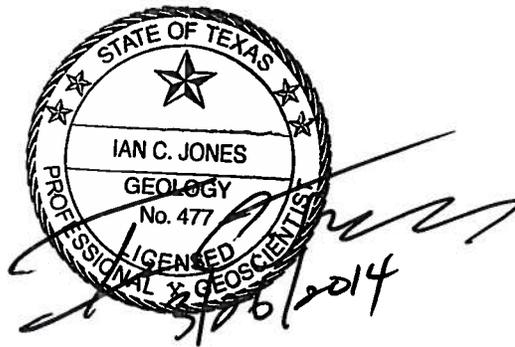

GAM RUN 14-005: BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

by Ian C. Jones, Ph.D., P.G.
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Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6641
March 26, 2014



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EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (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. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

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

This report—Part 2 of a two-part package of information from the TWDB to Brazos Valley Groundwater Conservation District—fulfills the requirements noted above. Part 1 of the two-part package is the Historical Water Use/State Water Plan data report. The district will receive the Historical Water Use/State Water Plan 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 Brazos Valley Groundwater Conservation District should be adopted by the district on or before March 9, 2015 and submitted to the executive administrator of the TWDB on or before April 8, 2015. The current management plan for Brazos Valley Groundwater Conservation District expires on June 7, 2015.

This report discusses the methods, assumptions, and results from model runs using the groundwater availability models for the Carrizo-Wilcox, Queen City, Sparta, and Yegua-Jackson aquifers, and the Gulf Coast Aquifer System. This model run replaces the results of GAM Run 10-013 (Wade and Aschenbach, 2011). GAM Run 14-005 meets current standards set after the release of GAM Run 10-013 including use of the official aquifer boundaries within the district rather than the entire active area of the model within the district. This GAM Run also includes results from the recently updated groundwater availability model for the northern portion of the Gulf Coast Aquifer System (Kasmarek, 2013). Tables 1 through 5 summarize the groundwater availability model data required by statute, and Figures 1 through 5 show the area of the models from which the values in the tables were extracted. If after review of the figures, Brazos Valley Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB immediately.

Although the Brazos River Alluvium Aquifer occurs within the Brazos Valley Groundwater Conservation District, a groundwater availability model for this aquifer has not been developed at this time. If the district would like information for the Brazos River Alluvium Aquifer, the district may request it from the Groundwater Technical Assistance Section of the TWDB.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability models for the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers, the Yegua-Jackson Aquifer, and the northern portion of the Gulf Coast Aquifer System were run for this analysis. Water budgets for Brazos Valley Groundwater Conservation District were extracted for the historical model periods (1980-2000 for the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers, 1980-1997 for the Yegua-Jackson Aquifer, and 1980-2009 for the northern portion of the Gulf Coast Aquifer System) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow (upper), and net inter-aquifer flow (lower) for the portion of each aquifer located within the district is summarized in this report.

The groundwater availability model for the northern portion of the Gulf Coast Aquifer System uses MODFLOW's General-Head Boundary Package to simulate groundwater recharge and groundwater-surface water interaction. The general-head boundary was assigned over the outcrop areas of the aquifer. To estimate groundwater recharge and groundwater-surface water interaction separately, we assumed groundwater recharge to be inflow through the general-head boundary while discharge from the aquifer to surface water bodies was assumed to be outflow through the general-head boundary. We then calculated the water budget of these zones using ZONEBUDGET Version 3.01 (Harbaugh, 2009).

PARAMETERS AND ASSUMPTIONS:

Carrizo-Wilcox, Queen City, and Sparta aquifers

- We used version 2.02 of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. See Dutton and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers.
- This groundwater availability model includes eight layers which generally represent the Sparta Aquifer (Layer 1), the Weches Formation confining unit (Layer 2), the Queen City Aquifer (Layer 3), the Reklaw Formation confining unit (Layer 4), the Carrizo Formation (Layer 5), the Calvert Bluff Formation (Layer 6), the Simsboro Formation (Layer 7), and the Hooper Formation (Layer 8). Individual water budgets for the district were determined for the Sparta Aquifer (Layer 1), the Queen City Aquifer (Layer 3), and the Carrizo-Wilcox Aquifer (Layer 5 through Layer 8, collectively).
- Groundwater in the Carrizo-Wilcox, Queen City, and Sparta aquifers ranges from fresh to brackish in composition (Kelley and others, 2004). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh and total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish.
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

Yegua-Jackson Aquifer

- We used version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer. See Deeds and others (2010) for assumptions and limitations of the groundwater availability model.

- This groundwater availability model includes five layers which represent the outcrop of the Yegua-Jackson Aquifer and younger overlying units—the Catahoula Formation (Layer 1), the upper portion of the Jackson Group (Layer 2), the lower portion of the Jackson Group (Layer 3), the upper portion of the Yegua Group (Layer 4), and the lower portion of the Yegua Group (Layer 5).
- An overall water budget for the district was determined for the Yegua-Jackson Aquifer (Layer 1 through Layer 5, collectively, for the portions of the model that represent the Yegua-Jackson Aquifer). In separate water budget calculations we calculated groundwater flow between the Catahoula Formation and the underlying Yegua-Jackson Aquifer.
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

Gulf Coast Aquifer System

- We used version 3.01 of the groundwater availability model for the northern portion of the Gulf Coast Aquifer System for this analysis. See Kasmarek (2013) for assumptions and limitations of the model.
- The model has four layers which represent the Chicot Aquifer (Layer 1), the Evangeline Aquifer (Layer 2), the Burkeville Confining Unit (Layer 3), and the Jasper Aquifer and parts of the Catahoula Formation in direct hydrologic communication with the Jasper Aquifer (Layer 4).
- Water budgets for the district were determined for the Gulf Coast Aquifer System (Layers 1 through 4).
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

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 model results for the respective aquifers located within the district and averaged over the duration of the calibration and verification portion of the model run in the district, as shown in Tables 1 through 5.

- 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 or confining units. This flow is controlled by the relative water levels in each aquifer or confining unit and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs. “Inflow” to an aquifer from an overlying or underlying aquifer will always equal the “Outflow” from the other aquifer.

The information needed for the district’s management plan is summarized in Tables 1 through 5. 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 (Figures 1 through 5).

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

<i>Management Plan requirement</i>	<i>Aquifer or confining unit</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the district	Carrizo-Wilcox Aquifer	26,906
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Carrizo-Wilcox Aquifer	16,869
Estimated annual volume of flow into the district within each aquifer in the district	Carrizo-Wilcox Aquifer	17,840
Estimated annual volume of flow out of the district within each aquifer in the district	Carrizo-Wilcox Aquifer	10,051
Estimated net annual volume of flow between each aquifer in the district	To the Carrizo-Wilcox Aquifer from the Reklaw Formation confining unit	62
	To the Carrizo-Wilcox Aquifer from the down-dip portions of the equivalent formations	10,962

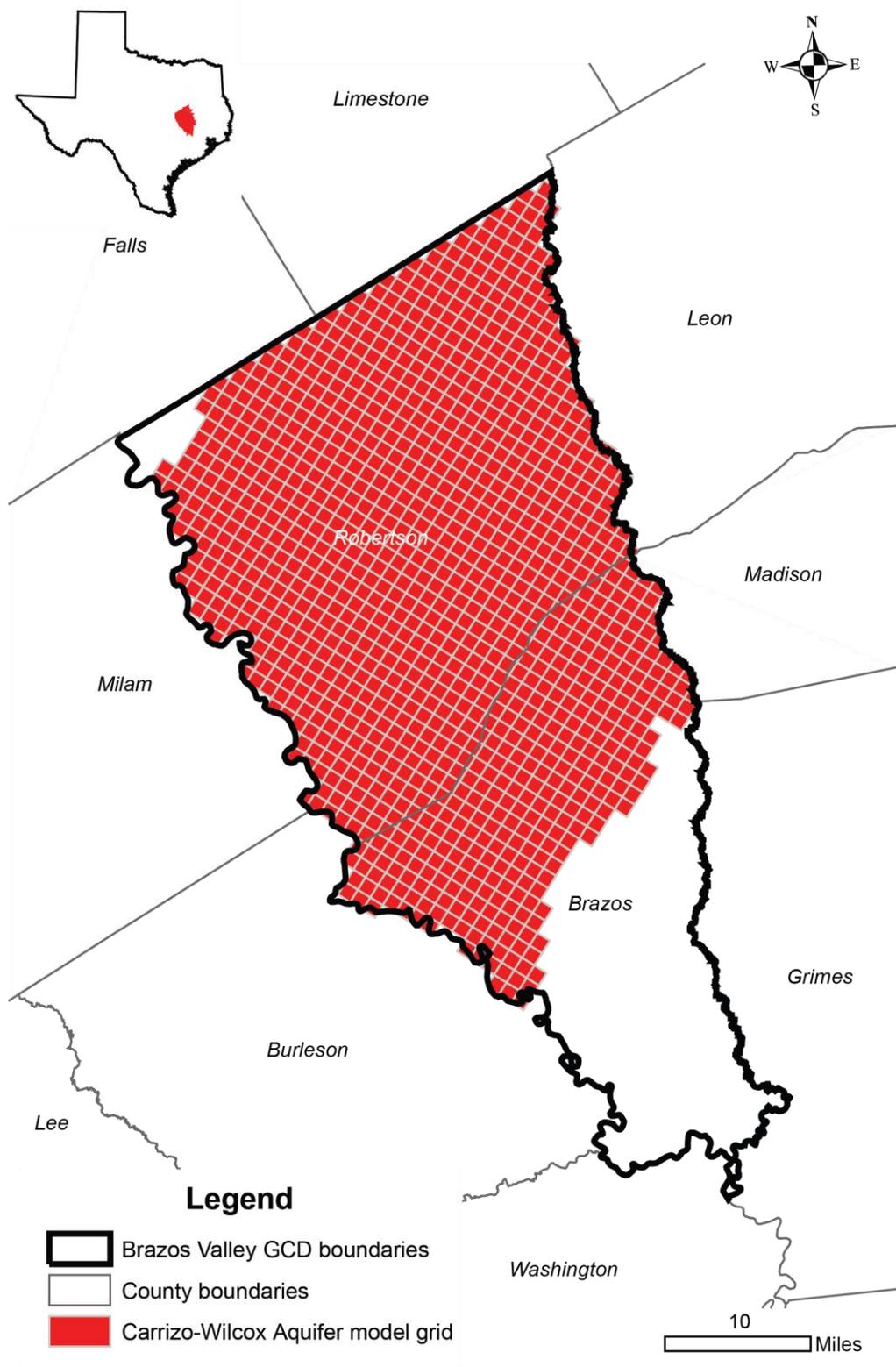


FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CARRIZO-WILCOX AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE CARRIZO-WILCOX AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE QUEEN CITY AQUIFER THAT IS NEEDED FOR BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

<i>Management Plan requirement</i>	<i>Aquifer or confining unit</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the district	Queen City Aquifer	6,091
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Queen City Aquifer	11,902
Estimated annual volume of flow into the district within each aquifer in the district	Queen City Aquifer	1,865
Estimated annual volume of flow out of the district within each aquifer in the district	Queen City Aquifer	815
Estimated net annual volume of flow between each aquifer in the district	To the Queen City Aquifer from the Weches Formation confining unit	209
	To the Queen City Aquifer from the Reklaw Formation confining unit	148
	From the Queen City Aquifer to the down-dip portion of the Queen City Formation	83



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

TABLE 3: SUMMARIZED INFORMATION FOR THE SPARTA AQUIFER THAT IS NEEDED FOR BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

<i>Management Plan requirement</i>	<i>Aquifer or confining unit</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the district	Sparta Aquifer	9,970
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Sparta Aquifer	1,861
Estimated annual volume of flow into the district within each aquifer in the district	Sparta Aquifer	617
Estimated annual volume of flow out of the district within each aquifer in the district	Sparta Aquifer	496
Estimated net annual volume of flow between each aquifer in the district	To the Sparta Aquifer from overlying stratigraphic units	714
	From the Sparta Aquifer to the Weches Formation confining unit	599
	From the Sparta Aquifer to the down-dip portion of the Sparta Formation	76

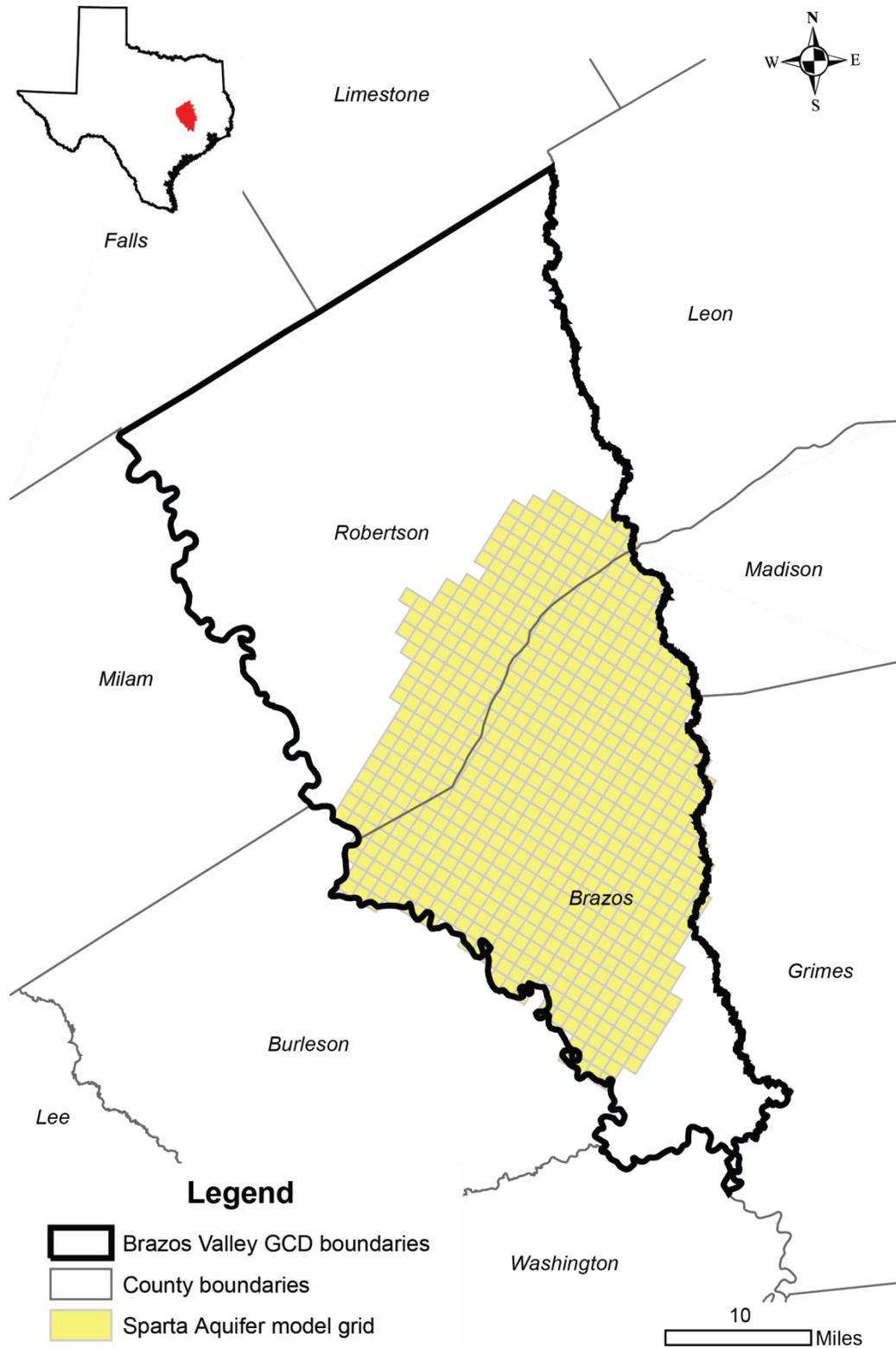


FIGURE 3: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE SPARTA AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE SPARTA AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 4: SUMMARIZED INFORMATION FOR THE YEGUA-JACKSON AQUIFER THAT IS NEEDED FOR BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

<i>Management Plan requirement</i>	<i>Aquifer or confining unit</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the district	Yegua-Jackson Aquifer	26,512
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Yegua-Jackson Aquifer	39,287
Estimated annual volume of flow into the district within each aquifer in the district	Yegua-Jackson Aquifer	12,029
Estimated annual volume of flow out of the district within each aquifer in the district	Yegua-Jackson Aquifer	9,921
Estimated net annual volume of flow between each aquifer in the district	To the Yegua-Jackson Aquifer from the confined portion of the Yegua and Jackson groups	178



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

TABLE 5: SUMMARIZED INFORMATION FOR THE GULF COAST AQUIFER SYSTEM THAT IS NEEDED FOR BRAZOS VALLEY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

<i>Management Plan requirement</i>	<i>Aquifer or confining unit</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	40
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer System	255
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	332
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	48
Estimated net annual volume of flow between each aquifer in the district	To the Gulf Coast Aquifer System from the confined portion of the Yegua and Jackson groups ¹	423

¹ Calculated using the groundwater availability model for the Yegua-Jackson Aquifer.

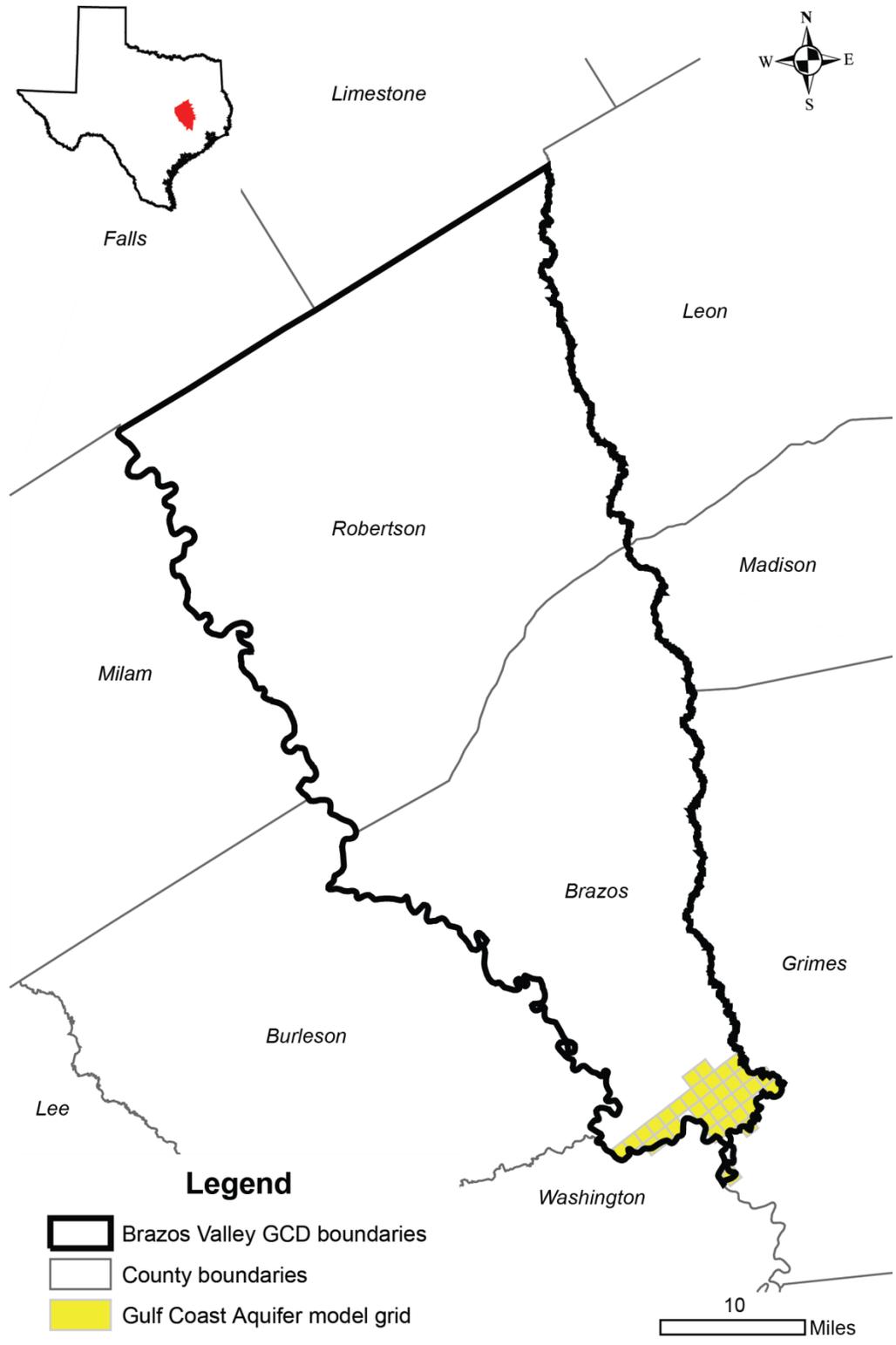


FIGURE 5: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE GULF COAST AQUIFER SYSTEM FROM WHICH THE INFORMATION IN TABLE 5 WAS EXTRACTED (THE GULF COAST AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

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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