GAM Run 06-09

by Shirley C. Wade, P.G.
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0883
May 31, 2006

REQUESTOR:

Mr. Robert Gresham on behalf of the Mid-East Texas Groundwater Conservation District (GCD). Mid-East Texas GCD includes Freestone County located in Regional Water Planning Area (Region) C, and Leon and Madison counties located in Region H.

DESCRIPTION OF REQUEST:

Mr. Gresham requested a groundwater availability model (GAM) run using the GAM for the central part of the Carrizo-Wilcox/ Queen City/ Sparta aquifers. The run involved adjusting pumping in the model in Freestone, Leon, and Madison counties to reflect changes in demand predictions in the 2006 Regional Water Plans. Mr. Gresham provided a table of County Water Demand Projections for 2000 through 2060 that was downloaded from the Texas Water Development Board water plan data web page (TWDB, 2006). Mr. Gresham asked that we estimate groundwater demand by assuming the groundwater portion is equal to the total demand for each use category except livestock and steam electric. Mr. Gresham asked us to assume that groundwater will contribute zero percent of steam electric demand and 50 percent of livestock demand.

The request included running the predictive model for the entire predictive period (50 years) based on the following estimated groundwater pumping demands:

(A) Year 2000 demands from 2006 regional water plans;

(B) Year 2000 demands from 2006 regional water plans increased by 50 percent;

(C) Year 2060 demands from 2006 regional water plans; and

(D) Year 2060 demands from 2006 regional water plans increased by 50 percent.

Mr. Gresham wanted the results to include plots of water-level differences, water budgets, and a discussion of the effects of the increased pumping on the aquifer.

METHODS:

- We estimated groundwater demands by county, from Mr. Gresham's assumptions and total demands from the 2001 and 2006 regional water plans (TWDB, 2006). The estimated groundwater demands are listed in Table 1.

- To generate pumping for the model runs (Table 1), the predictive pumping in the original central part of the Carrizo-Wilcox/ Queen City/ Sparta aquifers GAM in Freestone, Leon, and Madison counties was uniformly scaled by decade so that the total pumping for the entire predictive period in each of these counties was equal to the estimated groundwater demands shown in Table 1. The historical pumping in the model (1975 through 1999) was not changed.

- Pumping in all other counties in the GAM was not changed from the original model (Kelley and others, 2005; Dutton and others, 2003).

- The model was run for each of the four scenarios (Table 1) and water-level differences were calculated by subtracting simulated 2050 heads from the simulated 2050 heads for the baseline scenario (predictive pumping based on demands from the 2001 regional water plans).

- Water-level difference maps were plotted for Mid-East Texas GCD for the principal aquifer layers in the model (1, 3, 5, and 7). Layer 1 represents the Sparta aquifer, Layer 3 represents the Queen City aquifer, Layer 5 represents the Carrizo aquifer, and Layer 7 represents the Simsboro Formation of the Wilcox aquifer.

- Water budgets were extracted for 1999 (last year of the calibrated historical simulation) and for 2050.

Table1. Summary of pumpage, in acre-feet per year, used in model runs.

	***Baseline scenario (the pumpage varies by decade in the baseline scenario)**	**Run A—Year 2000 demands from 2006 regional water plans**	**Run B—Year 2000 demands from 2006 regional water plans increased by 50%**	**Run C—Year 2060 demands from 2006 regional water plans**	**Run D—Year 2060 demands from 2006 regional water plans increased by 50%**
Freestone	3,207 to 3,295	3,339	5,009	4,990	7,485
Madison	2,351 to 2,773	2,729	4,094	2,821	4,231
Leon	5,177 to 5,580	5,553	8,330	6,487	9,730

* Baseline scenario—predictive pumping based on demands from the 2001 regional water plans.

PARAMETERS AND ASSUMPTIONS:

- See Kelley and others (2005) and Dutton and others (2003) for assumptions and limitations of the GAM for the central part of the Carrizo-Wilcox/ Queen City/ Sparta aquifers.

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the entire GAM for the period of 1980 to 1999 ranges from 3.2 percent (Carrizo aquifer) to 7.8 percent (Sparta aquifer) of measured water levels (Kelley and others, 2004).

- The stream package in the central part of the Carrizo-Wilcox/ Queen City/ Sparta GAM has been updated from the original model (Kelley and others, 2005) to more accurately reflect average stream flow conditions. Updating the stream package changed heads near streams up to 20 feet compared with the original model. We are assuming the model calibration is not significantly affected. We will be checking the calibration in the next few months and we will do an addendum to this GAM Run, if necessary.

- The model includes eight layers representing: the Sparta aquifer (Layer 1), Weches confining unit (Layer 2), Queen City aquifer (Layer 3), Reklaw confining unit (Layer 4), Carrizo aquifer (Layer 5), Calvert Bluff Formation (Layer 6), Simsboro Formation (Layer 7), and Hooper Formation (Layer 8).

- Each model run included 25 years with historic pumping representing 1975 through 1999 and a 51-year predictive period representing 2000 through 2050.

- Recharge for the predictive period (2000 through 2050) is based on average annual precipitation. The average annual precipitation is the average of 1961 through 1990.

- Pumping changes are uniformly scaled across each county and across all use categories. This assumption implies that pumping in pumping centers, such as cities or industrial sites, changes at the same rate as distributed pumping, such as domestic or irrigation pumping. In Leon County, manufacturing and mining demand seem to increase more than the other categories compared with demands in the original model. So this assumption may not be valid in Leon County. However, these runs will still provide an estimate of the regional affects of increased pumping in the GCD.

- We assumed the spatial distribution and aquifer assignments from the original predictive dataset, based on the 2001 Regional Water Plan, are applicable.

- The GAM includes pumpage representing rural domestic, municipal, industrial, irrigation, and livestock uses.

RESULTS:

Water-level maps for the baseline scenario (predictive pumping based on demands from the 2001 regional water plans) in 2050 are shown in Figures 1 through 4.

Maps of water-level differences in Mid-East Texas GCD for runs A, B, C, and D are shown in Figures 5 through 20. Water-level difference maps are shown for the Sparta, Queen City, Carrizo, and Simsboro layers. Demands and scaling factors for the model pumping scenarios are listed in Table 2.

Water budgets for the Mid-East Texas GCD from the GAM for the central part of the Carrizo-Wilcox, Queen City, and Sparta aquifers are shown in Tables 3 through 8. The baseline scenario water budget is shown for 1999 and 2050 in Tables 3 and 4, respectively. Water budgets in 2050 for each scenario (A, B, C, and D) are shown in Tables 5 through 8. These tables show the annual flow, expressed in acre-feet, of water into (inflow) and out of (outflow) each aquifer in Mid-East Texas GCD. The components of the budgets shown in the tables include:

- Surface water inflow and outflow—This is the total surface water entering the aquifer (inflow) through streams or reservoirs, or total surface water exiting the aquifer (outflow) to streams, reservoirs, drains, or through evapotranspiration.

- Precipitation recharge—This is the areally distributed recharge due to precipitation falling on the outcrop areas of the aquifers.

- Net inter–aquifer flow—This describes the vertical flow, or leakage, between two aquifers. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer that define the amount of leakage that can occur. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer, except for the top layer where flow from and to overlying younger aquifers are simulated with a general head boundary condition.

- Lateral flow into and out of district—This component describes lateral flow within the aquifer between Mid-Texas GCD and adjacent counties.

- Change in storage—This component is the change of water stored in the aquifer. Negative change in storage is water that is removed from storage in the aquifer (that is, water levels decline). Positive change in storage is water that is added back into storage in the aquifer (that is, water levels increase). Change in storage is the net sum of water both going into and out of the aquifer because this is a county-wide budget, and water levels will decline in some areas (water is being removed from storage) and will rise in others (water is being added to storage).

- Wells—This component is water pumped from wells in each aquifer.

It is important to note that sub-regional water budgets for individual areas, such as the Mid-East Texas GCD area, are not exact. This is due to the one mile spacing of the model grid and because we assumed each model cell is assigned to a single county. The water budgets for an individual cell containing a county boundary are assigned to either one county or the other and therefore very minor variations in the county-wide budgets may be observed.

DISCUSSION:

Figures 5 through 20 depict water-level differences for Scenarios A through D. These differences indicate depth below the water-level elevation maps shown in Figures 1 through 4.

Water-level differences in the Sparta aquifer for the baseline compared with Scenarios A through D are shown in Figures 5, 9, 13, and 17, respectively. Scenarios A and C result in water levels that are at most 2 feet less in 2050 compared with the baseline scenario (Figures 5 and 13). Scenarios B and D result in water levels that are at most 10 feet less in 2050 compared with the baseline scenario (Figures 9 and 17).

Water-level differences in the Queen City aquifer for the baseline compared with Scenarios A through D are shown in Figures 6, 10, 14, and 18 respectively. Scenarios A and C result in water levels that are at most 2 feet less in 2050 compared with the baseline scenario (Figures 6 and 14). Scenarios B and D result in water levels that are at most 10 feet less in 2050 compared with the baseline scenario (Figures 10 and 18).

Water-level differences in the Carrizo aquifer for the baseline compared with Scenarios A through D are shown in Figures 7, 11, 15, and 19 respectively. Scenario A results in water levels that are at most 2 feet less in 2050 compared with the baseline scenario (Figure 7). Scenario C results in water levels that are up to 5 feet lower in 2050 (Figure 15). Scenarios B and D result in water levels that are at most 17 and 21 feet less respectively in 2050 compared with the baseline scenario (Figures 11 and 19).

Water-level differences in the Simsboro Formation for the baseline compared with Scenarios A through D are shown in Figures 8, 12, 16, and 20 respectively. Scenario A results in virtually the same water levels in 2050 as the baseline scenario (Figure 8). Scenario C results in water levels that at most 12 feet lower in 2050 (Figure 16). Scenarios B and D result in water levels that are at most 13 and 30 feet less respectively in 2050 compared with the baseline scenario (Figures 12 and 20).

It should be noted that most of the predicted drawdown in the Carrizo and Simsboro aquifers results from pumping outside of Mid-East Texas GCD (see Kelley and others, 2004). This discussion has focused only on additional drawdown related to increased pumping within Freestone, Leon, and Madison counties. Increased pumping outside of the GCD will also lead to additional drawdown in those counties.

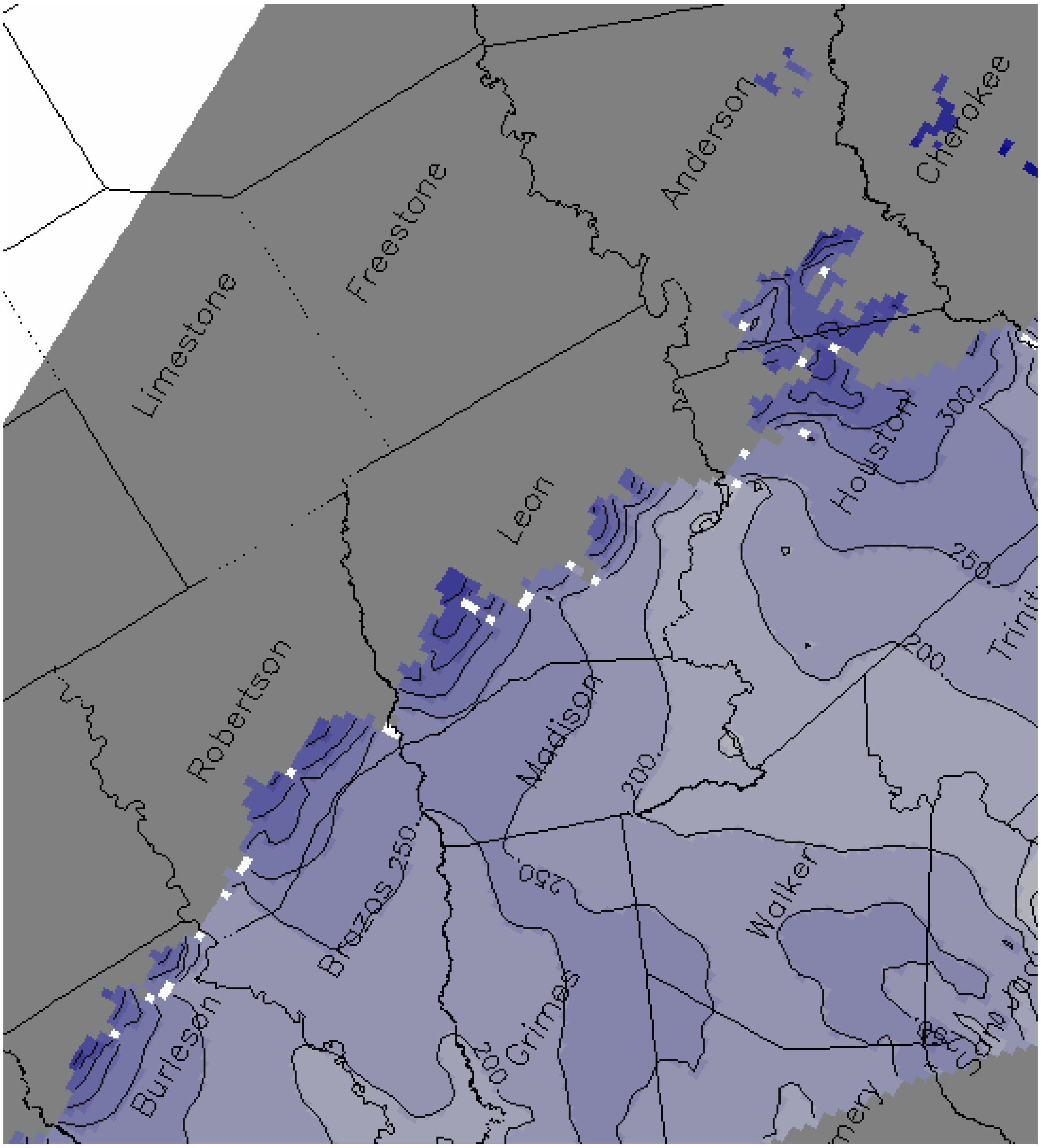


Figure 1. Simulated 2050 water levels in feet above mean sea level in the Sparta aquifer for the baseline scenario. The water-level contour interval is 50 feet. White blocks represent cells that have gone dry during the simulation.

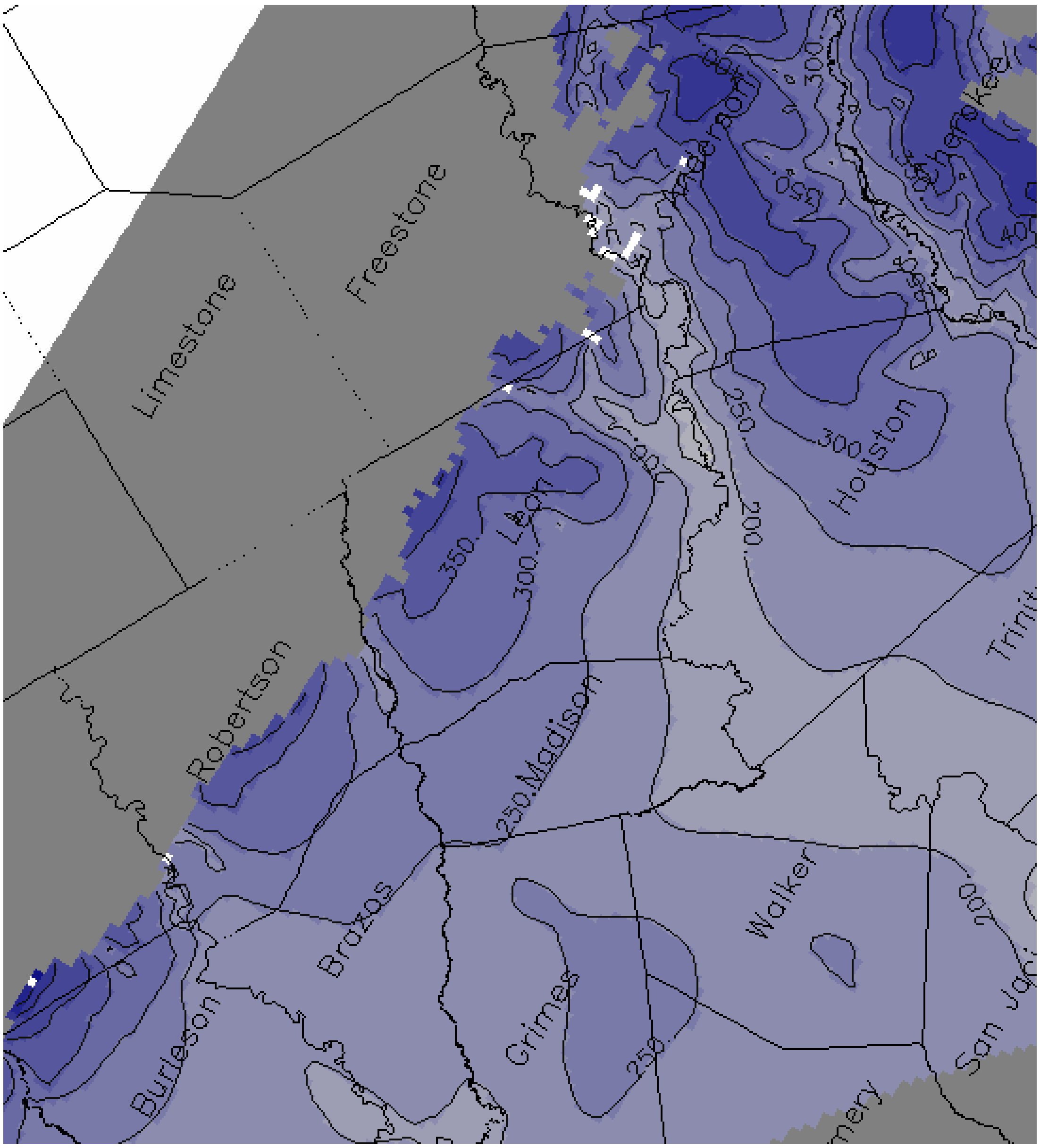


Figure 2. Simulated 2050 water levels in feet above mean sea level in the Queen City aquifer for the baseline scenario. The water-level contour interval is 50 feet. White blocks represent cells that have gone dry during the simulation.

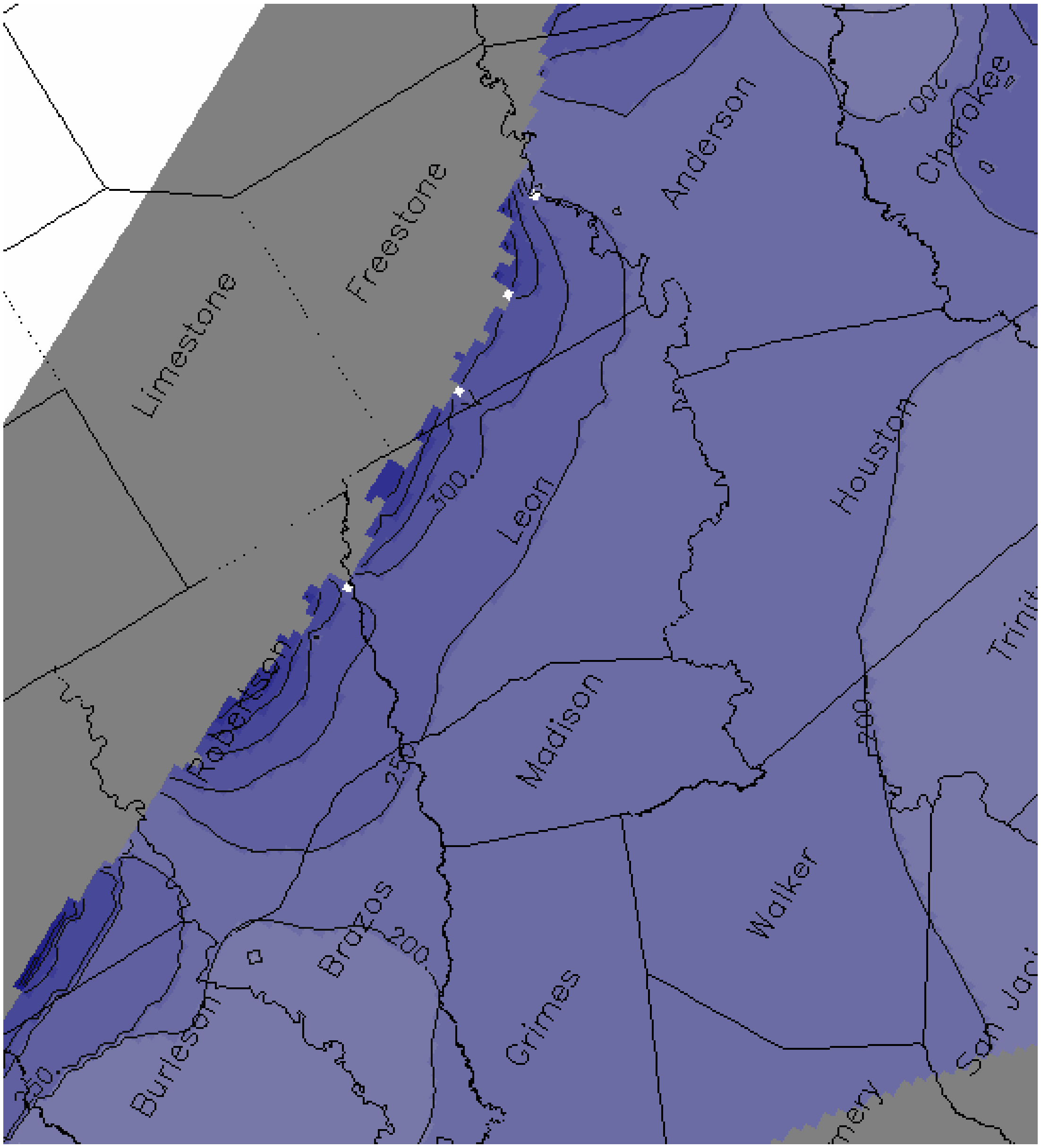


Figure 3. Simulated 2050 water levels in feet above mean sea level in the Carrizo aquifer for the baseline scenario. The water-level contour interval is 50 feet. White blocks represent cells that have gone dry during the simulation.

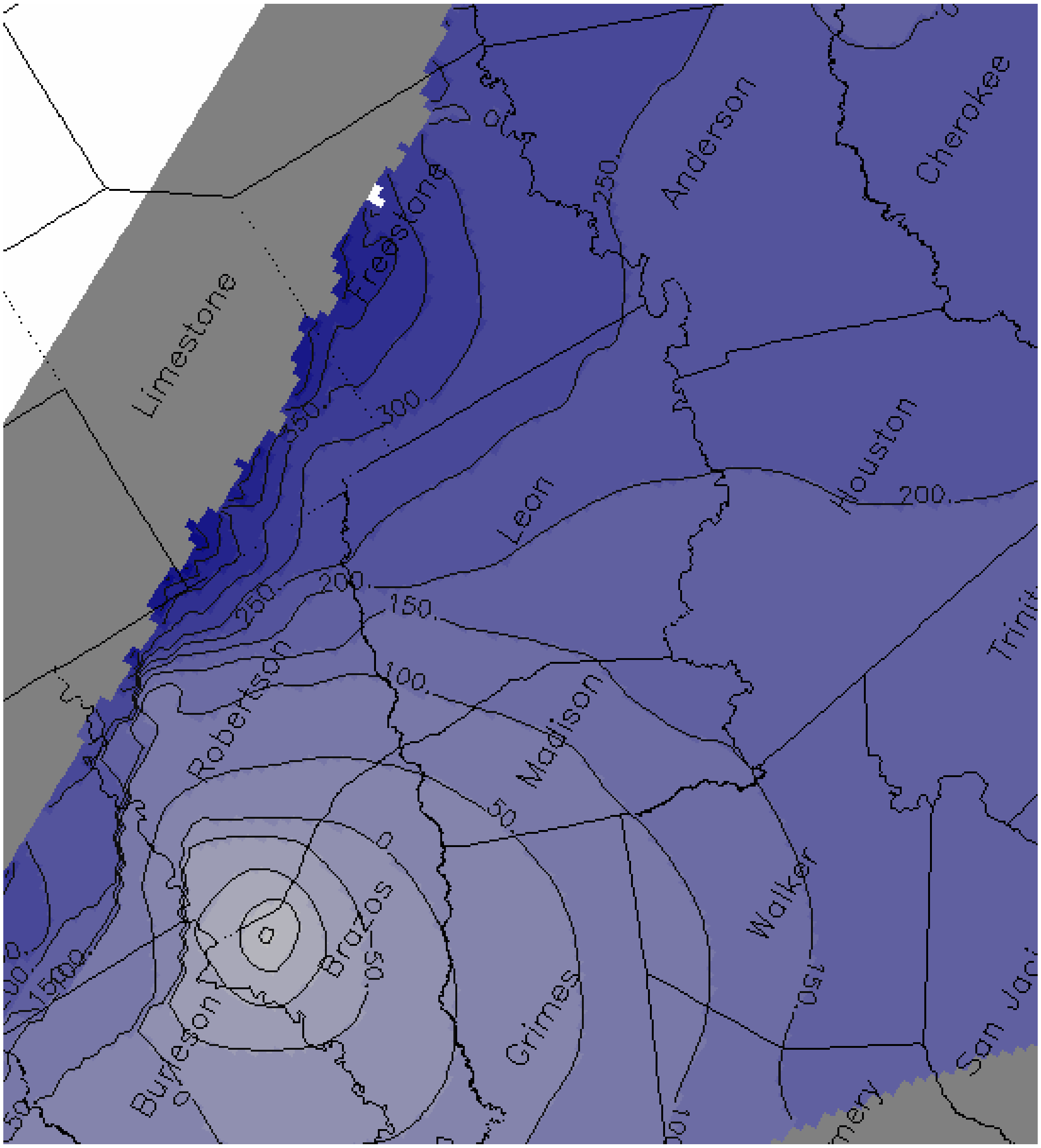


Figure 4. Simulated 2050 water levels in feet above mean sea level in the Simsboro Formation for the baseline scenario. The water-level contour interval is 50 feet. White blocks represent cells that have gone dry during the simulation.

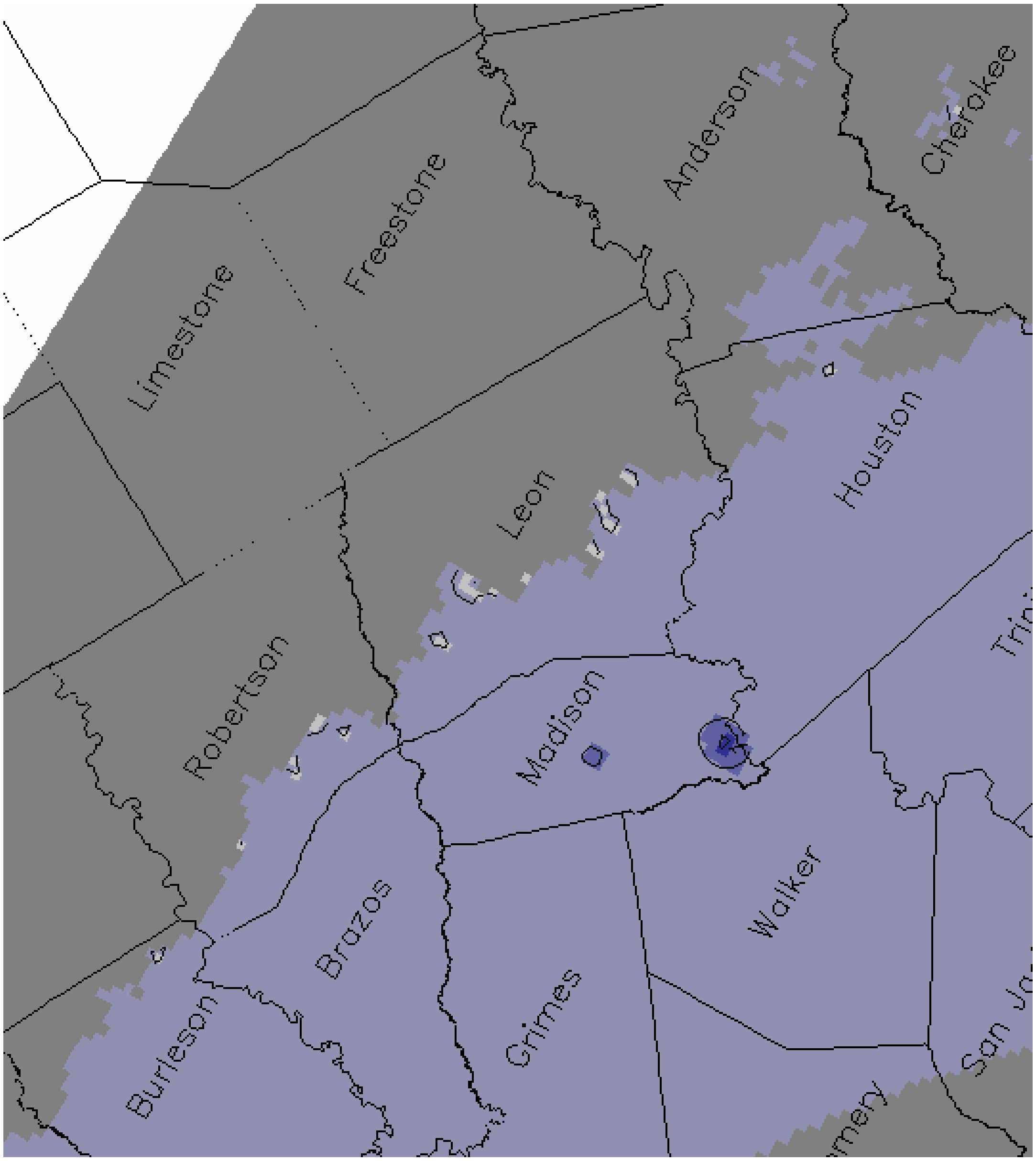


Figure 5. Simulated water-level differences in the Sparta aquifer for Scenario A (estimated pumping based on 2000 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario A. The maximum difference shown here is 2 feet in southeastern Madison County.

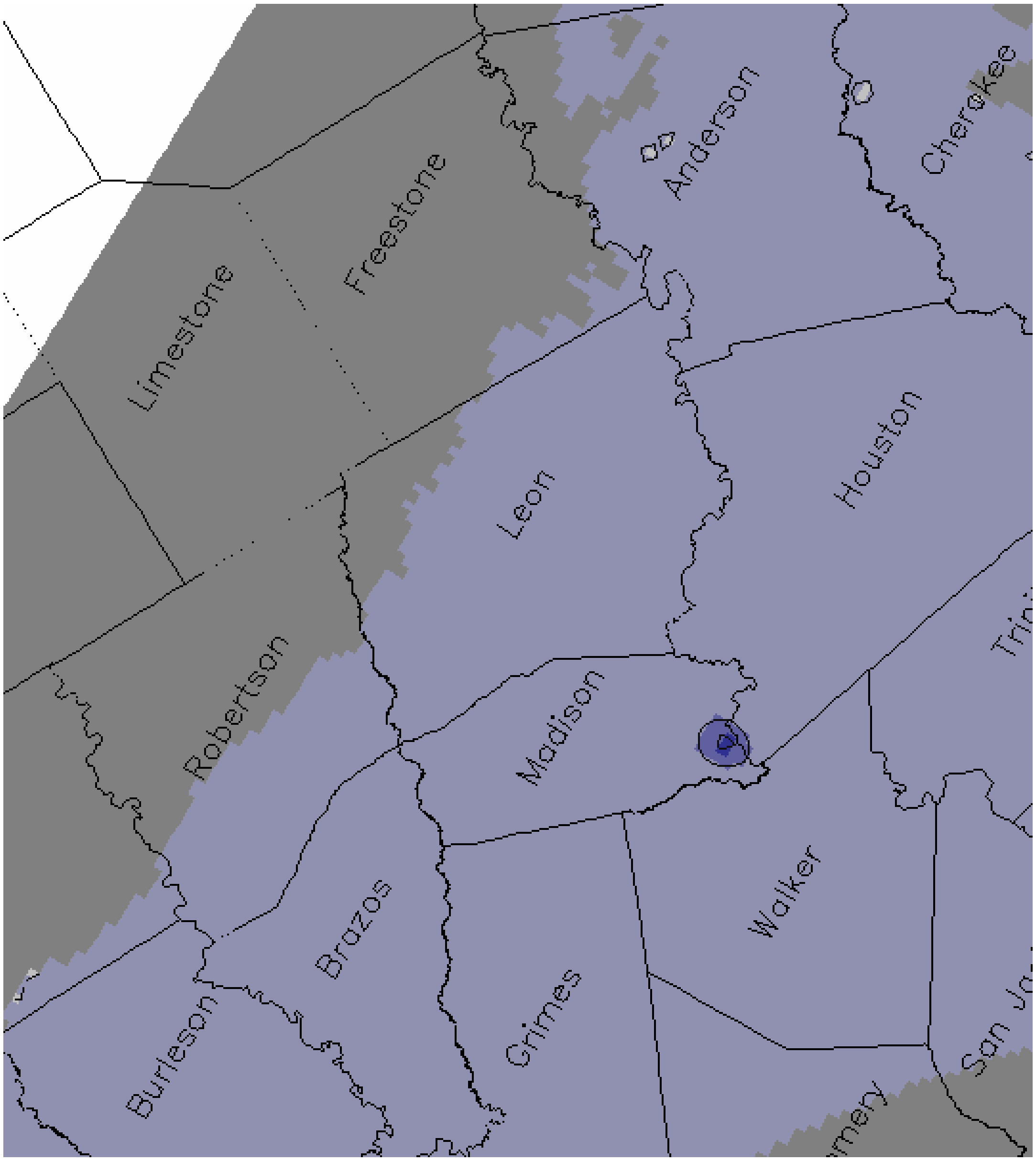


Figure 6. Simulated water-level differences in the Queen City aquifer for Scenario A (estimated pumping based on 2000 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario A. The maximum difference shown here is 2 feet in southeastern Madison County.

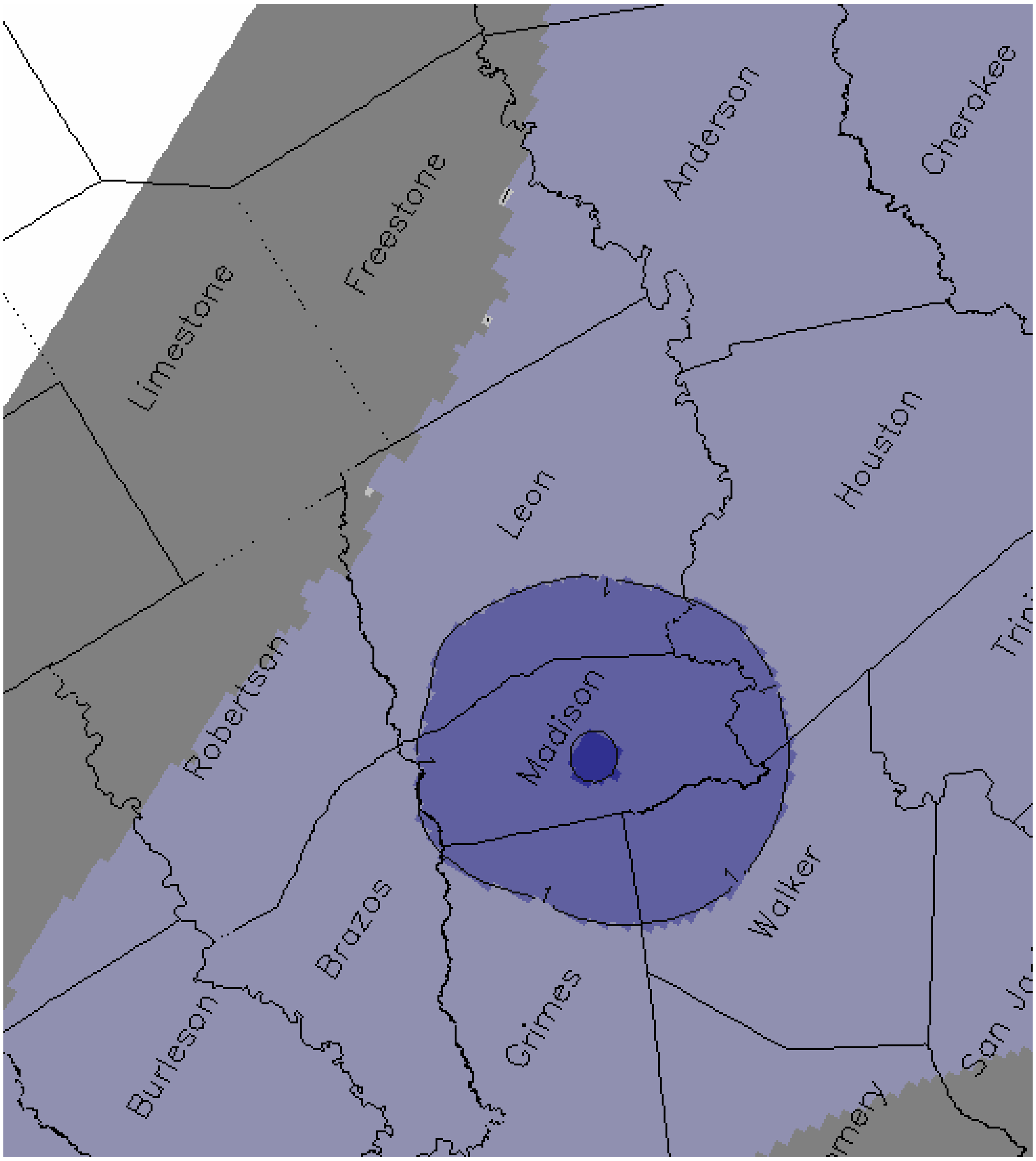


Figure 7. Simulated water-level differences in the Carrizo aquifer for Scenario A (estimated pumping based on 2000 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario A. The maximum difference shown here is 2 feet in central Madison County.

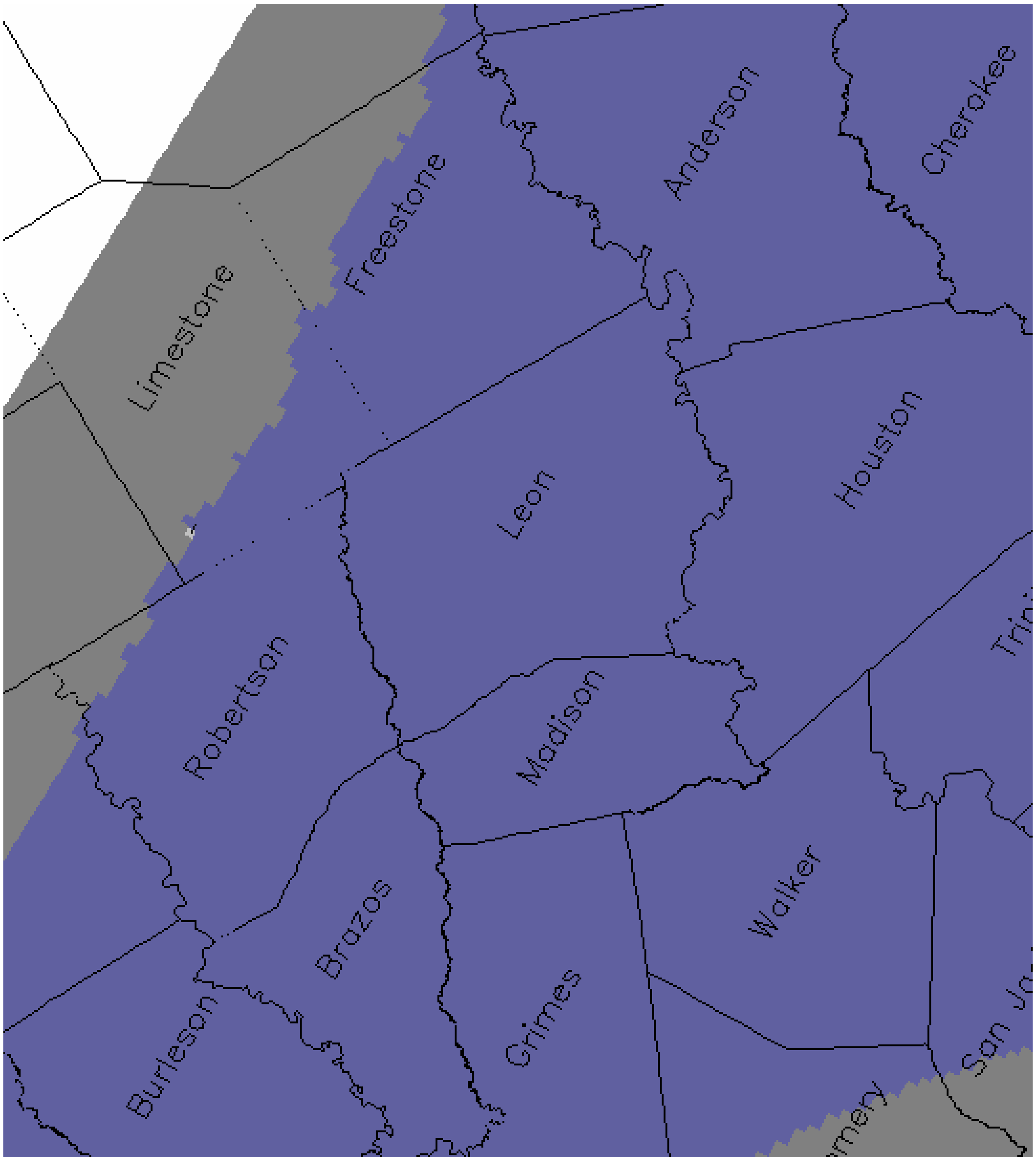


Figure 8. Simulated water-level differences in the Simsboro Formation for Scenario A (estimated pumping based on 2000 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario A. Maximum differences for the Simsboro aquifer are less than 1 foot for this scenario.

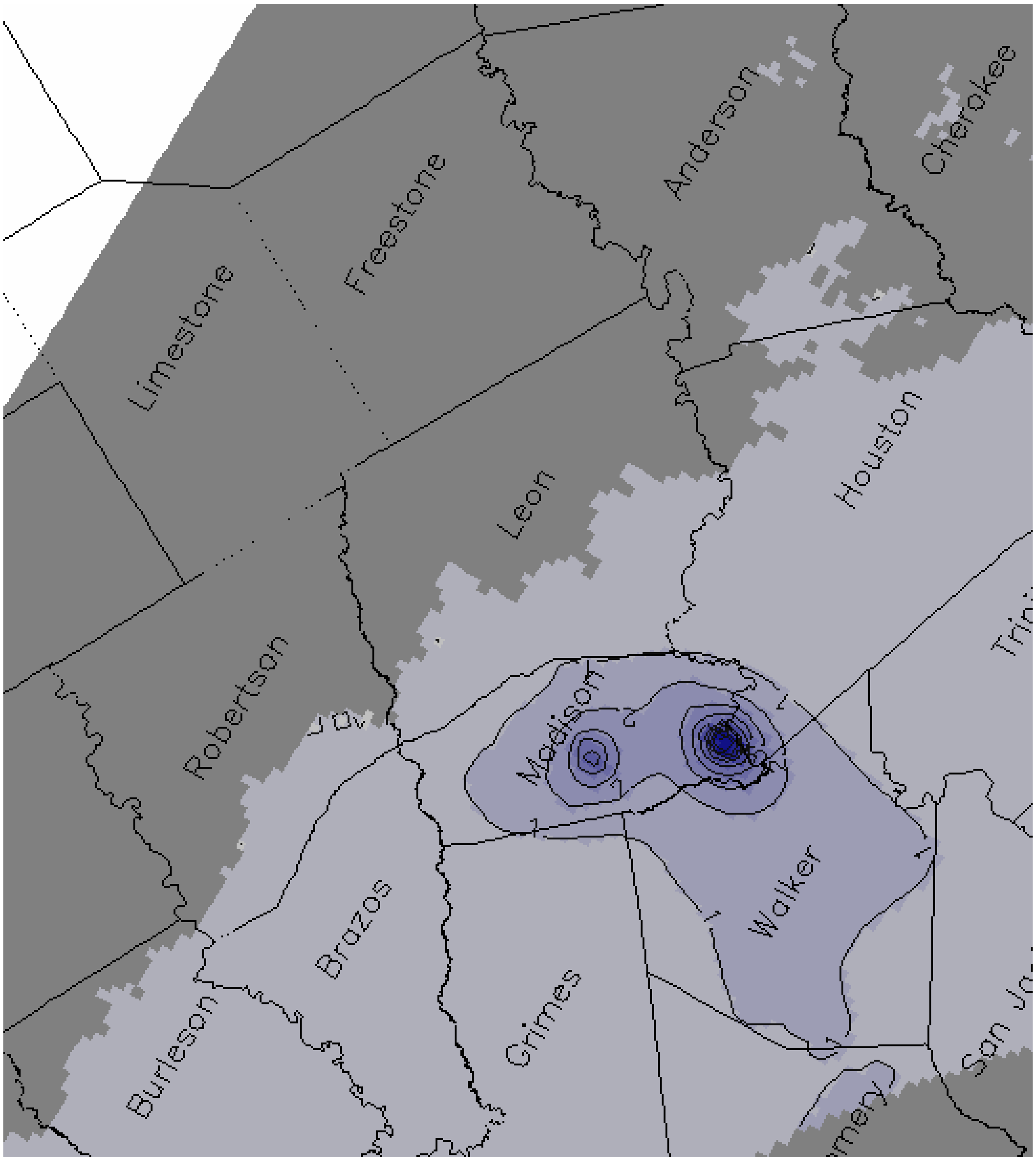


Figure 9. Simulated water-level differences in the Sparta aquifer for Scenario B (150 percent estimated pumping based on 2000 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario B. The maximum difference shown here is about 10 feet in southeastern Madison County.

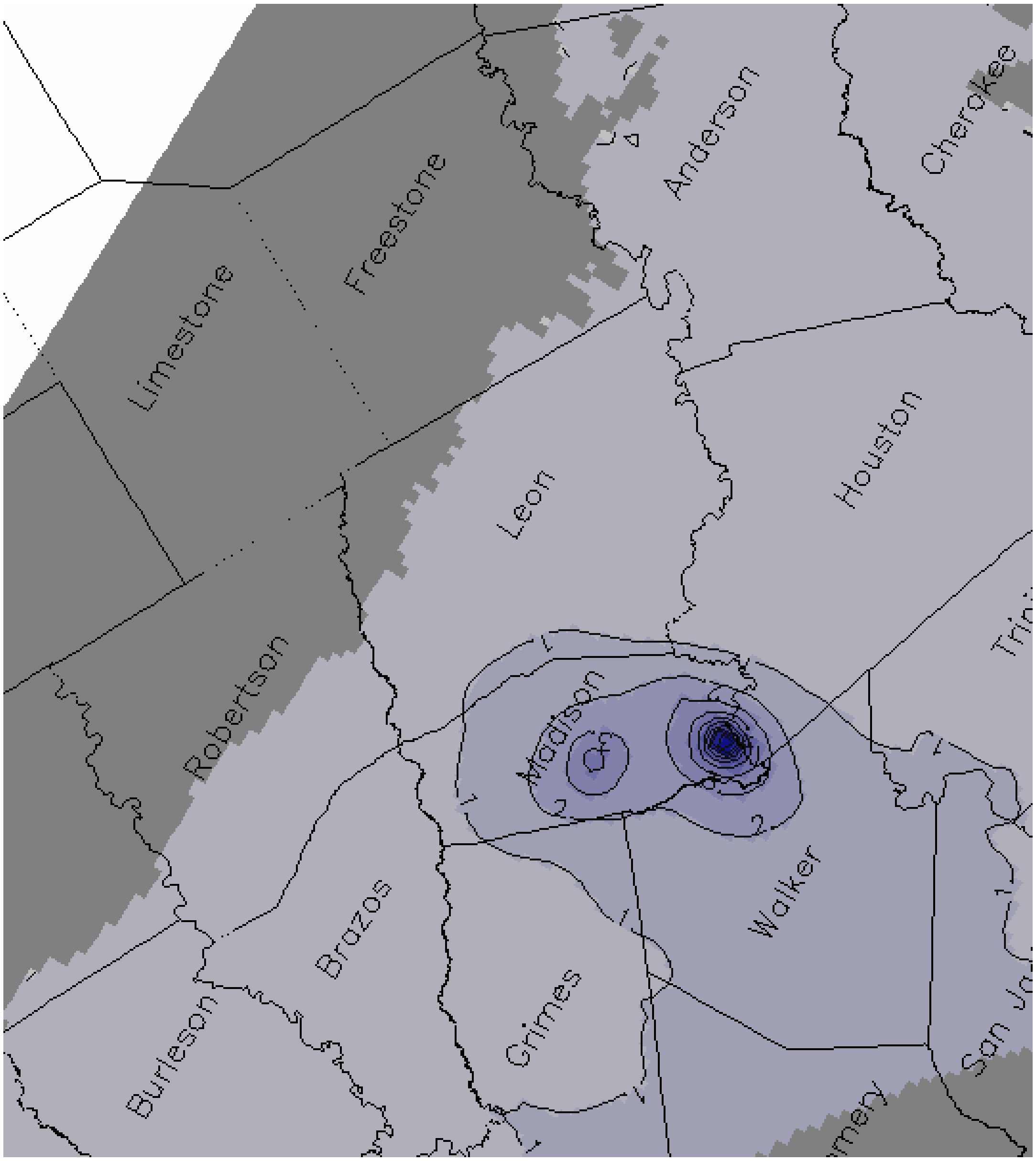


Figure 10. Simulated water-level differences in the Queen City aquifer for Scenario B (150 percent estimated pumping based on 2000 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario B. The maximum difference shown here is about 10 feet in southeastern Madison County.

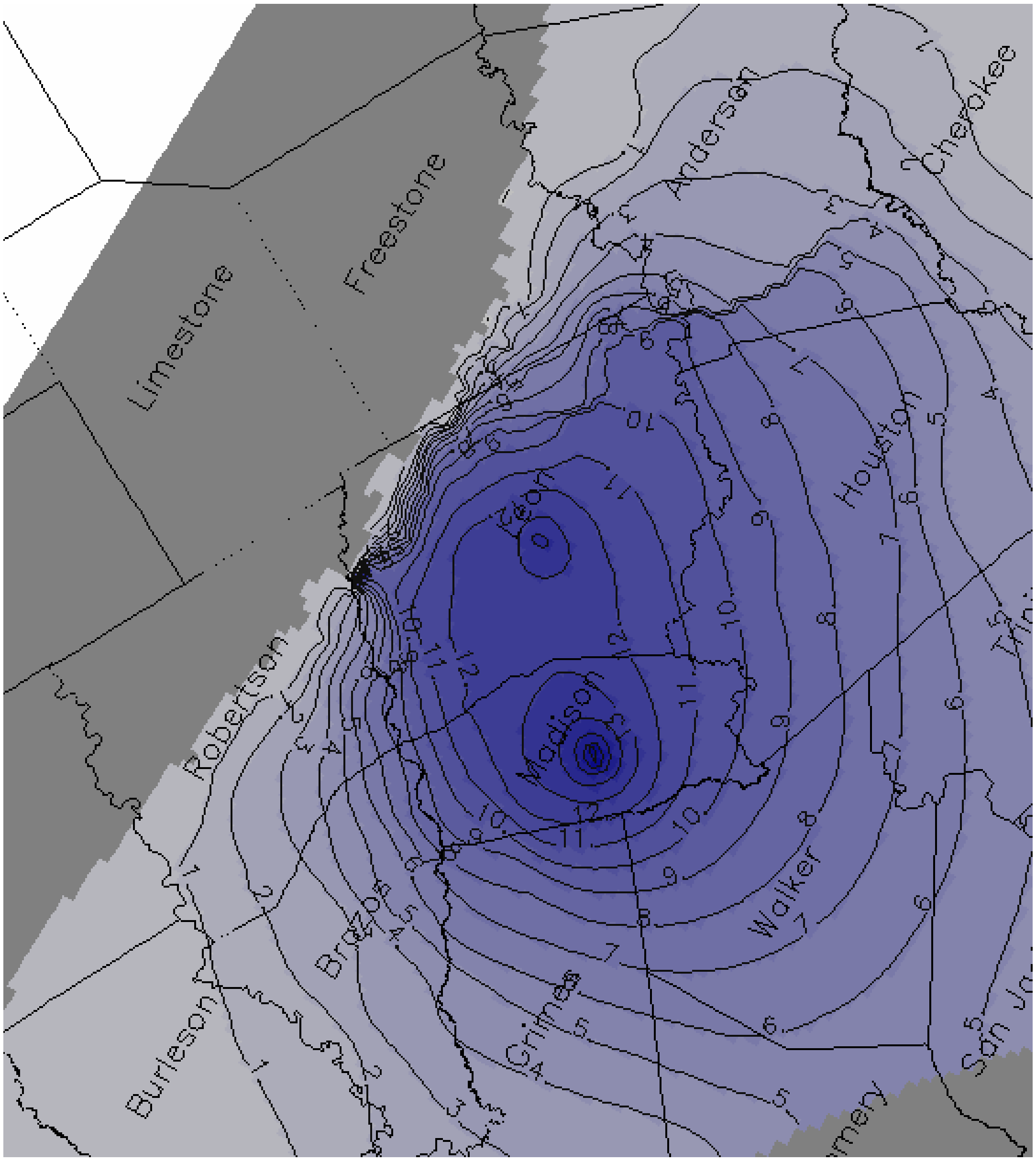


Figure 11. Simulated water-level differences in the Carrizo aquifer for Scenario B (150 percent estimated pumping based on 2000 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario B. The maximum difference shown here is about 17 feet in central Madison County.

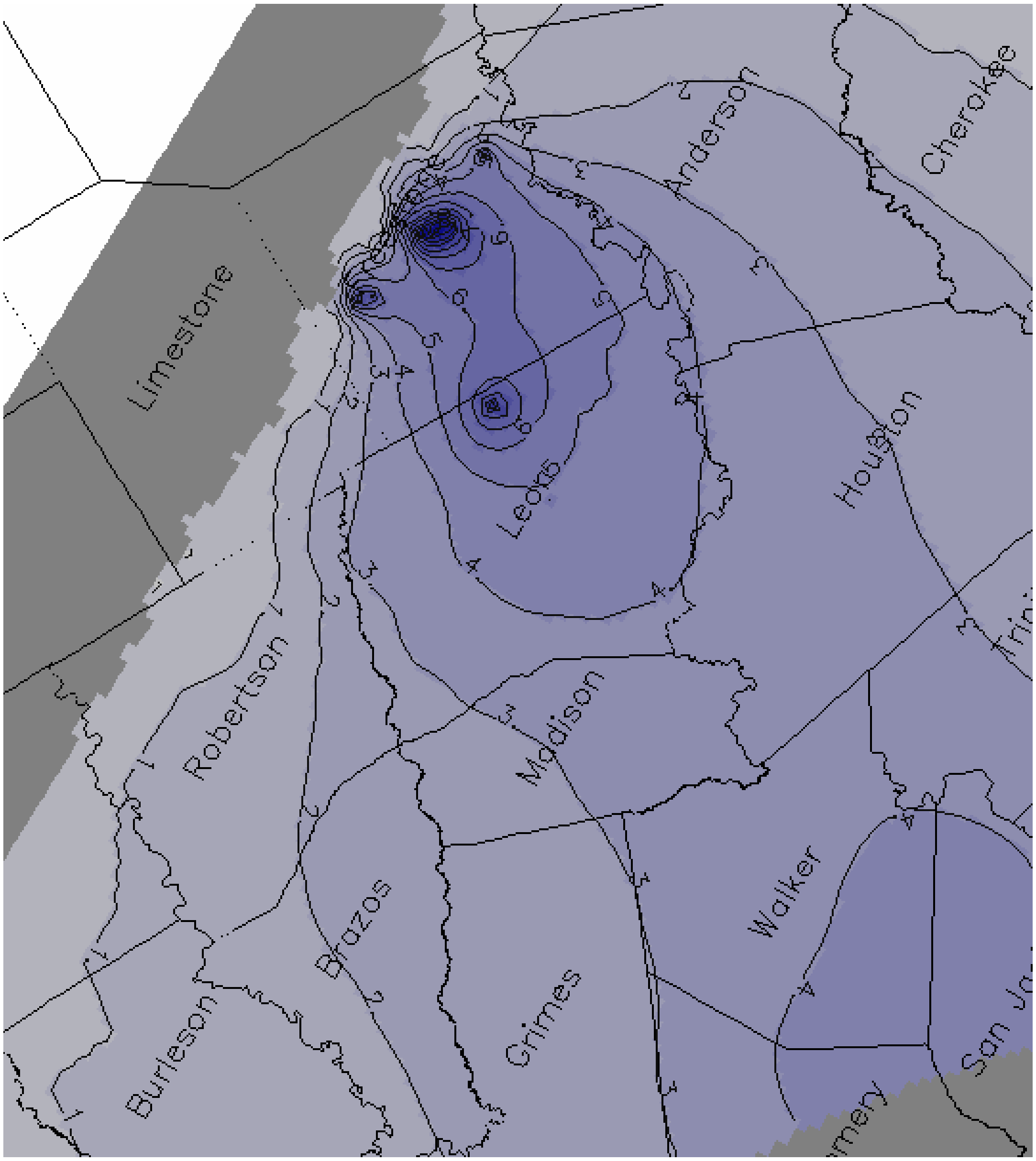


Figure 12. Simulated water-level differences in the Simsboro Formation for Scenario B (150 percent estimated pumping based on 2000 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario B. The maximum difference shown here is about 13 feet in central Freestone County.

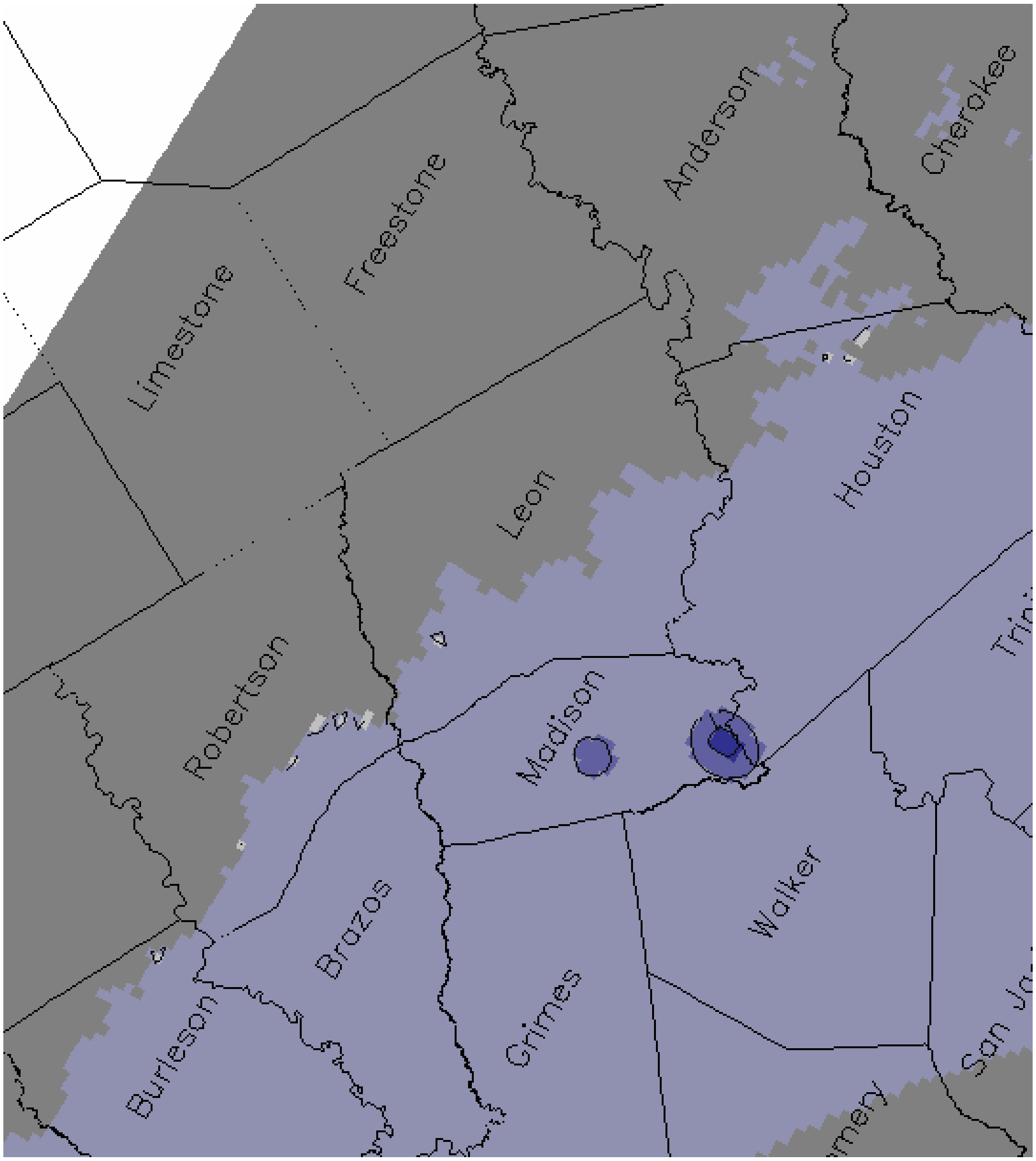


Figure 13. Simulated water-level differences in the Sparta aquifer for Scenario C (estimated pumping based on 2060 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario C. The maximum difference shown here is about 2 feet in southeastern Madison County.

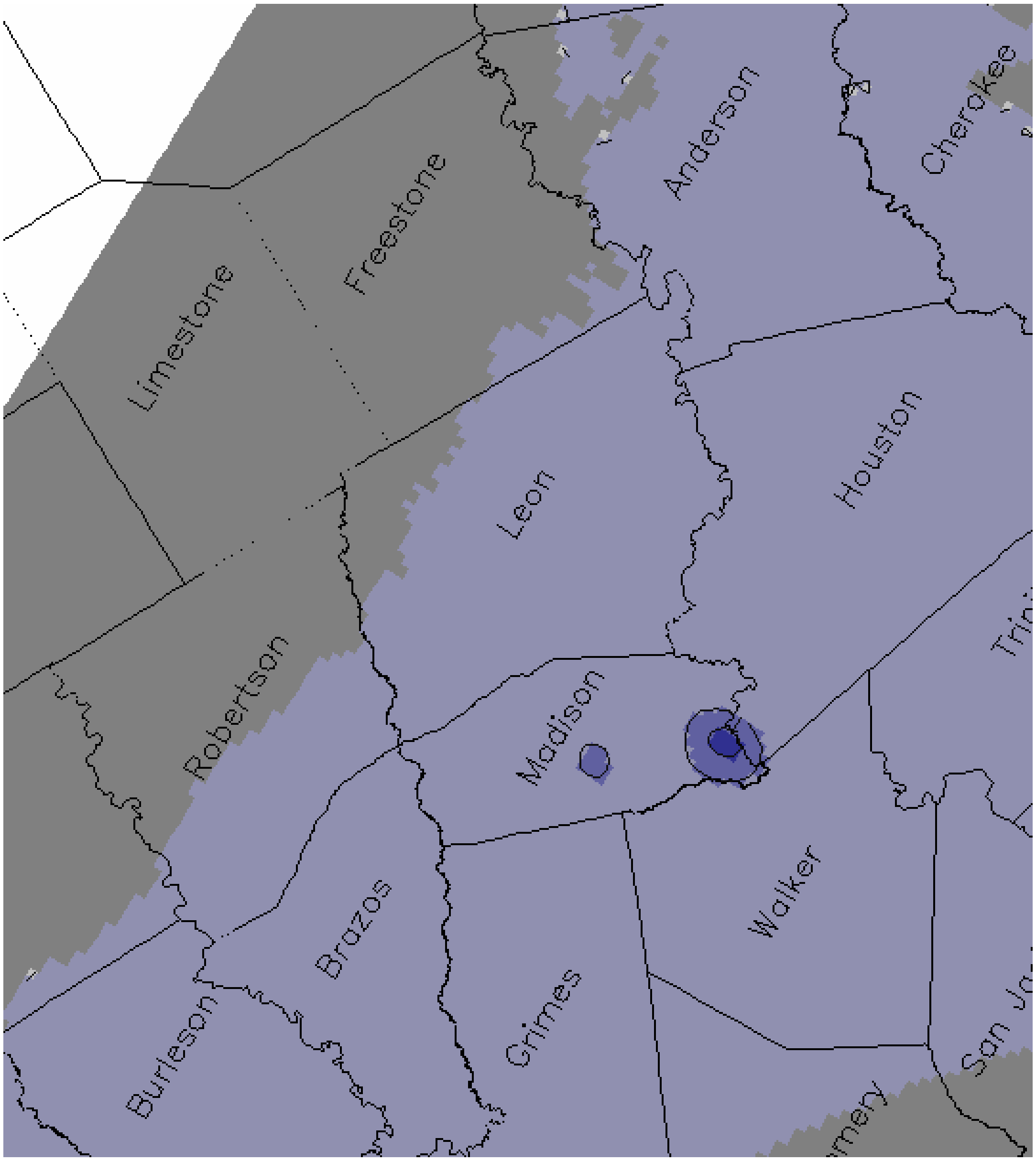


Figure 14. Simulated water-level differences in the Queen City aquifer for Scenario C (estimated pumping based on 2060 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario C. The maximum difference shown here is about 2 feet in southeastern Madison County.

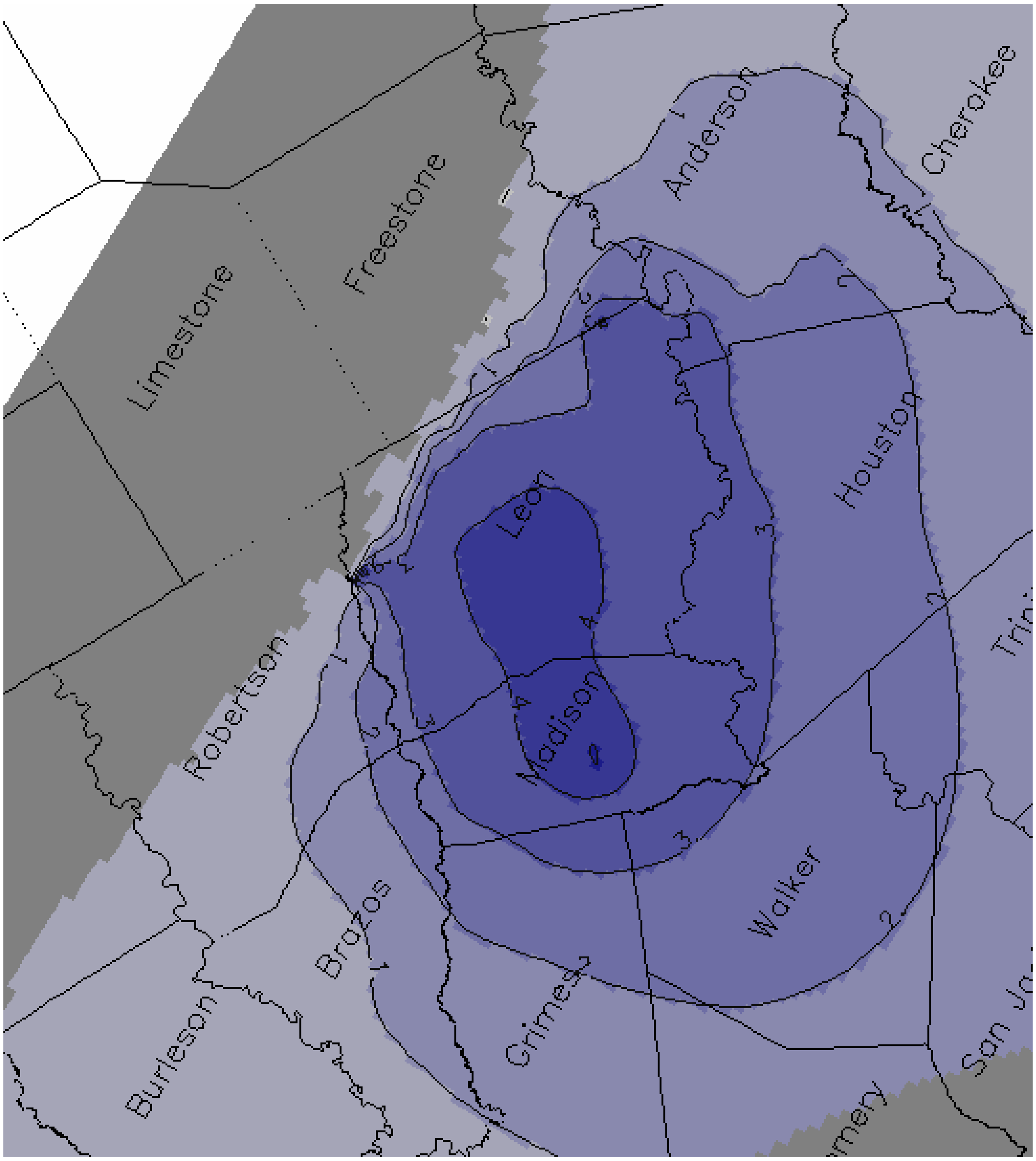


Figure 15. Simulated water-level differences in the Carrizo aquifer for Scenario C (estimated pumping based on 2060 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario C. The maximum difference shown here is about 5 feet in central Madison County.

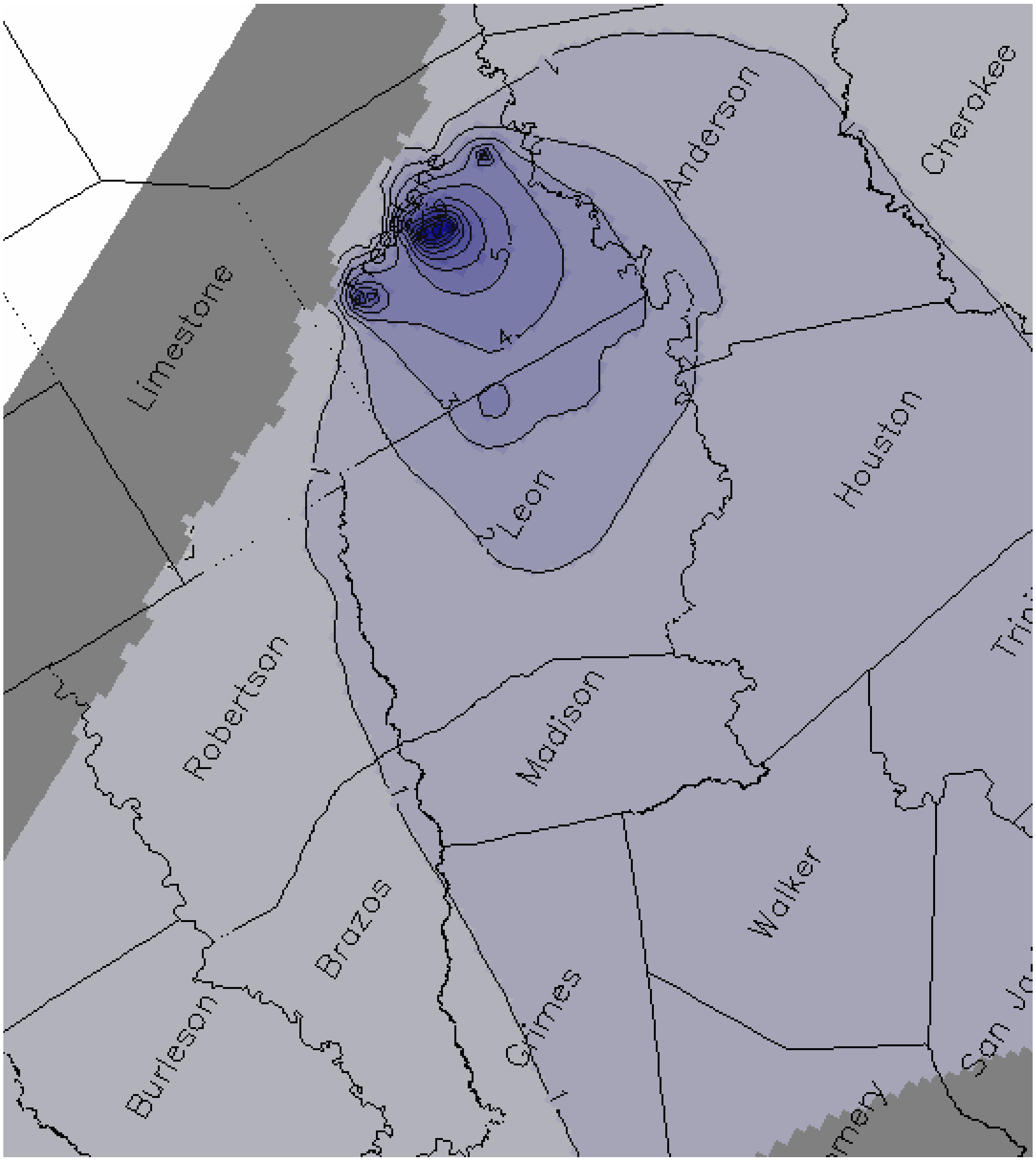


Figure 16. Simulated water-level differences in the Simsboro Formation for Scenario C (estimated pumping based on 2060 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario C. The maximum difference shown here is about 12 feet in central Freestone County.

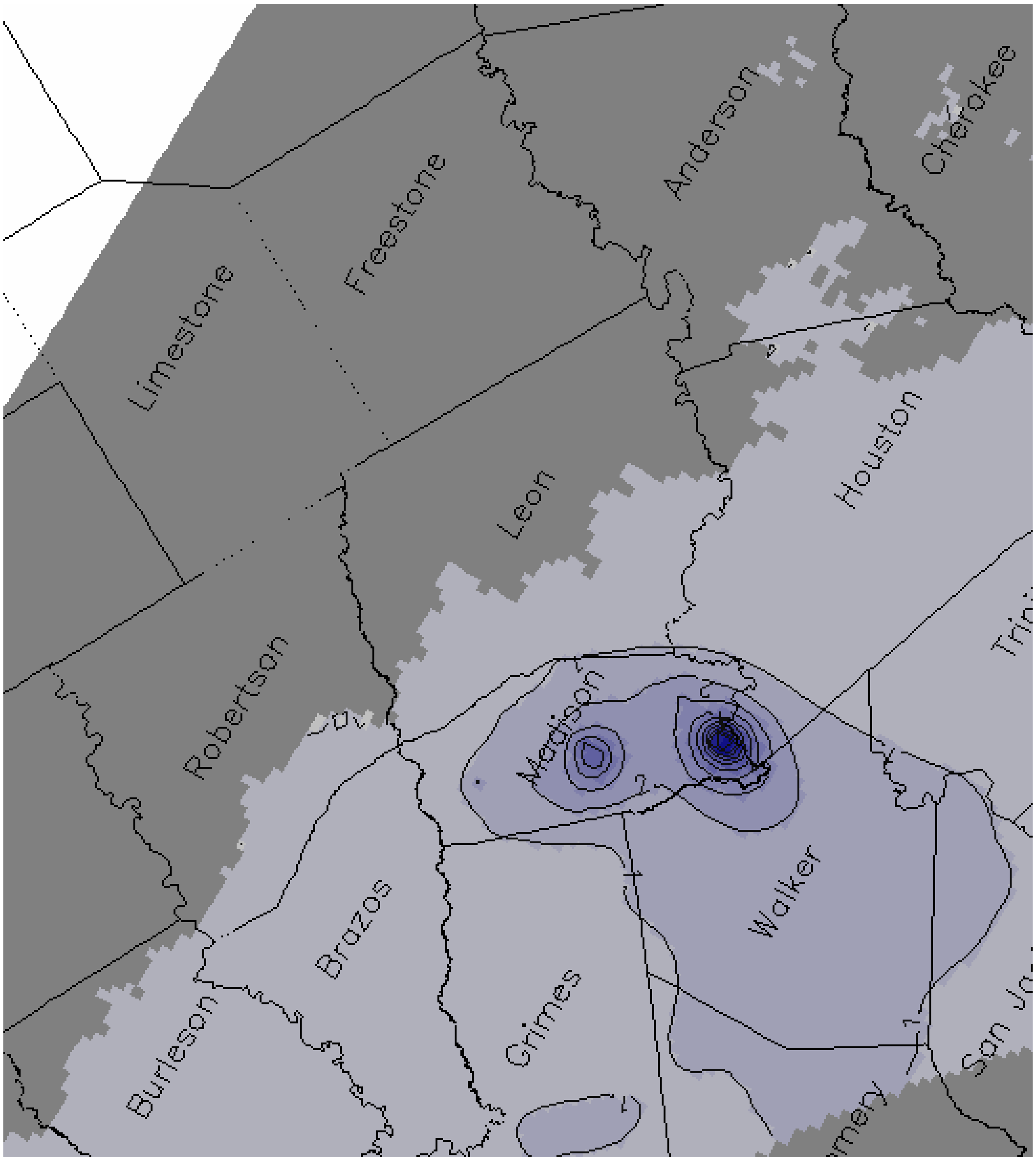


Figure 17. Simulated water-level differences in the Sparta aquifer for Scenario D (150 percent estimated pumping based on 2060 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario D. The maximum difference shown here is about 10 feet in southeastern Madison County.

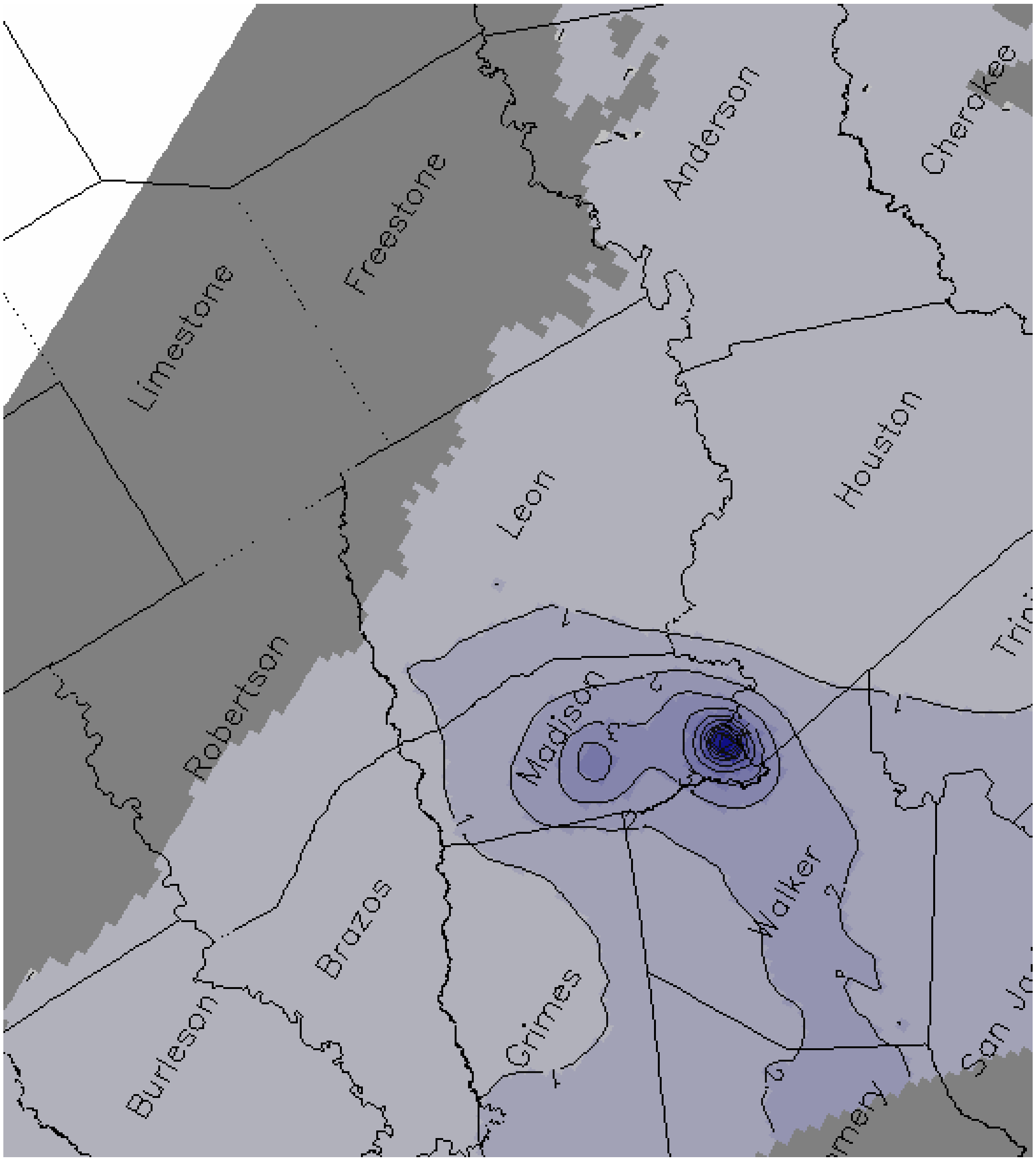


Figure 18. Simulated water-level differences in the Queen City aquifer for Scenario D (150 percent estimated pumping based on 2060 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario D. The maximum difference shown here is about 10 feet in southeastern Madison County.

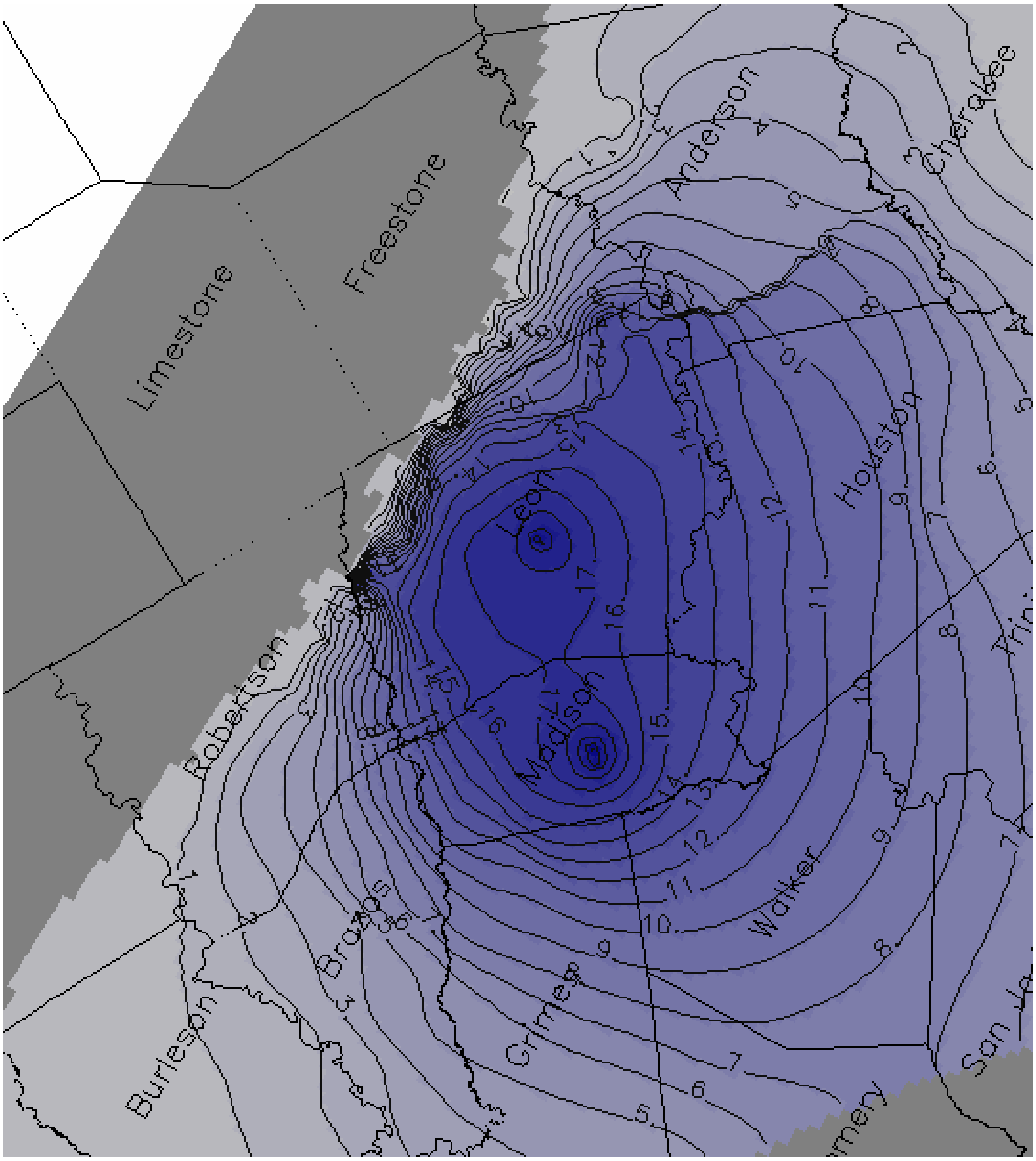


Figure 19. Simulated water-level differences in the Carrizo aquifer for Scenario D (150 percent estimated pumping based on 2060 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario D. The maximum difference shown here is about 21 feet in central Madison County.

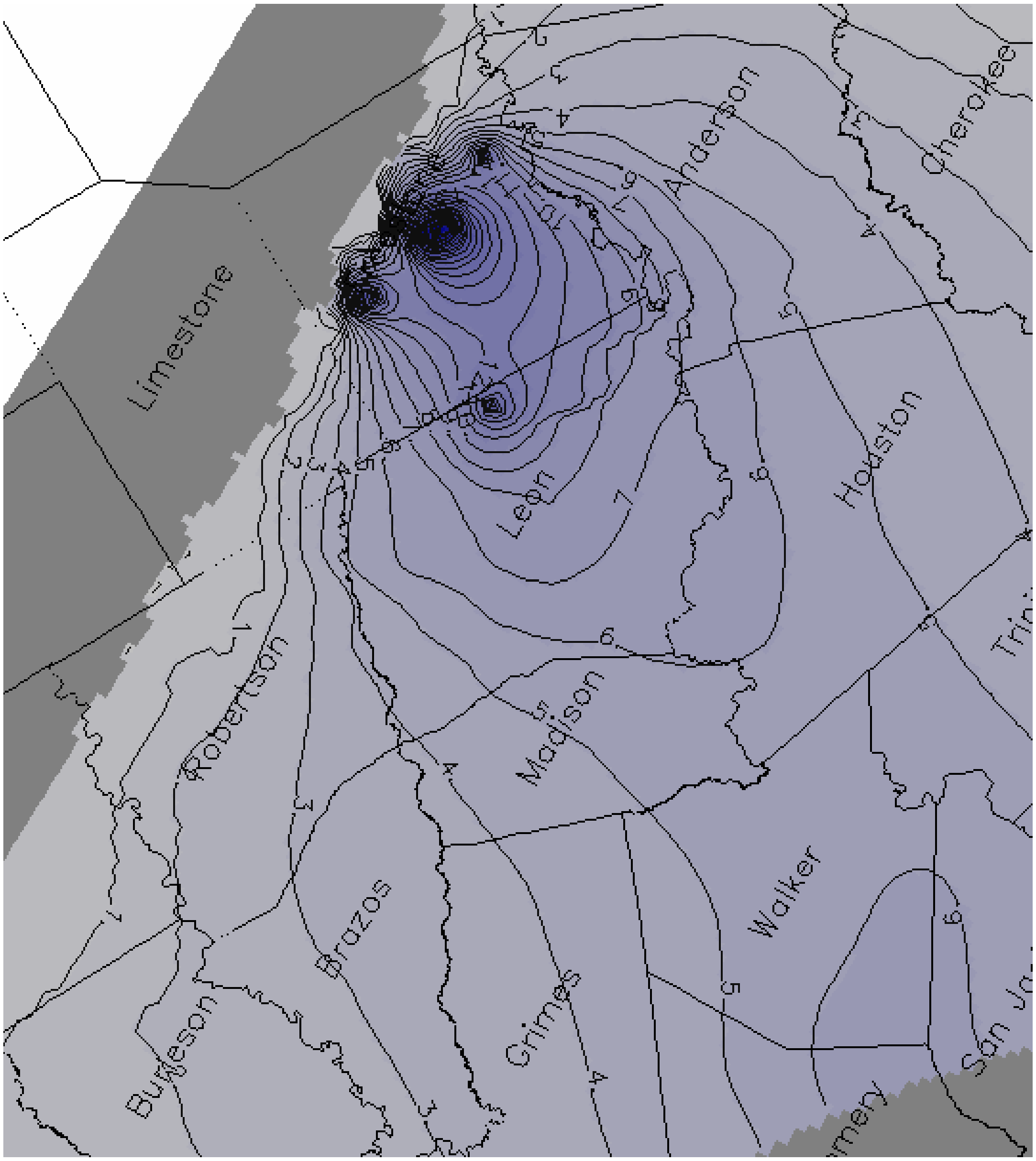


Figure 20. Simulated water-level differences in the Simsboro Formation for Scenario D (150 percent estimated pumping based on 2060 demands from 2006 regional water plans) compared with the baseline scenario. Water-level differences are shown with contour intervals of 1 foot. The differences are equal to water levels in 2050 for the baseline scenario minus water levels in 2050 for Scenario D. The maximum difference shown here is about 30 feet in central Freestone County.

Table 2. Estimated Mid-East Texas GCD groundwater demands based on 2006 regional water plans compared with predictive pumping in GAM for the central part of the Carrizo-Wilcox/Queen City/ Sparta GAM (Kelley and others, 2005).

County	Year	Model pumping	Estimated groundwater demand[1]	Factor[2]	150 percent of estimated demand	150 percent factor
Demands for the Year 2000						
Freestone	2010	3,228	3,339	1.0344	5,009	1.5516
Freestone	2020	3,207	3,339	1.0412	5,009	1.5617
Freestone	2030	3,237	3,339	1.0315	5,009	1.5473
Freestone	2040	3,268	3,339	1.0217	5,009	1.5326
Freestone	2050	3,295	3,339	1.0134	5,009	1.5200
Madison	2010	2,773	2,729	0.9841	4,094	1.4762
Madison	2020	2,676	2,729	1.0198	4,094	1.5297
Madison	2030	2,578	2,729	1.0586	4,094	1.5879
Madison	2040	2,453	2,729	1.1125	4,094	1.6688
Madison	2050	2,351	2,729	1.1608	4,094	1.7412
Leon	2010	5,580	5,553	0.9952	8,330	1.4927
Leon	2020	5,177	5,553	1.0726	8,330	1.6089
Leon	2030	5,234	5,553	1.0609	8,330	1.5914
Leon	2040	5,352	5,553	1.0376	8,330	1.5563
Leon	2050	5,562	5,553	0.9984	8,330	1.4976
Demands for the Year 2060						
Freestone	2010	3,228	4,990	1.5458	7,485	2.3188
Freestone	2020	3,207	4,990	1.5560	7,485	2.3340
Freestone	2030	3,237	4,990	1.5416	7,485	2.3123
Freestone	2040	3,268	4,990	1.5269	7,485	2.2904
Freestone	2050	3,295	4,990	1.5144	7,485	2.2716
Madison	2010	2,773	2,821	1.0173	4,231	1.5260
Madison	2020	2,676	2,821	1.0542	4,231	1.5813
Madison	2030	2,578	2,821	1.0943	4,231	1.6414
Madison	2040	2,453	2,821	1.1500	4,231	1.7250
Madison	2050	2,351	2,821	1.1999	4,231	1.7999
Leon	2010	5,580	6,487	1.1625	9,730	1.7438
Leon	2020	5,177	6,487	1.2530	9,730	1.8796
Leon	2030	5,234	6,487	1.2394	9,730	1.8591
Leon	2040	5,352	6,487	1.2121	9,730	1.8181
Leon	2050	5,562	6,487	1.1663	9,730	1.7495

1. Assumes 100 percent of all demands are met with groundwater except livestock (50 percent from groundwater) and steam electric (zero percent groundwater).

2. The factor is the ratio of county groundwater demand to total county pumping in the GAM. It is used as a cell multiplier to uniformly scale existing pumping in the model on a county-wide basis.

Table 3. Water budget for Mid-East Texas GCD in 1999 (GAM pumping based on historical water use). All values are acre-ft per year. Values are rounded to the nearest 1 acre-foot.

Aquifer	Layer	Precipitation recharge	Surface water inflow	Surface water outflow	Lateral inflow into district	Lateral outflow from district	Net inter-aquifer flow (upper)	Net inter-aquifer flow (lower)	Wells	Change in storage
Sparta	1	11,096	0	-5,644	1,255	-1,037	675	-2,239	-1,851	2,253
Weches	2	1,276	0	-302	98	-44	2,239	-2,339	0	930
Queen City	3	18,217	399	-18,345	2,156	-2,335	2,339	122	-859	1,693
Reklaw	4	1,779	56	-834	199	-216	-122	-112	0	751
Carrizo	5	9,418	0	-7,900	3,688	-7,755	112	-758	-1,667	-4,863
Calvert Bluff	6	11,688	2,489	-17,340	2,469	-4,198	758	-4,135	-990	-9,255
Simsboro	7	5,672	2,487	-11,215	6,935	-8,492	4,135	19	-3,044	-3,502
Hooper	8	2,112	0	-3,301	4,605	-4,527	-19	0	-493	-1,624
All	**Total**	**61,258**	**5,432**	**-64,881**	**21,404**	**-28,605**	**10,117**	**-9,442**	**-8,904**	**-13,616**

Table 4. Water budget for Mid-East Texas GCD after 50 years of pumping (2050) in the base case scenario (GAM pumping based on 2001 Regional Water Plan). All values are acre-ft per year. Values are rounded to the nearest 1 acre-foot.

Aquifer	Layer	Precipitation recharge	Surface water inflow	Surface water outflow	Lateral inflow into district	Lateral outflow from district	Net inter-aquifer flow (upper)	Net inter-aquifer flow (lower)	Wells	Change in storage
Sparta	1	16,396	31	-9,530	1,153	-1,117	-446	-2,991	-814	2,680
Weches	2	1,933	0	-257	99	-51	2,991	-3,522	0	1,195
Queen City	3	26,774	483	-19,992	1,903	-2,230	3,522	-809	-306	9,338
Reklaw	4	2,566	53	-1,396	206	-213	809	-1,341	0	684
Carrizo	5	14,565	0	-7,170	4,073	-6,888	1,341	-1,841	-5,185	-1,107
Calvert Bluff	6	19,337	2,496	-15,085	2,974	-4,665	1,841	-7,821	-1,364	-2,283
Simsboro	7	9,805	2,163	-10,639	10,289	-17,409	7,821	508	-3,047	-511
Hooper	8	3,675	35	-3,246	7,319	-7,399	-508	0	-490	-613
All	**Total**	**95,051**	**5,261**	**-67,315**	**28,017**	**-39,971**	**17,372**	**-17,818**	**-11,206**	**9,384**

Table 5. Water budget for Mid-East Texas GCD after 50 years of Pumping (2050) in Scenario A (2000 groundwater demands from 2006 Regional Water Plans). All values are acre-ft per year. Values are rounded to the nearest 1 acre-foot.

Aquifer	Layer	Precipitation recharge	Surface water inflow	Surface water outflow	Lateral inflow into district	Lateral outflow from district	Net inter-aquifer flow (upper)	Net inter-aquifer flow (lower)	Wells	Change in storage
Sparta	1	16,396	31	-9,528	1,172	-1,113	-342	-3,003	-943	2,668
Weches	2	1,933	0	-256	101	-50	3,003	-3,537	0	1,193
Queen City	3	26,774	483	-19,986	1,907	-2,228	3,537	-827	-321	9,335
Reklaw	4	2,566	53	-1,395	207	-212	827	-1,369	0	679
Carrizo	5	14,565	0	-7,141	4,116	-6,775	1,369	-1,818	-5,415	-1,100
Calvert Bluff	6	19,337	2,497	-15,063	2,981	-4,661	1,818	-7,823	-1,368	-2,280
Simsboro	7	9,805	2,163	-10,623	10,292	-17,404	7,823	513	-3,075	-507
Hooper	8	3,675	36	-3,242	7,322	-7,395	-513	0	-497	-613
All	**Total**	**95,051**	**5,262**	**-67,234**	**28,099**	**-39,837**	**17,522**	**-17,863**	**-11,620**	**9,375**

Table 6. Water budget for Mid-East Texas GCD after 50 years of Pumping (2050) in Scenario B (150 percent of 2000 groundwater demands from 2006 Regional Water Plans). All values are acre-ft per year. Values are rounded to the nearest 1 acre-foot.

Aquifer	Layer	Precipitation recharge	Surface water inflow	Surface water outflow	Lateral inflow into district	Lateral outflow from district	Net inter-aquifer flow (upper)	Net inter-aquifer flow (lower)	Wells	Change in storage
Sparta	1	16,396	31	-9,503	1,238	-1,096	100	-3,129	-1,414	2,620
Weches	2	1,933	0	-254	106	-49	3,129	-3,678	0	1,187
Queen City	3	26,774	485	-19,890	1,923	-2,211	3,678	-1,054	-482	9,218
Reklaw	4	2,566	53	-1,370	218	-203	1,054	-1,696	0	622
Carrizo	5	14,565	0	-6,639	4,573	-5,898	1,696	-1,642	-8,123	-1,469
Calvert Bluff	6	19,337	2,514	-14,625	3,036	-4,475	1,642	-8,190	-2,052	-2,809
Simsboro	7	9,805	2,171	-10,254	10,437	-17,093	8,190	725	-4,613	-633
Hooper	8	3,675	39	-3,162	7,397	-7,196	-725	0	-745	-716
All	**Total**	**95,051**	**5,293**	**-65,697**	**28,928**	**-38,221**	**18,763**	**-18,664**	**-17,429**	**8,019**

Table 7. Water budget for Mid-East Texas GCD after 50 years of Pumping (2050) in Scenario C (2060 groundwater demands from 2006 Regional Water Plans). All values are acre-ft per year. Values are rounded to the nearest 1 acre-foot.

Aquifer	Layer	Precipitation recharge	Surface water inflow	Surface water outflow	Lateral inflow into district	Lateral outflow from district	Net inter-aquifer flow (upper)	Net inter-aquifer flow (lower)	Wells	Change in storage
Sparta	1	16,396	31	-9,522	1,176	-1,112	-300	-3,032	-976	2,658
Weches	2	1,933	0	-256	101	-50	3,032	-3,570	0	1,191
Queen City	3	26,774	484	-19,956	1,908	-2,224	3,570	-891	-360	9,299
Reklaw	4	2,566	53	-1,384	209	-210	891	-1,465	0	661
Carrizo	5	14,565	0	-6,955	4,210	-6,555	1,465	-1,792	-6,160	-1,223
Calvert Bluff	6	19,337	2,507	-14,710	2,987	-4,580	1,792	-8,217	-1,738	-2,620
Simsboro	7	9,805	2,170	-10,288	10,351	-17,185	8,217	628	-4,317	-619
Hooper	8	3,675	39	-3,168	7,353	-7,230	-628	0	-742	-702
All	**Total**	**95,051**	**5,284**	**-66,239**	**28,296**	**-39,145**	**18,038**	**-18,338**	**-14,294**	**8,646**

Table 8. Water budget for Mid-East Texas GCD after 50 years of Pumping (2050) in Scenario D (150 percent of 2060 groundwater demands from 2006 Regional Water Plans). All values are acre-ft per year. Values are rounded to the nearest 1 acre-foot.

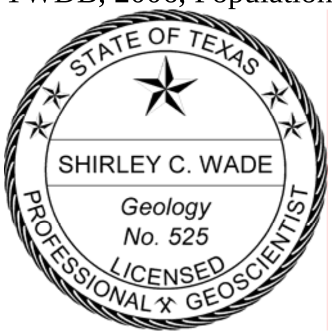
Aquifer	Layer	Precipitation recharge	Surface water inflow	Surface water outflow	Lateral inflow into district	Lateral outflow from district	Net inter-aquifer flow (upper)	Net inter-aquifer flow (lower)	Wells	Change in storage
Sparta	1	16,396	31	-9,494	1,244	-1,095	162	-3,174	-1,464	2,603
Weches	2	1,933	0	-253	106	-49	3,174	-3,726	0	1,186
Queen City	3	26,774	486	-19,845	1,925	-2,206	3,726	-1,150	-541	9,165
Reklaw	4	2,566	53	-1,353	221	-200	1,150	-1,840	0	597
Carrizo	5	14,565	0	-6,361	4,730	-5,582	1,840	-1,602	-9,240	-1,651
Calvert Bluff	6	19,337	2,529	-14,126	3,047	-4,356	1,602	-8,785	-2,608	-3,357
Simsboro	7	9,805	2,182	-9,745	10,536	-16,755	8,785	901	-6,476	-768
Hooper	8	3,675	44	-3,052	7,447	-6,956	-901	0	-1,114	-856
All	**Total**	**95,051**	**5,326**	**-64,230**	**29,256**	**-37,199**	**19,538**	**-19,376**	**-21,441**	**6,918**

REFERENCES:

Dutton, A. R., Harden, R., Nicot, J. P., and O’ Rourke, D., 2003, Groundwater availability model for the central part of the Carrizo-Wilcox aquifer in Texas: Bureau of Economic Geology, Final report prepared for the Texas Water Development Board.

Kelley, V. A., Deeds, N. E., Fryar, D. G., Nicot, J. P., Jones, T. L., Dutton, A. R., Unger-Holtz, T., and Machin J. L., 2004, Groundwater availability model for the Queen City and Sparta aquifers: Final report prepared for the Texas Water Development Board by INTERA Inc.

TWDB, 2006, Population and Water Demand Data Web Page, http://www.twdb.state.tx.us/data/popwaterdemand/



The seal appearing on this document was authorized by Shirley C. Wade, P.G., on May 31, 2006.