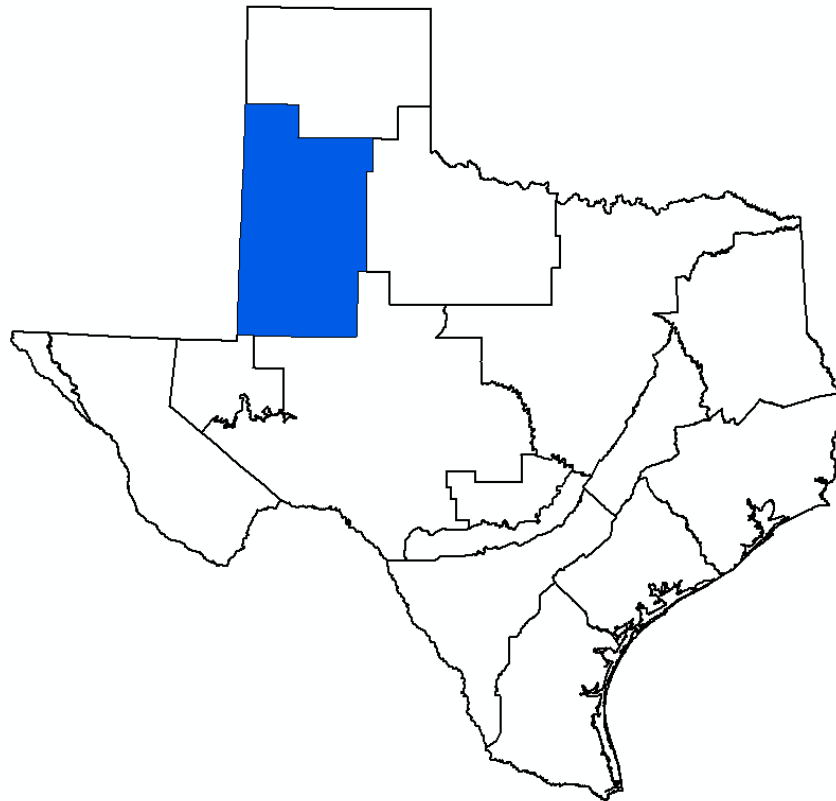


**Explanatory Report
For Desired Future Conditions
Ogallala, Edwards-Trinity (High Plains), and Dockum Aquifers
Groundwater Management Area 2
*(Draft 1)***



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1.0 Groundwater Management Area 2

Groundwater Management Area 2 is one of sixteen groundwater management areas in Texas and covers a large portion of the southern plains portion of west Texas (Figure 1).

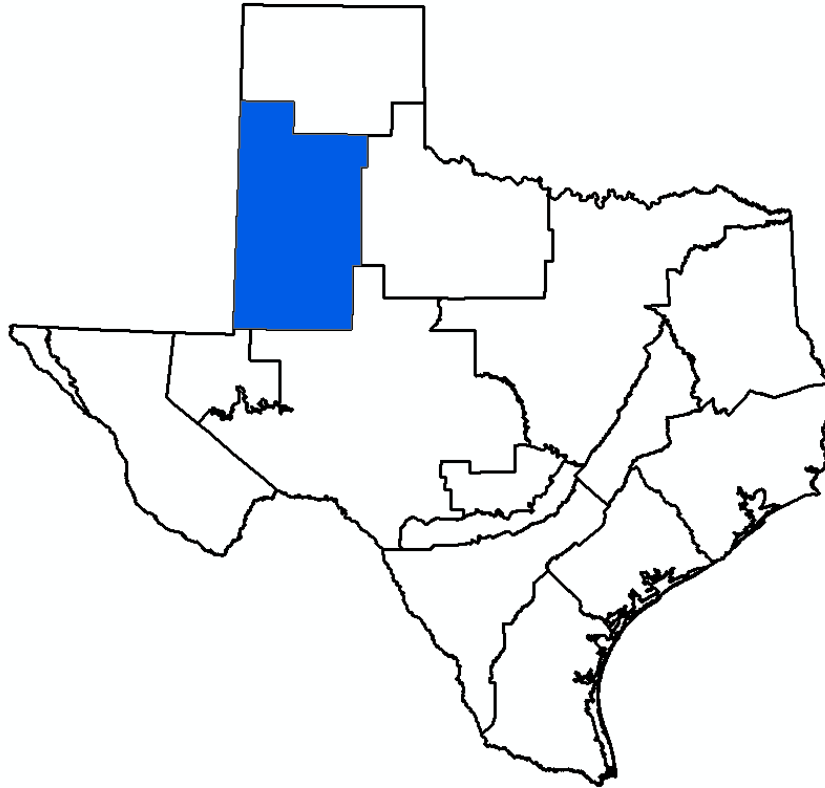


Figure 1. Groundwater Management Area 2

Groundwater Management Area 2 covers all or part of the following counties: Andrews, Bailey, Borden, Briscoe, Castro, Cochran, Crosby, Dawson, Deaf Smith, Floyd, Gaines, Garza, Hale, Hockley, Howard, Lamb, Lubbock, Lynn, Martin, Parmer, Swisher, Terry, and Yoakum (Figure 2).

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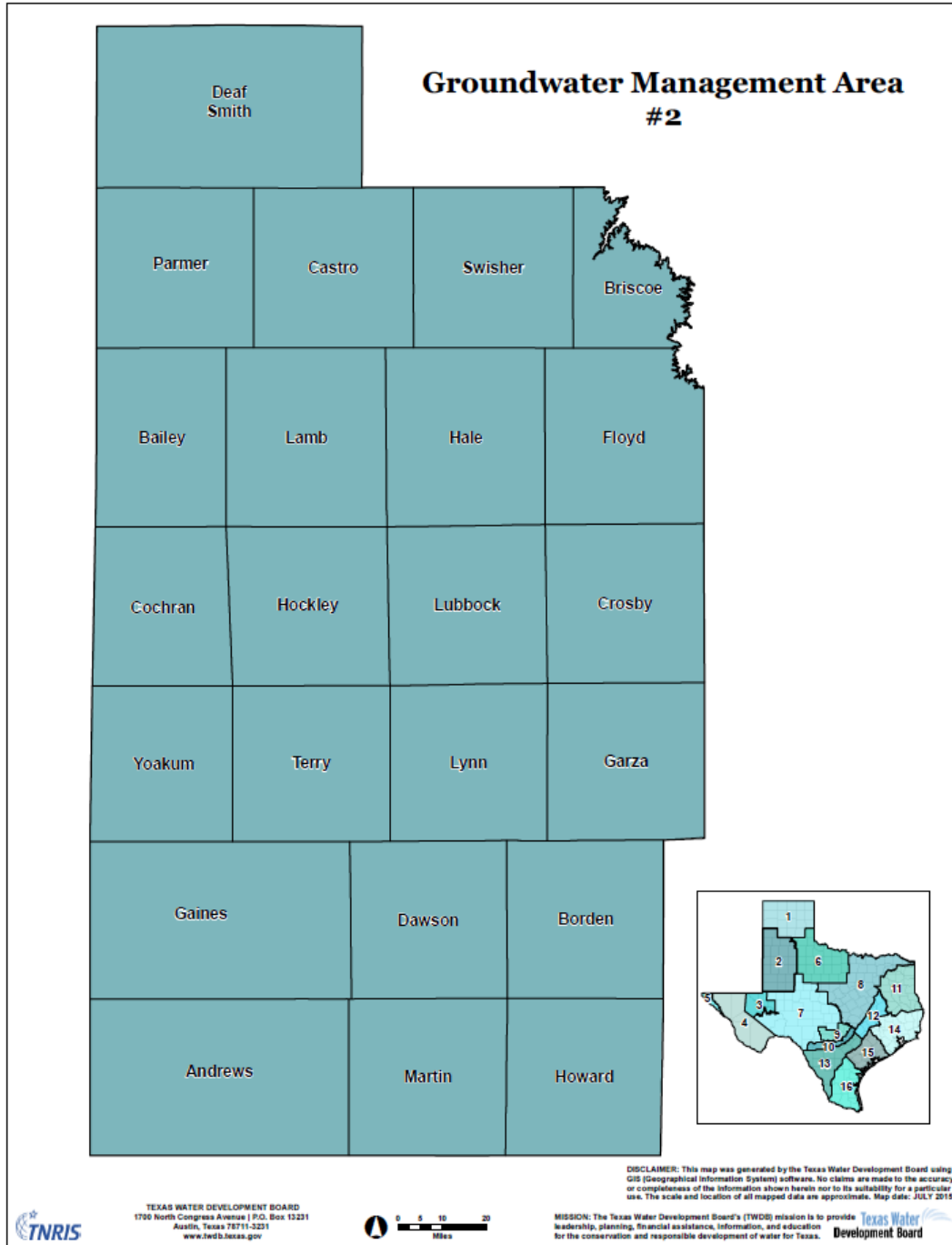


Figure 2. GMA 2 Counties (from TWDB)

There are seven groundwater conservation districts in Groundwater Management Area 2: Garza UWCD, High Plains UWCD No. 1, Llano Estacado UWCD, Mesa UWCD, Permian Basin, UWCD, Sandy Land UWCD, and South Plains UWCD.

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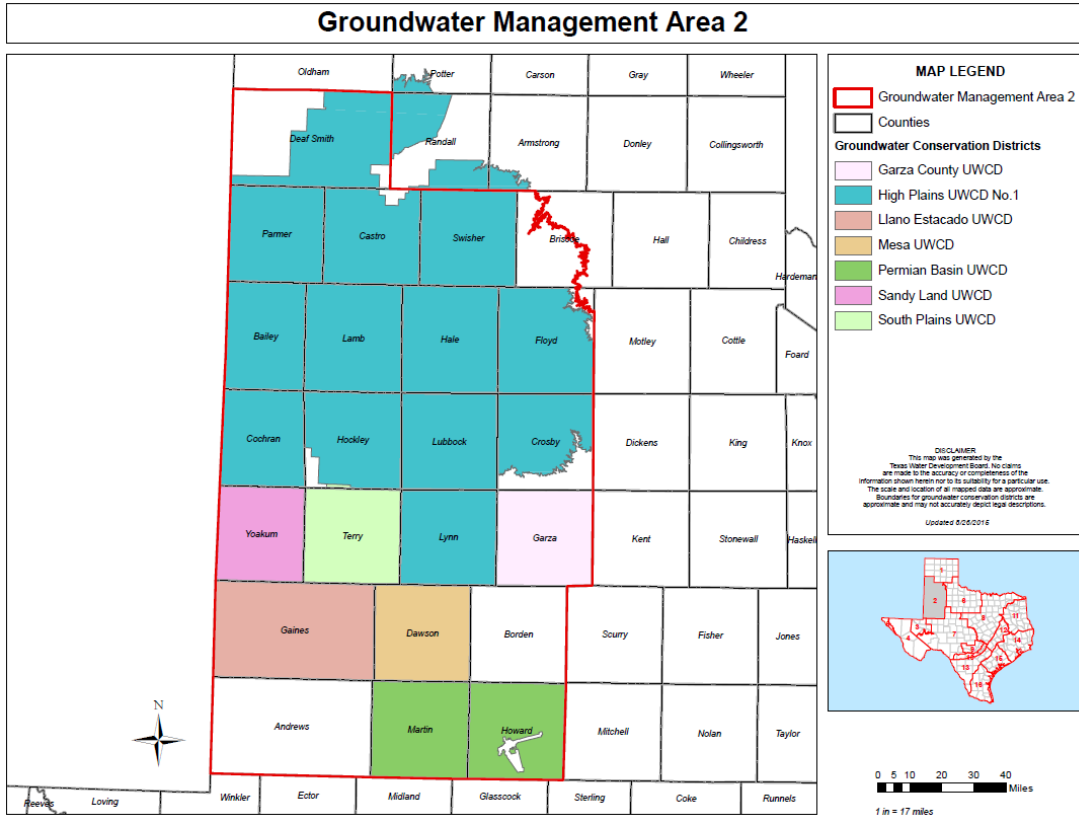


Figure 3. Groundwater Conservation Districts in GMA 2 (from TWDB)

2.0 Desired Future Conditions

2.1 Background

In GMA 2, the Ogallala Aquifer, and the underlying Edwards-Trinity (High Plains) Aquifer are managed as a single unit. Historic pumping has caused groundwater level declines to the point that individual well pumping rates in many areas of the Ogallala Aquifer have been reduced. In the future, pumping is expected to continue primarily for irrigation, and pumping rates will continue to decline as groundwater levels drop further. Water conservation techniques and irrigation technologies have advanced over the years and are expected to improve in the future to mitigate the economic effects of reduced well production.

In GMA 2, groundwater from the Dockum Aquifer has been pumped in relatively small amounts, largely due to poor water quality. However, increased pumping from the Dockum Aquifer is expected in the future as envisioned in the 2026 Llano Estacado Regional Water Plan (i.e. Region O Plan).

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The Texas Water Code and the Texas Water Development Board require that desired future conditions be a quantified condition of the aquifer in the future. The desired future condition cannot be expressed in terms of how much can be pumped from an aquifer. In GMA 2, the continued declines in groundwater levels in the Ogallala Aquifer will result in reductions in pumping rates. Thus, the drawdown that will occur in the future and the pumping rates that will decline in the future are linked.

Once a desired future condition is adopted by the groundwater conservation districts in GMA 2, the Texas Water Development Board will use the groundwater availability model to estimate the pumping that will achieve the desired future condition, or the modeled available groundwater (MAG).

2.2 Past Desired Future Conditions

2.2.1 2010 Desired Future Conditions

In 2010, GMA 2 adopted desired future conditions for the Ogallala and Edwards-Trinity (High Plains) aquifers that reflected the concept of managed decline of groundwater levels. In the High Plains UWCD area, the DFC was 50 percent of storage remaining after 50 years (50/50), and in the other areas of GMA 2, the DFC was expressed as a decadal decline rate.

Simulations with the Groundwater Availability Model were used at the time to develop the 2010 desired future condition. In the High Plains UWCD area, simulated pumping was adjusted in the GAM simulations to achieve 50 percent storage remaining in each county of the district. Although this approach treated every county within the district equally, it ignored the inherent variability of the aquifer in terms of saturated thickness and hydraulic conductivity. Future pumping in some High Plains UWCD counties was reduced to match the 50/50 goal, while other High Plains UWCD counties had artificial increases in simulated pumping above historic amounts simply to reach the 50/50 goal.

The adopted DFC in 2010 within High Plains UWCD could be viewed as somewhat arbitrary in that a specific reduction in groundwater levels was selected without the ability to fully understand the relationship between declining groundwater levels and reduced pumping rates. The decision to adopt these DFCs was, to a degree, based on the limitations of the Groundwater Availability Model that was then used. The DFC was also based on a concept where equality in outcome was a higher consideration than a management approach that first considered the hydraulic characteristics of the aquifer, the hydraulics of pumping wells in an unconfined aquifer where groundwater levels are dropping, and the associated economics of pumping groundwater for irrigation in an area where groundwater levels are dropping.

2.2.2 2016 Desired Future Conditions - Ogallala and Edwards-Trinity (High Plains)

On October 19, 2016, the groundwater conservation districts in Groundwater Management Area 2 adopted the desired future condition for the Ogallala and Edwards-Trinity (High Plains) aquifers. The desired future condition was expressed as an average drawdown of between 23 and 27 feet for all of GMA 2. The drawdown was calculated from the end of 2012 conditions to the year 2070.

The drawdown was expressed as a range due to the link between future pumping and future rainfall. As documented in GMA 2 Technical Memorandum 15-01 and GMA 2 Technical Memorandum 16-01, historic pumping is higher in dry years than in wet years. Since most of the water use in GMA 2 from the Ogallala Aquifer is for irrigation, producers pump more groundwater in dry years than in normal or wet years. The simulations assumed that initial pumping rates in the future would be between 100 percent and 150 percent of 2012 pumping rates. Essentially, in average or wet years, initial annual pumping would be approximately the same as 2012 pumping rates. In dry years, initial annual pumping rates could be as high as 150 percent of 2012 pumping rates based on the variation of pumping rates in the recent past.

Figure 4 presents the pumping results from the simulation for Scenario 8 from GMA 2 Technical Memorandum 15-01, and Scenario 16 from GMA 2 Technical Memorandum 16-01, and Figure 5 presents the drawdown associated with Scenarios 8 and 16. Scenario 8 assumes initial future pumping rates are 100 percent of 2012 pumping rates (average and wet conditions), and Scenario 10 assumes initial future pumping rates are 150 percent of 2012 pumping rates (dry conditions). Please note that by about 2045, the total pumping is expected to be about the same.

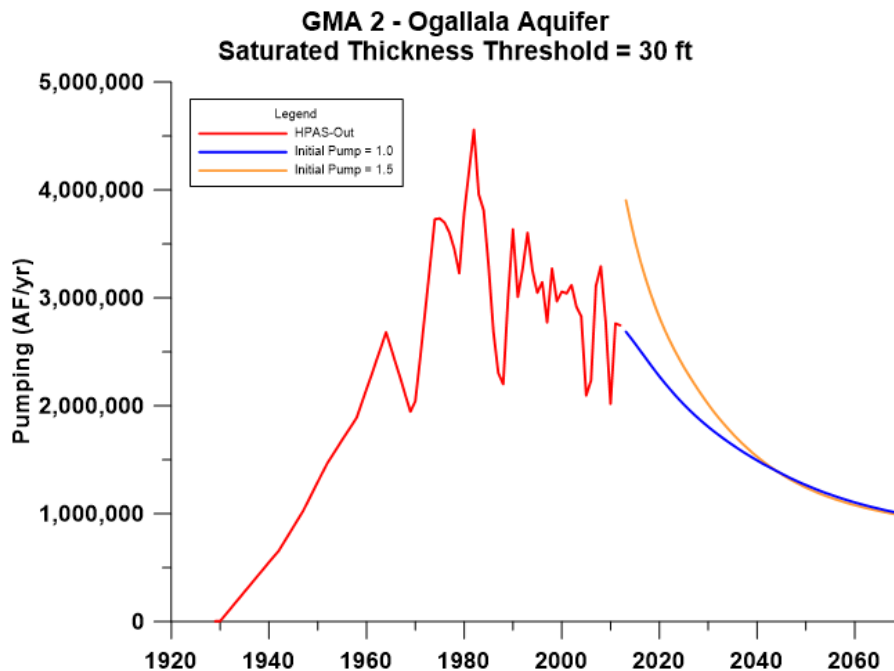


Figure 4. Historic and Simulated Future Pumping – Ogallala and Edwards-Trinity (High Plains) Aquifers in GMA 2

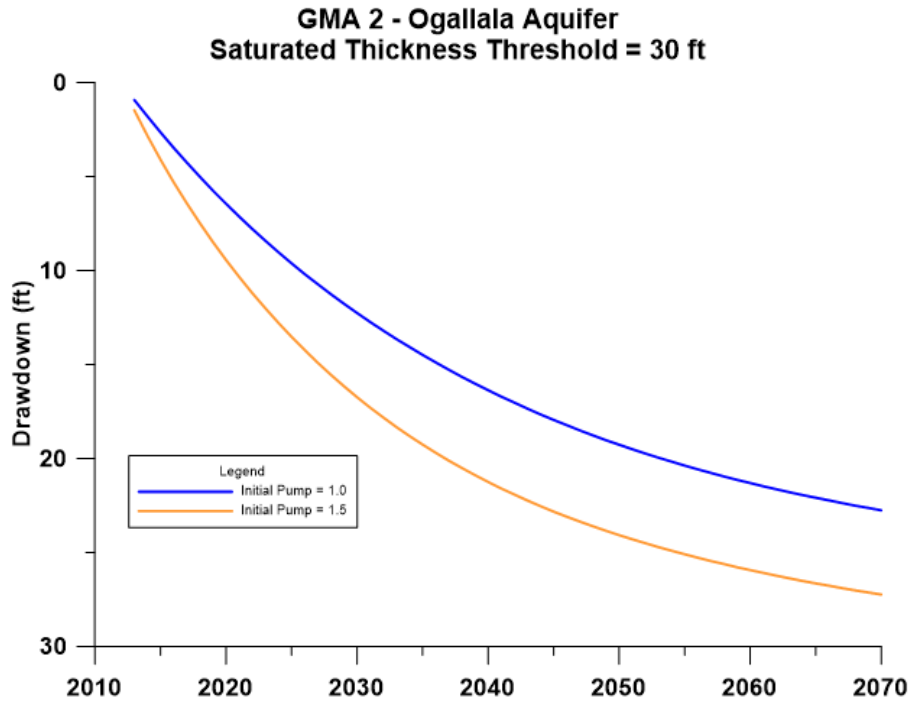


Figure 5. Simulated Average Drawdown – Ogallala and Edwards-Trinity (High Plains) Aquifers in GMA 2

2.2.3 2016 Desired Future Conditions - Dockum Aquifer

On October 19, 2016, the groundwater conservation districts in Groundwater Management Area 2 adopted the desired future condition for the Dockum Aquifer. The desired future condition for the Dockum Aquifer was expressed as an average drawdown of 27 feet for all of GMA 2. The drawdown is calculated from the end of 2012 conditions to the year 2070 and was based on Scenario 16 as documented in GMA 2 Technical Memorandum 16-01.

The average drawdown was calculated over the entire extent of the modeled area (not just the official aquifer boundary as defined by TWDB). Much of the area of the Dockum Aquifer in GMA 2 is brackish groundwater with salinity of over 3,000 mg/l total dissolved solids. Typically, TWDB does not recognize these areas as part of the official aquifer boundary. However, the groundwater conservation districts in GMA 2 included these areas and expected that this resource will be developed in the future.

Historic and simulated future pumping from the Dockum Aquifer is presented in Figure 6, and the simulated drawdown associated with the simulated future pumping is presented in Figure 7.

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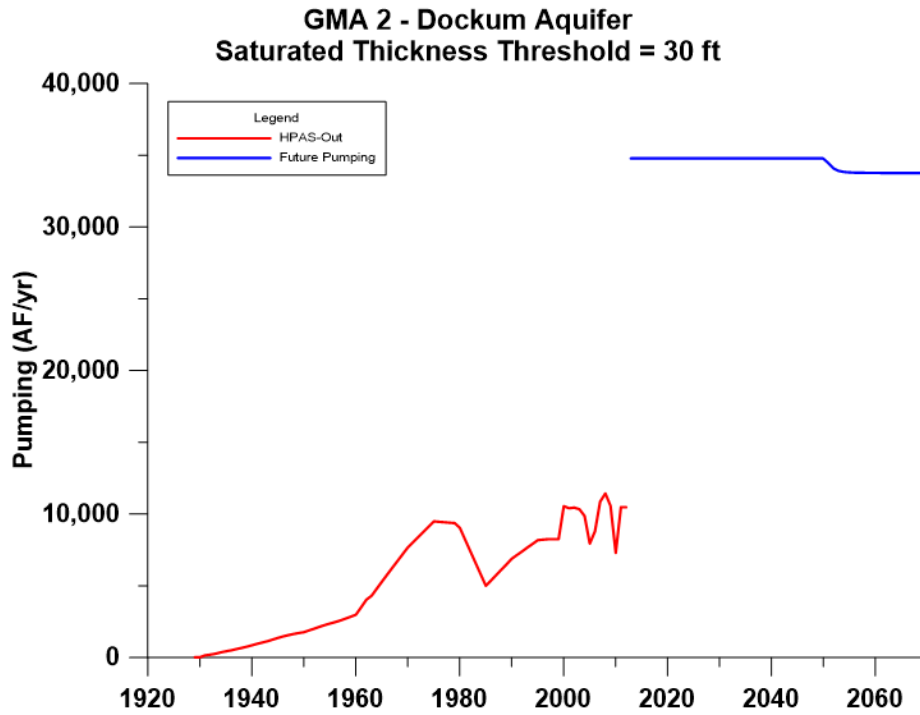


Figure 6. Historic and Simulated Future Pumping - Dockum Aquifer in GMA 2

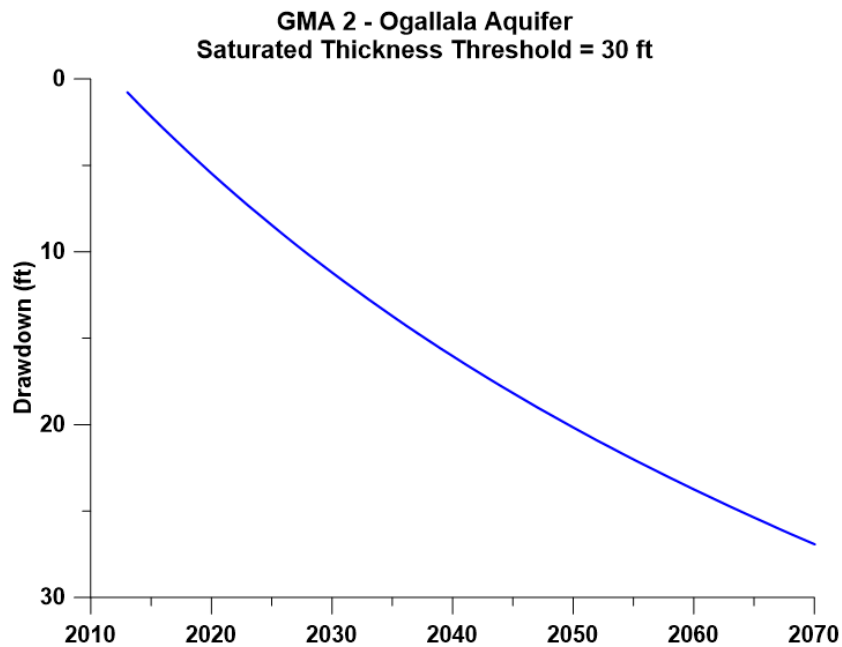


Figure 7. Simulated Average Drawdown - Dockum Aquifer in GMA 2

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2.2.4 2021 Desired Future Conditions

The 2021 desired future conditions were fundamentally the same as the 2016 desired future conditions in terms of concept and implementation. However, one of the uses of the modeled available groundwater (MAG) is to provide groundwater availability numbers to the Regional Water Planning groups. TWDB had advised all Groundwater Management Areas in Texas that, for this round of joint planning, TWDB would calculate MAGs through the year 2080. Because the primary characteristic of groundwater management in Groundwater Management Area 2 is the reduced groundwater production rates associated with declining saturated thickness of the Ogallala Aquifer, it was necessary for GMA 2 to complete an updated simulation with the Groundwater Availability Model to extend the simulation period an additional 10 years (the 2006 desired future conditions were based on simulations that extended to 2070).

The groundwater conservation districts in Groundwater Management Area 2 met on May 19, 2020 to discuss any needed updates to the desired future conditions. The joint planning process included a review of the November 1, 2016 Explanatory Report and the associated Technical Memoranda associated with the desired future condition adopted on October 19, 2016. The discussion during the May 19, 2020 meeting also included reviewing the results of an updated simulation with the Groundwater Availability Model that extended the simulation to 2080. After discussion, it was agreed that the underlying basis for the desired future conditions adopted on October 16, 2016, and the previous review of the nine statutory factors were sound. It was agreed that no modification was needed. However, there was a request to modify the simulation with respect to the simulated pumping in the Dockum Aquifer in selected counties.

As documented in GMA 2 Technical Memorandum 20-01, the base simulation that extended the 2016 simulation to 2080 was expanded to simulate alternative additional pumping in the Dockum Aquifer in Dawson, Gaines, Howard, and Martin counties. These simulations were reviewed at a GMA 2 meeting held on January 25, 2021, and Scenario 19 from GMA 2 Technical Memorandum 20-01 was chosen to be the basis of the 2021 desired future condition.

On March 25, 2021, the groundwater conservation districts in Groundwater Management Area 2 voted to propose desired future conditions as follows:

- A GMA 2-wide average drawdown of 28 feet between 2020 and 2080 for the Ogallala and Edwards-Trinity (High Plains) aquifers
- A GMA 2-wide average drawdown of 31 feet between 2020 and 2080 for the Dockum Aquifer

As documented in GMA 2 Technical Memorandum 20-01, the average drawdown calculations involve summing the drawdowns in all cells in an identified unit (e.g. county or GCD) and dividing the sum by the number of cells in the unit. Calculated average drawdowns based on the active cells in the model can be different than the calculated average drawdown based on the official aquifer boundary cells, which are often limited to groundwater less than 3,000 mg/l total dissolved solids. Because the GCDs in GMA 2 are actively managing groundwater with total dissolved solids greater than 3,000 mg/l, GMA 2 decided to express the average drawdown desired future

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conditions based on the active model cell average, not the official aquifer boundary average. Thus, modeled available groundwater values should also include active model area pumping totals, not the official aquifer boundary totals.

On August 17, 2021, after discussion of the comments received during the public comment period, the groundwater conservation districts in Groundwater Management Area 2 voted to adopt the proposed desired future conditions without modification.

2.3 2026 Desired Future Conditions

2.3.1 Update to HPAS - Limitations in Howard County

As noted in technical memoranda in 2015 and 2016, and in the explanatory report in 2021, development of DFCs on a county scale based on the High Plains Aquifer System Groundwater Availability Model (HPAS GAM, or GAM) was inappropriate based on a review of the results for several counties. The GAM provided reasonable results on a regional scale (i.e. GMA 2). Thus, the limitations of the GAM were used and acknowledged in the development of the DFCs in 2016 and 2021.

Of note were the limitations in Howard County. Recharge was conceptualized for the entire region and was not adjusted during model calibration on a smaller scale to address clear weaknesses. This approach resulted in an estimated Ogallala Aquifer recharge in Howard County prior to 1959 of about 3,000 AF/yr. Starting in 1959, recharge in Howard County was increased each year until it reached its “modern” value of about 23,000 AF/yr in 1982. Dockum Aquifer recharge from 1930 to 1956 was about 3,000 AF/yr in Howard County. Dockum Aquifer recharge in Howard County increased each year until 1979, when it reached its “modern” value of about 5,200 AF/yr.

The use of this conceptual approach affected the results of the model when it is used as a predictive tool in Howard County, even when the simulation is run to the year 2070 or 2080. Essentially, the transient effect of the increased recharge persisted for decades. Similar problems exist in other counties to varying degrees, especially in the Dockum Aquifer, and Howard County is presented for illustrative purposes.

The significance of the persistence of the effect of the increased recharge is manifested in the storage change hydrograph for the Ogallala and Edwards-Trinity (High Plains) aquifers presented and discussed in GMA Technical Memorandum 16-01 (Hutchison, 2016) and is reproduced here as Figure 8.

Note that prior to the increase in recharge (1959) storage was declining. When recharge was increased after 1959, storage was increasing. The simulated increase in pumping in 2013 associated with Scenario 16 resulted in a rapid decline in storage, but by about 2050, storage was once again stable and shows a slight gain each year. This analysis is useful to understand why the average drawdown in Howard County in the Ogallala Aquifer in Scenario 16 is essentially zero. It also shows that use of the average drawdown from any model run of the HPAS would be an inappropriate basis for a desired future condition in Howard County.

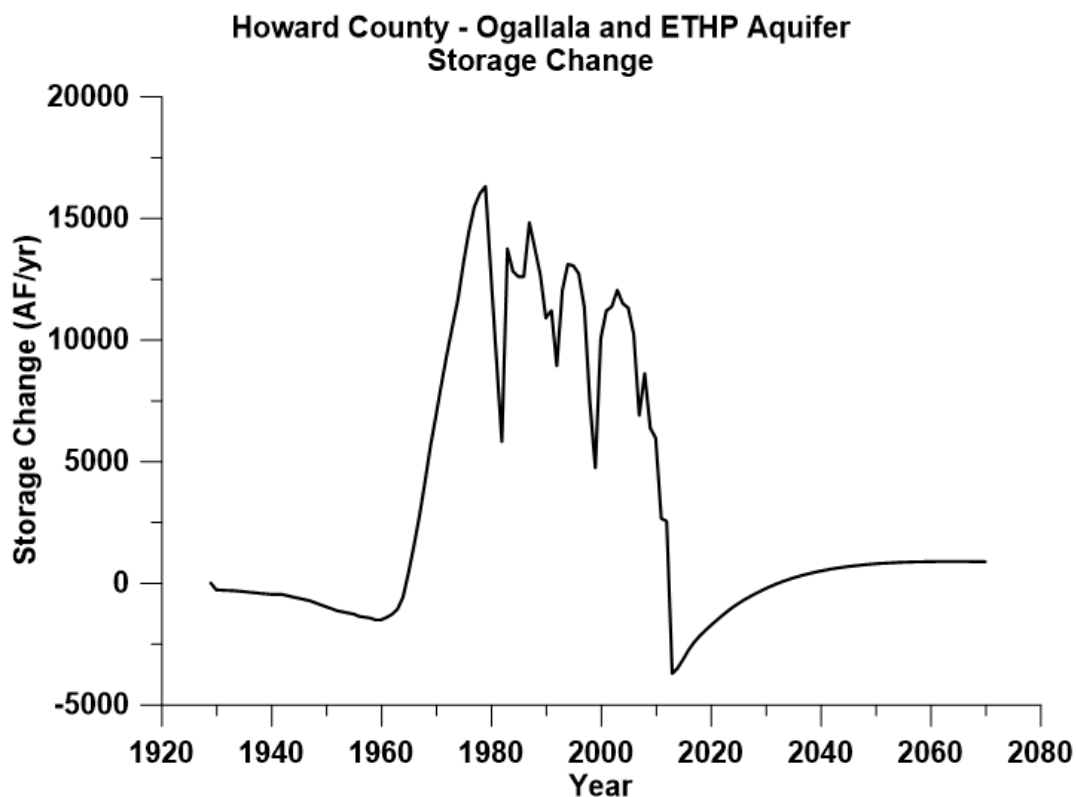


Figure 8. Howard County Storage Change from HPAS – Ogallala and ETPH Aquifer

In response to these expressed concerns on HPAS limitations, TWDB agreed to update the HPAS. Work began in mid-2023. Aside from the Howard County issue, TWDB extended the calibration period from 2012 to 2020. Two sets of draft model files were released in late 2024: one with the Howard County recharge update and a calibration period that ended in 2012, and one with the Howard County recharge update and a calibration period that ended in 2020.

2.3.2 Scenario 23 as the Basis of the Desired Future Condition

The discussion at GMA 2 focused on which version of the updated HPAS to use in the fourth round of joint planning (i.e. which baseline year to use for predictive scenarios, 2012 or 2020). As part of the decision-making process, three technical memoranda were prepared and discussed at GMA 2 meetings:

- Technical Memorandum 25-01 (Scenario 22 – 2012 baseline)
- Technical Memorandum 25-02 (Scenario 23 – 2020 baseline)
- Technical Memorandum 26-01 (Comparison of Scenario 22 and 23 simulated drawdowns with monitoring data)

Based on discussion and consideration of the material in these technical memoranda, the

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groundwater conservation districts in Groundwater Management Area 2 proposed the following desired future conditions at their meeting on March 25, 2026 that are based on the results of Scenario 23:

- Ogallala and Edwards-Trinity (High Plains) Aquifer: A GMA 2 wide average drawdown of 23 feet between 2020 and 2080.
- Dockum Aquifer: A GMA 2 wide average drawdown of 22 feet between 2020 and 2080.

Detailed decadal tables of pumping and drawdown are presented as follows:

- Table 1: Ogallala and Edwards-Trinity (High Plains) Aquifers: County Based
- Table 2: Dockum Aquifer: County Based
- Table 3: Ogallala, Edwards-Trinity (High Plains) and Dockum Aquifers: GCD Based

Table 1. County Based Dedadal Pumping and Drawdown - Ogallala and Edwards-Trinity (High Plains)

Scenario 23 (150% 2020 Pumping) - Ogallala-ETHP Aquifers (2020 Baseline, Revised Howard County Recharge)

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2020 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	18,401	17,649	17,062	16,530	16,053	15,606	1	2	2	3	3	4
Bailey	61,055	51,318	44,314	39,104	35,346	32,671	5	8	10	12	14	15
Borden	2,822	2,688	2,543	2,415	2,224	2,055	1	1	2	3	3	3
Briscoe	17,770	12,737	9,557	7,540	6,275	5,474	4	7	8	9	10	11
Castro	197,546	149,156	86,187	52,208	35,891	26,798	19	35	45	50	53	55
Cochran	79,731	71,473	63,971	56,626	50,316	45,629	5	9	12	15	17	19
Crosby	99,450	79,111	54,757	39,845	31,967	27,496	13	24	32	37	40	43
Dawson	92,088	88,134	84,700	81,461	78,474	75,822	5	9	13	16	19	21
DeafSmith	141,988	113,499	87,642	69,445	57,935	50,197	8	14	18	21	23	25
Floyd	107,507	104,408	99,020	90,168	76,299	61,458	10	20	30	38	46	51
Gaines	234,968	207,848	181,109	159,328	144,591	135,435	8	14	18	21	23	25
Garza	13,242	11,814	11,033	10,567	10,267	10,063	3	5	6	7	8	9
Hale	173,438	96,717	58,382	41,291	32,622	28,490	18	27	32	34	35	36
Hockley	120,242	87,390	69,321	60,726	56,049	53,160	6	9	12	13	15	15
Howard	12,311	10,724	9,742	9,097	8,632	8,278	2	3	4	4	5	6
Lamb	149,253	93,695	68,524	57,080	51,219	47,844	13	19	23	24	26	26
Lubbock	150,326	127,910	112,887	103,527	97,282	92,714	7	13	16	19	21	22
Lynn	103,878	93,671	85,682	79,493	75,183	72,342	4	7	9	11	12	13
Martin	53,338	48,574	45,555	43,483	42,042	40,968	4	6	8	10	11	12
Parmer	120,365	86,307	62,247	47,994	39,211	33,458	11	18	23	26	28	30
Swisher	90,307	68,847	48,671	35,679	27,912	23,102	9	16	20	23	25	26
Terry	139,262	114,378	99,249	91,479	86,866	83,919	5	8	10	12	13	14
Yoakum	89,273	71,186	59,555	52,839	48,837	46,237	5	8	11	13	14	15
GMA2	2,268,487	1,809,194	1,461,717	1,247,927	1,111,490	1,019,207	8	13	17	20	21	23

Table 2. County Based Dedadal Pumping and Drawdown - Dockum Aquifer

Scenario 23 (150% 2020 Pumping) - Dockum Aquifer (2020 Baseline, Revised Howard County Recharge)

County	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2020 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Andrews	1,911	1,911	1,911	1,911	1,911	1,911	2	3	4	5	6	7
Bailey	11	11	11	11	11	11	2	4	6	8	10	11
Borden	298	298	298	298	298	298	0	0	0	0	0	0
Briscoe	116	116	116	116	116	116	2	4	5	6	7	7
Castro	48	48	48	48	48	48	11	23	33	42	49	56
Cochran	0	0	0	0	0	0	1	1	2	3	3	4
Crosby	2,548	2,549	2,549	2,549	2,549	2,549	10	17	22	26	29	31
Dawson	45	45	45	45	45	45	2	3	5	6	8	9
DeafSmith	5,455	5,452	5,428	5,418	5,415	5,413	9	17	24	29	34	37
Floyd	2,142	2,142	2,142	2,142	2,142	2,142	11	20	28	36	42	47
Gaines	57	57	57	57	57	57	3	7	10	13	16	18
Garza	342	342	342	342	342	342	0	0	0	0	0	0
Hale	202	202	202	202	202	202	14	26	35	43	49	54
Hockley	18	18	18	18	18	18	1	3	4	6	7	8
Howard	4,771	4,771	4,771	4,771	4,771	4,771	3	6	7	8	9	10
Lamb	6	6	6	6	6	6	7	14	19	24	29	32
Lubbock	4	4	4	4	4	4	5	9	13	17	20	23
Lynn	28	28	28	28	28	28	1	2	3	4	5	6
Martin	3,081	3,081	3,081	3,081	3,081	3,081	4	8	12	15	19	22
Parmer	0	0	0	0	0	0	9	17	24	30	36	42
Swisher	1,720	1,654	1,619	1,614	1,613	1,612	9	16	22	27	30	33
Terry	0	0	0	0	0	0	1	2	3	4	5	6
Yoakum	10	10	10	10	10	10	1	2	3	4	5	7
GMA2	22,814	22,745	22,686	22,671	22,666	22,665	5	9	13	17	20	22

Table 3. GCD Based Dedadal Pumping and Drawdown - Ogallala, Edwards-Trinity (High Plains), and Dockum

Scenario 23 (150% 2020 Pumping) - Ogallala-ETHP Aquifers (2020 Baseline, Revised Howard County Recharge)

GCD	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	13,242	11,814	11,033	10,567	10,267	10,063	3	5	6	7	8	9
High Plains	1,562,451	1,198,315	922,707	757,196	652,775	581,884	10	18	23	26	28	30
Llano Estacado	234,968	207,848	181,109	159,328	144,591	135,435	8	14	18	21	23	25
Mesa	92,088	88,134	84,700	81,461	78,474	75,822	5	9	13	16	19	21
Permian Basin	65,535	59,189	55,192	52,478	50,574	49,148	3	5	6	8	9	10
Sandy Land	89,273	71,186	59,555	52,839	48,837	46,237	5	8	11	13	14	15
South Plains	142,322	116,305	100,058	91,941	87,200	84,196	5	8	10	12	13	14

Scenario 23 (150% 2020 Pumping) - Dockum Aquifer (2020 Baseline, Revised Howard County Recharge)

GCD	Pumping (AF/yr) - All Active HPAS Cells						Average Drawdown from 2012 (ft) - All HPAS Active Cells					
	2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Garza	342	342	342	342	342	342	0	0	0	0	0	0
High Plains	11,940	11,871	11,812	11,797	11,792	11,790	8	14	20	25	29	33
Llano Estacado	57	57	57	57	57	57	3	7	10	13	16	18
Mesa	45	45	45	45	45	45	2	3	5	6	8	9
Permian Basin	7,614	7,614	7,614	7,614	7,614	7,614	4	7	10	12	14	16
Sandy Land	10	10	10	10	10	10	1	2	3	4	5	7
South Plains	0	0	0	0	0	0	1	2	3	4	5	6

3.0 Policy Justification

As developed more fully in this report, the desired future conditions were adopted after considering:

- Aquifer uses and conditions within Groundwater Management Area 2
- Water supply needs and water management strategies included in the 2012 State Water Plan
- Hydrologic conditions within Groundwater Management Area 2 including total estimated recoverable storage, average annual recharge, inflows, and discharge
- Other environmental impacts, including spring flow and other interactions between groundwater and surface water
- The impact on subsidence
- Socioeconomic impacts that are expected to occur
- The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 2 in groundwater as recognized under Texas Water Code Section 36.002
- The feasibility of achieving the desired future condition
- Other information

In addition, the desired future condition provides a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of water of groundwater in Groundwater Management Area 2.

As discussed earlier, the DFC that was adopted for the High Plains UWCD area of GMA 2 for the Ogallala Aquifer in 2010 was based on a concept where equality in outcome was emphasized more than a management approach that considered the hydraulic characteristics of the aquifer, the hydraulics of pumping wells in an unconfined aquifer where groundwater levels are dropping, and the associated economics of pumping groundwater for irrigation in an area where groundwater levels are dropping. The DFC adopted in 2016, 2021, and the update that is described in this explanatory report puts more emphasis on aquifer hydraulics, economics, and property rights than were considered before, at least in High Plains UWCD area of GMA 2 for the Ogallala Aquifer.

4.0 Technical Justification

The desired future conditions were developed based, in part, on simulations of alternative scenarios of future pumping using the Groundwater Availability Model (GAM) of the Ogallala, Edwards-Trinity (High Plains) and Dockum aquifers (Deeds and Jigmond, 2015) as updated by Cawthon and Wade (2025). This model utilizes a finite-difference code by the US Geological Survey that dynamically simulates the effect of declining groundwater levels on well production rates. Consequently, this model was used to evaluate the expected pumping rate declines in GMA 2 in the future under a wide variety of alternatives.

4.1 Model Simulations in 2015 and 2016

In 2015, GMA 2 completed 15 alternative simulations to understand the relationship between declining groundwater levels and reduced pumping rates. This analysis was documented in three technical memoranda (Hutchison, 2015a, 2015b, and 2015c). Based on the review of the results of Scenario 1 to 15, GMA 2 directed that a final simulation be completed (Scenario 16) as follows:

- GMA 2 requested that initial (beginning of 2013) Ogallala pumping be set to 150 percent of 2012 pumping and set the saturated thickness threshold to 30 feet to be consistent with the value used during the calibration period of the model. This essentially corresponds to the approach taken in Scenario 10 in GMA 2 Technical Memorandum 15-01. GMA 2 representatives also asked that results from the Ogallala and Edwards-Trinity (High Plains) aquifers be combined. This corresponds to layers 1 and 2 of the GAM in GMA 2. The DFC that was adopted for GMA 2 in 2010 combines the two aquifers, and the aquifers are managed as a single unit.
- Initial (2013) pumping for the Edwards-Trinity (High Plains) was set to either 150 percent of 2012 pumping or on the historic maximum depending on county. Scenario 10 used a consistent 150 percent of 2012 pumping, but historic pumping was higher in earlier years. GMA 2 representatives requested that pumping in those counties correspond to the historic maximum.
- Pumping in the Dockum Aquifer was also set to either 150 percent of 2012 pumping or historic maximum. In addition, areas with no historic pumping were assigned pumping. These counties typically fall outside the official TWDB boundaries of the Dockum Aquifer but were included in the model.

The results for Scenario 16 are documented in GMA 2 Technical Memorandum 16-01 (Hutchison, 2016). In reality, pumping withdrawals will vary according to rainfall. This is observed in the model calibration plots, where cyclical patterns of withdrawal are evident. The range of expected pumping in the development of the desired future condition accounts for uncertainty and timing of drought periods.

4.2 Model Simulations in 2020

In 2020, the model files associated with Scenario 16 were extended for 10 years to complete a simulation through 2080 to provide a basis for TWDB to calculate modeled available groundwater values for 2080 in support of the regional water planning process. This simulation was designated Scenario 16 – extended to 2080.

GMA 2 also completed Scenarios 17 to 21 to evaluate alternatives of increasing simulated Dockum Aquifer pumping from 2014 to 2018 in Dawson, Gaines, Howard, and Martin counties. After review and discussion at the January 25, 2021 GMA 2 meeting, Scenario 19 from GMA 2 Technical Memorandum 20-01 was chosen to be the basis of the 2021 desired future condition.

4.3 Model Simulations in 2025

The scenario numbering system used in 2016 and 2020 was continued, and Scenarios 22 and 23 were completed using the updated version of the HPAS. Scenario 22 implemented the update to Howard County recharge but used the original baseline year (2012). Scenario 23 used the full HPAS update, including the updated baseline year (2020). As noted above, GMA 2 relied on Scenario 23 for its updated desired future conditions (Hutchison, 2025).

5.0 Factor Consideration

Section 36.108(d) of the Texas Water Code requires that groundwater conservation districts include documentation of how nine listed factors were considered prior to proposing a desired future condition, and how the proposed desired future condition impact each factor. This section of the explanatory report summarizes the information that the groundwater conservation districts used in its deliberations and discussions.

5.1 Aquifer Uses and Conditions

For the purposes of the development of the desired future condition, the groundwater conservation districts in Groundwater Management Area 2 considered previous estimates of aquifer uses (i.e. pumping) documented in previous explanatory reports:

- Estimates of 1930 to 2012 input and output pumping from the GAM (Deeds and Jigmond, 2015)
- Estimates of pumping from 1980 and 1984 to 2013 from the TWDB groundwater pumping database
- Current modeled available groundwater for 2010 to 2060
- Estimates of pumping from the initial predictive simulation that was completed for GMA 1 as part of the contract to develop the GAM for 2013 to 2070

In addition, the pumping estimates from the updated HPAS (Cawthon and Wade, 2025) were evaluated. These updated estimates are included in this explanatory report as Appendix B.

Figure 9 presents a comparison of pumping (historical, baseline future pumping, and Scenario 23 future pumping). Please note that the baseline future pumping assumes 2020 pumping from the updated HPAS from 2021 to 2080 as documented in Cawthon and Wade (2025). In contrast, Scenario 23 pumping assumes that 2021 pumping is 1.5 times 2020 pumping to simulate short term increased pumping in response to drought conditions. Please note that by about 2060, total pumping is about the same in either predictive scenario.

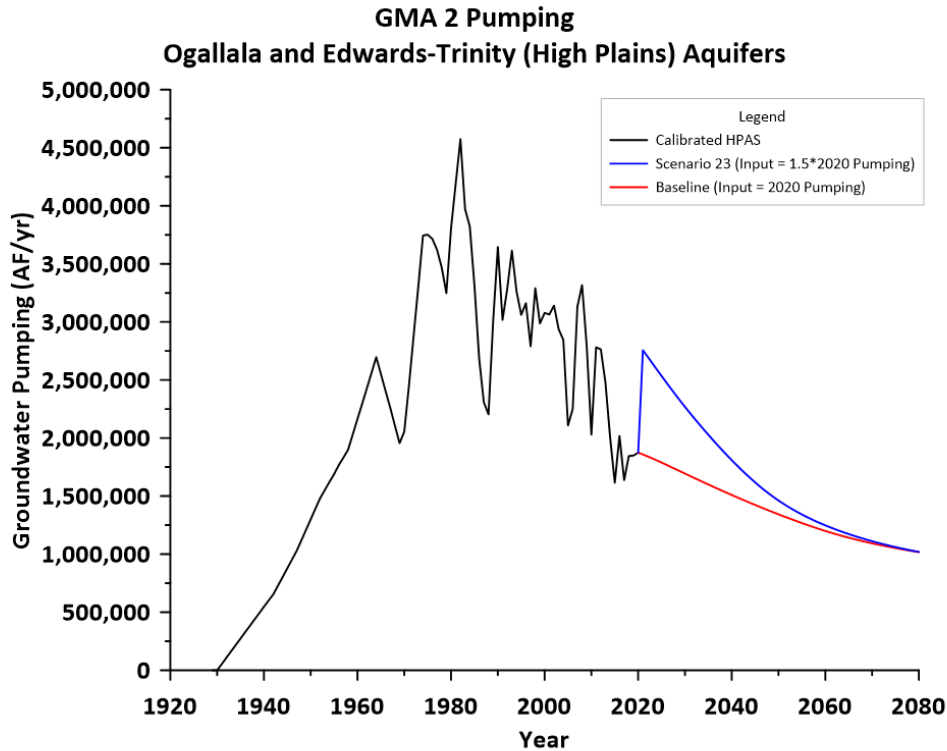


Figure 9. Historic Pumping and Two Scenarios of Future Pumping

5.2 Water Supply Needs and Water Management Strategies

The 2016 Region O Plan lists recommended water management strategies, some of which are for local groundwater development. The underlying basis for the proposed DFC is that pumping in the Ogallala Aquifer would increase to 150 percent of estimated 2020 pumping in 2021. The elevated level of 2020 pumping represents a scenario of increased usage during drought conditions. Future reductions in pumping through 2080 would be as a result of declining groundwater levels and the associated change in the hydraulics of pumping wells.

The recommended strategies also include the development of brackish groundwater. The Dockum DFC explicitly included increased pumping for the Dockum to accommodate these strategies, including areas of the Dockum that are not currently within the official boundaries of the Dockum Aquifer (as defined by TWDB) due to poor water quality.

5.3 Hydrologic Conditions within Groundwater Management Area 2

As required by statute, the groundwater conservation districts in Groundwater Management Area 2 considered total estimated recoverable storage, average annual recharge, inflows, and discharge prior to adopting a proposed desired future condition.

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5.3.1 Total Estimated Recoverable Storage (TERS)

As required by statute, the Texas Water Development Board provided the groundwater conservation districts in Groundwater Management Area 2 with estimates of total recoverable storage (Kohlrenken and others, 2013). The report is included as Appendix C.

Please note that this estimate has not been updated with either the original HPAS or the updated HPAS. The TWDB storage estimates were developed based on the hydrogeologic framework and aquifer parameters of the old GAMs.

It is also noteworthy that the TERS estimates were taken from the last year of model calibration. For the Ogallala and Edwards-Trinity (High Plains), the TERS calculation was year 2000. The Dockum TERS estimates are based on 1997 data.

5.3.2 Average Annual Recharge, Inflows and Discharge

The average historic groundwater budget for Groundwater Management Area 2 for the Ogallala and Edwards-Trinity (High Plains) aquifers from output of the updated HPAS (Cawthon and Wade, 2025) and is presented in Table 4.

Table 4. GMA 2 Historic Groundwater Budget - Ogallala and Edwards-Trinity (High Plains)

	Average Flow in AF/yr (1929 to 2020)
Inflow	
Recharge from Precipitation	352,574
Inflow from Surface Water	52,115
Inflow from New Mexico	9,891
Total Inflow	414,580
Outflow	
Groundwater Pumping	2,182,383
Springs and Seeps	51,274
Evapotranspiration	16,451
Outflow to GMA 1	9,006
Outflow to GMA 3	209
Outflow to GMA 6	4,275
Outflow to GMA 7	1,698
Vertical flow to Dockum	2,828
Total Outflow	2,268,125
Inflow-Outflow	-1,853,545
Storage Change	-1,853,545
Model Error	0

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The average historic groundwater budget for Groundwater Management Area 2 for the Dockum Aquifer from output of the updated HPAS (Cawthon and Wade, 2025) and is presented in Table 5.

Table 5. GMA 2 Historic Groundwater Budget – Dockum Aquifer

Average Flow in AF/yr (1929 to 2020)	
Inflow	
Recharge from Precipitation	13,721
Inflow from Ogallala	2,828
Total Inflow	16,549
Outflow	
Groundwater Pumping	6,034
Springs and Seeps	4,364
Outflow to Surface Water	12,690
Evapotranspiration	6,318
Outflow to New Mexico	260
Outflow to GMA 1	1,794
Outflow to GMA 3	64
Outflow to GMA 6	1,429
Outflow to GMA 7	626
Total Outflow	33,579
Inflow - Outflow	-17,030
Storage Change	-17,029
Model Error	-1

Changes to groundwater budget components were estimated by comparing the Scenario 23 groundwater budget and the groundwater budget from the baseline scenario developed by Cawthon and Wade (2025). This isolates the changes caused by assuming the pumping would increase after 2020 to accommodate drought conditions (Scenario 23) as compared with simulating 2020 pumping as a baseline.

Table 6 summarizes the analysis for the Ogallala and Edwards-Trinity (High Plains) aquifers and Table 7 summarizes the analysis for the Dockum Aquifer.

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Table 6. Predictive Scenarios Groundwater Budgets - Ogallala and Edwards-Trinity (High Plains)

Average Flow in AF/yr (2021 to 2080)		
Inflow	Baseline Scenario	Scenario 23
Inflow from Surface Water	95,762	99,098
Recharge from Precipitation	661,832	661,832
Inflow from New Mexico	13,908	13,631
Inflow from GMA 1	3,582	4,132
Inflow from Dockum	7,001	9,006
Total Inflow	782,085	787,699
Outflow		
Groundwater Pumping	1,372,534	1,614,325
Springs and Seeps	31,885	28,881
Evapotranspiration	7,773	6,520
Outflow to GMA 3	208	208
Outflow to GMA 6	511	34
Outflow to GMA 7	1,289	1,373
Total Outflow	1,414,200	1,651,340
Inflow - Outflow	-632,115	-863,641
Storage Change	-632,115	-863,642
Model Error	0	0

Note: Baseline Scenario Input Pumping = 2020 Pumping
Scenario 23 Input Pumping = 1.5 * 2020 Pumping

Analysis of Source of Increased Pumping

Increase in Pumping (AF/yr)	241,791
Increase in Storage Decline (AF/yr)	231,527
Increased Storage Decline (% of Pumping Increase)	96

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Table 7. Predictive Scenarios Groundwater Budgets - Dockum

Average Flow in AF/yr (2021 to 2080)		
Inflow		
Recharge from Precipitation	18,523	18,523
Total Inflow	18,523	18,523
Outflow		
Groundwater Pumping	15,167	22,720
Springs and Seeps	4,803	4,796
Outflow to Surface Water	14,668	14,581
Evapotranspiration	7,138	7,111
Outflow to Ogallala	7,001	9,006
Outflow to New Mexico	257	257
Outflow to GMA 1	1,156	1,175
Outflow to GMA 3	82	85
Outflow to GMA 6	1,082	1,109
Outflow to GMA 7	595	599
Total Outflow	51,951	61,439
Inflow -Outflow	-33,427	-42,915
Storage Change	-33,420	-42,907
Model Error	-7	-8

Note: Baseline Scenario Input Pumping = 2020 Pumping
 Scenario 23 Input Pumping = 1.5 * 2020 Pumping

Analysis of Source of Increased Pumping

Increase in Pumping and Outflow to Ogallala (AF/yr)	9,557
Increase in Storage Decline (AF/yr)	9,488
Increased Storage Decline (% of Pumping Increase)	99

5.4 Other Environmental Impacts, Including Spring Flow and Other Interactions between Groundwater and Surface Water

The evaluation of all water budget components was discussed in Section 5.3.2 above.

5.5 Subsidence

Subsidence has not been an issue historically in these aquifers in GMA 2.

Applying the desired future condition average drawdown to the recently released subsidence tool on the Texas Water Development Board website, the Total Weighted Risk for the Ogallala Aquifer is 5.00 and is 3.59 for the Dockum Aquifer. As noted in the tool, a risk score of 0 is low risk and a risk score of 10 is high risk. Predicted subsidence using the tool is 0.00 feet for the Dockum Aquifer and 0.08 feet for the Ogallala Aquifer from 2010 to 2080.

5.6 Socioeconomic Impacts

Texas Tech and Texas AgriLife Extension Services published a report in 2011 that assessed the economics of proposed groundwater management strategies in Groundwater Management Area 2 (Weinheimer and others, 2011). This report stated that the declining saturated thickness would result in 33 percent fewer irrigated acres over the next 50 years as the region converts to dryland production. The study also found that the aggregate economic impacts from the selected water management policies implemented by the districts will have “very little negative impact relative to the baseline scenario”.

Please note that this conclusion was based on the 2010 DFC, which included a 50/50 concept for the High Plains UWCD area of GMA 2. It was noted in the report that it was possible that individual farms could be impacted by the “proposed strategies”, especially those with very high wells yields and the ability to apply irrigation water over a long period of time.

The areas that would be impacted include those where pumping is artificially and arbitrarily limited to achieve an equal 50/50 condition across the entire area. The concept of equal outcomes was specifically rejected as part of the development of the proposed DFC for the Ogallala discussed in this explanatory report. The DFCs adopted in 2016, 2021, and 2026 implicitly recognize the variability of the aquifer (e.g. saturated thickness and well yields) and recognize that differences in pumping in various areas of GMA 2 are, in part, the result of the economics of pumping groundwater for beneficial use.

Thus, the limited economic impacts of the DFCs adopted in 2010 found in Weinheimer and others (2011) are substantially eliminated by the DFCs adopted in 2016, 2021, and 2026.

5.7 Impact on Private Property Rights

The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 2 in groundwater are

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recognized under Texas Water Code Section 36.002.

The DFC is consistent with protecting property rights. As discussed in the socioeconomic impacts discussion in Section 5.6, under the 50/50 concept, Weinheimer and others (2015) found a limited condition where there could be impacts as the result of the imposition of an equal outcome management concept that is embedded in the 2010 DFCs. The 2016, 2021, and 2026 DFCs have eliminated that concern since the current DFCs implicitly recognizes that the aquifer conditions vary across the region, and that property rights are best protected when the pumping is limited only by the physics of groundwater flow and by the economics of pumping groundwater for a beneficial use.

5.8 Feasibility of Achieving the Desired Future Condition

Groundwater levels are routinely monitored by the districts and by the TWDB in GMA 2. Evaluating the monitoring data is a routine task for the districts, and the comparison of these data with the model results that were used to develop the DFCs is covered in each district's management plan. Details of this analysis were documented in Hutchison (2026) and demonstrated the feasibility of achieving the desired future conditions.

5.9 Other Information

GMA 2 did not consider any other information in developing the DFCs.

6.0 Discussion of Other Desired Future Conditions Considered

During the development of the proposed DFCs in 2016, a total of sixteen GAM simulations were evaluated and considered. As described earlier, the initial fifteen simulations were used to develop Scenario 16, which was the basis for the proposed DFC.

Also considered in 2015 and 2016 was continuation of a 50/50 concept. However, as described in more detail above, this equal-outcome approach was rejected in favor of proposed DFCs that implicitly considered aquifer conditions and aquifer variability, economics of pumping groundwater in light of declining groundwater levels, and property rights over an arbitrary approach that emphasizes equal outcomes on a county scale.

In 2020, five additional GAM simulations were evaluated relative to alternative Dockum Aquifer pumping scenarios. The results of the additional simulations were reviewed and discussed in early 2021, and selected Scenario 19 as the basis for the proposed DFC as documented in Technical Memorandum 20-01.

In 2025, the updated HPAS was used to consider two alternative baseline years for predictive simulations. Scenario 22 considered continuation of the use of 2012 as the baseline year, and Scenario 23 considered the use of 2020 as the baseline year.

Scenario 23 was also compared with a scenario completed as part of the HPAS update (Cawthon and Wade, 2025) that simulated a condition where 2020 pumping remained as the initial pumping for a predictive scenario through 2080. This alternative did not consider the variability of pumping for irrigation during drought years.

The groundwater conservation districts in Groundwater Management Area 2 decided to shift the baseline year to 2020 and base the DFCs on Scenario 23 (i.e. initial pumping was set as 150 percent of 2020 pumping to account for drought conditions).

7.0 Discussion of Other Recommendations

To be completed after public comment period

7.1 Oral Comments at Public Hearings

7.2 Written Comments

8.0 References

Cawthon, T. and Wade, S., 2025. Extension of the Groundwater Availability Model for the High Plains Aquifer System through 2020 (version 1.02). Texas Water Development Board, June 2025. 187p.

Deeds, N.E. and Jigmond, M., 2015. Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model. Prepared by INTERA Incorporated for Texas Water Development Board, 640p.

Hutchison, W.R., 2015a. Ogallala Aquifer: Initial Predictive Simulations. GMA 2 Technical Memorandum 15-01, Draft 1, Prepared for Groundwater Management Area 2. December 22, 2015, 61p.

Hutchison, W.R., 2015a. Ogallala Aquifer: Initial Predictive Simulations. GMA 2 Technical Memorandum 15-01, Draft 1, Prepared for Groundwater Management Area 2. December 22, 2015, 61p.

Hutchison, W.R., 2015b. Edwards-Trinity (High Plains) Aquifer: Initial Predictive Simulations. GMA 2 Technical Memorandum 15-02, Draft 1, Prepared for Groundwater Management Area 2. December 22, 2015, 26p.

Hutchison, W.R., 2015c. Dockum Aquifer: Initial Predictive Simulations. GMA 2 Technical Memorandum 15-03, Draft 1, Prepared for Groundwater Management Area 2. December 22, 2015, 27p.

Hutchison, W.R., 2025. Documentation of Scenario 23: Joint Planning Simulation with the Updated High Plains Aquifer System Groundwater Availability Model. Prepared for Groundwater Management Area 2, August 22, 2025, 19p.

Hutchison, W.R., 2026. Comparison of Measured Drawdown with Simulated Drawdowns from Scenario 22 (2012 Baseline) and Scenario 23 (2020 Baseline) in Groundwater Management Area 2. Prepared for Groundwater Management Area 2, March 6, 2026. 10p.

Kohlrenken, W., Boghici, R., and Jones, I., 2013, GAM Task 13-026: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 2. Texas Water Development Board, Groundwater Resources Division, Groundwater Availability Modeling Section, September 19, 2013, 26p.

Weinheimer, J. Johnson, P., Johnson, J, Guerrero, B., and Amosson, S., 2011. Economic Assessment of Proposed Groundwater Management Strategies in Groundwater Management Area 2. Final Report submitted 8/31/2011, Department of Agricultural and Applied Economics, Texas Tech University and Texas AgriLife Extension Service, 73p.

Appendix A

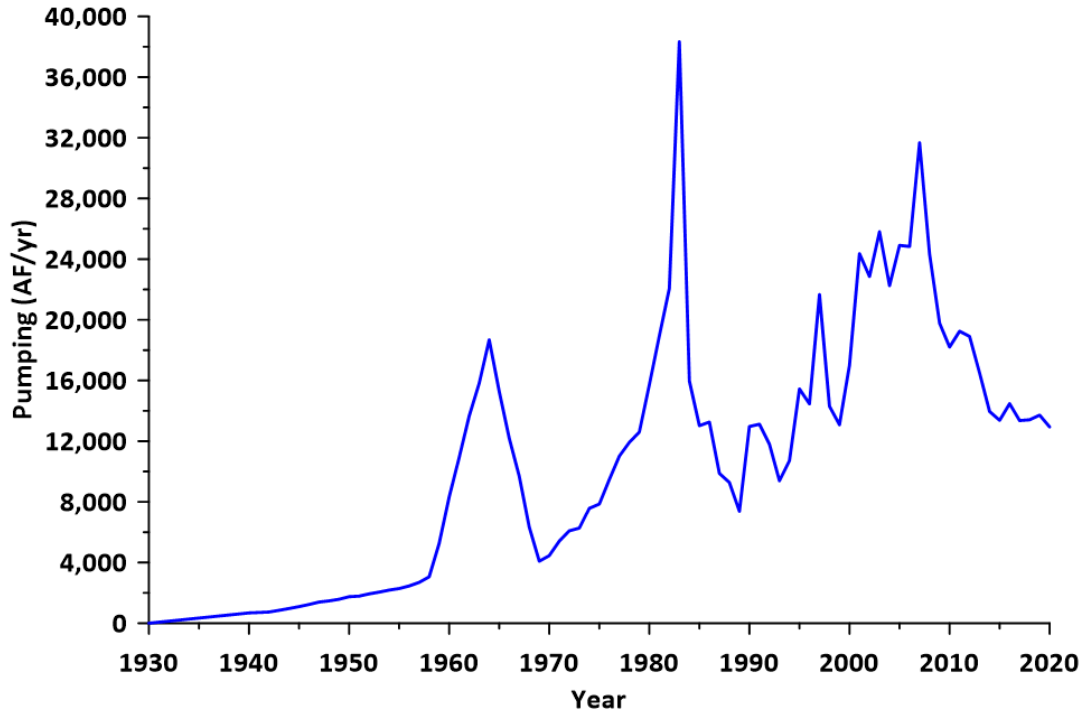
Desired Future Conditions Resolution and Posted Notice

(To be Added)

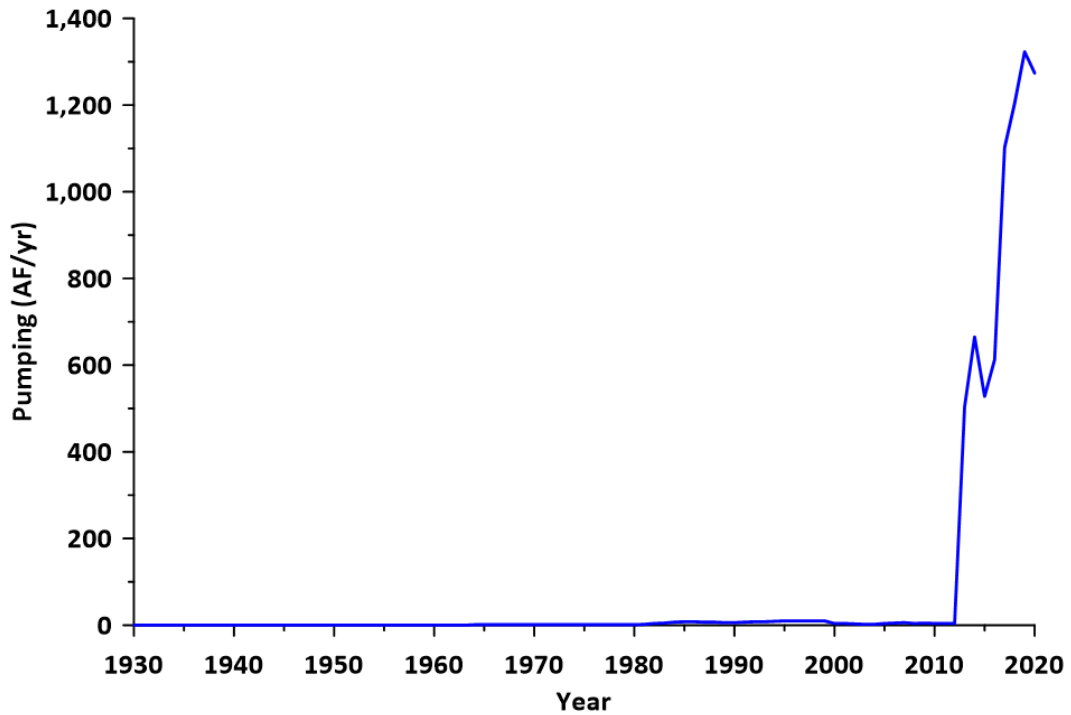
Appendix B

Groundwater Use Estimates from Updated HPAS

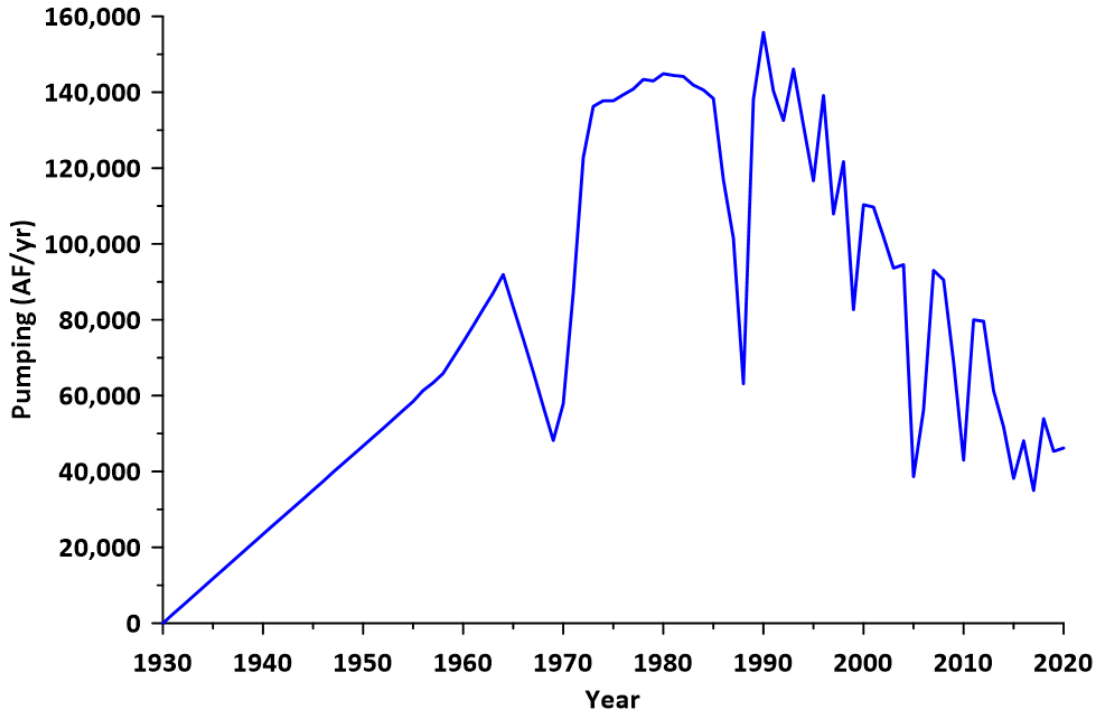
**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Andrews County (Model Domain)**



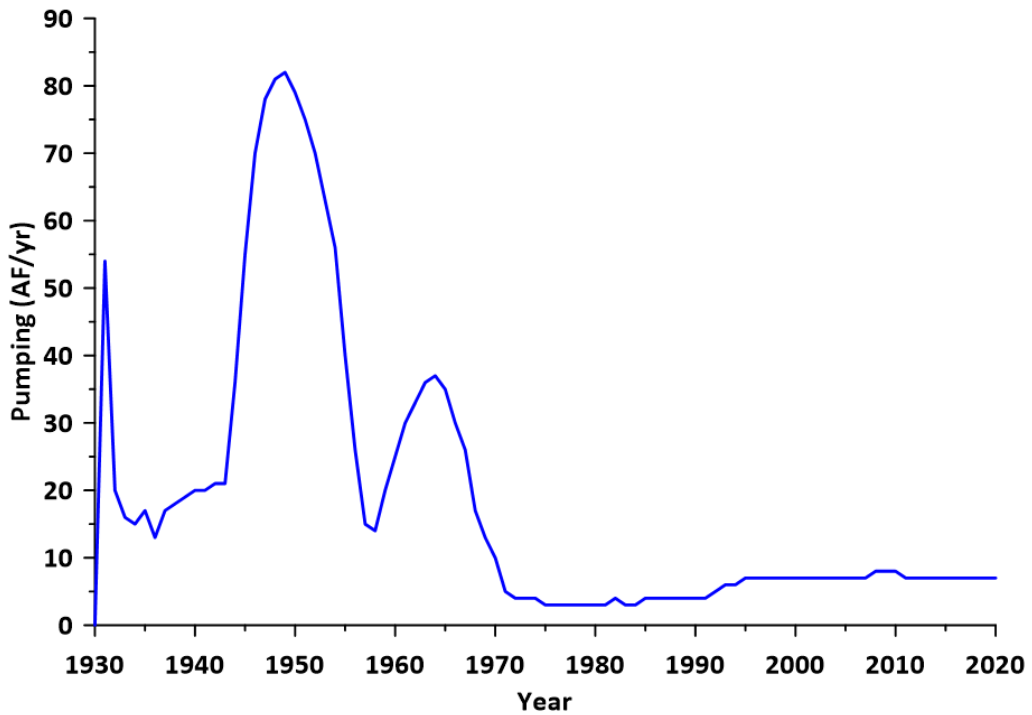
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Andrews County (Model Domain)**



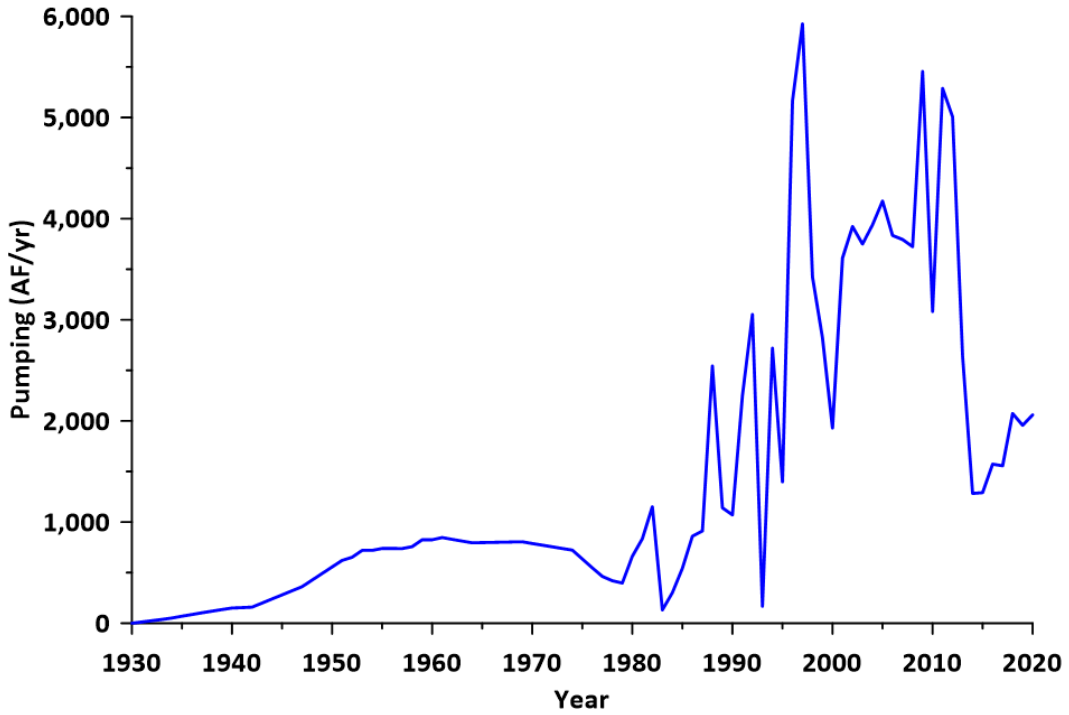
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Bailey County (Model Domain)**



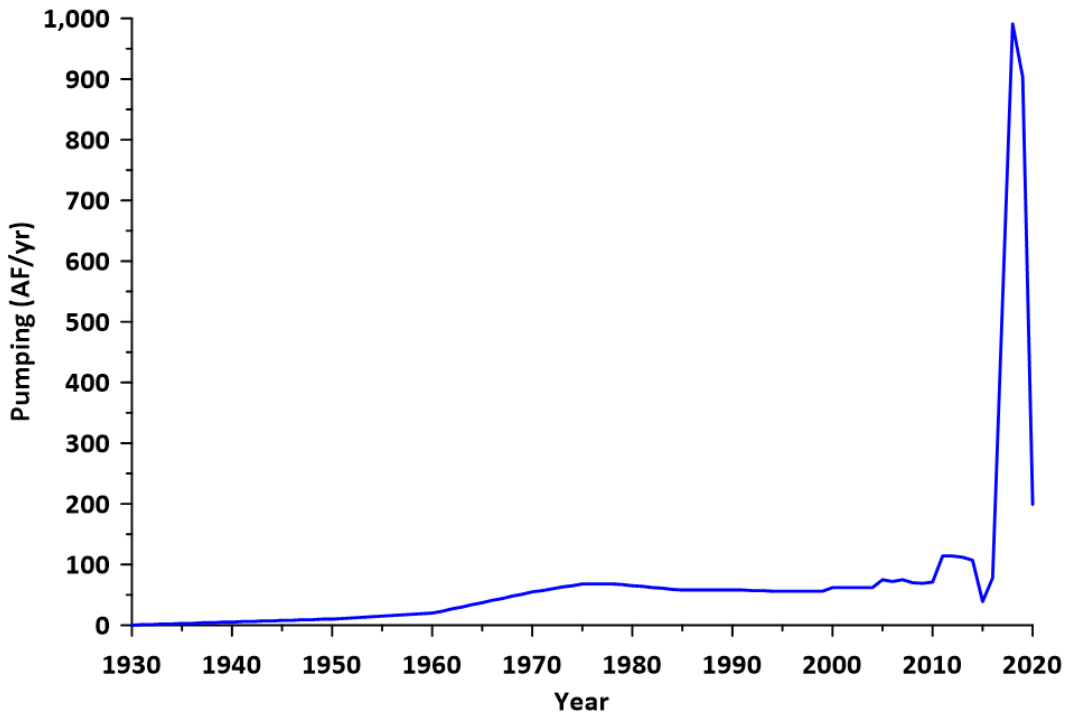
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Bailey County (Model Domain)**



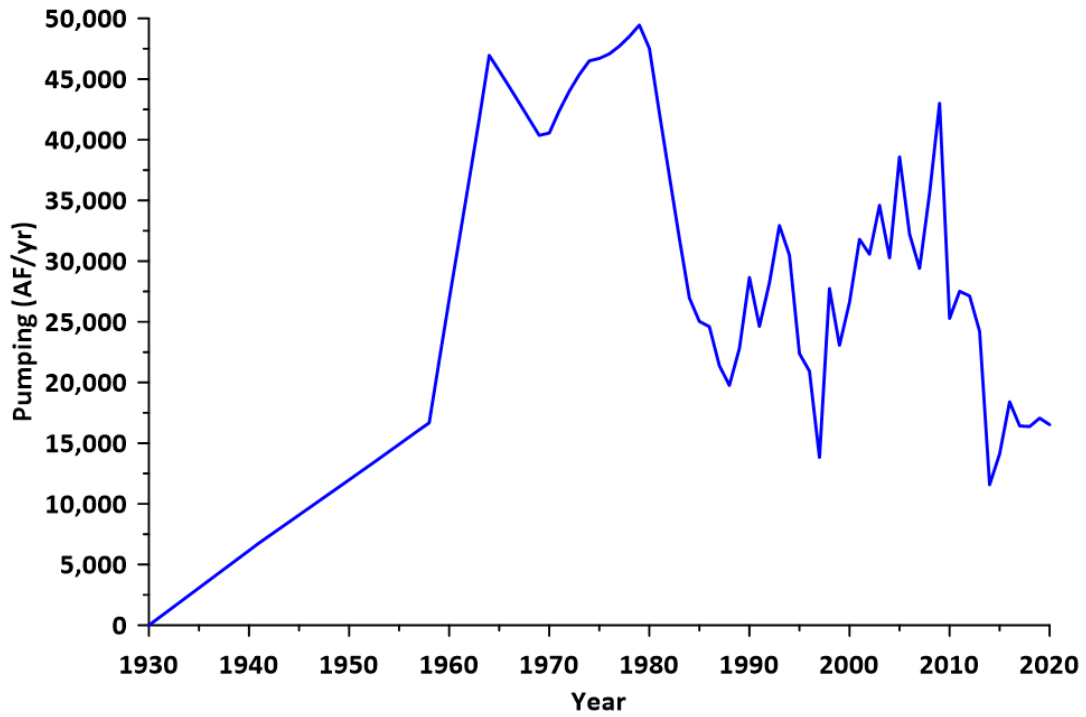
**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Borden County (Model Domain)**



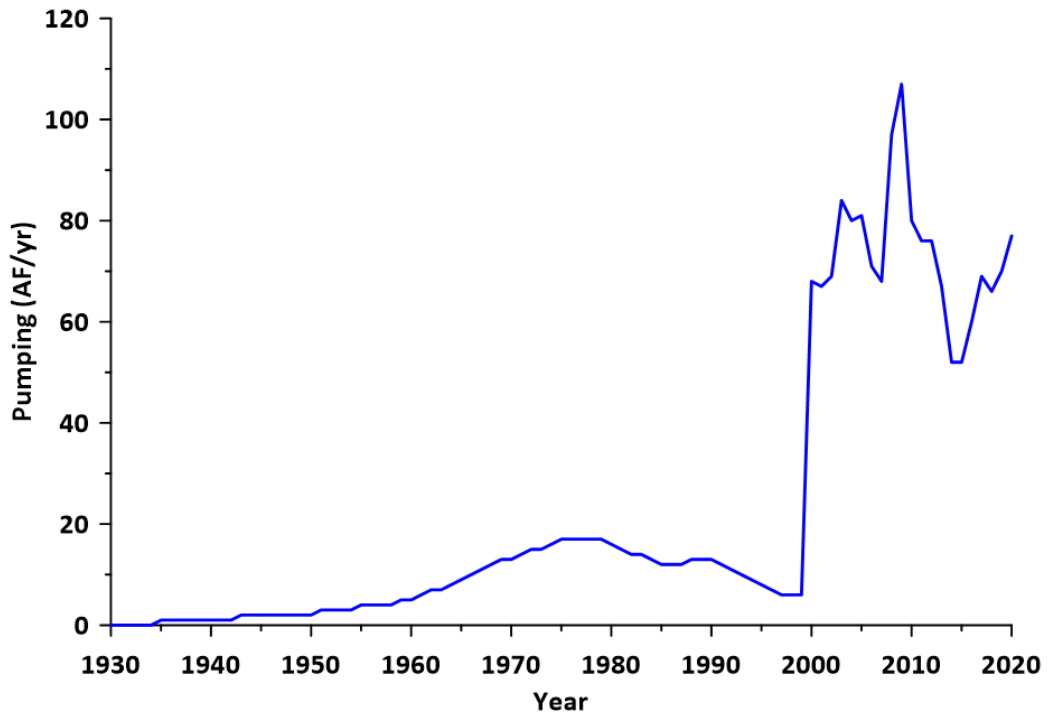
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Borden County (Model Domain)**



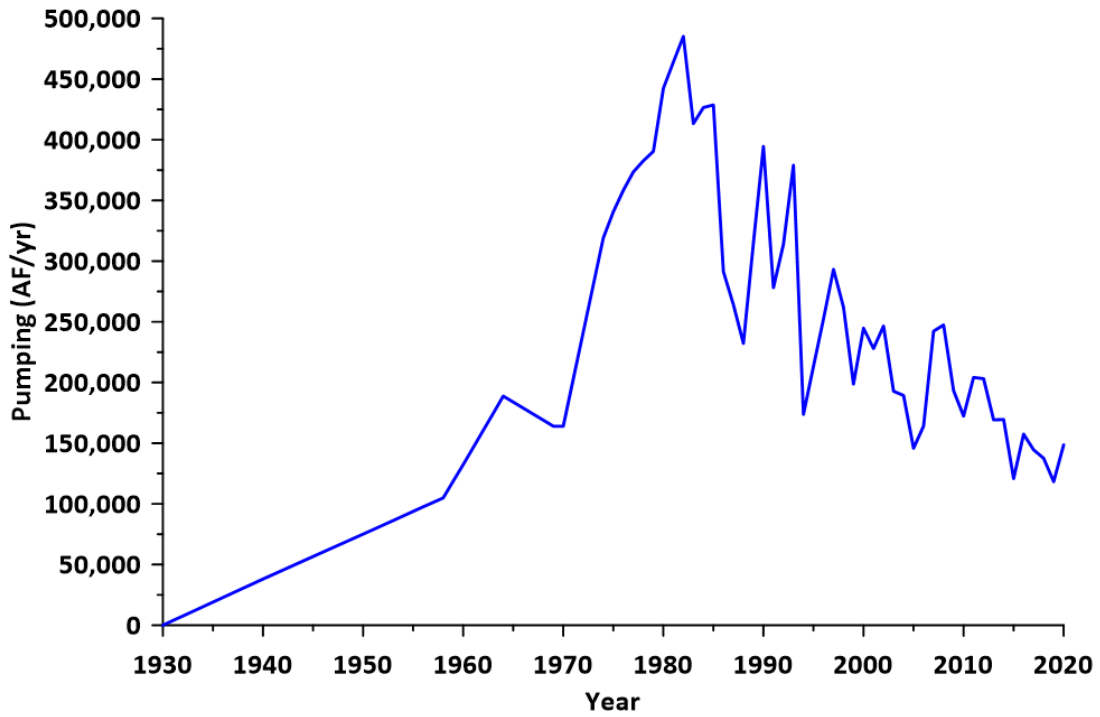
**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Briscoe County (Model Domain)**



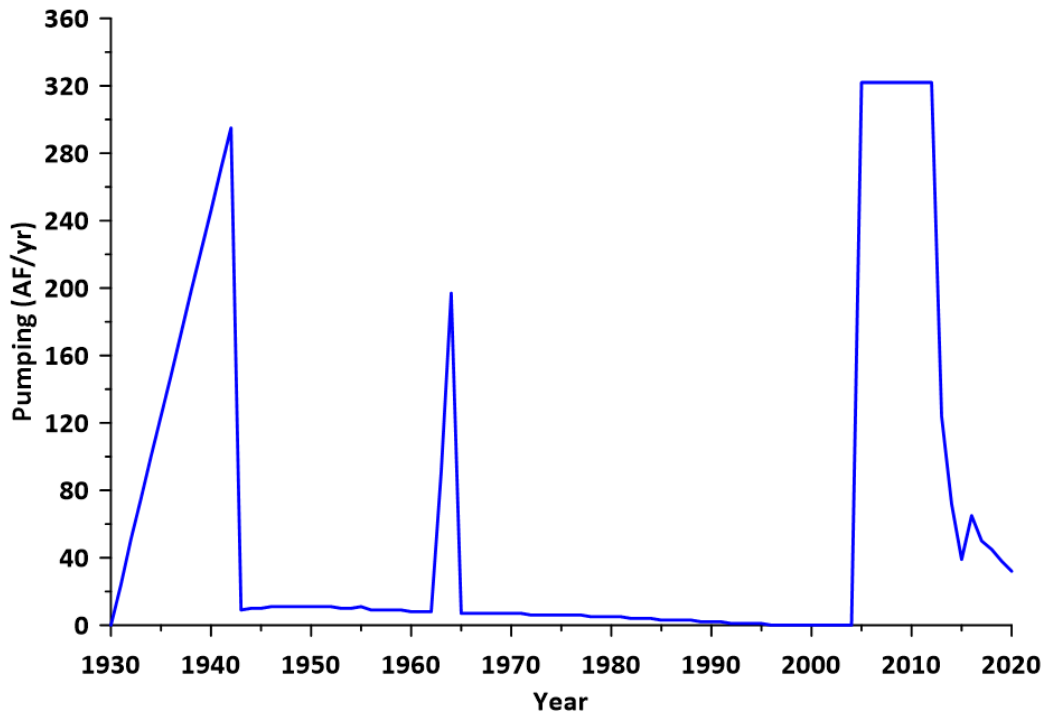
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Briscoe County (Model Domain)**



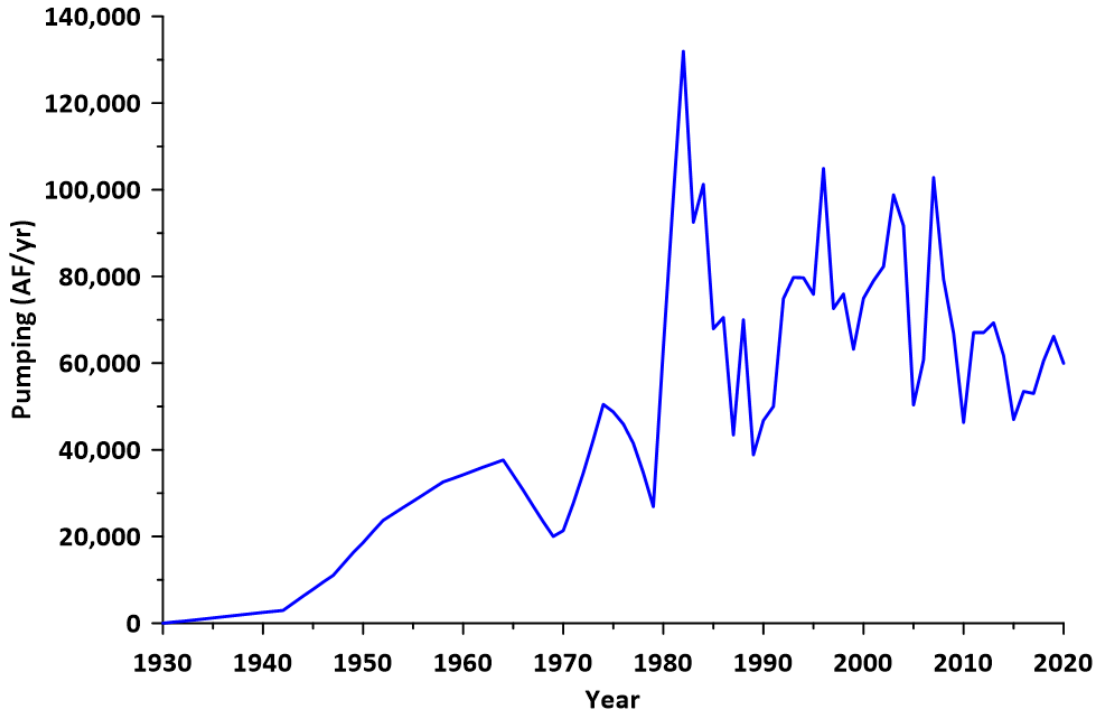
**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Castro County (Model Domain)**



**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Castro County (Model Domain)**

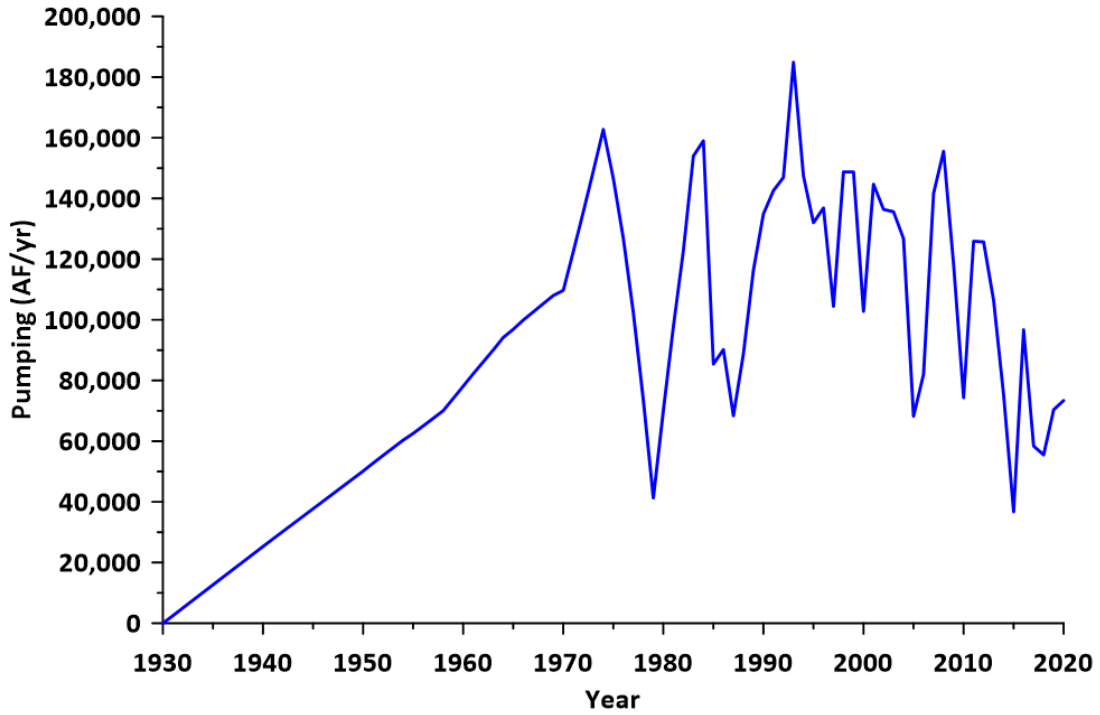


**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Cochran County (Model Domain)**

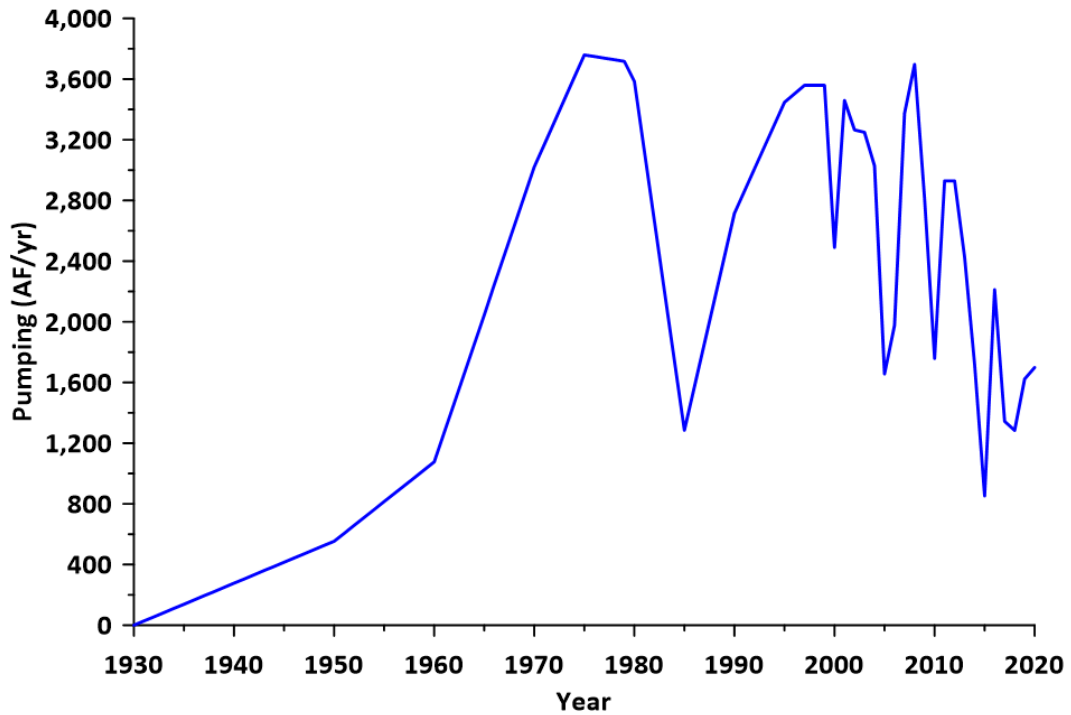


No Dockum pumping in Cochran County

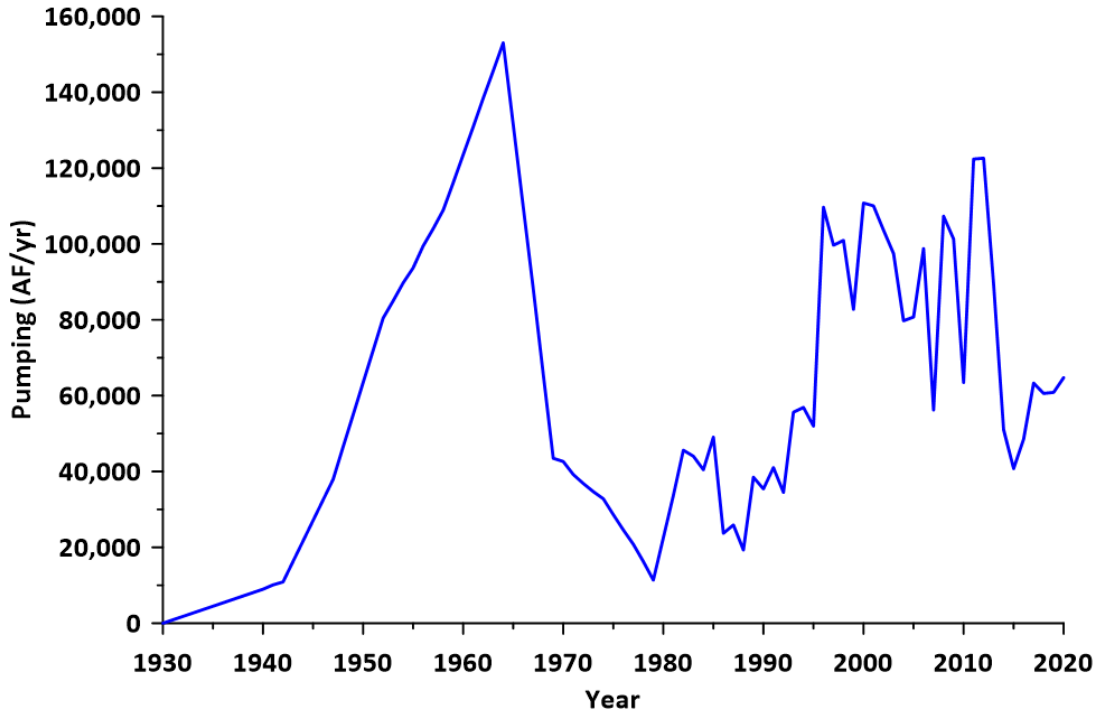
**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Crosby County (Model Domain)**



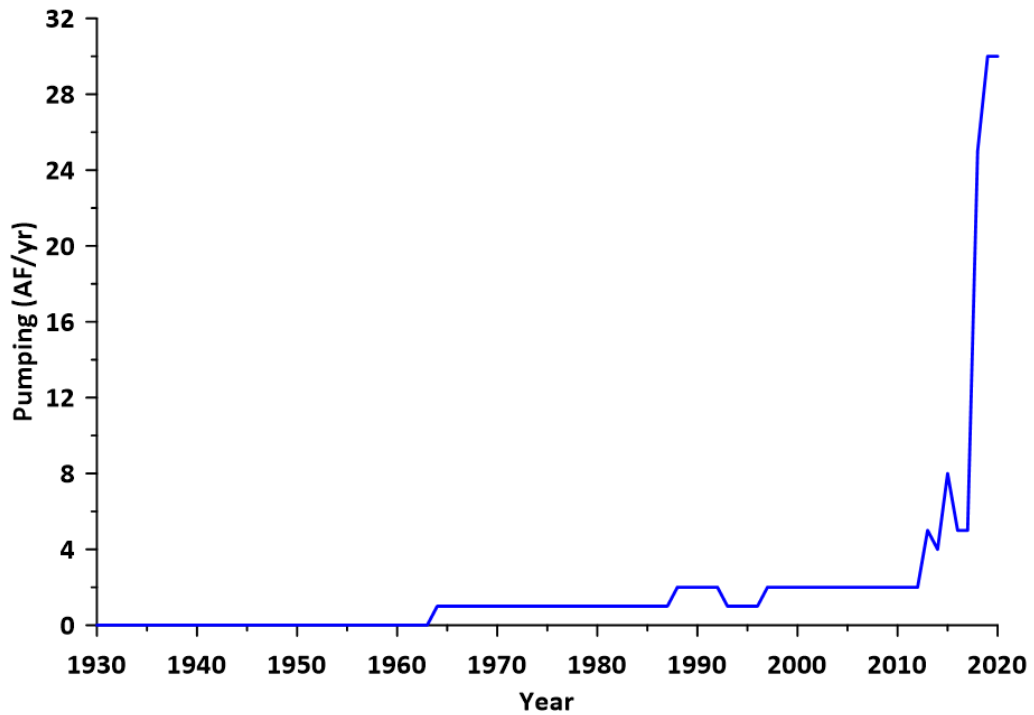
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Crosby County (Model Domain)**



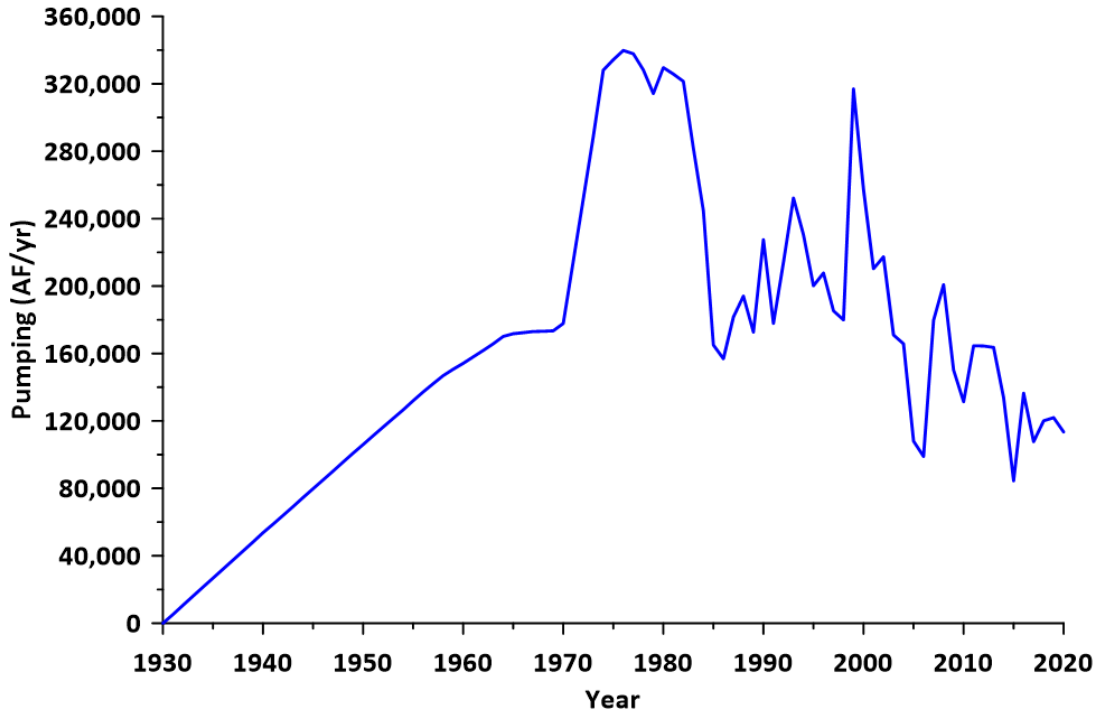
**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Dawson County (Model Domain)**



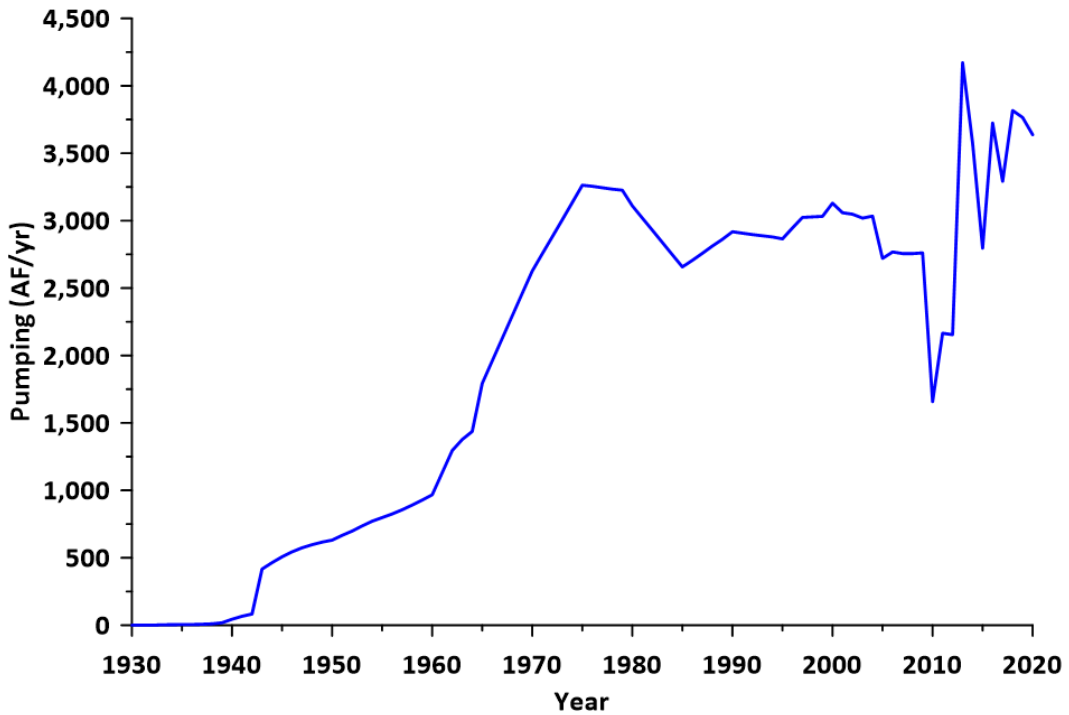
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Dawson County (Model Domain)**



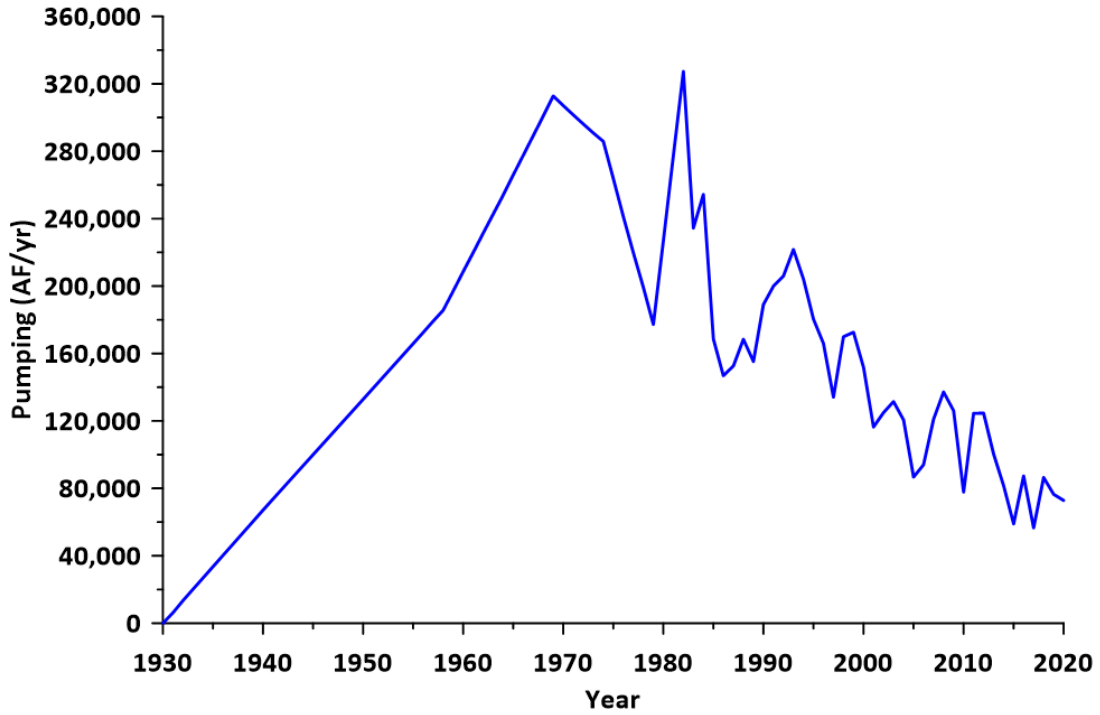
**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Deaf Smith County (Model Domain)**



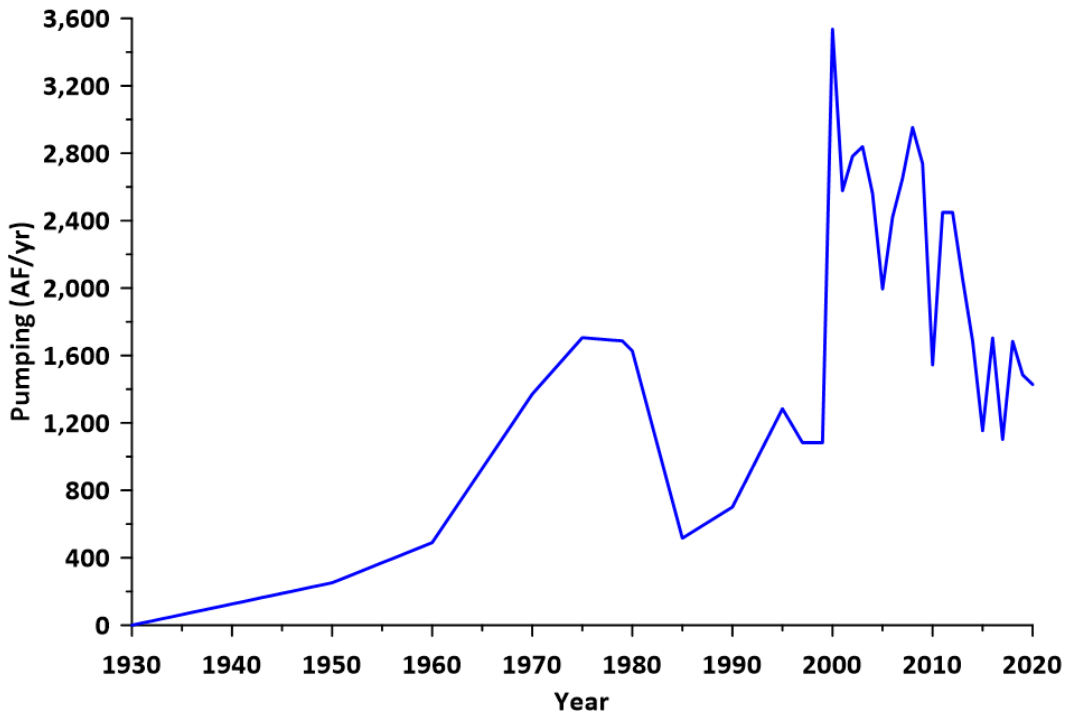
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Deaf Smith County (Model Domain)**



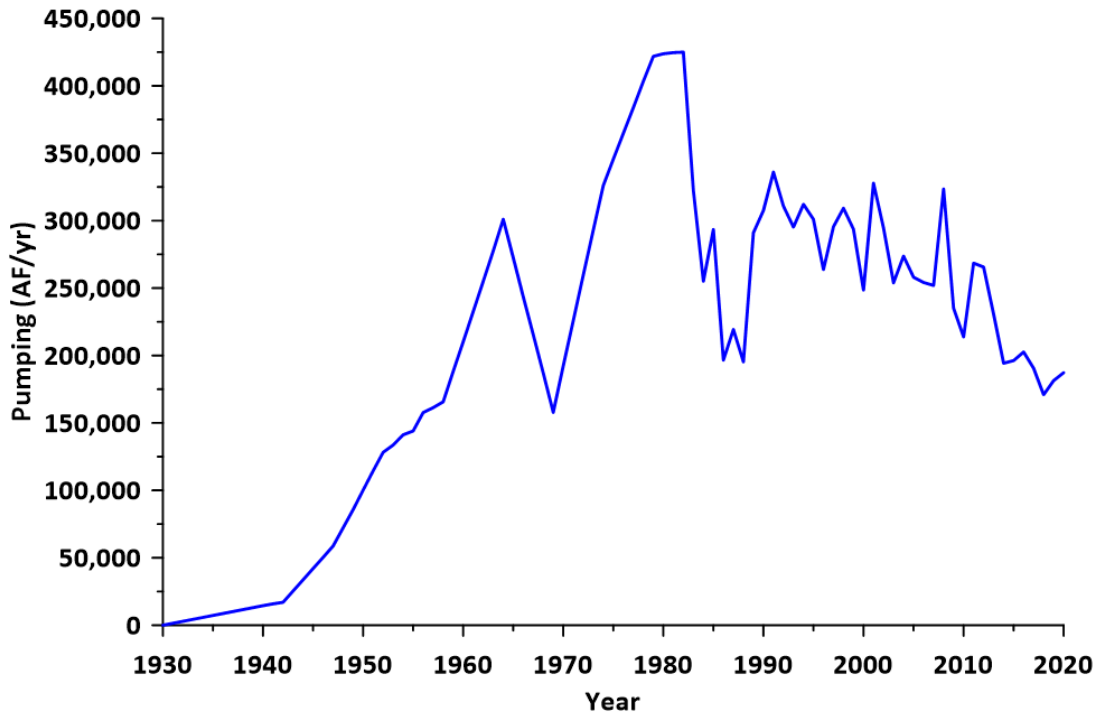
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Ogallala and Edwards-Trinity (High Plains) Aquifers
Floyd County (Model Domain)**



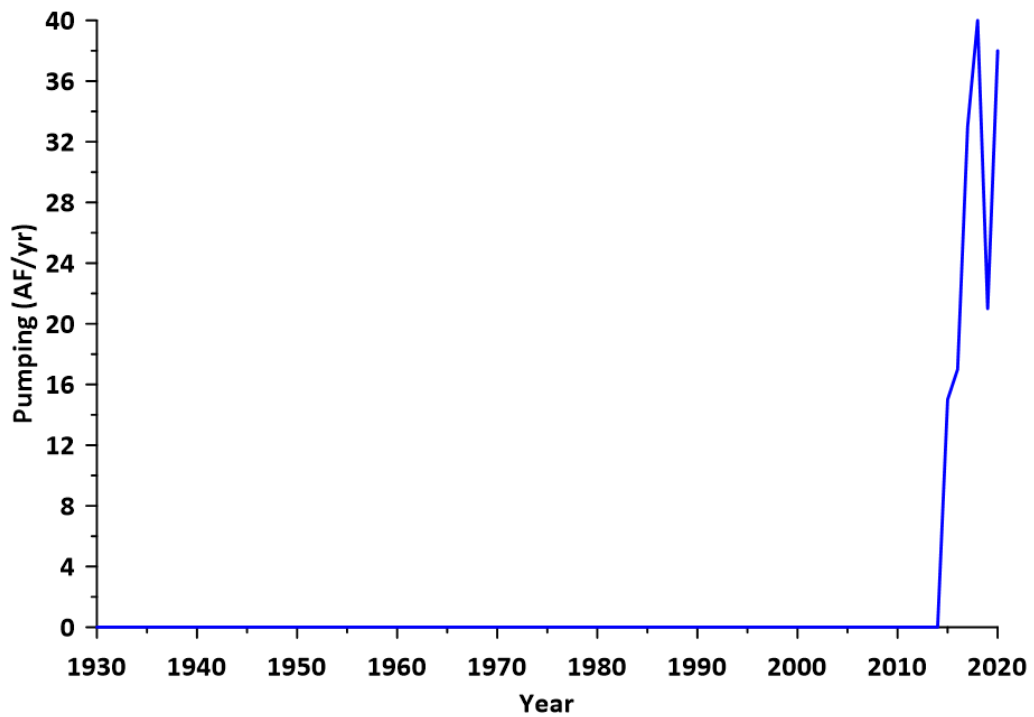
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Dockum Aquifer
Floyd County (Model Domain)**



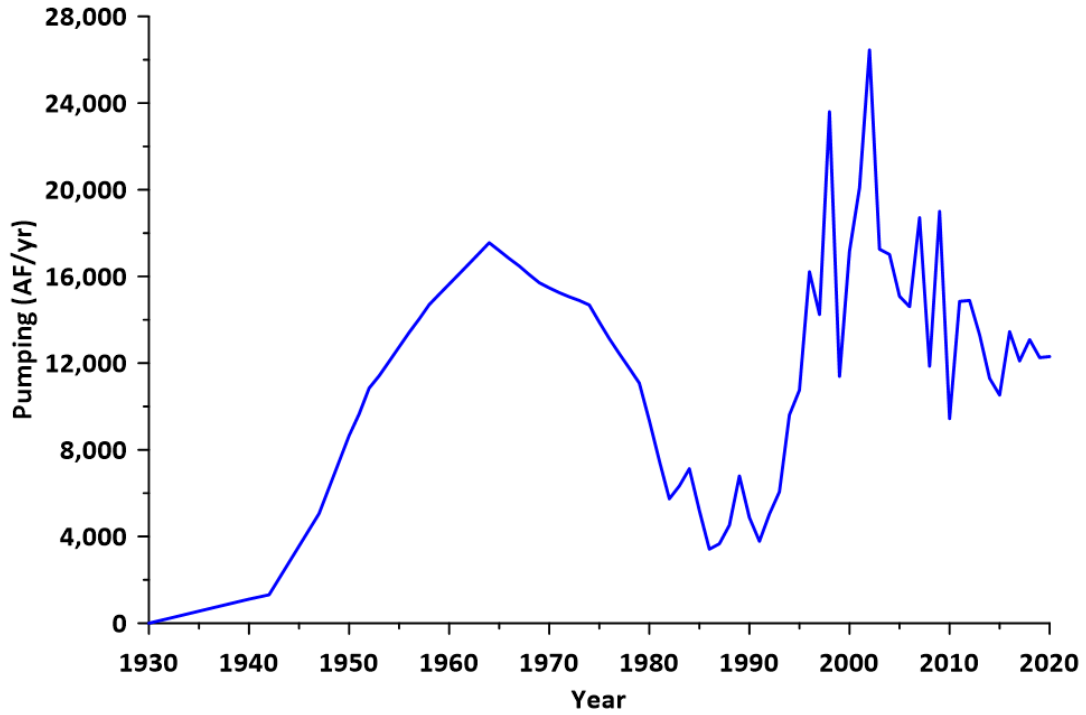
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Ogallala and Edwards-Trinity (High Plains) Aquifers
Gaines County (Model Domain)**



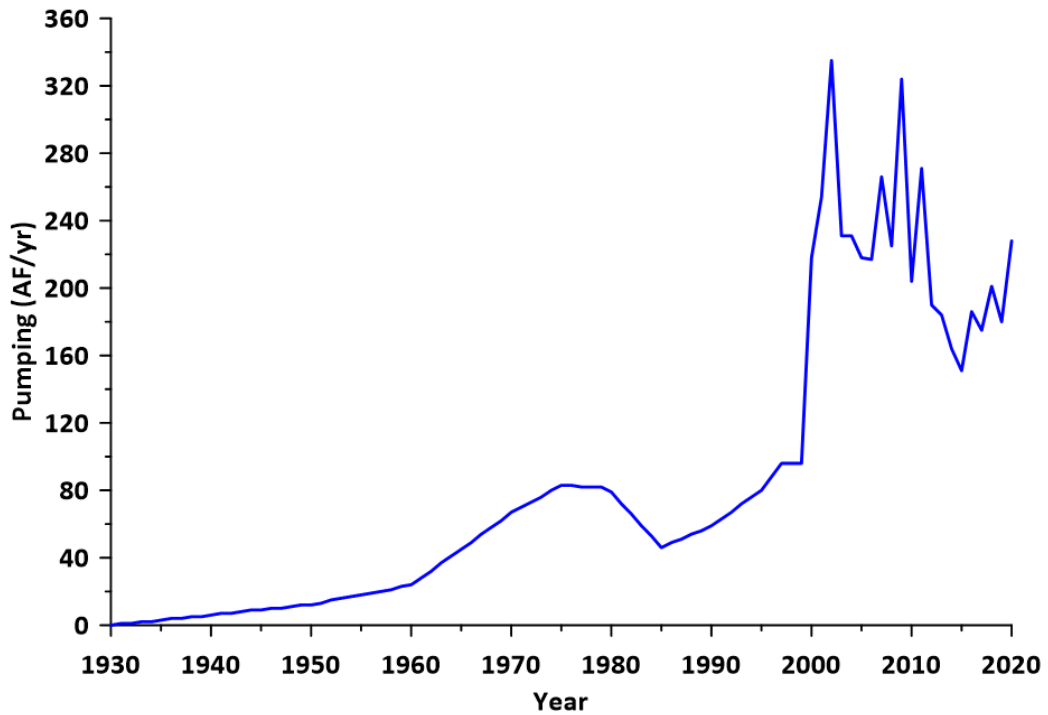
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Dockum Aquifer
Gaines County (Model Domain)**



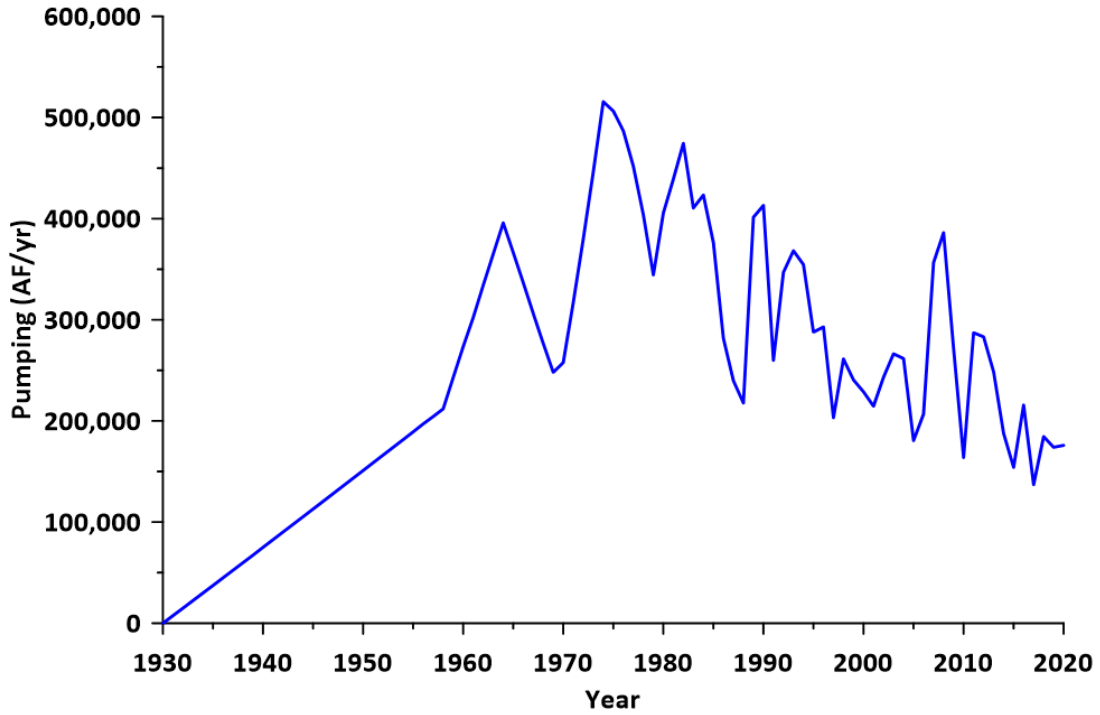
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Ogallala and Edwards-Trinity (High Plains) Aquifers
Garza County (Model Domain)**



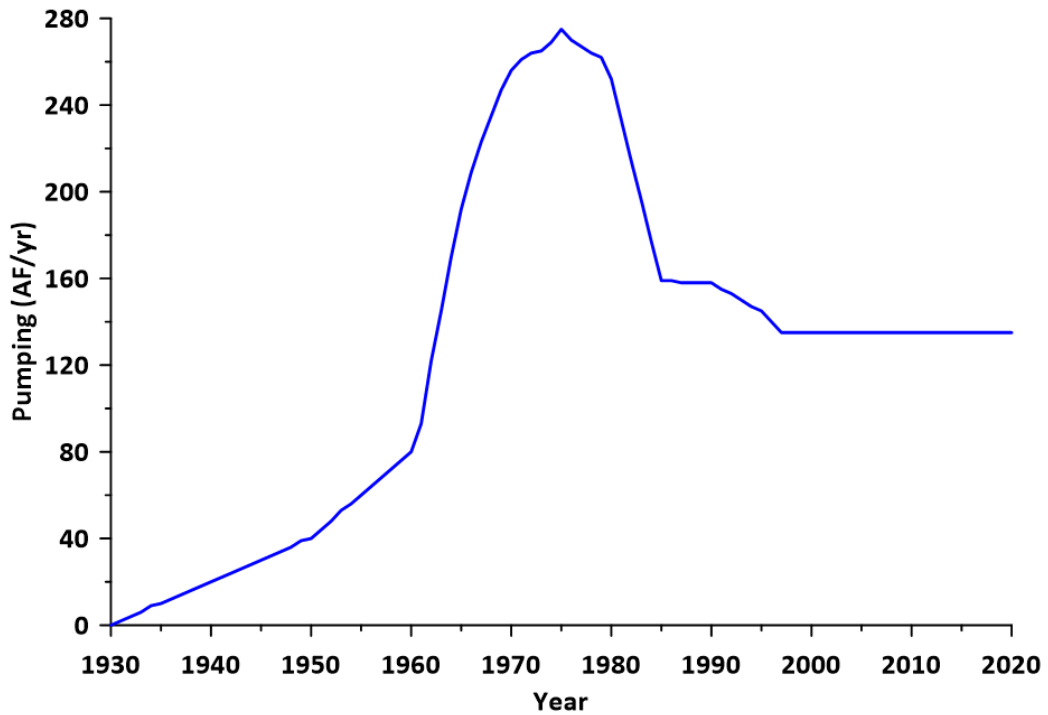
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Dockum Aquifer
Garza County (Model Domain)**



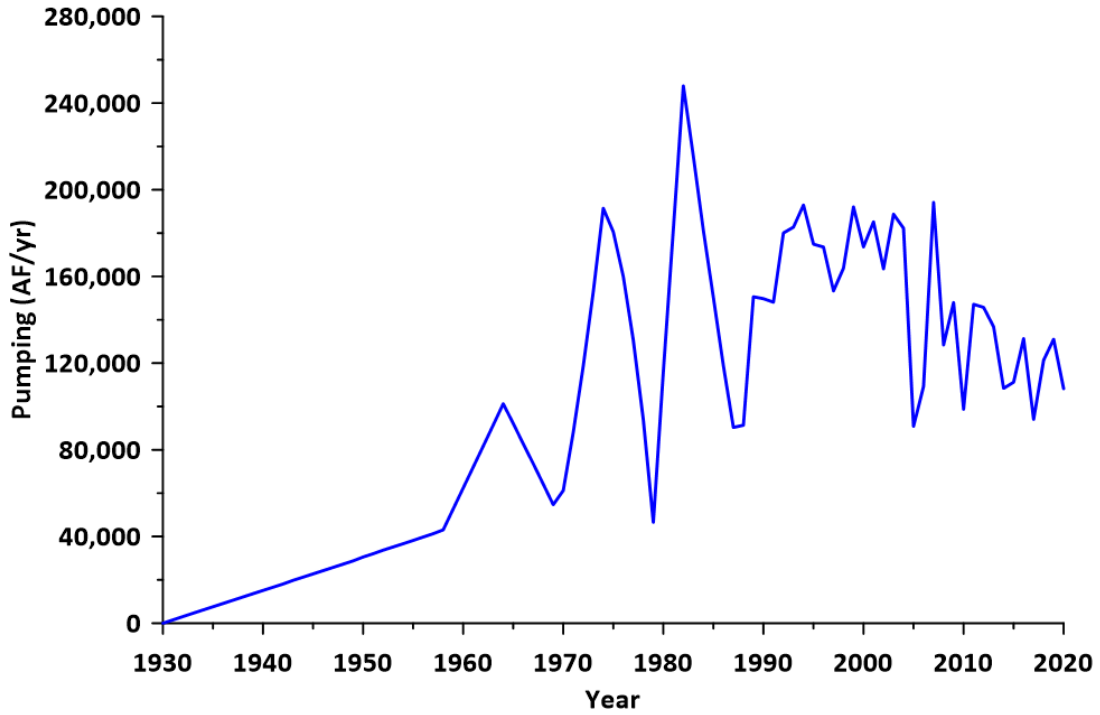
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Ogallala and Edwards-Trinity (High Plains) Aquifers
Hale County (Model Domain)**



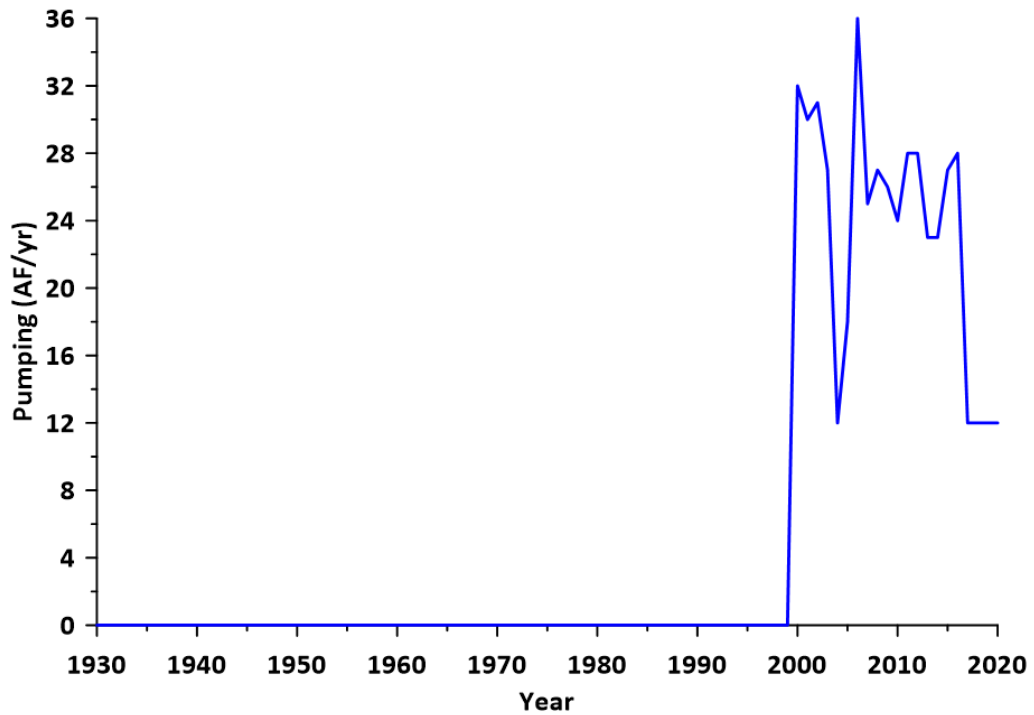
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Hale County (Model Domain)**



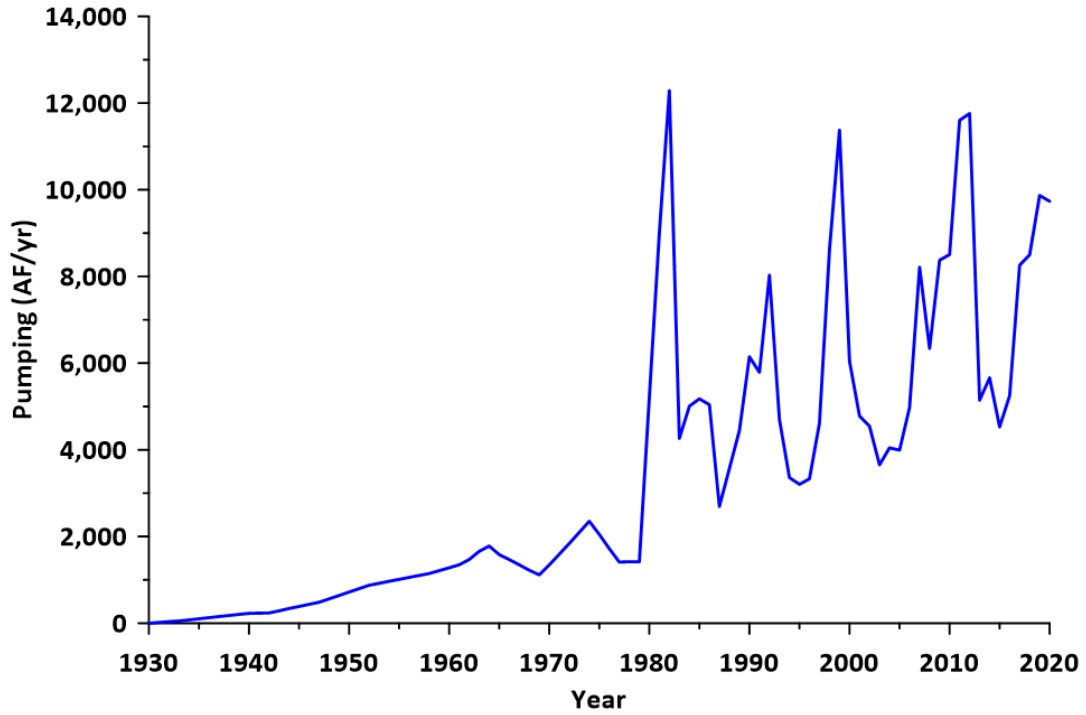
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Ogallala and Edwards-Trinity (High Plains) Aquifers
Hockley County (Model Domain)**



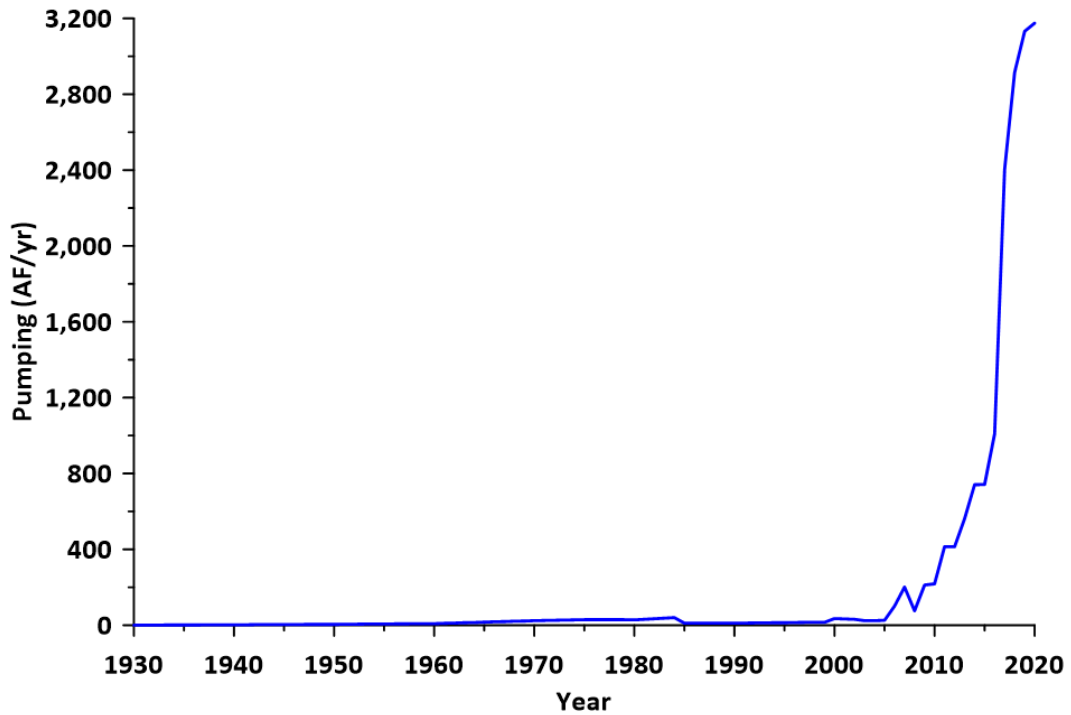
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Hockley County (Model Domain)**



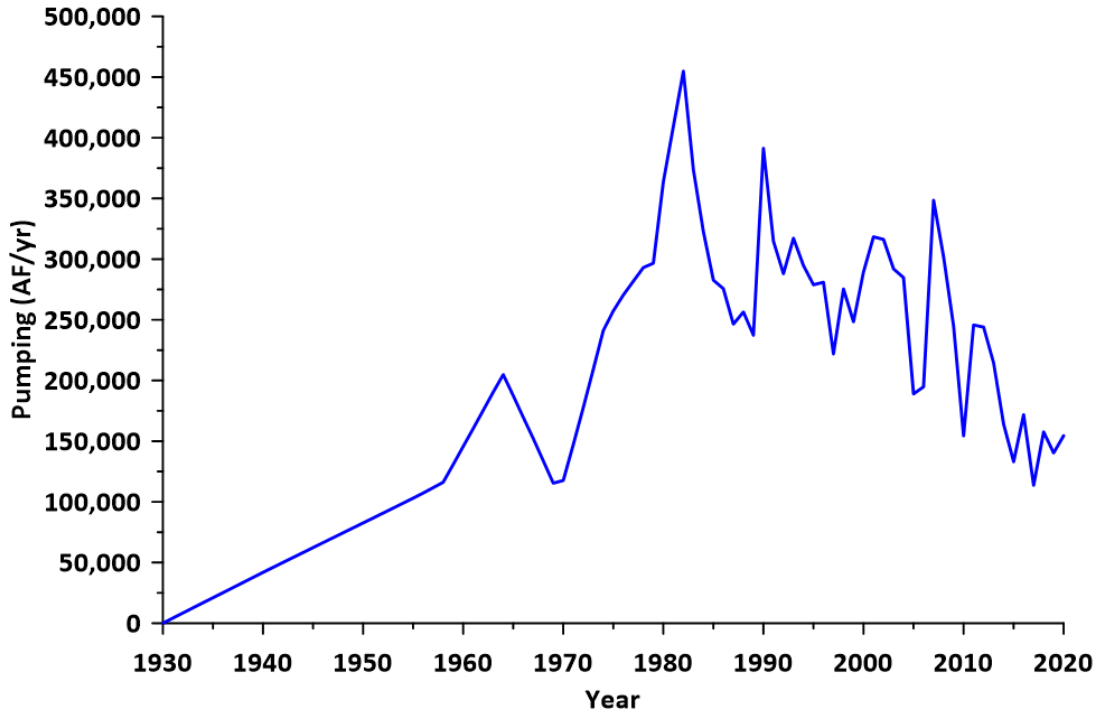
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Ogallala and Edwards-Trinity (High Plains) Aquifers
Howard County (Model Domain)**



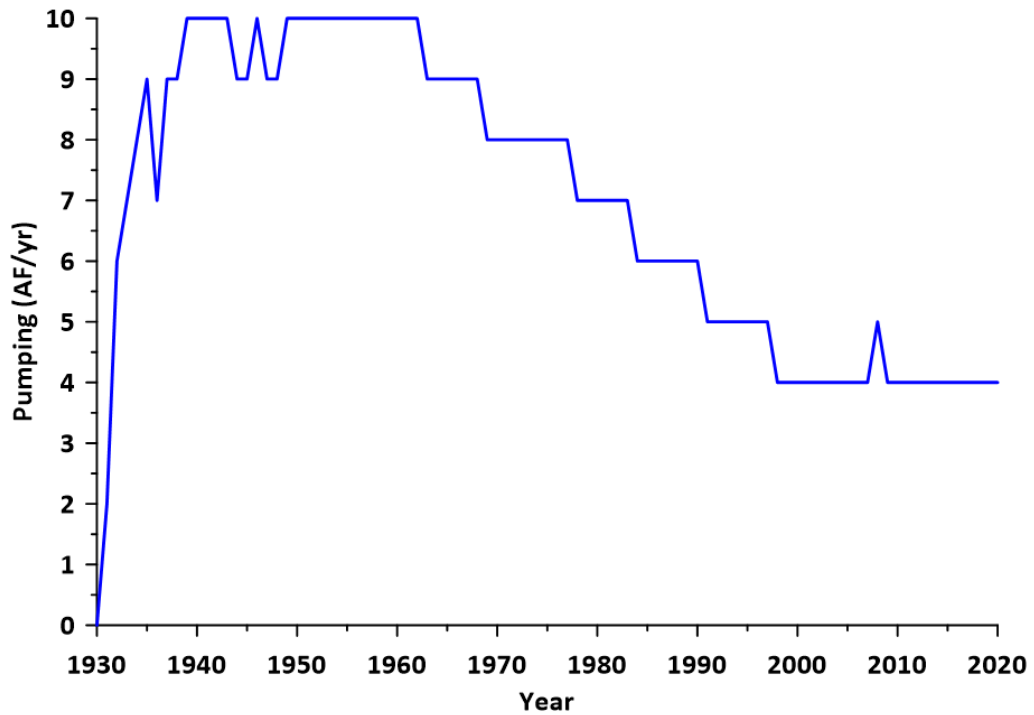
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Howard County (Model Domain)**



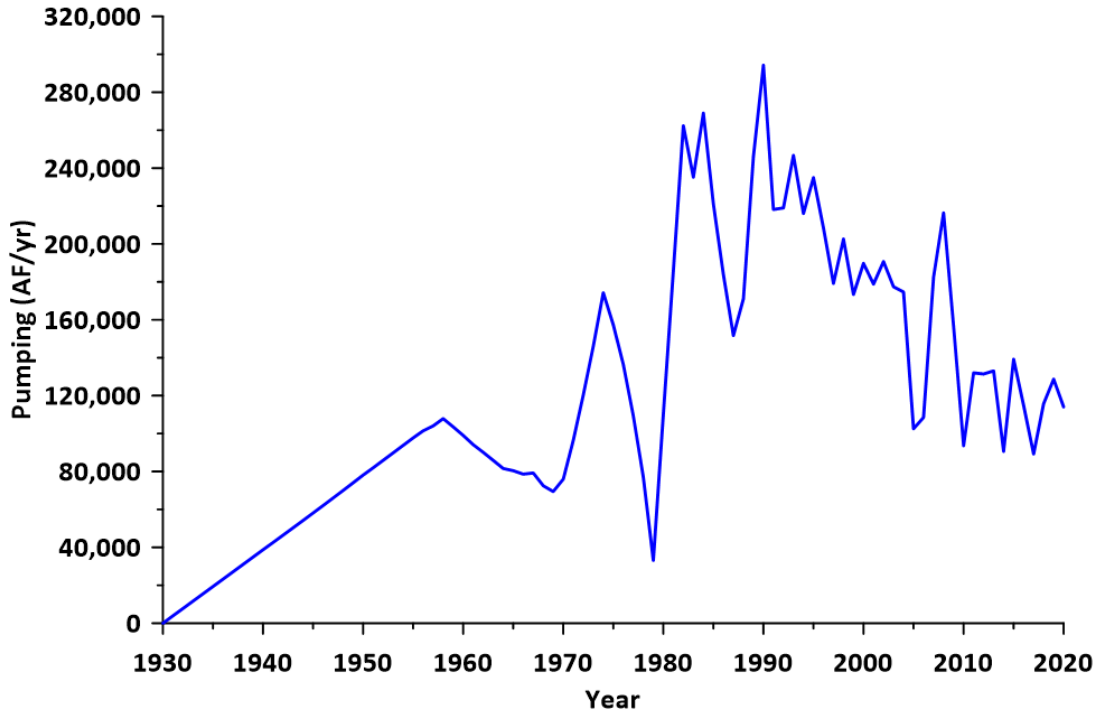
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Ogallala and Edwards-Trinity (High Plains) Aquifers
Lamb County (Model Domain)**



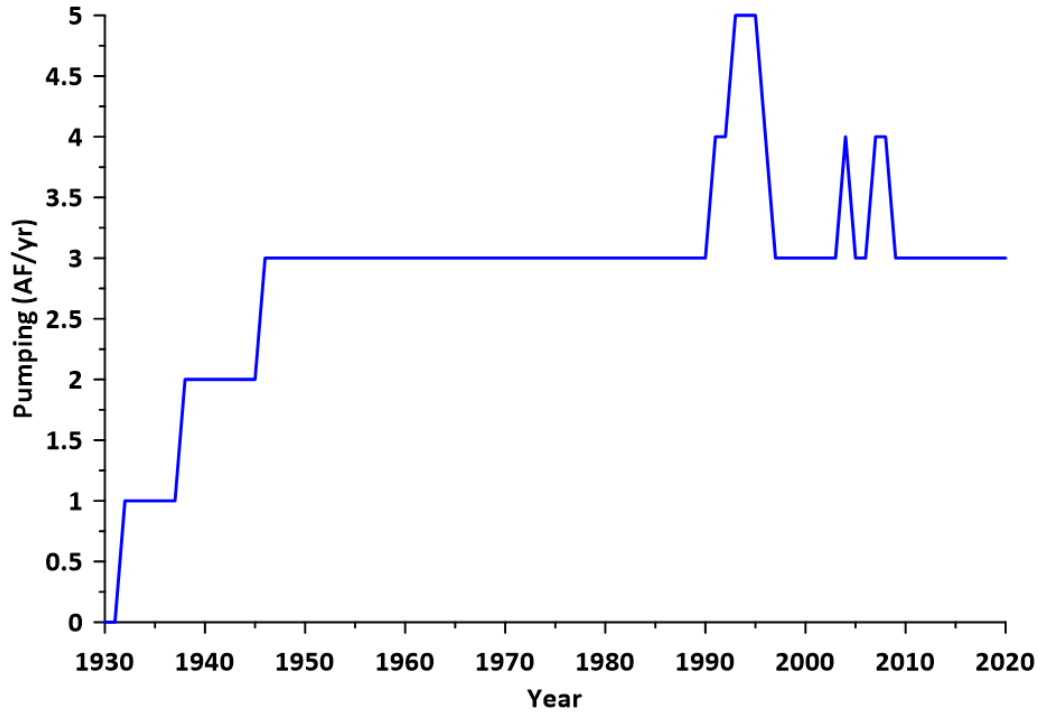
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Lamb County (Model Domain)**



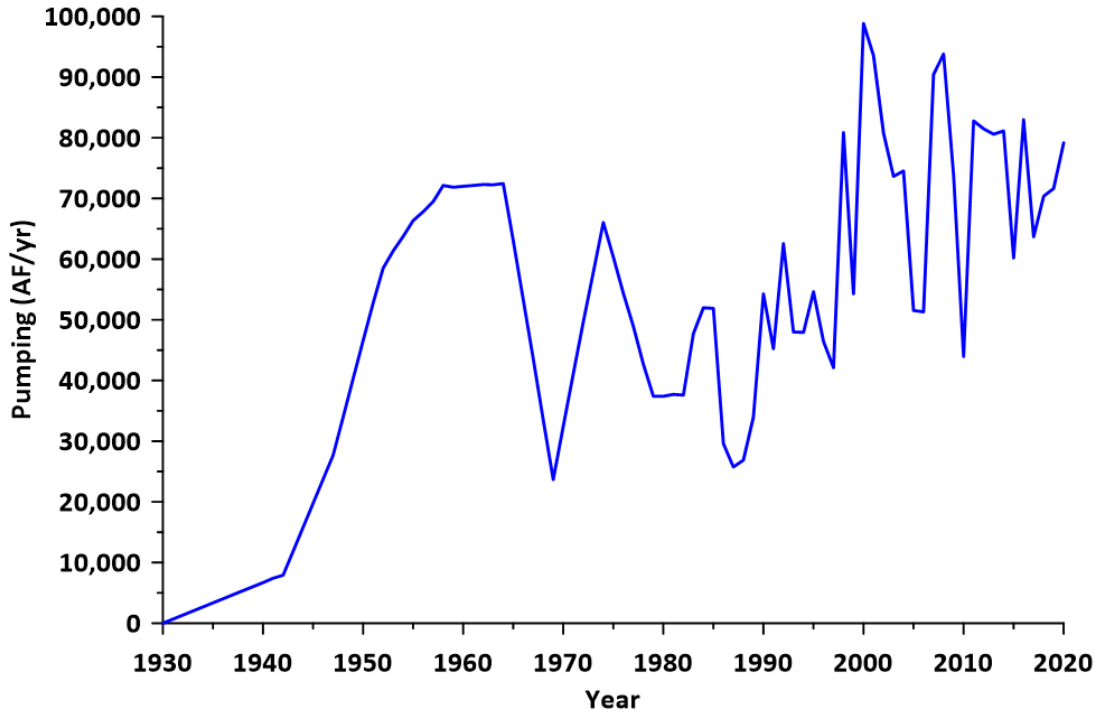
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Lubbock County (Model Domain)**



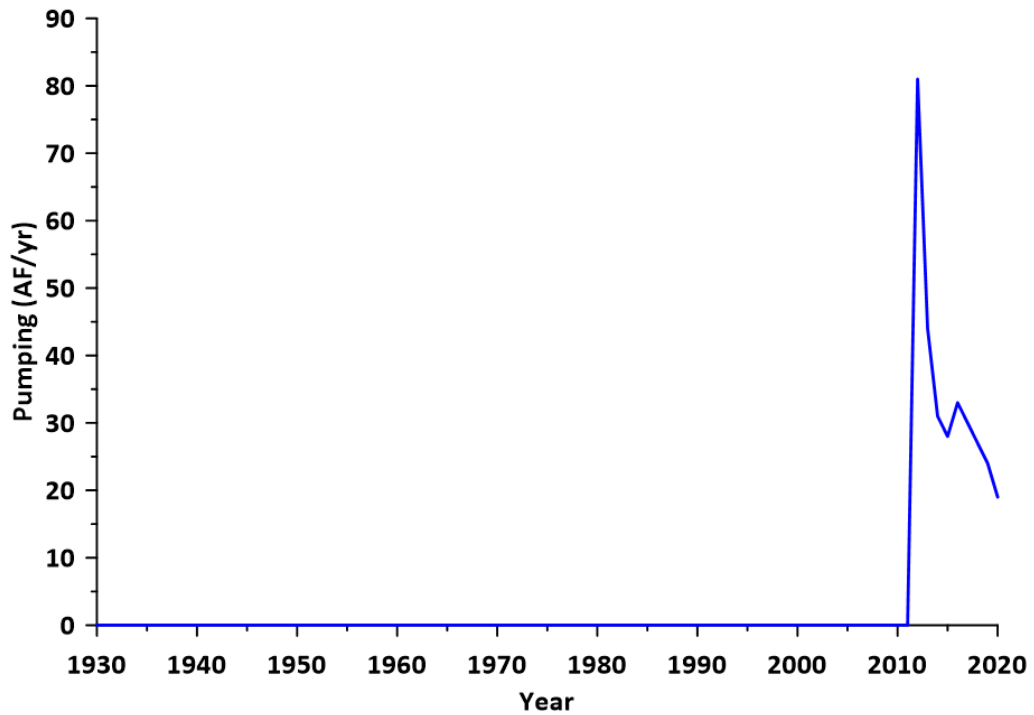
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Lubbock County (Model Domain)**



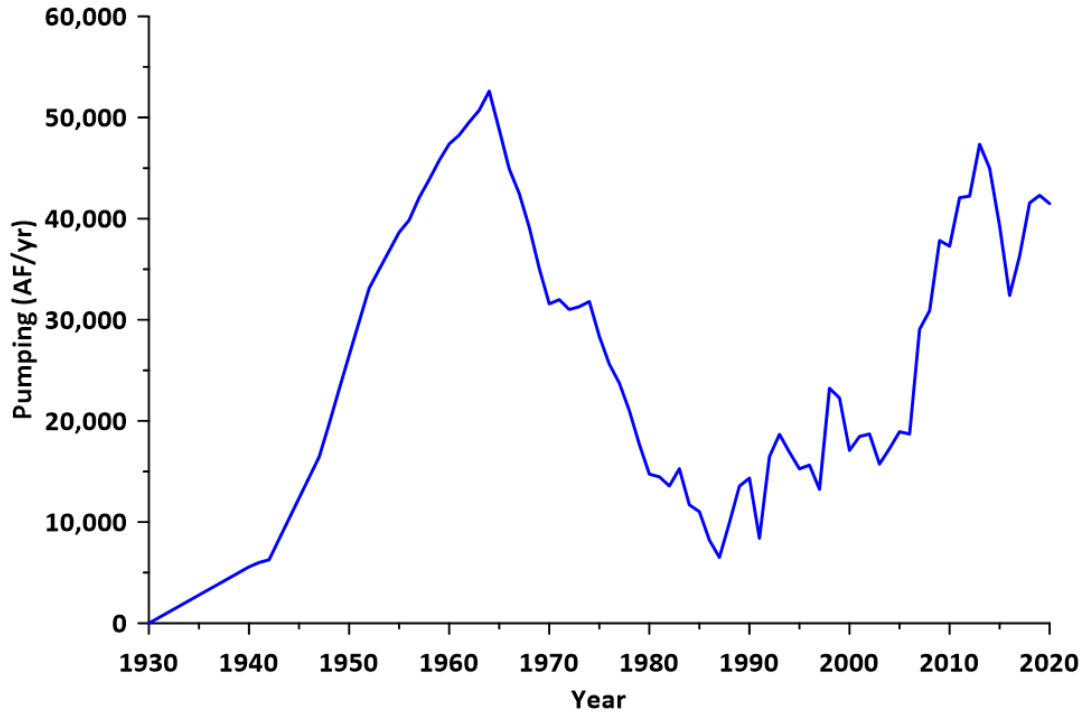
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Ogallala and Edwards-Trinity (High Plains) Aquifers
Lynn County (Model Domain)**



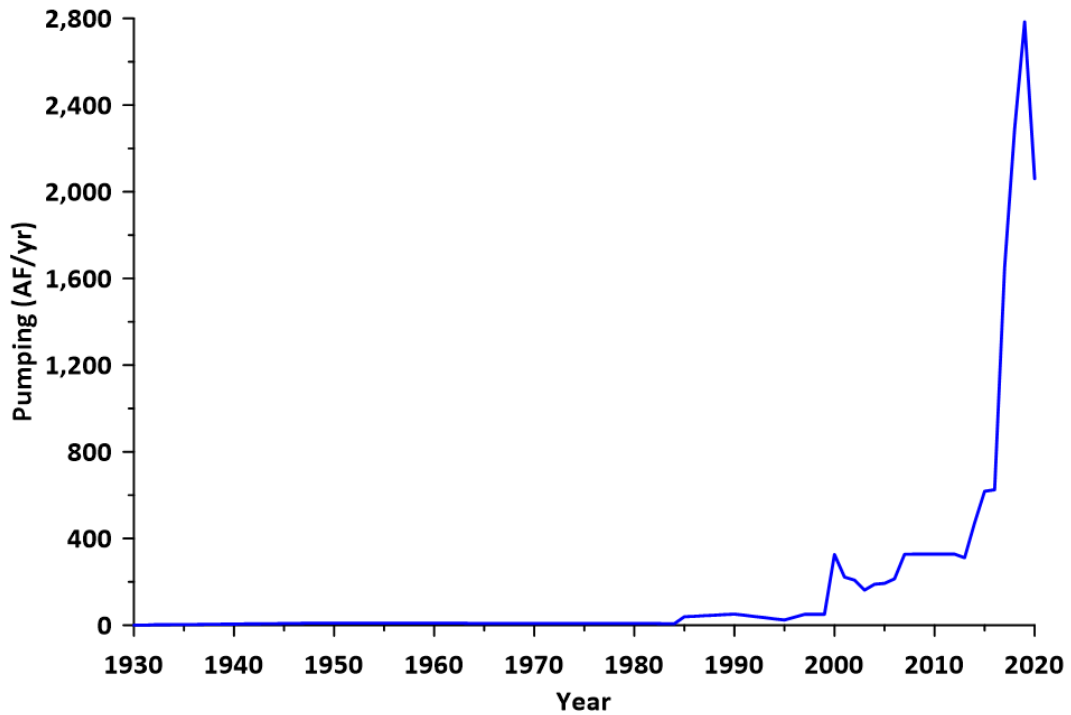
**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Lynn County (Model Domain)**



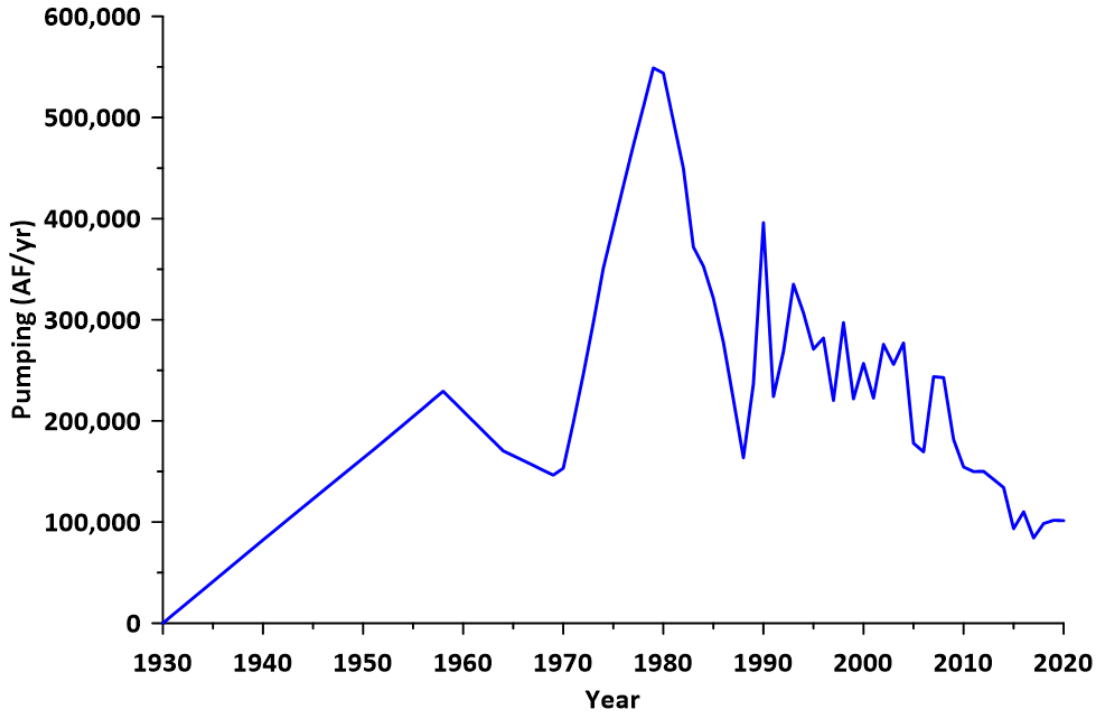
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Ogallala and Edwards-Trinity (High Plains) Aquifers
Martin County (Model Domain)**



**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Martin County (Model Domain)**

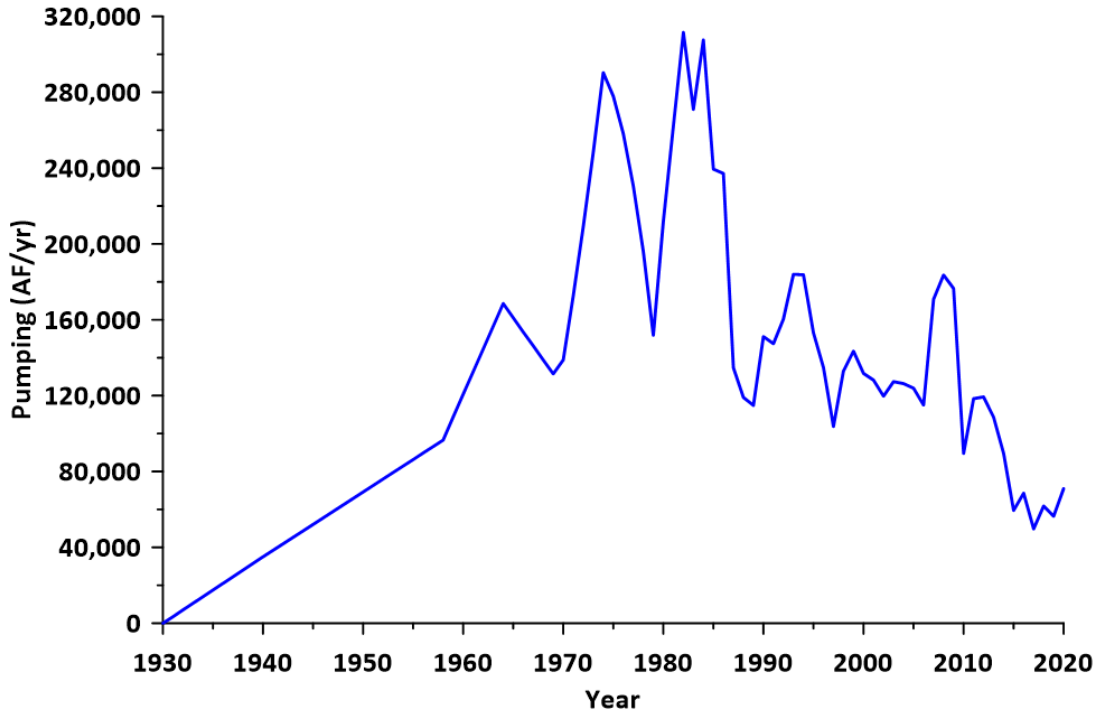


**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Parmer County (Model Domain)**

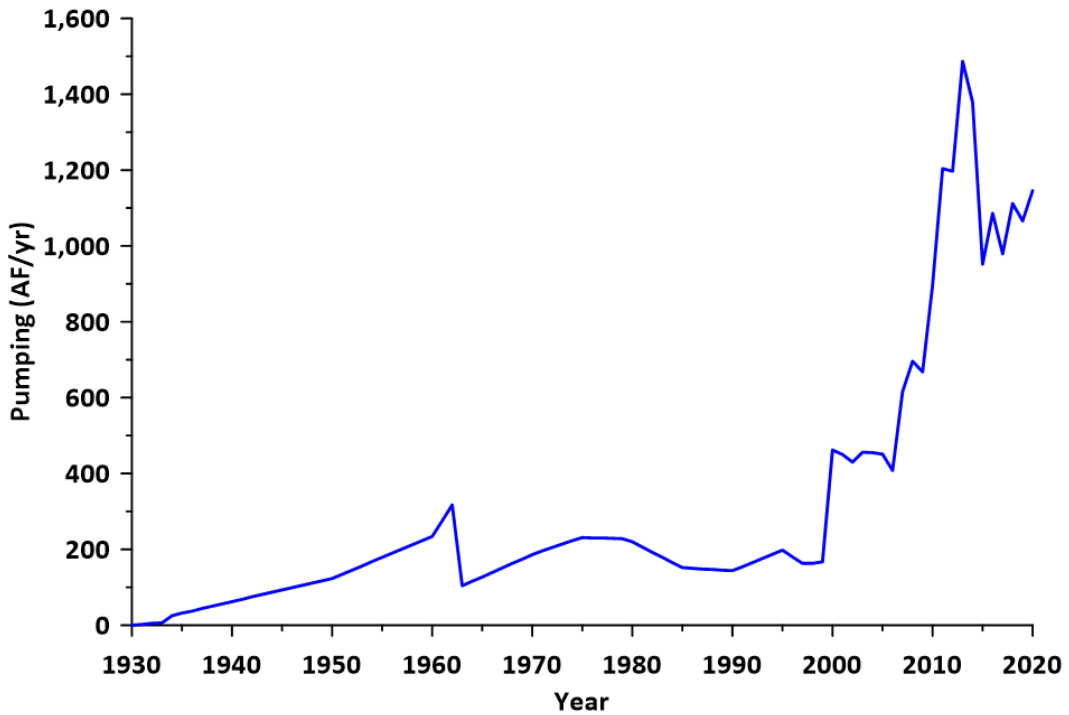


No Dockum pumping in Parmer County

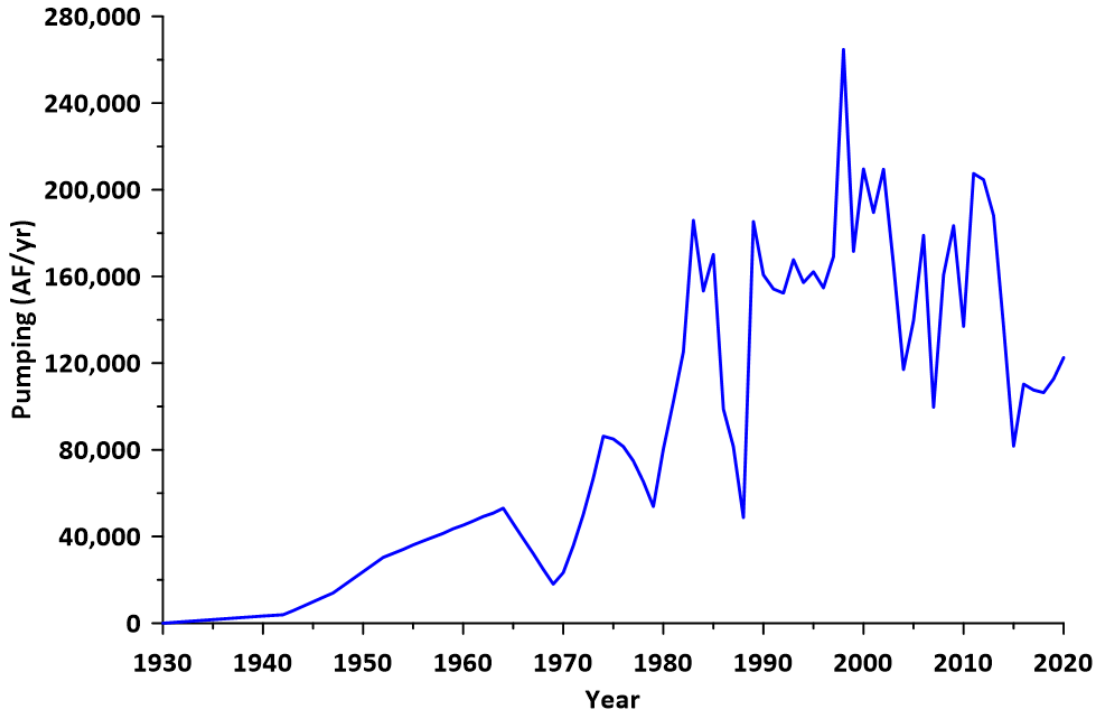
**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Swisher County (Model Domain)**



**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Swisher County (Model Domain)**

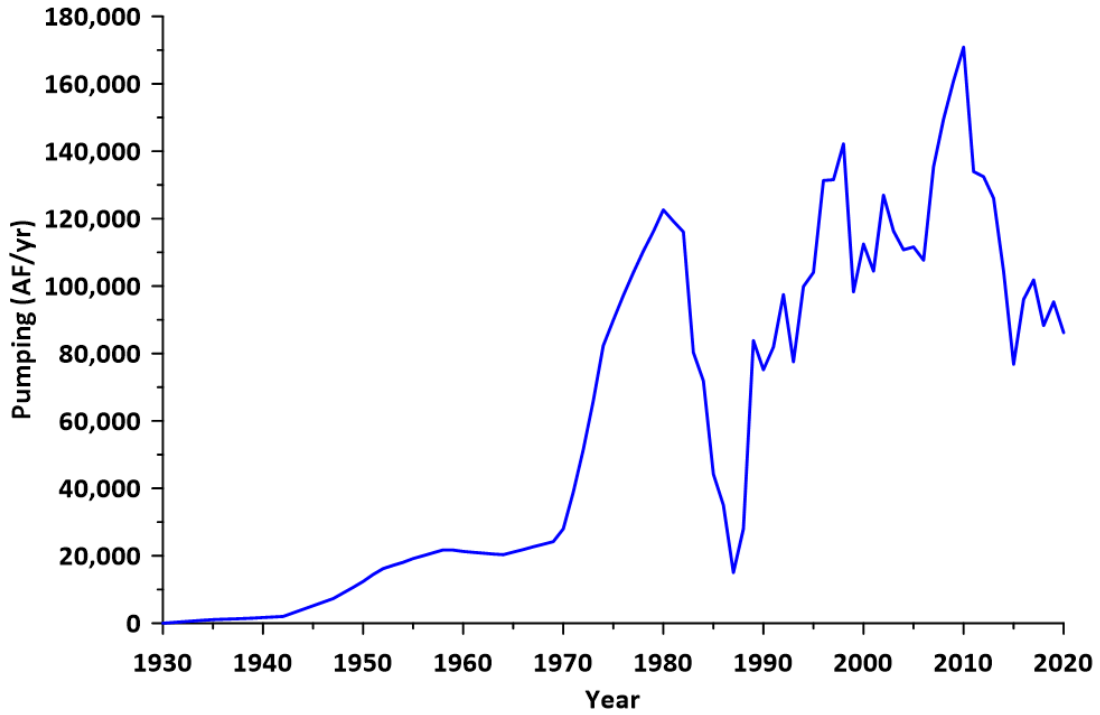


**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Terry County (Model Domain)**

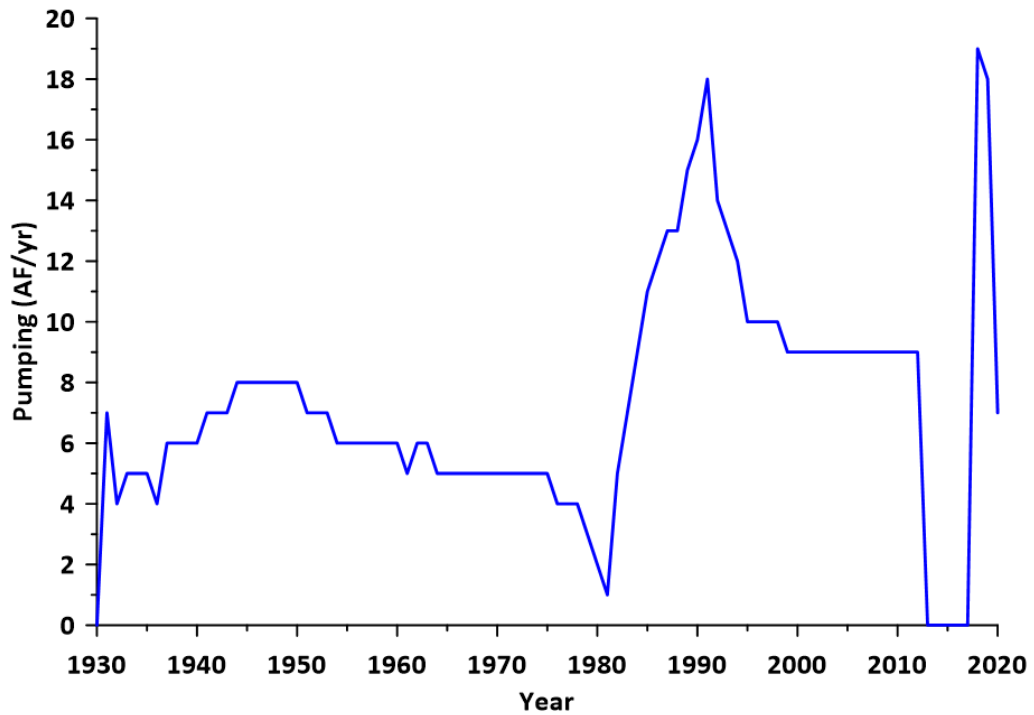


No Dockum pumping in Terry County

**HPAS Groundwater Pumping Estimates
Ogallala and Edwards-Trinity (High Plains) Aquifers
Yoakum County (Model Domain)**



**HPAS Groundwater Pumping Estimates
Dockum Aquifer
Yoakum County (Model Domain)**

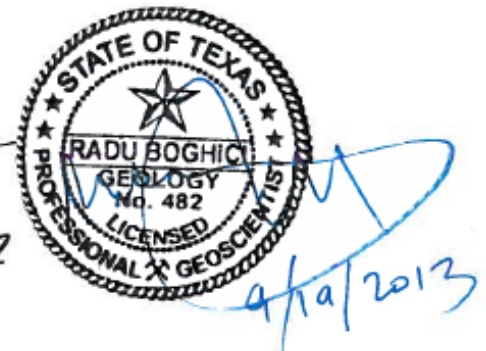
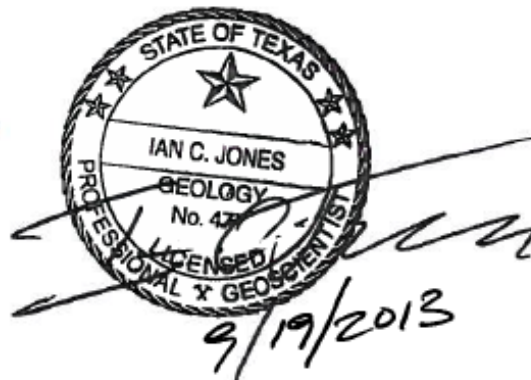


Appendix C

TWDB GAM Task 13-026, Total Estimated Recoverable Storage for GMA 2

GAM TASK 13-026: TOTAL ESTIMATED RECOVERABLE STORAGE FOR AQUIFERS IN GROUNDWATER MANAGEMENT AREA 2

by William Kohlrenken, Radu Boghici, P.G., and Ian Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-8279¹
September 19, 2013



Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by William Kohlrenken under her direct supervision. The seals appearing on this document were authorized by Cynthia K. Ridgeway, P.G. 471, Ian C. Jones, P.G. 477, and Radu Boghici, P.G. 482 on September 19, 2013.

The total estimated recoverable storage in this report was calculated as follows: the Dockum Aquifer, Edwards-Trinity (High Plains), and Ogallala aquifers (William Kohlrenken); the Seymour Aquifer (Radu Boghici); and the Edwards-Trinity (Plateau) and Pecos Valley aquifers (Ian Jones).

¹ This is the office telephone number for William Kohlrenken

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GAM TASK 13-026: TOTAL ESTIMATED RECOVERABLE STORAGE FOR AQUIFERS IN GROUNDWATER MANAGEMENT AREA 2

by William Kohlrenken, Radu Boghici, P.G., and Ian Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-8279²
September 19, 2013

EXECUTIVE SUMMARY:

Texas Water Code, § 36.108 (d) (Texas Water Code, 2011) states that, before voting on the proposed desired future conditions for a relevant aquifer within a groundwater management area, the groundwater conservation districts shall consider the total estimated recoverable storage as provided by the executive administrator of the Texas Water Development Board (TWDB) along with other factors listed in §36.108 (d). Texas Administrative Code Rule §356.10 (Texas Administrative Code, 2011) defines the total estimated recoverable storage as the estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume.

This report discusses the methods, assumptions, and results of analyses to estimate the total recoverable storage for the Dockum, Edwards-Trinity (High Plains), Edwards-Trinity (Plateau), Ogallala, Seymour, and Pecos Valley aquifers within Groundwater Management Area 2. Tables 1 through 12 summarize the total estimated recoverable storage required by the statute. Figures 2 through 7 indicate the extent of the groundwater availability models used to estimate the total recoverable storage.

DEFINITION OF TOTAL ESTIMATED RECOVERABLE STORAGE:

The total estimated recoverable storage is defined as the estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25 percent and 75

² This is the office telephone number for William Kohlrenken

percent of the porosity-adjusted aquifer volume. In other words, we assume that between 25 and 75 percent of groundwater held within an aquifer can be removed by pumping.

The total recoverable storage was estimated for the portion of each aquifer within Groundwater Management Area 2 that lies within the official lateral aquifer boundaries as delineated by George and others (2011). Total estimated recoverable storage values may include a mixture of water quality types, including fresh, brackish, and saline groundwater, because the available data and the existing groundwater availability models do not permit the differentiation of different water quality types. These values do not take into account the effects of land surface subsidence, degradation of water quality, or any changes to surface water-groundwater interaction as the result of extracting groundwater from the aquifer.

METHODS:

To estimate the total recoverable storage of an aquifer, we first calculated the total storage in an aquifer within the official aquifer boundary in the groundwater management area. The total storage is the volume of groundwater that can be removed by completely draining the aquifer.

Aquifers can be either unconfined or confined (Figure 1). A well screened in an unconfined aquifer will have a water level equal to the water level in the aquifer outside the well. Thus, unconfined aquifers have water levels within the aquifers. A confined aquifer is bounded by low permeable geologic units at the top and bottom, and the aquifer is under hydraulic pressure above the ambient atmospheric pressure. The water level at a well screened in a confined aquifer will be above the top of the aquifer. As a result, calculation of total storage is also different between unconfined and confined aquifers. For an unconfined aquifer, the total storage is equal to the volume of groundwater that makes the water level fall to the aquifer bottom. For a confined aquifer, the total storage contains two parts. The first part is the groundwater released from the aquifer when the water level falls from above the top of the aquifer to the top of the aquifer. The reduction of hydraulic pressure in the aquifer by pumping causes expansion of groundwater and deformation of aquifer solids. The aquifer is still fully saturated to this point. The second part, just like unconfined aquifer, is the groundwater released from the aquifer when the water level falls from the top to the bottom of the aquifer. Given the same aquifer area and water level drop, the amount of water

released in the second part is much greater than the first part. The difference is quantified by two parameters: storativity related to confined aquifer and specific yield related to unconfined aquifer. For example, storativity values range from 10^{-5} to 10^{-3} for most confined aquifers, while the specific yield values can be 0.01 to 0.3 for most unconfined aquifers. The equations for calculating the total storage are presented below:

- for unconfined aquifers

$$Total\ Storage = V_{drained} = Area \times S_y \times (Water\ Level - Bottom)$$

- for confined aquifers

$$Total\ Storage = V_{confined} + V_{drained}$$

- confined part

$$V_{confined} = Area \times [S \times (Water\ Level - Top)]$$

or

$$V_{confined} = Area \times [S_s \times (Top - Bottom) \times (Water\ Level - Top)]$$

- unconfined part

$$V_{drained} = Area \times [S_y \times (Top - Bottom)]$$

where:

- $V_{drained}$ = storage volume due to water draining from the formation (acre-feet)
- $V_{confined}$ = storage volume due to elastic properties of the aquifer and water(acre-feet)
- $Area$ = area of aquifer (acre)
- $Water\ Level$ = groundwater elevation (feet above mean sea level)
- Top = elevation of aquifer top (feet above mean sea level)
- $Bottom$ = elevation of aquifer bottom (feet above mean sea level)
- S_y = specific yield (no units)
- S_s = specific storage (1/feet)
- S = storativity or storage coefficient (no units)

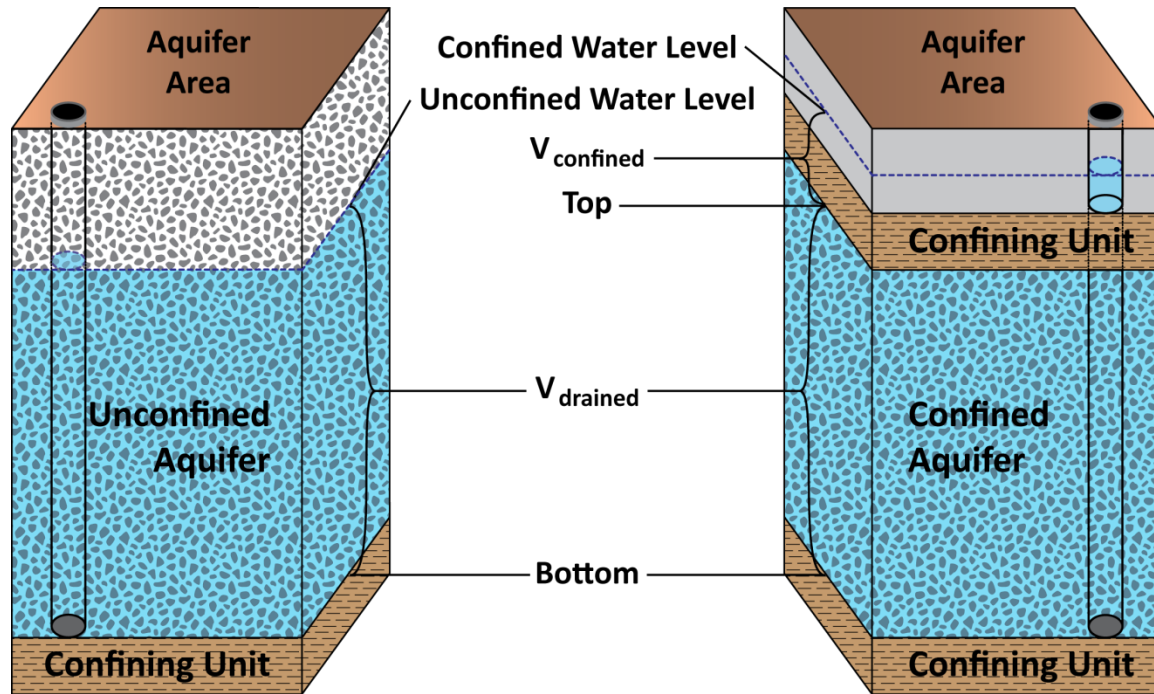


FIGURE 1. SCHEMATIC GRAPH SHOWING THE DIFFERENCE BETWEEN UNCONFINED AND CONFINED AQUIFERS.

As presented in the equations, calculation of the total storage requires data, such as aquifer top, aquifer bottom, aquifer storage properties, and water level. For the Dockum, Edwards-Trinity (High Plains), Edwards-Trinity (Plateau), Ogallala, and Seymour aquifers in Groundwater Management Area 2, we extracted this information from existing groundwater availability model input and output files on a cell-by-cell basis. This information was contained in model input and output files on a cell-by-cell basis. In the absence of groundwater availability model(s), the total storage will be calculated using other approaches.

Python scripts and a FORTRAN-90 program were developed and used to expedite the storage calculation. The total recoverable storage was calculated as the product of the total storage and an estimated factor ranging from 25 percent to 75 percent.

The following methodology was used to estimate total recoverable storage for parts of the Pecos Valley and Edwards-Trinity (Plateau) aquifers in Groundwater Management Area 2 that were not included in the 1-layered alternative groundwater flow model covering these aquifers (Hutchison and others, 2011). The excluded parts of the respective aquifers are relatively thin, mostly located along the margins of the respective aquifers in the western part of the model.

Recoverable storage in areas outside of the model but within the official aquifer boundaries is estimated by first establishing a relationship between aquifer thickness and saturated thickness. Where aquifer thickness is the difference between the elevations of the aquifer top and base, and saturated thickness is the difference between the water table and aquifer base elevations. In each of the three aquifers included in this model there is a generally linear relationship between aquifer thickness and saturated thickness. In the Pecos Valley Aquifer, the ratio between saturated thickness and aquifer thickness is approximately 0.8, while in the Edwards-Trinity (Plateau) and Trinity aquifers, it is 0.9 and 0.6, respectively. Saturated thickness in the non-modeled areas is estimated using these ratios.

The three aquifers—Pecos Valley and Edwards-Trinity (Plateau) aquifers, and the Hill Country portion of the Trinity Aquifer—are assumed to be unconfined. Consequently, storage in each model cell representing parts of the respective aquifers excluded from the groundwater flow model is estimated using the following equation:

$$Total\ Storage = V_{drained} = Area \times S_y \times H_{sat}$$

where:

- $V_{drained}$ = storage volume due to water draining from the formation (acre-feet)
- $Area$ = area of aquifer (acre)
- S_y = specific yield (no units)
- H_{sat} = estimated saturated thickness (feet)

Storage volumes estimated using this method were added to the storage volumes from the remainder of the modeled area to estimate the total recoverable storage for the entire aquifer.

PARAMETERS AND ASSUMPTIONS:

Dockum Aquifer

- We used version 1.01 of the groundwater availability model for the Dockum Aquifer to estimate the total recoverable storage. See Ewing and others (2008) for assumptions and limitations of the groundwater availability model.
- This groundwater availability model includes three layers which generally represent the younger geologic units overlying the Dockum Aquifer (Layer 1), the upper portion of the Dockum Aquifer (Layer 2), and the lower portion of the Dockum Aquifer (Layer 3).
- Of the three layers, total estimated recoverable storage was determined and combined for layers representing the Dockum Aquifer (layers 2 and 3).
- The down-dip boundary of the Dockum Aquifer in this model was set to approximately coincide with the extent of the available geologic data, well beyond any active portion (groundwater use) of the aquifer (Ewing and others, 2008). Consequently, the model extends into zones of brackish and saline groundwater. The official extent of the Dockum Aquifer was used to exclude this area (George and others, 2011).

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

- We used version 2.01 of the groundwater availability model to estimate the total recoverable storages of the southern portion of the Ogallala and Edwards-Trinity (High Plains) aquifers. This model is an expansion on and update to the previously developed groundwater availability model for the southern portion of the Ogallala Aquifer described in Blandford and others (2003). See Blandford and others (2008) and Blandford and others (2003) for assumptions and limitations of the groundwater availability model.
- This groundwater availability model includes 4 layers which represent the southern portion of the Ogallala (Layer 1) and the Edwards-Trinity (High Plains) (primarily Edwards, Comanche Peak, and Antlers Sand formations; layers 2-4).

- Of the four layers, total estimated recoverable storage was determined for the Ogallala Aquifer (Layer 1) and Edwards-Trinity (High Plains) Aquifer (layers 2-4) in Groundwater Management Area 2.

Edwards-Trinity (Plateau) and Pecos Valley aquifers

- We used alternative groundwater flow model for the Edwards-Trinity (Plateau) Aquifer. See Hutchison and Others (2011) for assumptions and limitations of the alternative numerical groundwater flow model.
- This 1-layer groundwater flow model simulates groundwater flow through the Pecos Valley and Edwards-Trinity (Plateau) aquifers, and the Hill Country portion of the Trinity Aquifer.
- In this model, where the Pecos Valley and Edwards-Trinity (Plateau) aquifer overlap, total storage is assigned to the Pecos Valley Aquifer.

Seymour Aquifer

- We used version 1.01 of the groundwater availability model for the Seymour and Blaine aquifers. See Ewing and others (2004) for assumptions and limitations of the groundwater availability model.
- This groundwater availability model includes two layers, representing the Seymour (Layer 1) and Blaine (Layer 2) aquifers. In areas where the Blaine Aquifer does not exist the model roughly replicates the various Permian units located in the study area.
- Of the two layers, total estimated recoverable storage was determined using the cells in the model that represent the Seymour Aquifer in Layer 1.

RESULTS:

Tables 1 through 12 summarize the total estimated recoverable storage required by statute. The county and groundwater conservation district total estimates are rounded to two significant figures. Figures 2 through 7 indicate the extent of the groundwater availability models in Groundwater Management Area 2 for the Dockum, Edwards-Trinity (High Plains), Edwards-Trinity (Plateau), Ogallala, Seymour, and Pecos Valley aquifers from which the storage information was extracted.

TABLE 1. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE DOCKUM AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>County</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
Andrews	220,000,000	55,000,000	165,000,000
Borden	7,600,000	1,900,000	5,700,000
Briscoe	18,000,000	4,500,000	13,500,000
Castro	7,000,000	1,750,000	5,250,000
Crosby	30,000,000	7,500,000	22,500,000
Deaf Smith	130,000,000	32,500,000	97,500,000
Floyd	40,000,000	10,000,000	30,000,000
Gaines	200,000,000	50,000,000	150,000,000
Garza	4,900,000	1,225,000	3,675,000
Hale	16,000,000	4,000,000	12,000,000
Howard	22,000,000	5,500,000	16,500,000
Martin	11,000,000	2,750,000	8,250,000
Parmer	30,000,000	7,500,000	22,500,000
Swisher	66,000,000	16,500,000	49,500,000
Total	802,500,000	200,625,000	601,875,000

TABLE 2. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT (GCD)³ FOR THE DOCKUM AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>Groundwater Conservation District (GCD)</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
Garza County UWCD ⁴	4,900,000	1,225,000	3,675,000
High Plains UWCD No.1	250,000,000	62,500,000	187,500,000
Llano Estacado UWCD	200,000,000	50,000,000	150,000,000
Permian Basin UWCD	32,000,000	8,000,000	24,000,000
No District	310,000,000	77,500,000	232,500,000
Total	796,900,000	199,225,000	597,675,000

³ The total estimated recoverable storages by groundwater conservation district and county aquifer may not be the same because the numbers have been rounded to two significant figures.

⁴ UWCD is the abbreviation for Underground Water Conservation District.

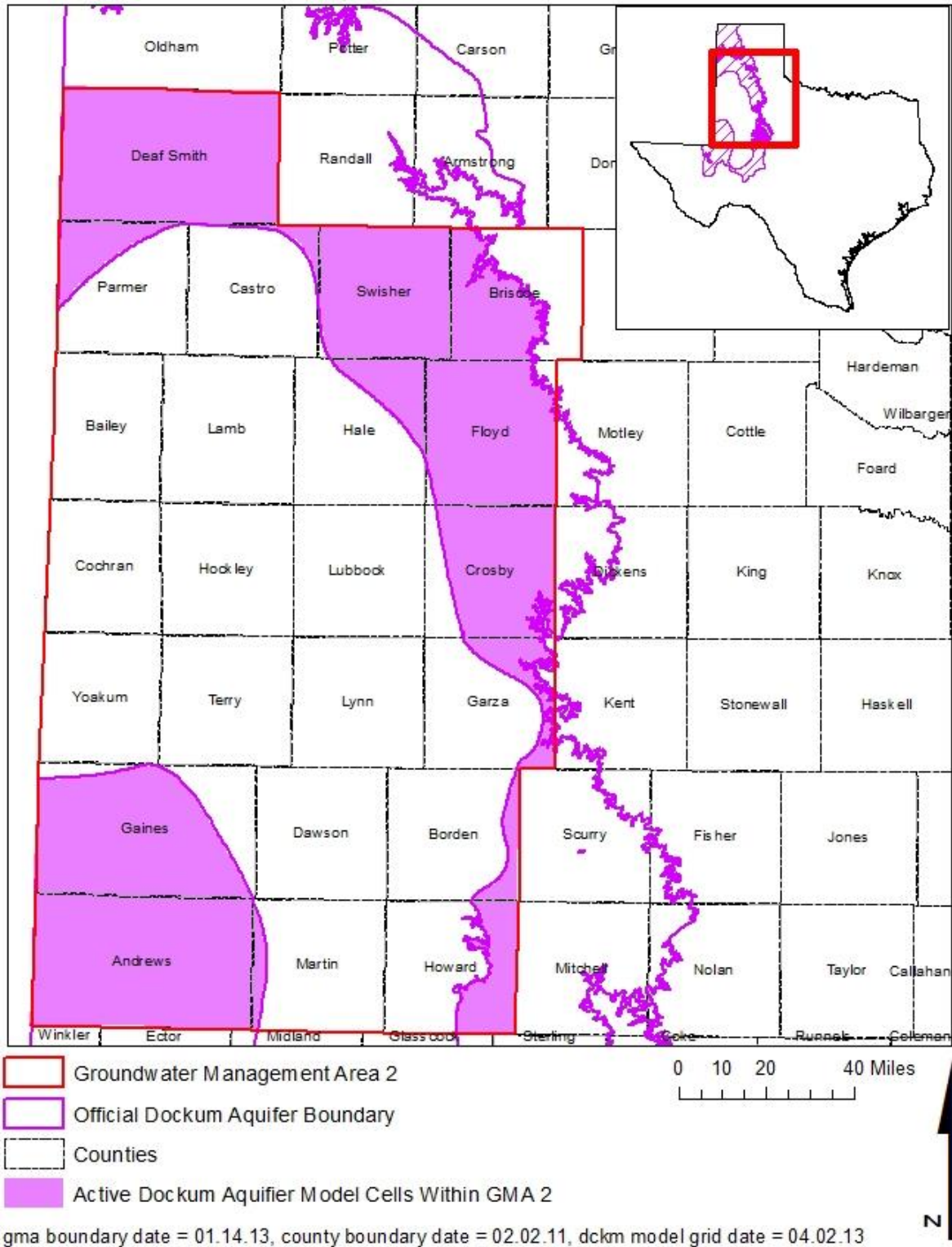


FIGURE 2. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL OF THE DOCKUM AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLES 1 AND 2) WITHIN GROUNDWATER MANAGEMENT AREA (GMA) 2.

TABLE 3. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>County</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
Bailey	690,000	172,500	517,500
Borden	1,600,000	400,000	1,200,000
Cochran	1,700,000	425,000	1,275,000
Dawson	1,000,000	250,000	750,000
Floyd	730,000	182,500	547,500
Gaines	3,100,000	775,000	2,325,000
Garza	120,000	30,000	90,000
Hale	870,000	217,500	652,500
Hockley	2,200,000	550,000	1,650,000
Lamb	500,000	125,000	375,000
Lubbock	2,000,000	500,000	1,500,000
Lynn	3,400,000	850,000	2,550,000
Terry	3,300,000	825,000	2,475,000
Yoakum	2,500,000	625,000	1,875,000
Total	23,710,000	5,927,500	17,782,500

TABLE 4. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT (GCD)⁵ FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>Groundwater Conservation District (GCD)</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
Garza County UWCD ⁶	120,000	30,000	90,000
High Plains UWCD No.1	12,000,000	3,000,000	9,000,000
Llano Estacado UWCD	3,100,000	775,000	2,325,000
Mesa UWCD	1,000,000	250,000	750,000
Sandy Land UWCD	2,500,000	625,000	1,875,000
South Plains UWCD	3,300,000	825,000	2,475,000
No District	1,700,000	425,000	1,275,000
Total	23,720,000	5,930,000	17,790,000

⁵ The total estimated recoverable storages by groundwater conservation district and county aquifer may not be the same because the numbers have been rounded to two significant figures.

⁶ UWCD is the abbreviation for Underground Water Conservation District.

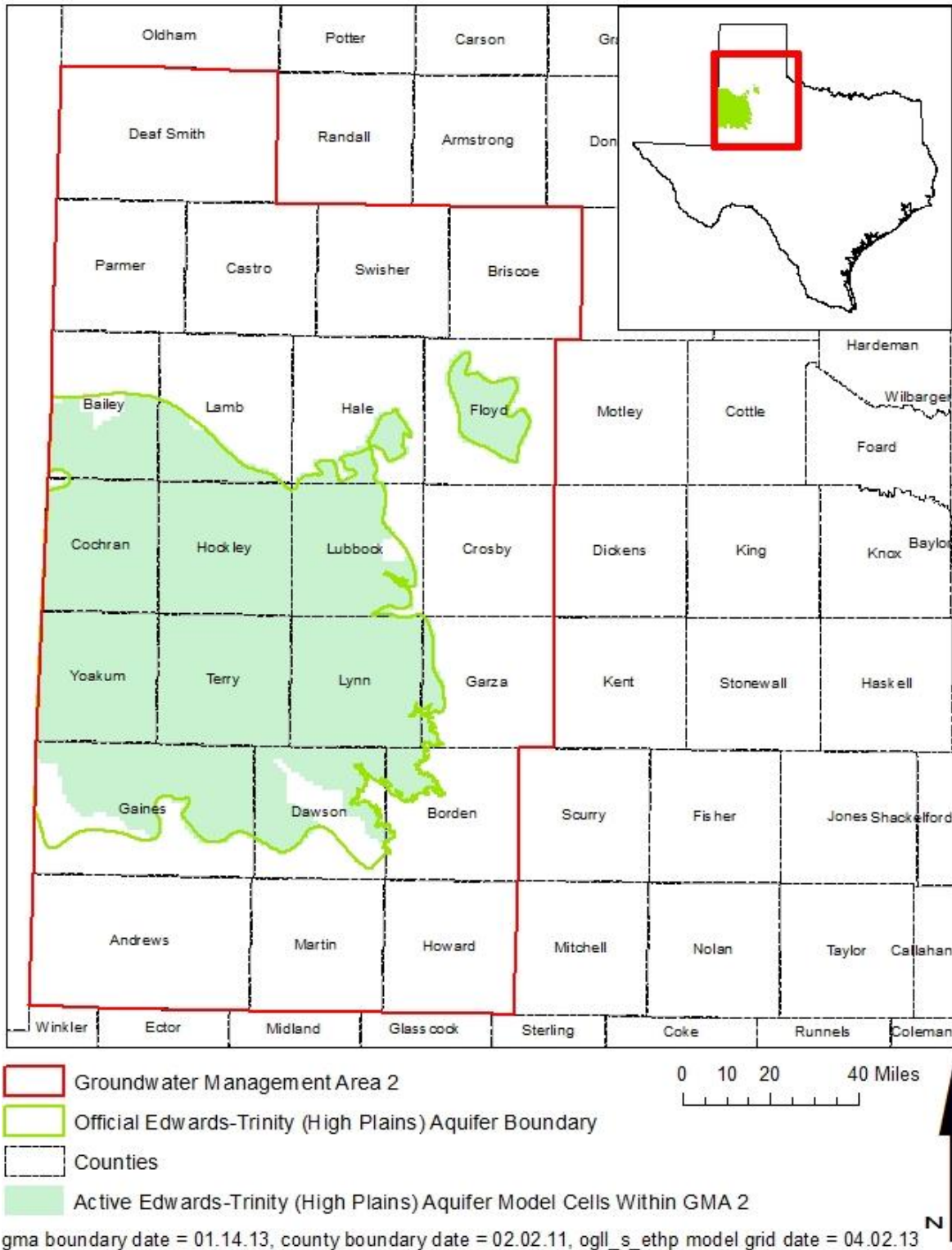


FIGURE 3. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (HIGH PLAINS) AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLES 3 AND 4) WITHIN GROUNDWATER MANAGEMENT AREA (GMA) 2.

TABLE 5. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>County</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
Andrews	32,000	8,000	24,000
Howard	61,000	15,250	45,750
Martin	49,000	12,250	36,750
Total	142,000	35,500	106,500

TABLE 6. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT (GCD) FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>Groundwater Conservation District (GCD)</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
Permian Basin UWCD ⁷	95,000	23,750	71,250
No District	47,000	11,750	35,250
Total	142,000	35,500	106,500

⁷ UWCD is the abbreviation for Underground Water Conservation District.

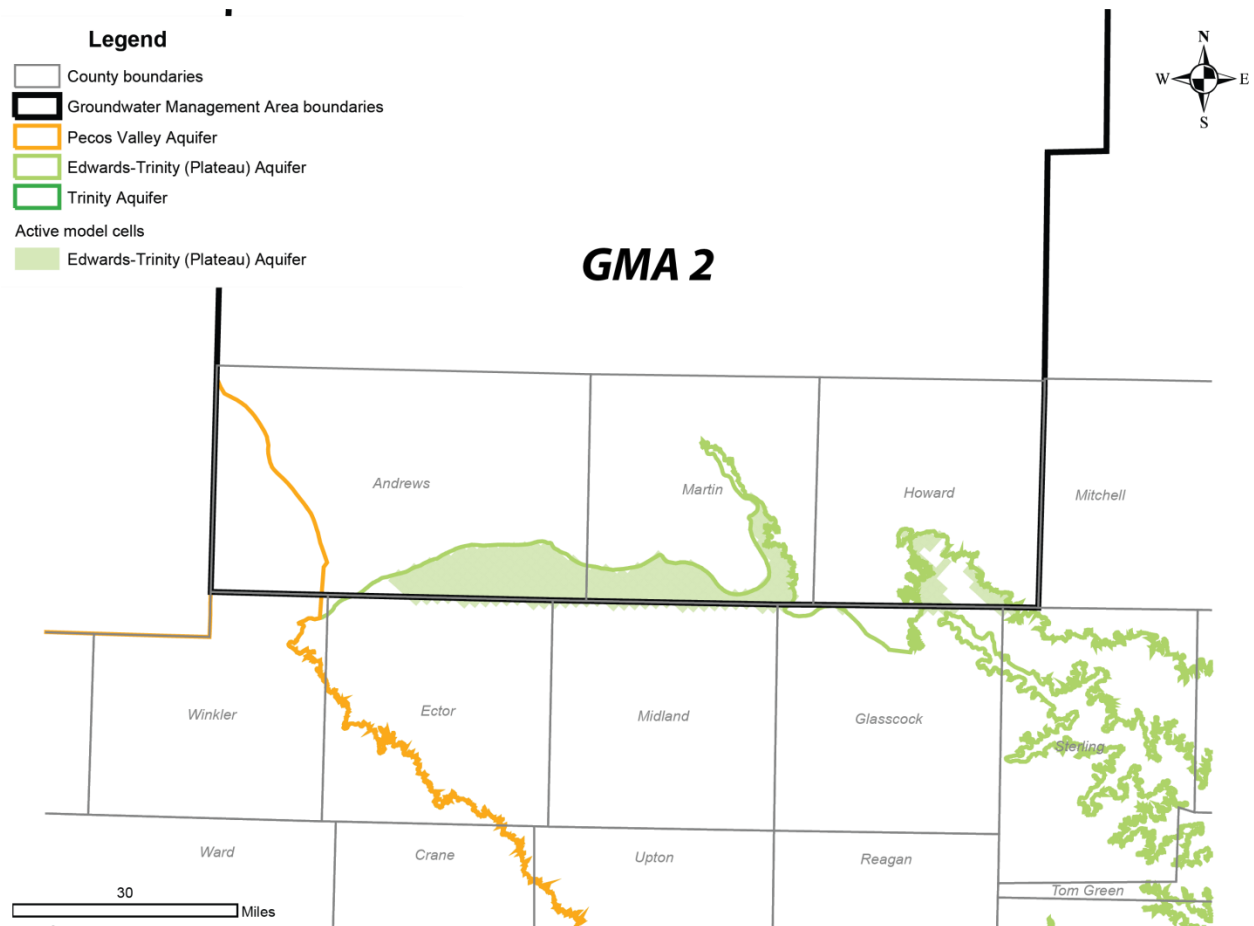


FIGURE 4. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLES 5 AND 6) WITHIN GROUNDWATER MANAGEMENT AREA (GMA) 2.

TABLE 7. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE OGALLALA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>County</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
Andrews	5,400,000	1,350,000	4,050,000
Bailey	2,900,000	725,000	2,175,000
Borden	310,000	77,500	232,500
Briscoe	2,100,000	525,000	1,575,000
Castro	9,500,000	2,375,000	7,125,000
Cochran	2,900,000	725,000	2,175,000
Crosby	12,000,000	3,000,000	9,000,000
Dawson	7,400,000	1,850,000	5,550,000
Deaf Smith	8,300,000	2,075,000	6,225,000
Floyd	12,000,000	3,000,000	9,000,000
Gaines	11,000,000	2,750,000	8,250,000
Garza	1,100,000	275,000	825,000
Hale	9,500,000	2,375,000	7,125,000
Hockley	5,900,000	1,475,000	4,425,000
Howard	2,300,000	575,000	1,725,000
Lamb	8,600,000	2,150,000	6,450,000
Lubbock	7,000,000	1,750,000	5,250,000
Lynn	5,000,000	1,250,000	3,750,000
Martin	7,100,000	1,775,000	5,325,000
Parmer	3,900,000	975,000	2,925,000
Swisher	7,600,000	1,900,000	5,700,000
Terry	5,200,000	1,300,000	3,900,000
Yoakum	2,200,000	550,000	1,650,000
Total	139,210,000	34,802,500	104,407,500

TABLE 8. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT (GCD)⁸ FOR THE OGALLALA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>Groundwater Conservation District (GCD)</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
Garza County UWCD ⁹	1,100,000	275,000	825,000
High Plains UWCD No.1	90,000,000	22,500,000	67,500,000
Llano Estacado UWCD	11,000,000	2,750,000	8,250,000
Mesa UWCD	7,400,000	1,850,000	5,550,000
Permian Basin UWCD	9,300,000	2,325,000	6,975,000
Sandy Land UWCD	2,200,000	550,000	1,650,000
South Plains UWCD	5,300,000	1,325,000	3,975,000
No District	12,000,000	3,000,000	9,000,000
Total	138,300,000	34,575,000	103,725,000

⁸ The total estimated recoverable storages by groundwater conservation district and county aquifer may not be the same because the numbers have been rounded to two significant figures.

⁹ UWCD is the abbreviation for Underground Water Conservation District.

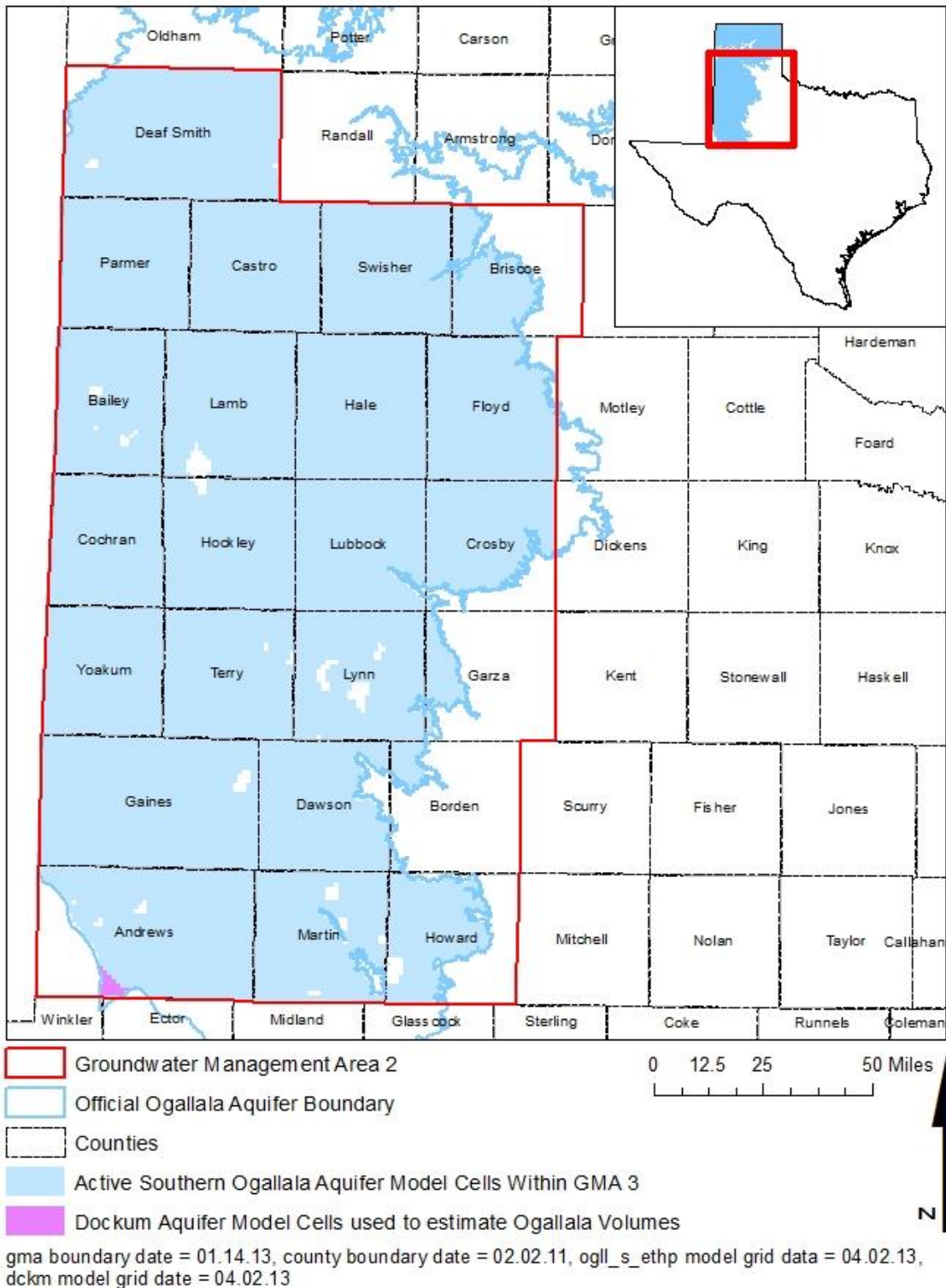


FIGURE 5. EXTENT OF THE GROUNDWATER AVAILABILITY MODELS FOR THE SOUTHERN PORTION OF THE OGALLALA AQUIFER AND DOCKUM AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLES 7 AND 8) WITHIN GROUNDWATER MANAGEMENT AREA (GMA) 2.

TABLE 9. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE SEYMOUR AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>County</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
Briscoe	57,000	14,250	42,750
Total	57,000	14,250	42,750

TABLE 10. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT (GCD) FOR THE SEYMOUR AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>Groundwater Conservation District</i>	<i>Total Storage (acre-feet)</i>	<i>25 percent of Total Storage (acre-feet)</i>	<i>75 percent of Total Storage (acre-feet)</i>
No District	57,000	14,250	42,750
Total	57,000	14,250	42,750

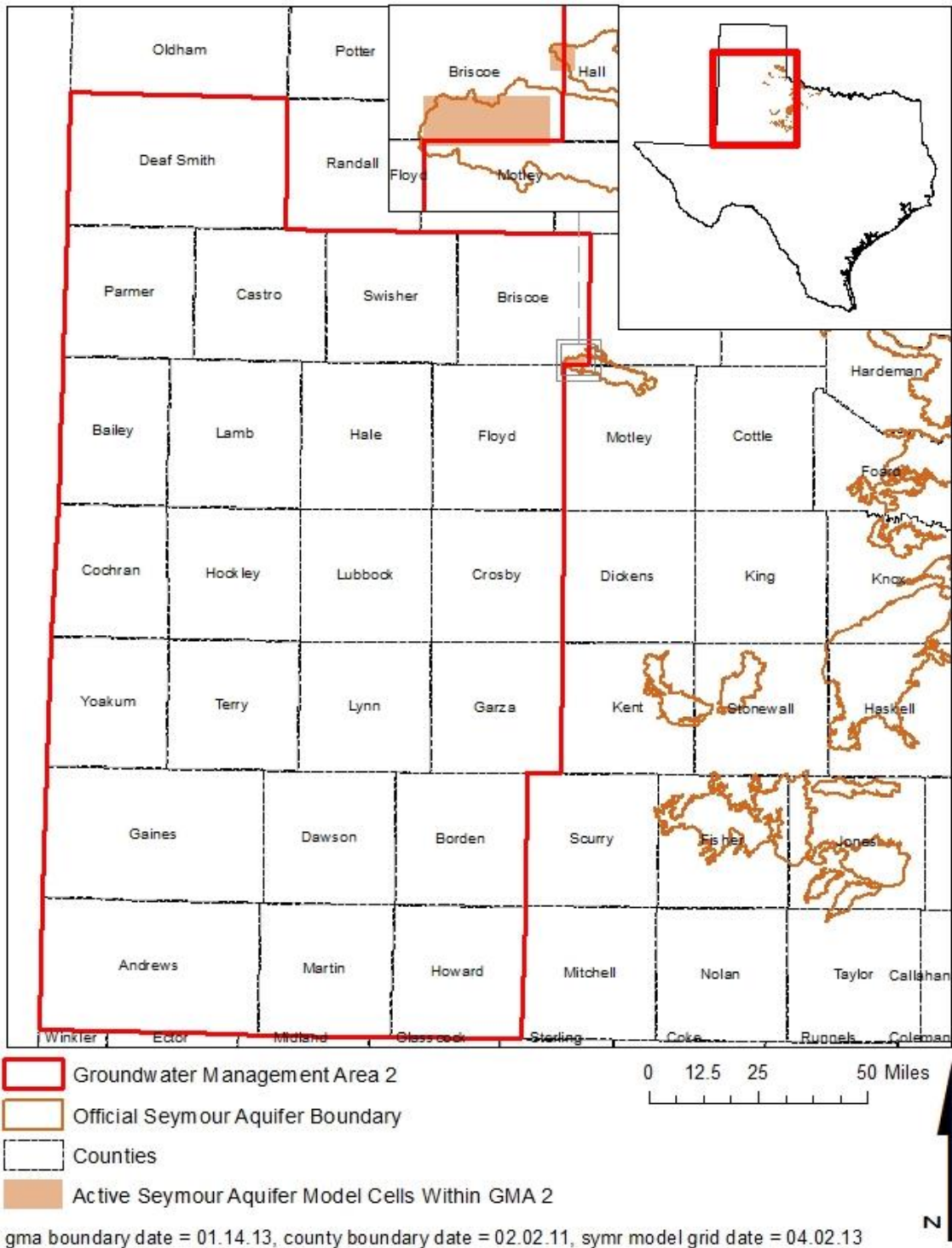


FIGURE 6. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL OF THE SEYMOUR AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLES 9 AND 10) WITHIN GROUNDWATER MANAGEMENT AREA 2.

TABLE 11. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE PECOS VALLEY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>County</i>	<i>Total Storage (acre-feet)</i>	<i>25% of Total Storage (acre-feet)</i>	<i>75% of Total Storage (acre-feet)</i>
Andrews	2,000,000	500,000	1,500,000
Total	2,000,000	500,000	1,500,000

TABLE 12. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT (GCD) FOR THE PECOS VALLEY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 2. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

<i>Groundwater Conservation District</i>	<i>Total Storage (acre-feet)</i>	<i>25% of Total Storage (acre-feet)</i>	<i>75% of Total Storage (acre-feet)</i>
No District	2,000,000	500,000	1,500,000
Total	2,000,000	500,000	1,500,000

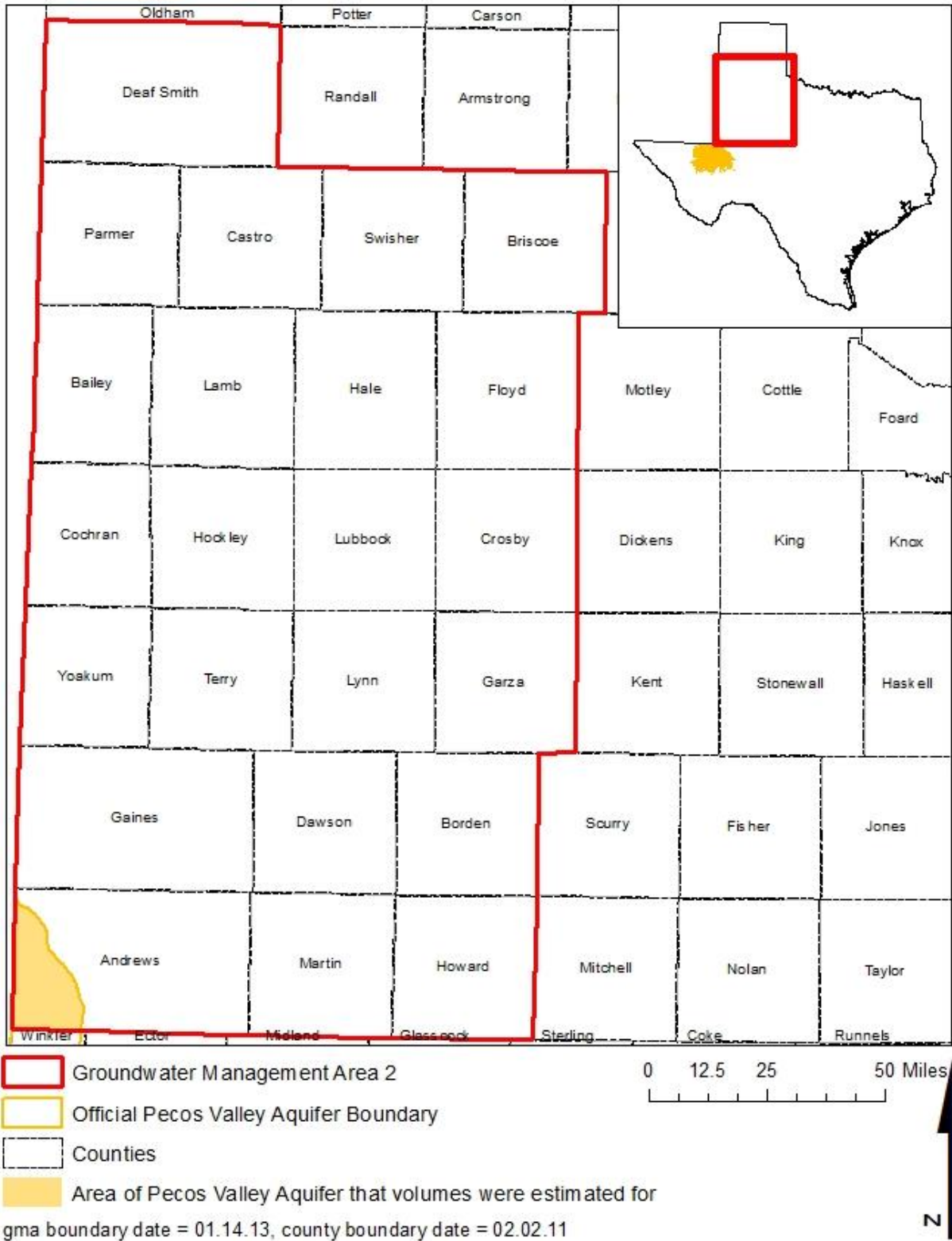


FIGURE 7. AREA OF THE PECOS VALLEY AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLES 11 AND 12) WITHIN GROUNDWATER MANAGEMENT AREA (GMA) 2.

LIMITATIONS

The groundwater models used in completing this analysis are the best available scientific tools 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.”

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.

REFERENCES:

- Blandford, T.N., Blazer, D.J., Calhoun, K.C., Dutton, A.R., Naing, T., Reedy, R.C., and Scanlon, B.R., 2003, Groundwater availability of the southern Ogallala aquifer in Texas and New Mexico—Numerical simulations through 2050: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 158 p., http://www.twdb.texas.gov/groundwater/models/gam/ogll_s/OGLL_S_Full_Report.pdf
- Blandford, T.N., Kuchanur, M., Standen, A., Ruggiero, R., Calhoun, K.C., Kirby, P., and Shah, G., 2008, Groundwater availability model of the Edwards-Trinity (High Plains) Aquifer in Texas and New Mexico: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 176 p., http://www.twdb.texas.gov/groundwater/models/gam/ethp/ETHP_Model_Report.pdf.
- Ewing, J.E., Jones, T.L., Pickens, J.F., Chastain-Howley, A., Dean, K.E., Spear, A.A., 2004, Groundwater availability model for the Seymour Aquifer: Final report prepared for the

- Texas Water Development Board by INTERA, Inc., 533 p.,
http://www.twdb.texas.gov/groundwater/models/gam/symr/SYMR_Model_Report.pdf.
- Ewing, J.E., Jones, T.L., Yan, T., Vreugdenhil, A.M., Fryar, D.G., Pickens, J.F., Gordon, K., Nicot, J.P., Scanlon, B.R., Ashworth, J.B., and Beach, J., 2008, Groundwater Availability Model for the Dockum Aquifer - Final Report: contract report to the Texas Water Development Board, 510 p.,
http://www.twdb.texas.gov/groundwater/models/gam/dckm/DCKM_Model_Report.pdf
- .
- George, P. G., Mace, R. E., and Petrossian, R., 2011, Aquifers of Texas, Texas Water Development Board Report 380,
<http://www.twdb.texas.gov/groundwater/aquifer/index.asp>
- Hutchison, W. R., Jones, I. C., and Anaya, R., 2011, Update of the Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas: Unpublished report, Texas Water Development Board, 60 p.,
http://www.twdb.texas.gov/groundwater/models/alt/eddt_p_2011/ETP_PV_One_Layer_Model.pdf
- National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p., http://www.nap.edu/catalog.php?record_id=11972.
- Texas Administrative Code, 2011, [http://info.sos.state.tx.us/pls/pub/readtac\\$ext.viewtac](http://info.sos.state.tx.us/pls/pub/readtac$ext.viewtac)
- Texas Water Code, 2011, <http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf>