GAM Run 10-021

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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 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 Rolling Plains Groundwater Conservation District for its groundwater management plan. The groundwater management plan for the Rolling Plains Groundwater Conservation District was due for approval by the Executive Administrator of the Texas Water Development Board before October 17, 2010.

This report discusses the method, assumptions, and results from model runs using the groundwater availability models for the Seymour Aquifer, and the Blaine Aquifer. Tables 1 through 2 summarize the groundwater availability model data required by the statute, and figures 1 through 2 show the area of each model from which the values in Tables were extracted.

METHODS:

We ran the groundwater availability model for the Seymour and Blaine aquifers and (1) extracted water budgets for each month of the 1980 through 1999 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 Seymour and Blaine aquifers located within the district.

PARAMETERS AND ASSUMPTIONS:

Seymour and Blaine aquifers

- We used the command line Version 1.01 of the groundwater availability model for the Seymour and Blaine aquifers. See Ewing and others (2004) for assumptions and limitations of the groundwater availability model for the Seymour and Blaine aquifers.
- We used USGS MODFLOW-2000 code version 1.15.01 to run the model for the Seymour and Blaine aquifers. The GMG solver input file that accompanied the original model was modified to be consistent with the format required by version 1.15.01. The GMG input file that accompanied the original model

(Ewing and others, 2004) did not include inputs for semi-coarsening, ISC, and relaxation, RELAX, parameters. Default values of 1 were used for both.

- The MODFLOW-2000 executable from Ewing and others (2004) for the Seymour and Blaine aquifers was modified from standard MODFLOW-2000 to write multiple cell-by-cell budget files. In order to run the model using USGS MODFLOW-2000 version 1.15.01 and to use the output for further post-processing with ZONEBUDGET, the stream, recharge, well, evapotranspiration, and drain files were modified to write cell-by-cell flows to unit 50. Also, the name file was modified to explicitly specify output file names, as is required in standard MODFLOW-2000.

- The groundwater availability model includes two layers, representing the Seymour (Layer 1) and Blaine (Layer 2) aquifers. In areas where the Blaine Aquifer does not exist the model roughly replicates the various Permian units located in the study area.

- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) of the entire model for the period of 1990 to 1999 ranges from 19.6 feet (Seymour Aquifer) to 26.4 feet (Blaine Aquifer), representing one percent and three percent of the range of measured water levels respectively (Ewing and others, 2004).

- All stress periods of the groundwater availability model for the Seymour and Blaine aquifers are monthly. The current model run for 1980 through 1999, therefore, consisted of 240 individual stress periods.

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 run (1980 through 1999 for the Seymour and Blaine aquifers) in the district, as shown in Table 1 through Table 2. The components of the modified budgets shown in Tables include:

- Precipitation recharge - This is the aerially 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 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 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 to 2).

The areas from which water budgets were extracted were different for each layer of the groundwater availability model for the Seymour and Blaine aquifers. In layer 1, all active model cells within the district were used, representing the Seymour Aquifer. In Layer 2, only those active cells within the district representing the Blaine Aquifer were used. Active model cells within the district representing other Permian sediments were excluded in Layer 2. Net flows within the district from the Blaine to the other Permian sediments and from the other Permian sediments to the Blaine are included in the last row of table 2.

Table 1: Summarized information required for the Rolling Plains Groundwater Conservation District's groundwater management plan for the Seymour Aquifer. All values are reported in acre-feet per year. All numbers are rounded to the nearest 1 acre-foot. Reported flow estimates include both fresh and brackish waters present in the aquifers.

Management Plan requirement	Aquifer or confining unit	Results[1]
Estimated annual amount of recharge from precipitation to the district	Seymour Aquifer	105,272
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Seymour Aquifer	16,266
Estimated annual volume of flow into the district within each aquifer in the district	Seymour Aquifer	98
Estimated annual volume of flow out of the district within each aquifer in the district	Seymour Aquifer	1,769
Estimated net annual volume of flow between each aquifer in the district	Net flows leaving Seymour Aquifer and entering underlying Permian Units	7,259

Note 1: A mass balance error of one percent or less is normally considered acceptable for water budgets extracted from numerical flow models (Anderson and Woessner, 1992); however, the water budgets for some stress periods of the groundwater availability model for the Seymour and Blaine aquifers exceeded one percent. After investigating the cause and several alternative approaches to defining the water budget it was determined that, after averaging all 240 stress periods together, the results are reasonable and appropriate for the purposes of the district's management plan.

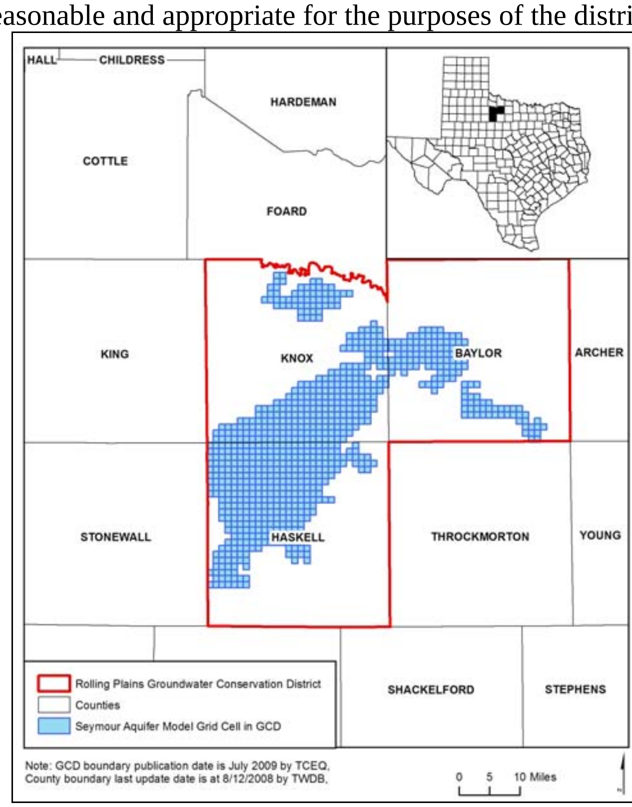

Figure 1: Area of the groundwater availability model for the Seymour Aquifer from which the information in Table 1 was extracted (the aquifer extent within the Rolling Plains Groundwater Conservation District boundary).

Table 2: Summarized information required for the Rolling Plains Groundwater Conservation District's groundwater management plan for the Blaine Aquifer. All values are reported in acre-feet per year. All numbers are rounded to the nearest 1 acre-foot. Reported flow estimates include both fresh and brackish waters present in the aquifers.

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Blaine Aquifer	642
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Blaine Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Blaine Aquifer	1,467
Estimated annual volume of flow out of the district within each aquifer in the district	Blaine Aquifer	261
Estimated net annual volume of flow between each aquifer in the district	Net flows leaving Blaine into the Permain Unit	4,119

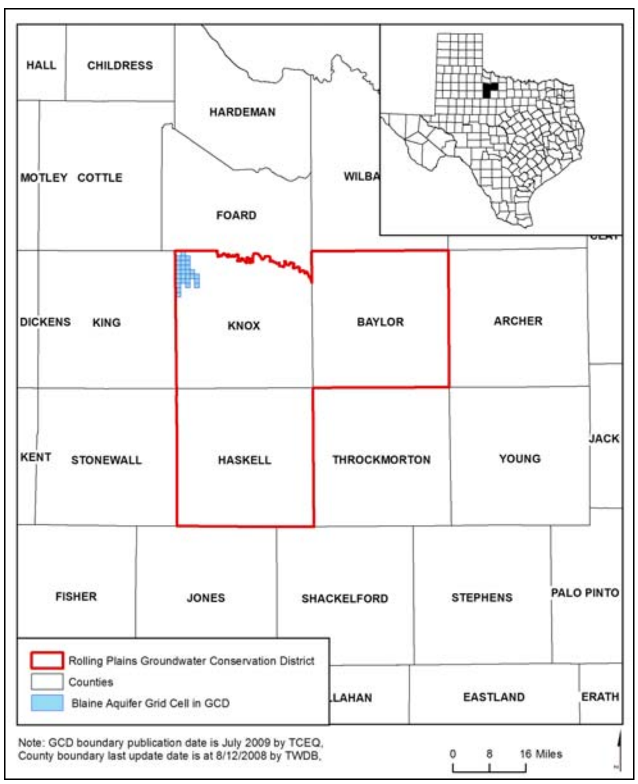

Figure 2: Area of the groundwater availability model for the Blaine Aquifer from which the information in Table 2 was extracted (the aquifer extent within the Rolling Plains Groundwater Conservation District boundary).

REFERENCES:

Anderson, M.P., and Woessner, W.W., 1992, Applied Groundwater Modeling, Simulation of Flow and Advective Transport, Academic Press, Inc., New York, 381 p.

Chiang, W., and Kinzelbach, W., 2001, Groundwater Modeling with PMWIN, 346 p.

Ewing, J.E., Jones, T.L., Pickens, J.F., Chastain-Howley, A., Dean, K.E., Spear, A.A., 2004, Groundwater availability model for the Seymour Aquifer: Final report prepared for the Texas Water Development Board by INTERA, Inc., 533 p.