GAM Run 03-07

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REQUESTOR:

Mr. Garret Engelking on behalf of the Refugio Groundwater Conservation District.

DESCRIPTION OF REQUEST:

What is the water budget of Refugio County based on 2002 and 2006 water demand estimates?

METHODS:

We used the groundwater availability model (GAM) for the central part of the Gulf Coast aquifer (Chowdhury and others, 2004) to determine the water budget of Refugio County. First, we ran the model for the period 2000 through 2050 using pumping based on water demand estimates from the 2001 regional water plans and the 2002 State Water Plan. We then ran the model for the period 2000 through 2060 using pumping based on water demand estimates being prepared for the 2006 regional water plans. In both model runs, we extracted water budget data for a zone representing Refugio County from the overall model results (Figure 1). This zone includes the Aransas and San Antonio rivers.

PARAMETERS AND ASSUMPTIONS:

- See Waterstone and Parsons (2003) and Chowdhury and others (2004) for assumptions and limitations of the GAM. Root mean squared error for the entire central Gulf Coast aquifer model is up to 46 feet (Chowdhury and others, 2004).
- Neither pumping scenario includes the Lower Guadalupe Water Supply Project (LGWSP).
- The GAM assumes that pumping in the Evangeline aquifer only occurs in the upper part of the Evangeline aquifer (see GAM run 04-10 for additional information).
- Pumping estimates for the 2006 run assume the same spatial and vertical distributions as well as the same groundwater and surface water allocations that were used in the 2002 State Water Plan.
- The pumping values in the water budget represent total pumping for municipal, rural domestic, irrigation, industrial, and livestock uses. These values were obtained for Refugio County from the 2002 State Water Plan and 2006 regional water plan estimates. These estimates suggest that pumping in Refugio County accounts for 75 to 80 percent of 2002 water demands and 70 to 75 percent based on 2006 demand estimates

- Cross-formational flow between the aquifers that compose the Gulf Coast aquifer is influenced by the relationship between water levels in the respective aquifers. Groundwater flows out of the aquifer with higher water levels. In the case of the Chicot and Evangeline aquifers, increased drawdown in the Evangeline aquifer may decrease cross-formational flow to and induce drawdown in the overlying Chicot aquifer.
- The model results reflect average recharge and evapotranspiration rates throughout the predictive period. Stream-flow is calculated by the model. There is no drought-of-record represented in these simulations.
- Drains are used to simulate wetlands that occur throughout the Gulf Coast region. In the model, groundwater discharges only when water levels rise above a set elevation.

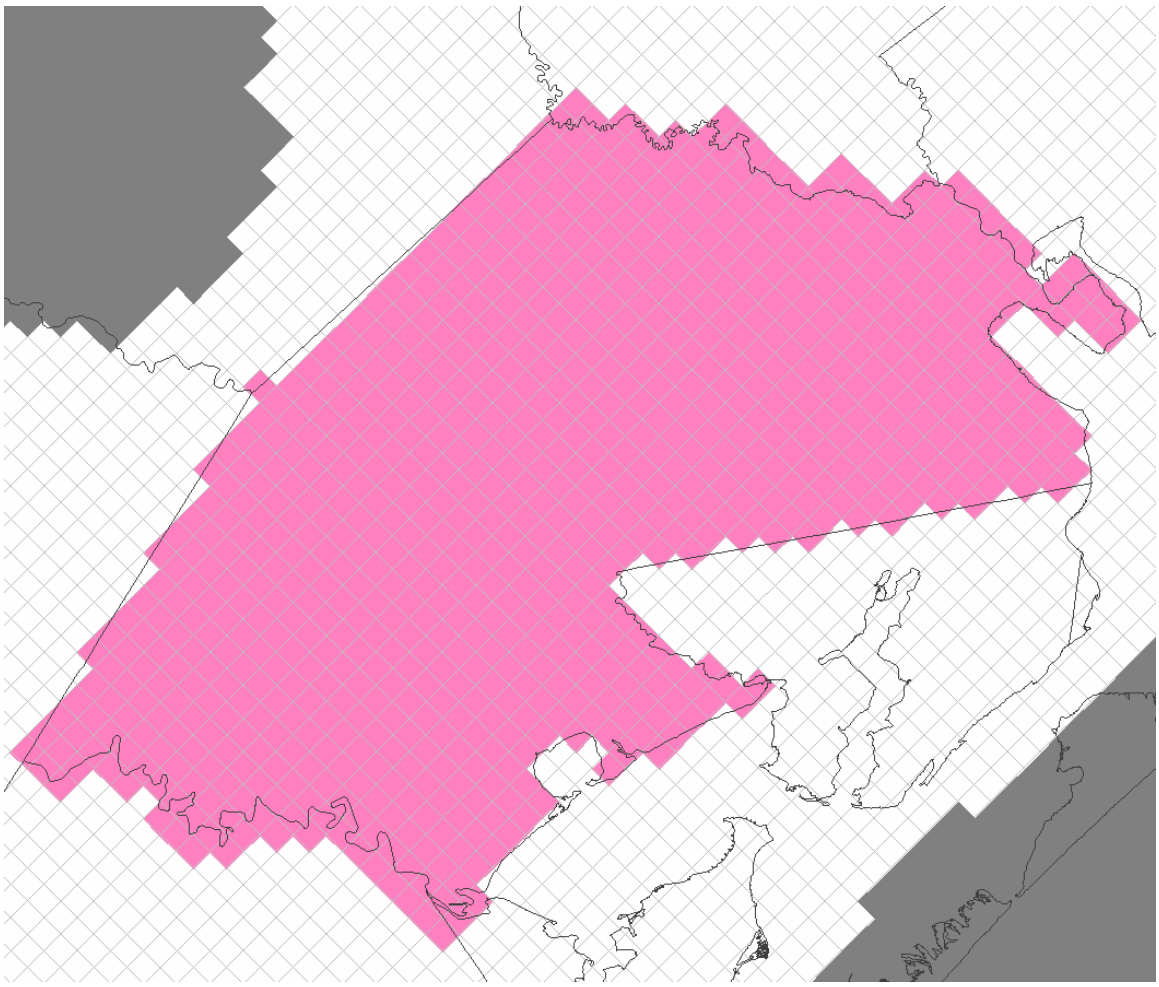

Figure 1. The pink grid cells denotes the zone used to extract the water budget of Refugio County from the groundwater availability model for the central part of the Gulf Coast aquifer. The zone has been extended slightly to include cells representing the Aransas and San Antonio rivers that form the southern and northern boundaries of Refugio County, respectively.

RESULTS

Tables 1 and 2 contain water-budget data for each layer in the GAM that constitutes the Gulf Coast aquifer in Refugio County. These layers, the Chicot aquifer, Evangeline aquifer, and Burkeville confining unit, constitute Layers 1, 2, and 3 in the model. Layer 4 in the model, the Jasper aquifer, is not simulated in Refugio County. Table 3 summarizes the net water budgets for the entire county based on the 2002 and 2006 water demand estimates.

Note: in Table 3, a negative value for storage indicates increased groundwater storage within the aquifer while a positive value indicates less groundwater in storage. Over the 60-year predictive model run, the net amount of groundwater going into storage decreases over time. Beginning in the 2030s, groundwater coming out of storage in Refugio County exceeds groundwater going into storage in Refugio County. This is the result of declining water levels in the aquifer as the total amount of water in stored in the aquifer decreases as total outflows from the aquifer exceed inflows.

REFERENCES:

Chowdhury, A. H., Wade, S., Mace, R. E., and Ridgeway, C., 2004, Groundwater availability model of the Central Gulf Coast aquifer system: Numerical simulations through 1999: Texas Water Development Board, draft report, 108 p.

Waterstone Environmental Hydrology and Engineering, Inc., and Parsons Engineering Science, Inc., 2003, Groundwater availability of the central Gulf Coast aquifer: numerical simulations to 2050 central Gulf Coast, Texas. Prepared for the Texas Water Development Board, unpublished report, 156 p.

Table 1. Water budget for Refugio County based on 2002 water demands (values in acre-feet per year).

Layer 1: Chicot

Flow Term	2010		2020		2030	
	In	Out	In	Out	In	Out
Storage	0	179	0	33	1	12
Horizontal Exchange	16,617	10,067	16,858	10,015	16,895	10,014
Exchange (Upper)	n/a	n/a	n/a	n/a	n/a	n/a
Exchange (Lower)	4,343	413	4,393	406	4,406	401
Wells	0	704	0	649	0	616
Drains	n/a	172	n/a	174	n/a	174
Recharge	17,020	n/a	17,020	n/a	17,020	n/a
Evapotranspiration	n/a	2,098	n/a	2,101	n/a	2,102
Head-Dependent Boundaries	0	6,833	0	6,857	0	6,862
Stream Leakage	30,439	47,943	30,254	48,291	30,219	48,360
Sum	68,419	68,409	68,525	68,525	68,541	68,541

Layer 2: Evangeline

Flow Term	2010		2020		2030	
	In	Out	In	Out	In	Out
Storage	0	10	0	3	1	2
Horizontal Exchange	6,412	1,821	6,426	1,826	6,444	1,848
Exchange (Upper)	413	4,337	406	4,387	401	4,400
Exchange (Lower)	28	1	27	1	26	1
Wells	0	676	0	641	0	621
Drains	n/a	0	n/a	0	n/a	0
Recharge	n/a	n/a	n/a	n/a	n/a	n/a
Evapotranspiration	n/a	n/a	n/a	n/a	n/a	n/a
Head-Dependent Boundaries	n/a	n/a	n/a	n/a	n/a	n/a
Stream Leakage	n/a	n/a	n/a	n/a	n/a	n/a
Sum	6,853	6,846	6,859	6,859	6,872	6,872

Layer 3: Burkeville

Flow Term	2010		2020		2030	
	In	Out	In	Out	In	Out
Storage	4	5	3	6	3	6
Horizontal Exchange	32	4	32	5	32	5
Exchange (Upper)	1	28	1	27	1	26
Exchange (Lower)	n/a	n/a	n/a	n/a	n/a	n/a
Wells	0	0	0	0	0	0
Drains	n/a	n/a	n/a	n/a	n/a	n/a
Recharge	n/a	n/a	n/a	n/a	n/a	n/a
Evapotranspiration	n/a	n/a	n/a	n/a	n/a	n/a
Head-Dependent Boundaries	n/a	n/a	n/a	n/a	n/a	n/a
Stream Leakage	n/a	n/a	n/a	n/a	n/a	n/a
Sum	37	37	37	37	37	37

Table 1. Continued.

Layer 1: Chicot

Flow Term	2040		2050	
	In	Out	In	Out
Storage	3	6	5	3
Horizontal Exchange	16,887	10,022	16,846	10,038
Exchange (Upper)	n/a	n/a	n/a	n/a
Exchange (Lower)	4,390	402	4,359	407
Wells	0	594	0	578
Drains	n/a	174	n/a	174
Recharge	17,020	n/a	17,020	n/a
Evapotranspiration	n/a	2,102	n/a	2,102
Head-Dependent Boundaries	0	6,861	0	6,857
Stream Leakage	30,222	48,360	30,242	48,313
Sum	68,522	68,522	68,472	68,472

Layer 2: Evangeline

Flow Term	2040		2050	
	In	Out	In	Out
Storage	3	1	5	0
Horizontal Exchange	6,449	1,889	6,449	1,938
Exchange (Upper)	402	4,384	407	4,353
Exchange (Lower)	26	1	26	1
Wells	0	605	0	595
Drains	n/a	n/a	n/a	n/a
Recharge	n/a	n/a	n/a	n/a
Evapotranspiration	n/a	n/a	n/a	n/a
Head-Dependent Boundaries	n/a	n/a	n/a	n/a
Stream Leakage	n/a	n/a	n/a	n/a
Sum	6,881	6,880	6,887	6,887

Layer 3: Burkeville

Flow Term	2040		2050	
	In	Out	In	Out
Storage	3	6	4	6
Horizontal Exchange	32	5	32	5
Exchange (Upper)	1	26	1	26
Exchange (Lower)	n/a	n/a	n/a	n/a
Wells	0	0	0	0
Drains	n/a	n/a	n/a	n/a
Recharge	n/a	n/a	n/a	n/a
Evapotranspiration	n/a	n/a	n/a	n/a
Head-Dependent Boundaries	n/a	n/a	n/a	n/a
Stream Leakage	n/a	n/a	n/a	n/a
Sum	37	37	37	37

n/a – not applicable; Head-Dependant Boundaries represent flow to Gulf of Mexico.

Table 2. Water budget for Refugio County based on 2006 water demands (values in acre-feet per year).

Layer 1: Chicot

Flow Term	2010		2020		2030	
	In	Out	In	Out	In	Out
Storage	1	214	2	23	3	8
Horizontal Exchange	16,528	10,119	16,706	10,087	16,703	10,096
Exchange (Upper)	n/a	n/a	n/a	n/a	n/a	n/a
Exchange (Lower)	4,405	394	4,421	386	4,405	387
Wells	0	762	0	755	0	728
Drains	n/a	173	n/a	174	n/a	174
Recharge	17,020	n/a	17,020	n/a	17,020	n/a
Evapotranspiration	n/a	2,098	n/a	2,100	n/a	2,101
Head-Dependent Boundaries	0	6,818	0	6,838	0	6,838
Stream Leakage	30,457	47,833	30,291	48,077	30,278	48,077
Sum	68,410	68,410	68,440	68,441	68,407	68,407

Layer 2: Evangeline

Flow Term	2010		2020		2030	
	In	Out	In	Out	In	Out
Storage	0	22	1	1	3	0
Horizontal Exchange	6,443	1,775	6,487	1,795	6,498	1,830
Exchange (Upper)	394	4,399	386	4,416	387	4,399
Exchange (Lower)	28	1	27	1	27	1
Wells	0	670	0	689	0	685
Drains	n/a	n/a	n/a	n/a	n/a	n/a
Recharge	n/a	n/a	n/a	n/a	n/a	n/a
Evapotranspiration	n/a	n/a	n/a	n/a	n/a	n/a
Head-Dependent Boundaries	n/a	n/a	n/a	n/a	n/a	n/a
Stream Leakage	n/a	n/a	n/a	n/a	n/a	n/a
Sum	6,864	6,866	6,902	6,902	6,915	6,915

Layer 3: Burkeville

Flow Term	2010		2020		2030	
	In	Out	In	Out	In	Out
Storage	4	4	3	5	3	5
Horizontal Exchange	32	4	32	5	32	5
Exchange (Upper)	1	28	1	27	1	27
Exchange (Lower)	n/a	n/a	n/a	n/a	n/a	n/a
Wells	0	0	0	0	0	0
Drains	n/a	n/a	n/a	n/a	n/a	n/a
Recharge	n/a	n/a	n/a	n/a	n/a	n/a
Evapotranspiration	n/a	n/a	n/a	n/a	n/a	n/a
Head-Dependent Boundaries	n/a	n/a	n/a	n/a	n/a	n/a
Stream Leakage	n/a	n/a	n/a	n/a	n/a	n/a
Sum	37	37	37	37	37	37

Table 2. Continued.

Layer 1: Chicot

Flow Term	2040		2050		2060	
	In	Out	In	Out	In	Out
Storage	4	4	6	2	6	3
Horizontal Exchange	16,678	10,106	16,641	10,114	16,592	10,129
Exchange (Upper)	n/a	n/a	n/a	n/a	n/a	n/a
Exchange (Lower)	4,371	391	4,334	398	4,308	403
Wells	0	728	0	729	0	677
Drains	n/a	174	n/a	174	n/a	174
Recharge	17,020	n/a	17,020	n/a	17,020	n/a
Evapotranspiration	n/a	2,101	n/a	2,100	n/a	2,100
Head-Dependent Boundaries	0	6,836	0	6,834	0	6,834
Stream Leakage	30,298	48,033	30,321	47,970	30,332	47,939
Sum	68,371	68,372	68,321	68,321	68,257	68,258

Layer 2: Evangeline

Flow Term	2040		2050		2060	
	In	Out	In	Out	In	Out
Storage	4	0	6	0	4	0
Horizontal Exchange	6,502	1,862	6,498	1,895	6,483	1,934
Exchange (Upper)	391	4,365	398	4,328	403	4,302
Exchange (Lower)	27	1	28	1	28	1
Wells	0	695	0	705	0	682
Drains	n/a	n/a	n/a	n/a	n/a	n/a
Recharge	n/a	n/a	n/a	n/a	n/a	n/a
Evapotranspiration	n/a	n/a	n/a	n/a	n/a	n/a
Head-Dependent Boundaries	n/a	n/a	n/a	n/a	n/a	n/a
Stream Leakage	n/a	n/a	n/a	n/a	n/a	n/a
Sum	6,924	6,924	6,929	6,928	6,919	6,919

Layer 3: Burkeville

Flow Term	2040		2050		2060	
	In	Out	In	Out	In	Out
Storage	3	5	4	4	4	4
Horizontal Exchange	32	5	32	5	32	5
Exchange (Upper)	1	27	1	28	1	28
Exchange (Lower)	n/a	n/a	n/a	n/a	n/a	n/a
Wells	0	0	0	0	0	0
Drains	n/a	n/a	n/a	n/a	n/a	n/a
Recharge	n/a	n/a	n/a	n/a	n/a	n/a
Evapotranspiration	n/a	n/a	n/a	n/a	n/a	n/a
Head-Dependent Boundaries	n/a	n/a	n/a	n/a	n/a	n/a
Stream Leakage	n/a	n/a	n/a	n/a	n/a	n/a
Sum	37	37	37	37	37	37

n/a – not applicable; Head-Dependant Boundaries represent flow to Gulf of Mexico.

Table 3. Summarized water budget for Refugio County based on 2002 and 2006 water demands (values in acre-feet per year).

Flow Term	2010	2020	2030	2040	2050	2060
2002 Demands						
Storage	-189	-39	-16	-3	5	--
Horizontal Exchange	11,169	11,471	11,505	11,452	11,346	--
Exchange (Upper)	-3,952	-4,007	-4,023	-4,007	-3,971	--
Exchange (Lower)	3,958	4,013	4,029	4,013	3,977	--
Wells	-1,380	-1,290	-1,237	-1,199	-1,173	--
Drains	-172	-174	-174	-174	-174	--
Recharge	17,020	17,020	17,020	17,020	17,020	--
Evapotranspiration	-2,098	-2,101	-2,102	-2,102	-2,102	--
Head-Dependent Boundaries	-6,833	-6,857	-6,862	-6,861	-6,857	--
Stream Leakage	-17,504	-18,037	-18,141	-18,139	-18,070	--
2006 Demands						
Storage	-235	-23	-4	4	9	7
Horizontal Exchange	11,104	11,339	11,303	11,239	11,157	11,040
Exchange (Upper)	-4,033	-4,056	-4,038	-4,001	-3,957	-3,926
Exchange (Lower)	4,038	4,061	4,044	4,007	3,963	3,932
Wells	-1,431	-1,444	-1,413	-1,423	-1,434	-1,359
Drains	-173	-174	-174	-174	-174	-174
Recharge	17,020	17,020	17,020	17,020	17,020	17,020
Evapotranspiration	-2,098	-2,100	-2,101	-2,101	-2,100	-2,100
Head-Dependent Boundaries	-6,818	-6,838	-6,838	-6,836	-6,834	-6,834
Stream Leakage	-17,376	-17,786	-17,799	-17,735	-17,649	-17,607