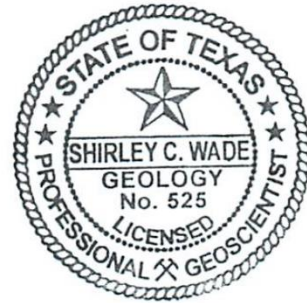# GAM Run 17-026: Middle Trinity Groundwater Conservation District Groundwater Management Plan

by Jerry Jianyou Shi, Ph.D., P.G.
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Groundwater Division
Groundwater Availability Modeling Section
512-936-0883
March 9, 2017

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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 Middle Trinity 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 at stephen.allen@twdb.texas.gov or 512-463-7317.

The groundwater management plan for the Middle Trinity Groundwater Conservation District should be adopted by the district on or before February 13, 2017, and submitted to the Executive Administrator of the TWDB on or before March 15, 2017. The current management plan for the Middle Trinity Groundwater Conservation District expires on May 14, 2017.

This report discusses the methods, assumptions, and results from model runs using version 2.01 of the groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (Kelley and others, 2014) and version 1.01 of the groundwater availability model for the Brazos River Alluvium Aquifer (Ewing and Jigmond, 2016). This model run replaces the results of GAM Run 16-002 (Shi, 2016) and includes results from the newly released groundwater availability model for the Brazos River Alluvium Aquifer. Tables 1 and 2 summarize the groundwater availability model data required by statute. Figures 1 and 2 show the areas of the models from which the values in the tables were extracted. If after review of the figures, Middle Trinity 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 models for the northern portion of the Trinity and Woodbine aquifers and the Brazos River Alluvium Aquifer were used for this analysis. The water budget for the Middle Trinity Groundwater Conservation District was extracted for selected years of the historical model period (1980 to 2012) using ZONEBUDGET Version 3.01 (Harbaugh, 2009) for the Trinity and Woodbine aquifers and ZONEBUDGET-USG (Panday and others, 2013) for the Brazos River Alluvium Aquifer. The average annual water budget values for recharge, surface water outflow, inflow to the district, and outflow from the district for the Trinity and Brazos River Alluvium 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. 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 that generally represent the following:

Layer 1 (the surficial outcrop area of the units in layers 2 through 8 and units younger than Woodbine Aquifer), Layer 2 (Woodbine Aquifer), Layer 3 (Washita and Fredericksburg Groups, and the Edwards (Balcones Fault Zone) Aquifer), and Layers 4 through 8 (Trinity Aquifer). Layers 2 through 7 also include pass-through cells.

• Perennial rivers and reservoirs were simulated using the MODFLOW River package. Ephemeral streams, flowing wells, springs, and evapotranspiration in riparian zones along perennial rivers were simulated using the MODFLOW Drain package. For this management plan, groundwater discharge to surface water includes groundwater leakage to all of the river and drain boundaries except for the groundwater loss along the riparian zone.

• The model was run using MODFLOW-NWT (Niswonger and others, 2011).

Brazos River Alluvium Aquifer

• We used version 1.01 of the groundwater availability model for the Brazos River Alluvium Aquifer released on December 16, 2016. See Ewing and Jigmond (2016) for assumptions and limitations of the model.

• The groundwater availability model for the Brazos River Alluvium Aquifer contains three layers. Layers 1 and 2 represent the Brazos River Alluvium Aquifer and Layer 3 represents the surficial portions of the Carrizo-Wilcox, Queen City, Sparta, Yegua-Jackson, and Gulf Coast aquifers as well as various geologic units of the Cretaceous System.

• Perennial rivers and streams were simulated using the MODFLOW Streamflow-Routing package and ephemeral streams, were simulated using the MODFLOW River package. Springs were simulated using the MODFLOW Drain package.

• The model was run with MODFLOW-USG (unstructured grid; 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 model results for the Trinity and Brazos River Alluvium 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 and 2.

- 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.

The information needed for the district's management plan is summarized in Tables 1 and 2. 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 MIDDLE TRINITY 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	Trinity Aquifer	74,335
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, rivers, springs, and flowing wells	Trinity Aquifer	98,449
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	29,682
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	33,741
Estimated net annual volume of flow between each aquifer in the district	From the Washita Group of the Cretaceous System to the Trinity Aquifer	29,006
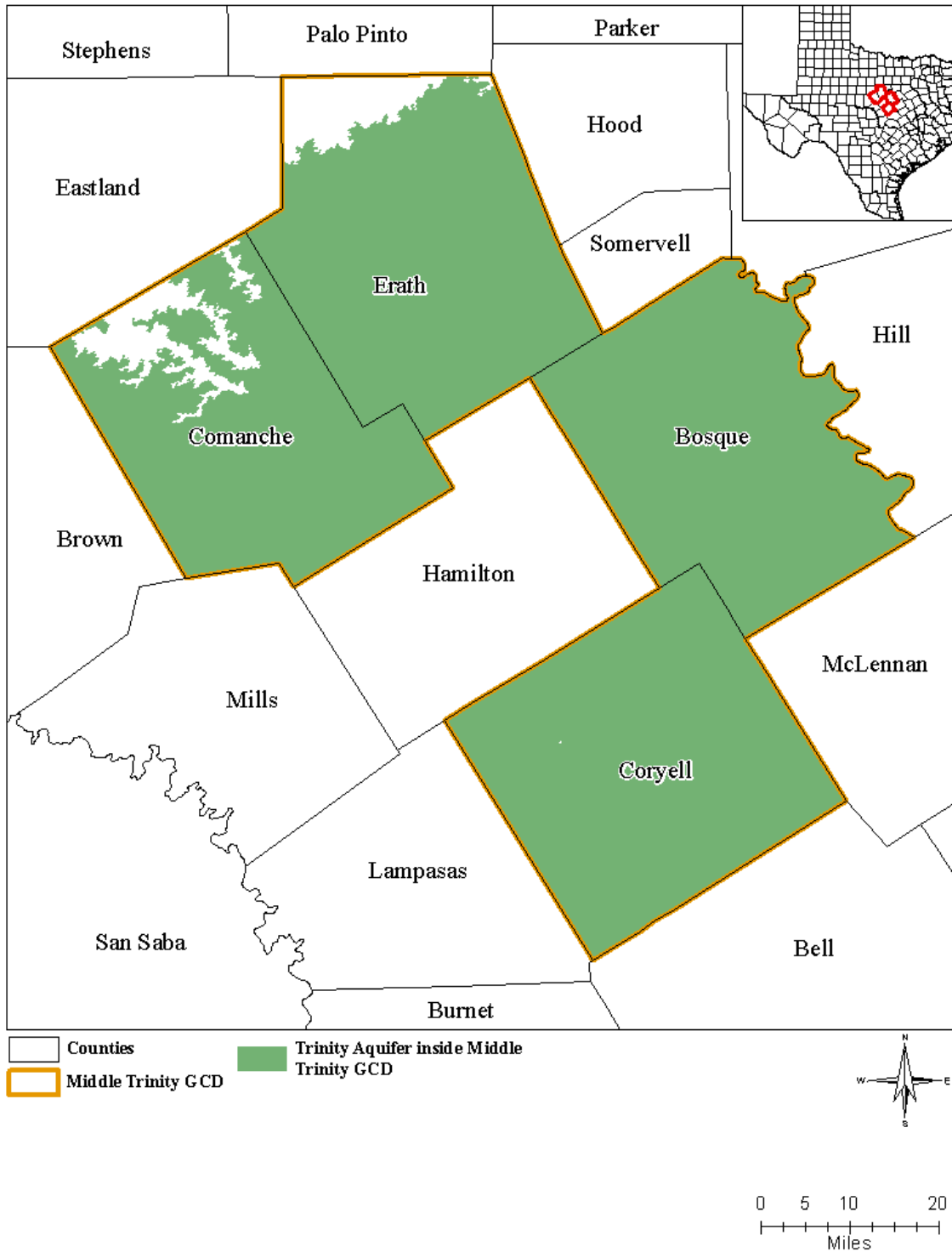
FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE TRINITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED FOR THE MIDDLE TRINITY GROUNDWATER CONSERVATION DISTRICT (GCD).

TABLE 2: SUMMARIZED INFORMATION FOR THE BRAZOS RIVER ALLUVIUM AQUIFER THAT IS NEEDED FOR MIDDLE TRINITY 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	Brazos River Alluvium Aquifer	516
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, rivers, springs, and flowing wells	Brazos River Alluvium Aquifer	845
Estimated annual volume of flow into the district within each aquifer in the district	Brazos River Alluvium Aquifer	236
Estimated annual volume of flow out of the district within each aquifer in the district	Brazos River Alluvium Aquifer	238
Estimated net annual volume of flow between each aquifer in the district	From the Washita Group of the Cretaceous System to the Brazos River Alluvium Aquifer	82
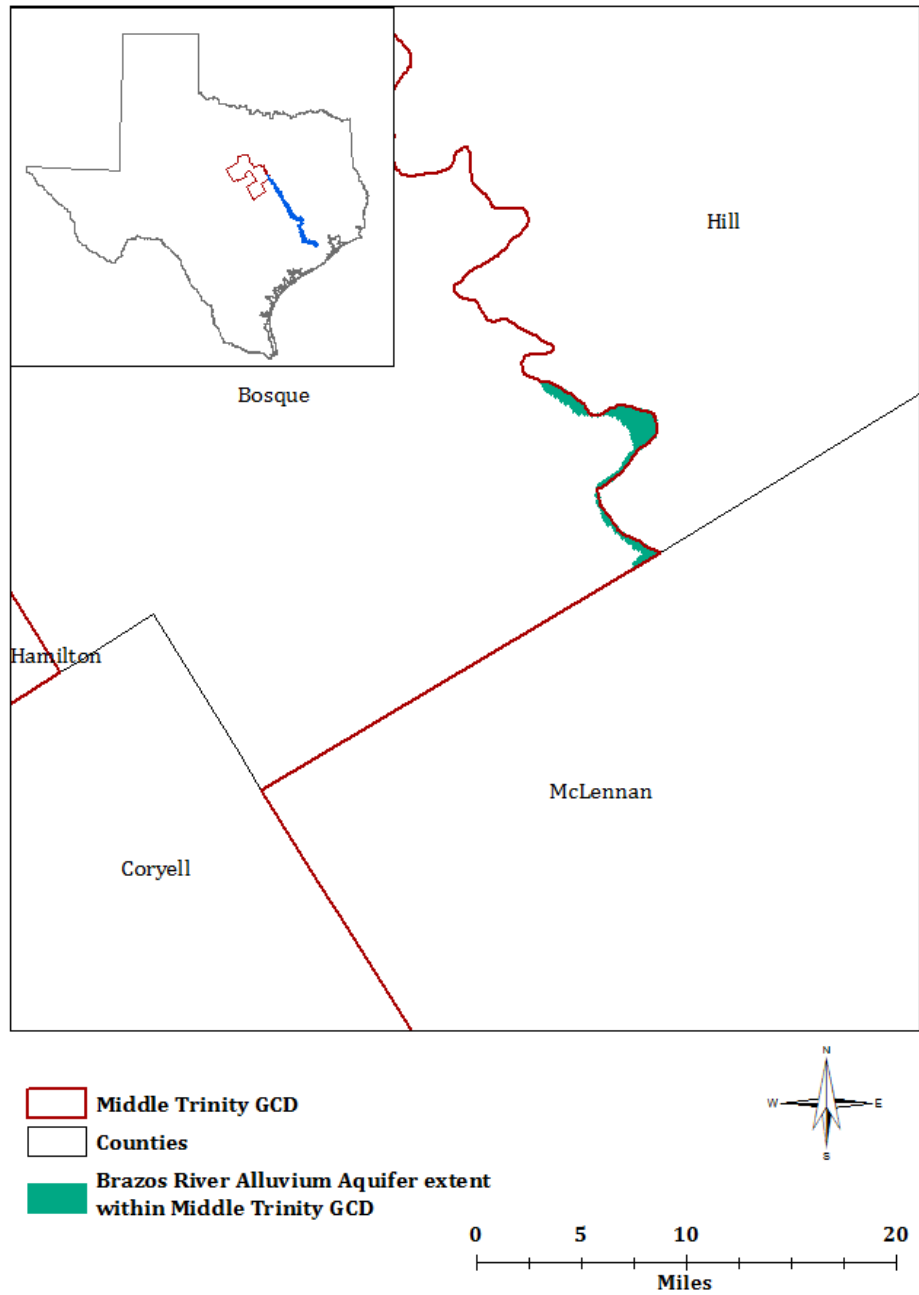
FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE BRAZOS RIVER ALLUVIUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED FOR THE MIDDLE TRINITY GROUNDWATER CONSERVATION DISTRICT (GCD).

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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Texas Water Code, 2015, http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf.