GAM RUN 19-011: COW CREEK GROUNDWATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-463-6641
March 5, 2019

STATE OF TEXAS
IAN C. JONES
GEOLOGY
No. 477
LICENSED
PROFESSIONAL GEOSCIENTIST

2/27/19

This page is intentionally blank.

GAM RUN 19-011: COW CREEK GROUNDWATER CONSERVATION DISTRICT GROUNDWATER MANAGEMENT PLAN

Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Division
Groundwater Availability Modeling Department
512-463-6641
March 5, 2019

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 Cow Creek 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 Cow Creek Groundwater Conservation District should be adopted by the district on or before November 4, 2019 and submitted to the Executive Administrator of the TWDB on or before December 4, 2019. The current management plan for the Cow Creek Groundwater Conservation District expires on

February 2, 2020.

We used two groundwater availability models to estimate the management plan information for the aquifers within the Cow Creek Groundwater Conservation District. Information for the Trinity and Edwards-Trinity (Plateau) aquifers is from version 2.01 of the groundwater availability model for the Hill Country portion of the Trinity Aquifer (Jones and others, 2011). Information for the Ellenburger-San Saba and Hickory aquifers is from version 1.01 of the groundwater availability model for the minor aquifers of the Llano Uplift region (Shi and others, 2016).

This report replaces the results of GAM Run 13-029 (Wade, 2013). GAM Run 19-011 includes results from the newly released groundwater availability model for the minor aquifers of the Llano Uplift Area (Shi and others, 2016). 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 Cow Creek 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 Cow Creek Groundwater Conservation District management plan. Water budgets were extracted for the historical model periods for the Trinity and Edwards-Trinity (Plateau) aquifers (1981 through 1997), and the Ellenburger-San Saba and Hickory aquifers (1980 through 2010) 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:

Edwards-Trinity (Plateau) and Trinity Aquifers

- We used version 2.01 of the groundwater availability model for the Hill Country portion of the Trinity Aquifer System. See Jones and others (2011) for assumptions and limitations of the groundwater availability model.
- The groundwater availability model includes four layers, representing (from top to bottom):
    1. the Edwards Group of the Edwards-Trinity (Plateau) Aquifer,
    2. the Upper Trinity Aquifer,
    3. the Middle Trinity Aquifer, and
    4. the Lower Trinity Aquifer.
- Water budget information for the Edwards-Trinity (Plateau) and Trinity aquifers were extracted from active model cells within the respective aquifer footprints.
- The General-Head Boundary (GHB) package of MODFLOW was used to represent flow out of the study area between the Hill Country portion of the Trinity Aquifer and the Edwards (Balcones Fault Zone) Aquifer or the confined parts of the Trinity Aquifer underlying the Edwards (Balcones Fault Zone) Aquifer.
- The groundwater availability model includes some portions of the Edwards Group outside the official boundary of the Edwards-Trinity (Plateau) Aquifer. Though flow for these areas is not explicitly reported, the interaction between the Edwards Group (outside the Edwards-Trinity Plateau Aquifer) and the underlying Trinity Aquifer would be shown in the “flow between aquifers” segment of Table 1, if Layer 1 was present in the district.
- Only the outcrop area of the Hill County portion of the Trinity Aquifer was modeled, and the down-dip extent that underlies the Edwards (Balcones Fault Zone) Aquifer is not included.
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

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 area. See Shi and others (2016) for assumptions and limitations of the model.
- The groundwater availability model for the minor aquifers in Llano Uplift area 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 version (Panday and others, 2013).

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 Trinity, Edwards-Trinity (Plateau), Ellenburger-San Saba, and Hickory aquifers, located within Cow Creek Groundwater Conservation District and averaged 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 EDWARDS-TRINITY (PLATEAU) AQUIFER FOR COW CREEK 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	Edwards-Trinity (Plateau) Aquifer	6,046
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	3,061
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	4,020
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	290
Estimated net annual volume of flow between each aquifer in the district	Flow from the Edwards-Trinity (Plateau) Aquifer into the Trinity Aquifer	6,429

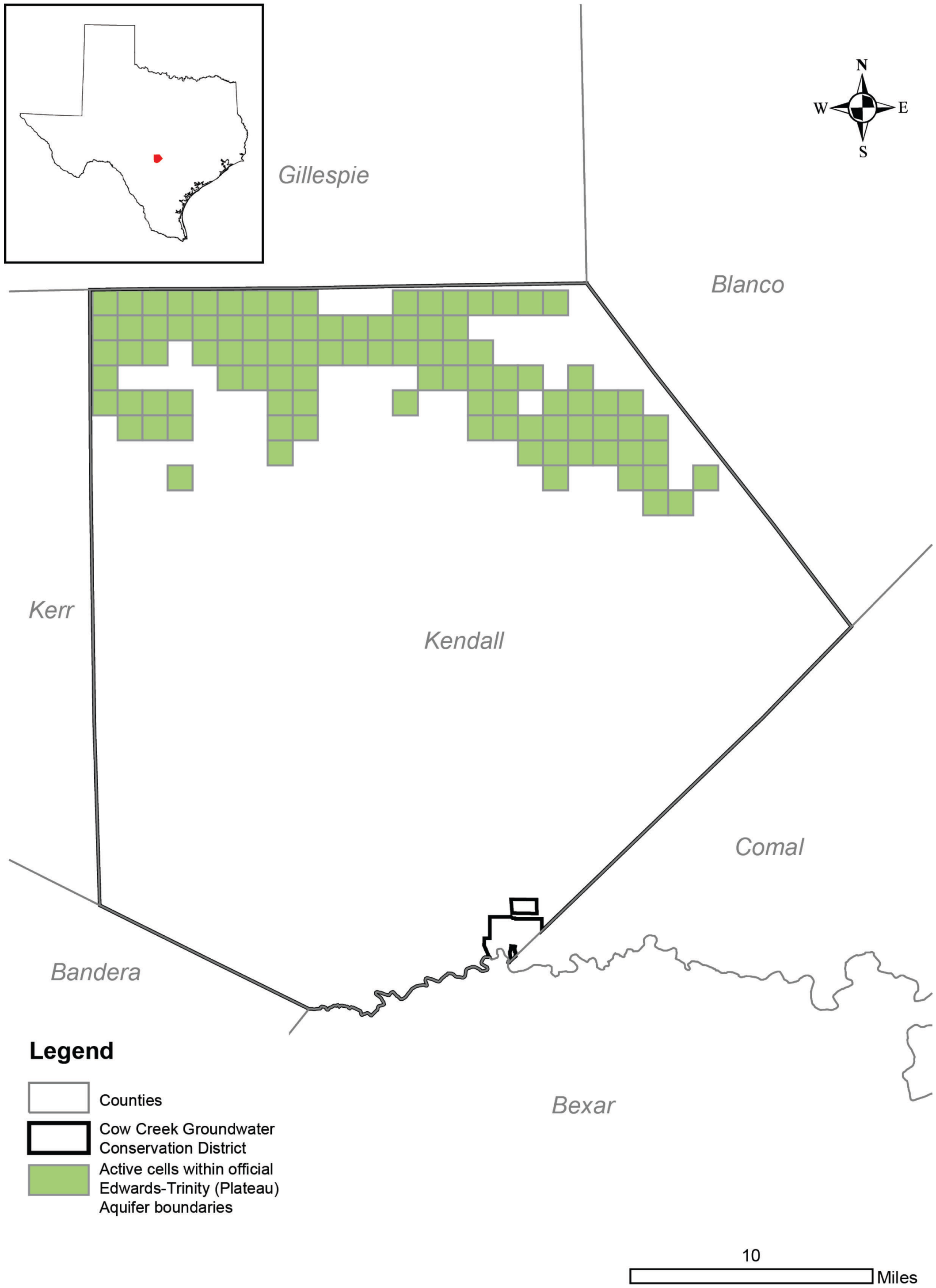

FIGURE 1. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2. SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER FOR COW CREEK 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	50,110
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Trinity Aquifer	31,131
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	7,917
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	30,915
Estimated net annual volume of flow between each aquifer in the district	Flow from the Edwards-Trinity (Plateau) Aquifer into the Trinity Aquifer	6,429
	Flow from the Edwards Group into the Trinity Aquifer	58

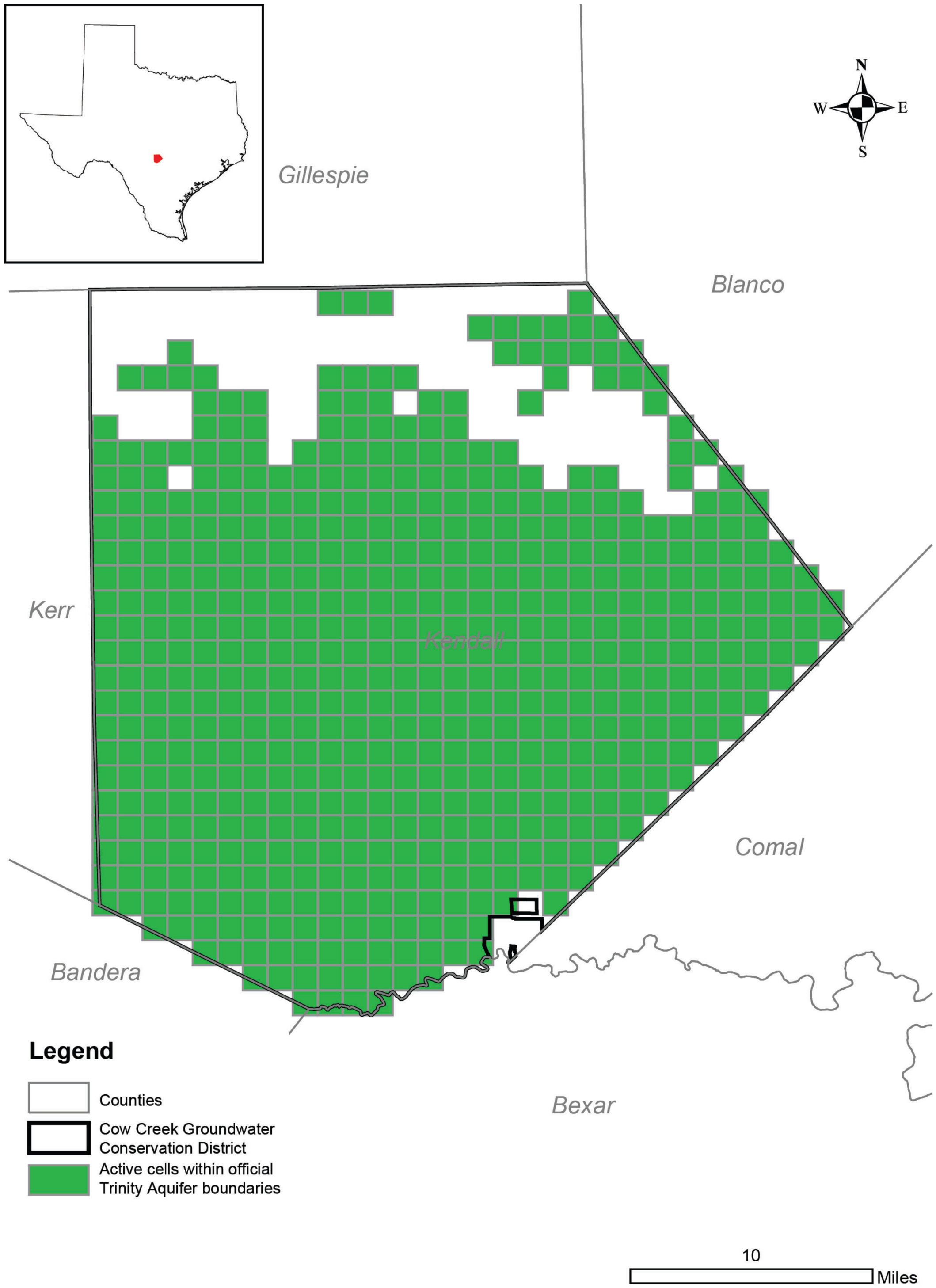

FIGURE 2. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE TRINITY AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3. SUMMARIZED INFORMATION FOR THE ELLENBURGER-SAN SABA AQUIFER FOR COW CREEK 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	Ellenburger-San Saba Aquifer	0
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	0
Estimated annual volume of flow into the district within each aquifer in the district	Ellenburger-San Saba Aquifer	5,059
Estimated annual volume of flow out of the district within each aquifer in the district	Ellenburger-San Saba Aquifer	4,811
Estimated net annual volume of flow between each aquifer in the district	Flow into the Ellenburger-San Saba Aquifer from the Hickory Aquifer	1,626
	Flow from the Ellenburger-San Saba Aquifer to brackish units	3,948
	Flow into the Ellenburger-San Saba Aquifer from overlying confining unit	4,743
	Flow from the Ellenburger-San Saba Aquifer into underlying confining unit	2,746
	Flow into the Ellenburger-San Saba Aquifer from underlying Precambrian units	75

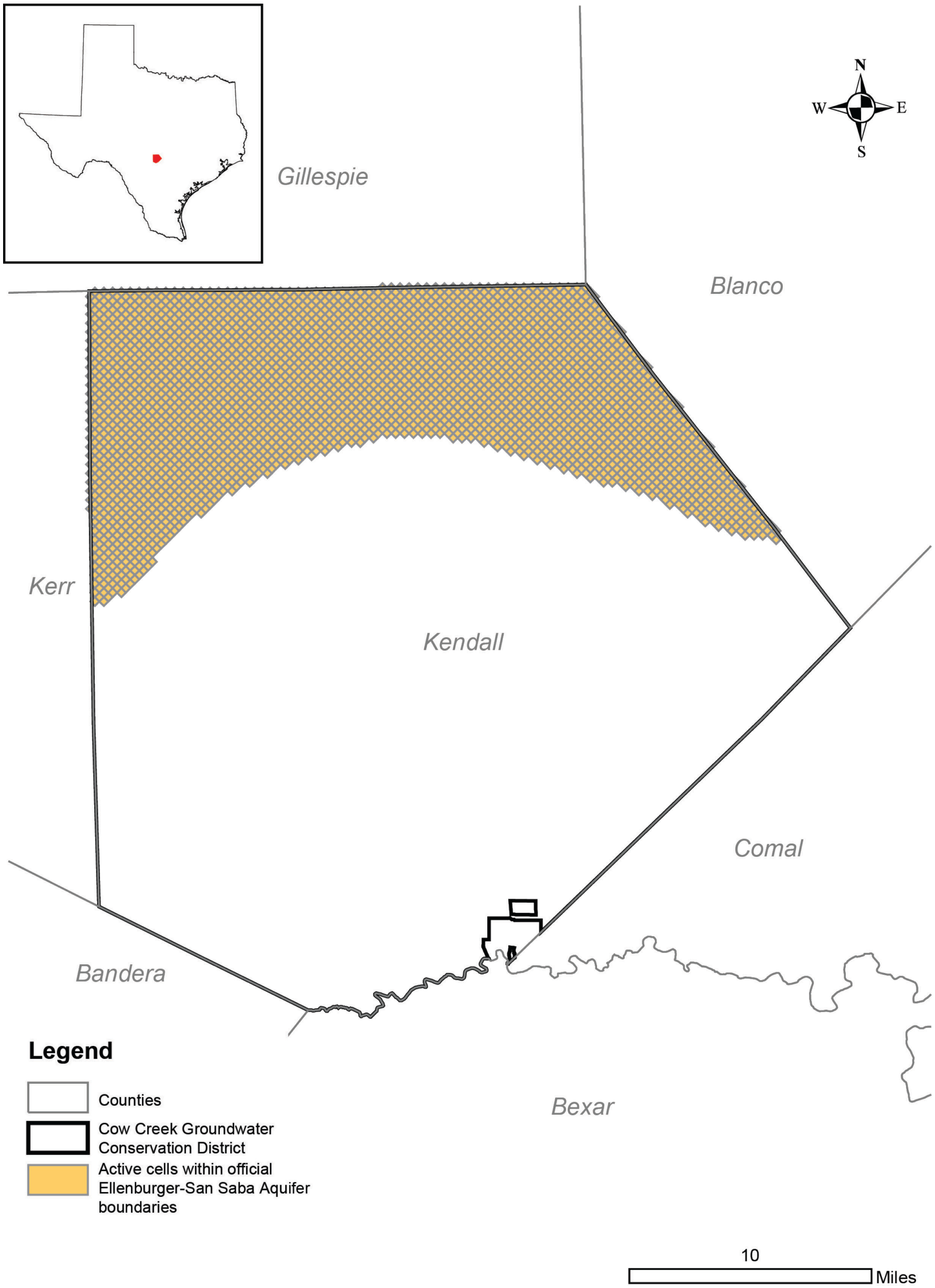

FIGURE 3. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE ELLENBURGER-SAN SABA AQUIFER FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 4. SUMMARIZED INFORMATION FOR THE HICKORY AQUIFER FOR COW CREEK 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	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	2,696
Estimated annual volume of flow out of the district within each aquifer in the district	Hickory Aquifer	2,065
Estimated net annual volume of flow between each aquifer in the district	Flow from the Hickory Aquifer into the Ellenburger-San Saba Aquifer	1,623
	Flow into the Hickory Aquifer from overlying confining units	2,753
	Flow from the Hickory Aquifer into underlying confining units	200
	Flow into the Hickory Aquifer from brackish Ellenburger-San Saba	1,288
	Flow from the Hickory Aquifer into the brackish Hickory Formation	280

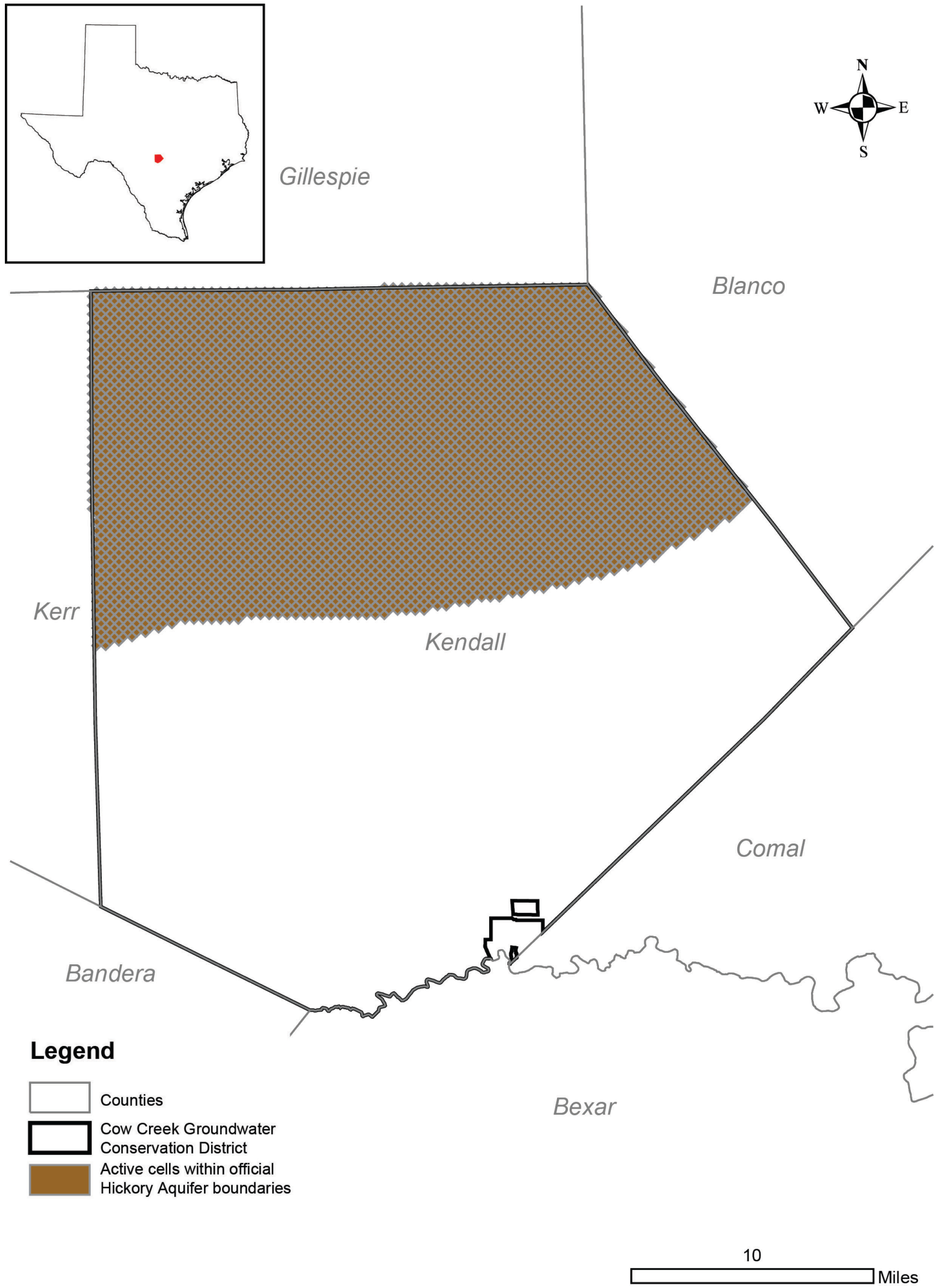

FIGURE 4. AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE HICKORY AQUIFER FROM WHICH THE INFORMATION IN TABLE 4 WAS EXTRACTED (THE AQUIFER SYSTEM EXTENT WITHIN THE DISTRICT BOUNDARY).

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:

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., and McDonald, M. G., 1996, User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference groundwater flow model: U.S. Geological Survey Open-File Report 96–485, 56 p.

Jones, I. C., Anaya, R., and Wade, S. C., 2011, Groundwater availability model: Hill Country portion of the Trinity Aquifer of Texas: Texas Water Development Board Report 377, 165 p.

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.

Shi, J., Boghici, R., Kohlrenken, W., and Hutchison, W.R., 2016, Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory). Texas Water Development Board Report, 435 p., http://www.twdb.texas.gov/groundwater/models/gam/llano/Llano_Uplift_Numerical_Model_Report_Final.pdf.

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

Wade, S. C., 2013, GAM Run 13-029: Cow Creek Groundwater Conservation District Management Plan, 22 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR13-029.pdf