GAM Run 09-018

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EXECUTIVE SUMMARY:

Texas 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 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.

The purpose of this model run is to provide information to Llano Estacado Underground Water Conservation District for its groundwater management plan. The groundwater management plan for Llano Estacado Underground Water Conservation District is due for approval by the Executive Administrator of the Texas Water Development Board before September 14, 2010.

This report discusses the methods, assumptions, and results from model runs using the groundwater availability models for the Ogallala (southern portion), Edwards-Trinity (High Plains), and Dockum aquifers. Table 1 summarizes the groundwater availability model data required by statute for Llano Estacado Underground Water Conservation District's groundwater management plan. Figure 1 shows the area of the model from which the values in Table 1 were extracted.

METHODS:

We ran the groundwater availability models and (1) extracted water budgets for each year of the calibrated portion of the models, 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. The calibrated portion of the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer is from 1980 through 2000. The calibrated portion of the groundwater availability model for the Dockum Aquifer is from 1980 through 1997.

PARAMETERS AND ASSUMPTIONS:

Groundwater Availability Model for Southern Portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer

- We used version 2.01 of the groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer. This model is an expansion on and update to the previously developed groundwater availability model for the southern portion of the Ogallala Aquifer described in Blandford and others (2003). See Blandford and others (2008) and Blandford and others (2003) for assumptions and limitations of the groundwater availability model.

- The model includes four layers representing the southern portion of the Ogallala and Edwards-Trinity (High Plains) aquifers. The units comprising the Edwards-Trinity (High Plains) Aquifer (primarily Edwards, Comanche Peak, and Antlers Sand formations) are separated from the overlying Ogallala Aquifer by a layer of Cretaceous shale, where present.

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) for the Ogallala Aquifer in 2000 is 33 feet. The mean absolute error for the Edwards-Trinity (High Plains) Aquifer in 1997 is 25 feet (Blandford and others, 2008). This represents 1.8 and 3.0 percent of the hydraulic head drop across the model area for each aquifer, respectively.

- Irrigation return flow was accounted for in the groundwater availability model by a direct reduction in agricultural pumping as described in Blandford and others (2003).

- The groundwater availability model for the southern portion of the Ogallala Aquifer and the Edwards-Trinity (High Plains) Aquifer does not consider flow between these aquifers and underlying units (Blandford and others, 2008).

- We used Groundwater Vistas version 5.30 Build 10 (Environmental Simulations, Inc., 2007) as the interface to process model output.

Groundwater Availability Model for the 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: geologic units overlying the Dockum Aquifer including the Ogallala, Edwards-Trinity (High Plains), Edwards-Trinity (Plateau), Pecos Valley, and Rita Blanca aquifers (Layer 1), the upper portion of the Dockum Aquifer (Layer 2), and the lower portion of the Dockum Aquifer (Layer 3).

- 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 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, only the results from model grid cells representing springs were incorporated into the surface water outflow values shown in Table 1.

- We used Groundwater Vistas version 5.30 Build 10 (Environmental Simulations, Inc., 2007) as the interface to process model output for the groundwater availability model for the Dockum Aquifer.

RESULTS:

A groundwater budget summarizes the water entering and leaving the aquifer according to the groundwater availability model. The models are based on the U.S. Geological Survey's MODFLOW 2000 groundwater modeling code (Harbaugh and others, 2000). Selected components were extracted from the groundwater budget for the aquifers located within the district and averaged over the duration of the calibrated portion of the model run (1980 to 1997 or 1980 to 2000) in the district, as shown in Table 1. The components of the modified budgets shown in Table 1 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.

The information needed for the district's management plan is summarized in Table 1. 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 model cell's centroid. 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 needed for Llano Estacado Underground Water Conservation District's groundwater management plan. All values are reported in acre-feet per year. All numbers are 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	Ogallala Aquifer	93,272[a]
	Edwards and Comanche Peak formations	0[b]
	Antlers Sand Formation	0[b]
	Upper portion of the Dockum Aquifer	0[b]
	Lower portion of the Dockum Aquifer	0[b]
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Ogallala Aquifer	2,338
	Edwards and Comanche Peak formations	55
	Antlers Sand Formation	0[b]
	Upper portion of the Dockum Aquifer	0[b]
	Lower portion of the Dockum Aquifer	0[b]

Table 1: Continued from above

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual volume of flow into the district within each aquifer in the district	Ogallala Aquifer	4,637
	Edwards and Comanche Peak formations	358
	Antlers Sand Formation	399
	Upper portion of the Dockum Aquifer	1,059
	Lower portion of the Dockum Aquifer	599
Estimated annual volume of flow out of the district within each aquifer in the district	Ogallala Aquifer	6,013
	Edwards and Comanche Peak formations	136
	Antlers Sand Formation	164
	Upper portion of the Dockum Aquifer	564
	Lower portion of the Dockum Aquifer	384
Estimated net annual volume of flow between each aquifer in the district	From the Ogallala Aquifer to underlying shale and Edwards and Comanche Peak formations	32,881
	From overlying Ogallala Aquifer and shale into the Edwards and Comanche Peak formations	32,658
	From the Edwards and Comanche Peak formations into the Antlers Sand Formation	20,506
	From the upper portion of the Dockum Aquifer into overlying units	1,254
	From the lower to the upper portion of the Dockum Aquifer	249

[a] Irrigation return flow was accounted for in the model by a direct reduction in agricultural pumping as described in Blandford and others (2003).

[b] The models do not consider recharge or surface water discharge in these units in the district due to the presence of the overlying Ogallala Aquifer.

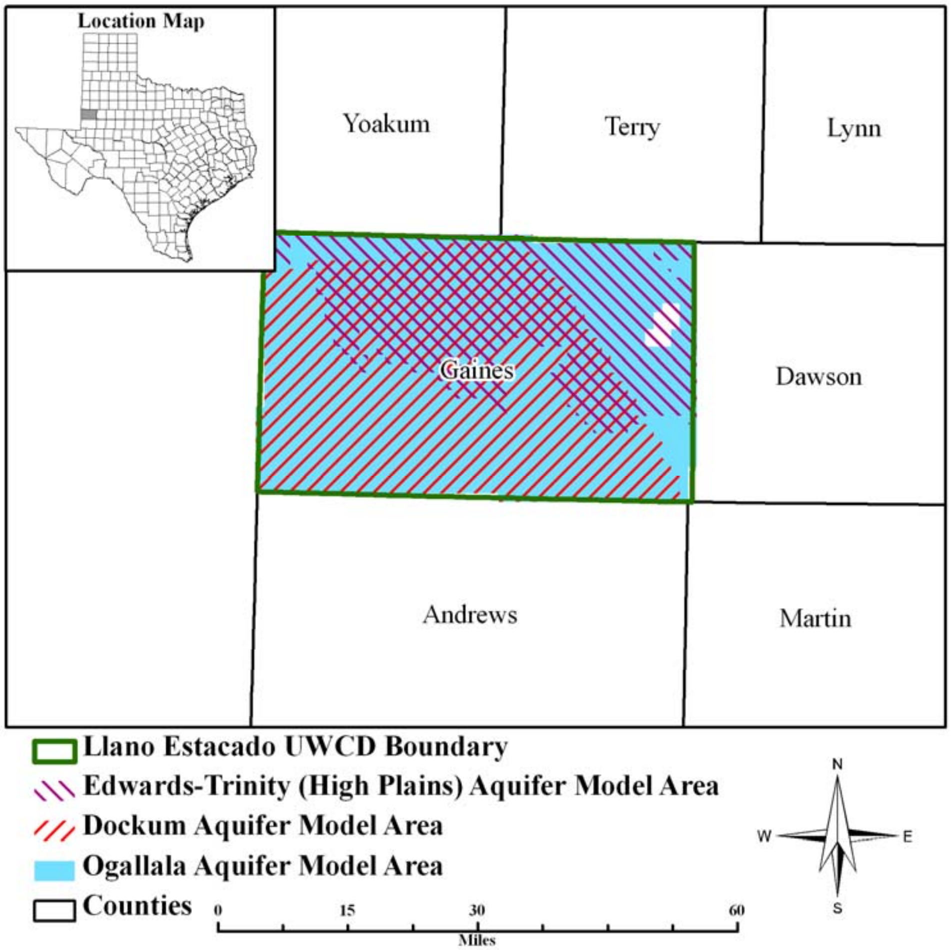

Figure 1: Area of the groundwater availability models from which the information in Table 1 was extracted. Note that model grid cells that straddle a political boundary were assigned to one side of the boundary based on the centroid of the model cell as described above.

REFERENCES:

Blandford, T.N., Blazer, D.J., Calhoun, K.C., Dutton, A.R., Naing, T., Reedy, R.C., and Scanlon, B.R., 2003, Groundwater availability of the southern Ogallala aquifer in Texas and New Mexico—Numerical simulations through 2050: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 158 p.

Blandford, T.N., Kuchanur, M., Standen, A., Ruggiero, R., Calhoun, K.C., Kirby, P., and Shah, G., 2008, Groundwater availability model of the Edwards-Trinity (High Plains) Aquifer in Texas and New Mexico: Final report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 176 p.

Environmental Simulations, Inc., 2007, Guide to using Groundwater Vistas Version 5, 381 p.

Ewing, J.E., Jones, T.L., Yan, T., Vreugdenhil, A.M., Fryar, D.G., Pickens, J.F., Gordon, K., Nicot, J.P., Scanlon, B.R., Ashworth, J.B., and Beach, J., 2008, Groundwater Availability Model for the Dockum Aquifer – Final Report: contract report to the Texas Water Development Board, 510 p.

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.

Cynthia K. Ridgeway is Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G., on July 24, 2009.