GAM Task 13-027: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 3

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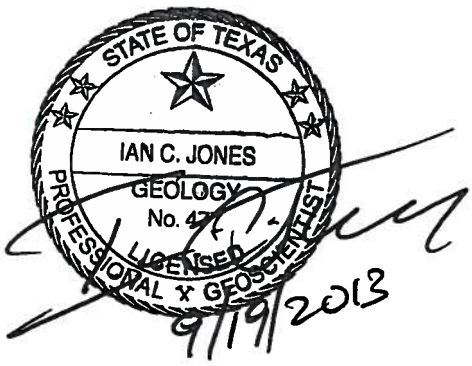
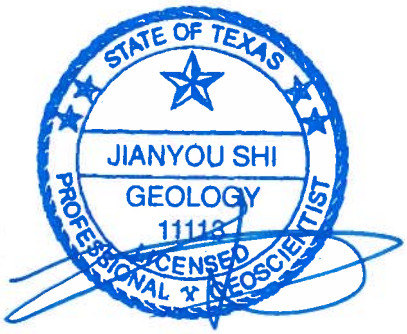
September 19, 2013





The seals appearing on this document were authorized by Ian C. Jones, P.G. 477, Radu Boghici, P.G. 482, and Jerry Shi, P.G. 11113 on September 19, 2013.

The total estimated recoverable storage in this report was calculated as follows: the Capitan Reef Complex, Edwards-Trinity (Plateau), and Pecos Valley aquifers (Ian Jones), the Igneous Aquifer (Radu Boghici), the Dockum and Ogallala aquifers (William Kohlrenken), and the Rustler Aquifer (Jerry Shi).

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GAM TASK 13-027: TOTAL ESTIMATED RECOVERABLE STORAGE FOR AQUIFERS IN GROUNDWATER MANAGEMENT AREA 3

by Ian C. Jones, Ph.D., P.G., Radu Boghici, P.G.,
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EXECUTIVE SUMMARY:

Texas Water Code, §36.108 (d) (Texas Water Code, 2011) states that, before voting on their proposed desired future conditions for a relevant aquifer within a groundwater management area, the groundwater conservation district(s) 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 Capitan Reef Complex, Dockum, Edwards-Trinity (Plateau), Pecos Valley, Rustler, Igneous, and Ogallala aquifers within Groundwater Management Area 3. Tables 1 through 14 summarize the total estimated recoverable storage required by the statute. Figures 4 through 10 indicate the official extent of the aquifers in Groundwater Management Area 3 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

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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 the aquifer within Groundwater Management Area 3 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 between different water quality types. The total estimated recoverable storage values do not take into account the effects of land surface subsidence, degradation of water quality, or any changes to surface water-groundwater interaction that may occur due to pumping.

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—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 outside the well—in the aquifer. 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 in 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 removed by pumping 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

  $$Total\ Storage \quad V_{drained} \quad Area \quad S \quad (Water\ Level - Bottom)$$

- for confined aquifers

  $$Total\ Storage \quad V_{confined} \quad V_{drained}$$

  - confined part

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

    or

    $$V_{confined} \quad Area \quad [\,S_s \quad (\mathrm{Top} - \quad \mathrm{ottom}) \quad (Water\ Level - Top)]$$

  - unconfined part

    $$V_{drained} \quad Area \quad \left[S \quad (Top - Bottom)\right]$$

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)

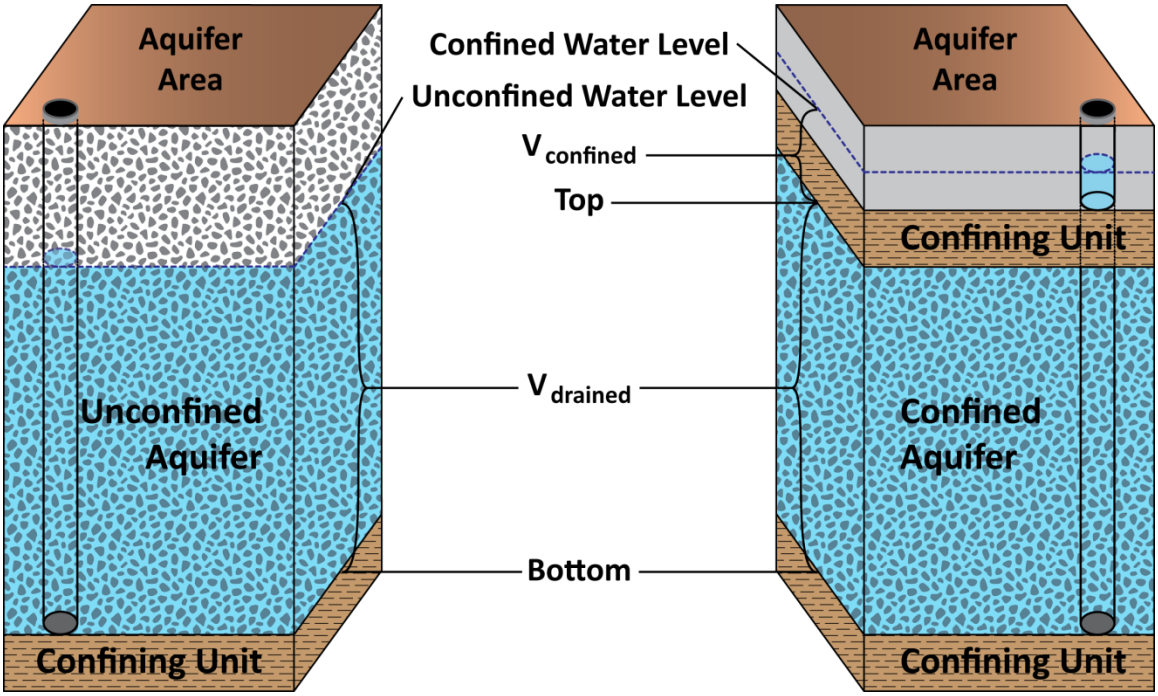

FIGURE 1. SCHEMATIC SHOWING THE DIFFERENCE BETWEEN UNCONFINED AND CONFINED AQUIFERS.

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, most of the Edwards-Trinity (Plateau), Pecos Valley, Rustler, and Ogallala aquifers in Groundwater Management Area 3, we extracted this information from existing groundwater availability model input and output files on a cell-by-cell basis. For aquifers or parts of aquifers without groundwater availability model(s), an analogous approach is used.

For the Capitan Reef Complex Aquifer in Groundwater Management Area 3 we used surfaces for the aquifer top and base constructed by Standen and others (2009). Due to insufficient water-level data to construct a water-level map we calculated total storage for the Capitan Reef Complex Aquifer assuming that $V_{confined}$ is very small relative to $V_{drained}$ and therefore insignificant. We extracted the aquifer top and base data using a grid with 1 square mile cells (Figure 2) and calculated total storage for each cell using the above equations. Finally, the total estimated recoverable storage was calculated as the product of the total storage and an estimated factor ranging from 25 percent to 75 percent.

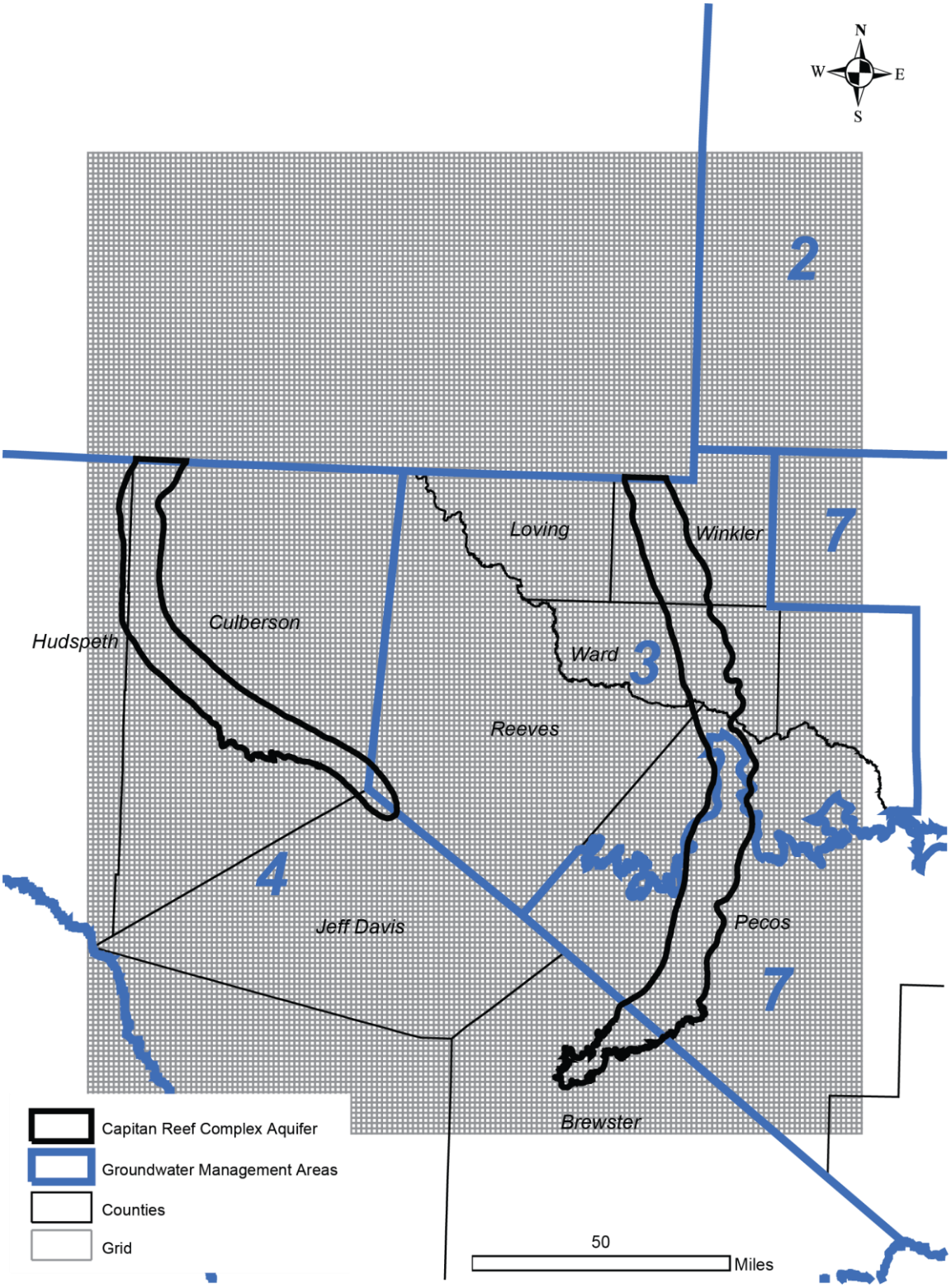

FIGURE 2. THE GRID USED TO CALCULATE TOTAL STORAGE FOR THE CAPITAN REEF COMPLEX AQUIFER.

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 3 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.

Two aquifers in Groundwater Management Area 3—Pecos Valley and Edwards-Trinity (Plateau) aquifers—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.

The “Method of the Wedges” was used to calculate total storage for the Igneous Aquifer in Groundwater Management Area 3 which was excluded from the groundwater availability model

for the Igneous Aquifer and parts of the West Texas Bolsons Aquifer (Beach and others, 2004). This area, excluded from the groundwater availability model, occurs along the margins of the Igneous Aquifer where the aquifer pinches out and is difficult to model. Total storage in this part of the aquifer was calculated based on the assumption that it takes the form of a right-wedge (Figure 3). Total storage was calculated by multiplying the volume of the assumed right-wedge by an assumed specific yield.

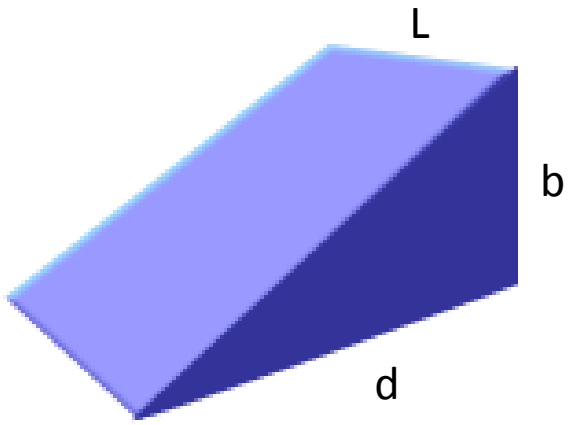

FIGURE 3. A SCHEMATIC OF THE RIGHT-WEDGE USED TO CALCULATE TOTAL STORAGE IN THE IGNEOUS AQUIFER IN GROUNDWATER MANAGEMENT AREA 3.

The volume of the right-edge was calculated using the formula:

$$V \quad 0.5 \quad b \quad L \quad d$$

Where:

- *b* = the average saturated thickness of the last row of active model cells bordering the "wedge";
- *L* = the length of the last row of active model cells bordering the "wedge"; and
- *d* = the average distance between the last row of active model cells and the aquifer boundary.

PARAMETERS AND ASSUMPTIONS:

Capitan Reef Complex Aquifer

- The Capitan Reef Complex Aquifer within Groundwater Management Area 3 is under confined conditions throughout the area.
- The potentiometric surface was not constructed due to insufficient water-level data. Instead, we assumed that confined part of total storage is much smaller than the unconfined part and is therefore insignificant. The justification for this assumption is that the aquifer thickness and specific yield used to calculate the unconfined part of the total storage are much larger than the confined head—difference between the water level and aquifer top elevations—and the storativity or specific storage used to calculate the confined part of the total storage.
- We used the base and top of the Capitan Reef Complex Aquifer constructed by Standen and others (2009). These surfaces were used to calculate aquifer thickness.
- No storage data was discovered for the area. We used conservative estimates for specific yield of 0.05 based on borehole geophysics data for the Capitan Reef Complex Aquifer (Garber and others, 1989).
- The total storage was calculated for each cell by multiplying cell area, aquifer thickness and a specific yield of 0.05.
- Total storage data from grid was summed by county and groundwater conservation district within Groundwater Management Area 3.

Rustler Aquifer

- We used version 1.01 of the groundwater availability model for the Rustler Aquifer to estimate the total recoverable storage for the Rustler Aquifer. See Ewing and Others (2012) for assumptions and limitations of the groundwater availability model.
- This groundwater availability model includes two numerical layers which represent the Dockum Aquifer/Dewey Lake Formation (Layer 1) and the Rustler Aquifer (Layer 2).
- Model Layer 2 was used to calculate the total estimated recoverable storage for the Rustler Aquifer.

Dockum and Ogallala Aquifers

- We used version 1.01 of the groundwater availability model for the Dockum Aquifer to estimate the total recoverable storage for the aquifer. See Ewing and other (2008) for assumptions and limitations of the groundwater availability model.
- This 3-layer groundwater availability model includes two layers—Layers 2 and 3—which represent the Dockum Aquifer. We used Layer 1 which simulates the stratigraphic units overlying the Dockum Aquifer to calculate total storage in the Ogallala Aquifer in Groundwater Management Area 3.
- The groundwater availability model for the Dockum Aquifer includes down-dip portions of the Dockum Group that are not included in the official aquifer boundaries (Ewing and other, 2008). The down-dip boundary of the Dockum Aquifer is based on the 5,000 milligrams per liter (m/L) total dissolved solids concentration line while the model extends beyond that incorporating highly saline parts of the Dockum Group.

Pecos Valley and Edwards-Trinity (Plateau) 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.

Igneous Aquifer

- The part of the Igneous Aquifer in Groundwater Management Area 3 is not included in version 1.01 of the Igneous Aquifer and parts of the West Texas Bolsons—Wild Horse, Michigan, Ryan, and Lobo flats (Beach and Others,2004).
- Total storage was calculated based on aquifer thickness and length data and an assumed specific yield value of 0.01 obtained from the groundwater availability model by Beach and others (2004).

RESULTS:

Tables 1 through 14 summarize the total estimated recoverable storage required by statute. The county and groundwater conservation district total estimates are rounded to two significant figures. Figures 4 through 10 indicate the extents of the Capitan Reef Complex, Rustler, Dockum, Edwards-Trinity (Plateau), Igneous, Ogallala, and Pecos Valley aquifers in Groundwater Management Area 3 used to estimate the total recoverable storage information.

TABLE 1. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE CAPITAN REEF COMPLEX AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Pecos	2,800,000	700,000	2,100,000
Reeves	930,000	232,500	697,500
Ward	5,900,000	1,475,000	4,425,000
Winkler	6,100,000	1,525,000	4,575,000
Total	15,730,000	3,932,500	11,797,500

TABLE 2. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[3] FOR THE CAPITAN REEF COMPLEX AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	12,000,000	3,000,000	9,000,000
Middle Pecos GCD	2,800,000	700,000	2,100,000
Reeves County GCD	930,000	232,500	697,500
Total	15,730,000	3,932,500	11,797,500

[3] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant figures.

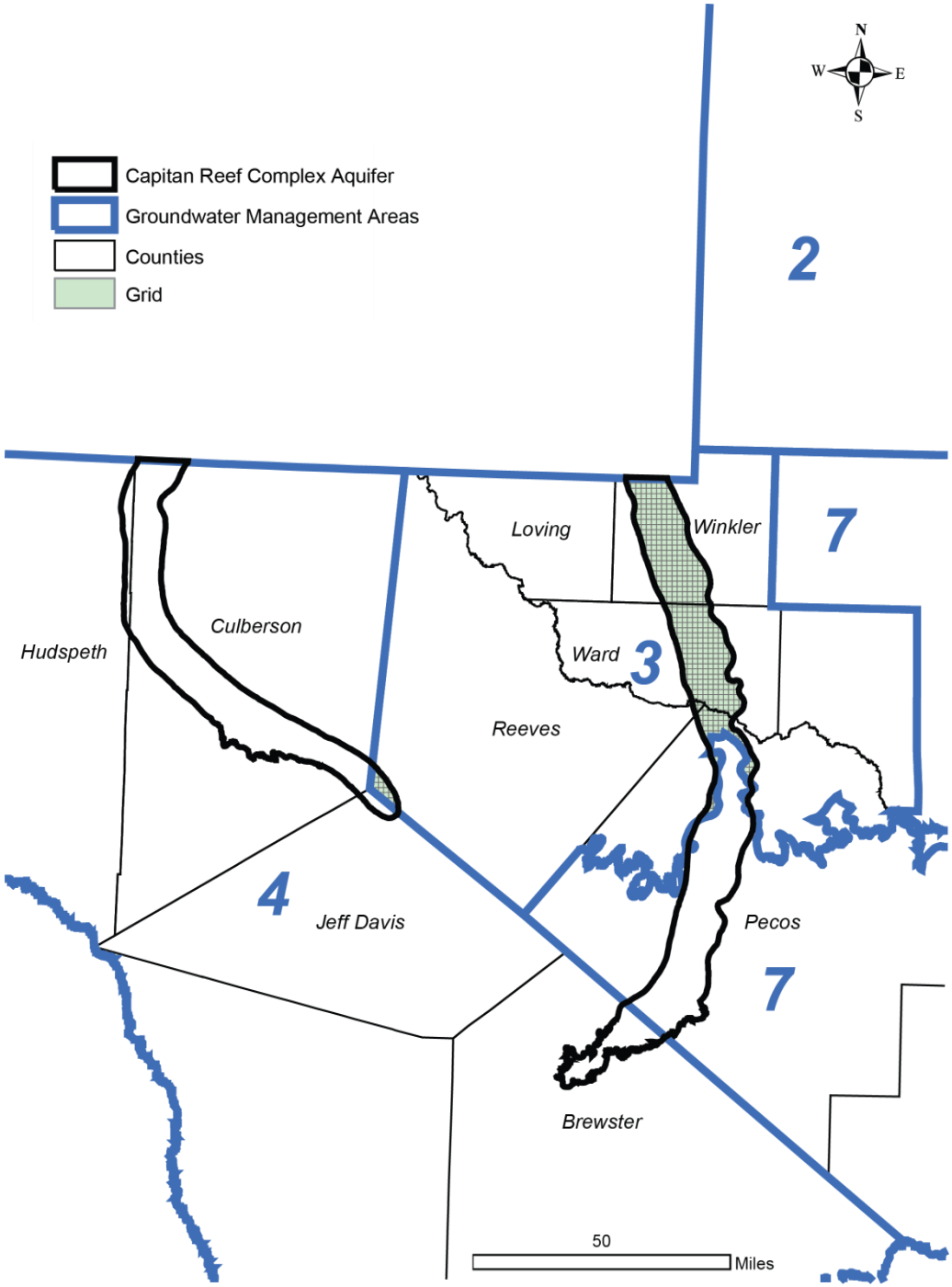

FIGURE 4. AREA OF THE CAPITAN REEF COMPLEX AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE WITHIN GROUNDWATER MANAGEMENT AREA 3.

TABLE 3. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE RUSTLER AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT NUMBERS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Loving	3,400,000	850,000	2,550,000
Pecos	3,600,000	900,000	2,700,000
Reeves	19,000,000	4,750,000	14,250,000
Ward	980,000	245,000	735,000
Total	26,980,000	6,745,000	20,235,000

TABLE 4. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[4] FOR THE RUSTLER AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT NUMBERS.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	4,000,000	1,000,000	3,000,000
Middle Pecos GCD	3,600,000	900,000	2,700,000
Reeves County GCD	19,000,000	4,750,000	14,250,000
Total	26,600,000	6,650,000	19,950,000

[4] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant figures.

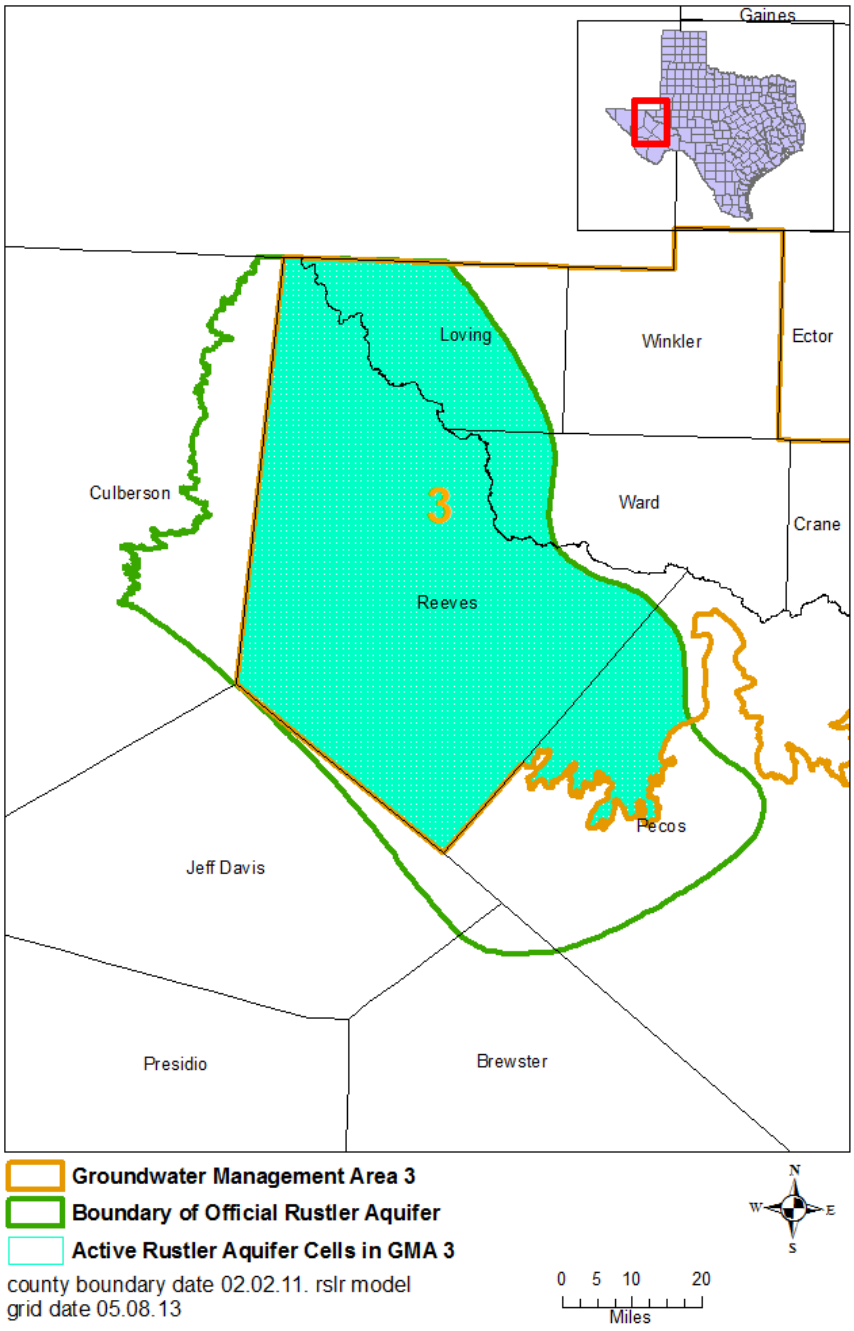

FIGURE 5. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE RUSTLER AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE RUSTLER AQUIFER IN GROUNDWATER MANAGEMENT AREA 3.

TABLE 5. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE DOCKUM AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. COUNTY TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT DIGITS.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Crane	30,000,000	7,500,000	22,500,000
Loving	4,500,000	1,125,000	3,375,000
Pecos	17,000,000	4,250,000	12,750,000
Reeves	12,000,000	3,000,000	9,000,000
Ward	18,000,000	4,500,000	13,500,000
Winkler	42,000,000	10,500,000	31,500,000
Total	123,500,000	30,875,000	92,625,000

TABLE 6. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[5] FOR THE DOCKUM AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED TO TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	95,000,000	23,750,000	71,250,000
Middle Pecos GCD	17,000,000	4,250,000	12,750,000
Reeves County GCD	12,000,000	3,000,000	9,000,000
Total	124,000,000	31,000,000	93,000,000

[5] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant figures.

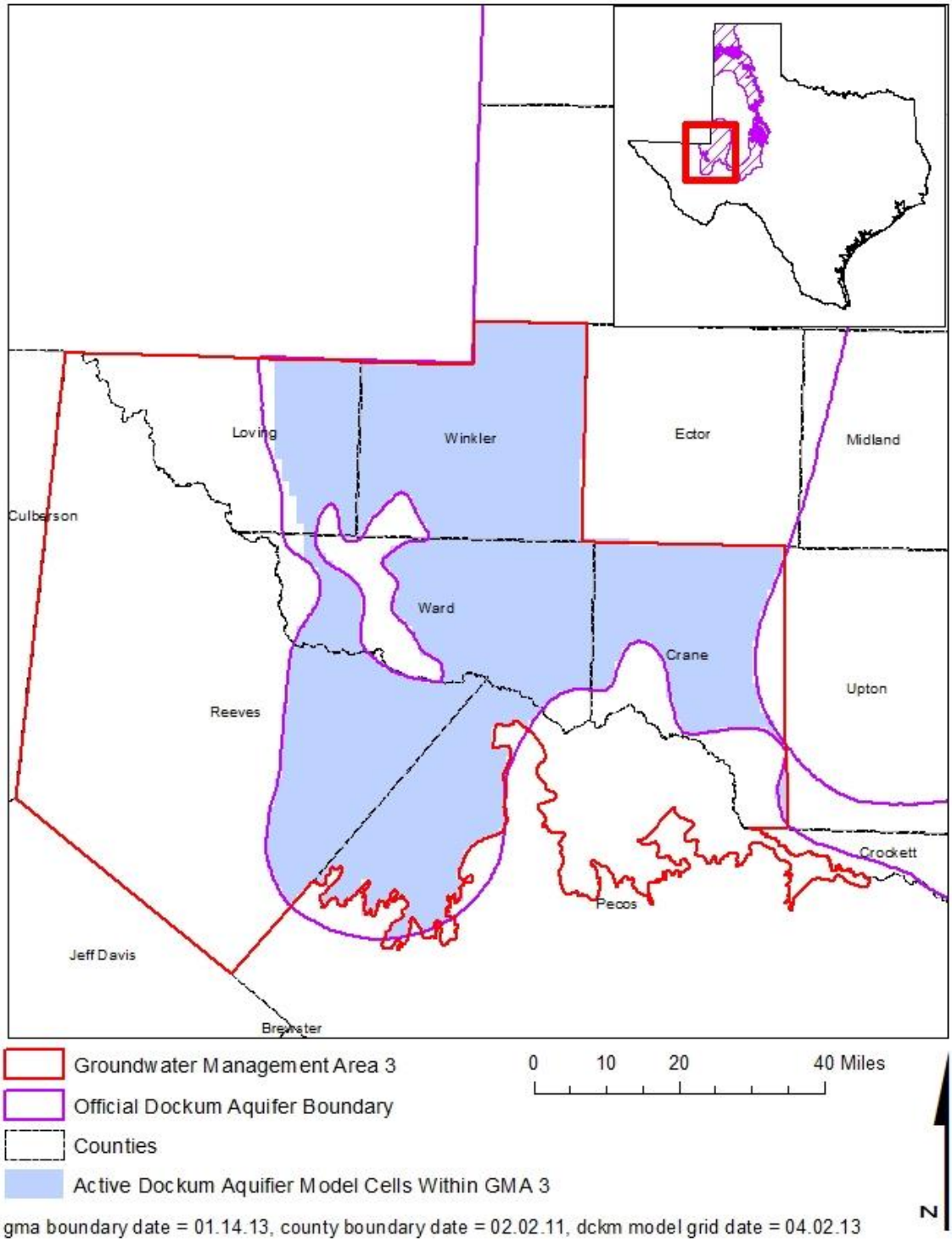

FIGURE 6. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE DOCKUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 3.

TABLE 7. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Crane	27,000	6,750	20,250
Reeves	360,000	90,000	270,000
Winkler	3,300	825	2,475
Total	390,300	97,575	292,725

TABLE 8. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[6] FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	390,000	97,500	292,500
Total	390,000	97,500	292,500

[6] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant figures.

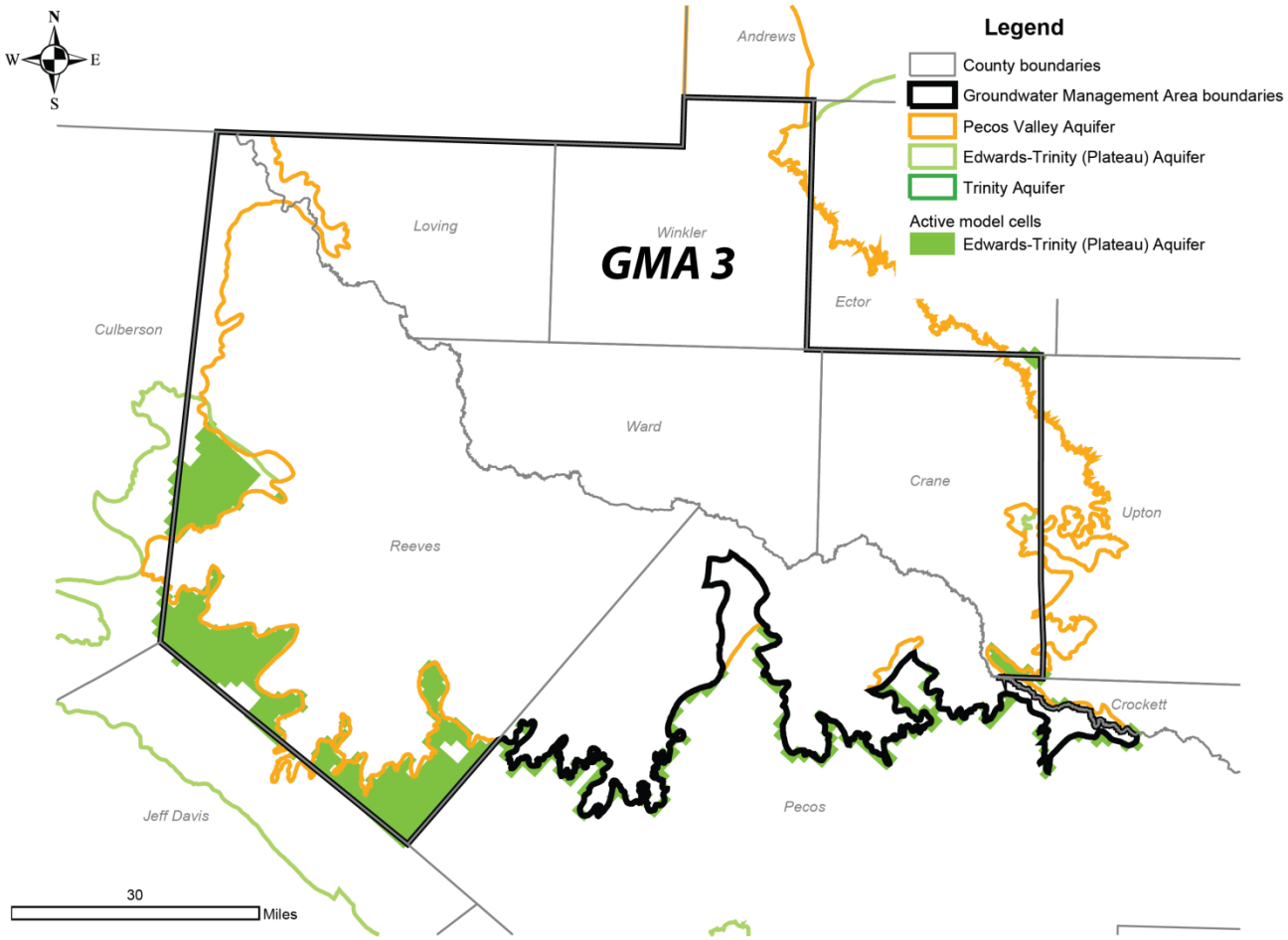

FIGURE 7. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN GROUNDWATER MANAGEMENT AREA 3.

TABLE 9. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE IGNEOUS AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Reeves	54,000	13,500	40,500
Total	54,000	13,500	40,500

TABLE 10. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[7] FOR THE IGNEOUS AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Reeves County GCD	54,000	13,500	40,500
Total	54,000	13,500	40,500

[7] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant figures.

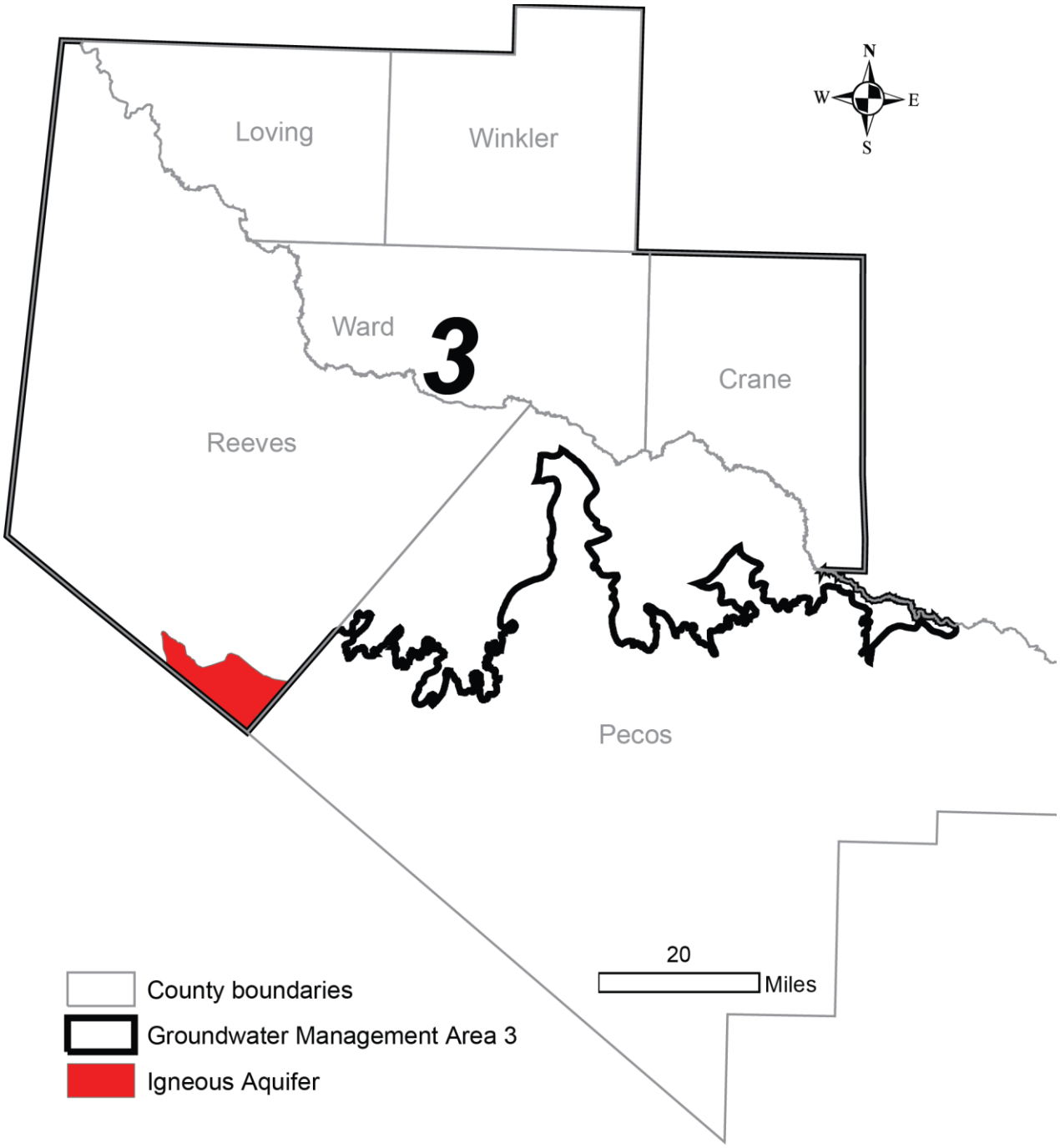

FIGURE 8. AREA OF THE IGNEOUS AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE WITHIN GROUNDWATER MANAGEMENT AREA 3.

TABLE 11. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE OGALLALA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Winkler	9,600	2,400	7,200
Total	9,600	2,400	7,200

TABLE 12. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[8] FOR THE OGALLALA AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	9,600	2,400	7,200
Total	9,600	2,400	7,200

[8] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant figures.

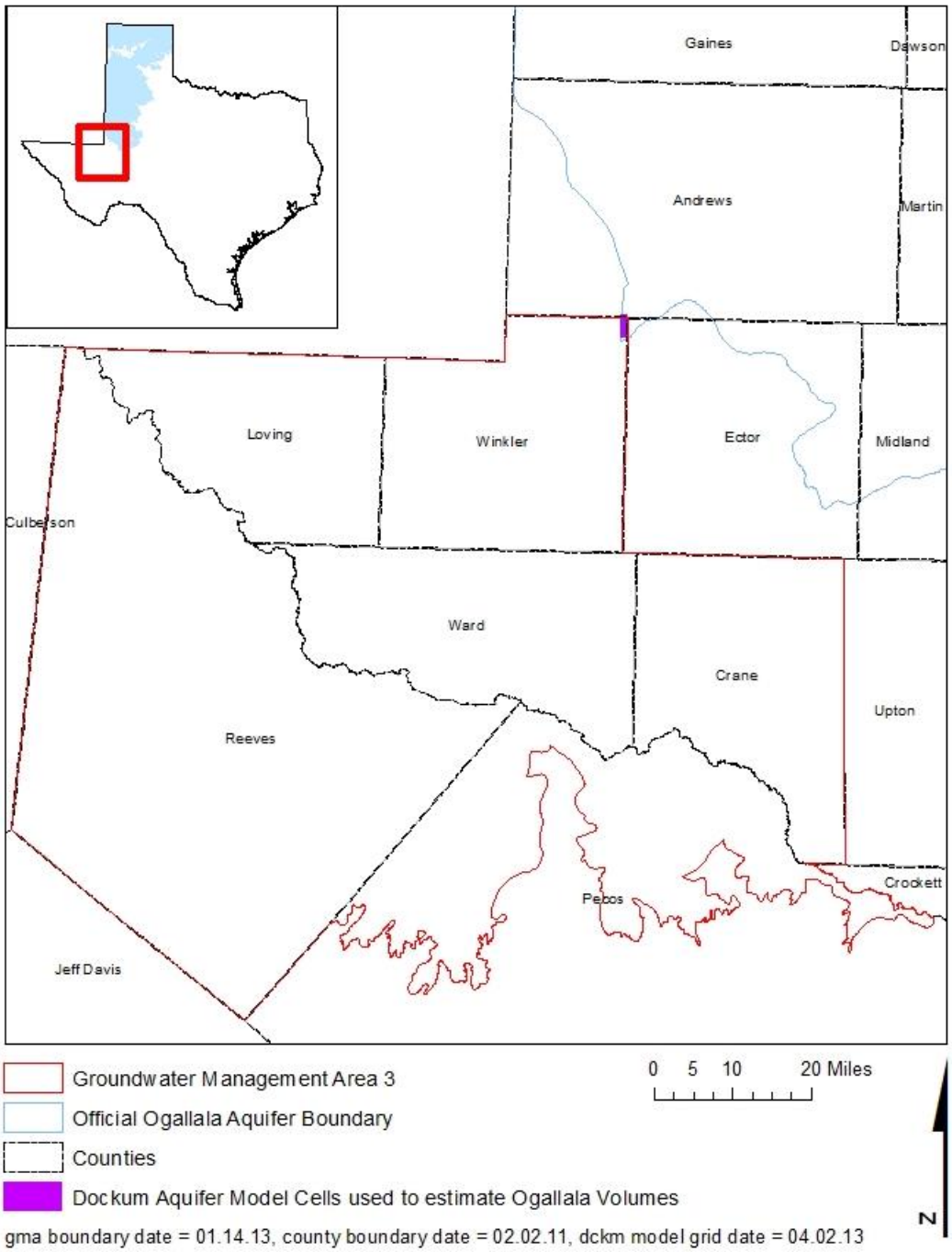

FIGURE 9. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE OGALLALA AQUIFER IN GROUNDWATER MANAGEMENT AREA 3.

TABLE 13. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE PECOS VALLEY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Crane	13,000,000	3,250,000	9,750,000
Loving	32,000,000	8,000,000	24,000,000
Pecos	29,000,000	7,250,000	21,750,000
Reeves	180,000,000	45,000,000	135,000,000
Ward	34,000,000	8,500,000	25,500,000
Winkler	21,000,000	5,250,000	15,750,000
Total	309,000,000	77,250,000	231,750,000

TABLE 14. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[9] FOR THE PECOS VALLEY AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 3. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN TWO SIGNIFICANT FIGURES.

Groundwater Conservation District (GCD)	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
No District	100,000,000	25,000,000	75,000,000
Middle Pecos GCD	29,000,000	7,250,000	21,750,000
Reeves County GCD	180,000,000	45,000,000	135,000,000
Total	309,000,000	77,250,000	231,750,000

[9] The total estimated recoverable storage values by groundwater conservation district and county for an aquifer may not be the same because the numbers have been rounded to two significant figures.

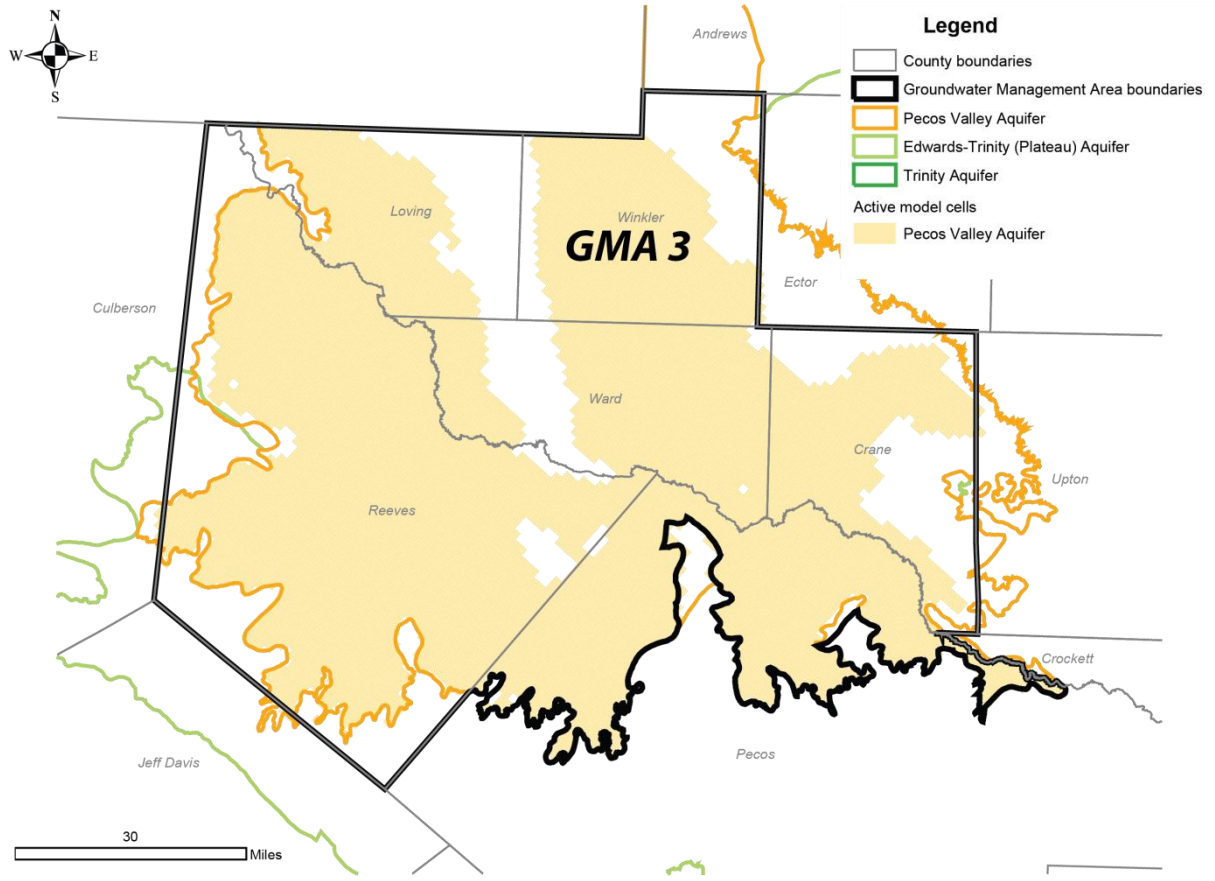

FIGURE 10. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AND PECOS VALLEY AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE PECOS VALLEY AQUIFER IN GROUNDWATER MANAGEMENT AREA 3.

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.

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