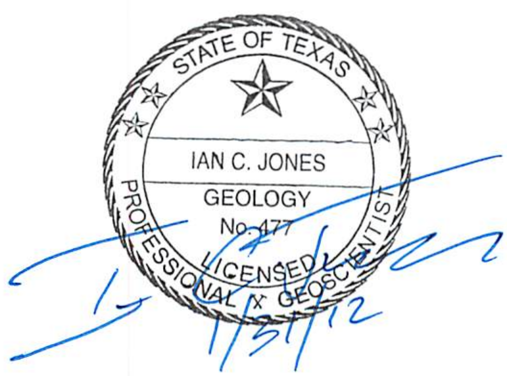
GAM Run 11-019: Southeast Texas Groundwater Conservation District Management Plan

by Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6641
January 31, 2012



The seal appearing on this document was authorized by Ian C. Jones, Ph.D., P.G. 477 on January 31, 2012.

This page is intentionally blank

GAM RUN 11-019: SOUTHEAST TEXAS GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

by Ian C. Jones, Ph.D., P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6641
January 31, 2012

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 (TWDB) together with any available site-specific information provided by the district to the Executive Administrator for review and comment. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

- the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
- 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
- the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

The purpose of this report is to provide Part 2 of a two-part package of information to the Southeast Texas Groundwater Conservation District to incorporate in its management plan to fulfill the requirements noted above.

The groundwater management plan for Southeast Texas Groundwater Conservation District is due for approval by the Executive Administrator of the TWDB before January 8, 2013. This report discusses the methods, assumptions, and results from the model runs using the groundwater availability models for the Yegua-Jackson Aquifer and the northern part of the Gulf Coast Aquifer. Tables 1 and 2 summarize the groundwater availability model data required by the statute, and figures 1 and 2 show the area of each model from which the values in the respective tables were extracted. This model run replaces the results of GAM Run 06-06. GAM Run 11-019 meets current standards set after GAM Run 06-06 was completed. Differences in the results of the two model runs are due to differences in the method of extracting data from the model(s) and the addition of information from the groundwater availability model for the Yegua-Jackson Aquifer. If after review of the figures, Southeast Texas Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB immediately.

METHODS:

The groundwater availability models for the Yegua-Jackson Aquifer and the northern part of the Gulf Coast Aquifer (1980 through 1999) were run for this analysis. Water budgets for each year of the transient model period were extracted and the average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, and net inter-aquifer flow for the portions of the aquifers located within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Yegua-Jackson Aquifer

- Version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer was used for this analysis. See Deeds and others (2010) for assumptions and limitations of the groundwater availability model for the Yegua-Jackson Aquifer.

- This groundwater availability model includes five layers, which generally correspond to (from top to bottom):

    - Parts of the Catahoula Formation, surficial alluvium units, and Yegua-Jackson outcrop,

    - Upper Jackson unit,

    - Lower Jackson unit,

    - Upper Yegua unit, and

    - Lower Yegua unit.

- Of the five layers listed above, individual water budgets for the district were determined for the combined units of the Yegua-Jackson Aquifer (Layers 2 through 5) and only the parts of layer 1 that directly overlay the outcrop portion of the Yegua-Jackson Aquifer. Data for the Catahoula Formation is included in the model results for the Gulf Coast Aquifer.

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 31, 24, and 25 feet for the Jackson Group, Upper Yegua, and Lower Yegua, respectively, for the calibration period (1980 to 1997) (Deeds and others, 2010). These mean absolute errors are between six and ten percent of the range of measured water levels (Deeds and others, 2010).

- Groundwater in the Yegua-Jackson Aquifer ranges from fresh to brackish in composition (Deeds and others, 2010). Groundwater with total dissolved solids of less than 1,000 milligrams per liter is considered fresh and total dissolved solids of 1,000 to 10,000 milligrams per liter is considered brackish.

- Groundwater Vistas version 5 (Environmental Sciences, Inc., 2007) was used as the interface to process model output.

Gulf Coast Aquifer (northern part)

- Version 2.01 of the groundwater availability model for the northern part of the Gulf Coast Aquifer was used for this analysis. See Kasmarek and Robinson (2004) for assumptions and limitations of the groundwater availability model for the northern part of the Gulf Coast Aquifer.

- This groundwater availability model includes four layers, which generally correspond to (from top to bottom):

    - Chicot Aquifer,
    - Evangeline Aquifer,
    - Burkville confining unit, and
    - Jasper Aquifer and parts of the Catahoula Formation in direct hydrologic communication with the Jasper Aquifer.

- Water budgets for the district were determined for the Gulf Coast Aquifer (Layers 1 through 4).

- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 34 feet for the Chicot Aquifer, 43 feet for the Evangeline Aquifer, and 47 feet for the Jasper Aquifer for 1977 (Kasmarek and Robinson, 2004). For the year 2000, the root mean square error is 31, 40, and 34 feet for the Chicot, Evangeline, and Jasper aquifers, respectively.

- Groundwater in the Gulf Coast Aquifer displays fresh compositions with total dissolved solids of less than 1,000 milligrams per liter (Chowdhury and others, 2006).

- Groundwater Vistas version 5 (Environmental Sciences, Inc., 2007) was used as the interface to process model output.

RESULTS:

A groundwater budget shows 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 period 1980 through 1999, as shown in tables 1 and 2. The components of the modified budget shown in tables 1 and 2 include:

- Precipitation recharge—The areally distributed recharge originating from precipitation falling on the outcrop areas of the aquifers within the district.

- Surface water outflow—The total water discharging from the aquifer (outflow) to surface water such as streams, reservoirs, and drains (springs).

- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent areas.

- Flow between aquifers—The net vertical flow 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 and 2. It is important to note that sub-regional water budgets are not exact. This is due to the 1 square mile 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 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 and 2).

TABLE 1: SUMMARIZED INFORMATION FOR THE YEGUA-JACKSON AQUIFER THAT IS NEEDED FOR SOUTHEAST TEXAS GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. THESE FLOWS INCLUDE BRACKISH WATERS.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Yegua-Jackson Aquifer	5
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Yegua-Jackson Aquifer	152
Estimated annual volume of flow into the district within each aquifer in the district	Yegua-Jackson Aquifer	751
Estimated annual volume of flow out of the district within each aquifer in the district	Yegua-Jackson Aquifer	798
Estimated net annual volume of flow between each aquifer in the district	From Yegua-Jackson Aquifer into overlying units	33

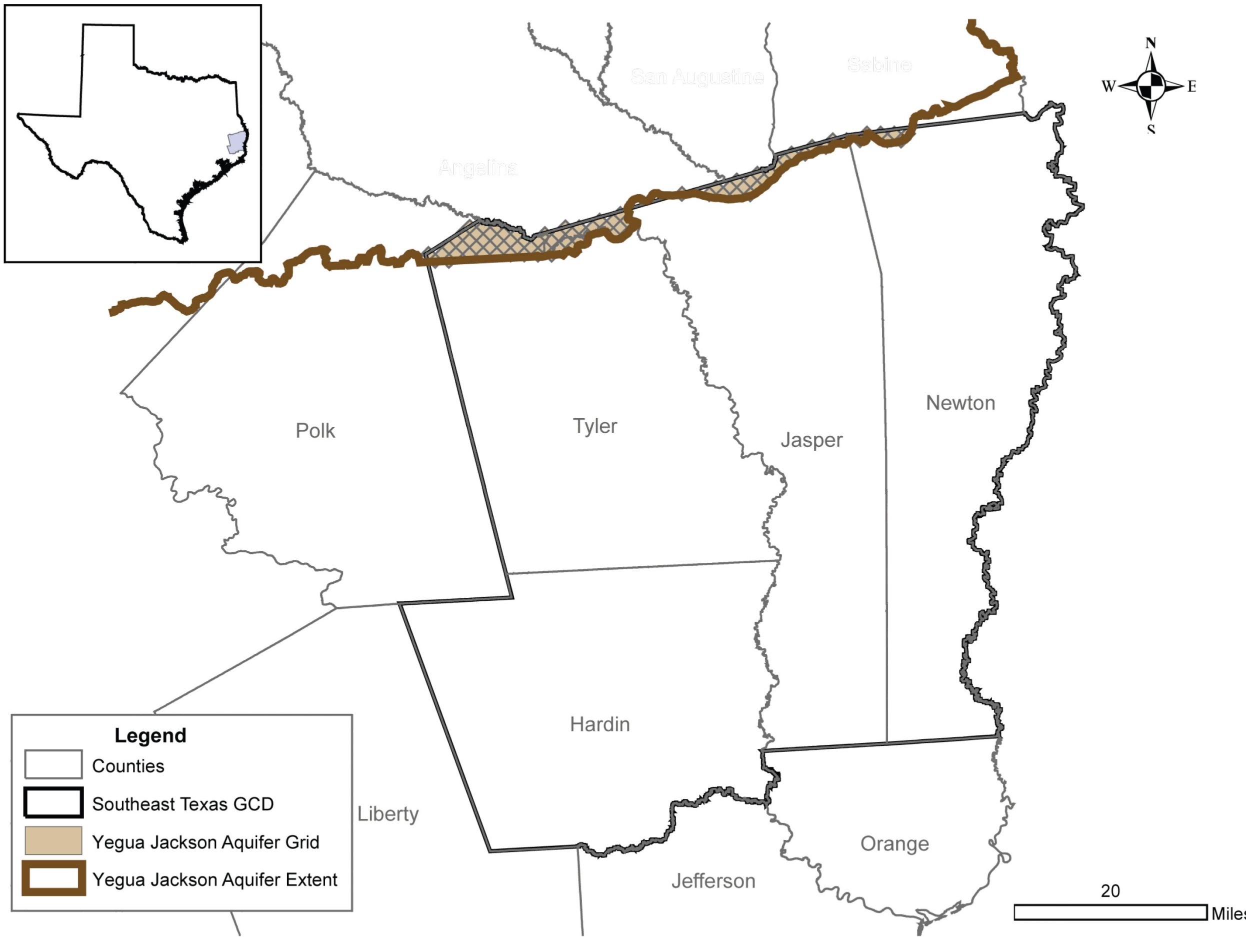


FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE YEGUA-JACKSON AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE GULF COAST AQUIFER THAT IS NEEDED FOR SOUTHEAST TEXAS GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT. THESE FLOWS MAY INCLUDE FRESH AND BRACKISH WATERS.

Management Plan requirement	*Aquifer*	*Results*
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer	92,886
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer	22,871
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer	12,293
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer	15,669
Estimated net annual volume of flow between each aquifer in the district	Gulf Coast Aquifer	0

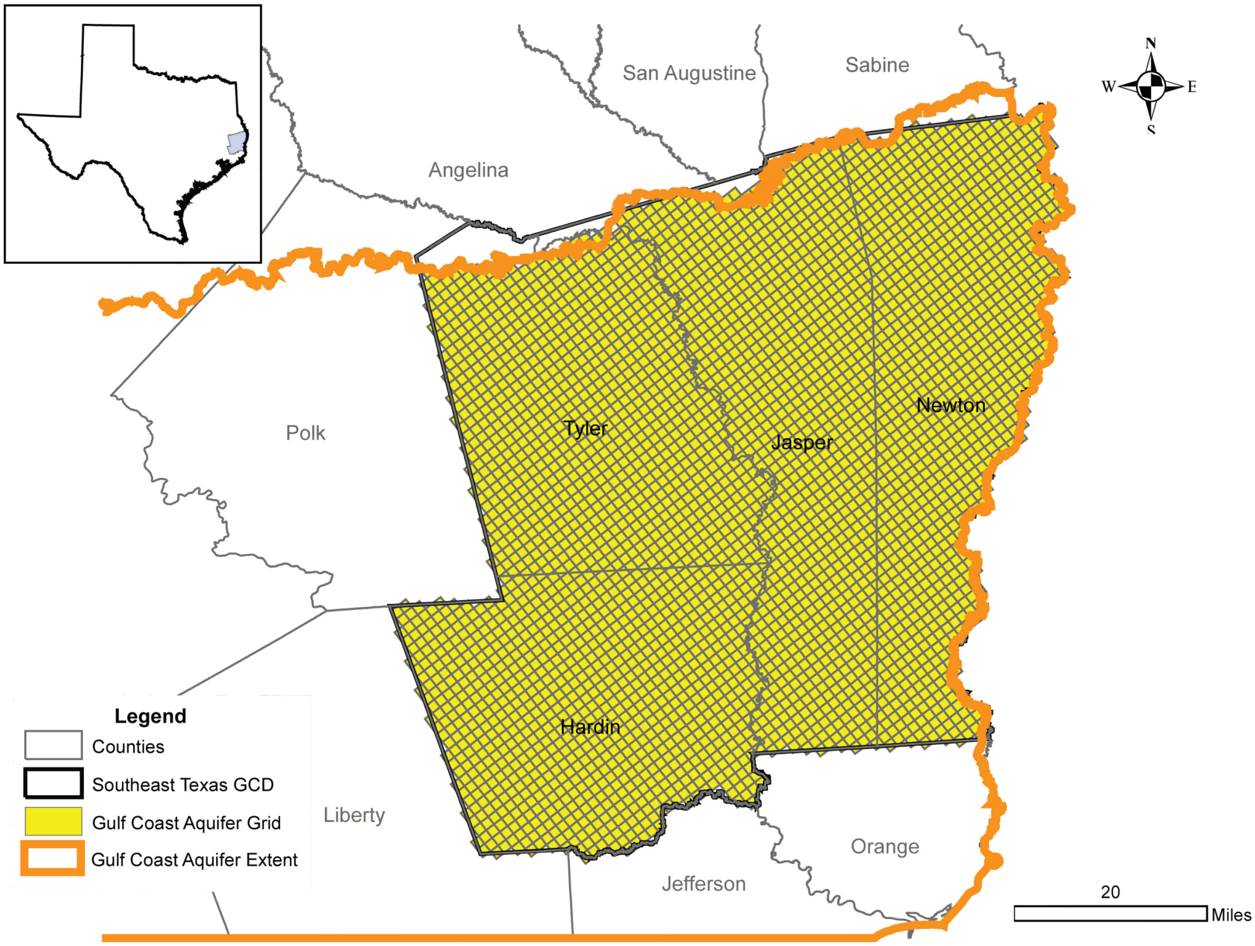


FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE GULF COAST AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS

The groundwater model(s) used in completing this analysis is the best available scientific tool that can be used to meet the stated objective(s). To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> *"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."*

A key assumption used in the groundwater model to evaluate historic groundwater flow conditions concerns the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and interaction with streams are specific to particular historic time periods.

Because the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations related to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, groundwater conservation districts should work with the TWDB to refine this analysis in the future as additional data are available concerning how the aquifer responds to the actual amount and location of pumping over time. Historic precipitation patterns—the basis for the spatial distribution of recharge—also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

REFERENCES:

Chowdhury, A.H., Boghici, R., and Hopkins, J., , Hydrochemistry, Salinity Distribution, and Trace Constituents: Implications for Salinity Sources, Geochemical Evolution, and Flow Systems Characterization, Gulf Coast Aquifer, Texas: In: Mace, R.E., Davidson, S.C., Angle, E.S., and Mullican, W.F. (eds.), Aquifers of the Gulf Coast of Texas: Texas Water Development Board Report 365, p. 81-128, http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R365/ch05-GC_Chemistry.pdf.

Deeds, N.E., Yan, T., Singh, A., Jones, T.L., Kelley, V.A., Knox, P.R., Young, S.C., 2010, Groundwater Availability model for the Yegua-Jackson Aquifer: Prepared for the Texas Water Development Board, 582 p., http://www.twdb.texas.gov/gam/ygjk/Yegua-Jackson_GAM_Final.pdf.

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

Kasmarek, M.C., and Robinson, J.L., 2004, Hydrogeology and Simulation of Groundwater Flow and Land-Surface Subsidence in the Northern Part of the Gulf Coast Aquifer System, Texas: United States Geological Survey Scientific investigations Report 2004-5102, 111 p., http://www.twdb.texas.gov/gam/glfc_n/glfc_n.asp.

National Research Council, 2007, Models in Environmental Regulatory Decision Making. Committee on Models in the Regulatory Decision Process: National Academies Press, Washington D.C., 287 p.