AND RIVER BASIN FOR EACH DECADE BETWEEN 2020 AND 2070. VALUES ARE IN ACRE-FEET PER YEAR. NOTE: THE VALUES LISTED IN THIS TABLE HAVE BEEN POPULATED PAST THE DATES NOTED IN PARAMETERS AND ASSUMPTIONS SECTION (SEE TABLE 9) USING THE TREND OF RESULTS.

County	RWPA	River Basin	2020	2030	2040	2050	2060	2070
Brewster	E	Rio Grande	7,327	7,327	7,327	7,327	7,327	7,327
Total			**7,327**	**7,327**	**7,327**	**7,327**	**7,327**	**7,327**

TABLE 11. MODELED AVAILABLE GROUNDWATER FOR THE WEST TEXAS BOLSONS AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD, UWCD), COUNTY, AND AQUIFER SEGMENT FOR EACH DECADE BETWEEN 2020 AND 2050. VALUES ARE IN ACRE-FEET PER YEAR. THE SALT BASIN PORTION OF THE WEST TEXAS BOLSONS AQUIFER INCLUDES WILD HORSE, MICHIGAN, LOBO FLATS, AND RYAN FLAT.

Groundwater Conservation District	County	Aquifer Segment	2020	2030	2040	2050
Culberson County GCD	Culberson	Wild Horse, Michigan, and Lobo Flats	35,749	35,678	35,601	35,550
Jeff Davis County UWCD	Jeff Davis	Ryan Flat	6,055	6,055	5,989	5,960
Presidio County UWCD	Presidio	Ryan Flat	9,112	8,982	8,834	8,710
Presidio County UWCD	Presidio	Presidio and Redford Bolsons	7,661	7,661	7,661	7,661
Total			**58,577**	**58,376**	**58,085**	**57,881**

TABLE 12. MODELED AVAILABLE GROUNDWATER FOR THE WEST TEXAS BOLSONS AQUIFER IN GROUNDWATER MANAGEMENT AREA 4 SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER SEGMENT FOR EACH DECADE BETWEEN 2020 AND 2070. NOTE: THE VALUES LISTED IN THIS TABLE HAVE BEEN POPULATED PAST THE DATES NOTED IN PARAMETERS AND ASSUMPTIONS SECTION (SEE TABLE 11) USING THE TREND OF RESULTS. VALUES ARE IN ACRE-FEET PER YEAR.

County	RWPA	River Basin	Aquifer Segment	2020	2030	2040	2050	2060	2070
Culberson	E	Rio Grande	Wild Horse, Michigan, and Lobo Flats	35,749	35,678	35,601	35,550	35,476	35,409
Jeff Davis	E	Rio Grande	Ryan Flat	6,055	6,055	5,989	5,960	5,927	5,892
Presidio	E	Rio Grande	Ryan Flat	9,112	8,982	8,834	8,710	8,571	8,436
Presidio	E	Rio Grande	Presidio and Redford Bolsons	7,661	7,661	7,661	7,661	7,661	7,661
Total				**58,577**	**58,376**	**58,085**	**57,881**	**57,635**	**57,397**

LIMITATIONS:

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

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

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

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

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

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GAM Run 16-030_Addendum: Culberson County Groundwater Conservation District Modeled Available Groundwater for the West Texas Bolsons Aquifer

By Shirley C. Wade, Ph. D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
(512) 936-0883
June 24, 2020

Shirley C. Wade
6/24/2020

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GAM RUN 16-030_ADDENDUM: CULBERSON COUNTY GROUNDWATER CONSERVATION DISTRICT MODELED AVAILABLE GROUNDWATER FOR THE WEST TEXAS BOLSONS AQUIFER

By Shirley C. Wade, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
(512) 936-0883
June 24, 2020

EXECUTIVE SUMMARY:

Culberson County Groundwater Conservation District requested via email on June 8, 2020 that the TWDB provide the modeled available groundwater for the West Texas Bolsons Aquifer with their district divided into three geographic areas. The three geographic areas are the Lobo Flat, the Michigan Flat, and the Wild Horse Flat (Figure 1). Culberson County Groundwater Conservation District provided Geographic Information System (GIS) shapefiles for each area.

We used the geographic area shapefiles to update the (GIS) grid file for the groundwater availability model for the Igneous and parts of the West Texas Bolsons Aquifer. In addition, we made small adjustments to the geographic area assignments in the (GIS) grid file to fully capture the extent of the bolsons used for the original modeled available groundwater analysis (Figure 1; Boghici and Bradley, 2018; Oliver, 2011, Oliver, 2010a; Oliver, 2010b). We then used the revised grid to extract the modeled available groundwater values from the previous model results (Table 1).

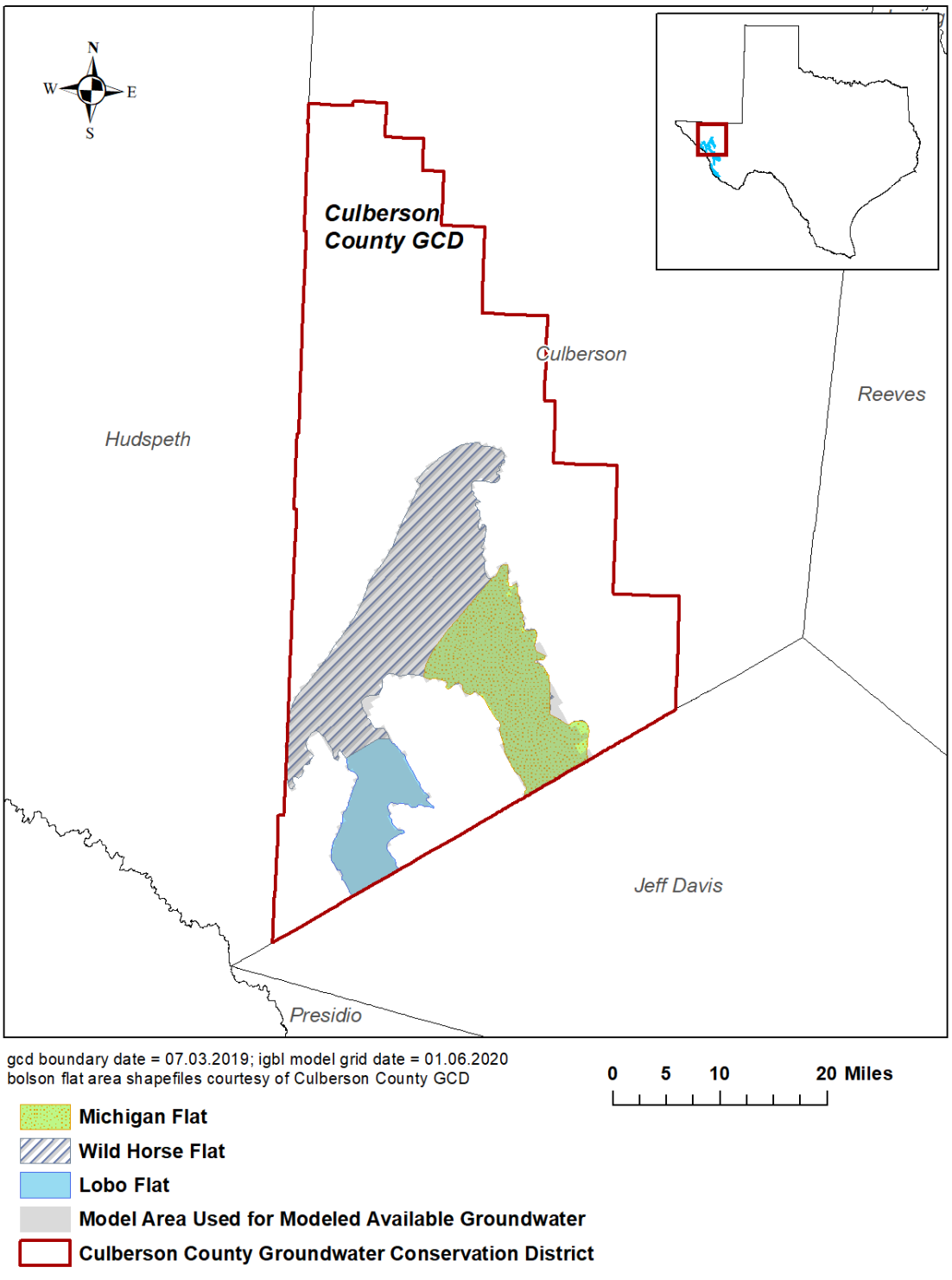

FIGURE 1: LOCATION OF THE GEOGRAPHIC AREAS OF THE WEST TEXAS BOLSONS AQUIFER LOCATED IN CULBERSON COUNTY GROUNDWATER CONSERVATION DISTRICT (GCD).

TABLE 1: MODELED AVAILABLE GROUNDWATER FOR THE WEST TEXAS BOLSONS AQUIFER SPLIT BETWEEN GEOGRAPHIC AREAS IN CULBERSON COUNTY GROUNDWATER CONSERVATION DISTRICT. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Area	2020	2030	2040	2050	2060
Lobo Flat	11,112	11,112	11,097	11,092	11,087
Wild Horse Flat	20,568	20,542	20,501	20,475	20,455
Michigan Flat	4,071	4,025	4,004	3,984	3,969
Culberson County Groundwater Conservation District Total	35,751	35,679	35,602	35,551	35,510

LIMITATIONS:

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

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

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

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

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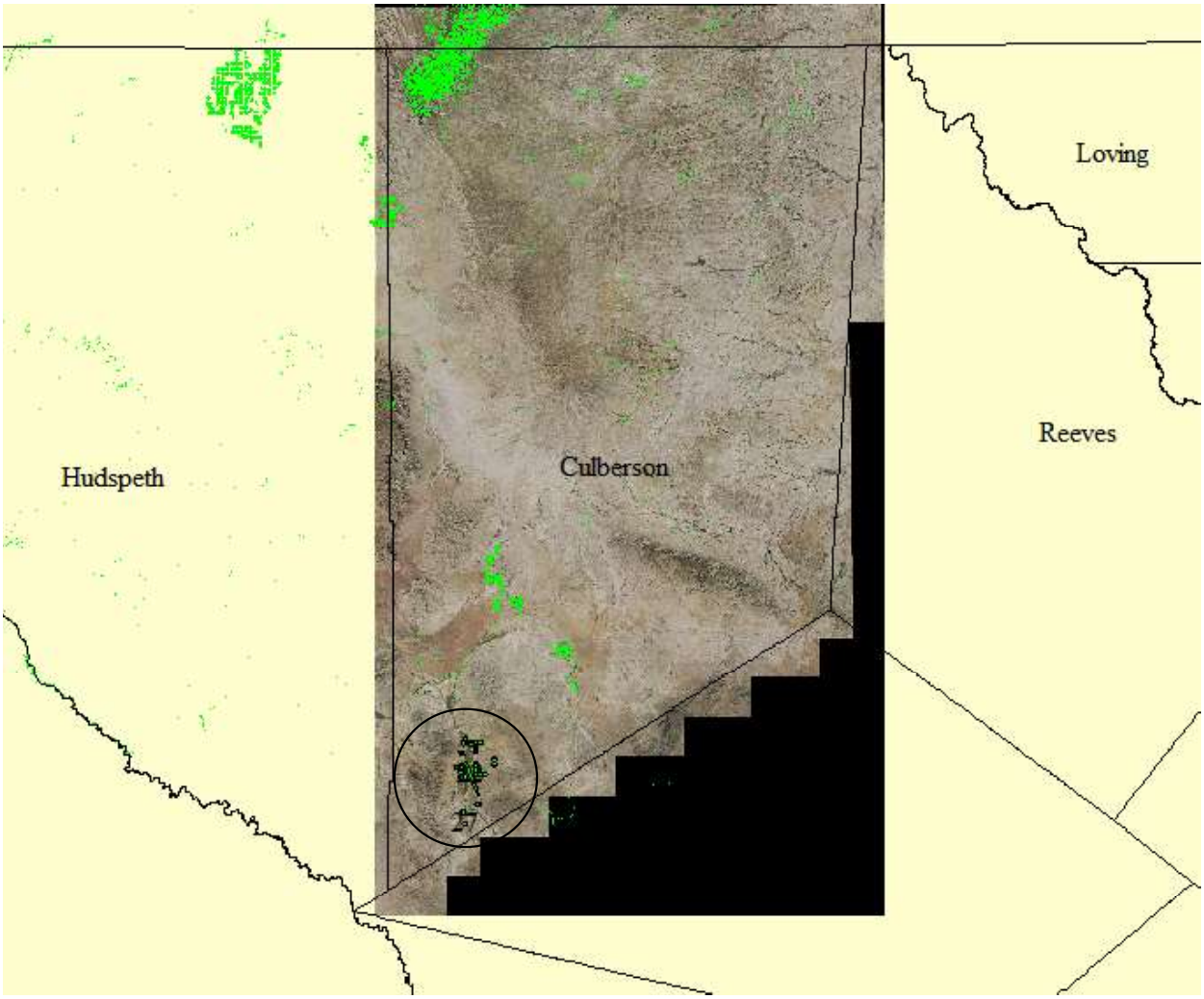
Appendix B – 2015 Irrigated Land Study of Culberson County & Analysis of Rain/Fall Runoff Volumes for Wild Horse Arroyo, Lobo Road, Culberson County, Texas

Estimate of Agricultural Irrigation Water Use in Culberson County, Texas 2015 Using LANDSAT 8 NDVI Images and CCGCD Records



Review Draft - Prepared for the

Culberson County Groundwater Conservation District

February 27, 2017
Revised April 4, 2017

A.W. Blair, P.E. Ph.D.
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Austin, Texas

1. Introduction and Summary

As requested by the Culberson County Groundwater Conservation District this report was prepared in accordance with generally recognized engineering principles, practice, and methods and documents the estimated amount of groundwater pumped for irrigation of agricultural land in Lobo Flat, Culberson County in 2015, and the projected amount of groundwater that will be pumped in 2016. This report uses LANDSAT 8 multispectral images for July 23, 2015 and NAIP high resolution aerial images taken in October of 2014 to estimate the amount irrigated crop land.

2. 2015 Rainfall and Temperature Data, and LANDSAT 8 Images

Figure 1 and 2 show that the Lobo Flat area of Culberson County received between 1 and 2 inches of rainfall during June of 2015. The annual rainfall was between 10 and 15 inches for both years. Because of the low annual rainfall amounts, low average humidity, and high temperatures in Culberson County, all agricultural crops are irrigated.

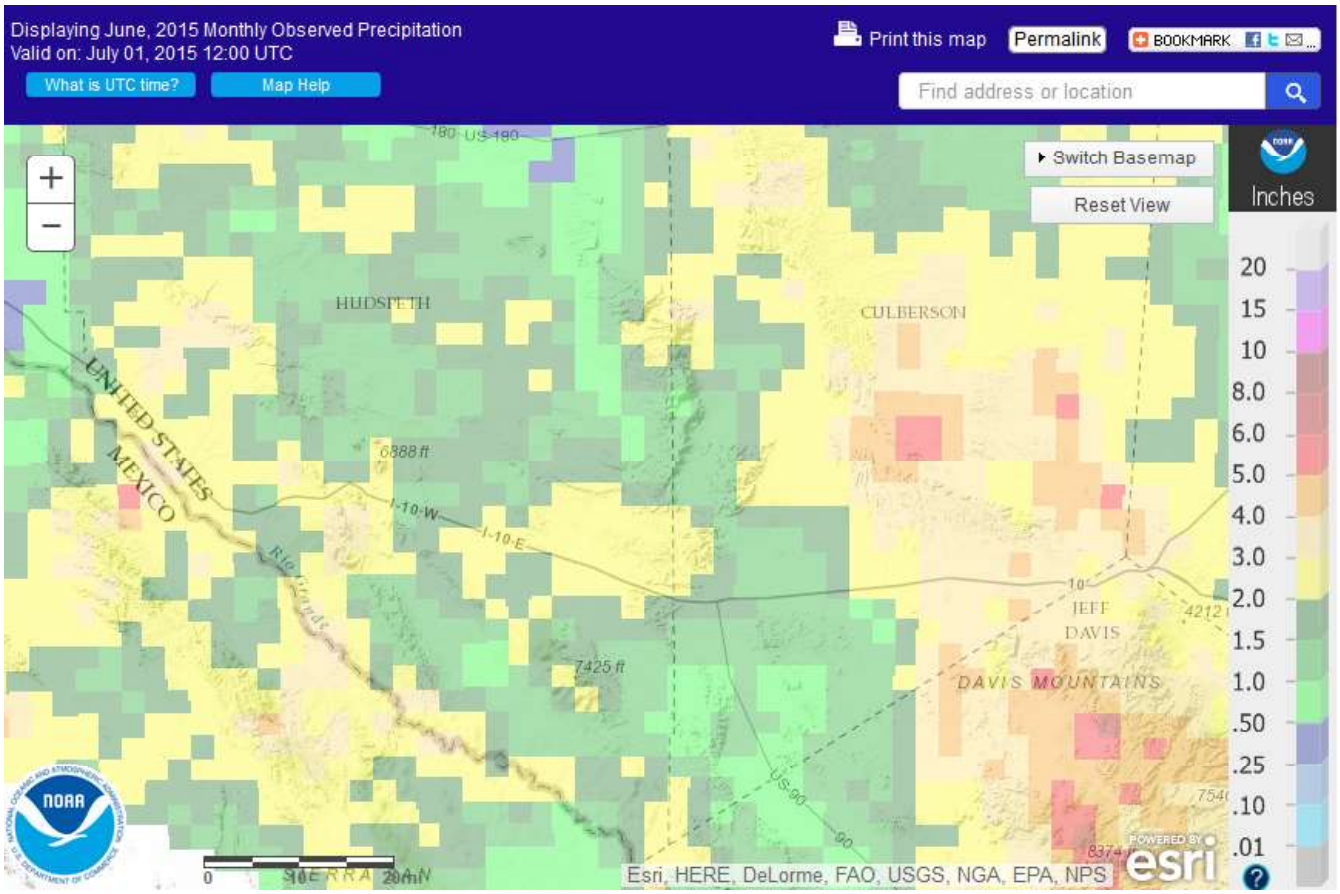

Figure 1 - NWS June 2015 Estimated Rainfall Amounts for Culberson County, Texas

3. NDVI Calculations and Images

The Normalized Difference Vegetation Index (NDVI) was calculated from the LANDSAT 8 Red and Near Infra-Red Bands for the, July 23, 2015 image. The NDVI values range from -1.0 to 1.0 with typical values for water surface being less than 0.0 and bare soil being equal to or slightly greater than 0.0, and healthy vegetation having values of greater than 0.20. The exact NDVI values are specific to the unique characteristics of the images used, the time of year, the type of vegetation, and recent climatic events (rainfall, cold weather, drought). Figure 3 shows the resulting calculated vegetative areas with and NDVI value greater or equal to 0.40 for 2015. Because of seasonal rainfall, Figure 2 shows some amount of natural vegetative areas located near or in areas of storm water runoff or runoff ponding or in the alpine or riparian areas of Guadalupe National Park (northern portion of image on the right).

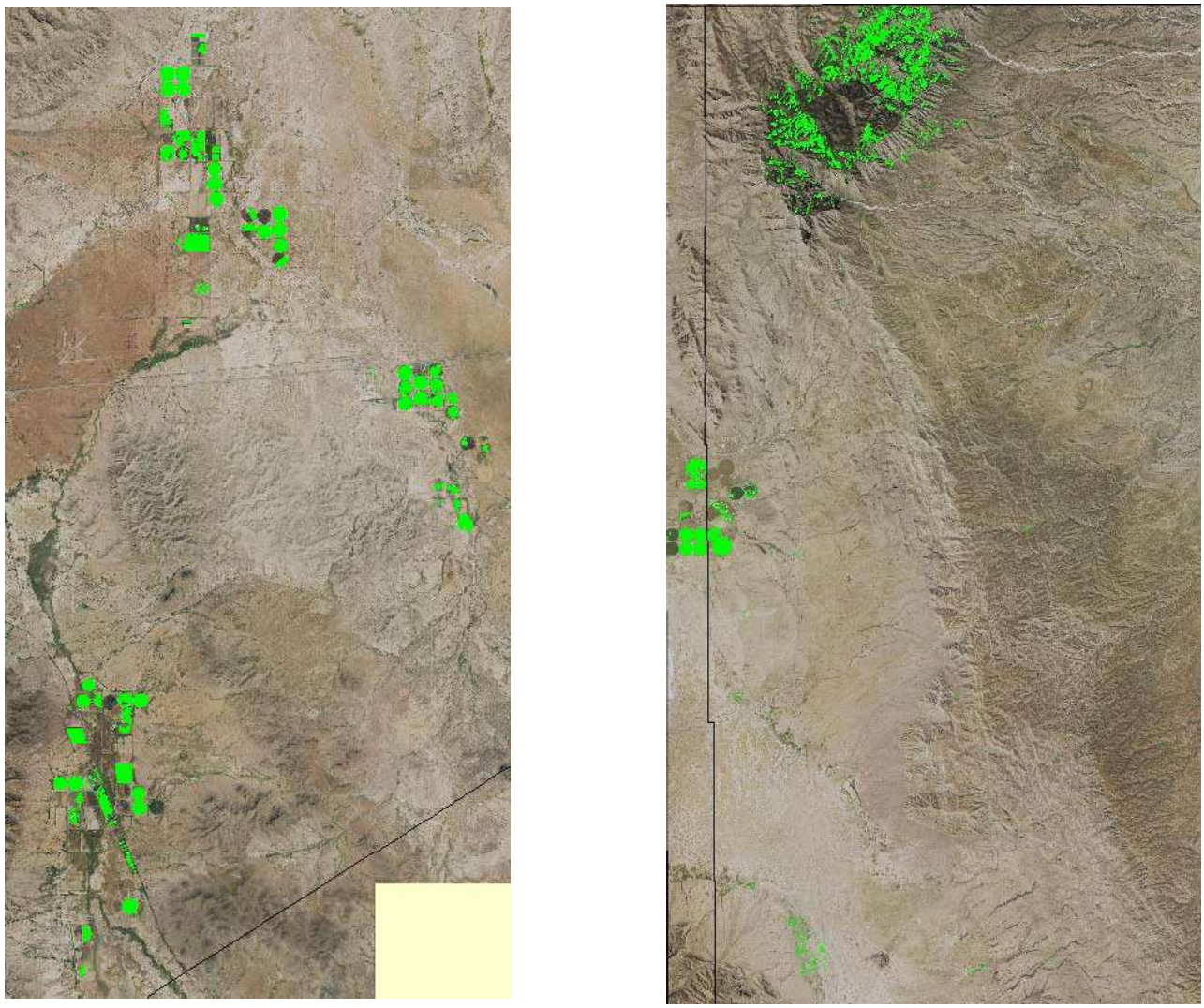

Figure 2 – 2015 LANDSAT 8 NDVI Image Overly on 2014 NAIP Aerial Images of Wild Horse, Lobo, and Michigan Flats, Culberson County (Left) and Diablo Farms /Salt Flat Area (Right)

Figure 4 shows the NDVI overlay from the July 23, 2015 LANDSAT 8 Images for the Lobo Flat Area of Culberson County, and the irrigated field perimeters digitized from the October 2014 NAIP High Resolution Aerial Images. Similar analysis was done for the Wildhorse Flat, Michigan Flat, and Diablo Farm (Salt Flat) areas.

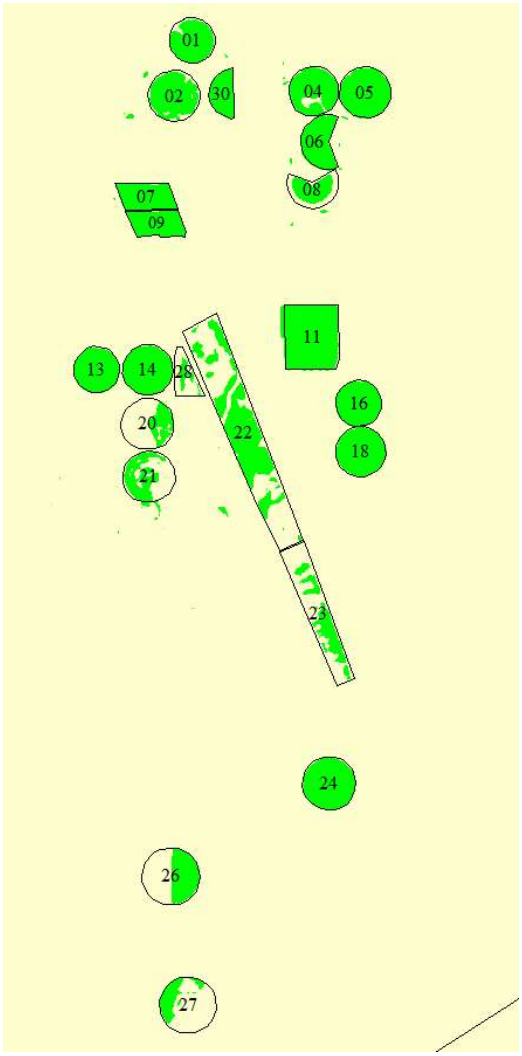

Figure 4 – July 23, 2015 LANDSAT 8 NDVI => 0.40 Overlay of Lobo Flat Area - Culberson County

4.0 Estimate of Amount of Irrigated Land, Water Source, and Amount of Water Use

Culberson County has four distinct areas of irrigated agriculture: 1) Lobo Flat, 2) Michigan Flat, 3) Wild Horse Flat, and the portion of Diablo Farms (Armstrong Farms) located east of Salt Flats, Texas near the Hudspeth-Culberson County line. The only source of irrigation water in all of these areas is groundwater. The primary crops grown are alfalfa for bailed hay and mature pecan orchards. Alfalfa is typically harvested (cut) between six and eight times per year.

During each harvest cycle there is a period of time (typically 7 to 10 days) in which the amount of leaf area on the alfalfa is minimal and the soil is dry. During this harvest period the NDVI values of an alfalfa field may be less than 0.20. Multiple LANDSAT images, ground observations, and/or high resolution aerial images are required to accurately estimate the amount of irrigated land.

Table 1 shows the estimated amount of irrigated land and the estimated amount of on-farm water use (pumped groundwater) based on the NDVI analysis and Estimated Average Pumped Volume per crop. The District requires that all groundwater pumped for non-exempt use which include agricultural irrigation is metered and reported periodically to the District.

In general, the number of irrigated acres was greater than the NDVI estimated acreage and the reported amount of water pumped was less than Estimated Average Pumped Volumes. Some of difference between reported and NDVI estimate acreage may be explained by the reported acres being gross field size whereas the NDVI estimated acreage was based on actively growing crops. Also, the reported acres might include fields that were irrigated in the late Fall that were not detected using the NDVI methods.

Table 1 –Estimated and 2015 Irrigated Land and Pumped Irrigation Water

Year	County	Crop Num	CropName	Lobo Flat Acres	Wildhorse Acres	Michigan Acres	Diablo Farms Acres	Total Acres	Rate Acre_Inches per Acre	Total On-Farm Water Use AF	Ground Water AF	Surface Water AF
2015	Culberson	1	COTTON (or other row crops)	**354**	-	**996**	-	**1,350**	**30**	**3,375**	**3,375**	-
2015	Culberson	2	SORGHUM				-	-	**34**	-	-	-
2015	Culberson	3	CORN				-	-	**36**	-	-	-
2015	Culberson	5	WHEAT				-	-	**36**	-	-	-
2015	Culberson	6	OTHER_GRAIN (Oats)				-	-	**30**	-	-	-
2015	Culberson	7	FORAGE_HAY_PASTURE and SUDAN				-	-	**24**	-	-	-
2015	Culberson	10	VINEYARD				-	-	**36**	-	-	-
2015	Culberson	12	ALFALFA	**1,640**	**3,166**	**996**	**1,040**	**6,842**	**42**	**23,947**	**23,947**	-
2015	Culberson		PECANS	**646**	**620**	**100**		**1,366**	**48**	**5,464**	**5,464**	
2015	Culberson	14	VEGETABLES				-	-	**34**	-	-	-
2015	Culberson	15	OTHER (yards and gardens)				-	-	**24**	-	-	-
			Total Irrigated	**2,640**	**3,786**	**2,092**	**1,040**	**9,558**		**32,786**	**32,786**	-
			District Reports Irrigated Acres*	**3,409**	**3,475**	**2,700**	**1,040**	**10,624**				
			*** Note: District did not report irrigated acres for Diablo Farms in 2015**									

Review Draft - Technical Memorandum Regarding

Analysis of Rainfall-Runoff Volumes for Wild Horse Arroyo at Lobos Road Crossing, Culberson County

Storm of August 28-29, 2019

January 31, 2020

Prepared for
Culberson County Groundwater Conservation District
Van Horn, Texas

By

A.W. Blair Engineering
Texas PE Firm No. 1709
Austin, Texas

AW BLAIR ENGINEERING

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2 USGS Topographic Map of Lobos Valley

3 Aerial View of Wild Horse Draw near Lobos Road

4 Picture of Water Level Recorder

5 Estimate Rainfall Depth August 28, 2019

6 Estimate of Rainfall Depth August 29, 2019

7 FHA HY8 Stage/Discharge Relationship for Single 36” Diameter CMP at Wild Horse Draw

8 Runoff Hydrograph and Cumulative Flow Curve

Introduction and Background

Culberson Country Groundwater Conservation District (the District) is studying potential methods for increasing groundwater recharge in the Lobo Flat Area south of Van Horn, Texas. This memorandum documents the part of the study regarding estimating stormwater flows in Wild Horse Draw (also know as Wild Horse Arroyo or Creek) near the northern limits of Lobo Flat where water flowing in the draw exits the flat. Figure 1 shows the culvert crossing the county road looking north (downstream). Figure 2 is a USGS topographic map of the area. Figure 3 show aerial image of the crossing and surrounding land. Wild Horse Draw is confined by levees both upstream and downstream of the culvert crossing.

Figure 1: Wild Horse Draw – Eleven 36" Diameter CMP Culverts

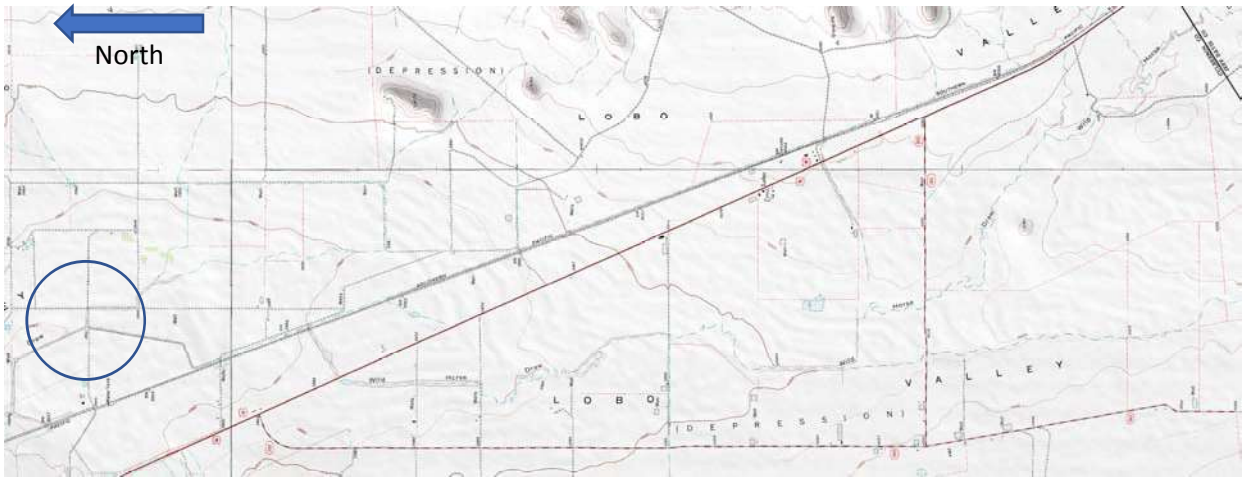


Figure 2: USS Topographic Map showing North Arrow and location of culverts (circle).

Figure 3: Aerial Image of Culvert Crossing and Surrounding Land

Measurement of Flow Depth (Stage) in Wild Horse Draw (Arroyo)

Figure 4 on the next page shows the installation of water level sensor on a 1.5 inch diameter metal pole. The sensor measures absolute pressure (unvented) and requires the measure water level data to be adjusted for any large changes in barometric pressure during the storm event. The sensor was installed 0.25 feet above the bottom of the metal pole.

The sensor has a 5 year battery that will need replacing prior to 2025. It is recommended that the district install a weather station with a tipping bucket recording rain gauge on the top of the sensor pole.

Figure 4: Insitu AquaTroll Water Level Sensor and Data Logger

Estimate of Storm Duration and Rainfall Depth

The NOAA Advance Hydrologic Prediction Services Quantitative Precipitation Estimates (https://water.weather.gov/precip/) were used to estimate the duration and amounts of rainfall for the August 28-29, 2019 event. Figure 5 and 6 show that rainfall occurred during both days. The estimate of the total precipitation for the area upstream of the culvert was between 0.75 and 1.25 inches over the 2 day period. The water level sensor detected the first increase in water level on August 29, 2019 at 2:10 am and drainage continuing until August 29, 2019 at 11:40 am for a duration of runoff of 9 ½ hours.

Stage/Discharge Relationship

The upstream invert elevation of each of the 11 CMP culverts was surveyed and referenced to the bottom of the metal pole used to support the water level sensor (see Figure 4). The entrance to some of the culverts was restricted near the bottom of the culvert by what appeared to be concrete spilled during the construction of the bridge. This spilled concrete increase the height of the water needed for water to first flow into 5 of the 11 culverts. The USA Federal Highways Administration HY-8 Culvert Hydraulics software was used to estimate the flow through a typical culvert assuming no backwater effects of flow downstream of the culverts. The total flow through the 11 culverts was modeled using the stage/discharge relationship for the typical culvert and adjusting for the unique invert elevation of each culvert. Figure 7 shows the Stage/Discharge relationship for a single culvert.

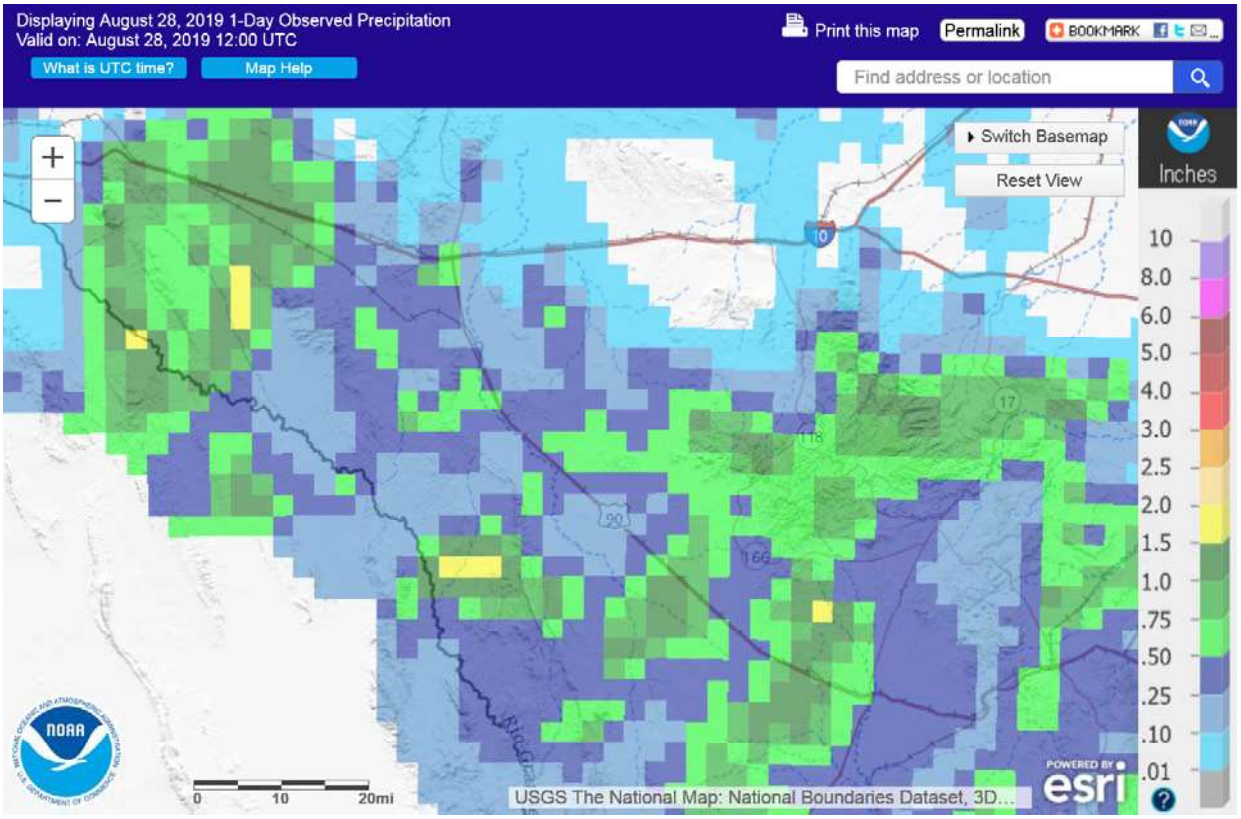


Figure 5: August 28, 2019 Observed Precipition (NOAA Radar)

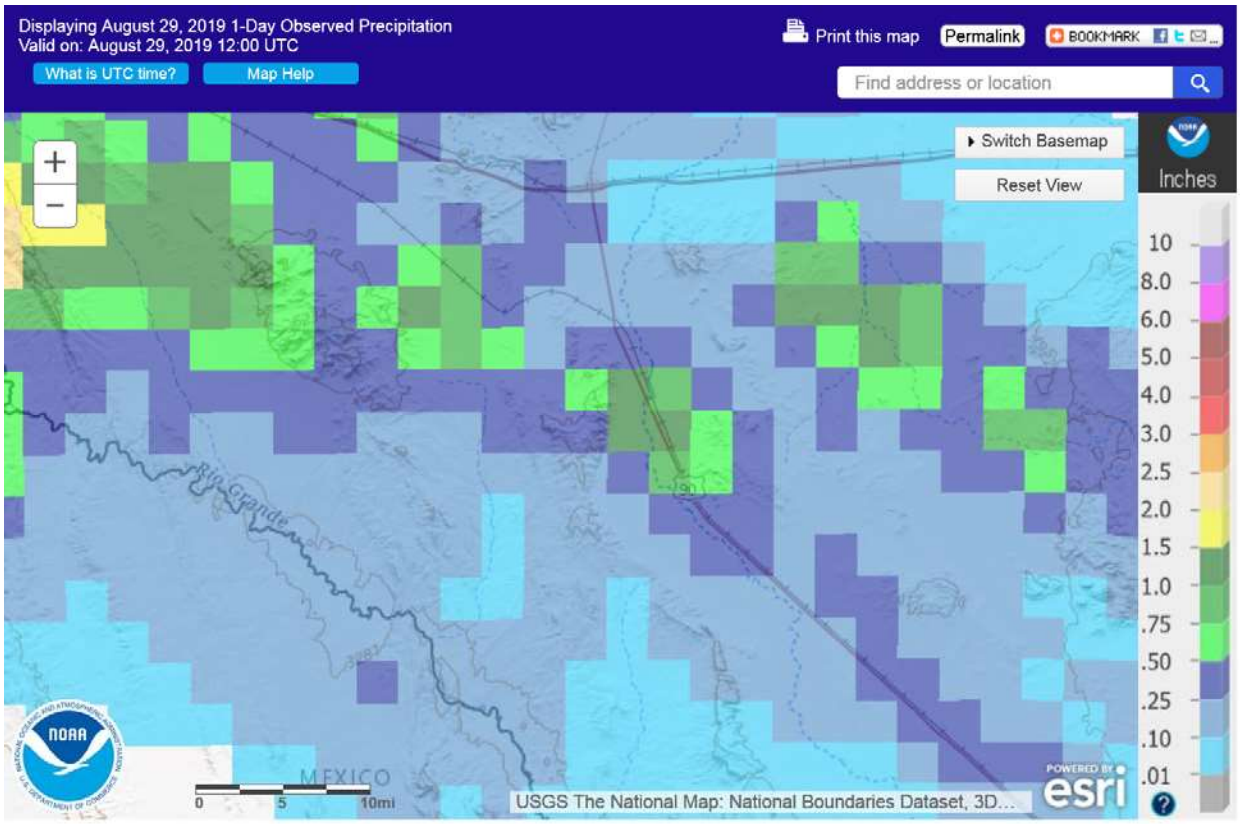


Figure 6: August 29, 2019 Observed Precipitation (NOAA Radar)

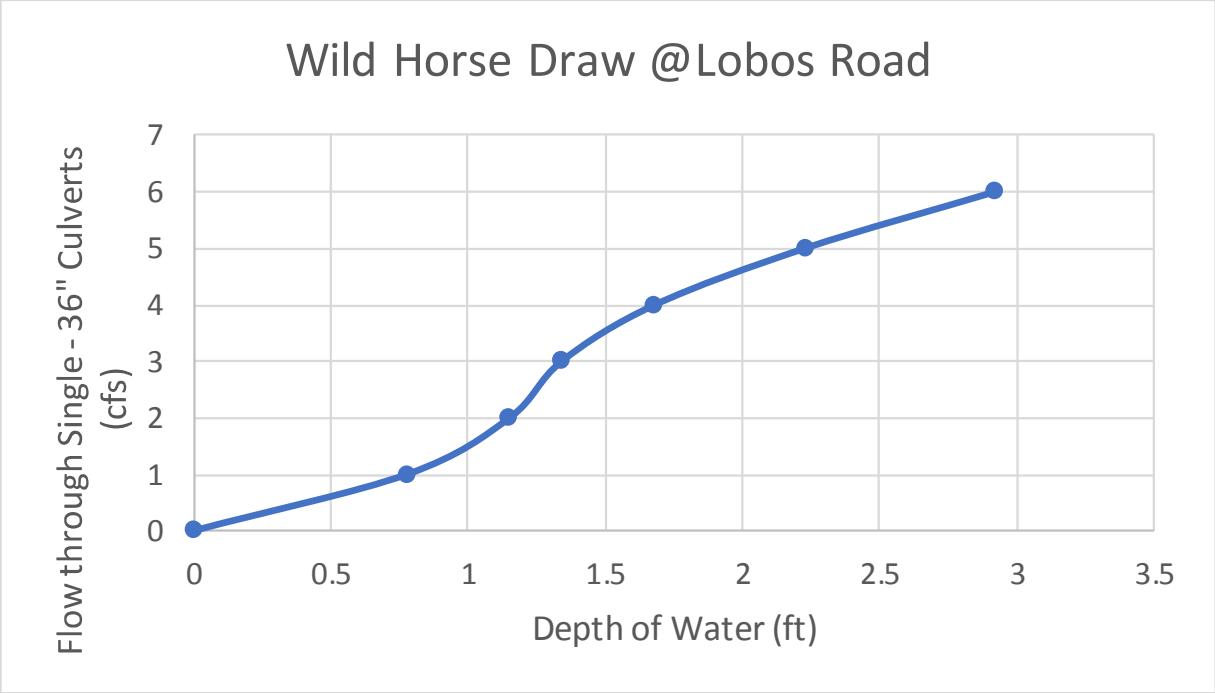


Figure 7: Stage/Discharge Relationship for Single 36" Diameter CMP Culvert

Estimate of Total Volume of Flow

Figure 8 shows the Flow Hydrograph for the entire storm event. The exact duration of the rain event is unknown (less than 2 days) and the duration of the runoff event was 9 ½ hours. The peak runoff rate was approximately 5 cfs for a very short duration and the total runoff flowing through the culvert was 1.3 acre-feet.

Estimate of Recharge to Alluvium Aquifer in Lobo Flat

The August 29, 2019 rainfall/runoff event appears to be caused by locally runoff within the Lobo Flat area. The Wild Horse Draw watershed covers a very large area with the flow channel starting approximately 65 miles upstream of the culverts (to the south) with many lateral flow paths draining into Wild Horse Arroyo. The total depth of rain was not sufficient to generate any runoff except in the immediate drainage area. If the average total rainfall of 1 inch is assumed to cover the entire Lobo Flat area (over 100,000 acres) then total amount of rainfall is approximately equal to 8,300 acre-feet. The measured flow through the culverts was 1.3 acre-feet or 0.015 % of the total rainfall. This calculation suggests that the average rainfall depth over the Lobo Flat area was much less than 1 inch and/or the initial abstraction of rainfall is equal to or greater than 1 inch.

The NOAA Atlas 14 Point Precipitation Frequency estimates that 24 Hour Storm with a return period of 1 year for the Lobo Flat area is between 1.17 to 1.89 inches which is similar to the August 29, 2019 event. The depth for the same duration (24 hours) for a 25 year return period is 4.3 inches.

Determining the amount of recharge from this event is very difficult since most rainfall events in a desert environment generate very little runoff. Often, 100% of the rainfall evaporates or infiltrates into the soil. Most if not all of the water that infiltrates over land does not contribute to recharge but is

consumed by evapotranspiration. The only potential area for recharge is in area where the Wild Horse arroyo channel bed co-exists with exposed alluvium (rock, gravel, and sand). The bed of the Wild Horse arroyo in the Lobo Flat is primarily sandy loam or silty loam with some clay. This soil type does allow some infiltration but typically only a small fraction of the amount of water that might infiltrate through a gravel bed.

Based on the total amount of the data presented in this report and general knowledge of the soil conditions in Lobo Flat area my estimate of the total recharge for this storm event to be between 0 to 5 acre-feet. For any significant about of recharge to occur in Lobo Flat the total rainfall from a storm event likely needs to exceed 2 to 4 inches in 24 hours.

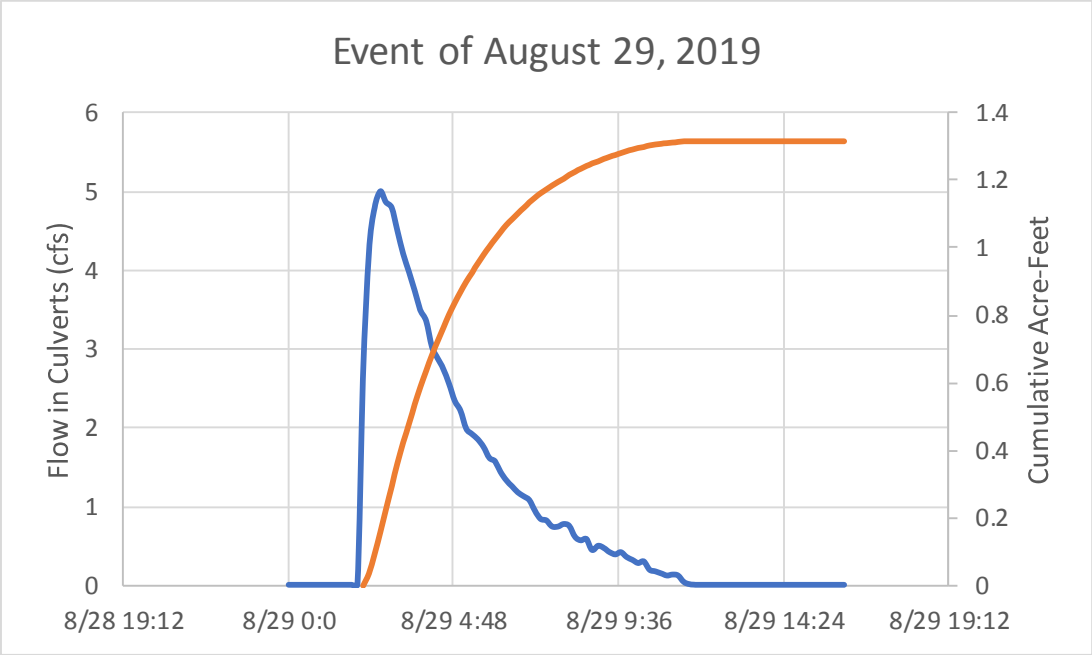


Figure 8: Runoff Hydrograph and Cumulative Flow Curves

Summary

Estimate of Total Volume of Recharge to alluvium aquifer within Lobo Flat from event: 0 to 5 acre-feet

Estimate of Total Volume of Flow in Wild Horse Draw August 29, 2019: 1.3 acre-feet

Estimate of Peak Flow Rate in Wild Horse Draw – August 29, 2019 – 6 cfs

Estimate of Average Rain Fall Depth Contributing to Runoff – August 28 and 29, 2019 – 0.50 to 1.5 inches

Appendix C – Notice of Hearing

CULBERSON COUNTY GROUNDWATER CONSERVATION DISTRICT
NOTICE OF PUBLIC HEARING
ON PROPOSED CHANGES TO 2018 MANAGEMENT PLAN

Notice is hereby given that the Culberson County Groundwater Conservation District ("District") proposes action on CHANGING OF CCGCD ADOPTED 2018 GROUNDWATER MANAGEMENT PLAN. Copies of the District General Manager's proposed action and the DRAFT RULES AND DRAFT 2018 MANAGEMENT PLAN are available for public inspection on the District website at ccgwcd.org and by email request. For inspection of the proposed DRAFT MANAGEMENT PLAN in person, please contact Summer Webb the General Manager at (432) 386-3437.

The District will conduct a **PUBLIC HEARING** pursuant to its authority under Chapter 8816 of the Texas Special District Local Laws Code, Chapter 36 of the Texas Water Code, and the District's Rules to consider ADOPTING THE AMENDED 2018 GROUNDWATER MANAGEMENT PLAN and to provide interested members of the public an opportunity to appear and provide oral or written comments to the District regarding the proposed amended permit. WRITTEN COMMENTS OR PROPOSALS ARE TO BE TO THE GENERAL MANAGER BY January 6, 2021, at 2 PM. The public hearing will be at the following location at the indicated date and time:

Location: **Culberson County Groundwater Conservation District Office**
1300 West Broadway, Van Horn, Texas

Virtual: **https://global.gotomeeting.com/join/345885413 or**
(872)240-3412 access code: 345-885-413

Date and Time: **January 13, 2021, at 2:00 PM**

The District General Manager will propose that the District Board grant adoption as follows:

1) ADOPTION OF PROPOSED CHANGES TO 2018 GROUNDWATER MANAGEMENT PLAN FOR FINAL SUBMISSION TO THE TEXAS WATER DEVELOPMENT BOARD.

Affected persons may request a contested case hearing on the proposed MANAGEMENT PLAN by submitting such a request in writing to the District no later than 2:00 pm on January 6, 2021. If no timely written request for a contested case hearing is filed, such ADOPTION OF 2018 MANAGEMENT PLAN, will be presented to the District Board on the date of the hearing for final action.

PERSONS WITH DISABILITIES WHO PLAN TO ATTEND THE DISTRICT HEARING AND WHO MAY NEED AUXILIARY AIDS OR SERVICES SUCH AS INTERPRETERS FOR PERSONS WHO ARE DEAF OR HEARING IMPAIRED, READERS, LARGE PRINT, OR BRAILLE, ARE REQUESTED TO CONTACT SUMMER WEBB, GENERAL MANAGER, AT (432) 283-1548, AT LEAST FIVE (5) WORK DAYS PRIOR TO THE MEETING SO THAT APPROPRIATE ARRANGEMENTS CAN BE MADE. PERSONS WHO DESIRE THE ASSISTANCE OF AN INTERPRETER IN CONJUNCTION WITH THEIR ORAL PRESENTATION AT THIS MEETING ARE ALSO REQUESTED TO CONTACT SUMMER WEBB AT LEAST FIVE (5) DAYS PRIOR TO THE MEETING SO THAT APPROPRIATE ARRANGEMENTS CAN BE MADE.

APPENDIX D – Estimated Historical Groundwater Use and 2017 State Water Plan Datasets

Estimated Historical Groundwater Use And 2017 State Water Plan Datasets:

Culberson County Groundwater Conservation District

by Stephen Allen

Texas Water Development Board

Groundwater Division

Groundwater Technical Assistance Section

stephen.allen@twdb.texas.gov

(512) 463-7317

January 12, 2021

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 1/12/2021. 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 2019. TWDB staff anticipates the calculation and posting of these estimates at a later date.

CULBERSON COUNTY *45.35% (multiplier)* All values are in acre-feet

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2018	GW	337	0	616	0	16,220	116	17,289
	SW	0	0	0	0	0	6	6
2017	GW	229	1	427	0	19,103	111	19,871
	SW	0	0	0	0	0	6	6
2016	GW	320	0	156	0	16,042	127	16,645
	SW	0	0	0	0	0	7	7
2015	GW	324	0	196	0	20,716	125	21,361
	SW	0	0	0	0	0	6	6
2014	GW	297	0	90	0	13,288	122	13,797
	SW	0	0	0	0	0	6	6
2013	GW	263	0	44	0	12,092	125	12,524
	SW	0	0	0	0	0	6	6
2012	GW	278	0	17	0	25,161	111	25,567
	SW	0	0	0	0	0	6	6
2011	GW	312	2	6	0	16,152	112	16,584
	SW	0	0	0	0	0	6	6
2010	GW	337	0	10	0	19,162	112	19,621
	SW	0	0	5	0	0	6	11
2009	GW	346	0	15	0	17,500	118	17,979
	SW	0	0	8	0	0	6	14
2008	GW	254	0	19	0	15,664	129	16,066

	SW	0	0	10	0	0	7	17
2007	GW	273	0	0	0	7,620	126	8,019
	SW	0	0	0	0	0	7	7
2006	GW	277	0	0	0	9,329	112	9,718
	SW	0	0	0	0	0	6	6
2005	GW	317	0	0	0	9,962	97	10,376
	SW	0	0	0	0	0	5	5
2004	GW	474	0	0	0	8,735	118	9,327
	SW	0	0	0	0	0	6	6
2003	GW	326	0	0	0	9,982	111	10,419
	SW	0	0	0	0	0	6	6

Projected Surface Water Supplies
TWDB 2017 State Water Plan Data

CULBERSON COUNTY

45.35% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	Source Name	2020	2030	2040	2050	2060	2070
E	LIVESTOCK, CULBERSON	RIO GRANDE	RIO GRANDE LIVESTOCK LOCAL SUPPLY	7	7	7	7	7	7
E	MINING, CULBERSON	RIO GRANDE	RIO GRANDE OTHER LOCAL SUPPLY	35	35	35	35	35	35
	Sum of Projected Surface Water Supplies (acre-feet)			**42**	**42**	**42**	**42**	**42**	**42**

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.

CULBERSON COUNTY

45.35% (multiplier)

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
E	COUNTY-OTHER, CULBERSON	RIO GRANDE	29	32	32	33	34	34
E	IRRIGATION, CULBERSON	RIO GRANDE	18,107	17,720	17,341	16,970	16,607	16,251
E	LIVESTOCK, CULBERSON	RIO GRANDE	136	136	136	136	136	136
E	MINING, CULBERSON	RIO GRANDE	229	562	632	503	382	290
E	VAN HORN	RIO GRANDE	662	711	737	761	775	784
	Sum of Projected Water Demands (acre-feet)		**19,163**	**19,161**	**18,878**	**18,403**	**17,934**	**17,495**

Projected Water Supply Needs
TWDB 2017 State Water Plan Data

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

CULBERSON COUNTY

All values are in acre-feet

RWPG	WUG	WUG Basin	2020	2030	2040	2050	2060	2070
E	COUNTY-OTHER, CULBERSON	RIO GRANDE	75	70	69	67	66	65
E	IRRIGATION, CULBERSON	RIO GRANDE	57	911	1,747	2,565	3,366	4,150
E	LIVESTOCK, CULBERSON	RIO GRANDE	0	0	0	0	0	0
E	MINING, CULBERSON	RIO GRANDE	-291	-1,025	-1,178	-895	-628	-425
E	VAN HORN	RIO GRANDE	689	640	614	590	576	567
	Sum of Projected Water Supply Needs (acre-feet)		**-291**	**-1,025**	**-1,178**	**-895**	**-628**	**-425**

Projected Water Management Strategies
TWDB 2017 State Water Plan Data

CULBERSON COUNTY

WUG, Basin (RWPG)

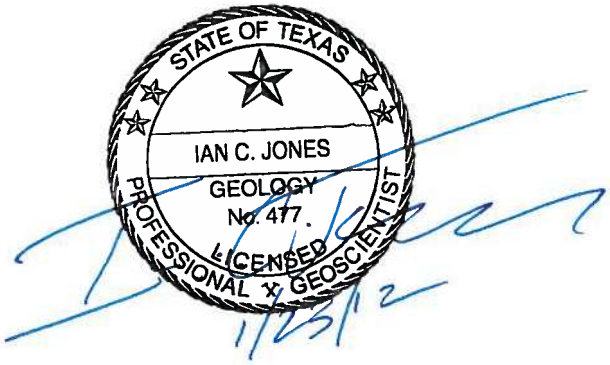
All values are in acre-feet

Water Management Strategy	Source Name [Origin]	2020	2030	2040	2050	2060	2070
MINING, CULBERSON, RIO GRANDE (E)							
CULBERSON COUNTY - ADDITIONAL GROUNDWATER WELLS - RUSTLER AQUIFER	RUSTLER AQUIFER [CULBERSON]	590	590	590	590	590	590
CULBERSON COUNTY MINING - ADDITIONAL GROUNDWATER WELL - WEST TEXAS BOLSONS AQUIFER	WEST TEXAS BOLSONS AQUIFER [CULBERSON]	590	590	590	590	590	590
		1,180	**1,180**	**1,180**	**1,180**	**1,180**	**1,180**
VAN HORN, RIO GRANDE (E)							
CITY OF VAN HORN - WATER LOSS AUDIT AND MAIN-LINE REPAIR	DEMAND REDUCTION [CULBERSON]	30	30	30	30	30	30
		30	**30**	**30**	**30**	**30**	**30**
Sum of Projected Water Management Strategies (acre-feet)		**1,210**	**1,210**	**1,210**	**1,210**	**1,210**	**1,210**

Appendix E - .TWDB GAM Run 11-018

GAM Run 11-018: Culberson County Groundwater Conservation District Management Plan

by Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6641
January 23, 2012



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GAM RUN 11-018: CULBERSON COUNTY GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

by Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6641
January 23, 2012

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, groundwater conservation districts shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

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

The purpose of this report is to provide Part 2 of a two-part package of information from the Texas Water Development Board to Culberson County Groundwater Conservation District management plan to fulfill the requirements noted above.

The groundwater management plan for Culberson County Groundwater Conservation District is due for approval by the Executive Administrator of the Texas Water Development Board before January 29, 2013. This report discusses the method, assumptions, and results from the model runs using the groundwater availability models for the Igneous Aquifer and the Red Light Draw, Green River Valley, Eagle Flat, Wild Horse Flat, Michigan Flat and Lobo Flat parts of the West Texas Bolsons Aquifer. Tables 1 and 2 summarize the groundwater availability model data required by the statute, and figures 1 and 2 show the area of each model layer from which the

values in the respective tables were extracted. This model run replaces the results of GAM Run 06-02. GAM Run 11-018 meets current standards set after GAM Run 06-02. Differences in the results of the two model runs are due to differences in the method of extracting data from the model(s). If after review of the figures, Culberson County Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the Texas Water Development Board immediately.

METHODS:

The groundwater availability models for the Igneous Aquifer and the Wild Horse Flat, Michigan Flat and Lobo Flat parts of the West Texas Bolsons Aquifer (1980 through 1999) and the Red Light Draw, Green River Valley, and Eagle Flat parts of the West Texas Bolsons (30-year simulation) were run for this analysis. In the case of the groundwater availability model for the Igneous Aquifer and the Wild Horse Flat, Michigan Flat and Lobo Flat parts of the West Texas Bolsons Aquifer, water budgets for each year of the transient model period were extracted and the average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow for the portions of the aquifers located within the district are summarized in this report. In the case of the groundwater availability model for the Red Light Draw, Green River Valley, and Eagle Flat parts of the West Texas Bolsons water budget data was extracted from the transient 30-year stress period.

PARAMETERS AND ASSUMPTIONS:

Igneous and West Texas Bolsons Aquifers (Wild Horse Flat, Michigan Flat and Lobo Flat)

- Version 1.01 of the groundwater availability model for the Igneous Aquifer and the Wild Horse Flat, Michigan Flat and Lobo Flat parts of the West Texas Bolsons Aquifer was used for this analysis. See Beach and others (2004) for assumptions and limitations of the groundwater availability model for the Igneous Aquifer and the Wild Horse Flat, Michigan Flat and Lobo Flat parts of the West Texas Bolsons Aquifer.

- This groundwater availability model includes three layers, which generally correspond to (from top to bottom):

    1 the Wild Horse Flat, Michigan Flat and Lobo Flat parts of the West Texas Bolsons Aquifer,

2 the Igneous Aquifer, and

3 underlying Cretaceous and Permian units.

- Of the three layers listed above, individual water budgets for the district were determined for the West Texas Bolsons Aquifer (Layer 1), and the Igneous Aquifer (Layer 2).

- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 35 feet for the West Texas Bolsons Aquifer, and 35 feet for the Igneous Aquifer for the calibration period (1950 to 1990) and 35 and 150 feet for the same aquifers, respectively, in the verification period (1991 to 2000) (Beach and others, 2004). These root mean square errors are between three and five percent of the range of measured water levels (Beach and others, 2004).

- Groundwater in the Igneous and West Texas Bolsons aquifers ranges from fresh to brackish in composition (Beach and others, 2004). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh and total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish.

- Processing MODFLOW for Windows (PMWIN) version 5.3 (Chiang and Kinzelbach, 1998) was used as the interface to process model output.

West Texas Bolsons Aquifers (Red Light Draw, Green River Valley, and Eagle Flat)

- Version 1.01 of the groundwater availability model for the Red Light Draw, Green River Valley, and Eagle Flat parts of the West Texas Bolsons Aquifer was used for this analysis. See Beach and others (2008) for assumptions and limitations of the groundwater availability model for the Red Light Draw, Green River Valley, and Eagle Flat parts of the West Texas Bolsons Aquifer.

- This groundwater availability model includes three layers, which generally correspond to (from top to bottom):

1 the Red Light Draw, Green River Valley, and Eagle Flat parts of the West Texas Bolsons Aquifer,

2 Cretaceous, Permian and Paleozoic units, and

3 Cretaceous, Paleozoic and basement units.

- Of the three layers listed above, individual water budgets for the district were determined for the West Texas Bolsons Aquifer (Layer 1).

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 56 feet for the West Texas Bolsons Aquifer, and 99 and 119 feet for the underlying layers for the calibration (steady-state) period (Beach and others, 2008). These root mean square errors are between four and eleven percent of the range of measured water levels (Beach and others, 2008).

- Groundwater in the West Texas Bolsons aquifers displays fresh compositions with total dissolved solids of less than 1,000 milligrams per liter (Beach and others, 2008).

- Groundwater Vistas version 5 (Environmental Sciences, Inc., 2007) was used as the interface to process model output.

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability models. Selected components were extracted from the groundwater budget for the aquifers located within the district and averaged over the period 1980 through 1999, as shown in tables 1 and 2. Water budgets for the West Texas Bolsons Aquifer from the two groundwater availability models are combined. The groundwater availability model for the Red Light Draw, Green River Valley, and Eagle Flat extends into Wild Horse Flat where it overlaps with the groundwater availability model for the Igneous Aquifer and the Wild Horse Flat, Michigan Flat and Lobo Flat parts of the West Texas Bolsons Aquifer. Only the water budget from the groundwater availability model for the Igneous Aquifer and the Wild Horse Flat, Michigan Flat and Lobo Flat parts of the West Texas Bolsons Aquifer was used in the overlap area due to limitations in the groundwater availability model for the Red Light Draw, Green River Valley, and Eagle Flat parts of the West Texas Bolsons Aquifer. The components of the modified budget shown in tables1 and 2 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 drains (springs).

- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent areas.

- Flow between aquifers—The net vertical flow between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer or confining unit and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer.

The information needed for the District's management plan is summarized in tables 1 and 2. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located (see figures 1 and 2).

TABLE 1: SUMMARIZED INFORMATION FOR THE WEST TEXAS BOLSONS AQUIFER THAT IS NEEDED FOR CULBERSON COUNTY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. THESE FLOWS INCLUDE BRACKISH WATERS.

Management Plan requirement		
Estimated annual amount of recharge from precipitation to the district	West Texas Bolsons Aquifer	2,107
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	West Texas Bolsons Aquifer	494
Estimated annual volume of flow into the district within each aquifer in the district	West Texas Bolsons Aquifer	7,453
Estimated annual volume of flow out of the district within each aquifer in the district	West Texas Bolsons Aquifer	629
Estimated net annual volume of flow between each aquifer in the district	From the Igneous Aquifer and other underlying units into the West Texas Bolsons Aquifer	5,238*

*Note some of the flow reported in Table 2 is included in this value.

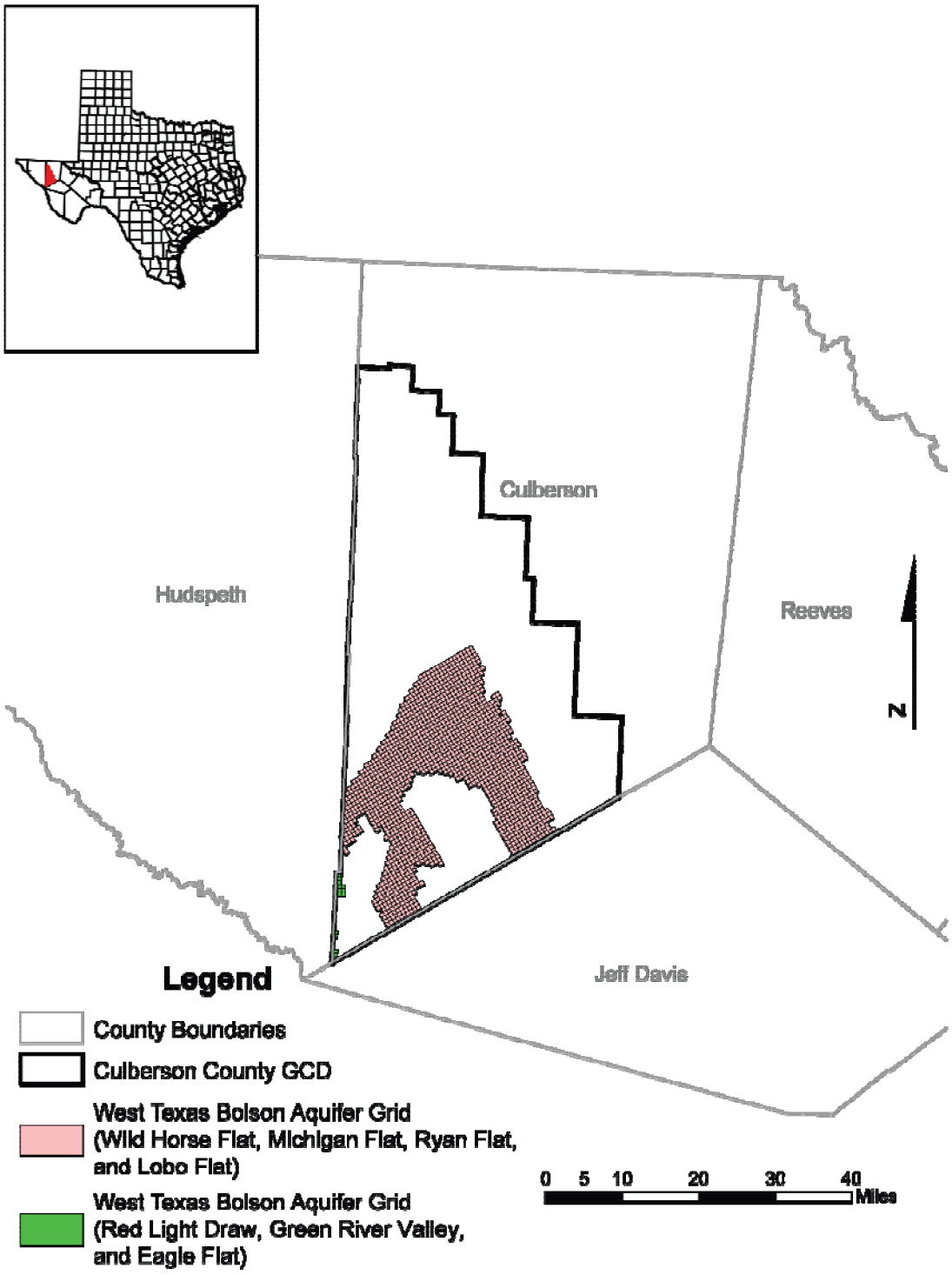

FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE WEST TEXAS BOLSONS AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE IGNEOUS AQUIFER THAT IS NEEDED FOR CULBERSON COUNTY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. THESE FLOWS MAY INCLUDE FRESH AND BRACKISH WATERS.

Management Plan requirement		
Estimated annual amount of recharge from precipitation to the district	Igneous Aquifer	671
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Igneous Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Igneous Aquifer	1,037
Estimated annual volume of flow out of the district within each aquifer in the district	Igneous Aquifer	463
Estimated net annual volume of flow between each aquifer in the district	From the Igneous Aquifer into the West Texas Bolsons Aquifer	1,562*

- Some of the flow reported in Table 2 are included in Table 1.

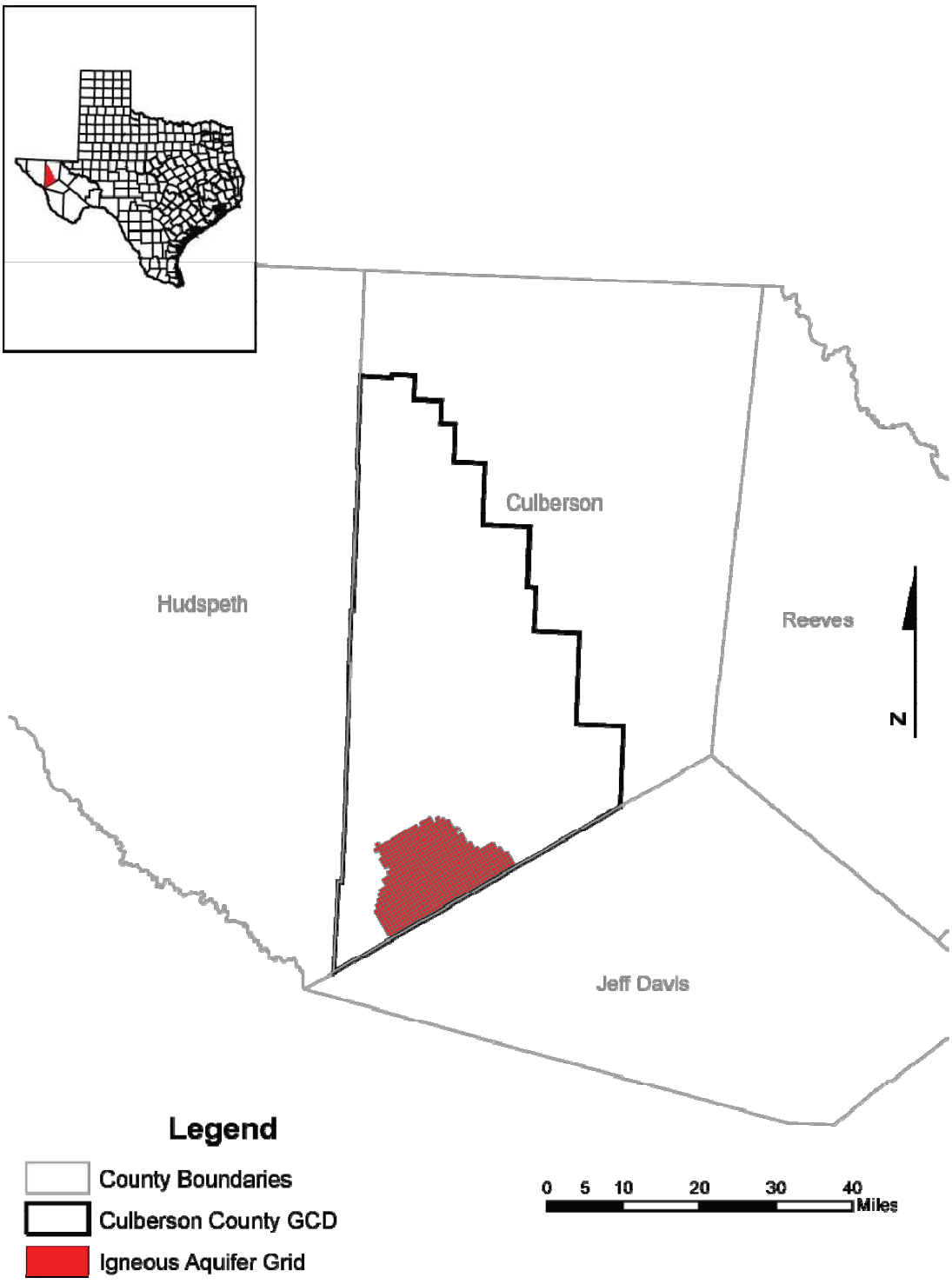

FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE IGNEOUS AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS

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

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

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

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

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

REFERENCES:

Beach, J.A., Ashworth, J.B., Finch, S.T., Chastain-Howley, A., Calhoun, K., Urbanczyk, K.M., Sharp, J.M., and Olson, J., 2004, Groundwater Availability Model for the Igneous and Parts of the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) Aquifers: Contract report to the Texas Water Development Board, 407 p., http://www.twdb.texas.gov/gam/bol_ig/IGBL_GAM_Full_Report.pdf .

Beach, J.A., Symank, L., Huang, Y., Ashworth, J.B., Davidson, T., Collins, E.W., Hibbs, B.J., Darling, B.K., Urbanczyk, K.M., Calhoun, K., and Finch, S., 2008, Groundwater Availability Model for the West Texas Bolsons (Red Light Draw, Green River Valley, and Eagle Flat) Aquifer: Contract report to the Texas Water Development Board, 320 p., http://www.twdb.texas.gov/gam/wtbl/wtbl_GAM_Final_Report.pdf .

Chiang, W.H., and Kinzelbach, W., 1998, Processing Modflow - A Simulation System for Modeling Groundwater Flow and Pollution: Software Manual, 325 p.

Environmental Simulations, Inc., 2007, Guide to Using Groundwater Vistas Version 5, 381 p.

National Research Council, 2007, Models in Environmental Regulatory Decision Making. Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p.

Appendix F - Copy of Resolution Adopting Management Plan

Resolution of the

Culberson County Groundwater Conservation District

(the District)

Whereas, the District in accordance with Chapter 36 of the Texas Water Code has provided public notice of hearing regarding amendment and adoption of the District's Groundwater Management Plan;

Whereas, the District has held three public meetings soliciting public comments regarding the proposed draft amended management plan and a quorum of the board was present for all meetings;

Whereas, copies of all written comments regarding the proposed management plan have been provided to each of the District's Board Members;

Therefore, the Board of Directors adopted the proposed management plan, as amended, and shall send a copy of the plan to the Texas Water Development Board for certification, to the Chair of the Far West Texas Water Planning Group, and to the general managers of each of the groundwater districts within Groundwater Management Area 4 of Texas.

V R Cottrell
_____

, Chairman

Cruz Parada
_____

, Secretary

Appendix G- Agenda for January 13, 2021 Board Meeting and Hearing on Groundwater Management Plan

AGENDA

CULBERSON COUNTY GROUNDWATER CONSERVATION DISTRICT
SPECIAL MEETING
Wednesday, January 13, 2021, 2:00 p.m.
at the following location:
Culberson County Groundwater Conservation District Office
1300 W. Broadway
Van Horn, TX 79855

GoToMeeting: https://global.gotomeeting.com/join/345885413
Call in: 1(872)240-3412 access code: 345-885-413#

HEARING ON MANAGEMENT PLAN

1. District presentation
2. Public Comment

REGULAR MEETING

1. Call to Order
2. Determination of a Quorum
3. Proof of Notice of Meeting
4. Public Comment
5. Discuss/Act On: Adoption of Management Plan
6. Discuss/Act On: Approval of Minutes
    a. November 11, 2020
7. Discuss/Act On: Resolution and Order No.2020-11-11_WildHorse NHUPP Allocation
8. Discuss/Act On: Lobo Management Zone
9. Discuss/Act On: Audited Financial Statement
10. Discuss/Act On: Re-Sale Bids
11. Discuss/Act On: Payment of Bills, Budget Line Items, and Bank Reconciliations
12. Discuss/Act On: Agenda Items for February Meeting
13. Public Comment
14. Adjournment

"Culberson County Groundwater Conservation District reserves the right to convene in Executive Session on any agenda or discussions items if discussion of said items falls under the exceptions listed in Chapter 551, Texas Government Code, known as the "Open Meetings Act".

I, the undersigned authority of the District, do hereby certify that the above notice is a true and correct copy of said notice and that such notice was posted on the District website at ccgwcd.org at least 72 hours prior to the time of said public hearing.

Date: 1/9/2021

Summer Webb
Summer Webb, General Manager

Appendix H – Minutes from CCGCD Meeting 3/10/2021

Culberson County Groundwater Conservation District
Minutes of GMA 4 DCF Hearing & Regular Meeting
Wednesday, March 10, 2021- 2:00pm PM CST
1300 W. Broadway
Van Horn, Texas

HEARING ON GMA-4 DESIRED FUTURE CONDITIONS

1. District Presentation- 2:04-2:06
2. Public Comment- none

REGULAR MEETING

1 Call to Order – Meeting was called to order at 2:02 pm by Chairman Vance Cottrell. This meeting was held in person and was also available through GoTo Meeting.

2 Determination of a Quorum – Members present was Chairman Vance Cottrell, Director Cruz Parada, Director Lacey Koehn, Director George Strickhausen and Director Lane Brewster. A quorum was determined. Also present was General Manager Summer Webb. Members of the public and interested parties present are listed on the sign in sheet attached.

3. Proof of Notice of Meeting – Proof of notice of the meeting was posted appropriately and timely.

4. Public Comment-
    a. Pepe Guevara- Pecan Grove Farms has just finished planting on the new WH property, planting roughly 200 acres in double density. He also stated appreciation for continued effort in the Lobo Management Zone.

5. Discuss/Act On: Minutes –
    a. Regular Meeting January 13, 2021- Director Parada made a motion to approve; with a second by Director Strickhausen. All members were in favor and the motion passed.

6. Discuss/Act On: Management Plan- Director Strickhausen made a motion to approve the MP; with a second from Director Parada. All members were in favor and the motion passed.

7. Discuss/Act On: Transfer HUPP13B to HUPP13C- Approved by GM Webb. Transfer permit in full from Capital Farm Credit to Donald Kubecka.

8. Discuss/Act On: Annual Water Use and Water Level Report- Director Brewster made a motion to approve the report as presented; with a second by Director Strickhausen. All members were in favor and the motion passed.

9. Discuss/Act On: Lobo Management Zone- Chairman Cottrell directed GM Webb to start having Lobo stakeholder meetings and bring back information to the Board.

10. Discuss/Act On: Audited Financial Statement- Director Parada made a motion to accept the audit as presented; with a second by Director Brewster. All members were in favor and the motion passed.

11. Discuss/Act On: Re-Sale Bid Requests- Director Brewster made a motion to approve; with a second by Director Parada. All members were in favor and the motion passed.

12. Discuss/Act On: Payment of Bills, Budget Line Items, and Bank Reconciliations- Director Parada made a motion to approve payment on all bills as presented; with a second from Director Brewster. All members were in favor and the motion passed.
13. Discuss/Act On: Agenda Items for April Meeting- Lobo and Lobo Resolution.
14. Public Comment-
    a. Jose Guevara- appreciates the focus on the Lobo Aquifer
15. Adjournment- Chairman Vance Cottrell called for a motion to adjourn; which was brought by Director Brewster, with a second by Director Parada. All members were in favor and the motion passed. The meeting adjourned at 2:50p.

Vance Cottrell
Chairman, Vance Cottrell

Lane Brewster
Vice Chairman, Lane Brewster

Cruz Parada
Member, Cruz Parada

Lacey Koehn
Member, Lacey Koehn

George Strickhausen
Member, George Strickhausen

AGENDA

CULBERSON COUNTY GROUNDWATER CONSERVATION DISTRICT
REGULAR MEETING
Wednesday, March 10, 2021, 2:00 p.m.
at the following locations:
Culberson County Groundwater Conservation District Office
1300 W. Broadway
Van Horn, TX 79855

GoToMeeting: https://global.gotomeeting.com/join/217053373
Call in: 1-571-317-3112# access code: 217-053-373

HEARING ON GMA-4 DESIRED FUTURE CONDITIONS

1. District presentation
2. Public Comment

REGULAR MEETING

1. Call to Order
2. Determination of a Quorum
3. Proof of Notice of Meeting
4. Public Comment
5. Discuss/Act On: Approval of Minutes
    a. January 13, 2021
6. Discuss/Act On: Adoption of Management Plan
7. Discuss/Act On: Transfer HUPP13B to HUPP13C
8. Discuss/Act On: Annual Water Use and Water Level Report
9. Discuss/Act On: Lobo Management Zone
10. Discuss/Act On: Audited Financial Statement
11. Discuss/Act On: Re-Sale Bids
12. Discuss/Act On: Payment of Bills, Budget Line Items, and Bank Reconciliations
13. Discuss/Act On: Agenda Items for April Meeting
14. Public Comment
15. Adjournment

"Culberson County Groundwater Conservation District reserves the right to convene in Executive Session on any agenda or discussions items if discussion of said items falls under the exceptions listed in Chapter 551, Texas Government Code, known as the "Open Meetings Act".

I, the undersigned authority of the District, do hereby certify that the above notice is a true and correct copy of said notice and that such notice was posted on the District website at ccgwcd.org at least 72 hours prior to the time of said public hearing.

Date: 3/5/2021

Summer Webb

Summer Webb, General Manager

Filed this 5th day of March A.D. 2021
at 1:10 o'clock P.M.
Linda McDonald
District Clerk
By [illegible] Deputy