GAM Run 10-055 MAG Version 2: Modeled Available Groundwater for the Yegua-Jackson Aquifer in Groundwater Management Area 14

by Wade Oliver
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 936-2386
July 9, 2012

Updated to Version 2 by Radu Boghici and Shirley Wade to reflect refined modeled available groundwater estimates

Cynthia K. Ridgeway, the Manager of the Groundwater Availability Modeling Section is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on July 9, 2012.

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EXECUTIVE SUMMARY:

The modeled available groundwater for the Yegua-Jackson Aquifer as a result of the desired future conditions adopted by the members of Groundwater Management Area 14 is approximately 7,900 acre-feet per year between 2010 and 2060. This is shown divided by county, regional water planning area, and river basin in Table 2 for use in the regional water planning process. Modeled available groundwater is summarized by county, regional water planning area, river basin, and groundwater conservation district in tables 3 through 6. The modeled available groundwater amounts were estimated by iteratively adjusting the pumping between 2010 and 2060 in the groundwater availability model for the Yegua-Jackson Aquifer in the areas defined by the districts as relevant for the joint planning process.

The first version of this report showed modeled available groundwater for Jasper, Newton, and Tyler counties based on the pumping assumed in the groundwater availability model simulation. However, Groundwater Management Area 14 only specified desired future conditions in the Yegua-Jackson Aquifer for Grimes, Polk, Walker, and Washington counties. Therefore, we updated this report to only depict modeled available groundwater in Grimes, Polk, Walker, and Washington counties.

REQUESTOR:

Mr. Lloyd Behm of Bluebonnet Groundwater Conservation District on behalf of Groundwater Management Area 14

DESCRIPTION OF REQUEST:

In a letter dated August 25, 2010, Mr. Lloyd Behm provided the Texas Water Development Board (TWDB) with the desired future conditions of the Yegua-Jackson Aquifer adopted by the members of Groundwater Management Area 14. The desired future conditions, as shown in Resolution No. 2010-01, are:

Grimes County (Bluebonnet Groundwater Conservation District)

- From estimated 2010 conditions, the average drawdown of the unconfined portion of the Yegua should not exceed approximately 10 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the confined portion of the Yegua should not exceed approximately 15 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the brackish confined portion of the Yegua should not exceed approximately 20 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the unconfined portion of the Jackson should not exceed approximately 10 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the confined portion of the Jackson should not exceed approximately 15 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the brackish confined portion of the Jackson should not exceed approximately 20 feet average drawdown across the areas of occurrence of the aquifer.

Polk County (Lower Trinity Groundwater Conservation District)

- From estimated 2010 conditions, the average drawdown of the Yegua-Jackson should not exceed approximately 2 feet average drawdown across the areas of occurrence of the aquifer.

Walker County (Bluebonnet Groundwater Conservation District)

- From estimated 2010 conditions, the average drawdown of the unconfined portion of the Yegua should not exceed approximately 10 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the confined portion of the Yegua should not exceed approximately 15 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the brackish confined portion of the Yegua should not exceed approximately 20 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the unconfined portion of the Jackson should not exceed approximately 10 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the confined portion of the Jackson should not exceed approximately 15 feet average drawdown across the areas of occurrence of the aquifer.
- From estimated 2010 conditions, the average drawdown of the brackish confined portion of the Jackson should not exceed approximately 20 feet average drawdown across the areas of occurrence of the aquifer.

Washington County

- From estimated 2010 conditions, no additional drawdown of the Yegua Jackson across the area of occurrence of the aquifer.

In response to receiving the adopted desired future conditions, the Texas Water Development Board has estimated the modeled available groundwater for the groundwater conservation districts within Groundwater Management Area 14.

METHODS:

The locations of Groundwater Management Area 14, the Yegua-Jackson Aquifer, and the groundwater availability model cells that represent the aquifer are shown in Figure 1. The TWDB previously completed several predictive groundwater availability model simulations of the Yegua-Jackson Aquifer to assist the members of Groundwater Management Area 14 in developing a desired future condition. These simulations are documented in Groundwater Availability Modeling (GAM) Task 10-012 (Oliver, 2010).

In the results presented in GAM Task 10-012, no distinction was made between the unconfined, confined, and brackish confined portions of the aquifer. As shown above, the desired future conditions for Grimes and Walker counties were divided into unconfined, confined, and brackish confined areas of the aquifer and were developed with the assistance of Mr. Randy Williams of Bar-W Groundwater Exploration. In order to ensure the analysis here was consistent with the intent of the desired future conditions, the TWDB requested, and Mr. Williams provided, the delineations of the unconfined, confined, and brackish confined areas. These are shown in figures 2 and 3 for the Yegua and Jackson portions of the aquifer, respectively. Note in Figure 2 that the unconfined and confined portions of the Yegua unit were not provided within Walker County. However, the limits of these two areas were determined using the locations of the overlying unconfined area of the Jackson unit and the brackish confined area of the Yegua unit.

The TWDB used the groundwater availability model when analyzing desired future conditions for the Yegua-Jackson Aquifer. Because none of the previously run simulations matched the desired future conditions in Grimes and Walker counties, it was necessary to perform an additional run for this analysis. In this run, pumping was kept at the same level as the “base” scenario in GAM Task 10-012 for areas outside Grimes and Walker counties. In Grimes and Walker counties, the zones provided by Mr. Williams were implemented into the groundwater availability model as shown in figures 2 and 3. It is important to note that, though there are active areas in the model in Grimes and Walker counties outside of these zones, these areas were not included when estimating drawdown or pumping.

Pumping was adjusted in each of the above zones using PEST (Watermark Numerical Computing, 2004), an industry-standard inverse modeling software package, to match—to the extent possible—the above desired future conditions.

The best fit that could be achieved through this process was within 1-foot of each of the desired future conditions and is considered well within the uncertainty of the model. These values are shown in Table 1. Because a precise match could not be made, the TWDB requested confirmation from the districts in Groundwater Management Area 14 that the drawdowns achieved were consistent with the intent of the desired future conditions. This confirmation was received at the Groundwater Management Area 14 meeting held on May 24, 2011.

The modeled available groundwater as a result of the desired future conditions for the Yegua-Jackson Aquifer in Groundwater Management Area 14 is approximately 7,900 acre-feet per year. This pumping was then divided by county, regional water planning area, river basin, and groundwater conservation district (Figure 4).

PARAMETERS AND ASSUMPTIONS:

- We used version 1.01 of the groundwater availability model for the Yegua-Jackson Aquifer. See Deeds and others (2010) for assumptions and limitations of the groundwater availability model.

- The model includes five layers representing the Yegua-Jackson Aquifer and the overlying Catahoula unit.

- Deeds and others (2010) define which areas of the model correspond to the Lower Yegua, Upper Yegua, Lower Jackson, Upper Jackson and Catahoula units. The locations of the unconfined zones for Grimes and Walker counties provided by Mr. Randy Williams did not precisely correspond to the modeled definition of these areas. Since the outcrop (and unconfined) layer of the model (Layer 1) is intended to represent the conditions at a particular location, regardless of the unit named, the zones provided by Mr. Williams were honored when integrating those areas into the model.

- As reported in Deeds and others (2010), the mean absolute errors (a measure of the difference between simulated and measured water levels during model calibration) for the Jackson Group (combined upper and lower Jackson units), Upper Yegua, and Lower Yegua portions of the aquifer for the historical-calibration period of the model are 31.1, 23.9, and 24.5 feet, respectively. These represent

10.3, 5.7, and 6.3 percent of the hydraulic head drop across each model area, respectively.

- The recharge used for the model simulation represents average recharge as described in Deeds and others (2010).

- The model results presented in this report were extracted from all areas of the model representing the units comprising the Yegua-Jackson Aquifer. This includes some areas outside the "official" boundary of the aquifers shown in the 2007 State Water Plan (TWDB, 2007). For this reason, the results may reflect water of quality ranging from fresh to brackish and saline.

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. This is distinct from "managed available groundwater," shown in the draft version of this report dated July 12, 2011, which was a permitting value and accounted for the estimated use of the aquifer exempt from permitting. This change was made to reflect changes in statute by the 82nd Texas Legislature, effective September 1, 2011.

Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits. The estimated amount of pumping exempt from permitting, which the TWDB is now required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

RESULTS:

The desired future conditions, drawdown achieved in the TWDB "best fit" simulation, and estimated pumping for each of the areas defined above are shown in Table 1. Notice that the drawdowns achieved in the model simulation are all within approximately 1-foot of the desired future condition.

As described in the Methods section above, pumping was kept at the same level as the "base" scenario in GAM Task 10-012 in the areas outside those shown in

Table 1. The modeled available groundwater for all areas within Groundwater Management Area 14 for the Yegua-Jackson Aquifer is shown divided by county, regional water planning area, and river basin in Table 2. This is also summarized by county, regional water planning area, river basin, and groundwater conservation district in tables 3, 4, 5, and 6, respectively. In Table 6, note that the modeled available groundwater is subtotaled for only district areas relevant to the desired future conditions.

LIMITATIONS:

The groundwater model used in developing estimates of modeled available groundwater is the best available scientific tool that can be used to estimate the pumping that will achieve the desired future conditions. Although the groundwater model used in this analysis is the best available scientific tool for this purpose, it, like all models, has limitations. 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 develop estimates of modeled available groundwater is the need to make assumptions about the location in the aquifer where future pumping will occur. As actual pumping changes in the future, it will be necessary to evaluate the amount of that pumping as well as its location in the context of the assumptions associated with this analysis. Evaluating the amount and location of future pumping is as important as evaluating the changes in groundwater levels, spring flows, and other metrics that describe the condition of the groundwater resources in the area that relate to the adopted desired future condition.

Given these limitations, users of this information are cautioned that the modeled available groundwater numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. Because the application of 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 relating 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 future groundwater pumping as well as whether or not they are achieving their desired future conditions. Because of the limitations of the model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine the modeled available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

REFERENCES:

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: Final Report Prepared for the Texas Water Development Board by INTERA, Inc., 582 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.

Oliver, W., 2010, GAM Task 10-012, Texas Water Development Board Groundwater Availability Modeling Task Report, 48 p.

Texas Water Development Board, 2007, Water for Texas – 2007 – Volumes I-III; Texas Water Development Board Document No. GP-8-1, 392 p.

TABLE 1: COMPARISON BETWEEN DESIRED FUTURE CONDITIONS (DFCS) FOR THE YEGUA-JACKSON AQUIFER IN GROUNDWATER MANAGEMENT AREA 14 AND THE "BEST FIT" DRAWDOWN ACHIEVED IN THE MODEL SIMULATION. THE ESTIMATED PUMPING ASSOCIATED WITH THE SIMULATION FOR EACH AREA WITH A DEFINED DESIRED FUTURE CONDITION IS ALSO SHOWN.

County	*Unit*	*DFC (feet of drawdown)*	*TWDB "Best Fit" Scenario Drawdown (feet)*	*Pumping (acre-feet per year)*
Grimes	Yegua (Unconfined)	10	9.3	1,083
Grimes	Yegua (Confined)	15	15.8	0
Grimes	Yegua (Brackish Confined)	20	19.8	312
Grimes	Jackson (Unconfined)	10	10.0	1,729
Grimes	Jackson (Confined)	15	14.9	22
Grimes	Jackson (Brackish Confined)	20	20.0	132
Polk	Yegua-Jackson	2	2.5	360
Walker	Yegua (Unconfined)	10	10.1	366
Walker	Yegua (Confined)	15	15.0	40
Walker	Yegua (Brackish Confined)	20	20.0	340
Walker	Jackson (Unconfined)	10	9.7	3,342
Walker	Jackson (Confined)	15	15.5	0
Walker	Jackson (Brackish Confined)	20	19.9	86
Washington	Yegua-Jackson	0	-0.7	134

TABLE 2: MODELED AVAILABLE GROUNDWATER FOR THE YEGUA-JACKSON AQUIFER IN GROUNDWATER MANAGEMENT AREA 14. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE DIVIDED BY COUNTY, REGIONAL WATER PLANNING AREA, AND RIVER BASIN.

County	*Region*	*Basin*	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Grimes	G	Brazos	1,954	1,954	1,954	1,954	1,954	1,954
Grimes	G	San Jacinto	80	80	80	80	80	80
Grimes	G	Trinity	1,244	1,244	1,244	1,244	1,244	1,244
Polk	H	Trinity	0	0	0	0	0	0
Polk	I	Neches	360	360	360	360	360	360
Walker	H	San Jacinto	351	351	351	351	351	351
Walker	H	Trinity	3,823	3,823	3,823	3,823	3,823	3,823
Washington	G	Brazos	134	134	134	134	134	134
Washington	G	Colorado	0	0	0	0	0	0
Total			**7,946**	**7,946**	**7,946**	**7,946**	**7,946**	**7,946**

TABLE 3: MODELED AVAILABLE GROUNDWATER FOR THE YEGUA-JACKSON AQUIFER SUMMARIZED BY COUNTY IN GROUNDWATER MANAGEMENT AREA 14 FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

County	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Grimes	3,278	3,278	3,278	3,278	3,278	3,278
Polk	360	360	360	360	360	360
Walker	4,174	4,174	4,174	4,174	4,174	4,174
Washington	134	134	134	134	134	134
Total	**7,976**	**7,946**	**7,946**	**7,946**	**7,946**	**7,946**

TABLE 4: MODELED AVAILABLE GROUNDWATER FOR THE YEGUA-JACKSON AQUIFER SUMMARIZED BY REGIONAL WATER PLANNING AREA IN GROUNDWATER MANAGEMENT AREA 14 FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

Region	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
G	3,412	3,412	3,412	3,412	3,412	3,412
H	4,174	4,174	4,174	4,174	4,174	4,174
I	360	360	360	360	360	360
Total	**7,946**	**7,946**	**7,946**	**7,946**	**7,946**	**7,946**

TABLE 5: MODELED AVAILABLE GROUNDWATER FOR THE YEGUA-JACKSON AQUIFER SUMMARIZED BY RIVER BASIN IN GROUNDWATER MANAGEMENT AREA 14 FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

Basin	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Brazos	2,088	2,088	2,088	2,088	2,088	2,088
Neches	360	360	360	360	360	360
San Jacinto	431	431	431	431	431	431
Trinity	5,067	5,067	5,067	5,067	5,067	5,067
Total	**7,946**	**7,946**	**7,946**	**7,946**	**7,946**	**7,946**

TABLE 6: MODELED AVAILABLE GROUNDWATER FOR THE YEGUA-JACKSON AQUIFER SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT (GCD) IN GROUNDWATER MANAGEMENT AREA 14 FOR EACH DECADE BETWEEN 2010 AND 2060. RESULTS ARE IN ACRE-FEET PER YEAR.

Groundwater Conservation District	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Bluebonnet GCD	7,452	7,452	7,452	7,452	7,452	7,452
Lower Trinity GCD	360	360	360	360	360	360
District Areas Considered Relevant in Desired Future Conditions	**7,812**	**7,812**	**7,812**	**7,812**	**7,812**	**7,812**
No District	134	134	134	134	134	134
Total	**7,946**	**7,946**	**7,946**	**7,946**	**7,946**	**7,946**

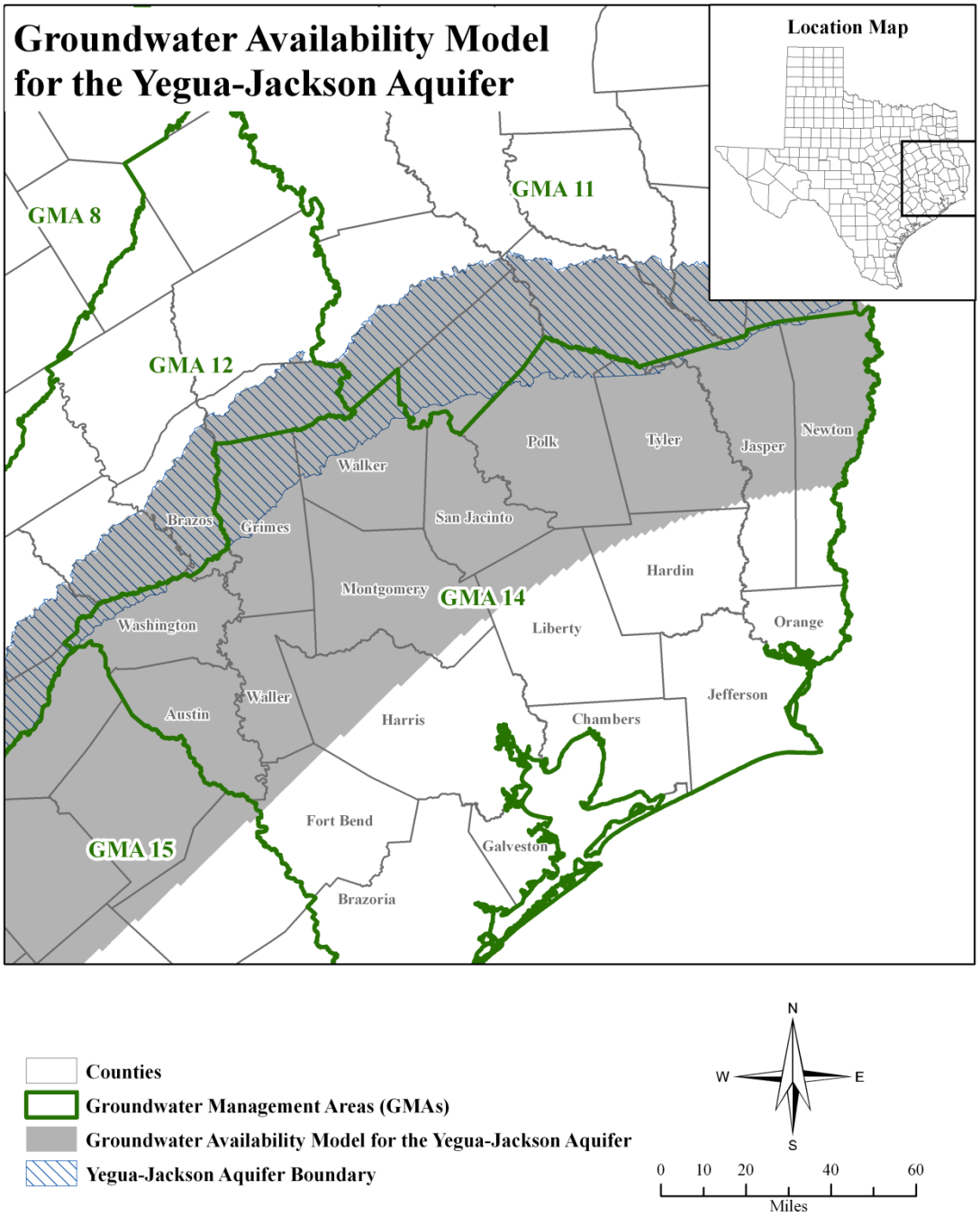

FIGURE 1. MAP SHOWING THE AREAS COVERED BY THE GROUNDWATER AVAILABILITY MODEL REPRESENTING THE YEGUA-JACKSON AQUIFER.

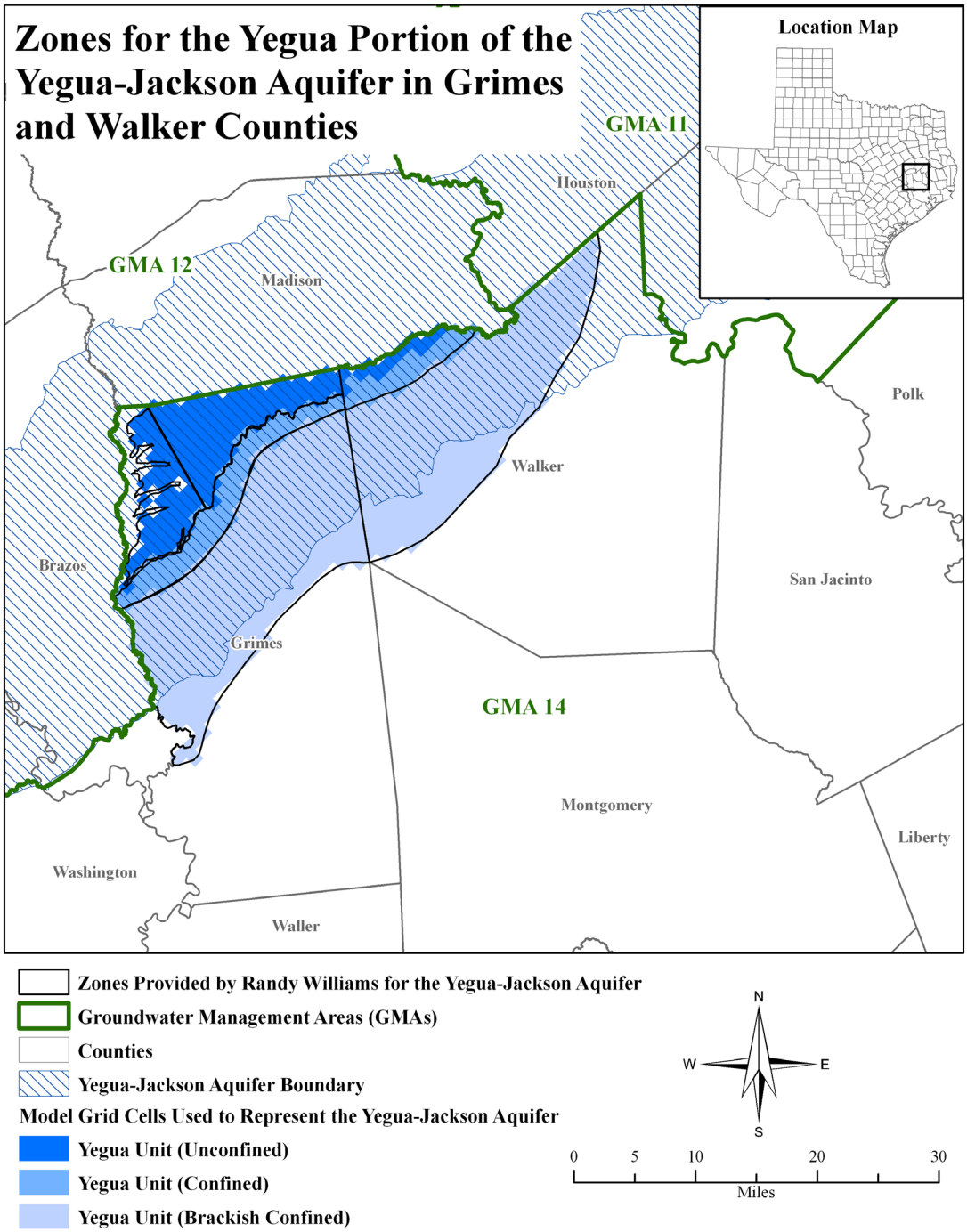

FIGURE 2. MAP SHOWING THE ZONES PROVIDED BY MR. RANDY WILLIAMS FOR THE YEGUA PORTION OF THE YEGUA-JACKSON AQUIFER IN GRIMES AND WALKER COUNTIES.

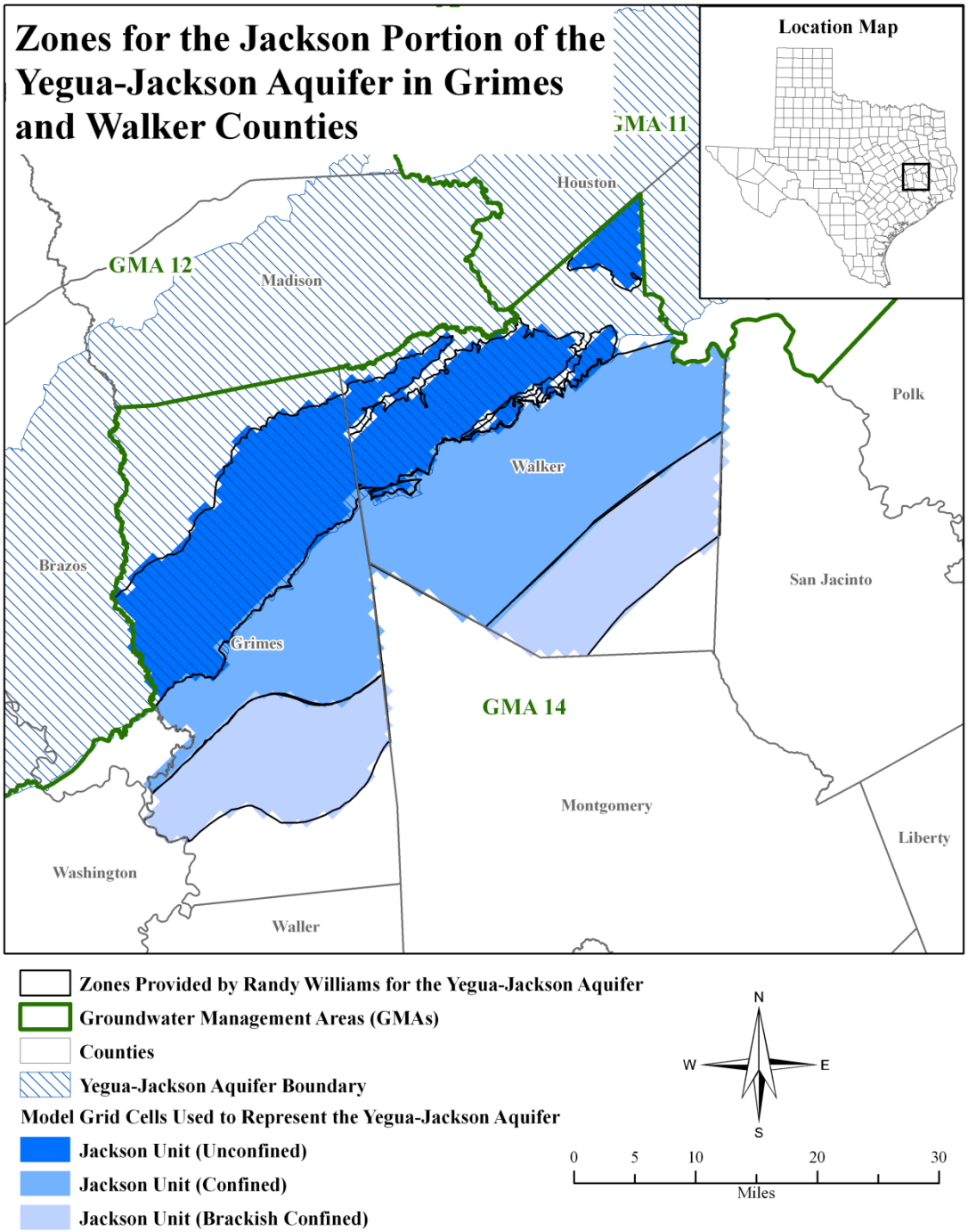

FIGURE 3. MAP SHOWING THE ZONES PROVIDED BY MR. RANDY WILLIAMS FOR THE JACKSON PORTION OF THE YEGUA-JACKSON AQUIFER IN GRIMES AND WALKER COUNTIES.

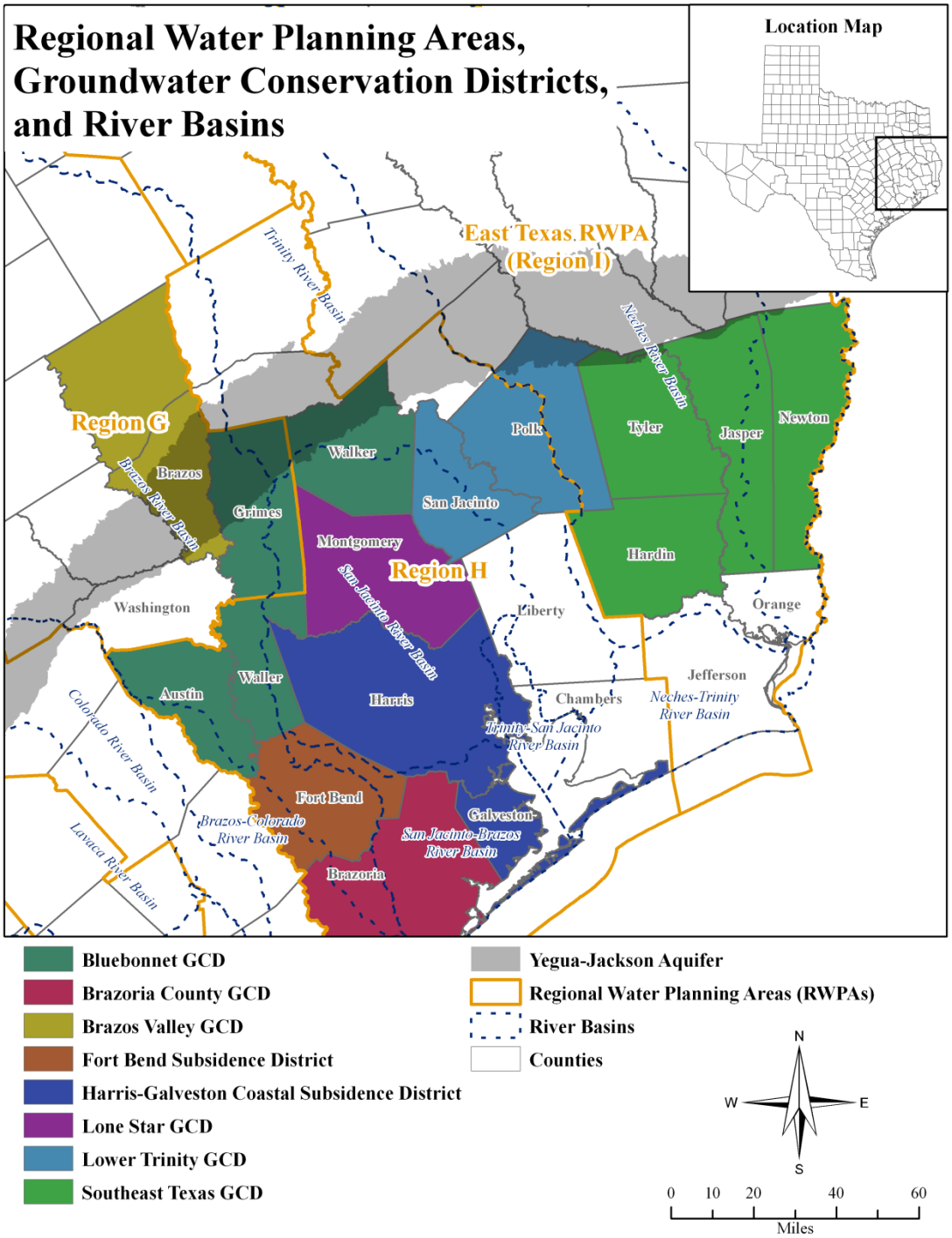

FIGURE 4. MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS, COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 14.