GAM Run 12-019: Coke County Underground Water Conservation District Management Plan

by William Kohlrenken
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Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-8279
November 16, 2012

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EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), 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.

The purpose of this report is to provide Part 2 of a two-part package of information to Coke County Underground Water Conservation District for its groundwater management plan. The groundwater management plan for the Coke County Underground Water Conservation District is due for approval by the executive administrator of the TWDB before December 4, 2013.

This report discusses the method, assumptions, and results from model runs using the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer, the Lipan Aquifer, and the Dockum Aquifer. Tables 1 through 3 summarize the groundwater availability model data required by the statute, and figures 1 through 3 show the area

of the models from which the values in the tables were extracted. This model run replaces the results of GAM Run 07-39 (Tu, 2007). GAM Run 12-019 meets current standards set after the release of GAM Run 07-39 and it is based on the most current groundwater district boundaries and water budget extraction methods. If after review of the figures, Coke County Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB immediately. The TWDB has also approved, for planning purposes, alternative models that can have water budget information extracted for the district. These alternative models include the 1-layer alternative model for the Edwards-Trinity (Plateau) Aquifer and the alternative model for the Dockum Aquifer. Please contact the author of this report if a comparison report using these models is desired.

METHODS:

Groundwater availability models for the Edwards-Trinity (Plateau) Aquifer (1981-2000), Lipan Aquifer (1980-1999), and the Dockum Aquifer (1980-1997) were run for this analysis. Water budgets for each year of the transient model period were extracted using ZONEBUDGET Version 3.01 (Harbaugh, 2009) and 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 portions of the aquifers located within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Edwards-Trinity (Plateau) Aquifer

- We used Version 1.01 of the groundwater availability model of the Edwards-Trinity (Plateau) Aquifer for this analysis. See Anaya and Jones (2009) for assumptions and limitations of the model.
- The model has two layers which represent the Edwards portions of the Edwards-Trinity (Plateau) Aquifer in layer one, and Trinity portions of the Edwards-Trinity (Plateau) Aquifer in layer two.
- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) is 143 feet for the

transient calibration period. This represents 6 percent of the range of measured water levels (Anaya and Jones, 2009).

- The model was run with MODFLOW-96 (Harbaugh and MacDonald, 1996).

Lipan Aquifer

- We used Version 1.01 of the groundwater availability model for the Lipan Aquifer for this analysis. See Beach and others (2004) for assumptions and limitations of the groundwater availability model.
- The Lipan Aquifer model includes one layer representing the Quaternary Leona Formation, portions of the underlying Permian Formations, and the Edwards-Trinity (Plateau) Aquifer to the west, south, and north.
- The model uses general head boundaries to simulate the eastern and western aquifer boundaries. Inflow on the general-head boundary to the west represents inflow from the Edwards-Trinity (Plateau) Aquifer. The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model for the Lipan Aquifer is 18 feet for the calibration period (1980-89) and 17 feet for the verification period (1990-99: Beach and others, 2004).
- The model was run with MODFLOW-96 (Harbaugh and MacDonald, 1996).

Dockum Aquifer

- We used Version 1.01 of the groundwater availability model for the Dockum Aquifer. See Ewing and others (2008) for assumptions and limitations of the groundwater availability model.
- The model includes three layers representing the younger geologic units overlying the Dockum Aquifer (layer 1), the upper portion of the Dockum Aquifer (layer 2), and the lower portion of the Dockum Aquifer (layer 3).
- Of the three layers, individual water budgets for the district were determined for the Dockum Aquifer (Layers 2 and 3). The water budgets for Layers 2 and 3 are combined.
- The aquifers represented in Layer 1 of the groundwater availability model are only included in the model for the purpose of more accurately representing flow between these units and the Dockum Aquifer. This model

is not intended to explicitly simulate flow in these overlying units (Ewing and others, 2008).

- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 82 feet for the Upper Dockum Aquifer, and 108 feet for the Lower Dockum Aquifer for the calibration period (1980 to 1990) and 83 and 78 feet for the same aquifers, respectively, in the verification period (1991 to 1999) (Ewing and others, 2008). These root mean square errors are between three and five percent of the range of measured water levels (Ewing and others, 2008).

- The MODFLOW Drain package was used to simulate both evapotranspiration and springs. However, there were no model grid cells representing springs within the district so there was no drain flow incorporated into the surface water outflow values.

- Groundwater in the Dockum Aquifer ranges from fresh to brine in composition (Ewing and others, 2008). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh, total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish, and total dissolved solids greater than 10,000 to 35,000 milligrams per liter are considered saline.

- 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 aquifers located within the district and averaged over the duration of the calibration and verification portion of the model runs in the district. The components of the modified budget shown in tables 1 through 3 include:

- 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 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 through 3. 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 district or county boundaries, 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 (see figures 1 through 3).

TABLE 1: SUMMARIZED INFORMATION FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER THAT IS NEEDED FOR COKE COUNTY 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	Edwards-Trinity (Plateau) Aquifer	5,832
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	6,693
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	1,235
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	545
Estimated net annual volume of flow between each aquifer in the district	From Edwards-Trinity (Plateau) to older underlying units	56

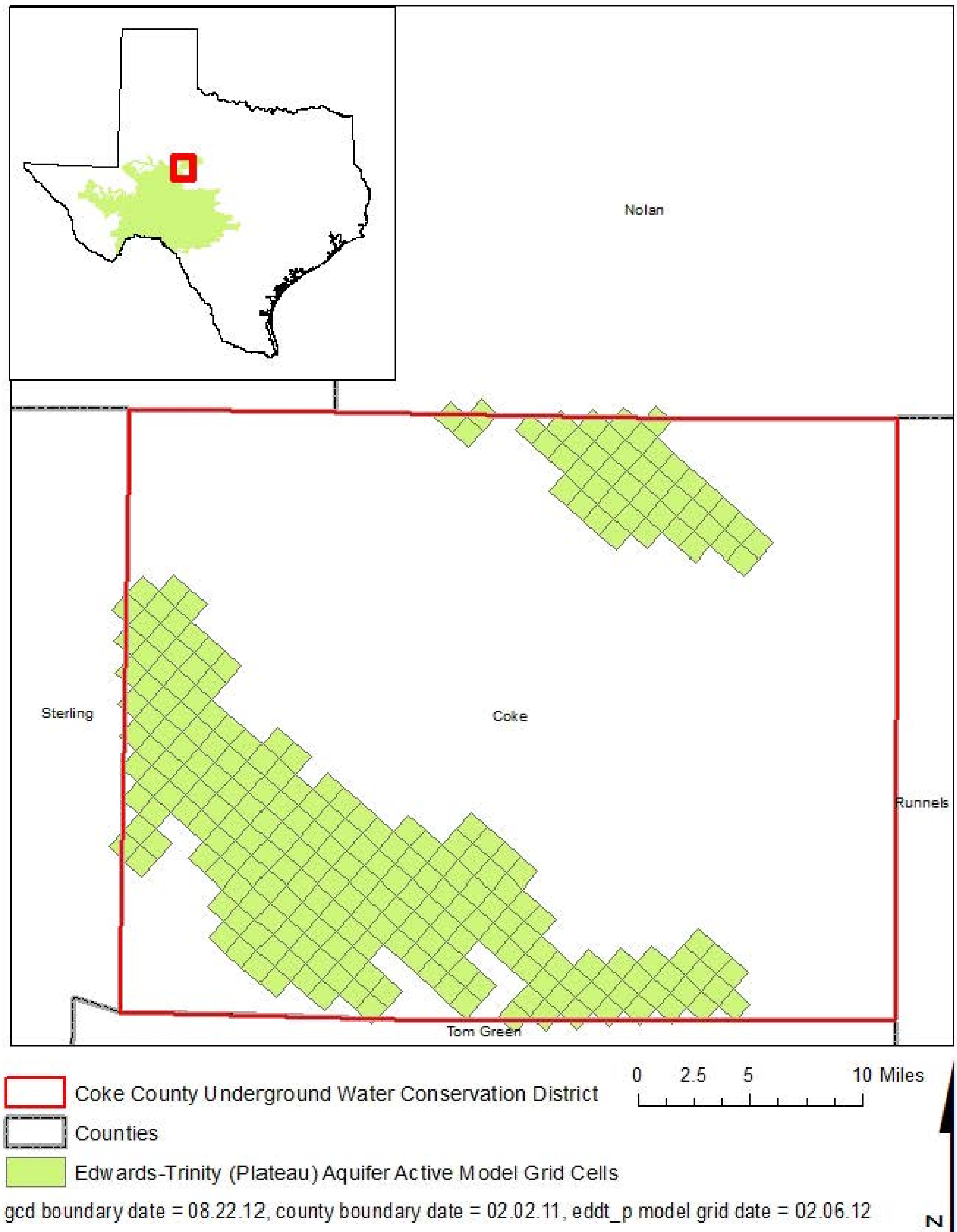

FIGURE 1: AREA OF ACTIVE MODEL CELLS FOR THE EDWARDS-TRINITY (PLATEAU) AQUIFER IN COKE COUNTY UNDERGROUND WATER CONSERVATION DISTRICT FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE LIPAN AQUIFER THAT IS NEEDED FOR COKE COUNTY 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	Lipan Aquifer	265
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Lipan Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Lipan Aquifer	299
Estimated annual volume of flow out of the district within each aquifer in the district	Lipan Aquifer	930
Estimated net annual volume of flow between each aquifer in the district	From the Edwards-Trinity (Plateau) and other units into the Lipan Aquifer	385

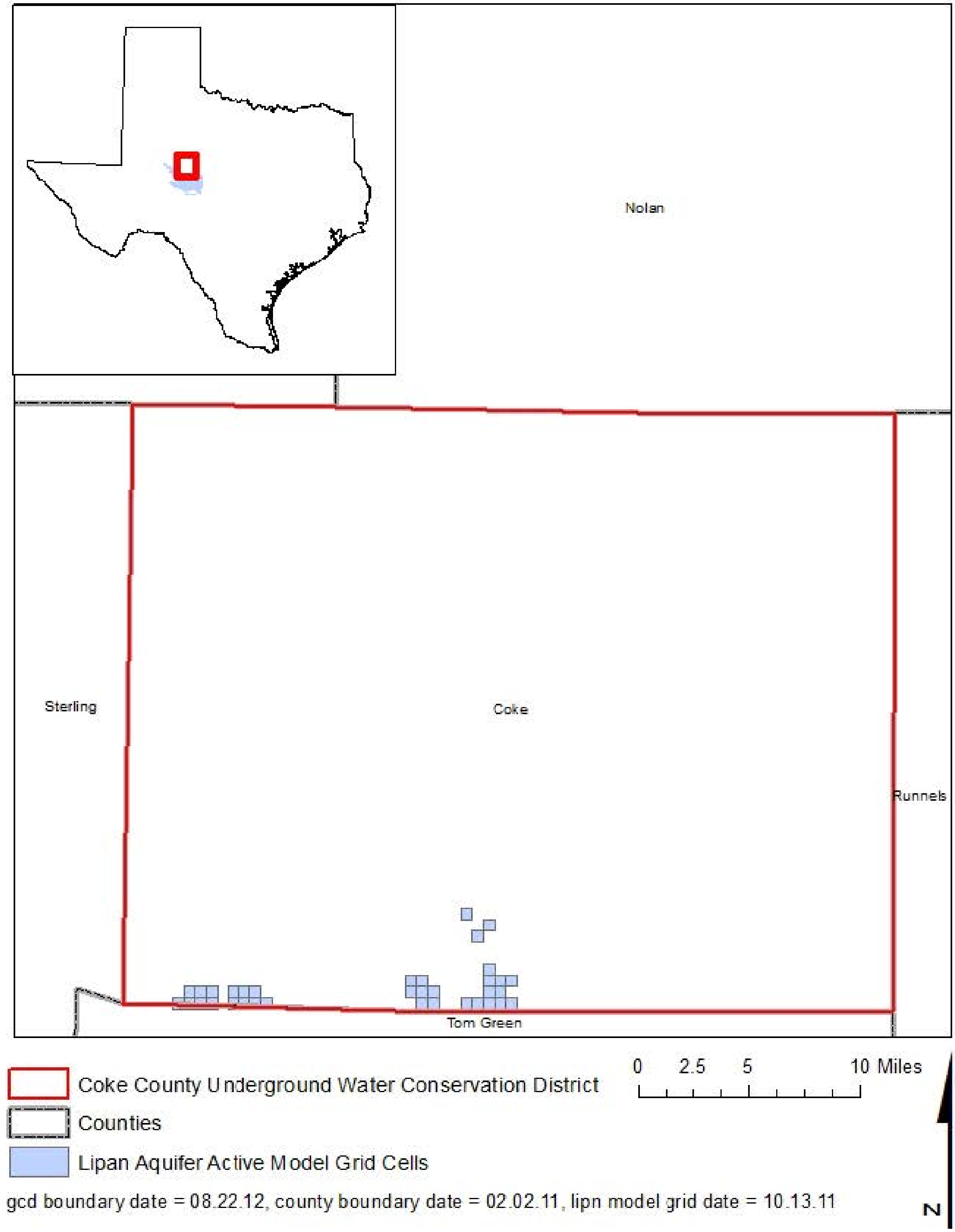

FIGURE 2: AREA OF ACTIVE MODEL CELLS FOR THE LIPAN AQUIFER IN COKE COUNTY UNDERGROUND WATER CONSERVATION DISTRICT FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 3: SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER THAT IS NEEDED FOR COKE COUNTY 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	Dockum Aquifer	105
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	37
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	27
Estimated net annual volume of flow between each aquifer in the district	From Dockum Aquifer to younger overlying units	116

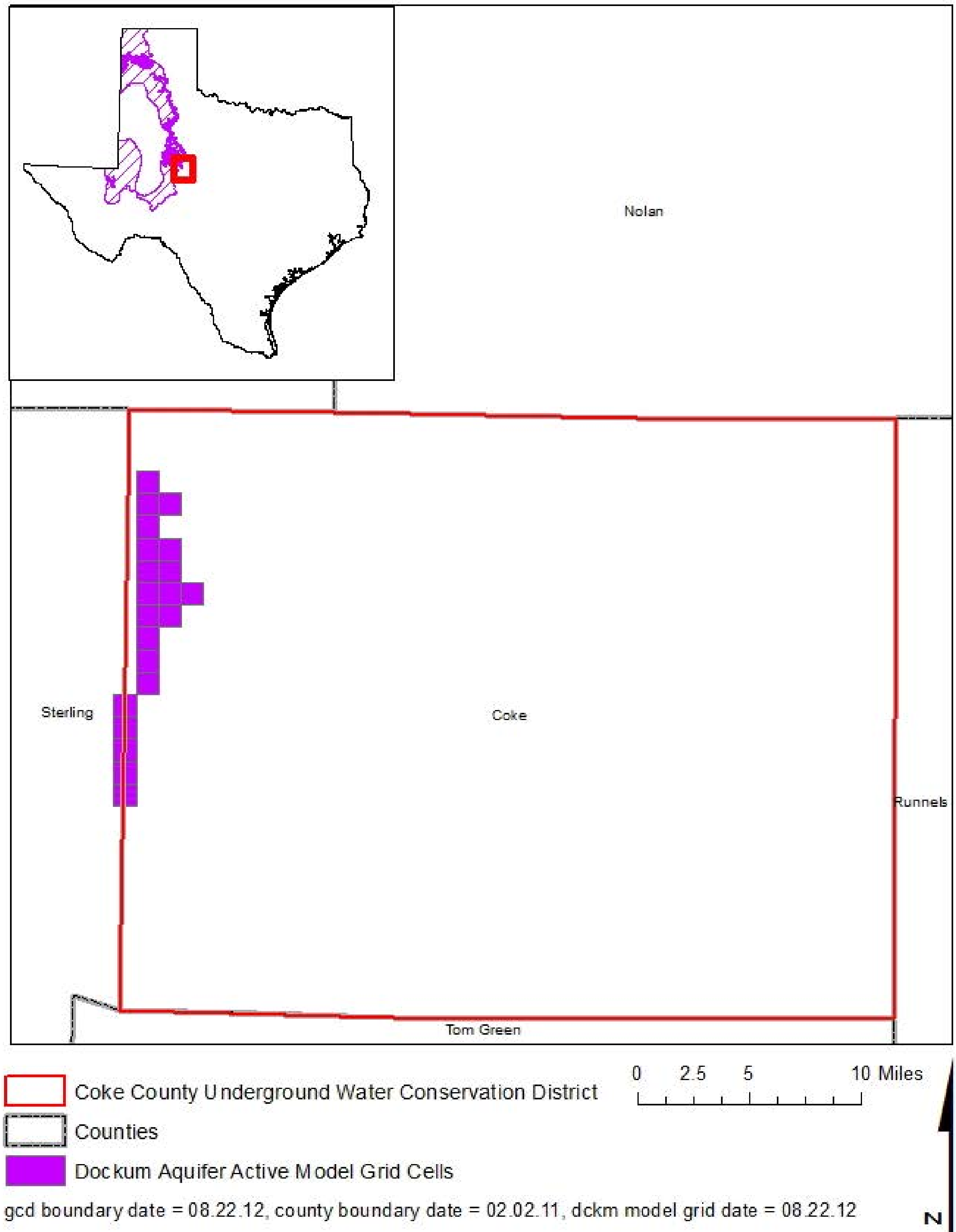

FIGURE 3: AREA OF ACTIVE MODEL CELLS FOR THE DOCKUM AQUIFER IN COKE COUNTY UNDERGROUND WATER CONSERVATION DISTRICT FROM WHICH THE INFORMATION IN TABLE 3 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS:

The groundwater model(s) used in completing this analysis is the best available scientific tool that can be used to meet the stated objective(s). 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 streamflow are specific to a particular historic time period.

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating 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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