GAM Run 10-026

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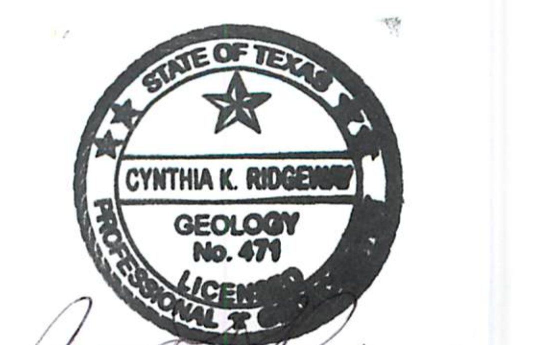

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, groundwater conservation districts shall use groundwater availability modeling information provided by the Executive Administrator of the Texas Water Development Board 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:

(1) the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
(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.

This report supersedes GAM Run 08-13 dated April 8, 2008. The purpose of this report is to provide information to Sterling County Underground Water Conservation District for its groundwater management plan. A groundwater availability model was not previously completed for the Dockum Aquifer, but a model that includes the Sterling County Underground Water Conservation District was released in January 2009. In addition, a groundwater availability model for the Lipan Aquifer was not included in the previous report. The groundwater management plan for Sterling County Underground Water Conservation District is due for approval by the Executive Administrator of the Texas Water Development Board before January 25, 2011.

This report discusses the methods, assumptions, and results from model runs using the groundwater availability models for the Lipan Aquifer, the Edwards-Trinity (Plateau) 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 each model from which the values in the respective tables were extracted.

METHODS:

We ran the groundwater availability models for the Lipan Aquifer (1980 through 1999), the Edwards-Trinity (Plateau) Aquifer (1980 through 2000), and the Dockum Aquifer (1980 through 1997) and (1) extracted water budgets for each year of the transient model period and (2) averaged the 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.

PARAMETERS AND ASSUMPTIONS:

Lipan Aquifer

- We used version 1.01 of the groundwater availability model for the Lipan Aquifer. See Beach and others (2004) for assumptions and limitations of the groundwater availability model for the Lipan Aquifer.

- 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 extent only covers a small area along the eastern portion of the district. However, the official aquifer boundary extends through the central portion of the district. Due to this, the model under-estimates groundwater resources in the district in regards to this 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 to 1989) and 17 feet for the verification period (1990 to 1999: Beach and others, 2004).

- We used Processing MODFLOW for Windows (PMWIN) version 5.3 (Chiang and Kinzelbach, 2001) as the interface to process model output.

Edwards-Trinity (Plateau) Aquifer

- We used version 1.01 of the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer. See Anaya and Jones (2009) for assumptions and limitations of this model.

- The Edwards-Trinity (Plateau) Aquifer model includes two layers representing the Edwards Group and associated limestone hydrostratigraphic units (Layer 1) and the undifferentiated Trinity Group hydrostratigraphic units (Layer 2). An individual water budget for the district was determined for the Edwards-Trinity (Plateau) Aquifer (Layer 1 and Layer 2 collectively).

- The General-Head Boundary (GHB) package of MODFLOW was used to represent flow out of the study area and into the Dockum Aquifer.

- The root mean square error (a measure of the difference between simulated and measured water levels) of the Edwards-Trinity (Plateau) groundwater availability model for the period of 1980 through 2000 is 143 feet, or six percent of the range of measured water levels (Anaya and Jones, 2009).

- We used Processing MODFLOW for Windows (PMWIN) version 5.3 (Chiang and Kinzelbach, 2001) as the interface to process model output.

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.

- This groundwater availability model includes three layers, representing (from top to bottom):

    1. younger geologic units overlying the Dockum Aquifer,
    2. the upper portion of the Dockum Aquifer, and
    3. the lower portion of the Dockum Aquifer.

    An individual water budget for the district was determined for the Dockum Aquifer (Layers 1 through Layer 3, collectively).

- 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 General-Head Boundary (GHB) package of MODFLOW was applied to the areas in Layer 1 with a high conductance in order to properly mimic water levels in these units. Where the GHB correlates with the Ogallala Aquifer, transient head values for the GHB were taken from the historical portion of the groundwater availability model (Blandford and others, 2003; Dutton, 2004; Ewing and others, 2008). Outside of the footprint of the Ogallala Aquifer, GHB values for the Dockum Aquifer model were estimated from land surface elevation (Ewing and others, 2008; discussed in Oliver and Hutchison, 2010). Since GHB values for the portion of the model within the district are based on estimates from land surface elevations, it is believed to be more appropriate to use the GHB values from the Edwards-Trinity (Plateau) Aquifer model water budget to describe the relationship between the Edwards-Trinity (Plateau) Aquifer and the Dockum Aquifer.

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) in the entire model between 1980 and 1997 is 65.0 feet and 69.6 feet for the upper and lower portions of the Dockum Aquifer, respectively (Ewing and others, 2008). This represents 2.7 and 3.0 percent of the hydraulic head drop across the model area for these same aquifers, respectively.

- 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 shown in Table 3.

- We used Groundwater Vistas Version 5 (Environmental Simulations, Inc. 2007) as the interface to process model output.

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected components were extracted from the groundwater budget 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, as shown in tables 1 through 3. The components of the modified budget shown in tables 1 through 3 include:

- Precipitation recharge—This is 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—This is the total water exiting the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).

- Flow into and out of district—This component describes lateral flow within the aquifer between the district and adjacent counties.

- Flow between aquifers—This describes the vertical flow, or leakage, 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 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 Lipan Aquifer that is needed for Sterling 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	102
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	277
Estimated annual volume of flow out of the district within each aquifer in the district	Lipan Aquifer	443
Estimated net annual volume of flow between each aquifer in the district	Not applicable	Not applicable

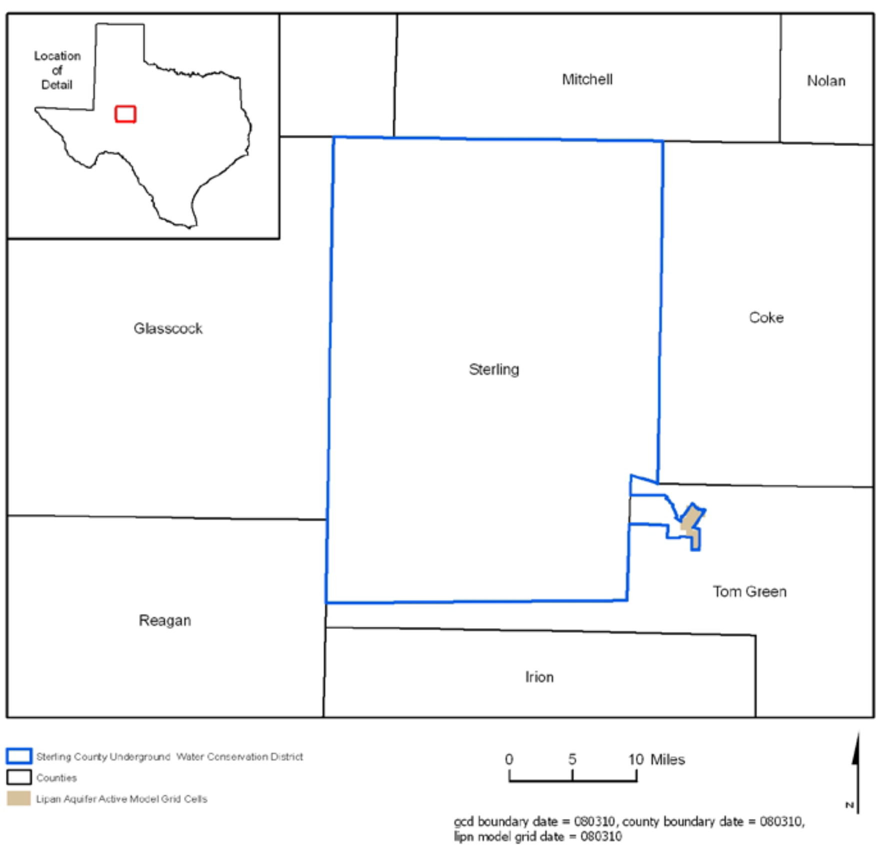

Figure 1: Area of the groundwater availability model for the Lipan Aquifer from which the information in Table 1 was extracted (the aquifer extent within the district boundary).

Table 2: Summarized information for the Edwards-Trinity (Plateau) Aquifer that is needed for Sterling 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	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	10,236
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	6,097 [A]
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	1,704
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	4,461
Estimated net annual volume of flow between each aquifer in the district	Edwards-Trinity (Plateau) Aquifer to the Dockum Aquifer	1,170

Footnote:
A – Approximately 75% of this flow may be going to the non-modeled portion of the Lipan Aquifer either directly or indirectly.

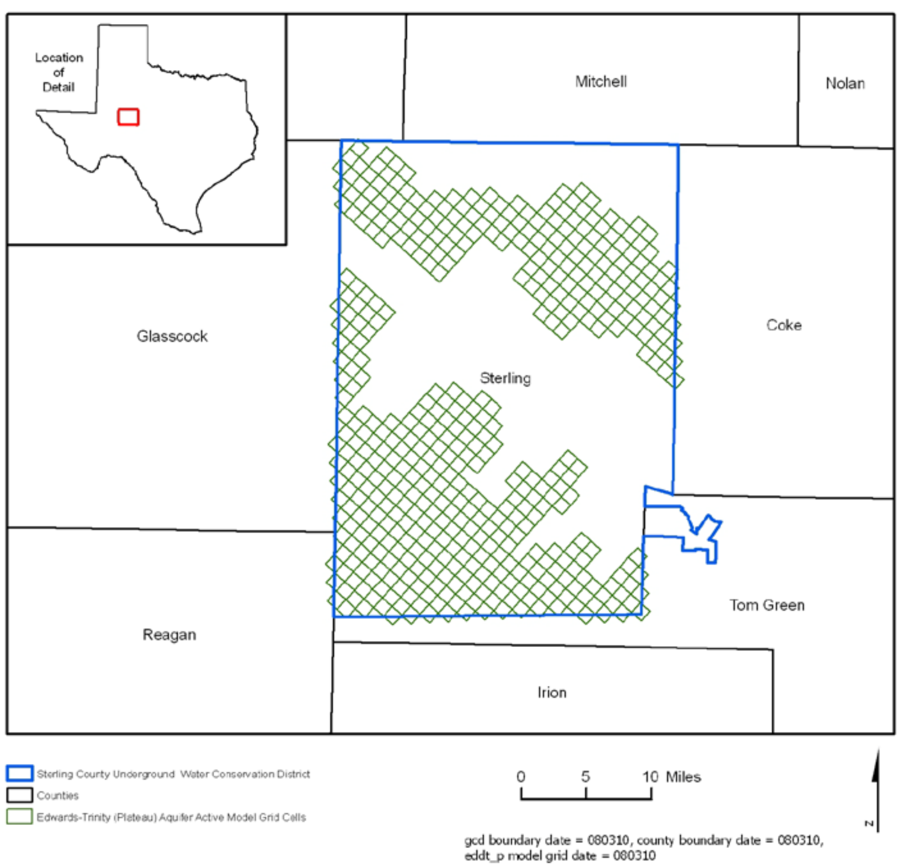

Figure 2: Area of the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer from which the information in Table 2 was extracted (the aquifer extent within the district boundary).

Table 3: Summarized information for the Dockum Aquifer that is needed for Sterling 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	439
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	224
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	7,073
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	5,741
Estimated net annual volume of flow between each aquifer in the district	Edwards-Trinity (Plateau) Aquifer to the Dockum Aquifer	1,170 [B]

Footnote:
B – The net outflow from the General Head Boundary (GHB) in the Edwards-Trinity (Plateau) Aquifer should be used instead of the value from the Dockum Aquifer (see "Parameters and Assumptions" section of this report).

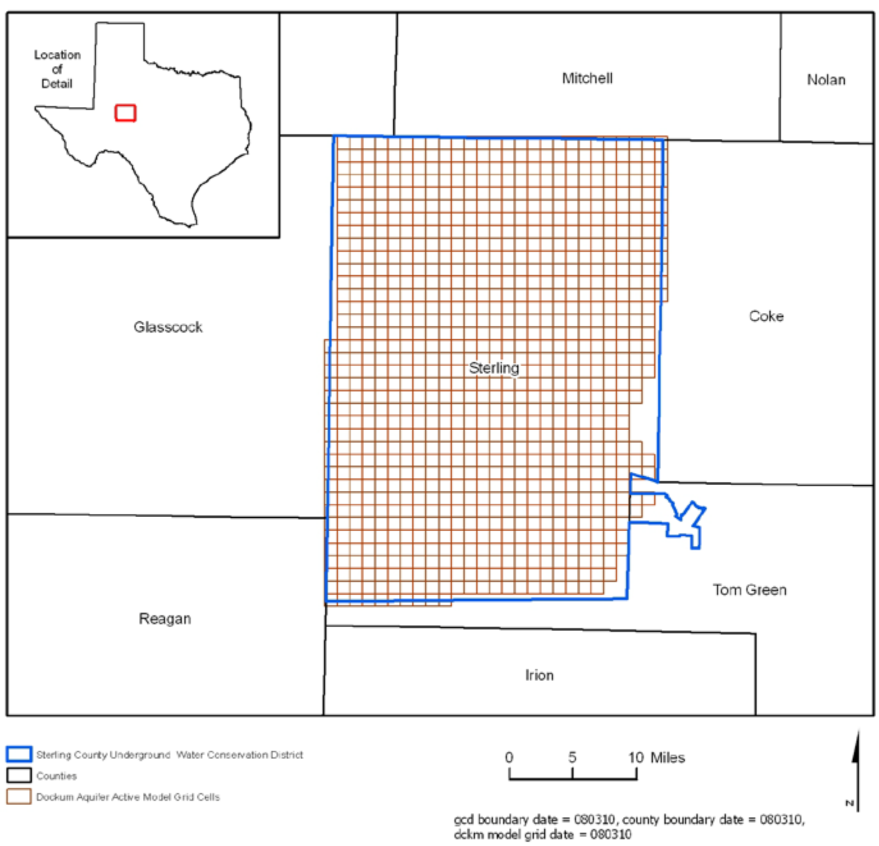

Figure 3: Area of the groundwater availability model for the southern portion of the Dockum Aquifer from which the information in Table 3 was extracted (the aquifer extent within the district boundary).

REFERENCES:

Anaya, R., and Jones, I., 2009, Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas: Texas Water Development Board Report 373, 103 p., http://www.twdb.state.tx.us/gam/eddt_p/eddt_p.htm.

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