GAM run 08-08

by Shirley Wade, P.G.
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0883
January 25, 2008

REQUESTOR:

Mr. Allan Lange, General Manager for the Lipan-Kickapoo Water Conservation District.

DESCRIPTION OF REQUEST:

To assist in preparation of his district management plan (and as a supplement to GAM Run 06-15), Mr. Lange requested a table listing the following information from the Groundwater Availability Models in his district:

- storage,
- springs and seeps,
- general head boundary,
- wells,
- rivers and streams,
- recharge (precipitation and inflow from other aquifers), and
- evapotranspiration

METHODS:

To address the request, we ran the groundwater availability model for the Lipan Aquifer for the 1980 through 1998 period, and we ran the groundwater availability model for the Edwards-Trinity (Plateau) Aquifer for the 1980 through 1998 period and averaged the results.

PARAMETERS AND ASSUMPTIONS:

We used the following assumptions in this analysis:

- We used versions 1.01 of the groundwater availability models for the Lipan Aquifer and the Edwards-Trinity (Plateau) Aquifer.

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

- See Anaya and Jones (2004) for assumptions and limitations of the groundwater availability model for the Edwards-Trinity (Plateau) 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 Edwards-Trinity (Plateau) Aquifer model includes two layers representing the Edwards and associated limestones (Layer 1) and the undifferentiated Trinity units (Layer 2) in the district.

- 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 root mean squared error (a measure of the difference between simulated and actual water levels during model calibration) in the entire groundwater availability model representing the Edwards-Trinity (Plateau) Aquifer for the period of 1990 to 2000 is 143 feet, or six percent of the range of measured water levels (Anaya and Jones, 2004).

- Recharge rates for both models are based on (1980 – 2000) precipitation (Beach and others, 2004; Anaya and Jones, 2004).

RESULTS:

A groundwater budget (Tables 1 and 2) summarizes how the model estimates water entering and leaving the aquifer. The components of the water budget are described below.

- Storage—This component is the change in the amount of water stored in the aquifer. The storage component that is included in “Inflow” is water that is removed from storage in the aquifer (that is, water levels decline). The storage component that is included in “Outflow” is water that is added back into storage in the aquifer (that is, water levels increase). This component of the budget is often seen as water both going into and out of the aquifer because this is a county-wide budget, and water levels will decline in some areas (water is being removed from storage) and will rise in others (water is being added to storage).

- Reservoirs – This is water that leaks from reservoirs into the aquifer or from the aquifer into the reservoir. This component can be shown as ”Inflow” or ”Outflow” in the budget.

- Springs and seeps— This is water that drains from an aquifer if water levels are above the elevation of the spring or seep. This component is always shown as “Outflow”, or discharge, from an aquifer. Springs and seeps are simulated in the model using the MODFLOW Drain package. The spring discharge from the model of the Lipan Aquifer in Tom Green County represents discharge to the North Concho River.

- General-Head Boundary (GHB)—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.

- Wells—This is water produced from rural domestic, municipal, industrial, irrigation, and livestock wells in the aquifer. For this model, this component is always shown as “Outflow” from an aquifer, because all wells included in the model produce (rather than inject) water. Wells are simulated in the model using the MODFLOW Well package.

- Rivers and Streams—This is water that flows between streams and rivers and an aquifer. The direction and amount of flow depends on the water level in the stream or river and the aquifer. In areas where water levels in the stream or river are above the water level in the aquifer, water flows into the aquifer and is shown as “Inflow” in the budget. In areas where water levels in the aquifer are above the water level in the stream or river, water flows out of the aquifer and into the stream and is shown as “Outflow” in the budget. Rivers and streams are simulated using the MODFLOW Stream package.

- Recharge—This component simulates areally distributed recharge due to precipitation falling on the outcrop areas of aquifers. Recharge is always shown as “Inflow” into an aquifer. This component does not include runoff from precipitation events that may later recharge an aquifer as stream losses, which is included in the model using the stream (or river) package. Recharge is simulated in the model using the MODFLOW Recharge package.

- Evapotranspiration—This is water that flows out of an aquifer due to direct evaporation and plant transpiration. This component of the budget will always be shown as “Outflow”. Evapotranspiration is simulated in the model using the MODFLOW Evapotranspiration (EVT) package.

- Lateral flow between counties—This component describes lateral flow within the aquifer between adjacent counties.

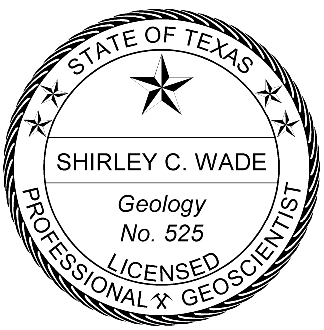
It is important to note that sub-regional water budgets for individual counties are not exact. This is due to the one-mile spacing of the model grid and because we assumed each model cell is assigned to a single county. The water budgets for an individual cell containing a county boundary are assigned to either one county or the other and therefore very minor variations in the county-wide budgets may be observed. Also, the Lipan-Kickapoo budget terms in Table 1 are not equal to the sum of Tom Green, Concho, and Runnels Counties because some areas of those counties are not included in the Water Conservation District.

REFERENCES:

Anaya, R., and Jones, I., 2004, Groundwater availability model for the Edwards-Trinity (Plateau) and Cenozoic Pecos Alluvium aquifer systems, Texas: Texas Water Development Board, GAM Report, 208 p.

Beach, James A., Burton, Stuart, and Kolarik, Barry, 2004, Groundwater availability model for the Lipan Aquifer in Texas: final report prepared for the Texas Water Development Board by LBG-Guyton Associates

Smith, R. 2006, GAM Run 06-15 Final Report, Texas Water Development Board GAM Run Report, August 9, 2006, 3 pp.



The seal appearing on this document was authorized by Shirley C. Wade, P.G. on February 12, 2008.

Table 1: Groundwater flow budget for each county in the model and for the Lipan-Kickapoo Water Conservation District (WCD), averaged for the years 1980 through 1998 from the groundwater availability model of the Lipan Aquifer. Flows are reported in acre-feet per year.

	Coke		Concho		Irion		Runnels		Schleicher		Tom Green		Lipan-Kickapoo WCD	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Change in storage	143	-127	2,438	-1,138	118	-104	350	-258	39	-34	14,206	-3,631	17,349	-3,657
Reservoirs	0	0	0	0	0	0	0	0	0	0	9,068	-1,511	1,481	-669
Springs and seeps[1]	0	0	0	0	0	0	0	0	0	0	0	-5,447	0	0
General head boundary (Inflow from Edwards-Trinity (Plateau) Aquifer along western boundary)	490	-219	630	-841	3,723	0	48	-2	0	0	6,602	0	5,706	-847
Wells	0	-1	0	-1,914	0	-12	0	-60	0	0	0	-27,891	0	-29,384
Rivers and streams	0	0	49	-7,485	2,160	-1	0	0	0	0	7,807	-9,229	6,050	-15,197
Direct precipitation recharge	1,735	0	15,718	0	2,761	0	2,621	0	395	0	42,425	0	50,801	0
Evapotrans-piration	0	-23	0	-12,554	0	-6,778	0	-5	0	-6	0	-35,545	0	-27,857
Lateral inflow	0	-1,998	5,487	-392	1,258	-3,125	1,472	-4,165	19	-412	8,248	-5,104	9,411	-13,190

1.The drain cells representing the North Concho River are not within the Lipan-KickapooWater Conservation District so the drain discharge is zero for the Lipan Aquifer model in the district. However, spring discharge values from the Edwards-Trinity Aquifer in the district in Tom Green County can be found in Table 2.

Note: a negative sign refers to flow out of the aquifer in the county or District. A positive sign refers to flow into the aquifer in the county or District. All numbers are rounded to the nearest 1 acre-foot.

Table 2: Groundwater flow budget for the Lipan-Kickapoo Water Conservation District, averaged for the years 1980 through 1998 from the groundwater availability model of the Edwards-Trinity (Plateau) Aquifer. Flows are reported in acre-feet per year.

	Edwards (Layer 1)	
	In	**Out**
Change in storage	1,333	-436
Reservoirs	0	0
Springs and seeps	0	-12,851
General head boundary	0	0
Wells	0	-169
Rivers and streams	0	-1,368
Direct precipitation recharge	11,282	0
Evapotranspiration	0	0
Lateral inflow	7,241	-2,821
Upper vertical flow	0	0
Lower vertical flow	15	-2,217
	Trinity (Layer2)	
Change in storage	356	-186
Reservoirs	0	0
Springs and seeps	0	-6,325
General head boundary	0	-54
Wells	0	-202
Rivers and streams	66	-3,039
Direct precipitation recharge	4,743	0
Evapotranspiration	0	0
Lateral inflow	4,080	-1,652
Upper vertical flow	2,226	15
Lower vertical flow	0	0

Note: a negative sign refers to flow out of the aquifer in the Lipan-KickapooWater Conservation District. A positive sign refers to flow into the aquifer in the District. All numbers are rounded to the nearest 1 acre-foot.