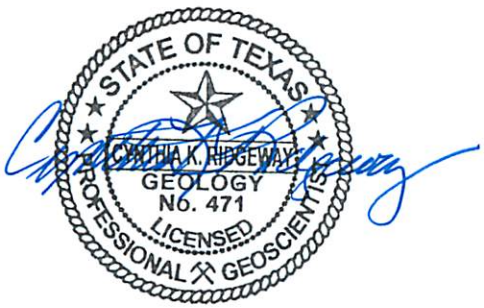
# GAM Run 10-045 MAG

**by Mr. Wade Oliver**

Edited and finalized by Shirley Wade, Ph.D., P.G., to reflect statutory changes effective September 1, 2011

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0883
July 9, 2012




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 Queen City Aquifer as a result of the desired future conditions adopted by the districts of Groundwater Management Area 12 increases from approximately 3,600 acre-feet per year to 5,500 acre-feet per year between 2010 and 2030, then declines to approximately 3,700 acre-feet per year between 2030 and 2060. This is shown divided by county, regional water planning area, and river basin in Table 2. The modeled available groundwater estimates were taken from model simulation "GAM12_7B" completed for Groundwater Management Area 12 by consultants retained by the districts to assist in developing desired future conditions. The Texas Water Development Board confirmed that this model simulation achieves the desired future conditions adopted by the districts of Groundwater Management Area 12.

## REQUESTOR:

Mr. Gary Westbrook of Post Oak Savannah Groundwater Conservation District on behalf of Groundwater Management Area 12

## DESCRIPTION OF REQUEST:

In a letter dated August 12, 2010, Mr. Gary Westbrook provided the Texas Water Development Board (TWDB) with the desired future conditions of the Queen City Aquifer adopted by the districts of Groundwater Management Area 12. The desired future conditions for the Queen City Aquifer, as presented in Appendix B of the resolution and adopted August 11, 2010 by the groundwater conservation districts within Groundwater Management Area 12, are shown in Table 1 (Groundwater Management Area 12, 2010).

Table 1. Desired future conditions (in feet of drawdown) for the Queen City Aquifer adopted by districts of Groundwater Management Area 12 (Groundwater Management Area 12, 2010).

| Groundwater Conservation District or County | Queen City Aquifer |
|---|---|
| Brazos Valley | 12 |
| Fayette County | 60 |
| Lost Pines | 13 |
| Mid-East Texas | 0 |
| Post Oak Savannah | 30 |
| Falls County | - |
| Limestone County | - |
| Navarro County | - |
| Williamson County | - |

As stated in Appendix B of the resolution adopted by the districts of Groundwater Management Area 12, the desired future conditions are considered to be "compatible and physically possible if

the difference between modeled drawdown results for model Run 12_7B and the [desired future condition] drawdown targets are within 5 feet or 5 percent of the [desired future condition] drawdown targets" (Groundwater Management Area 12, 2010).

In response to receiving the adopted desired future conditions, the TWDB has estimated the modeled available groundwater consistent with the above desired future conditions for each groundwater conservation district within Groundwater Management Area 12.

**METHODS:**

Groundwater Management Area 12 contains the central portion of the Queen City Aquifer, a minor aquifer in Texas as defined in the 2007 State Water Plan (TWDB, 2007). The location of Groundwater Management Area 12, the Queen City Aquifer, and the groundwater availability model cells that represent the aquifer are shown in Figure 1.

The groundwater conservation districts making up Groundwater Management Area 12 retained several consultants for assistance in developing desired future conditions for the Queen City Aquifer. Through this process, a model simulation was performed using the groundwater availability model for the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers. The pumping used for this model simulation, referred to as "GAM12_7B" in Appendix B of the resolution adopted by the districts of Groundwater Management Area 12 (Groundwater Management Area 12, 2010), was delivered to the TWDB on September 10, 2010 by James Beach of LBG-Guyton Associates. The TWDB then performed an independent analysis confirming that the desired future conditions are physically possible and that the levels of pumping considered by the districts of Groundwater Management Area 12 in the pumping file for "GAM12_7B" (Groundwater Management Area 12, 2010) achieve the desired future conditions within the tolerances stated above. A comparison of the desired future conditions and the drawdowns calculated by the TWDB using the pumping file from model simulation "GAM12_7B" (Groundwater Management Area 12, 2010) is shown as an appendix to this report.

Since the model results using the pumping file for "GAM12_7B" (Groundwater Management Area 12, 2010) were consistent with the above desired future conditions they were used for the modeled available groundwater below. This pumping assumed by the districts' consultants was then divided by county, regional water planning area, river basin, and groundwater conservation district. These areas are shown in Figure 2.

**PARAMETERS AND ASSUMPTIONS:**

The parameters and assumptions for the model run using the groundwater availability model for the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers are described below:

- Version 2.02 of the groundwater availability model for the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers was used for this analysis. See Dutton and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model.

- This groundwater availability model includes eight layers that generally correspond to (from top to bottom):

  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 measured water levels during model calibration) in the groundwater availability model is 22 feet for the Sparta Aquifer, 27 feet for the Queen City Aquifer, 36 feet for the Carrizo Aquifer, and 31 feet for the Simsboro Aquifer for the calibration period (1980 through 1989) and 24, 33, 32, and 43 feet for the same aquifers, respectively, in the verification period (1990 through 1999) (Kelley and others, 2004).

- Cells were assigned to individual counties, river basins, regional water planning areas, and groundwater conservation districts as shown in the August 3, 2010 version of file that associates the model grid to political and natural boundaries for the Carrizo-Wilcox, Queen City, and Sparta aquifers. Note that some minor adjustments were made to the file to better reflect the relationship of model cells to political boundaries.

- The recharge used for the model run represents average recharge as described in Kelley and others (2004).

**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. 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 required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

**RESULTS:**

The modeled available groundwater for the Queen City Aquifer in Groundwater Management Area 12 consistent with the above desired future conditions increases from approximately 3,600 acre-feet per year to 5,500 acre-feet per year between 2010 and 2030, then declines to

approximately 3,700 acre-feet per year from 2030 to 2060. This has been divided by county, regional water planning area, and river basin for each decade between 2010 and 2060 for use in the regional water planning process (Table 2). The modeled available groundwater is also summarized by county, regional water planning area, river basin, and groundwater conservation district in Tables 3, 4, 5, and 6, respectively.

**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 AND ASSOCIATED MODEL RUNS:

Dutton, A.R., Harden, B., Nicot, J.P., and O'Rourke, D., 2003, Groundwater availability model for the central part of the Carrizo-Wilcox Aquifer in Texas: Contract report to the Texas Water Development Board, 295 p.

Groundwater Management Area 12, 2010, Resolution to Adopt Desired Future Conditions for Aquifer(s) in Groundwater Management Area 12, 62 p.

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.

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

Table 2. Modeled Available Groundwater in acre-feet for the Queen City Aquifer in Groundwater Management Area 12 by county, regional water planning area, and river basin.

| County | Regional Water Planning Area | Basin | Year | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
| Bastrop | K | Brazos | 284 | 244 | 598 | 219 | 216 | 216 |
| | | Colorado | 714 | 659 | 1,626 | 599 | 591 | 590 |
| | | Guadalupe | 197 | 192 | 541 | 213 | 216 | 216 |
| Brazos | G | Brazos | 512 | 604 | 634 | 587 | 533 | 529 |
| Burleson | G | Brazos | 382 | 415 | 446 | 446 | 446 | 446 |
| Fayette | K | Colorado | 387 | 436 | 478 | 513 | 565 | 570 |
| | | Guadalupe | 0 | 0 | 0 | 0 | 0 | 0 |
| Freestone | C | Trinity | 0 | 0 | 0 | 0 | 0 | 0 |
| Lee | G | Brazos | 72 | 72 | 61 | 58 | 54 | 54 |
| | | Colorado | 48 | 48 | 54 | 55 | 57 | 57 |
| Leon | H | Brazos | 245 | 245 | 245 | 245 | 245 | 245 |
| | | Trinity | 349 | 349 | 349 | 349 | 349 | 349 |
| Madison | H | Brazos | 1 | 1 | 1 | 1 | 1 | 1 |
| | | Trinity | 379 | 379 | 379 | 379 | 379 | 379 |
| Milam | G | Brazos | 48 | 53 | 56 | 56 | 56 | 56 |
| Robertson | G | Brazos | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | | | **3,618** | **3,697** | **5,468** | **3,720** | **3,708** | **3,708** |

Table 3. Modeled Available Groundwater for the Queen City Aquifer summarized by county in Groundwater Management Area 12 for each decade between 2010 and 2060. Results are in acre-feet per year.

| County | Year | | | | | |
|---|---|---|---|---|---|---|
| | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
| Bastrop | 1,195 | 1,095 | 2,765 | 1,031 | 1,023 | 1,022 |
| Brazos | 512 | 604 | 634 | 587 | 533 | 529 |
| Burleson | 382 | 415 | 446 | 446 | 446 | 446 |
| Fayette | 387 | 436 | 478 | 513 | 565 | 570 |
| Freestone | 0 | 0 | 0 | 0 | 0 | 0 |
| Lee | 120 | 120 | 115 | 113 | 111 | 111 |
| Leon | 594 | 594 | 594 | 594 | 594 | 594 |
| Madison | 380 | 380 | 380 | 380 | 380 | 380 |
| Milam | 48 | 53 | 56 | 56 | 56 | 56 |
| Robertson | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **3,618** | **3,697** | **5,468** | **3,720** | **3,708** | **3,708** |

Table 4. Modeled Available Groundwater for the Queen City Aquifer summarized by regional water planning area in Groundwater Management Area 12 for each decade between 2010 and 2060. Results are in acre-feet per year.

| Regional Water Planning Area | Year | | | | | |
|---|---|---|---|---|---|---|
| | **2010** | **2020** | **2030** | **2040** | **2050** | **2060** |
| C | 0 | 0 | 0 | 0 | 0 | 0 |
| G | 1,062 | 1,192 | 1,251 | 1,202 | 1,146 | 1,142 |
| H | 974 | 974 | 974 | 974 | 974 | 974 |
| K | 1,582 | 1,531 | 3,243 | 1,544 | 1,588 | 1,592 |
| **Total** | **3,618** | **3,697** | **5,468** | **3,720** | **3,708** | **3,708** |

Table 5. Modeled Available Groundwater for the Queen City Aquifer summarized by river basin in Groundwater Management Area 12 for each decade between 2010 and 2060. Results are in acre-feet per year.

| Basin | Year | | | | | |
|---|---|---|---|---|---|---|
| | **2010** | **2020** | **2030** | **2040** | **2050** | **2060** |
| Brazos | 1,544 | 1,634 | 2,041 | 1,612 | 1,551 | 1,547 |
| Colorado | 1,149 | 1,143 | 2,158 | 1,167 | 1,213 | 1,217 |
| Guadalupe | 197 | 192 | 541 | 213 | 216 | 216 |
| Trinity | 728 | 728 | 728 | 728 | 728 | 728 |
| **Total** | **3,618** | **3,697** | **5,468** | **3,720** | **3,708** | **3,708** |

Table 6. Modeled Available Groundwater for the Queen City Aquifer summarized by groundwater conservation district (GCD) in Groundwater Management Area 12 for each decade between 2010 and 2060. Results are in acre-feet per year.

| Groundwater Conservation District | Year | | | | | |
|---|---|---|---|---|---|---|
| | **2010** | **2020** | **2030** | **2040** | **2050** | **2060** |
| Brazos Valley GCD | 512 | 604 | 634 | 587 | 533 | 529 |
| Fayette County GCD | 387 | 436 | 478 | 513 | 565 | 570 |
| Lost Pines GCD | 1,315 | 1,215 | 2,880 | 1,144 | 1,134 | 1,133 |
| Mid-East Texas GCD | 974 | 974 | 974 | 974 | 974 | 974 |
| Post Oak Savannah GCD | 430 | 468 | 502 | 502 | 502 | 502 |
| **Total** | **3,618** | **3,697** | **5,468** | **3,720** | **3,708** | **3,708** |

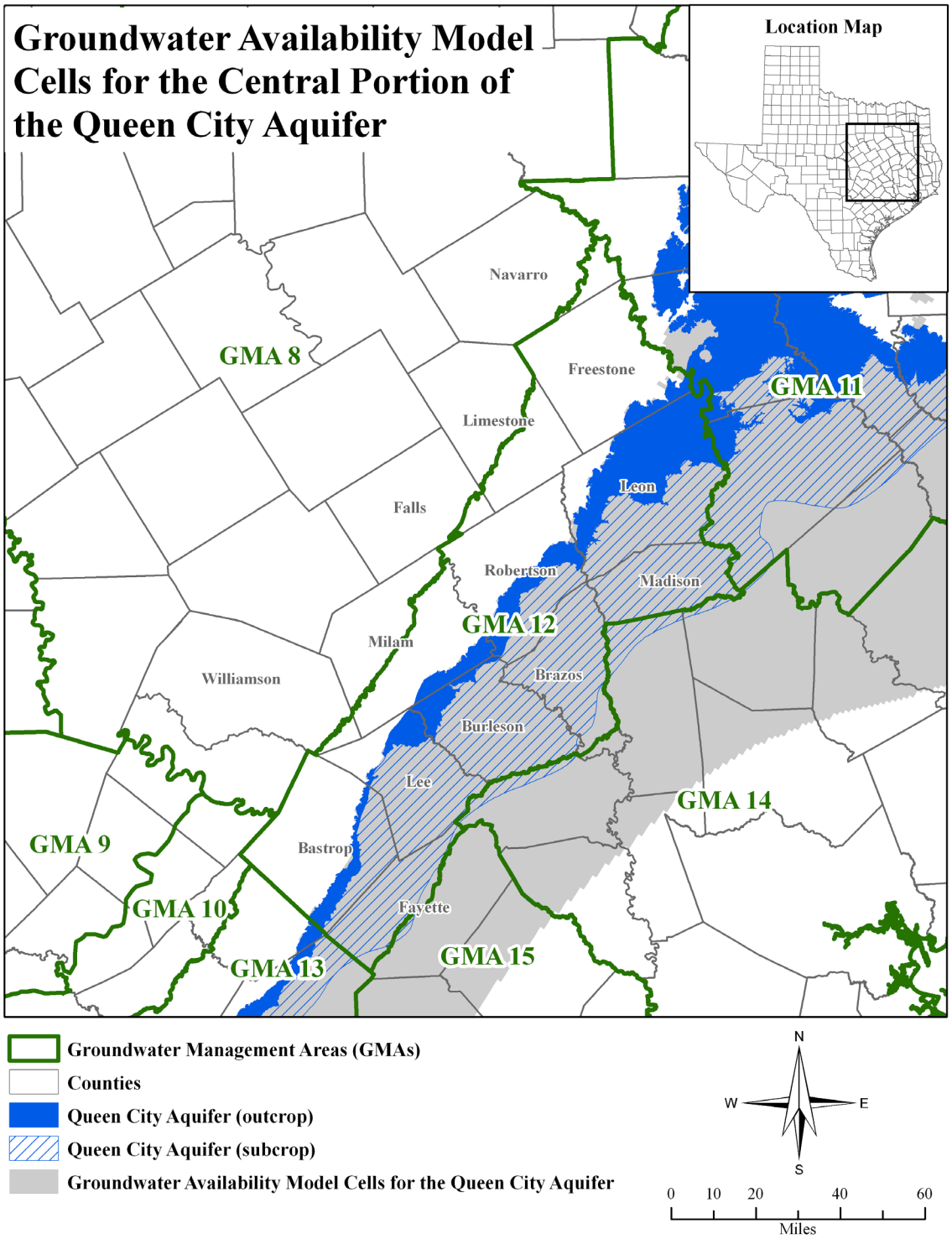


Figure 1. Map showing the areas covered by the groundwater availability model for the central portion of the Queen City Aquifer and the boundary of Groundwater Management Area 12.

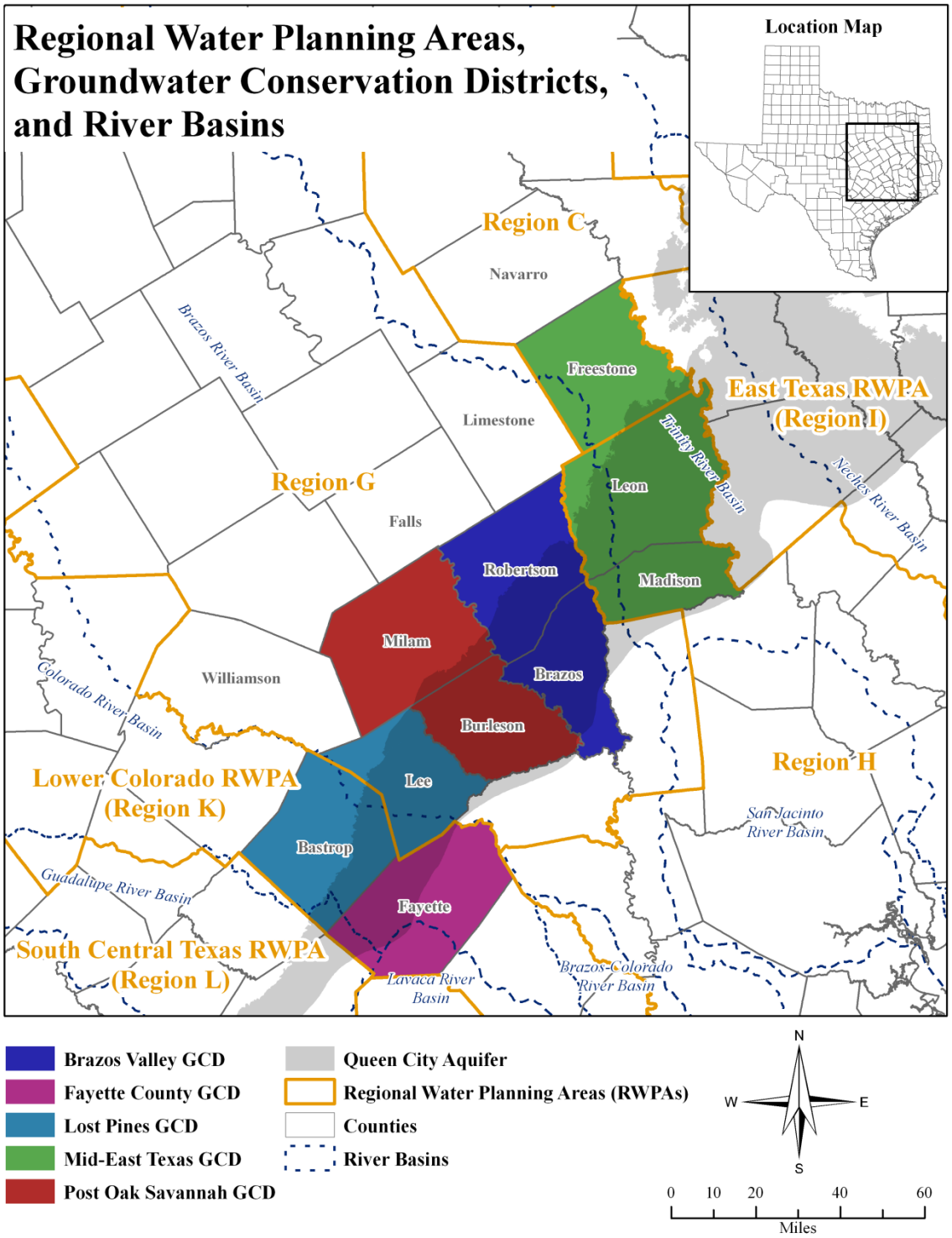


Figure 2. Map showing regional water planning areas (RWPAs), groundwater conservation districts (GCDs), counties, and river basins in and neighboring Groundwater Management Area 12.

# Appendix

## Comparison of Model Results to Desired Future Conditions

Table A-1. Comparison table showing Groundwater Management Area 12 adopted desired future conditions for the Queen City Aquifer, associated drawdowns presented in Appendix B of the desired future condition resolution (Groundwater Management Area 12, 2010), and the drawdowns calculated by the TWDB using the same pumping (well) file. All values are in feet of drawdown between January 2000 and December 2059. Negative values indicate a water level rise.

| Groundwater Conservation District or County | Aquifer Unit | Desired Future Condition | Calculated Drawdowns in Appendix B of Resolution | TWDB Calculated Drawdowns | Difference Between Desired Future Condition and TWDB Calculated Drawdowns |
|---|---|---|---|---|---|
| Brazos Valley | Carrizo | 47 | 48 | 48 | -1 |
| | Calvert Bluff | 106 | 109 | 109 | -3 |
| | Simsboro | 270 | 271 | 271 | -1 |
| | Hooper | 170 | 177 | 177 | -7 |
| Fayette County | Carrizo | 60 | 59 | 59 | 1 |
| | Calvert Bluff | - | 126 | 126 | - |
| | Simsboro | - | 220 | 219 | - |
| | Hooper | - | 172 | 172 | - |
| Lost Pines | Carrizo | 47 | 47 | 47 | 0 |
| | Calvert Bluff | 99 | 94 | 94 | 5 |
| | Simsboro | 237 | 236 | 236 | 1 |
| | Hooper | 129 | 133 | 133 | -4 |
| Mid-East Texas | Carrizo | 55 | 53 | 53 | 2 |
| | Calvert Bluff | 70 | 67 | 67 | 3 |
| | Simsboro | 115 | 114 | 114 | 1 |
| | Hooper | 95 | 96 | 96 | -1 |
| Post Oak Savannah | Carrizo | 65 | 61 | 61 | 4 |
| | Calvert Bluff | 140 | 137 | 136 | 4 |
| | Simsboro | 300 | 298 | 297 | 3 |
| | Hooper | 180 | 178 | 178 | 2 |
| Falls County | Carrizo | - | - | - | - |
| | Calvert Bluff | - | - | - | - |
| | Simsboro | 0 | -1 | -1 | 1 |
| | Hooper | 20 | 20 | 20 | 0 |
| Limestone County | Carrizo | - | - | - | - |
| | Calvert Bluff | 9 | 9 | 10 | -1 |
| | Simsboro | 43 | 43 | 43 | 0 |
| | Hooper | 40 | 40 | 40 | 0 |
| Navarro County | Carrizo | - | - | - | - |
| | Calvert Bluff | 0 | -1 | -1 | 1 |
| | Simsboro | 1 | 1 | 4 | -3 |
| | Hooper | 1 | 1 | 4 | -3 |
| Williamson County | Carrizo | - | - | - | - |
| | Calvert Bluff | -10 | -11 | -11 | 1 |
| | Simsboro | 50 | 47 | 47 | 3 |
| | Hooper | 55 | 56 | 55 | 0 |