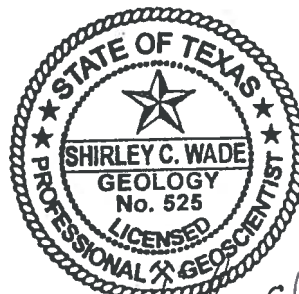
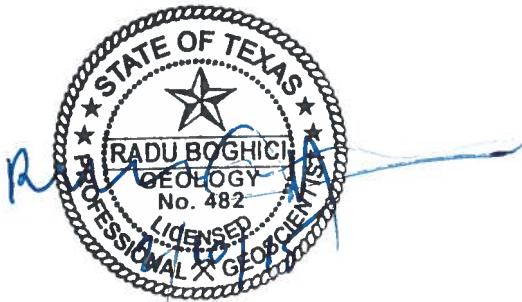


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# GAM RUN 14-015: SOUTHERN TRINITY GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

by Radu Boghici, P.G. and Shirley C. Wade, Ph.D., P.G.  
Texas Water Development Board  
Groundwater Resources Division  
Groundwater Availability Modeling Section  
(512) 463-5808  
February 9, 2015



*Shirley C. Wade*  
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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 (TWDB) 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:

- 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.

This report (Part 2 of a two-part package of information from the TWDB to Southern Trinity Groundwater Conservation District) fulfills the requirements noted above. Part 1 of the two-part package is the Estimated Historical Water Use/State Water Plan data report. The District will receive, or received, this data report from the TWDB Groundwater Technical Assistance Section. Questions about the data report can be directed to Mr. Stephen Allen, [Stephen.Allen@twdb.texas.gov](mailto:Stephen.Allen@twdb.texas.gov), (512) 463-7317.

The groundwater management plan for the Southern Trinity Groundwater Conservation District should be adopted by the District on or before April 8, 2015 and submitted to the executive administrator of the TWDB on or before May 8, 2015. The current management plan for the Southern Trinity Groundwater Conservation District expires on July 7, 2015.

This report discusses the methods, assumptions, and results from a model run using the recently adopted groundwater availability model (approved by the TWDB Executive Administrator on November 21, 2014) for the Trinity (northern portion) and Woodbine aquifers, version 2.01 (Kelley and others, 2014). This model run replaces the results of GAM Run 14-003 (Boghici, 2014) that used version 1.01 of the groundwater availability model for the Trinity (northern portion) and Woodbine aquifers (Bené and others, 2004). GAM Run 14-015 also meets current standards set after the release of GAM Run 08-69 (Oliver, 2008), which was provided to the District in 2008. Tables 1 and 2 summarize the groundwater availability model data required by statute to be included in the District's groundwater conservation management plan, and Figures 1 and 2 show the areas of the model from which the values in the tables were extracted. If after review of the figures, Southern Trinity Groundwater Conservation District determines that the District boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

The Southern Trinity Groundwater Conservation District is also underlain by the Brazos River Alluvium Aquifer; however, a groundwater availability model for this minor aquifer is not available at this time. If the District would like information for the Brazos River Alluvium Aquifer, they may request it from the Groundwater Technical Assistance Section of the TWDB.

### ***METHODS:***

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the updated groundwater availability model for the northern portion of the Trinity Aquifer and Woodbine Aquifer (Kelley and others, 2014) was run for this analysis. Water budgets for the Southern Trinity Groundwater Conservation District were extracted for the historical model periods (1980-2012) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average 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 portion of the aquifers located within the District are summarized in this report.

## ***PARAMETERS AND ASSUMPTIONS:***

### ***Northern portion of the Trinity Aquifer and Woodbine Aquifer***

- We used the updated groundwater availability model for the northern portion of the Trinity Aquifer and Woodbine Aquifer. See Kelley and others (2014) for assumptions and limitations of the updated groundwater availability model for the northern portion of the Trinity Aquifer and Woodbine Aquifer.
- The groundwater availability model includes eight layers, that generally correspond to:
  - the surficial outcrop area and the younger formations overlying the downdip portions of the Woodbine Aquifer and Washita and Fredericksburg groups (Layer 1),
  - the Woodbine Aquifer (Layer 2),
  - the Washita and Fredericksburg groups (Layer 3),
  - the Paluxy Aquifer (Layer 4),
  - the Glen Rose Formation (Layer 5),
  - the Hensell Sand (Layer 6),
  - the Pearsall Formation (Layer 7), and
  - The Hosston Formation (Layer 8).
- All model layers are present in the District. The Trinity Aquifer units (Layers 4 through 8) were combined collectively to calculate water budget values for the Trinity Aquifer.
- As described in Kelley and others (2014), the groundwater flow modeling program MODFLOW does not allow vertical flow through inactive cells. Therefore, where aquifers or formations represented by model Layers 2 through 7 do not exist under the surficial outcrop area of Layer 1, a 1-foot thickness was assigned to those layers to provide for vertical connection between layers.
- Groundwater in the Trinity Aquifer within Southern Trinity Groundwater Conservation District is generally fresh, with total dissolved solids concentrations ranging between 533 to 1,084 milligrams per liter (TWDB

Groundwater Database, 2014). There are no water quality data for Woodbine Aquifer within the District in the TWDB Groundwater Database (2014). In the neighboring Prairielands Groundwater Conservation District to the north, groundwater in the Woodbine Aquifer is fresh to brackish, with total dissolved solids concentrations ranging from 492 to 2,242 milligrams per liter (TWDB Groundwater Database, 2014).

- The model was run with MODFLOW-NWT (Niswonger and others, 2011).

## ***RESULTS:***

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the model results for the aquifers located within the District and averaged over the duration of the calibration and verification portion of the model run in the District, as shown in Tables 1 and 2.

- Precipitation recharge—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.
- Surface water outflow—the total volume of water discharging from the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).
- Flow into and out of District—the lateral flow within the aquifer between the District and adjacent counties.
- 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 Southern Trinity Groundwater Conservation District’s management plan is summarized in Tables 1 and 2. It is important to note that sub-regional water budgets are approximate. 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 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 (Figures 1 and 2). Please note that the results of this model run are different from the results of the model run 14-003 that were obtained from the older groundwater availability model. The changes can be attributed to several characteristics of the new model, such as differences in model layering, geologic boundaries, hydraulic properties distribution, and the use of MODFLOW modeling packages.

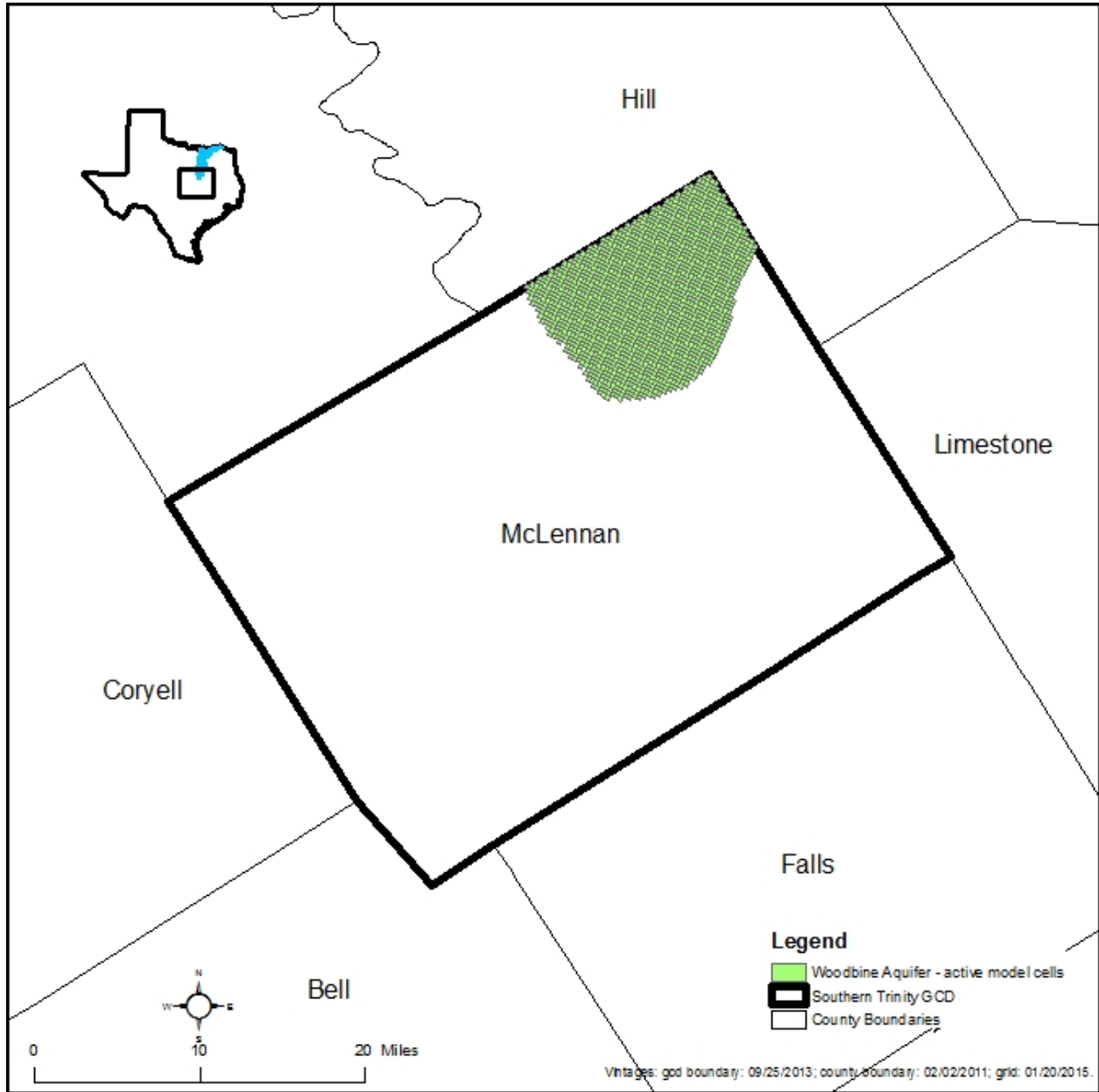
**TABLE 1: SUMMARIZED INFORMATION FOR THE WOODBINE AQUIFER THAT IS NEEDED FOR THE SOUTHERN TRINITY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-Feet PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.**

<i>Management Plan requirement</i>	<i>Aquifer or confining unit</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the District	Woodbine Aquifer	370
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Woodbine Aquifer	1,370
Estimated annual volume of flow into the District within each aquifer in the District	Woodbine Aquifer	223
Estimated annual volume of flow out of the District within each aquifer in the District	Woodbine Aquifer	8
Estimated net annual volume of flow between each aquifer in the District	From overlying younger units into the Woodbine Aquifer	71
Estimated net annual volume of flow between each aquifer in the District	From Woodbine Aquifer into the underlying Fredericksburg and Washita groups	188

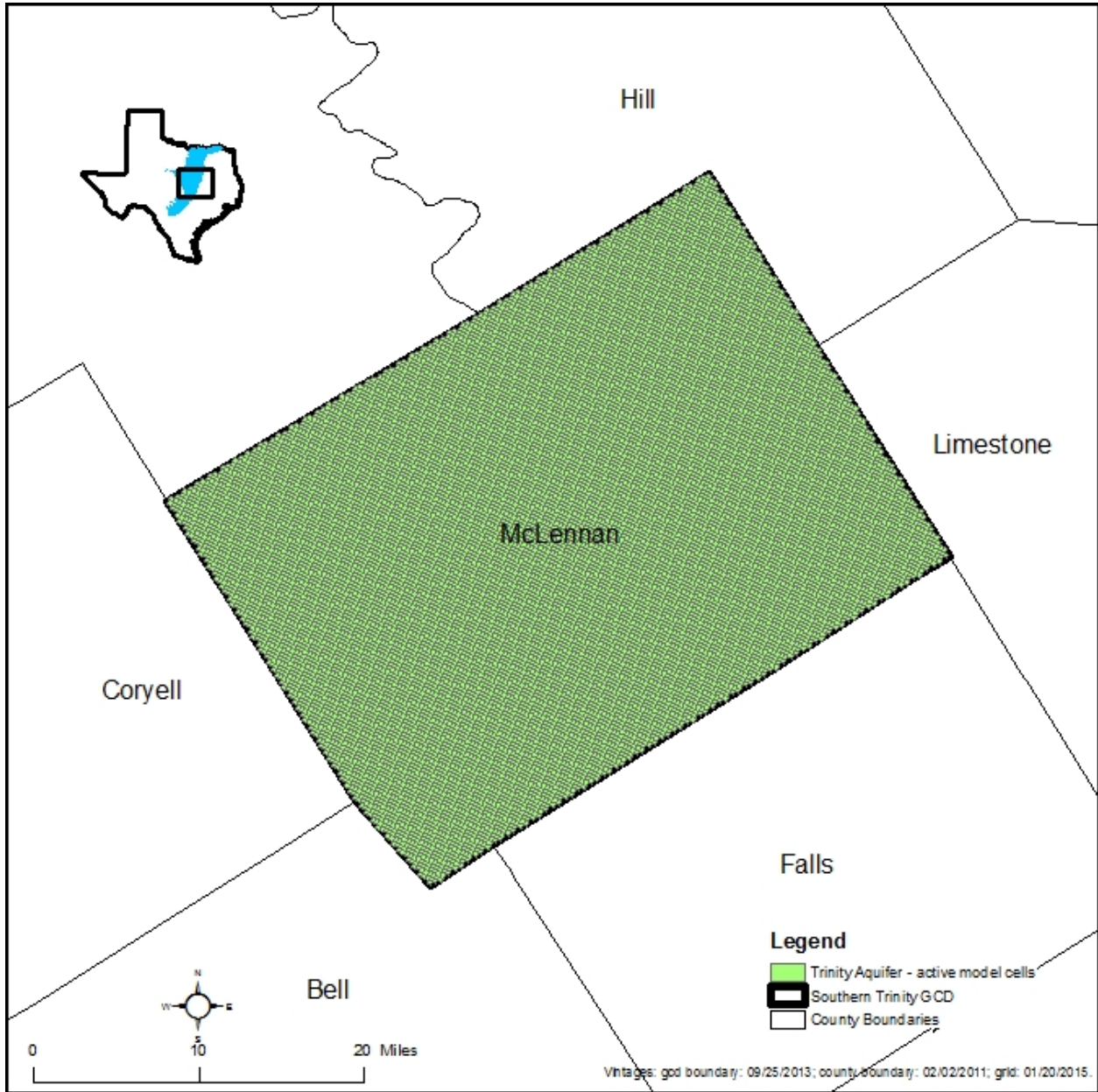
**TABLE 2: SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER THAT IS NEEDED FOR THE SOUTHERN TRINITY GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-Feet PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.**

<i>Management Plan requirement</i>	<i>Aquifer or confining unit</i>	<i>Results</i>
Estimated annual amount of recharge from precipitation to the District	Trinity Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	0
Estimated annual volume of flow into the District within each aquifer in the District	Trinity Aquifer	12,514
Estimated annual volume of flow out of the District within each aquifer in the District	Trinity Aquifer	1,251
Estimated net annual volume of flow between each aquifer in the District	From overlying Washita and Fredericksburg Confining Units into the Trinity Aquifer	534





**FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE TRINITY AQUIFER AND WOODBINE AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE WOODBINE AQUIFER FOOTPRINT EXTENT WITHIN THE DISTRICT BOUNDARY).**



**FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE TRINITY AQUIFER AND WOODBINE AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE TRINITY AQUIFER FOOTPRINT EXTENT WITHIN THE DISTRICT BOUNDARY).**

## **LIMITATIONS**

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. 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 aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about 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 application of the groundwater models 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, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns 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:**

- Bené, J., Harden, B., O'Rourke, D., Donnelly, A., and Yelderman, J., 2004, Northern Trinity/Woodbine Groundwater Availability Model: contract report to the Texas Water Development Board by R.W. Harden and Associates, 391 p., [http://www.twdb.texas.gov/groundwater/models/gam/trnt\\_n/TRNT\\_N\\_Model\\_Report.pdf](http://www.twdb.texas.gov/groundwater/models/gam/trnt_n/TRNT_N_Model_Report.pdf).
- Boghici, R., 2014, GAM Run 14-003: Texas Water Development Board, GAM Run 14-003 Management plan data for Southern Trinity GCD Report, 12 p., <http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR14-003.pdf>.
- Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models, U.S. Geological Survey Groundwater Software.
- Kelley, V.A., Ewing, J., Jones, T.L., Young, S.C., Deeds, N., and Hamlin, S., 2014, Updated Groundwater Availability Model of the Northern Trinity and Woodbine Aquifers: contract report prepared for North Texas GCD, Northern Trinity GCD, Prairielands GCD, and Upper Trinity GCD by INTERA Incorporated, Bureau of Economic Geology, and LBG-Guyton Associates, 990 p., [http://www.twdb.texas.gov/groundwater/models/gam/trnt\\_n/Final\\_NTGAM\\_Vol%20I%20Aug%202014\\_Report.pdf](http://www.twdb.texas.gov/groundwater/models/gam/trnt_n/Final_NTGAM_Vol%20I%20Aug%202014_Report.pdf).
- Niswonger, R.G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, a Newton formulation for MODFLOW-2005: USGS, Techniques and Methods 6-A37, 44 p.
- 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., [http://www.nap.edu/catalog.php?record\\_id=11972](http://www.nap.edu/catalog.php?record_id=11972).
- Oliver, Wade, 2008, GAM Run 08-69: Texas Water Development Board, GAM Run 08-69 Report, 6 p., <http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR08-69.pdf>.
- TWDB, 2014, Water Information, Integration, and Dissemination System, <http://wiid.twdb.texas.gov/> queried on August 12, 2014.