GAM Run 19-005: Saratoga Underground Water Conservation District Groundwater Management Plan

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March 15, 2019

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EXECUTIVE SUMMARY:

Texas Water Code, Section 36.1071(h) (Texas Water Code, 2011), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the Executive Administrator.

The TWDB provides data and information to the Saratoga Underground Water Conservation District in two parts. Part 1 is the Estimated Historical Water Use/State Water Plan dataset report, which will be provided to you separately by the TWDB Groundwater Technical Assistance Department. Please direct questions about the water data report to Mr. Stephen Allen at 512-463-7317 or stephen.allen@twdb.texas.gov. Part 2 is the required groundwater availability modeling information and this information includes:

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

The groundwater management plan for the Saratoga Underground Water Conservation District should be adopted by the district on or before July 18, 2019 and submitted to the Executive Administrator of the TWDB on or before August 18, 2019. The current management plan for the Saratoga Underground Water Conservation District expires on October 16, 2019.

This report replaces the results of GAM Run 13-019 (Seiter-Weatherford, 2013). GAM Run 19-005 includes results from the updated groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (Kelley and others, 2014) and the new groundwater availability model for the Llano Uplift minor aquifers (Shi and others, 2016). Tables 1, 2, 3, and 4 summarize the groundwater availability model data for the Trinity Aquifer, the Marble Falls Aquifer, the Ellenburger-San Saba Aquifer, and the Hickory Aquifer required by statute. Figures 1, 2, 3, and 4 show the area of the models from which the values in the tables were extracted. If, after review of the figures, the Saratoga Underground Water 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 Water Code, Section 36.1071(h), the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers and the groundwater availability model for the Llano Uplift minor aquifers were used to estimate information for the Saratoga Underground Water Conservation District management plan. Water budgets from the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers were extracted for the historical period (1980 through 2012) using Zonebudget Version 3.01 (Harbaugh, 2009). The water budgets from the groundwater availability model for the Llano Uplift minor aquifers were extracted for the historical period (1981 through 2010) using ZONBUDUSG version 1.01 (Panday and others, 2013). The average annual water budget values for recharge, surface-water outflow, inflow to the district, and outflow from the district for the aquifers within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Trinity Aquifer

- We used version 2.01 of the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers for this analysis. See Kelley and others (2014) for assumptions and limitations of the model.

- The model has eight layers which, in the area under the Saratoga Underground Water District, represent the Trinity Aquifer and younger units (Layers 1 through 3) and the Trinity Aquifer (Layers 4 through 8).
- Water budgets for the district were determined using the official aquifer boundaries from the associated model layers as described above.
- The model was run with MODFLOW-NWT (Niswonger and others, 2011).
- The groundwater discharge to surface water was calculated from the MODFLOW-NWT river and drain boundaries.

Marble Falls Aquifer, Ellenburger-San Saba Aquifer, and Hickory Aquifer

- We used version 1.01 of the groundwater availability model for the Llano Uplift minor aquifers for this analysis. See Shi and others (2016) for assumptions and limitations of the model.
- The model has eight layers which, in the area under the Saratoga Underground Water District, represent the Trinity Aquifer and younger units (Layer 1), confining units between the Trinity and Marble Falls (Layer 2), the Marble Falls Aquifer (Layer 3), confining units between Marble Falls and Ellenburger-San Saba (Layer 4), the Ellenburger-San Saba Aquifer (Layer 5), confining units between Ellenburger-San Saba and Hickory (Layer 6), the Hickory Aquifer (Layer 7), and the Precambrian (Layer 8).
- Water budgets for the district were determined using the official aquifer boundaries from the associated model layers as described above.
- The model was run with MODFLOW-USG Beta (Panday and others, 2013).
- The groundwater discharge to surface water was calculated from the MODFLOW-NWT river and drain boundaries.

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. The groundwater budget components listed below and reported in Tables 1, 2, 3, and 4 were extracted from the groundwater availability model results for the northern portion of the Trinity and Woodbine aquifers and for the Llano Uplift minor aquifers within Saratoga Underground Water Conservation District and averaged over the historical calibration periods.

1. 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.

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

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

4. Flow between aquifers—the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

Water budgets are estimates because of 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 FOR SARATOGA UNDERGROUND WATER CONSERVATION DISTRICT 'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	14,634
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Trinity Aquifer	32,519
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	7,764
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	4,626
Estimated net annual volume of flow between each aquifer in the district	From younger units to Trinity Aquifer	4,662

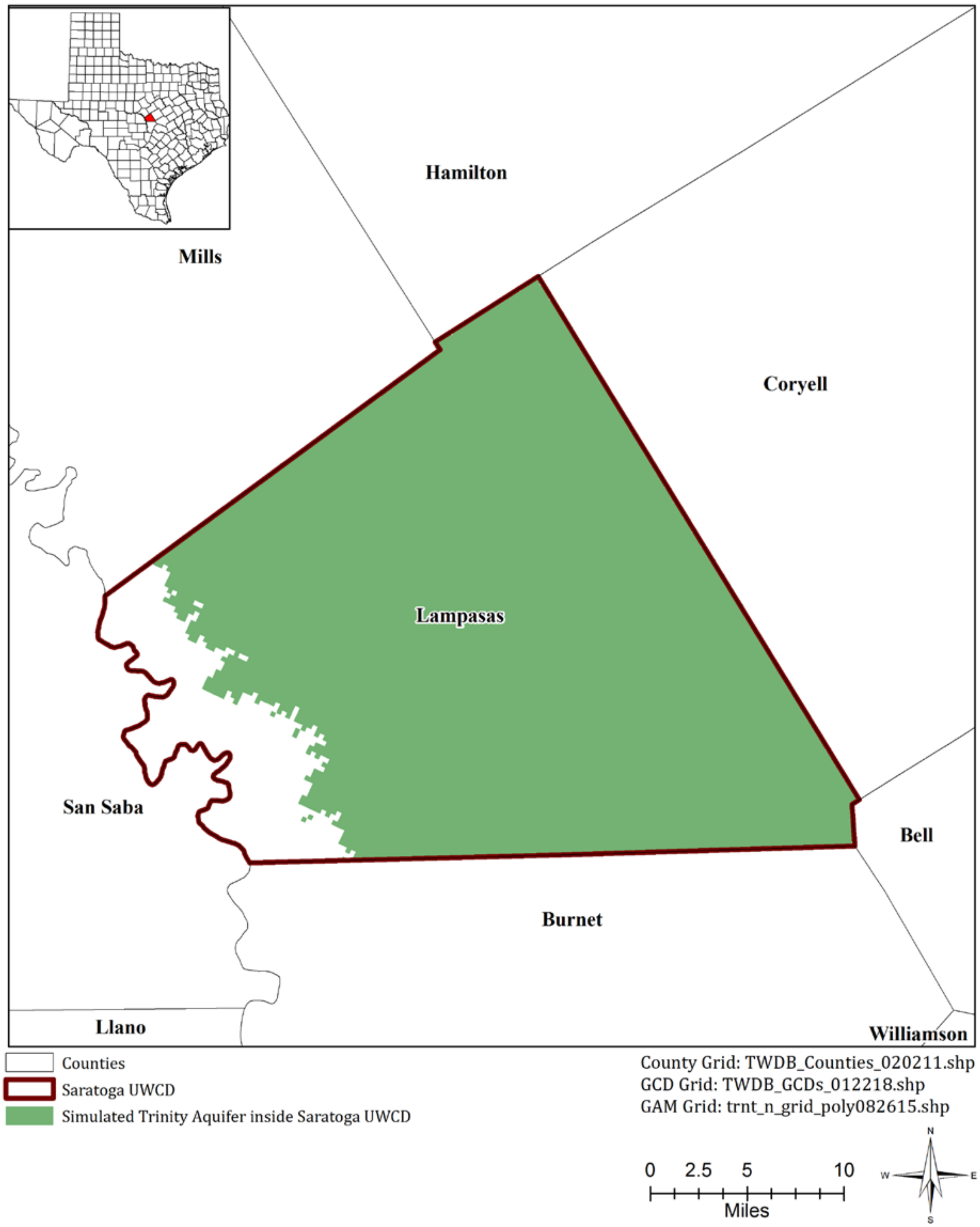

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE TRINITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE TRINITY AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE MARBLE FALLS AQUIFER FOR SARATOGA UNDERGROUND WATER CONSERVATION DISTRICT 'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Marble Falls Aquifer	1,649
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	6,769
Estimated annual volume of flow into the district within each aquifer in the district	Marble Falls Aquifer	1,799
Estimated annual volume of flow out of the district within each aquifer in the district	Marble Falls Aquifer	3,108
Estimated net annual volume of flow between each aquifer in the district	From Marble Falls Aquifer to Marble Falls units	1,084
	From Marble Falls Aquifer to units between Trinity and Marble Falls	395
	From Marble Falls Aquifer to Trinity Aquifer	35
	From units between Marble Falls and Ellenburger-San Saba to Marble Falls Aquifer	2,030
	From Marble Falls Aquifer to Ellenburger-San Saba Aquifer	87

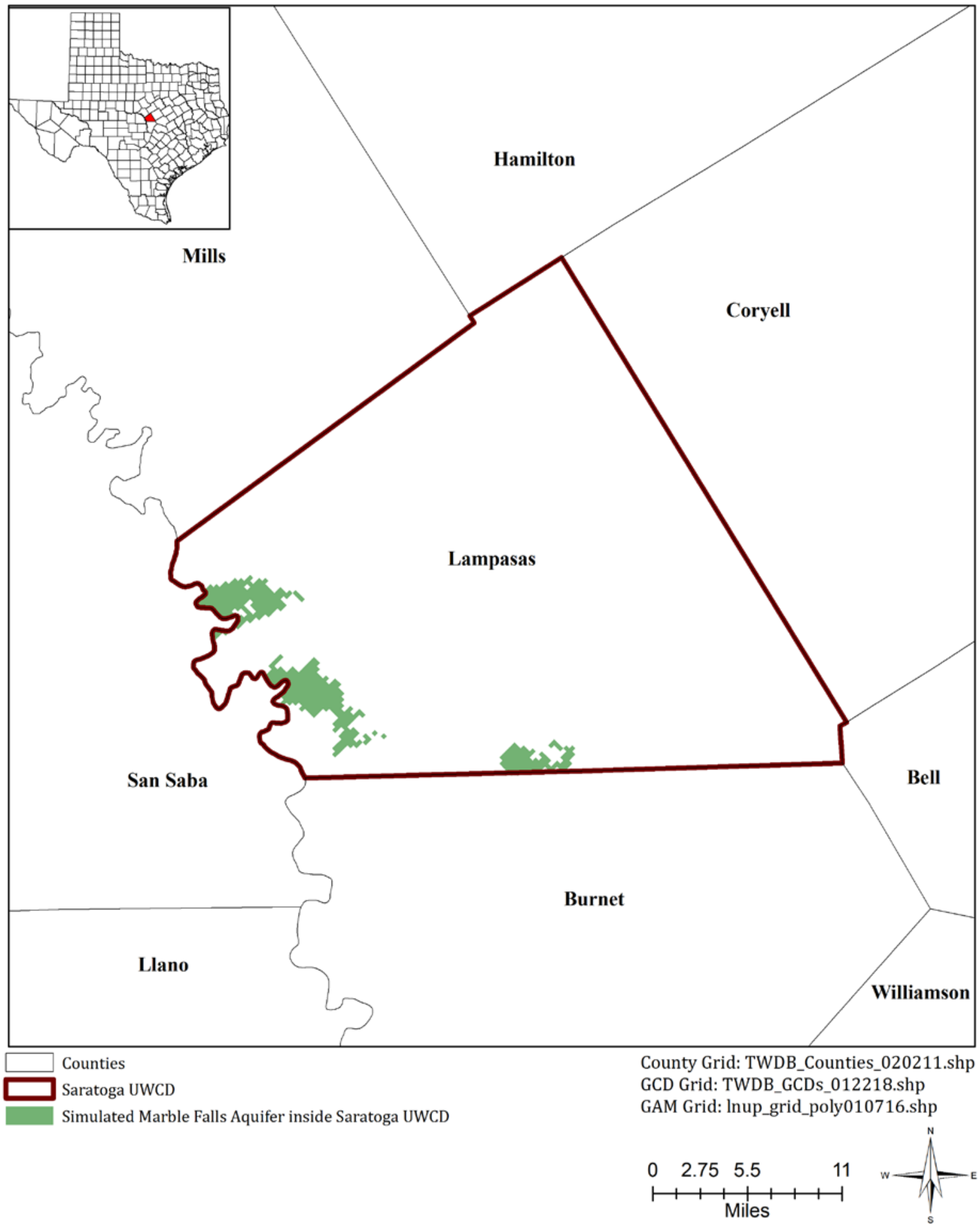

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE MARBLE FALLS AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE MARBLE FALLS AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE ELLENBURGER-SAN SABA AQUIFER FOR SARATOGA UNDERGROUND WATER CONSERVATION DISTRICT 'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Ellenburger-San Saba Aquifer	4,689
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	29,918
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	13,291
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	9,572
Estimated net annual volume of flow between each aquifer in the district	From Ellenburger-San Saba Aquifer to brackish portion	382
	From Trinity Aquifer to Ellenburger-San Saba Aquifer	1
	From Marble Falls Aquifer to Ellenburger-San Saba Aquifer	66
	From Ellenburger-San Saba Aquifer to units between Trinity and Marble Falls	1
	From Ellenburger-San Saba Aquifer to units between Marble Falls and Ellenburger-San Saba	1,712
	From units between Ellenburger-San Saba and Hickory to Ellenburger-San Saba Aquifer	811
	From Ellenburger-San Saba Aquifer to Hickory Aquifer	19

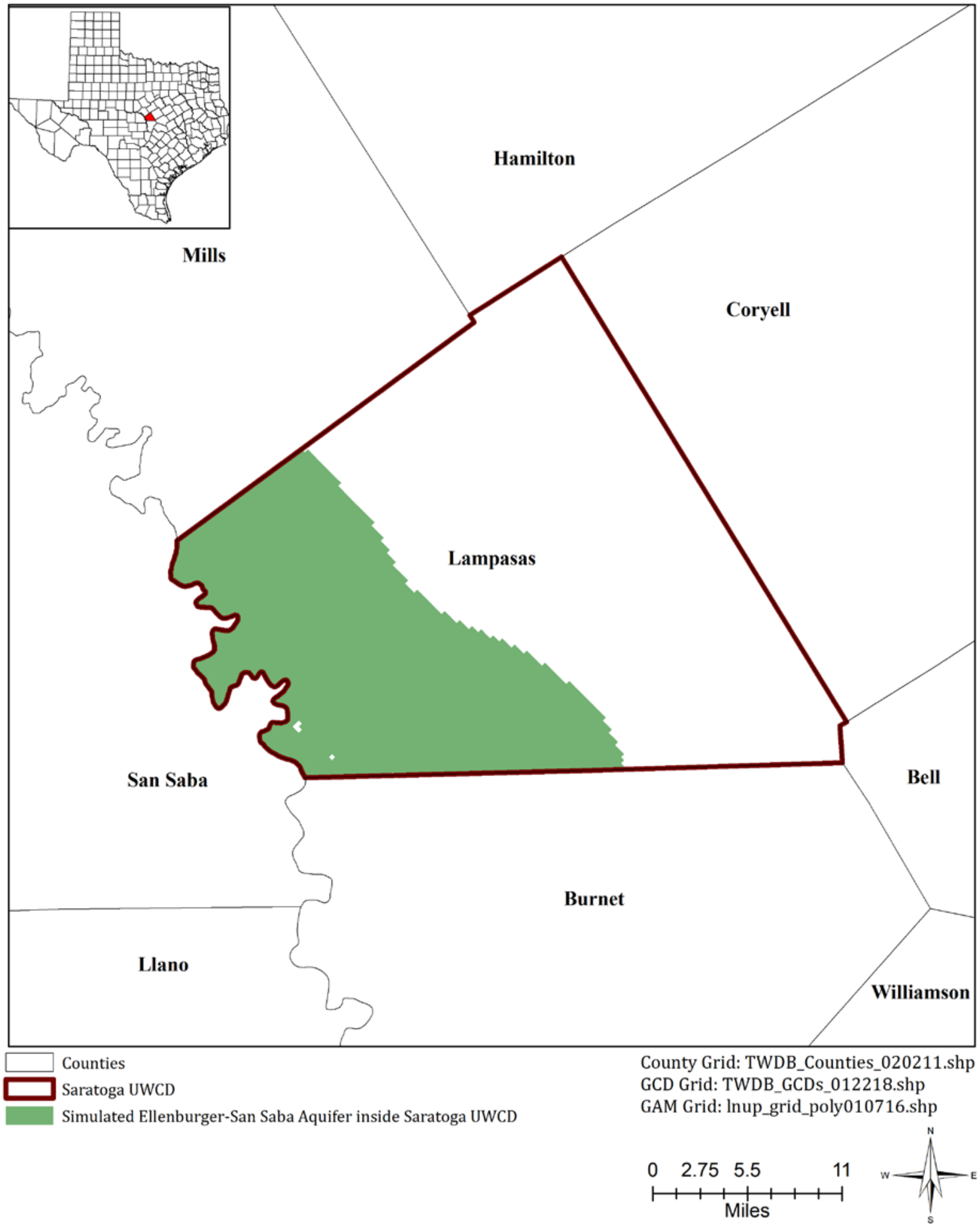

FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE ELLENBURGER-SAN SABA AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE ELLENBURGER-SAN SABA AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 4. SUMMARIZED INFORMATION FOR THE HICKORY AQUIFER FOR SARATOGA UNDERGROUND WATER CONSERVATION DISTRICT 'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Hickory Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Hickory Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Hickory Aquifer	3,791
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	2,285
Estimated net annual volume of flow between each aquifer in the district	From Hickory Aquifer to brackish portion	705
	From Ellenburger-San Saba Aquifer to Hickory Aquifer	28
	From Hickory Aquifer to units between Ellenburger-San Saba and Hickory	954
	From Precambrian Units to Hickory Aquifer	123

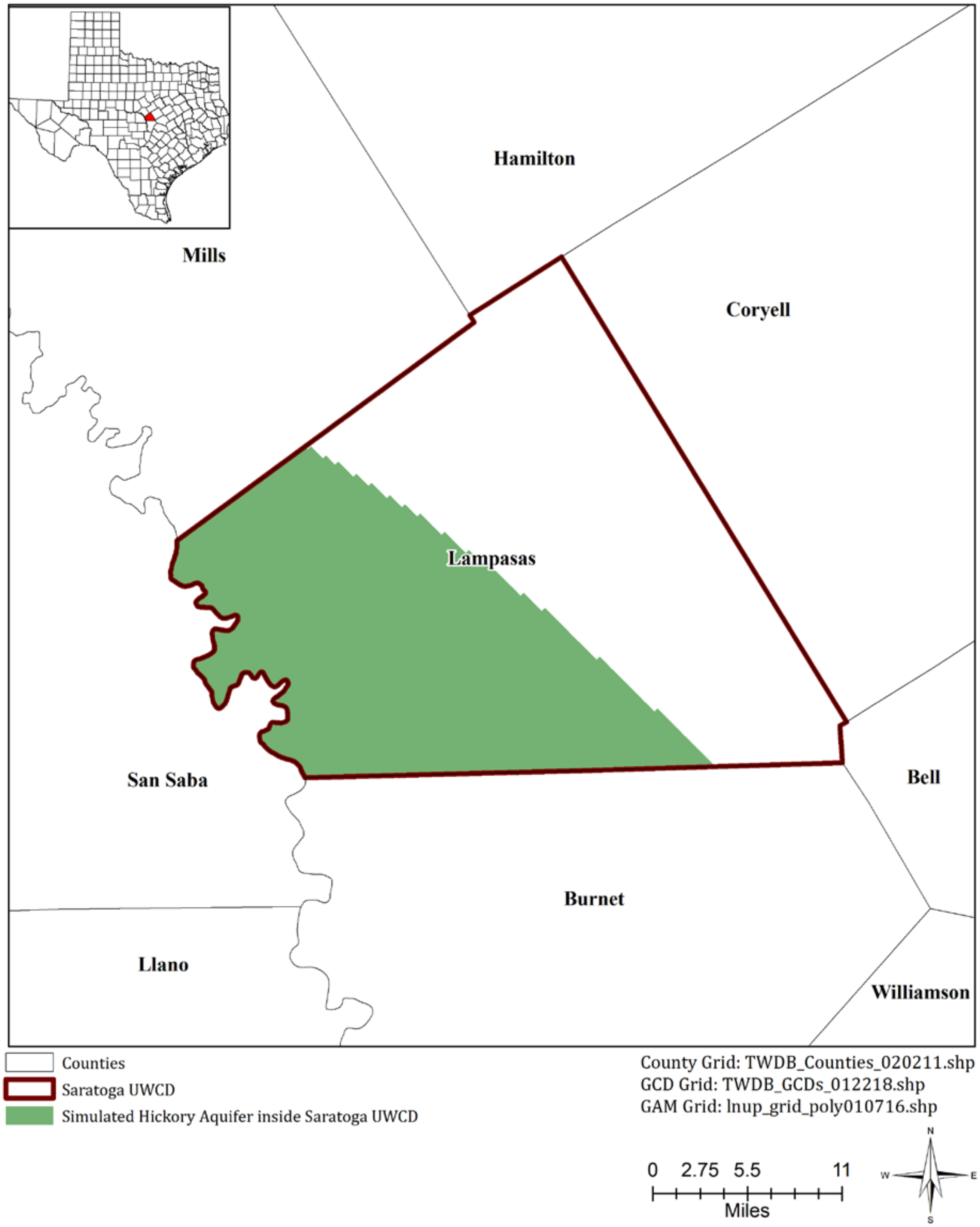

FIGURE 4. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE HICKORY AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE HICKORY AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS:

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

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

A key aspect of using the groundwater model to evaluate 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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