GAM Run 18-020: Mid-East Texas Groundwater Conservation District Groundwater Management Plan

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February 11, 2019

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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.

The TWDB provides data and information to the Mid-East Texas Groundwater 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 Mid-East Texas Groundwater Conservation District should be adopted by the district on or before May 6, 2019 and submitted to the

Executive Administrator of the TWDB on or before June 5, 2019. The current management plan for the Mid-East Texas Groundwater Conservation District expires on August 4, 2019.

We used two groundwater availability models to estimate the management plan information for the aquifers within the Mid-East Texas Groundwater Conservation District. Information for the Carrizo-Wilcox, Queen City, and Sparta aquifers is from version 3.01 of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Young and others, 2018). Information for the Yegua-Jackson Aquifer is from version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer (Deeds and others, 2010).

This report replaces the results of GAM Run 13-024 (Jones, 2013). GAM Run 18-020 includes results from the newly released and updated groundwater availability model for the Carrizo-Wilcox, Queen City, and Sparta aquifers (Young and others, 2018). Tables 1 through 4 summarize the groundwater availability model data required by statute and Figures 1 through 4 show the area of the models from which the values in the tables were extracted. If, after review of the figures, the Mid-East 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 two groundwater availability models mentioned above were used to estimate information for the Mid-East Texas Groundwater Conservation District management plan. Water budgets were extracted for the historical model periods for the Carrizo-Wilcox, Queen City, and Sparta aquifers (1980 through 2010) and Yegua-Jackson Aquifer (1980 through 1997) using ZONEBUDGET Version 3.01 (Harbaugh, 2009) or ZONEBUDGET-USG (Panday and others, 2013) as applicable. 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:

Carrizo-Wilcox, Queen City, and Sparta aquifers

- We used version 3.01 of the groundwater availability model for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. See Young and others (2018) 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 ten layers, which represent the Colorado or Brazos River Alluvium (Layer 1), the outcrop and shallow flow zone of all of the underlying aquifers (Layer 2), the Sparta Aquifer (Layer 3), the Weches Formation confining unit (Layer 4), the Queen City Aquifer (Layer 5), the Reklaw Formation confining unit (Layer 6), the Carrizo Formation (Layer 7), the Calvert Bluff Formation (Layer 8), the Simsboro Formation (Layer 9), and the Hooper Formation (Layer 10).

- Individual water budgets for the district were determined for the Sparta Aquifer (Layers 2 and 3), the Queen City Aquifer (Layers 2 and 5), and the Carrizo-Wilcox Aquifer (Layers 2 and 7 through 10, collectively).

- The model was run with MODFLOW-USG (unstructured grid; Panday and others, 2013).

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).

- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifers according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the groundwater availability model results for the Carrizo-Wilcox, Queen City, Sparta, and Yegua-Jackson aquifers over the historical calibration periods, as shown in Tables 1 through 4.

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.

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 CARRIZO-WILCOX AQUIFER FOR MID-EAST TEXAS GROUNDWATER 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	Carrizo-Wilcox Aquifer	105,777
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	113,293
Estimated annual volume of flow into the district within each aquifer in the district	Carrizo-Wilcox Aquifer	17,377
Estimated annual volume of flow out of the district within each aquifer in the district	Carrizo-Wilcox Aquifer	20,772
Estimated net annual volume of flow between each aquifer in the district	Flow from the Carrizo-Wilcox Aquifer into downdip Carrizo-Wilcox units	523
	Flow into the Carrizo-Wilcox Aquifer from the overlying Reklaw Confining Unit	1,491
	Flow into the Queen City Aquifer from the Carrizo-Wilcox Aquifer	1,394

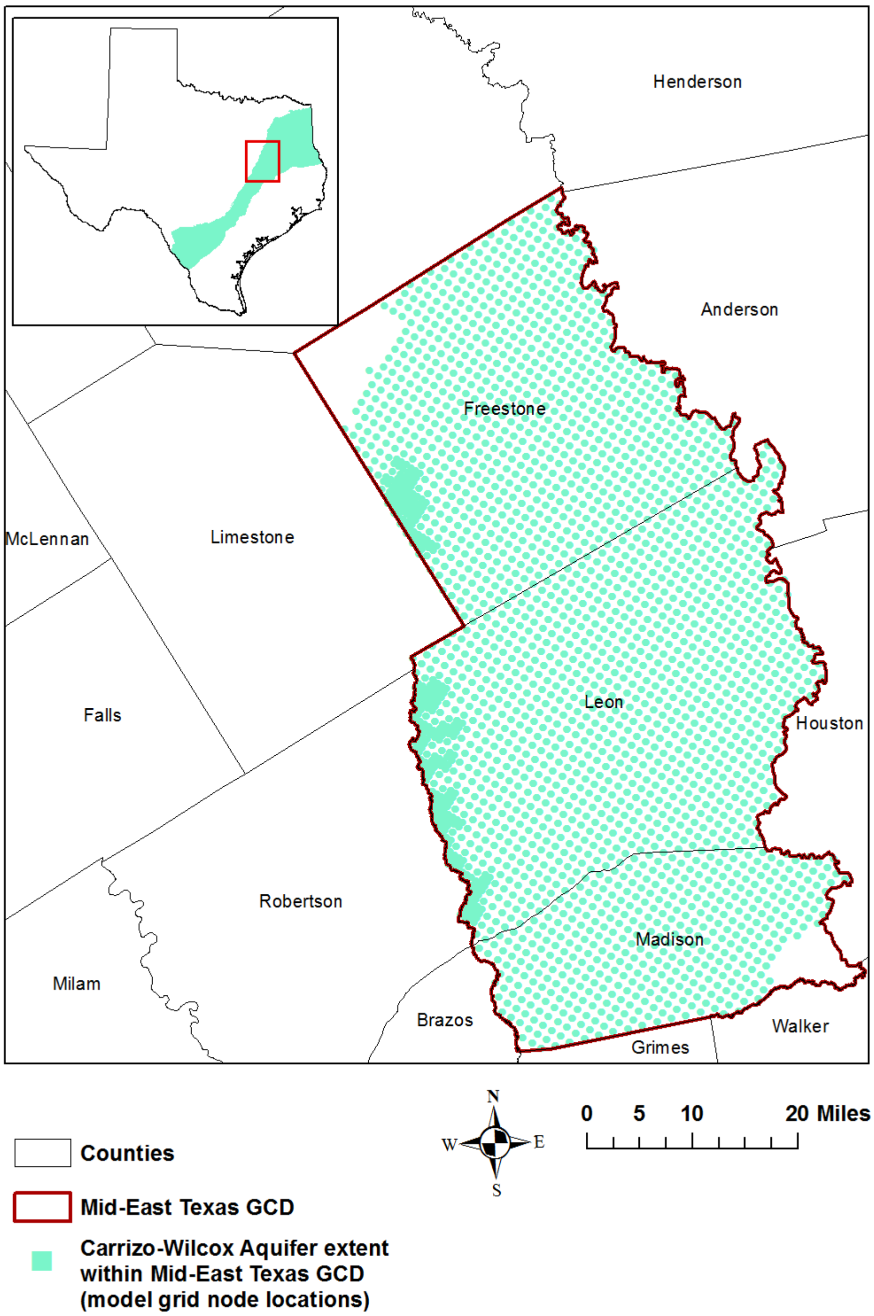

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE CARRIZO-WILCOX AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE QUEEN CITY AQUIFER FOR MID-EAST TEXAS GROUNDWATER 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	Queen City Aquifer	69,600
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	74,582
Estimated annual volume of flow into the district within each aquifer in the district	Queen City Aquifer	4,417
Estimated annual volume of flow out of the district within each aquifer in the district	Queen City Aquifer	3,886
Estimated net annual volume of flow between each aquifer in the district	Flow into the Queen City Aquifer from the Carrizo-Wilcox Aquifer	1,394
	Flow into the Queen City Aquifer from the underlying Reklaw Confining Unit	445
	Flow into the Queen City Aquifer from downdip Queen City units	11
	Flow from the Queen City Aquifer into the overlying Weches Confining Unit	872
	Flow into the Queen City Aquifer from the Sparta Aquifer	802

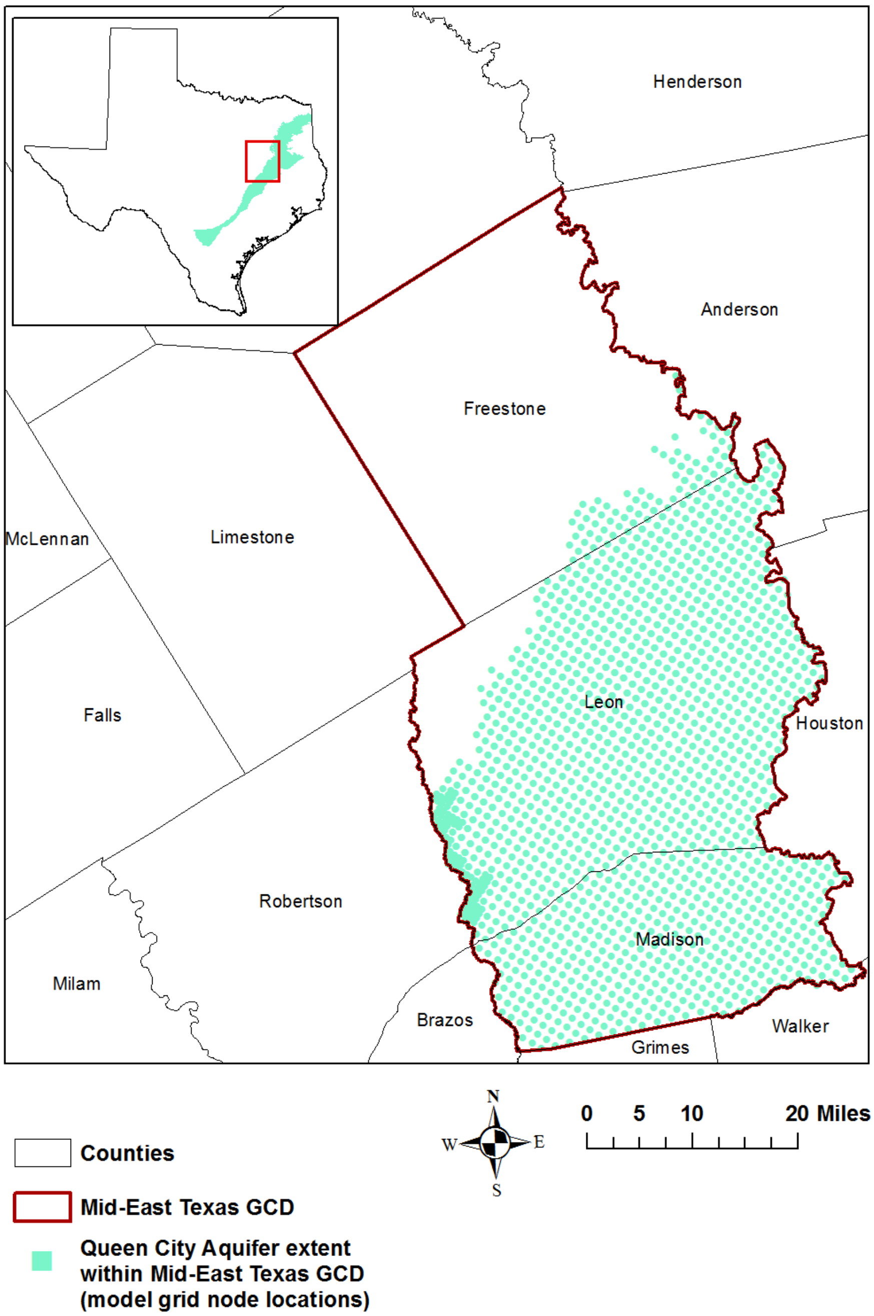

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE QUEEN CITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE SPARTA AQUIFER FOR MID-EAST TEXAS GROUNDWATER 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	Sparta Aquifer	21,332
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Sparta Aquifer	24,201
Estimated annual volume of flow into the district within each aquifer in the district	Sparta Aquifer	1,459
Estimated annual volume of flow out of the district within each aquifer in the district	Sparta Aquifer	1,513
Estimated net annual volume of flow between each aquifer in the district	Flow into the Queen City Aquifer from the Sparta Aquifer	725
	Flow into the Sparta Aquifer from the underlying Weches Confining Unit	949
	Flow from the Sparta Aquifer into overlying units	850

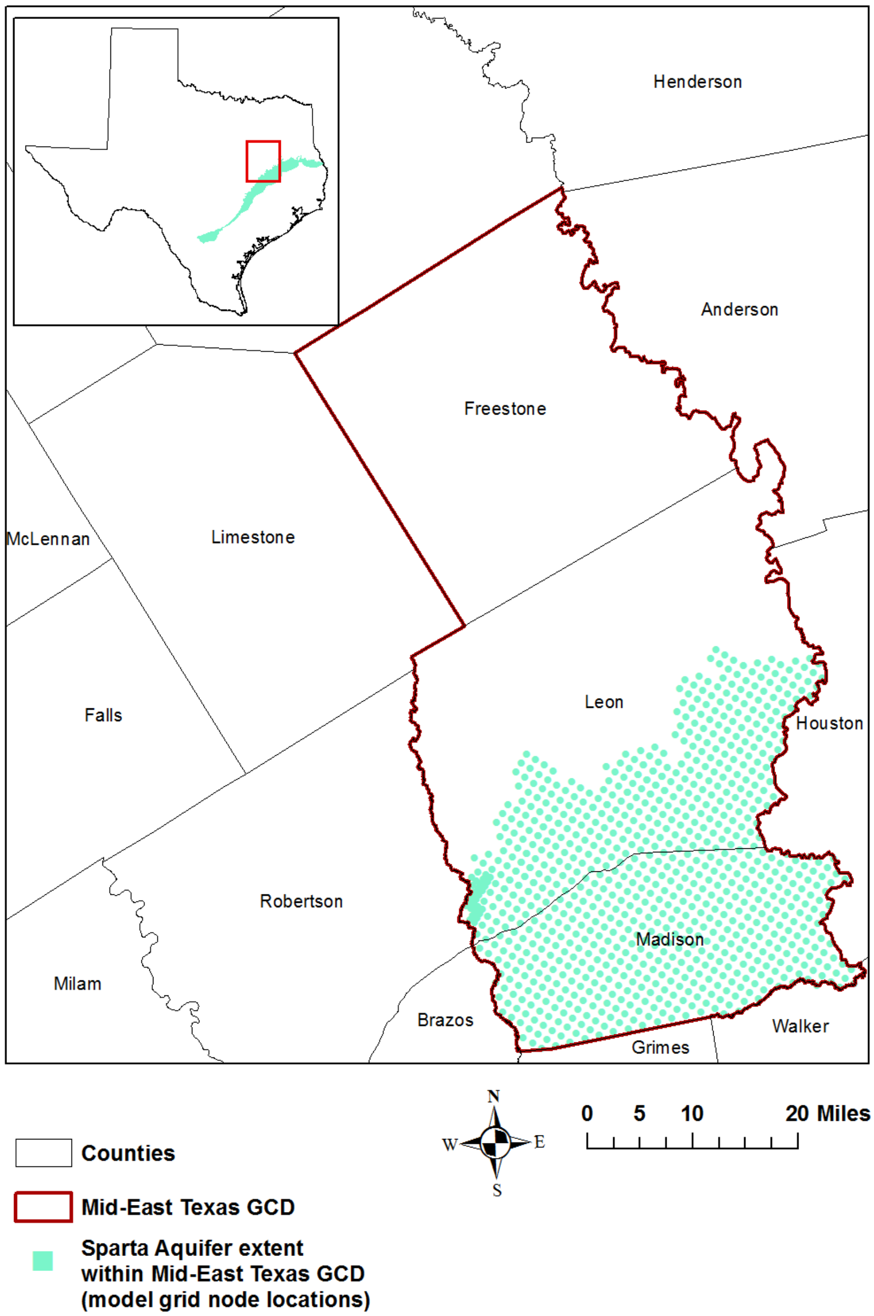

FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE SPARTA AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 4. SUMMARIZED INFORMATION FOR THE YEGUA-JACKSON AQUIFER FOR MID-EAST TEXAS GROUNDWATER 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	Yegua-Jackson Aquifer	31,137
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	46,448
Estimated annual volume of flow into the district within each aquifer in the district	Yegua-Jackson Aquifer	15,344
Estimated annual volume of flow out of the district within each aquifer in the district	Yegua-Jackson Aquifer	10,411
Estimated net annual volume of flow between each aquifer in the district	Yegua-Jackson Aquifer	0[1]

[1] The model assumptions include no groundwater flow between the Yegua-Jackson Aquifer and underlying units.

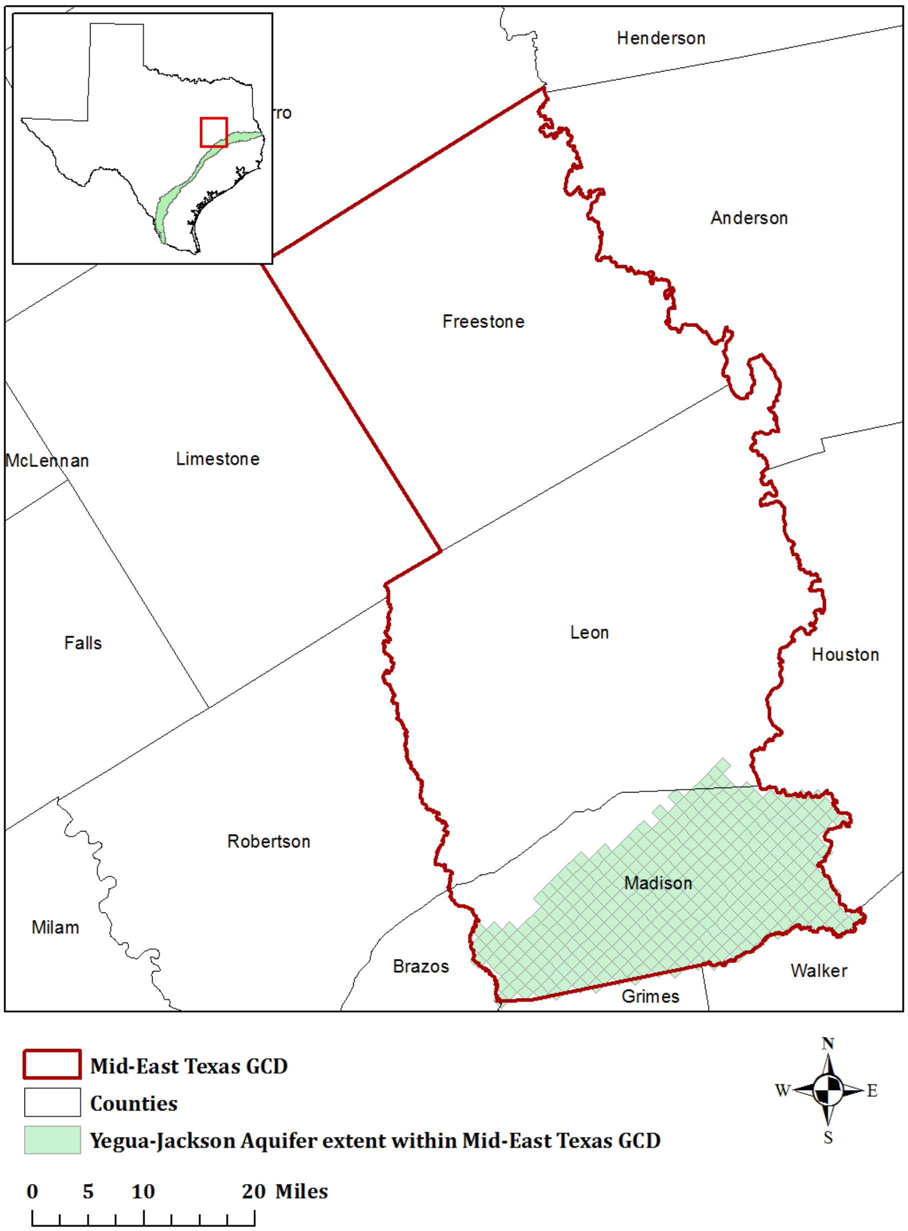

FIGURE 4. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE YEGUA-JACKSON AQUIFER FROM WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

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 historical groundwater flow conditions includes the assumptions about the location in the aquifer where historical pumping was placed. Understanding the amount and location of historical 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 historical 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. Historical 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.

REFERENCES:

Deeds, N. E., Yan, T., Singh, A., Jones, T. L., Kelley, V. A., Knox, P. R., and Young, S. C., 2010, Groundwater availability model for the Yegua-Jackson Aquifer: Final report prepared for the Texas Water Development Board by INTERA, Inc., 582 p., http://www.twdb.texas.gov/groundwater/models/gam/ygjk/YGJK_Model_Report.pdf.

Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models: U.S. Geological Survey Groundwater Software.

Harbaugh, A. W., Banta, E. R., Hill, M. C., and McDonald, M. G., 2000, MODFLOW-2000, the U.S. Geological Survey modular ground-water model -- User guide to modularization concepts and the Ground-Water Flow Process: U.S. Geological Survey Open-File Report 00-92, 121 p.

Jones, I. C., 2013, GAM Run 13-024: Mid-East Texas Groundwater Conservation District Management Plan, 16 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR13-024.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.

Panday, S., Langevin, C. D., Niswonger, R. G., Ibaraki, M., and Hughes, J. D., 2013, MODFLOW-USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6 chap. A45, 66 p.

Texas Water Code, 2011, https://statutes.capitol.texas.gov/docs/WA/pdf/WA.36.pdf

Young, S., Jigmond, M., Jones, T., and Ewing, T., 2018, Final Report: Groundwater Availability Model for the Central Portion of the Sparta, Queen City, and Carrizo-Wilcox Aquifers, Contract Report to the Texas Water Development Board, 942 p.