



TEXAS WATER DEVELOPMENT BOARD



E. G. Rod Pittman, *Chairman*
William W. Meadows, *Member*
Dario Vidal Guerra, Jr., *Member*

J. Kevin Ward
Executive Administrator

Jack Hunt, *Vice Chairman*
Thomas Weir Labatt III, *Member*
James E. Herring, *Member*

December 4, 2006

Ms. Leah Manning
Program Manager
LCRA-SAWS Water Project
P. O. Box 220
Austin, Texas 78767-0220

Re: Review of the draft-final model calibration report for the Chicot and Evangeline aquifers in Colorado, Wharton, and Matagorda counties

Dear Ms. Manning:

We have completed our review of the draft-final model calibration report. Our comments are attached. We are generally pleased with the calibration approach used to better understand the groundwater flow system in the Gulf Coast Aquifer of central Texas. However, we were unable to compare the content of the report with the groundwater model used to generate it as the model was unavailable during the review period. It is our understanding that some of the current model parameters may be revisited and revised. This will provide us another opportunity to review the report and an opportunity to review the model.

Thank you for allowing us to participate in the review process. Please let us know if you have any questions or comments on our review of the report.

Sincerely,

Robert E. Mace, Ph.D., P.G.
Director, Groundwater Resources Division

Enclosures

Cs: John E. Burke, Chair, Region K Regional Water Planning Group
Haskell Simon, Coastal Plains Groundwater Conservation District
Neil Hudgins, Coastal Plains and Coastal Bend Groundwater Conservation District
Carolyn L. Brittin, Director, Water Resources Planning, Texas Water Development Board
David Meesey, Manager, Regional Water Planning, Texas Water Development Board

Our Mission

To provide leadership, planning, financial assistance, information, and education for the conservation and responsible development of water for Texas.

P.O. Box 13231 • 1700 N. Congress Avenue • Austin, Texas 78711-3231
Telephone (512) 463-7847 • Fax (512) 475-2053 • 1-800-RELAYTX (for the hearing impaired)
URL Address: <http://www.twdb.state.tx.us> • E-Mail Address: info@twdb.state.tx.us
TNRIS - The Texas Information Gateway • www.tnris.state.tx.us
A Member of the Texas Geographic Information Council (TGIC)



**Review Comments by Texas Water
Development Board Staff on the Draft-Final
Report Entitled “Development of a Detailed
Groundwater Flow Model for the Chicot and
Evangeline Aquifers in Colorado, Wharton,
and Matagorda counties”
Prepared by the URS Corporation, Baer
Engineering, and INTERA Inc.**

November 30, 2006

The comments presented below are strictly based on a review of the above report. The content of the report was not compared against the groundwater model discussed in the report. The groundwater model was not available during the review period.

We have divided our comments into three parts: the first part represents more general comments with discussion, the second part represents specific technical comments with much less discussion, and the third part represents editorial comments with suggestions for improvements.

General Comments

We acknowledge the significant efforts put together by the project team to better understand and model the groundwater flow system in the central parts of the Gulf Coast Aquifer.

We particularly appreciate the team’s efforts in the following areas:

- thoughtful approaches for designing model calibration,
- simulation of groundwater-surface water interactions,
- recharge estimation (inclusion of baseflow, irrigation return flow, and topography),
- application of PEST to constrain calibration,
- use of numerous hydrographs for testing model calibration, and
- delineation of downdip extent of the flow boundary.

In addition, new information was collected on various topics essential for the development of this local scale groundwater model. Some of the information presented in this report is not final, which will be addressed during the final calibration in 2007. For example, there are issues with simulating flow along the eastern boundary of the model. The differences between the simulated and measured water levels in this area are considerably higher than in the rest of the model. Compaction of clays in the Gulf Coast Aquifer, which has often been considered as a source of water and a subsequent trigger for land-surface subsidence, has not been incorporated in the current model. Inclusion of this component into the current model would help evaluate whether possible compaction of clays due to increased pumping would affect existing model calibration in addition to possible land surface subsidence. Sensitivity of the various model calibration parameters have not been reported, which to our understanding will be undertaken during final model calibration. Along this line, it could be important to observe whether any changes to groundwater-surface water interaction occur by assigning pumpage in layer 1 of the model. Currently, no pumpage has been assigned to layer 1 of the model presumably due to shallow thickness (up to 150 feet) of the aquifer. However, numerous wells could be completed within the shallower areas of the Gulf Coast Aquifer. Groundwater pumpage distribution in the model area could also be better illustrated on a county and year basis.

The report requires a thorough review to improve the clarity of information presented on various topics. A lot of important graphics were presented in the report but some of these graphics were not adequately described in the text. Detailed description of these important findings, presented in a manner readily understood by the general public, would help in a greater understanding of the Gulf Coast Aquifer in Texas.

The report does not have a conclusion section. The report needs a conclusion section that would summarize the important findings of this investigation. Many references cited in the text are missing in the reference list. Therefore, some statements that were referred to in the text could not be further verified. Many of the color schemes used in the text and graphics were not readable in black and white print.

Specific Technical Comments

These technical comments are provided to better clarify technical items that are either inadequately or incorrectly described in the text.

(1) **Table 2-1, page 2-4, Average Recharge Values:** Please consider completing the table with the recharge rate from groundwater availability model of the central part of the Gulf Coast Aquifer (0.17 to 0.48 inches per year).

(2) **Pages 2-2 and 2-3:** It was stated that shallow groundwater in the area flows to depths of 20 to 100 feet with a travel time of a month to a few tens of years and deep groundwater flows to depths of 500 to 2,000 feet with travel times that range between 50 and 10,000 years. Please consider providing supporting information or appropriate reference to support these specified travel times.

(3) **Page 3-2, Figure 3-3:** Paragraph 2 describes the spatial extent and vertical layering of the model layers. Model layer 1 represents the shallow aquifer system and is up to 150 feet thick. Model layer 2 represents the Beaumont, layer 3 represents the Lissie, layer 4 represents the Willis, layer 5 represents the Upper Goliad, and layer 6 represents the lower Goliad formations. Figure 3-3 demonstrates the extent of the model layers in addition to showing locations of the active, inactive, and active thin cells. Active thin cells are cells that are 1 foot thick that are placed in the outcrop area to allow vertical communication between model layers above and below. However, when areas occupied by active thin cells are compared with thickness maps (Figures 3.18 to 3.21) presented in Deeds and others (2006), we observe that thin cell areas also occupy model areas with aquifer thicknesses that range from 20 to 100 feet. Please consider providing an explanation on why active thin cells include areas with appreciable aquifer thickness.

(4) **Page 4-1:** The following statements “For any given year, recharge is set at a constant rate and does not vary among the different months. For each calendar year, the average recharge rate varies as a non-linear function of total precipitation” appear contradictory and need further clarification.

(5) **Page 4-9, Figure 4-4:** This figure shows recharge distribution for the steady-state model. Large areas in Colorado and Austin counties show recharge in excess of 5 inches per year. It is unclear how much greater than 5 inches per year recharge occurs in the area. Please consider providing the range of calibrated recharge values in the legend for this recharge category. Please consider mentioning that such high values of recharge have not been previously used in developing groundwater models of the Gulf Coast Aquifer in Texas.

(6) **Page 5-4, Table 5-1:** Please consider providing consistent terminologies for depositional environments. For example, the Lissie, Willis, Upper, and Lower Goliad formations were grouped under “alluvial” and “coastal” depositional environments. Since alluvial environments could equally occur in the uplands and coastal settings, we suggest use of unique terms or that these specific environments are specifically defined to avoid confusion.

(7) **Page 5-12, Figure 5-3:** Figure 5-3 shows relationship between measured and estimated transmissivity from lithology. However, the data in the plot represent the Chicot and the Evangeline aquifers. Since, the transmissivity estimation was based on lithology, we expected that the data could as well be grouped based on specific formations used to develop the model layers.

(8) **Page 6-6:** It was stated that the conductance between the general head boundary node and the adjacent model cell was set to $1.06E6 \text{ ft}^2/\text{day}$. How sensitive are the conductance values to flow across the general head boundary?

(9) **Page 6-10, Figure 6-4:** Minimum river elevation using digital elevation models and Lower Colorado River Authority’s HEC RAS model: please consider updating figure to include the elevation used in the final model.

(10) **Page 7-1, paragraph 4:** For model layer 1, no flow conditions were used to simulate the eastern boundary. However, considerable water could potentially flow across the boundary given a layer thickness of up to 150 feet. Therefore, we suggest that the no-flow boundary be replaced with a general head boundary similar to that assigned in the remaining model layers.

(11) **Page 8-1, paragraph 2:** states county other water use consists primarily of unreported domestic water use. Please note that this category of use represents all municipal use outside of designated cities (populations greater than 500 during the last planning cycle) and, therefore, includes both unreported domestic water use and public water supply for rural use.

(12) **Page 8-8, paragraph 1:** The report lists two figures for figure 8-7 (one on page 8-15 and another on page 8-16). Please consider relabeling the figure on page 8-16 to Figure 8-8 and update the text accordingly. Also in the figure on page 8-16 it appears pumpage was assigned to cells where there does not appear to be a well in 2006. Please consider expanding the discussion in Section 8.4.4 to clarify how spatial distribution included cells without current wells or adjust the figure on page 8-16 to reflect current well locations more clearly. It is our understanding that the resource used for the spatial location of the irrigation wells was the TWDB groundwater database. This database contains only a fraction of all the irrigation wells in the state of Texas. Even though the data from the local groundwater conservation district's arrived too late to be incorporated into the model, it would possibly strengthen the validity or note the uncertainty of this methodology if the distribution of irrigation wells in the TWDB database was compared to the distribution of permitted irrigation wells by county from the groundwater conservation district data.

(13) **Page 8-8, paragraph 1:** states the method used for [spatially] locating wells was based on the known well locations in 2006. Please consider clarifying if this references the method discussed in Section 8.4.4. If this is the case, please consider cross-referencing text in Section 8.7 to Section 8.4.4.

(14) **Page 9-3, Figure 9-3:** It was stated in the text that for model layer 1, vertical hydraulic conductivity was uniform and set to 0.1. However, a distributed vertical hydraulic conductivity that ranges from 0.05 to 0.01 was shown for layer 1 in figure 9-3. Please consider clarifying the inconsistency between the text and the figure.

(15) **Page 9-5:** Tables 9-2 and 9-3 reports root mean squared error values by counties using the FWL5 package and the WEL package. However, part of the table is confusing, particularly the last column of values with root mean squared errors greater than 80. Please consider providing some description of these tables so that the values presented in each column are easily understood.

(16) **Page 9-6, paragraph 3:** This paragraph discusses problems with hydraulic head data. Please consider clarifying if the data retrieved from the TWDB groundwater

database were screened for publishable data and water level measurement comments indicated static water levels (remarks should be null or “1”). We are concerned using measurements from a pumping well as targets that may not reflect ambient water levels.

(17) **Page 9-6:** Figures 9-17 through 9-19 are confusing. Do contours on these maps represent residual values (differences between measured and simulated water levels) as stated in the caption of the figure? If yes, then these residuals are way too high. If they are simulated water levels for 1900–1910, 1910–1920, and 1920–1930, then please correct the caption. Please remove the reference to residuals from the caption if this is not what was presented in the map.

(18) **Page 9-7:** The report states that there is some spatial and temporal bias in the occurrences of the residuals. The model underpredicts heads in the central portion of the model and overpredicts along the boundaries. In addition, the residuals increase over time. How would this result affect the predictive simulations through 2060? We suggest that some discussion on this may help provide greater confidence in the model.

(19) **Page 9-7:** Figure 9-27 shows that during post-1950s, when groundwater pumping was increasing, baseflow discharge tends to show a corresponding decrease. During 1980s to 1990s, a reversal in flow occurs through the general head boundary. These observations of model response provide an illustration on how the aquifer behaves under various pumping conditions; therefore, please consider discussing these observations in the text.

(20) **Page 9-7, paragraph 4:** Appears to state conflicting conclusions. Please clarify. Report states center of the model under predicts hydraulic head in the center of the model yet calibration is quite good in Colorado, Wharton, and Matagorda counties.

(21) **Page 9-7, Paragraph 6:** Please consider noting that no pumping has been assigned in layer 1 of the model. Given that layer 1 occupies up to 150 feet of aquifer thickness and presumably contains numerous shallow wells, assigning no pumpage in this layer may potentially affect the degree of groundwater-surface water interactions and the net water budget in the model.

(22) **Page 9-8, Paragraph 2:** Please consider clarifying these sentences “Before 1953, there is a net upward movement of groundwater from layer 2 to layer 1. After 1953, there is a net upward movement of groundwater from layer 1 to layer 2”.

(23) **Page 9-14:** Steady-state cross-plot includes all layers; suggest separating out cross-plots for each layer. Also suggest including cross-plots for each layer of the transient run in the final report.

(24) **Page 9-17:** Figure 9-13 shows root mean squared error plots for the transient calibration. Numerous wells along the eastern model boundary show root mean squared error values in excess of 60 feet. This suggests that the flow near the general head boundary could be simulated better. As pumping in the central part of the model

presumably draws in more water across the general head boundary, how would this simulation affect calibration in other parts of the model area?

Editorial Comments

The editorial comments include comments with regard to missing references, inconsistencies between figures and text, unclear text, illegible graphics, and suggestions on their improvements.

(1) **Page 2-1:** Definitions for Chicot and Evangeline aquifers reference only two aquifers in the Gulf Coast Aquifer, while the definition for the Gulf Coast Aquifer also mentions the Burkeville Confining Unit and the Jasper Aquifer. This appears inconsistent and confusing. Please consider clarifying and adjusting text accordingly. Suggest stating the Chicot and Evangeline aquifers are the two 'main' aquifers that comprise the Gulf Coast Aquifer.

(2) **Page 3-2:** Young and others (2004) is not in the reference list.

(3) **Page 3-4, Figure 3.2:** Vertical Cross-Section: Suggest adding some point of reference for orientation such as Gulf of Mexico or South on the left axis and North or Outcrop on the right axis.

(4) **Page 4-3, reference to Figure 2-5:** Please consider adjusting to reference 4-2 or include corresponding figure in section 2.

(5) **Page 5-1:** Young et al. (2002), Kelly and others (2002), and Deeds and others (2002) are not included in the reference list.

(6) **Page 5-6:** Deeds et al. (2003) and Dutton et al. (2003) are not included in the reference list.

(7) **Page 5-8:** Kelly and others, 2004 is not included in the reference list.

(8) **Page 5-14, Figure 5-6:** Please consider updating references to 'faction' to 'fraction' in the legends.

(9) **Page 8-6:** References Figure 8-4 and states '...average pumpage rate of 24 AFY to yield 4 grid cells...', please consider updating text to '25 AFY' to agree with Figure 8-4.

(10) **Page 9-4, paragraph 2:** References TWDB and Harris-Galveston Subsidence District, suggest discarding TWDB data and use Harris-Galveston Subsidence District data since it is more comprehensive.

(11) **Page 9-5, paragraph 1:** Last sentence is unclear: "Nonetheless, the well package is often used in modeling because of it is simple to apply and simple to developed..."

- (12) **Page 9-6, paragraph 2:** References “RSM”, rest of section references “RMS”.
- (13) **Page 9-6, paragraph 3:** Fifth and sixth sentences are unclear: “A second issue is that after 1980, the many of the hydrographs show that heads are rebounding as a result of decrease pumping. A third issue is the wide-range of of in the range of fluctuations caused by irrigation pumping during the summer months.”
- (14) **Page 9-6, paragraph 2:** Last sentence is unclear or incomplete: “Another reason is that in Model Layer 1 the groundwater system is an unconfined.”
- (15) **Page 9-7, paragraphs 2, 3, 4:** Have numerous grammatical errors. Please review and update as needed.
- (18) **Page 9-10, Figure 9-2:** In the legend, there is a category of hydraulic conductivity values that range from 61–70 ft/d but no corresponding color zones for this range of values were reported. Therefore, we could not locate where this high hydraulic conductivity areas occur on the map.
- (19) **Pages 9-18 to 9-20:** The hydrographs in Figures 9-14 to 9-16 are too small to read. Suggest expanding to hydrographs per layer or including larger size hydrographs in appendix.
- (20) **Pages 9-21 to 9-30:** Figures 9-17 to 9-26 appear to have different contour intervals in each inset. Difficult to interpret due to size. Suggest enlarging.

References

Deeds, N., Knox, P., Budge, T., Baker, E., Galloway, B., and Dutton, A., 2006, A site conceptual model to support the development of a detailed groundwater model for Colorado, Wharton, and Matagorda counties, *in* Young, S. and Kelley, V. eds., prepared by URS Corporation, Baer Engineering, and INTERA, Inc., variously paginated.