GAM Run 16-006: Central Texas Groundwater Conservation District Management Plan

Jerry (Jianyou) Shi, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Section
(512) 463-5076

June 20, 2016

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EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h) (Texas Water Code, 2015), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the executive administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the executive administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

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

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

The groundwater management plan for the Central Texas Groundwater Conservation District should be adopted by the district on or before April 7, 2017, and submitted to the executive administrator of the TWDB on or before May 7, 2017. The current management plan for the Central Texas Groundwater Conservation District expires on July 6, 2017.

There are four aquifers identified by TWDB in the Central Texas Groundwater Conservation District: the Trinity, the Marble Falls, the Ellenburger-San Saba, and the Hickory aquifers. Two groundwater availability models were used to extract the management plan information for the aquifers within the Central Texas Groundwater Conservation District. Information for the Trinity Aquifer was extracted from version 2.01 of the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (Kelley and others, 2014). Information for the Marble Falls, Ellenburger-San Saba, and Hickory aquifers was extracted from version 1.01 of the groundwater availability model for the minor aquifers in the Llano Uplift region (Shi and others, 2016, under final review).

This report discusses the methods, assumptions, and results from the model runs for the Trinity, Marble Falls, Ellenburger-San Saba, and Hickory aquifers described above. This model run report replaces the results of GAM Run 10-066 (Aschenbach, 2011), which only included information for the Trinity Aquifer extracted using version 1.01 of the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (Bené and others, 2004).Tables 1 through 4 summarize the groundwater availability model data required by statute. Figures 1 through 4 show the areas of the models from which the values in Tables 1 through 4 were extracted.

If after review of the figures Central Texas Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers was used to extract information for the Trinity Aquifer. The water budget for the Trinity Aquifer within the Central Texas Groundwater Conservation District was extracted for selected years of the historical model period (1980 through 2012) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface-water outflow, inflow to the district, and outflow from the district for the Trinity Aquifer within the district are summarized in this report.

The water budgets for the Marble Falls, Ellenburger-San Saba, and Hickory aquifers within the Central Texas Groundwater Conservation District were extracted for selected years of the historical model period (1981 through 2010) using ZONEBUDGET USG Version 1.00. The average annual water budget values for recharge, surface-water outflow, inflow to the district, and outflow from the district for the Marble Falls, Ellenburger-San Saba, and Hickory aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Trinity Aquifer

- We used version 2.01 of the updated groundwater availability model for the northern portion of the Trinity and Woodbine aquifers. See Kelley and others (2014) for assumptions and limitations of the model.
- The groundwater availability model for the northern portion of the Trinity and Woodbine aquifers contains eight layers: Layer 1 (the surficial outcrop area of the units in layers 2 through 8 and units younger than Woodbine Aquifer), Layer 2 (Woodbine Aquifer and pass-through cells), Layer 3 (Washita and Fredericksburg, Edwards (Balcones Fault Zone), and pass-through cells), and Layers 4 through 8 (Trinity Aquifer).
- Perennial rivers and reservoirs were simulated using MODFLOW-NWT river package. Ephemeral streams, flowing wells, springs, and evapotranspiration in riparian zones along perennial rivers were simulated using MODFLOW-NWT drain package. For this management plan, groundwater discharge to surface water includes groundwater leakage to all of the river and drain boundaries minus the groundwater loss along the riparian zone.
- The model was run with MODFLOW-NWT (Niswonger and others, 2011).

Marble Falls, Ellenburger-San Saba, and Hickory Aquifers

- We used version 1.01 of the groundwater availability model for the minor aquifers in the Llano Uplift region. See Shi and others (2016) for assumptions and limitations of the model.
- The groundwater availability model for the minor aquifers in Llano Uplift region contains eight layers: Layer 1 (the Trinity Aquifer, Edwards-Trinity (Plateau) Aquifer, and younger alluvium deposits), Layer 2 (confining units), Layer 3 (the Marble Falls Aquifer and equivalent unit), Layer 4 (confining units), Layer 5 (Ellenburger-San Saba Aquifer and equivalent unit), Layer 6 (confining units), Layer 7 (the Hickory Aquifer and equivalent unit), and Layer 8 (Precambrian units).

- Perennial rivers and reservoirs were simulated using MODFLOW-USG river package. Springs were simulated using MODFLOW-USG drain package. For this management plan, groundwater discharge to surface water includes groundwater leakage to the river and drain boundaries.

- The model was run with MODFLOW-USG beta (development) version (Panday and others, 2013).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the models for the Trinity Aquifer and the Marble Falls, Ellenburger-San Saba, and Hickory aquifers within the district and averaged over the historical duration, as shown in Tables 1 through 4.

- Precipitation recharge—The areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers—where the aquifer is exposed at land surface—within the district.

- Surface-water outflow—The total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and drains (springs).

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

- Flow between aquifers—The net vertical flow between aquifers. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer that define the amount of leakage that occurs.

The information needed for the district's management plan is summarized in Tables 1 through 4. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

TABLE 1: SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER THAT IS NEEDED FOR CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST ONE ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	13,831
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Trinity Aquifer	13,727
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	2,908
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	12,285
Estimated net annual volume of flow between each aquifer in the district*	From Trinity Aquifer to Marble Falls Aquifer	8
	From Trinity Aquifer to Ellenburger-San Saba Aquifer	255
	From Hickory Aquifer to Trinity Aquifer	1

*Flows between each aquifer in the district were extracted from the groundwater availability model for the minor aquifers in the Llano Uplift region (see Tables 2 through 4).

TABLE 2: SUMMARIZED INFORMATION FOR THE MARBLE FALLS AQUIFER THAT IS NEEDED FOR CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST ONE ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Marble Falls Aquifer	2,181
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Marble Falls Aquifer	10,771
Estimated annual volume of flow into the district within each aquifer in the district	Marble Falls Aquifer	10
Estimated annual volume of flow out of the district within each aquifer in the district	Marble Falls Aquifer	60
Estimated net annual volume of flow between each aquifer in the district	From Trinity Aquifer to Marble Falls Aquifer	8
	From Ellenburger-San Saba Aquifer to Marble Falls Aquifer	1,165

TABLE 3: SUMMARIZED INFORMATION FOR ELLENBURGER-SAN SABA AQUIFER THAT IS NEEDED FOR CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST ONE ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ellenburger-San Saba Aquifer	68,860
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Ellenburger-San Saba Aquifer	69,378
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	20,593
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	7,663
Estimated net annual volume of flow between each aquifer in the district*	From Trinity Aquifer to Ellenburger-San Saba Aquifer	255
	From Ellenburger-San Saba Aquifer to Marble Falls Aquifer	1,165
	From Hickory Aquifer to Ellenburger-San Saba Aquifer	7,631

*The estimated volume of flow from the brackish portion of the Ellenburger-San Saba formations to the Ellenburger-San Saba Aquifer in the Central Texas Groundwater Conservation District is 3,697 acre-feet per year and was not included in the management plan requirement results. The estimated volume of flow from the Ellenburger-San Saba Aquifer to the brackish portion of the Ellenburger-San Saba formations in the Central Texas Groundwater Conservation District is 9,860 acre-feet per year and was not included in the management plan requirement results.

TABLE 4: SUMMARIZED INFORMATION FOR THE HICKORY AQUIFER THAT IS NEEDED FOR CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST ONE ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Hickory Aquifer	331
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Hickory Aquifer	3,302
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	7,955
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	6,374
Estimated net annual volume of flow between each aquifer in the district*	From Hickory Aquifer to Trinity Aquifer	1
	From Hickory Aquifer to Ellenburger-San Saba Aquifer	7,631

*The estimated volume of flow from the brackish portion of the Hickory Formation to the Hickory Aquifer in the Central Texas Groundwater Conservation District is two acre-feet per year and was not included in the management plan requirement results. The estimated volume of flow from the Hickory Aquifer to the brackish portion of the Hickory Formation in the Central Texas Groundwater Conservation District is 1,097 acre-feet per year and was not included in the management plan requirement results.

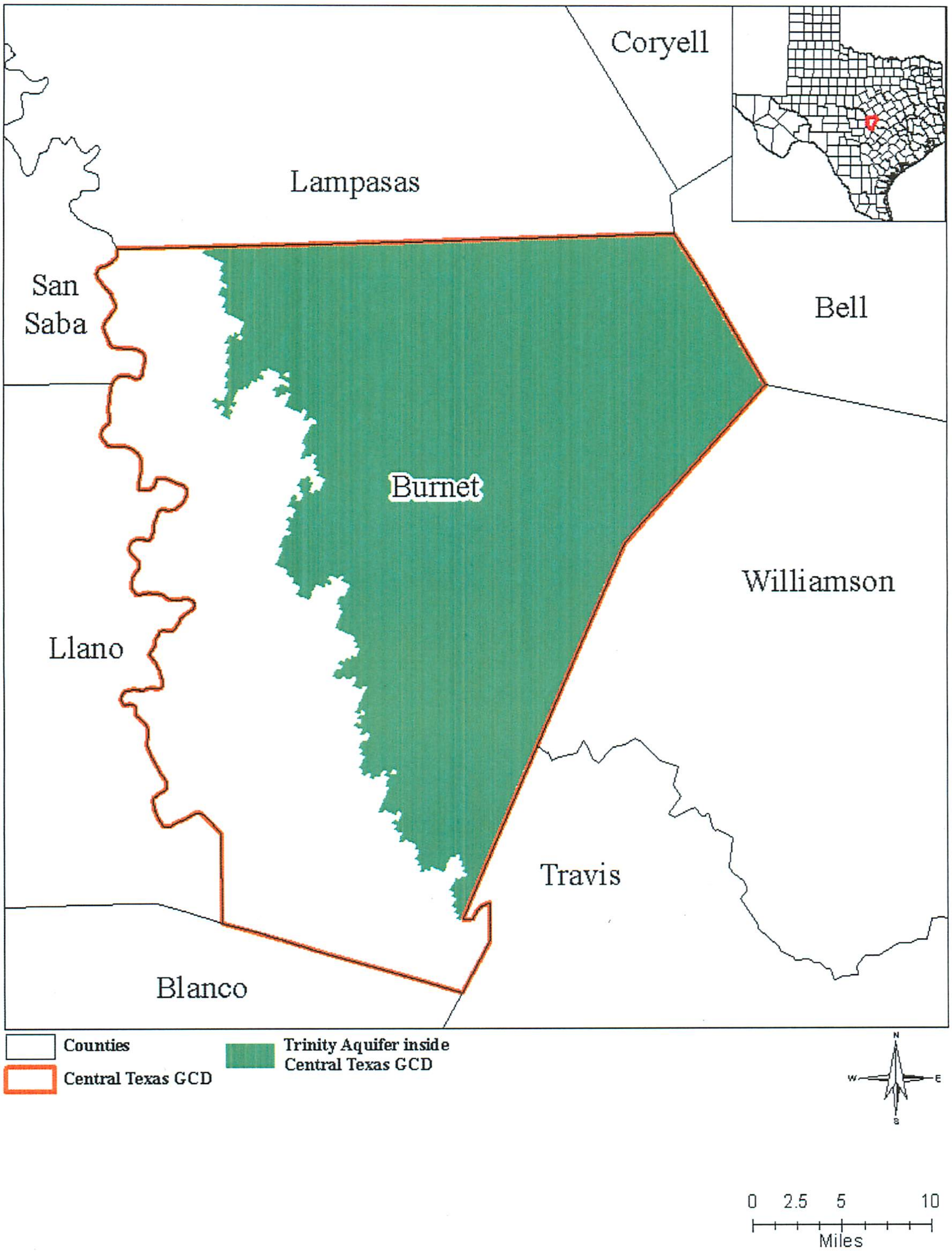

FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE TRINITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED FOR THE CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT (GCD).

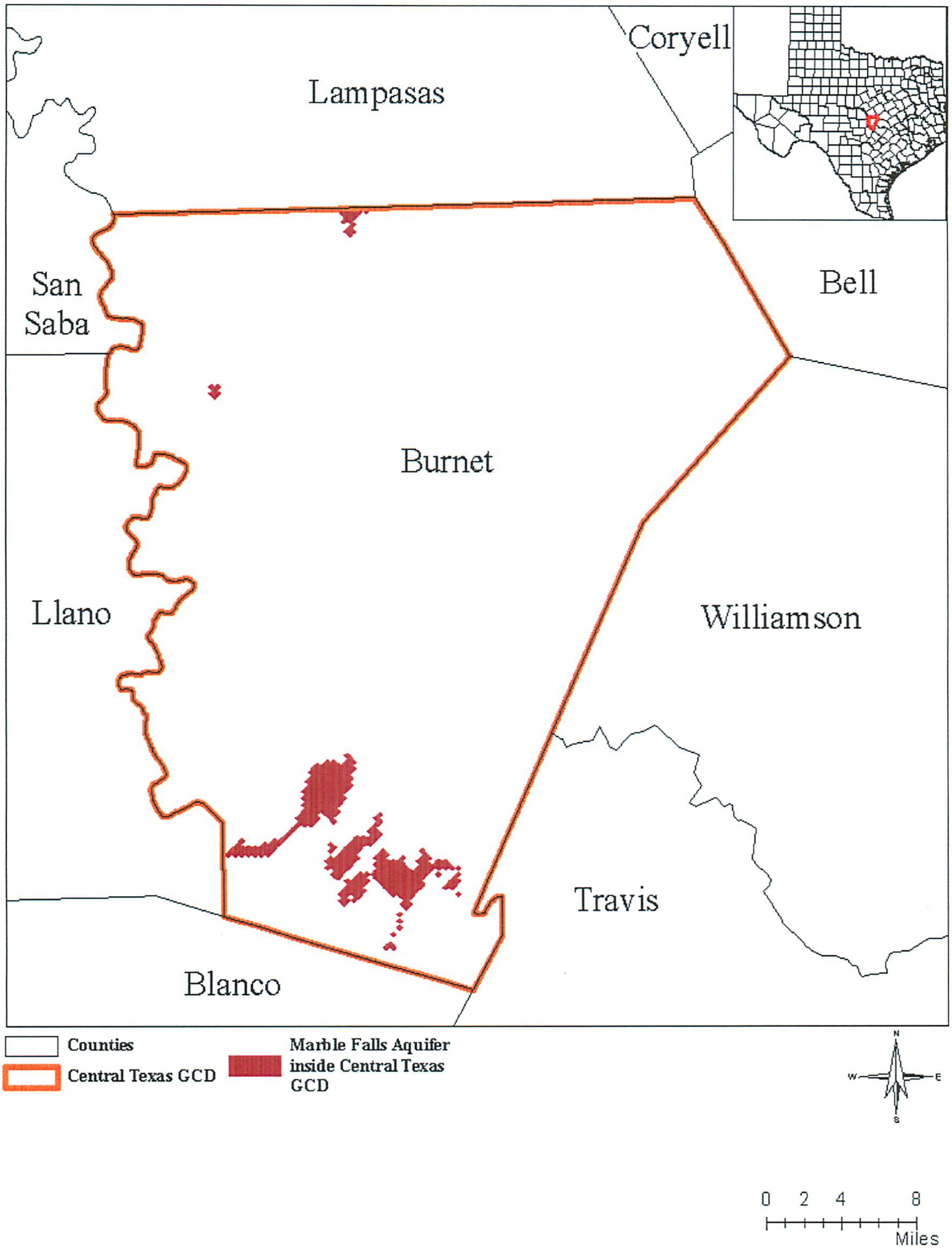

FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE MARBLE FALLS AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED FOR THE CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT (GCD).

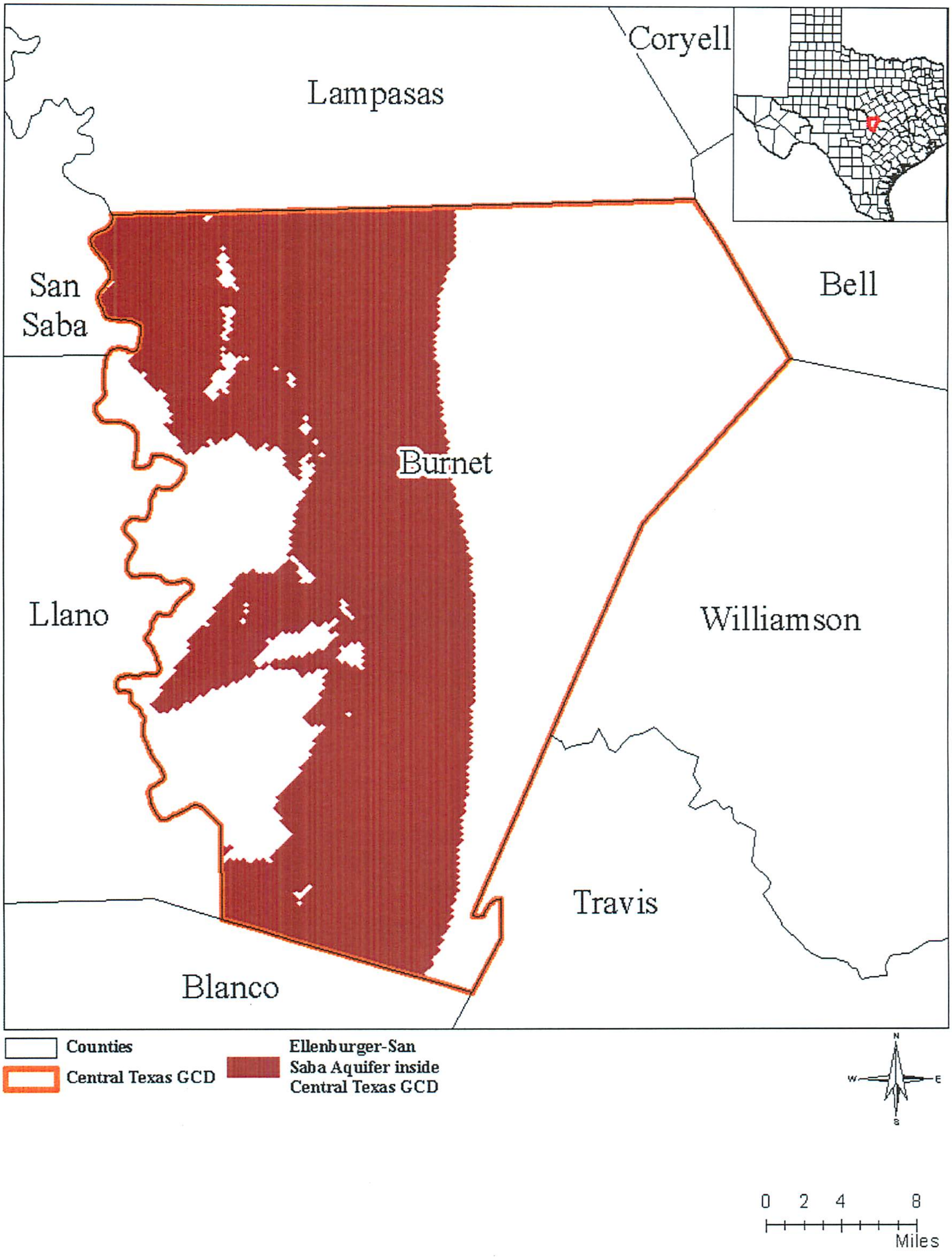

FIGURE 3: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE ELLENBURGER-SAN SABA AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED FOR THE CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT (GCD).

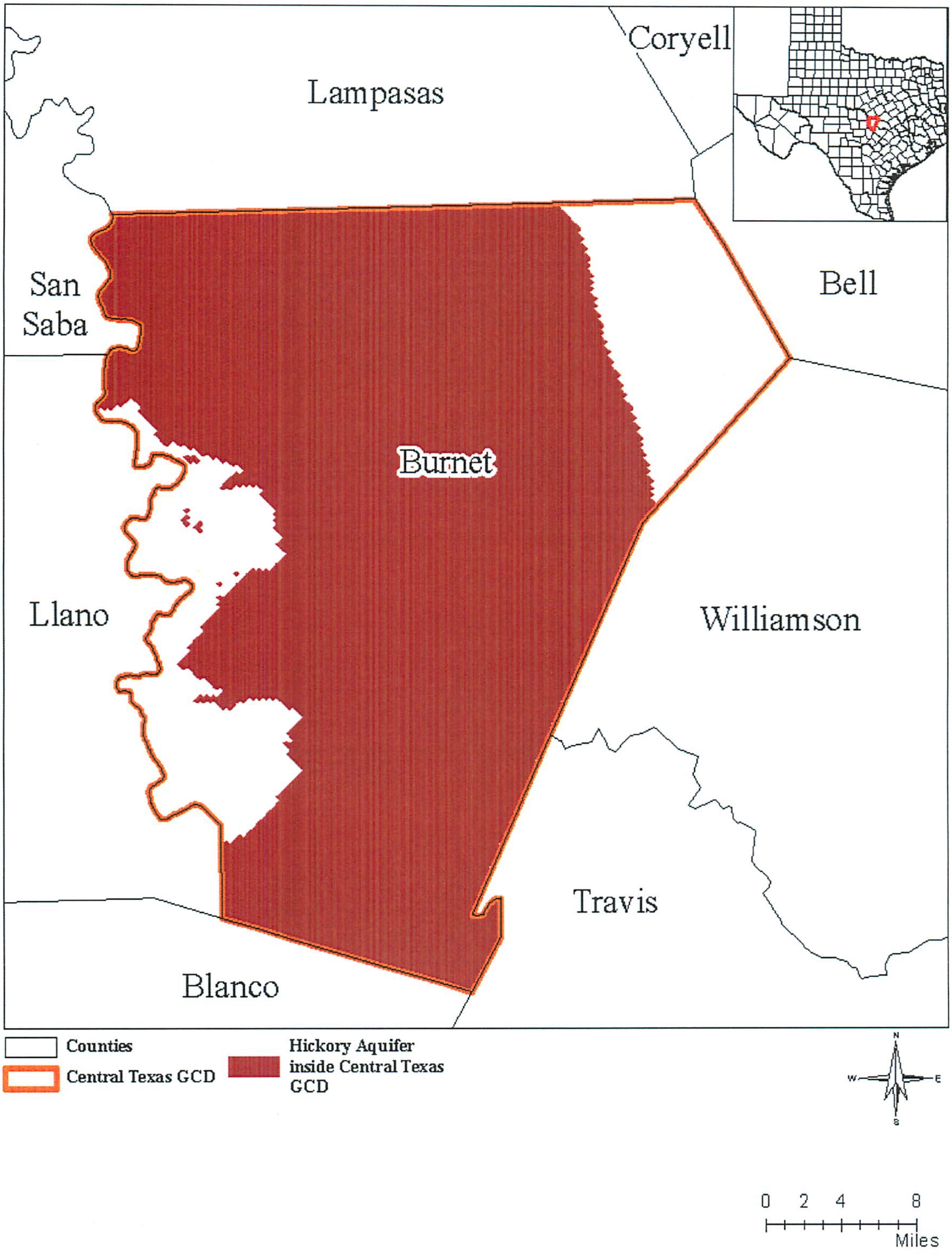

FIGURE 4: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE HICKORY AQUIFER FROM WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED FOR THE CENTRAL TEXAS GROUNDWATER CONSERVATION DISTRICT (GCD).

LIMITATIONS:

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

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

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

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

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

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