GAM Run 08-02

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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 in conjunction with any available site-specific information provided by the district and acceptable to the executive administrator. Information derived from groundwater availability models that shall be included in groundwater management plans include:

(1) the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;
(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 the McMullen Groundwater Conservation District needed for its groundwater management plan. The groundwater management plan for the McMullen Groundwater Conservation District is due for approval by the executive administrator of the Texas Water Development Board before October 24, 2008.

This report discusses the methods, assumptions, and results from model runs using the groundwater availability models for the central part of the Gulf Coast Aquifer and the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. Table 3 summarizes the groundwater availability model data required by statute for the McMullen Groundwater Conservation District's groundwater management plan.

Although the Yegua-Jackson Aquifer also occurs in McMullen County, a groundwater availability modeling for this minor aquifer has not been developed at this time. If the McMullen Groundwater Conservation District would like information for the Yegua-Jackson Aquifer, they can request it from the Groundwater Technical Assistance Section of the Texas Water Development Board.

METHODS:

We ran the groundwater availability models for the central part of the Gulf Coast Aquifer and the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers, and (1) extracted water budgets for each year of the 1980 or 1981 through 1999 period and (2) averaged the annual water budget values for recharge, surface water inflow, 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 Gulf Coast Aquifer, and the Carrizo-Wilcox, Queen City, and Sparta aquifers located within the district.

PARAMETERS AND ASSUMPTIONS:

Groundwater availability model for the central part of the Gulf Coast Aquifer

- We used Version 1.01 of the groundwater availability model for the central part of the Gulf Coast Aquifer. See Chowdhury and others (2004), and Waterstone and others (2003) for assumptions and limitations of the groundwater availability model for the central part of the Gulf Coast Aquifer.

- The model simulates groundwater flow through four hydrostratigraphic units. From top to bottom, these units, model layers, are: the Chicot Aquifer, Evangeline Aquifer, Burkeville Confining System, and the Jasper Aquifer.

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the entire model for 1999 is 26 feet, which is 4.6 percent of the hydraulic head drop across the model area (Chowdhury and others, 2004).

- The transient portion of the model has a total of 85 stress periods. Of these, monthly stress periods were assigned for 1987 through 1989 and 1996 through 1998. Monthly stress periods were assigned to better simulate possible effects of drought on the groundwater flow system. The remainders of the stress periods represent annual stress periods.

Groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers

- We used Version 2.01 of the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. See Deeds and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City and Sparta aquifers.

- The groundwater availability model includes eight layers, representing:
  1. the Sparta Aquifer (Layer 1),
  2. the Weches Confining Unit (Layer 2),

3. the Queen City Aquifer (Layer 3),
4. the Reklaw Confining Unit (Layer 4),
5. the Carrizo Aquifer (Layer 5),
6. the Upper Wilcox Aquifer (Calvert Bluff Formation—Layer 6),
7. the Middle Wilcox Aquifer (Simsboro Formation—Layer 7), and
8. the Lower Wilcox Aquifer (Hooper Formation—Layer 8).

- The root mean squared error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 23 feet for the Sparta Aquifer, 18 feet for the Queen City Aquifer, and 33 feet for the Carrizo Aquifer for the calibration period (1980 to 1989) and 19, 22, and 48 feet for the same aquifers, respectively, in the verification period (1990 to 1999) (Kelley others, 2004). These root mean squared errors are between seven and ten percent of the range of measured water levels (Kelley others, 2004).

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

RESULTS:

A groundwater budget summarizes the water entering and leaving the aquifer according to the groundwater availability model. The groundwater budget for the annual average values for the Gulf Coast Aquifer in the district (1981 to 1999) is shown in Table 1. Table 2 shows the groundwater budget for the Carrizo-Wilcox, Queen City, and Sparta aquifers (1980 to 1999) in the district. The components of the modified budgets shown in Tables 1 and 2 include:

- Surface water inflow and outflow—This is the total surface water entering the aquifer (inflow) through streams or reservoirs and the total surface water exiting the aquifer (outflow) to streams, reservoirs, drains (springs), and through evapotranspiration (return of moisture to the air through both evaporation from the soil and transpiration or loss of water vapor by plants).

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

- Net inter-aquifer flow—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.

- 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.

The information needed for the district's management plan is summarized in Table 3.

It is important to note that sub-regional water budgets for individual counties, such as McMullen County 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.

As described by Kalaswad and Arroyo (2006) and Kelly and others (2004) groundwater in the Gulf Coast Aquifer and the Carrizo-Wilcox, Queen City, and Sparta aquifers ranges from fresh to saline. The reported values in this report for flow terms include fresh (less than 1,000 milligrams per liter total dissolved solids), brackish (1,000 to 10,000 milligrams per liter total dissolved solids), and saline (greater than 10,000 milligrams per liter total dissolved solids) groundwater.

REFERENCES:

Chowdhury, A.H., Wade, S.,W., Mace, R.E., and Ridgeway, C., 2004, Groundwater availability model of the central Gulf Coast Aquifer system: Numerical simulations through 1999, Unpublished Texas Water Development Board report, 114 p. http://www.twdb.state.tx.us/gam/glfc_c/glfc_c_TWDB_SummaryReport.pdf

Deeds, N., Kelley, V.A., Fryar, D., Jones, T., Whallon, A.J., and Dean, K.E., 2003, Groundwater availability model for the Southern Carrizo-Wilcox Aquifer: contract report to the Texas Water Development Board, 452 p.

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

Kalaswad, S., and Arroyo, J., 2006, Status report on brackish groundwater and desalination in the Gulf Coast Aquifer of Texas *in* Mace, R.E., Davison, S.C., Angle, E.S., and Mullican, III, W.F., eds., Aquifers of the Gulf Coast of Texas: Texas Water Development Board Report 365, p. 231–240.

Kelley, V.A., Deeds, N.E., Fryar, D.G., and Nicot, J.P., 2004, Groundwater availability models for the Queen City and Sparta aquifers: Contract report to the Texas Water Development Board, 867 p.

Waterstone Environmental Hydrology and Engineering Inc. and Parsons, 2003, Groundwater availability of the Central Gulf Coast Aquifer: Numerical Simulations to 2050, Central Gulf Coast, Texas Contract report to the Texas Water Development Board, 157 p.

Table 1: Selected flow terms for each aquifer layer, into and out of the McMullen Groundwater Conservation District, averaged for the years 1981 through 1999 from the groundwater availability model of the central part of the Gulf Coast Aquifer. Flows include fresh, brackish, and saline waters. Flows are reported in acre-feet per year. All numbers are rounded to the nearest 1 acre-foot. Note: a negative sign refers to flow out of the aquifer in the district. A positive sign refers to flow into the aquifer in the district. N/A indicates the component is not applicable.

Aquifer	Surface water inflow	Surface water outflow	Lateral inflow into district	Lateral outflow from district	Net inter-aquifer flow (upper)	Net inter-aquifer flow (lower)
Chicot (Layer 1)	N/A	N/A	N/A	N/A	N/A	N/A
Evangeline (Layer 2)	N/A	N/A	N/A	N/A	N/A	N/A
Burkeville (Layer 3)	113	0	9	-7	0	-128
Jasper (Layer 4)	206	-833	265	-556	127	0

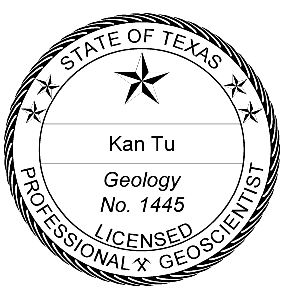
Table 2: Selected flow terms for each aquifer layer, into and out of the McMullen County Groundwater Conservation District, averaged for the years 1980 through 1999 from the groundwater availability model of the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers. Flows include fresh, brackish, to saline waters. Flows are reported in acre-feet per year. All numbers are rounded to the nearest 1 acre-foot. Note: a negative sign refers to flow out of the aquifer in the district. A positive sign refers to flow into the aquifer in the district.

Aquifer	Surface water inflow	Surface water outflow	Lateral inflow into district	Lateral outflow from district	Net inter-aquifer flow (upper)	Net inter-aquifer flow (lower)
Sparta (Layer 1)	0	0	412	-175	0	2,339
Weches (Layer 2)	0	0	71	-36	-2,339	2,175
Queen City (Layer 3)	0	0	788	-186	-2,175	-303
Reklaw (Layer 4)	0	0	144	-25	303	-681
Carrizo (Layer 5)	0	0	1,435	-1,929	681	606
Wilcox (Layer 6)	0	0	539	-460	-606	-80
Wilcox (Layer 7)	0	0	186	-53	80	48
Wilcox (Layer 8)	0	0	1,397	-287	-48	0

Table 3: Summarized information needed for the McMullen Groundwater Conservation District's groundwater management plan. All values are reported are expressed 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	Chicot	0
	Evangeline	0
	Burkeville	12
	Jasper	229
	Sparta	0
	Weches	0
	Queen City	0
	Reklaw	0
	Carrizo	0
	Wilcox(upper)	0
	Wilcox(middle)	0
	Wilcox(lower)	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Chicot	0
	Evangeline	0
	Burkeville	0
	Jasper	-833
	Sparta	0
	Weches	0
	Queen City	0
	Reklaw	0
	Carrizo	0
	Wilcox(upper)	0
	Wilcox(middle)	0
	Wilcox(lower)	0
Estimated annual volume of flow into the district within each aquifer in the district	Chicot	0
	Evangeline	0
	Burkeville	9
	Jasper	265
	Sparta	412
	Weches	71
	Queen City	788
	Reklaw	144
	Carrizo	1435
	Wilcox(upper)	539

Management plan requirement	**Aquifer or confining unit**	**Results**
	Wilcox(middle)	186
	Wilcox(lower)	1,397
Estimated annual volume of flow out of the district within each aquifer in the district	Chicot	0
	Evangeline	0
	Burkeville	-7
	Jasper	-556
	Sparta	-175
	Weches	-36
	Queen City	-186
	Reklaw	-25
	Carrizo	-1,929
	Wilcox(upper)	-460
	Wilcox(middle)	-53
	Wilcox(lower)	-287
Estimated net annual volume of flow between each aquifer in the district	Chicot into Evangeline	0
	Evangeline into Burkeville	0
	Burkeville intoJasper	128
	Sparta into Weches	2,339
	Weches into Queen City	2,175
	Rekalw into Queen City	303
	Reklaw into Carrizo	681
	Wilcox upper into Carrizo	606
	Wilcox middle into upper	80
	Wilcox lower into middle	48



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