GAM Run 07-17

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EXECUTIVE SUMMARY:

We ran the groundwater availability model for the southern part of the Queen City and Sparta aquifers, which includes the Carrizo-Wilcox Aquifer, using a specified pumpage annually for a 60-year predictive simulation along with average recharge, evapotranspiration rates, and initial streamflows. These model runs indicate that producing this amount of pumpage in the model for the predictive time period results in the following:

- water level declines of 10 to 60 feet in most of the Sparta and Queen City aquifers, with higher drawdowns in areas where additional pumpage was added to these aquifer (mainly Gonzales and McMullen counties);
- maximum water level declines of 180 feet in the Carrizo and upper Wilcox aquifers, centering around Frio and LaSalle counties; and
- water level declines in the middle and lower Wilcox aquifers showing significant impact from a brackish well field added to these aquifers in Atascosa County. Water levels in the rest of these aquifers show moderate declines.

REQUESTOR:

Mr. Mike Mahoney from the Evergreen Underground Water Conservation District (on behalf of Groundwater Management Area 13).

DESCRIPTION OF REQUEST:

Mr. Mahoney asked us to perform a model run using the groundwater availability model for the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers. This model run would be 60-year simulations using initial water levels from the end of the historic calibration simulation and average recharge conditions. Each year of the model run would use pumpage specified by the members of Groundwater Management Area 13.

METHODS:

The simulation was set up using average recharge and evapotranspiration rates and initial streamflows based on the historic calibration-verification runs, representing 1981 to 1999. These averages were then used for each year of the 60-year predictive simulation along with the specified pumpage. Resulting water levels and water level declines were then evaluated and are described in the Results section below.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the groundwater availability model for the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers are described individually below:

- We used Version 2.01 of the groundwater availability model for the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers.
- See Deeds and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers.
- The model includes eight layers representing: the Sparta Aquifer (layer 1), the Weches Formation (layer 2), the Queen City Aquifer (layer 3), the Reklaw Formation (layer 4), the Carrizo Aquifer (layer 5), the upper Wilcox Aquifer (layer 6), the middle Wilcox Aquifer (layer 7), and the lower Wilcox Aquifer (layer 8).
- Although the layer representing the Sparta Aquifer (layer 1) and the Queen City Aquifer (layer 3) extend to the Rio Grande in the model, the portion of these layers west of the Frio River are not recognized as part of either aquifer. No pumpage is assigned to these layers west of the Frio River, and although results (water levels) are shown for the entire layer in the figures, evaluation of impacts in these areas should be done with care.
- The root mean square error (a measure of the difference between simulated and actual water levels during model calibration) in the entire model for 1999 is 23 feet for the Sparta Aquifer, 18 feet for the Queen City aquifer, and 33 feet for the Carrizo aquifer (Kelley and others, 2004).
- Recharge rates, evapotranspiration rates, and initial streamflows are averages of historic estimates from 1981 to 1999.
- Pumpage used for each year of the 60-year predictive simulation was specified by members of Groundwater Management Area 13. Details on this pumpage are given below.

Specified Pumpage

The pumpage specified by the members of Groundwater Management Area 13 was based on the baseline pumpage constructed for GAM Run 07-16 (Donnelly, 2007). The assumptions used to create the baseline pumpage are detailed in the GAM Run 07-16 report (http://www.twdb.state.tx.us/gam/GAMruns/GR07-16.pdf) and will not be repeated in this report. The following modifications were made to the baseline pumpage to create the specified pumpage used in this simulation.

The baseline pumpage totals for each county in the model area were increased in most counties in the model area. Most of the county pumpage totals used in this simulation were based on average availability estimates from the 2007 state water plan. However some of the county pumpage totals shown in Table 1 were specified by an individual member of the groundwater management area and were not based on availability estimates. The pumpage totals for each county specified by the members of the groundwater management area are shown in Table 1.

The pumpage file used in the model run was based on the baseline pumpage used in GAM Run 07-16. Table 1 also includes the total pumpage for each county in the baseline pumpage file. In order to increase the pumpage from the baseline total to the specified total, pumpage was distributed evenly to all active cells in the county, or an area specified by members of the groundwater management area.

The Carrizo-Wilcox Aquifer is included in the groundwater availability model in four layers. Because availability estimates for the Carrizo-Wilcox Aquifer are not broken down into individual layers, the estimates for the total aquifer had to be divided between the four layers in the model. The amount assigned to each layer was based on the total assigned to each layer in the baseline pumpage data set. Table 2 provides a summary of the pumpage in each county in each layer of the Carrizo-Wilcox Aquifer in the baseline pumpage file and what was used in this model run.

In addition to increasing the county pumpage totals, several other modifications were made to the baseline pumpage to create the specified pumpage data set for this simulation. These include:

- An additional 6,400 acre-feet per year was added to the Carrizo Aquifer in southern Bexar County to represent a San Antonio Water System (SAWS) well field. The location of this well field is shown in Figure 1. One of the cells that the pumpage for this well field was assigned to is categorized as being located in Wilson County, and so the pumpage for this well field is partially attributed to Wilson County in Tables 1 and 2 and in the water budget tables in Appendix A.

- An additional 14,000 acre-feet per year was added to both the middle and lower Wilcox Aquifer layers in northern Atascosa County to represent a San Antonio Water System brackish well field. The location of this well field is also shown in Figure 1.

Table 1. Pumpage used in the baseline and current model runs. Pumpage totals are in acre-feet per year.

County	GAM Run 07-16 (Baseline) Pumpage			GAM Run 07-17 Specified Pumpage		
	Sparta Aquifer	Queen City Aquifer	Carrizo-Wilcox Aquifer	Sparta Aquifer	Queen City Aquifer	Carrizo-Wilcox Aquifer
Atascosa	517	964	55,009	1,150	4,380	83,009
Bastrop	--	--	691	--	--	28,000
Bee	--	--	77	--	--	394
Bexar	--	--	16,871	--	--	22,204
Caldwell	--	132	3,633	--	328	12,500
DeWitt	--	--	1	--	--	1
Dimmit	--	--	4,477	--	--	30,277
Fayette	--	--	2	--	--	400
Frio	87	66	110,004	1,260	8,000	130,765
Gonzales	552	240	11,605	3,750	7,500	28,942
Guadalupe	--	--	6,073	--	--	10,826
Karnes	--	--	471	--	--	1,803
LaSalle	1,316	2	8,285	1,400	420	34,810
Lavaca	--	--	1	--	--	1
Live Oak	--	--	85	--	--	2,399
Maverick	--	--	3,298	--	--	3,298
McMullen	0	0	120	600	1,105	7,909
Medina	--	--	5,008	--	--	6,966
Uvalde	--	--	596	--	--	27,093
Webb	--	--	915	--	--	17,176
Wilson	504	170	17,376	980	5,650	33,854
Zavala	--	--	48,763	--	--	48,763

Table 2. Pumpage used in the baseline and current model runs in each layer of the Carrizo-Wilcox Aquifer. Pumpage totals are in acre-feet per year.

	GAM Run 07-16 (Baseline) Pumpage				GAM Run 07-17 Specified Pumpage			
County	Carrizo Aquifer	Upper Wilcox Aquifer	Middle Wilcox Aquifer	Lower Wilcox Aquifer	Carrizo Aquifer	Upper Wilcox Aquifer	Middle Wilcox Aquifer	Lower Wilcox Aquifer
Atascosa	52,419	36	598	1,956	52,419	36	14,598	15,956
Bastrop	100	60	309	221	4,382	2,436	12,544	8,960
Bee	19	19	19	19	98	98	98	98
Bexar	3,513	0	6,633	6,725	8,847	0	6,633	6,725
Caldwell	924	0	1,169	2,186	1,284	0	4,024	7,524
DeWitt	1	0	0	0	1	0	0	0
Dimmit	2,917	1,321	189	50	19,739	8,932	1,272	334
Fayette	2	0	0	0	400	0	0	0
Frio	99,802	6,049	4,089	64	118,632	7,190	4,858	85
Gonzales	11,538	1	66	0	28,424	1	499	0
Guadalupe	1,224	0	3,240	1,608	2,184	0	5,778	2,868
Karnes	471	0	0	0	1,803	0	0	0
LaSalle	5,684	2,602	0	0	23,880	10,930	0	0
Lavaca	1	0	0	0	1	0	0	0
Live Oak	85	0	0	0	2,399	0	0	0
Maverick	596	276	856	1,570	596	276	856	1,570
McMullen	119	0	0	0	7,869	24	8	0
Medina	1,477	31	980	2,520	2,055	43	1,364	3,505
Uvalde	358	0	120	118	16,256	0	5,446	5,365
Webb	896	13	6	1	16,815	241	103	17
Wilson	15,986	40	772	578	31,247	71	1,451	1,087
Zavala	34,731	8,629	4,901	502	34,731	8,629	4,901	502

RESULTS:

Included in Appendix A are estimates of the water budgets after running the model for 60 years. The components of the water budget are described below.

- Wells—water produced from wells in each aquifer. In the model this component is always shown as "Outflow" from the water budget, because all wells included in the model produce (rather than inject) water. Wells are modeled in the model using the MODFLOW Well package. It is important to note that values in Appendix A for wells in the water budget may not precisely match the pumpage amounts requested in Tables 1 and 2 because of dry cells and slight deviations generated by the programs written to create the well package.

- Springs—water that drains from an aquifer if water levels are above the elevation of the spring. This component is always shown as "Outflow", or discharge, from the water budget. Springs are modeled in the model using the MODFLOW Drain package.

- Recharge—simulates areally distributed recharge due to precipitation falling on the outcrop (where the aquifer is exposed at land surface) areas of aquifers. Recharge is always shown as "Inflow" into the water budget.

- Vertical leakage (upward or downward)—describes the vertical flow, or leakage, between two layers (aquifers or confining units) in the model. This flow is controlled by the water levels in each of the layers and aquifer properties of each layer that define the amount of leakage that can occur. "Inflow" to an aquifer from an overlying or underlying layer will always equal the "Outflow" from the other layer.

- Storage—water stored in the aquifer. The storage component that is included in "Inflow" is water that is removed from storage in the aquifer (that is, water levels decline). The storage component that is included in "Outflow" is water that is added back into storage in the aquifer (that is, water levels increase). This component of the budget is often seen as water both going into and out of the aquifer because this is a regional 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).

- Lateral flow—describes lateral flow within an aquifer between a county and adjacent counties.

- Evapotranspiration—water that flows out of an aquifer due to direct evaporation and plant transpiration. This component of the budget will always be shown as "Outflow". Evapotranspiration is modeled in the model using the MODFLOW Evapotranspiration (EVT) package.

- Rivers and Streams—water that flows between streams and rivers and an aquifer. The direction and amount of flow depends on the water level in the stream or river and the aquifer. In areas where water levels in the stream or river are above the water level in the aquifer, water flows into the aquifer and is shown as "Inflow" in the budget. In areas where water levels in the aquifer are above the water level in the stream or river, water flows out of the aquifer and into the stream and is shown as "Outflow" in the budget. Rivers and streams are modeled in the model using the MODFLOW Stream package.

- General-Head Boundary (GHB)—The model uses general head boundaries to simulate the lateral aquifer boundaries. In addition, the downdip portions (areas where the layer is confined or covered by other aquifers or geologic formations) of the top are modeled with general head boundaries to simulate the vertical movement of groundwater between the Sparta Aquifer (layer 1) and younger sediments that overlie the Sparta Aquifer.

The results are described for the four aquifers in the model area; the Sparta Aquifer (layer 1 in the model), the Queen City Aquifer (layer 3), the Carrizo Aquifer (layer 5), and the

Wilcox Aquifer (layers 6, 7, and 8). Results for the other units included in the model are not discussed because they are not considered to be aquifers in the region.

A small number of model cells went dry during the model run. Approximately half of these cells went dry during the historic calibration time period, and therefore are not due to conditions from this predictive model run. All model cells that went dry during the run are located in the outcrop portions of the model, where the formations pinch out and the aquifer is found under unconfined conditions.

Initial water levels (which are from the end of the transient calibration run—the end of 1999) for the Sparta, Queen City, Carrizo, upper Wilcox, middle Wilcox, and lower Wilcox aquifers are shown in Figures 2 to 7. These figures show the starting water levels for this 60-year predictive model run. These figures all show that water levels are the highest in the outcrop portions of the aquifers located furthest to the north and/or west, and that water levels decrease as groundwater flows downdip, generally to the south and/or east. Initial heads or water levels in the Carrizo and Wilcox aquifers show a large cone of depression that has formed in Frio, LaSalle, Dimmit, and Zavala counties.

Water levels at the end of the 60-year predictive simulation for the Sparta, Queen City, Carrizo, upper Wilcox, middle Wilcox, and lower Wilcox aquifers are shown in Figures 8 to 13. Water levels at the end of the 60-year runs are very similar to initial water levels (Figures 2 to 7). Because differences between initial water levels and water levels after 60 years of pumpage can be difficult to discern in these figures, water level change maps were made. A water level change map shows the difference between the initial water levels (1999) and the water levels at the end of the 60-year run (2060).

Water level changes over the 60-year predictive simulation for the Sparta, Queen City, Carrizo, upper Wilcox, middle Wilcox, and lower Wilcox aquifers are shown in Figures 14 to 19. These figures indicate the following:

- Water level declines throughout most of Groundwater Management Area 13 in the Sparta Aquifer (Figure 14) are zero to forty feet, with larger declines of up to 90 feet centered on McMullen County. These declines are in response to increased pumpage in certain counties in the Sparta Aquifer, as shown in Table 1.

- Water level declines in the Queen City Aquifer (Figure 15) are between ten and sixty feet in most of the model area. As with the Sparta Aquifer, a larger area of higher drawdown is centered on McMullen County, with declines of over 100 feet. Another area of higher drawdown is in Gonzales County. Areas of higher declines are in response to increased pumpage in certain counties in the Queen City Aquifer, as shown in Table 1. An area of recovery is shown in northern Webb and Zavala counties, which was also seen in the baseline model run (Donnelly, 2007).

- Water level declines in the Carrizo Aquifer (Figure 16) are predicted to be very large over the next 60 years in much of the model area. Water level declines in most of the area are predicted to be greater than forty feet, and are over 160 feet in much of LaSalle and Frio counties. These declines are in response to significant increases in pumpage in this model run.

- Water level declines in the upper Wilcox Aquifer (Figure 17) show similar patterns as the Carrizo Aquifer, with large water level declines focused around Frio and LaSalle counties, and of more than forty feet in most of the rest of the model area.

- Water level declines in the middle Wilcox Aquifer (Figure 18) are between 25 and 150 feet for most of the model area, with a focused area of decline in Atascosa County where pumpage was added to represent a brackish well field. Drawdowns in this area are over 400 feet.

- Water level declines in the lower Wilcox Aquifer (Figure 19) also are dominated by the pumpage added in Atascosa County for a brackish well field. Drawdowns in the center of this area are over 400 feet.

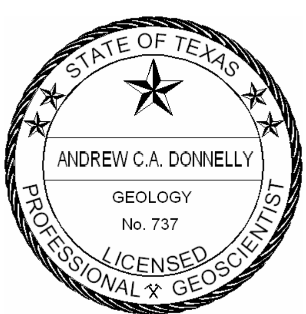
Because some of the desired future conditions (DFCs) for the groundwater management area may be based on discharge to springs or baseflow to rivers and streams, we also pulled the water budgets for each of these components for each county in the model area. These budgets are provided in Appendix A. The components of the water budget are divided up into “In” and “Out”, representing water that is coming into and leaving from the budget. As might be expected, water from wells is only in the “Out” column, representing water that is pulled out of the budget or aquifer system from wells. Likewise, recharge is only found in the “In” column. Streams and rivers, however, have values in both the “In” and “Out” columns. This is because some streams lose water to the aquifer, and some gain water from the aquifer depending on the water levels in the aquifer. Also included in these budgets are values for vertical leakage to overlying and underlying formations as well as lateral inflow from adjacent counties. Future model runs can be compared to these budgets to determine the impact of additional pumpage compared to this baseline run.

REFERENCES:

Deeds, N., Kelley, V., Fryar, D., Jones, T., Whallon, A. J., and Dean, K. E., 2003, Groundwater Availability Model for the Southern Carrizo-Wilcox Aquifer: contract report to the Texas Water Development Board, 452 p.

Donnelly, A.C.A., 2007, GAM Run 07-16, Texas Water Development Board GAM Run Report, 63 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.



The seal appearing on this document was authorized by Andrew C.A. Donnelly, P.G. 737, on October 26, 2007.

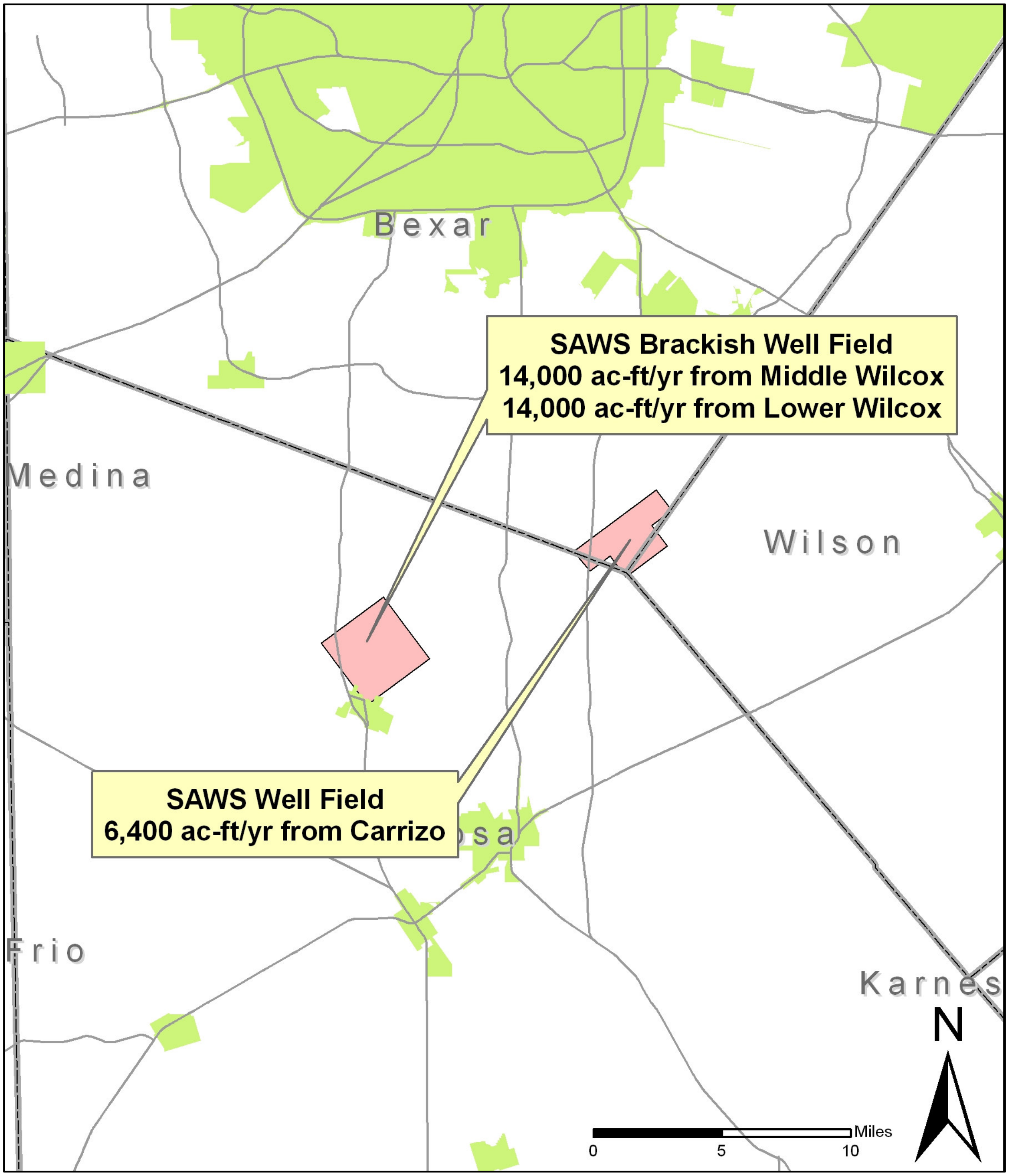


Figure 1. Location of San Antonio Water System (SAWS) well fields in Atascosa and Bexar counties.

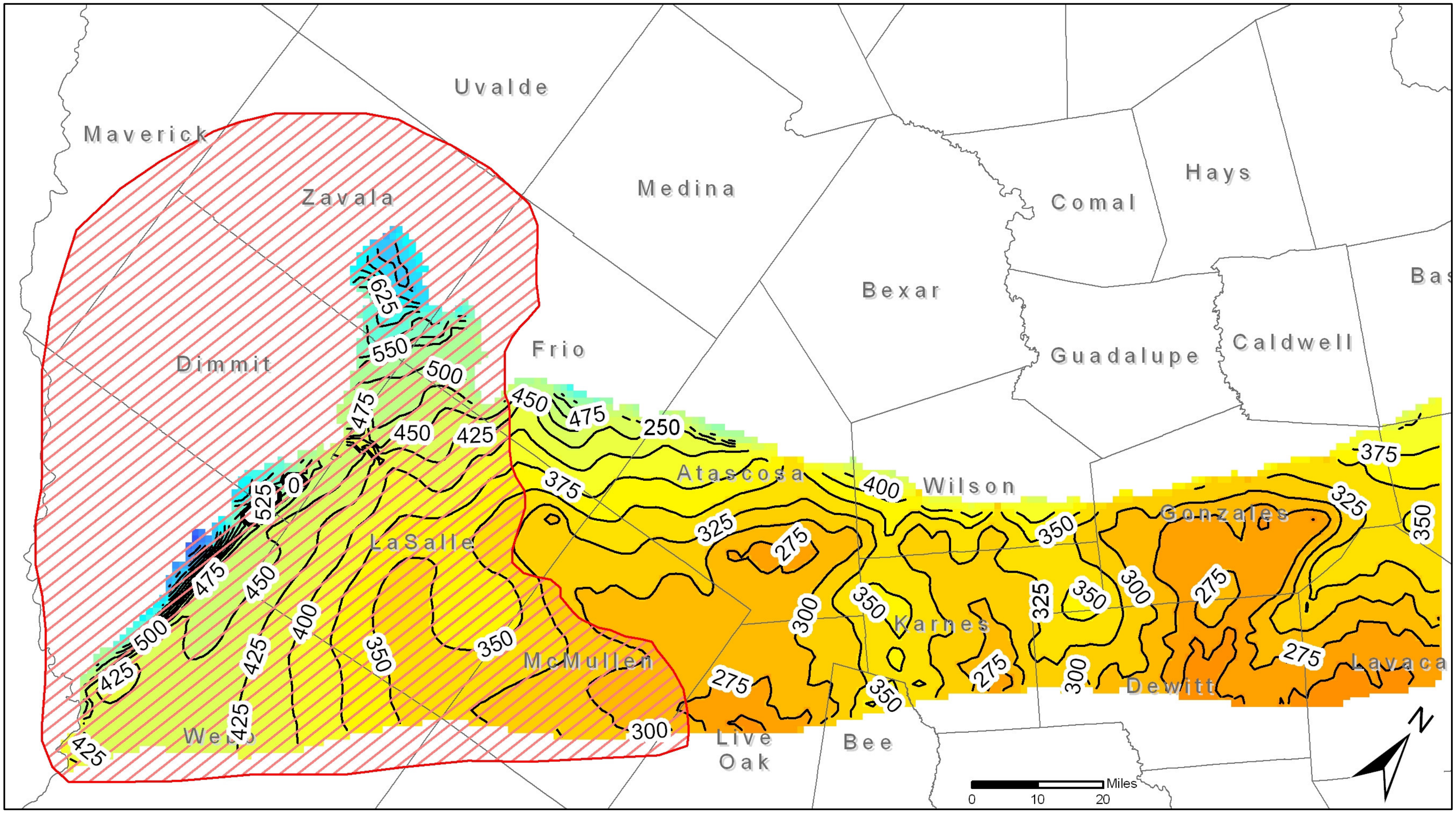


Figure 2. Initial water level elevations for the predictive model run in the Sparta Aquifer from the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. The area west of the Frio River (shown in red) is not considered to be part of the Sparta Aquifer and does not have any pumpage assigned to it.

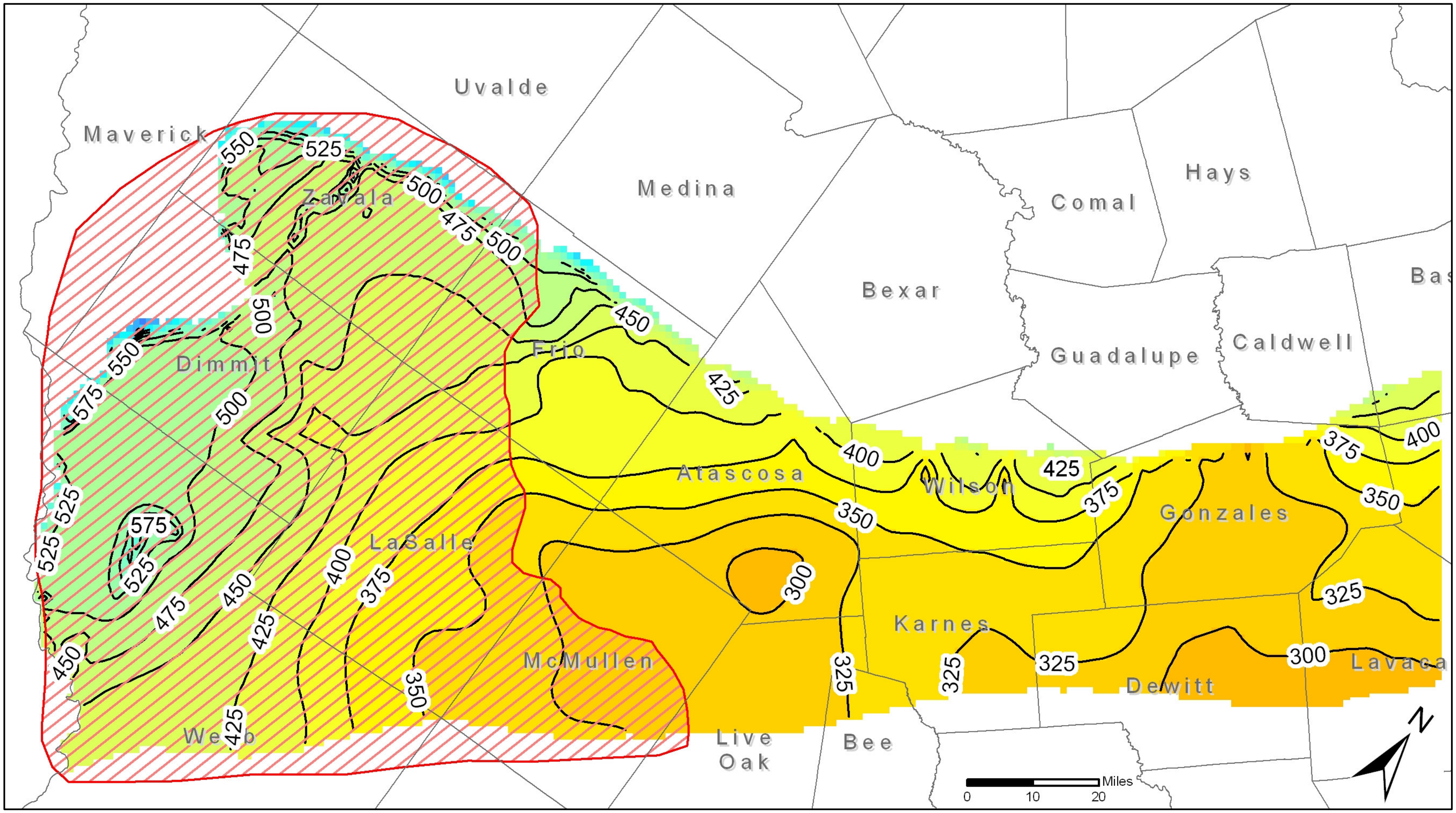


Figure 3. Initial water level elevations for the predictive model run in the Queen City Aquifer from the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. The area west of the Frio River (shown in red) is not considered to be part of the Queen City Aquifer and does not have any pumpage assigned to it. Dry model cells are shown in black.

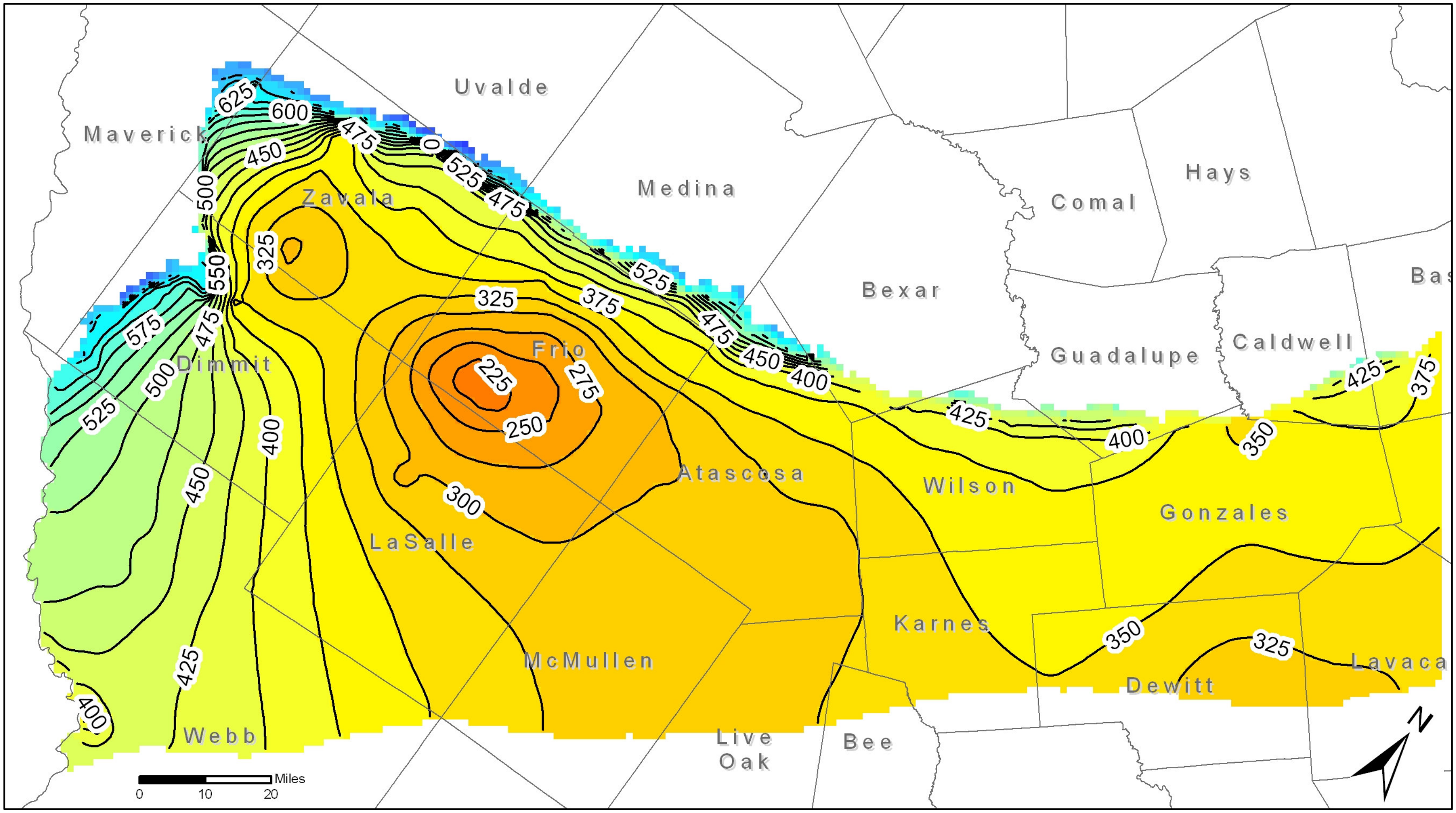


Figure 4. Initial water level elevations for the predictive model run in the Carrizo Aquifer from the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black.

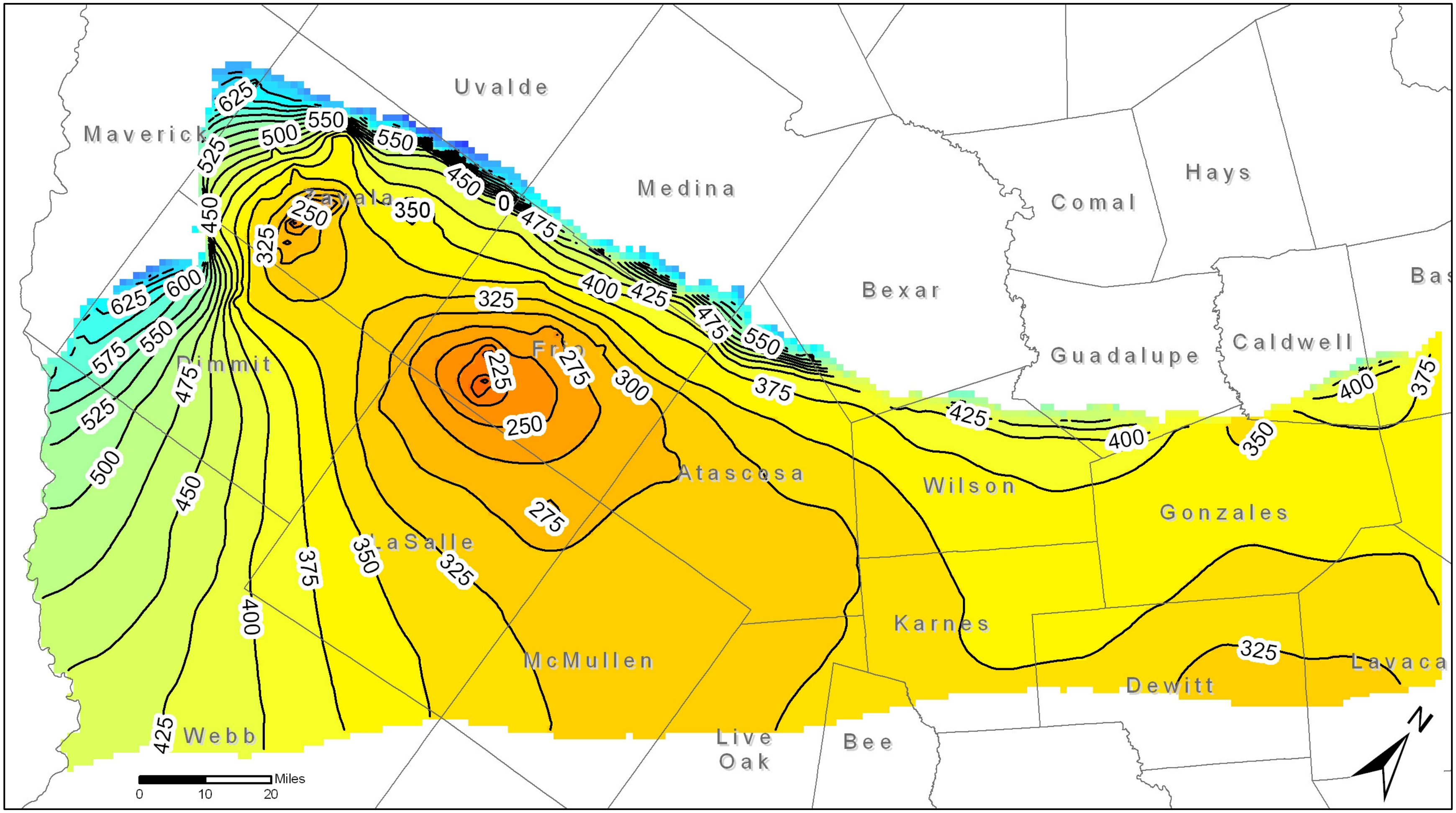


Figure 5. Initial water level elevations for the predictive model run in the upper Wilcox Aquifer from the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black.

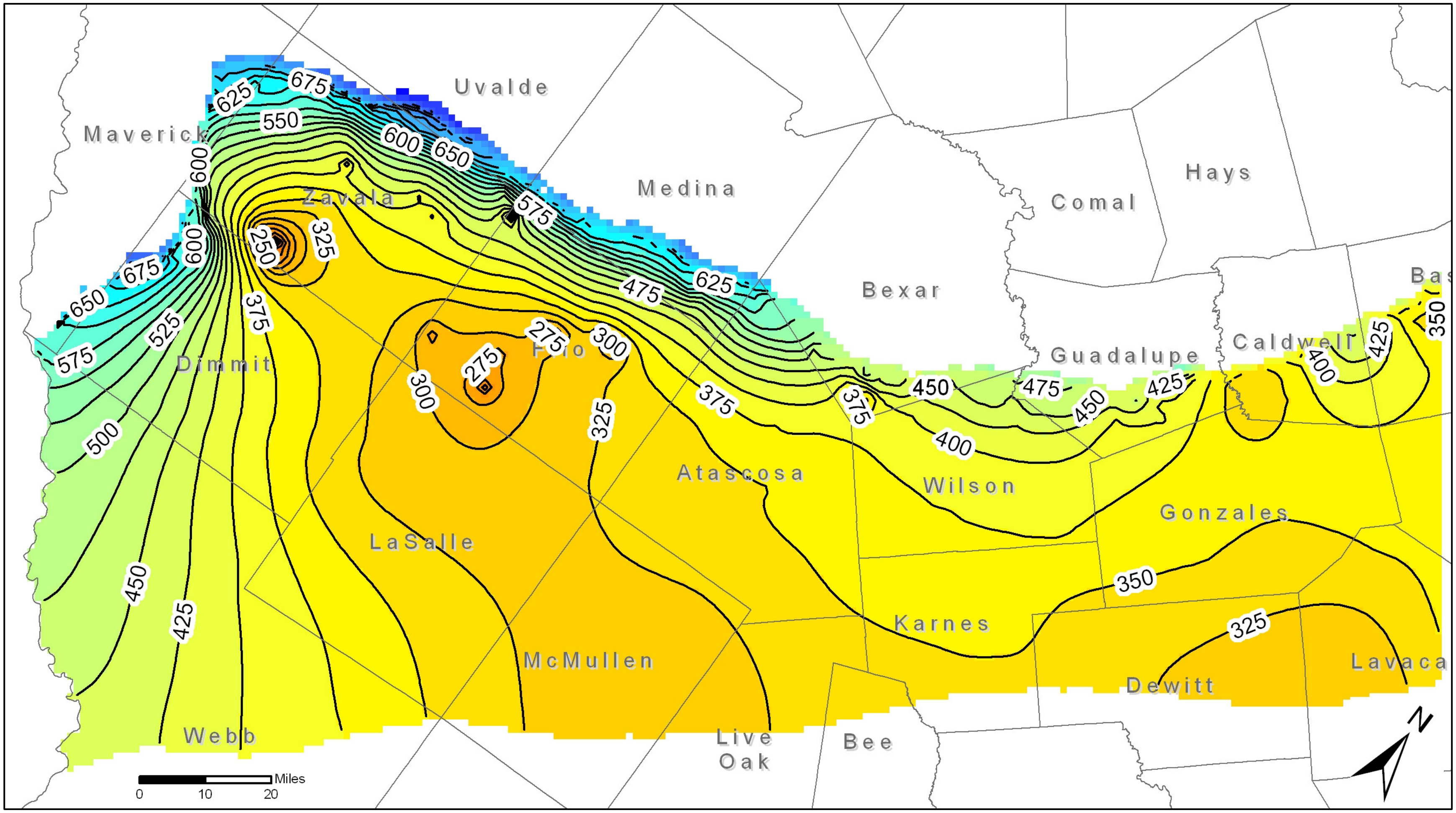


Figure 6. Initial water level elevations for the predictive model run in the middle Wilcox Aquifer from the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black.

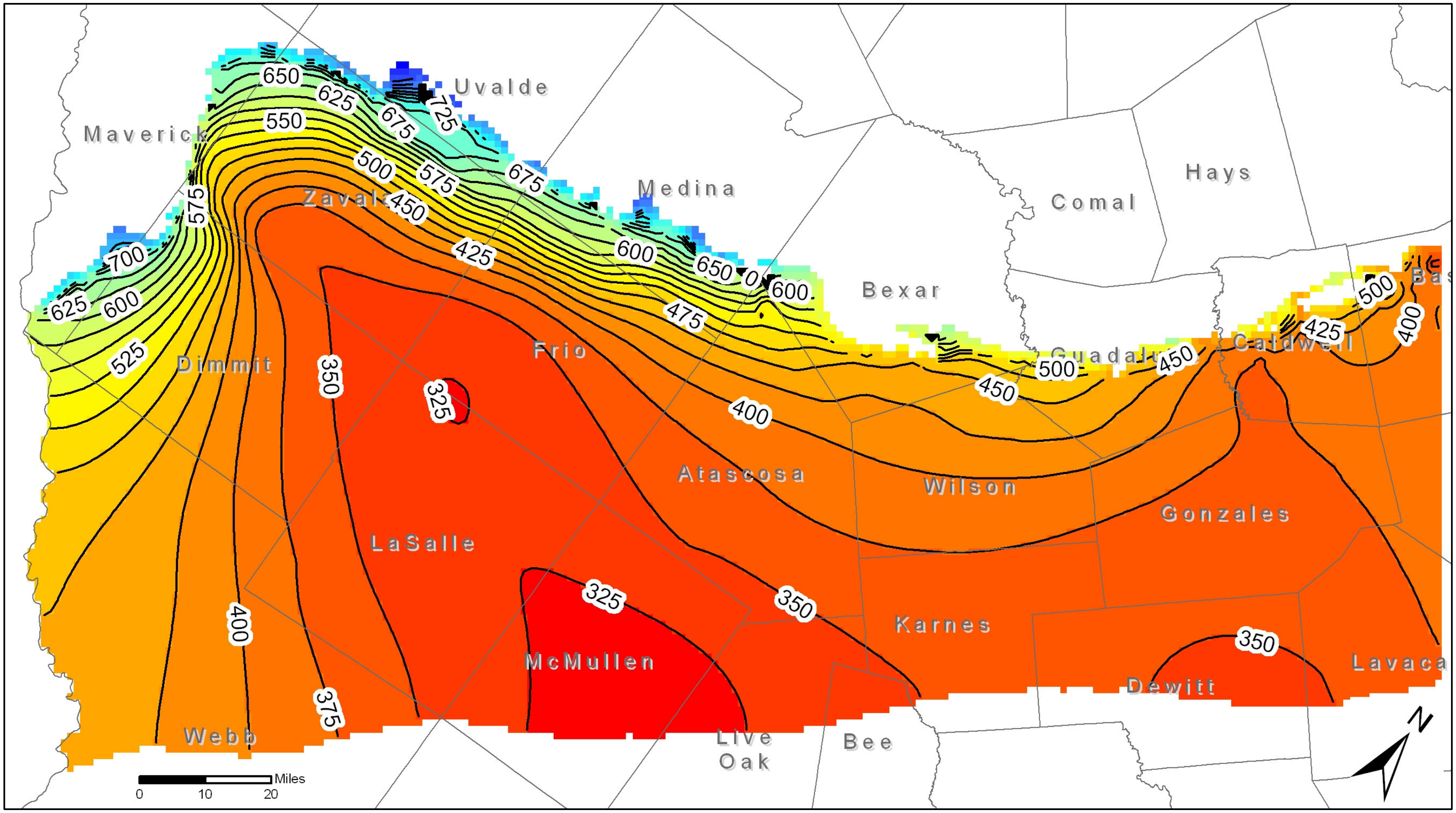


Figure 7. Initial water level elevations for the predictive model run in the lower Wilcox Aquifer from the southern part of the Queen City, Sparta, and Carrizo-Wilcox aquifers groundwater availability model. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black.

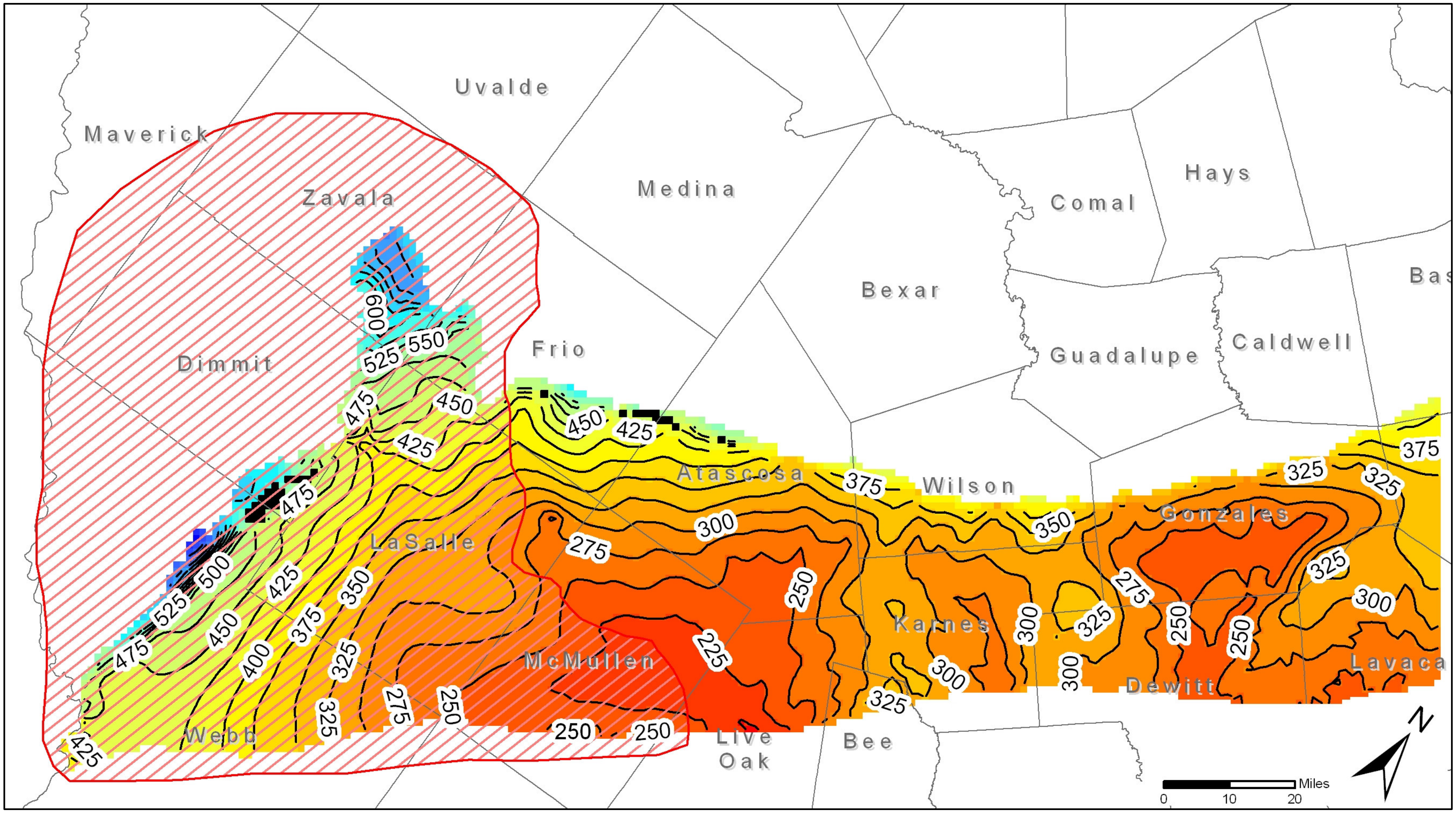


Figure 8. Water level elevations after 60 years using the specified pumpage in the Sparta Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black. The area west of the Frio River (shown in red) is not considered to be part of the Sparta Aquifer and does not have any pumpage assigned to it.

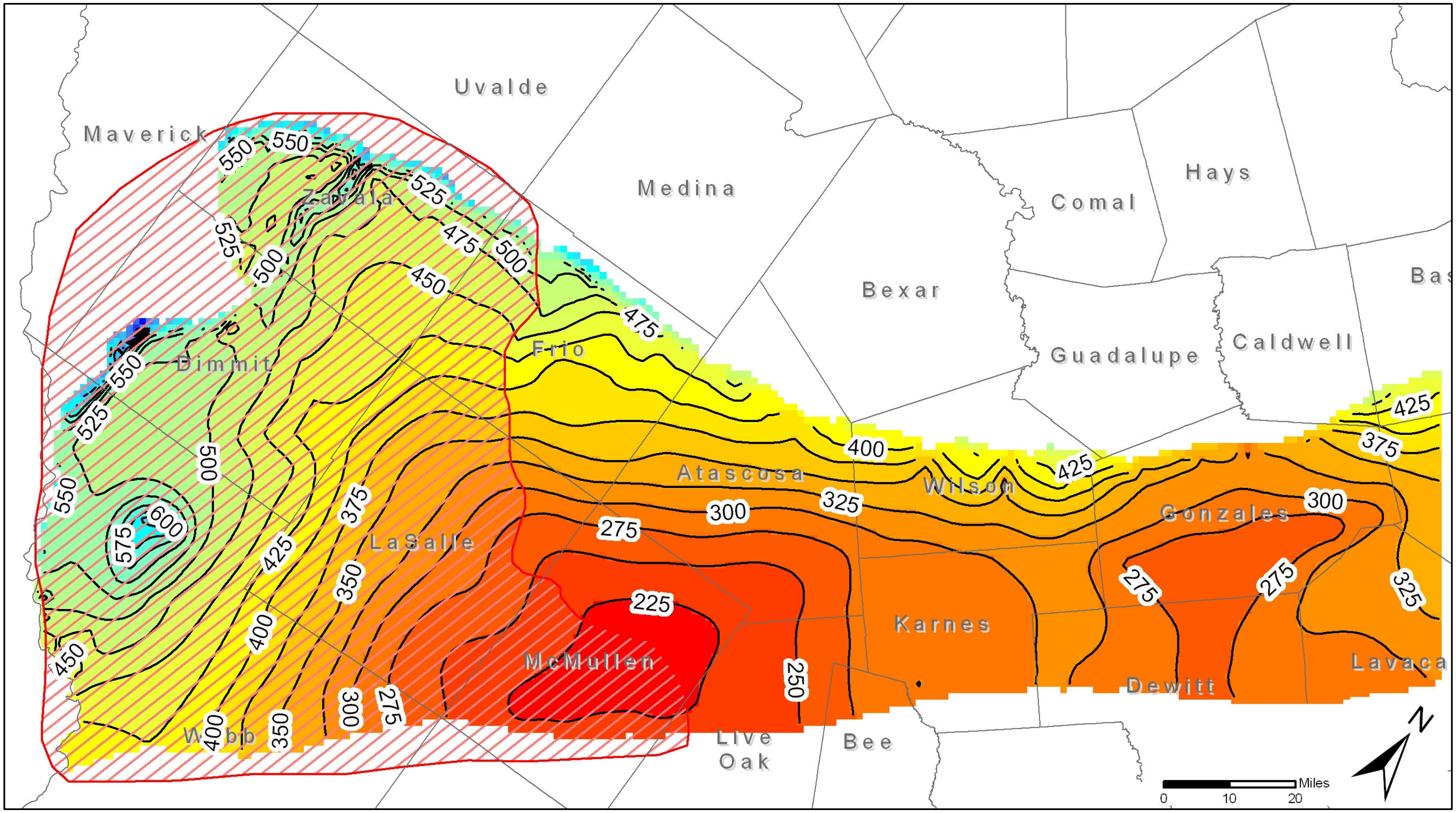


Figure 9. Water level elevations after 60 years using the specified pumpage in the Queen City Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black. The area west of the Frio River (shown in red) is not considered to be part of the Queen City Aquifer and does not have any pumpage assigned to it.

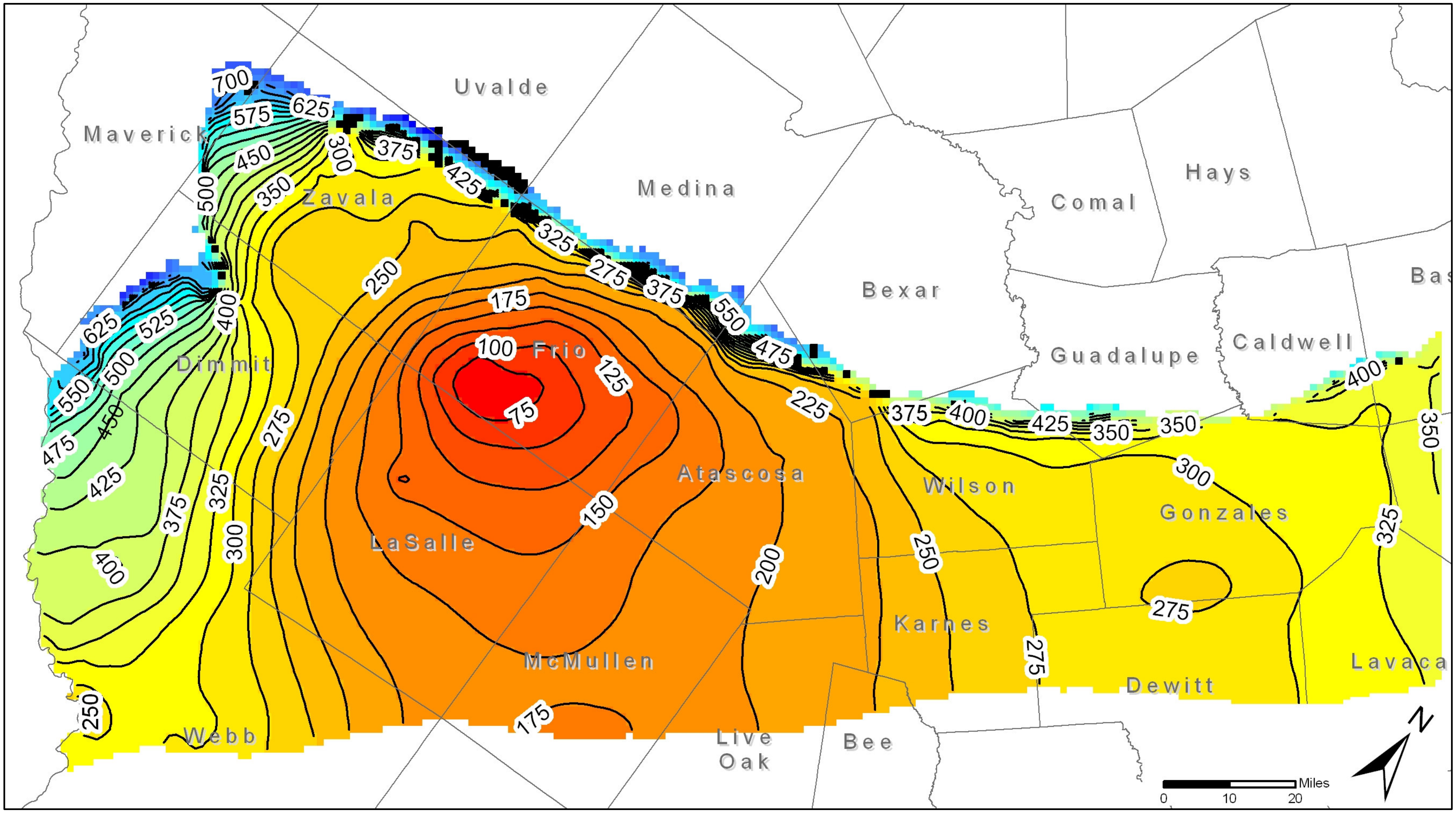


Figure 10. Water level elevations after 60 years using the specified pumpage in the Carrizo Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black.

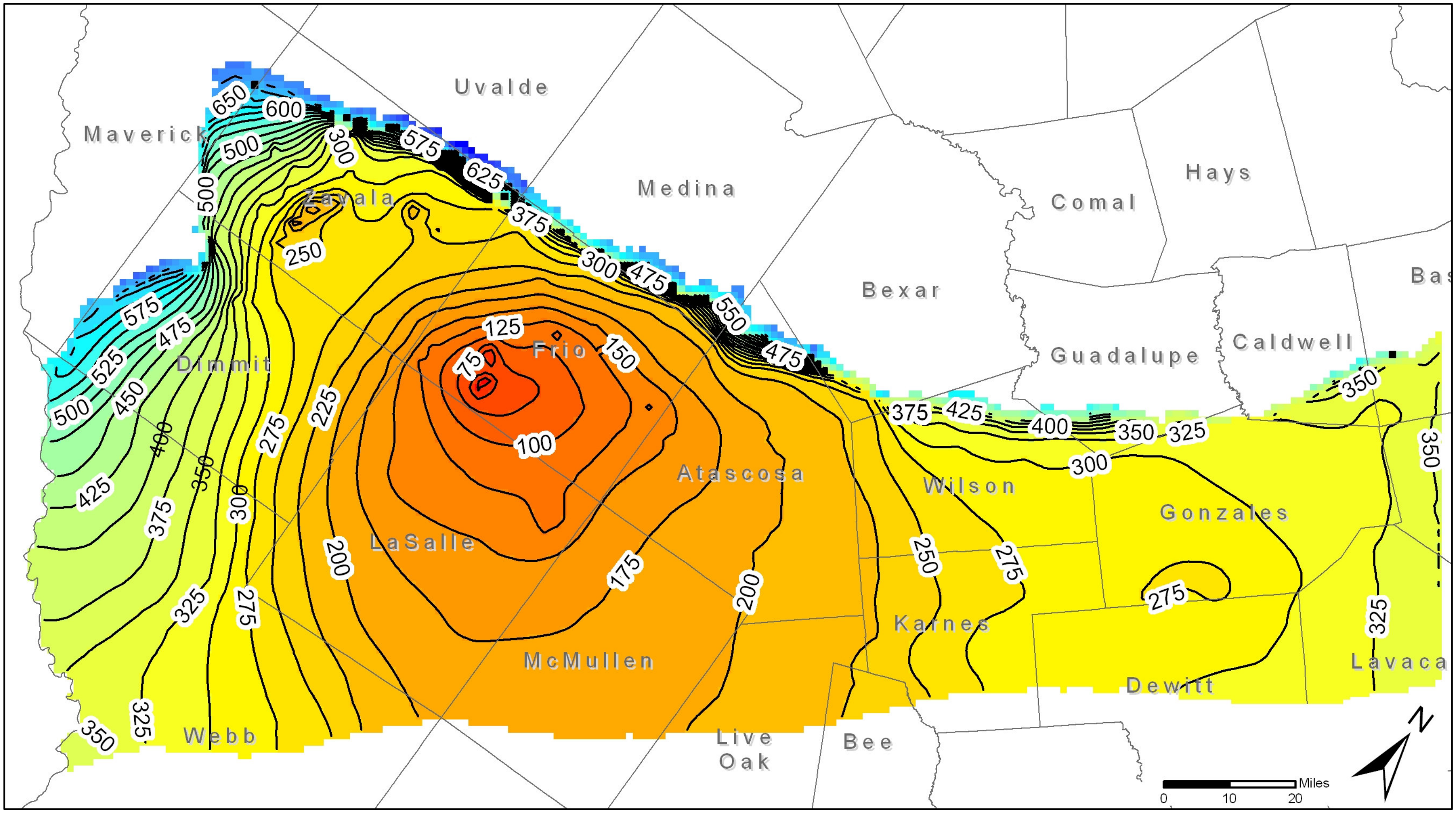


Figure 11. Water level elevations after 60 years using the specified pumpage in the upper Wilcox Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black.

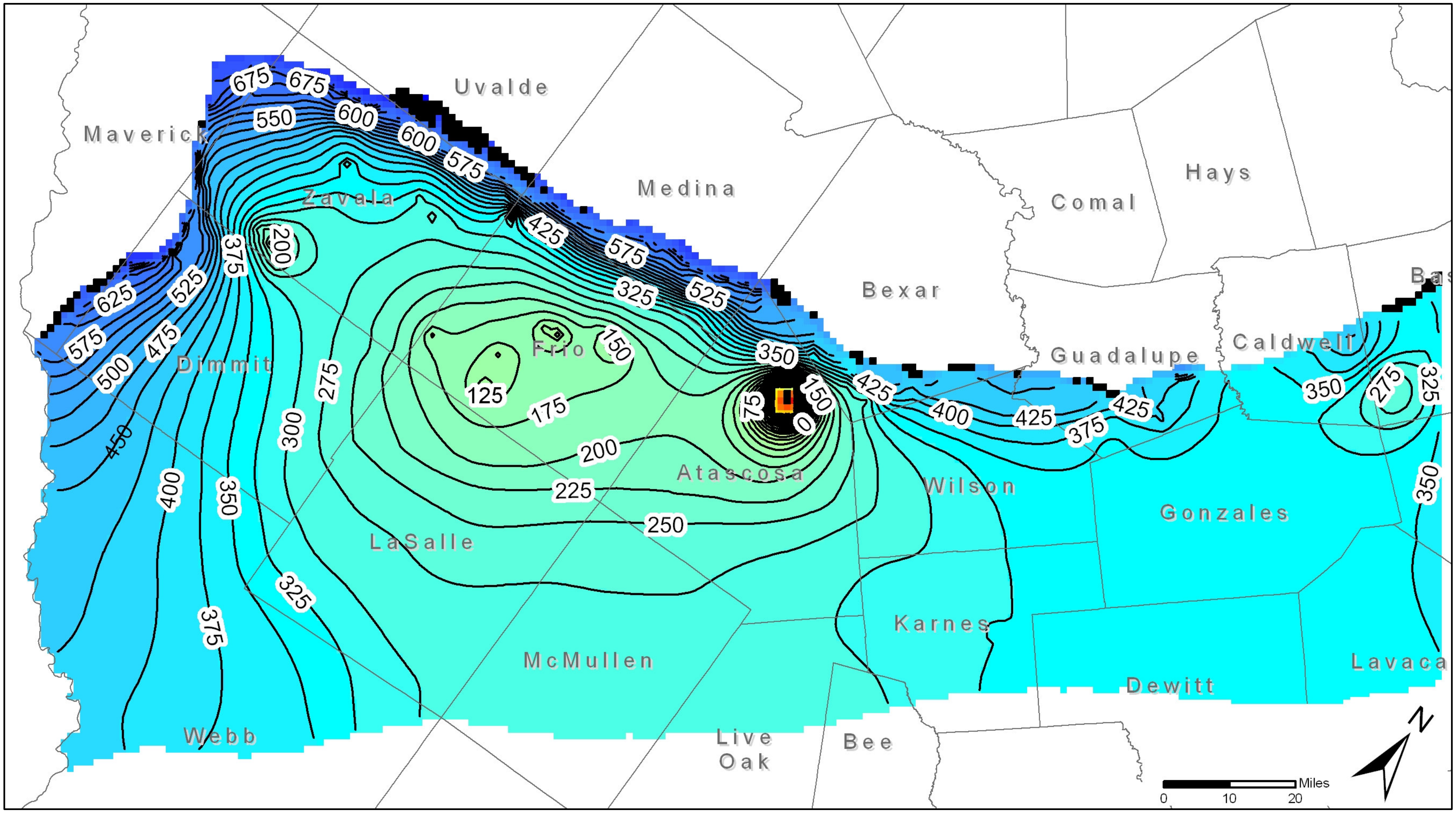


Figure 12. Water level elevations after 60 years using the specified pumpage in the middle Wilcox Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black.

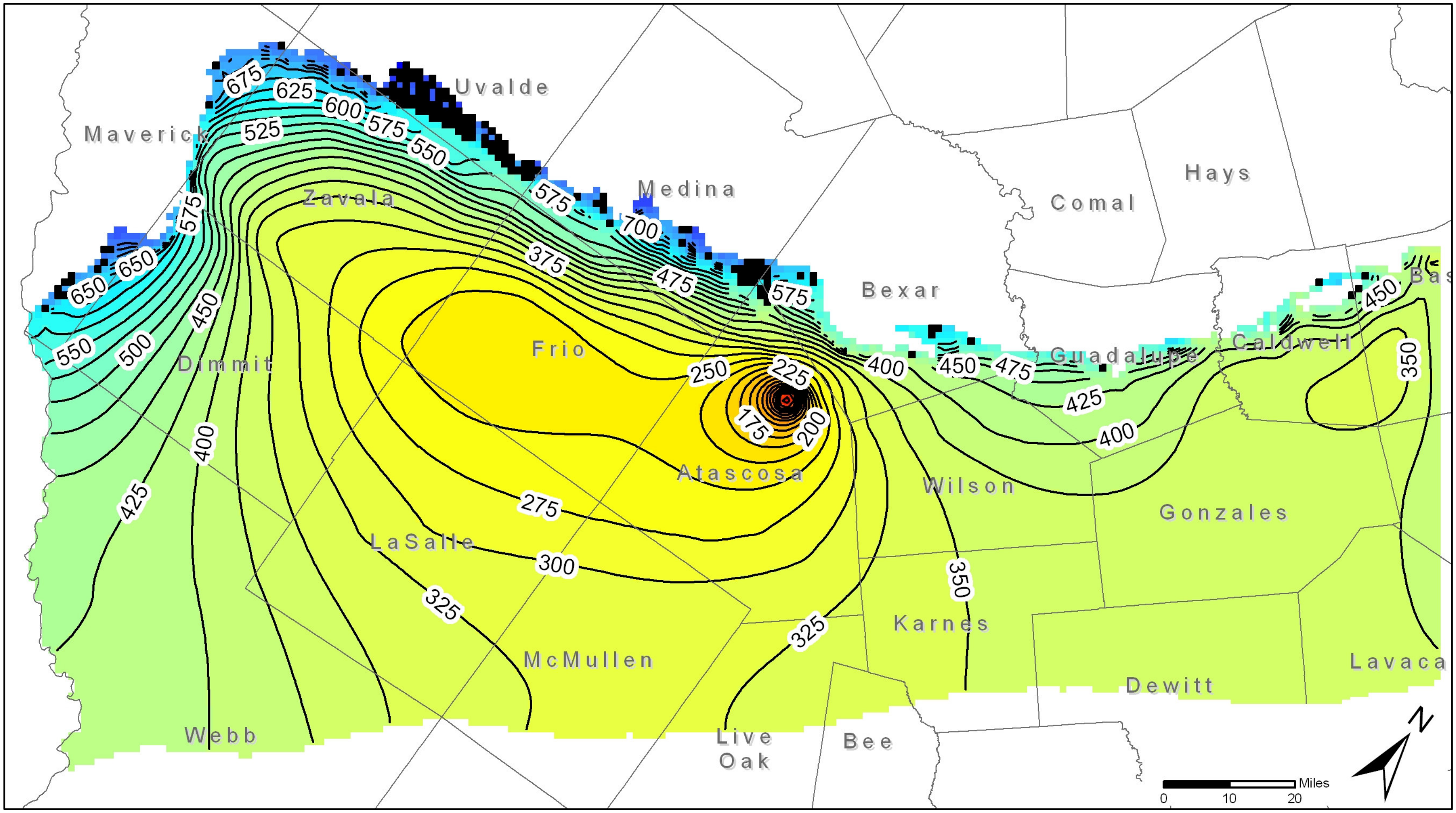


Figure 13. Water level elevations after 60 years using the specified pumpage in the lower Wilcox Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet. Dry model cells are shown in black.

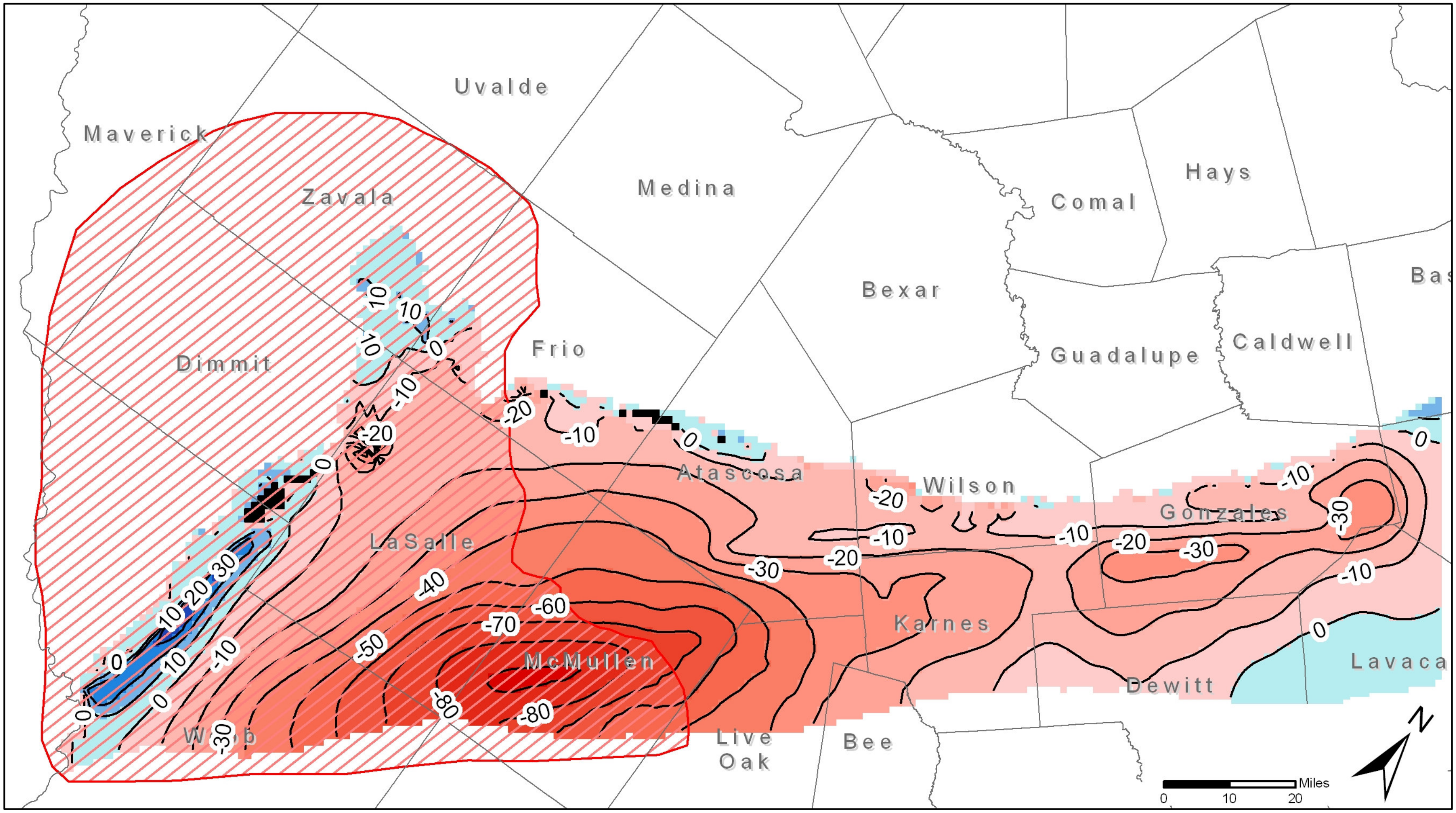


Figure 14. Water level changes after 60 years using the specified pumpage in the Sparta Aquifer. Water level changes are in feet. Contour interval is 10 feet. Areas of increasing water levels are shown in blue. Areas of decreasing water levels are shown in red. Dry model cells are shown in black. The area west of the Frio River (shown in red) is not considered to be part of the Sparta Aquifer and does not have any pumpage assigned to it.

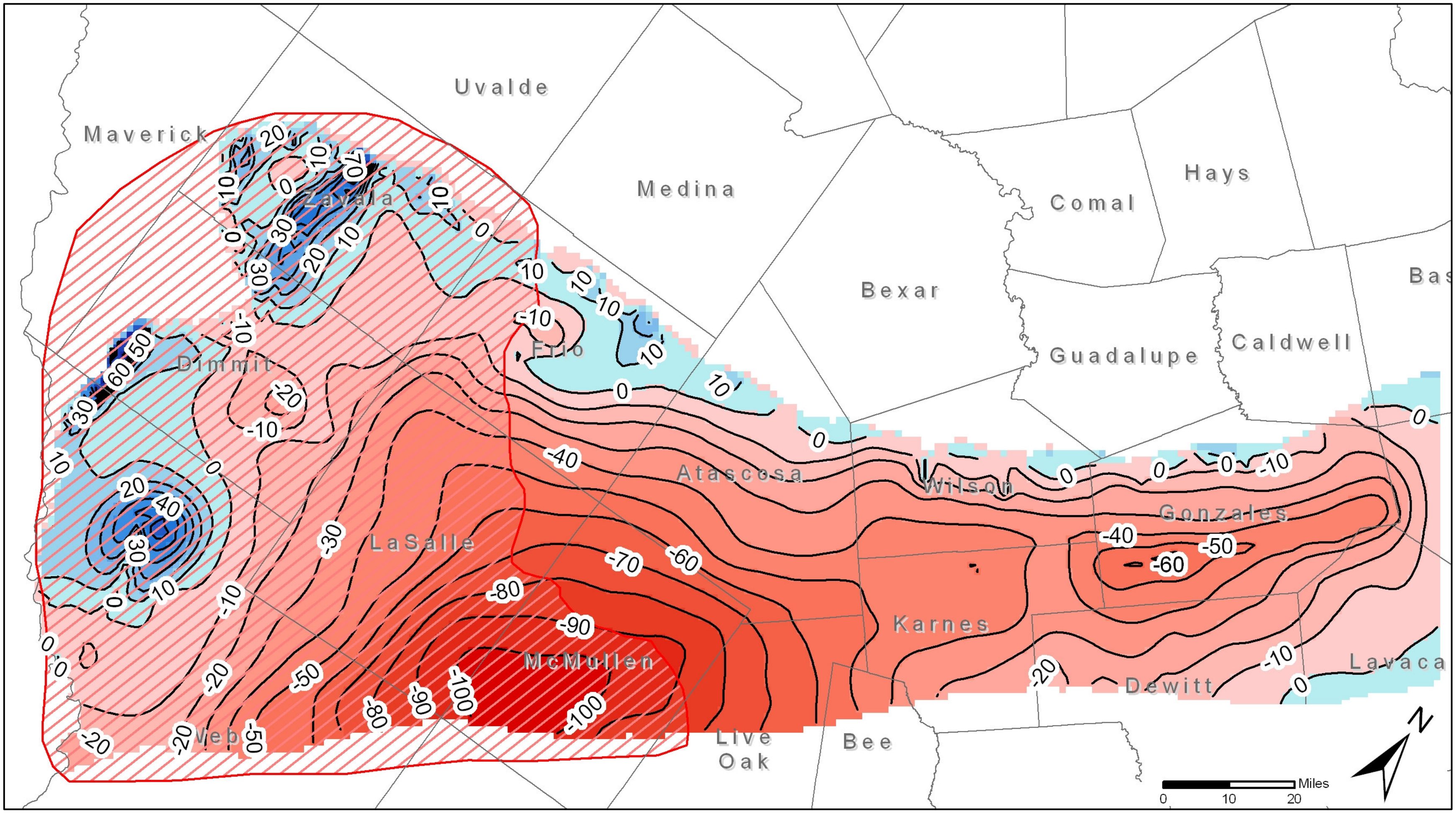


Figure 15. Water level changes after 60 years using the specified pumpage in the Queen City Aquifer. Water level changes are in feet. Contour interval is 10 feet. Areas of increasing water levels are shown in blue. Areas of decreasing water levels are shown in red. Dry model cells are shown in black. The area west of the Frio River (shown in red) is not considered to be part of the Queen City Aquifer and does not have any pumpage assigned to it.

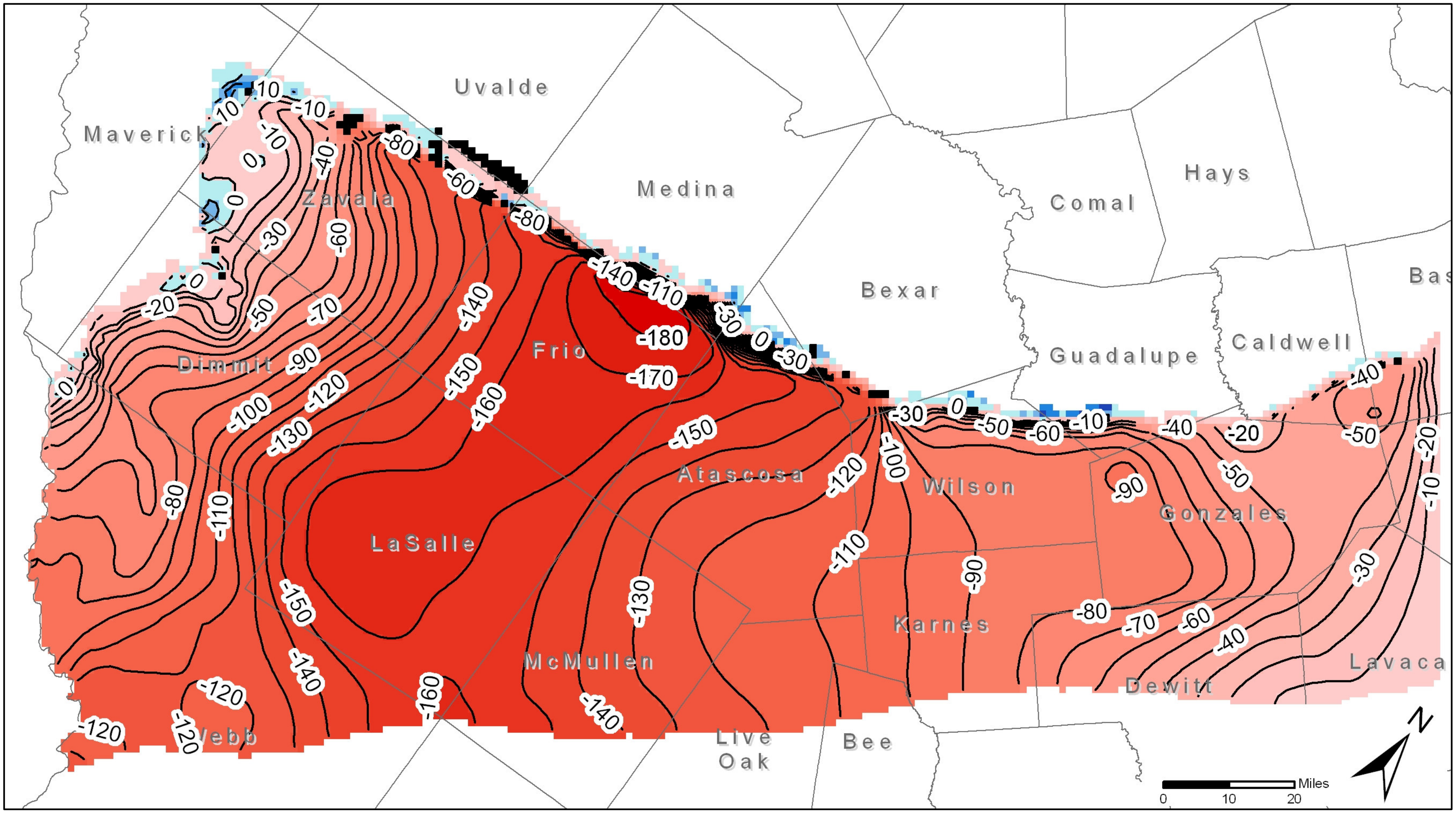


Figure 16. Water level changes after 60 years using the specified pumpage in the Carrizo Aquifer. Water level changes are in feet. Contour interval is 10 feet. Areas of increasing water levels are shown in blue. Areas of decreasing water levels are shown in red. Dry model cells are shown in black.

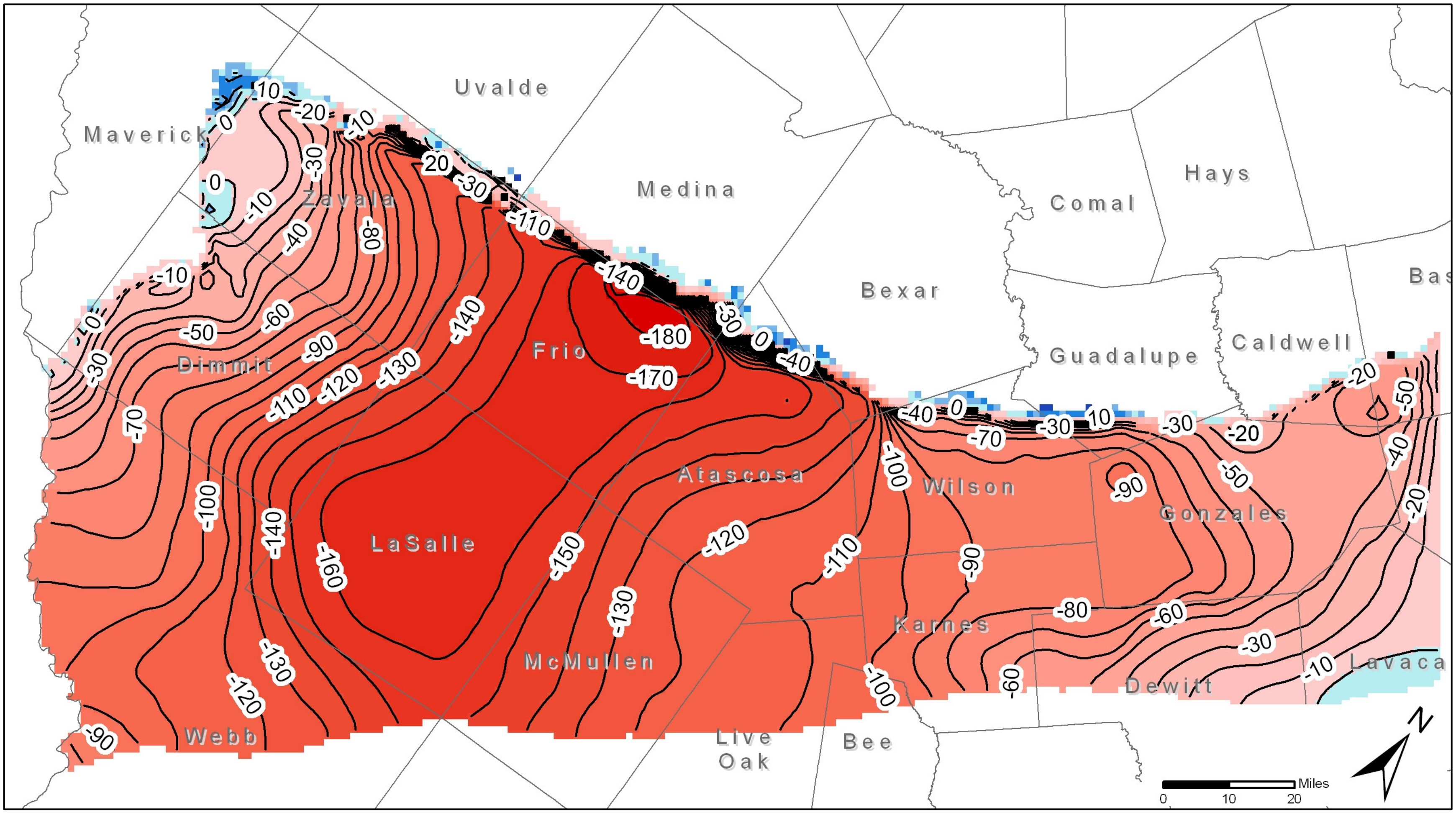


Figure 17. Water level changes after 60 years using the specified pumpage in the upper Wilcox Aquifer. Water level changes are in feet. Contour interval is 10 feet. Areas of increasing water levels are shown in blue. Areas of decreasing water levels are shown in red. Dry model cells are shown in black.

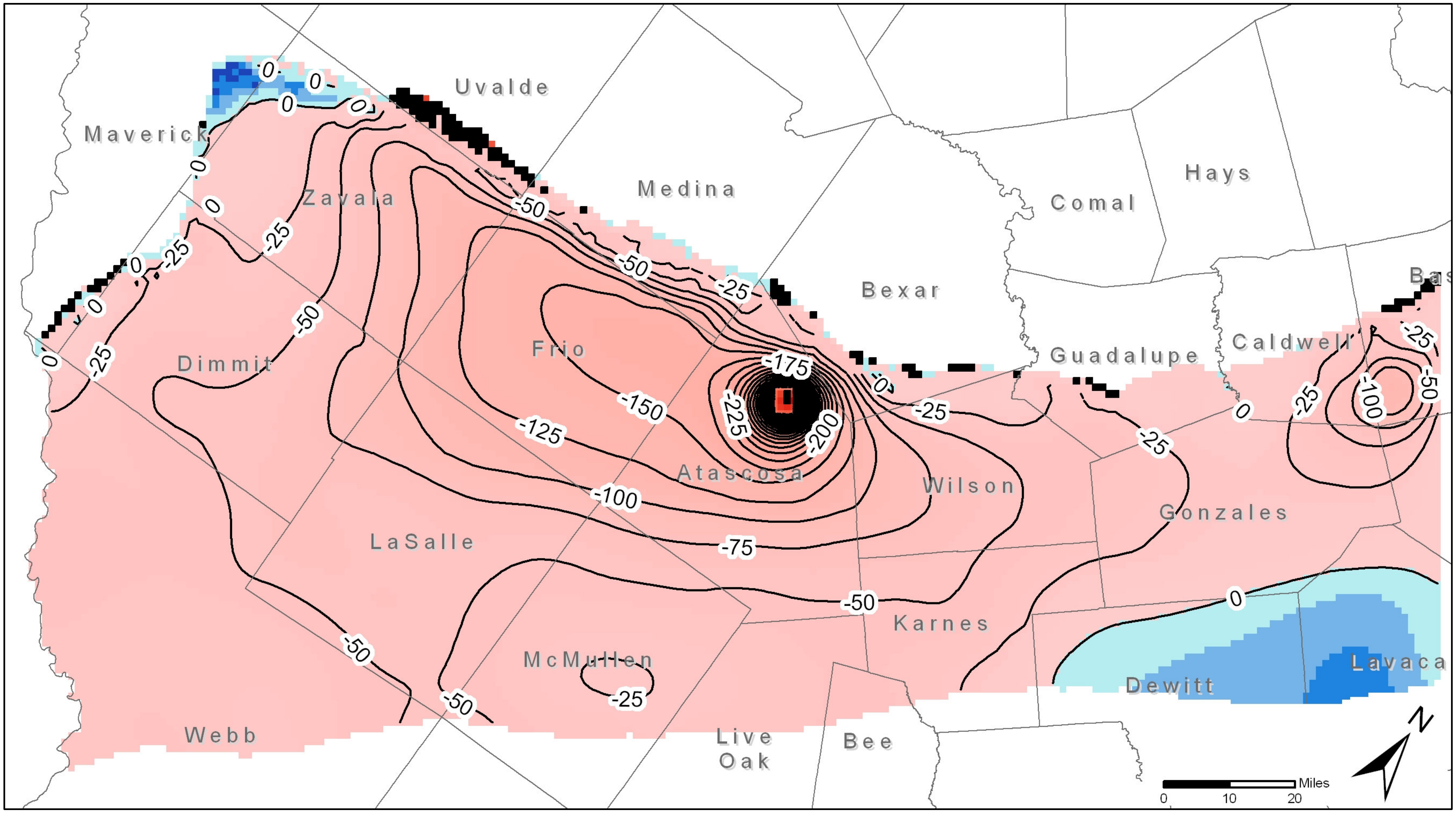


Figure 18. Water level changes after 60 years using the specified pumpage in the middle Wilcox Aquifer. Water level changes are in feet. Contour interval is 25 feet. Areas of increasing water levels are shown in blue. Areas of decreasing water levels are shown in red. Dry model cells are shown in black.

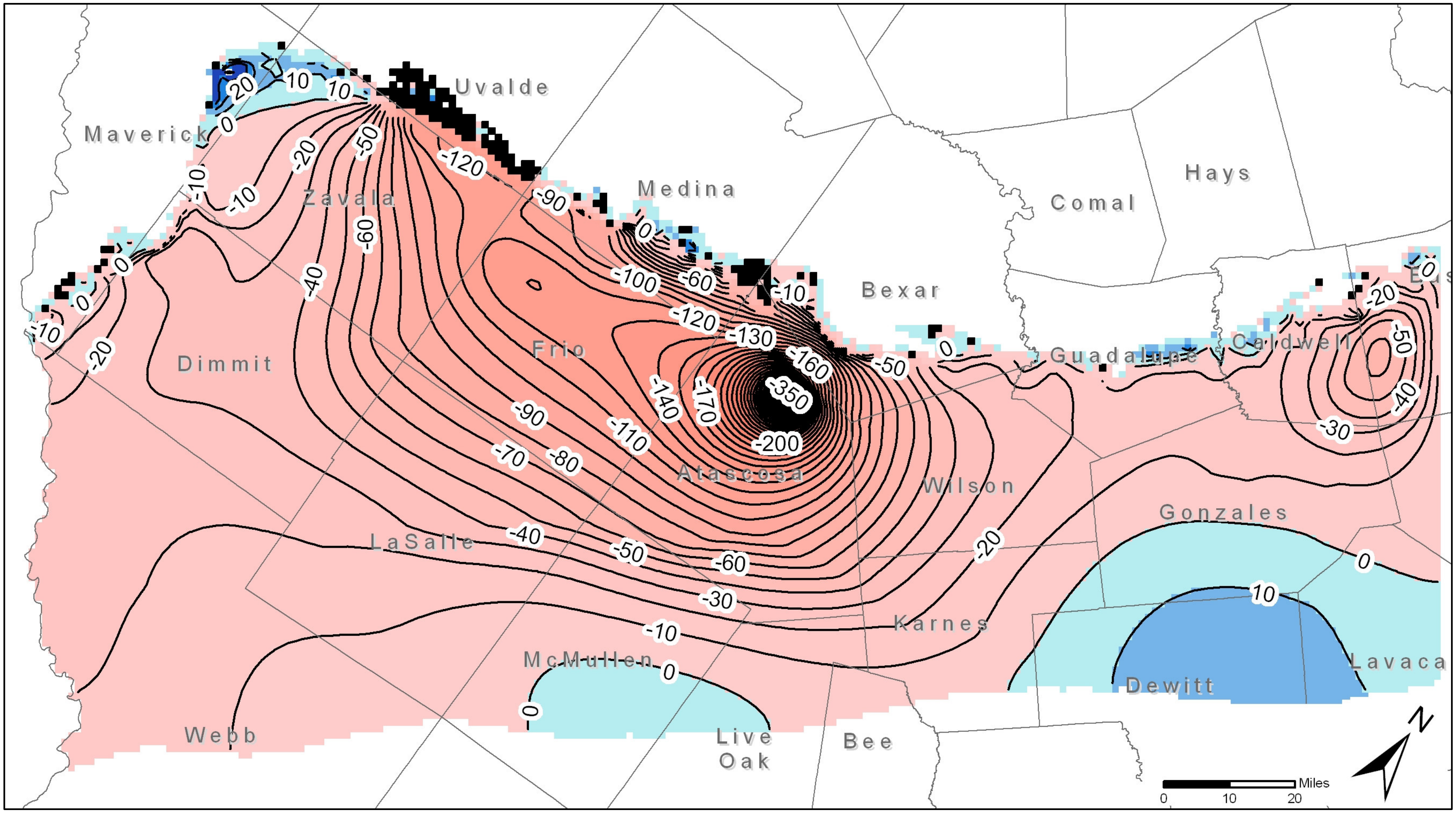


Figure 19. Water level changes after 60 years using the specified pumpage in the lower Wilcox Aquifer. Water level changes are in feet. Contour interval is 10 feet. Areas of increasing water levels are shown in blue. Areas of decreasing water levels are shown in red. Dry model cells are shown in black.

Appendix A

Summary of Budgets After 60 Years

Table A-1. Annual water budgets for each county in Groundwater Management Area 13 at the end of the 60-year predictive model run using the specified pumpage in the groundwater availability model for the southern part of the Queen City/Sparta Aquifer (which includes the Carrizo-Wilcox Aquifer). Values are reported in acre-feet per year.

	Atascosa		Bee		Bexar		Caldwell		De Witt		Dimmit		Frio	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Sparta														
Storage	805	116	26	0	--	--	--	--	90	0	666	385	1,642	230
Reservoirs (River Package)	0	0	0	0	--	--	--	--	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	--	--	--	--	0	0	0	0	0	0
Lateral Inflow (GHB Package)	7,033	2,016	79	8	--	--	--	--	215	502	263	13	8,477	495
Wells	0	1,149	0	0	--	--	--	--	0	0	0	0	0	1,221
Rivers and Streams (Stream Package)	231	413	0	0	--	--	--	--	0	0	491	840	373	186
Recharge	2,306	0	0	0	--	--	--	--	0	0	3,302	0	4,277	0
Evapotranspiration	0	0	0	0	--	--	--	--	0	0	0	154	0	74
Lateral Inflow	705	285	2	1	--	--	--	--	12	22	322	581	346	2,287
Vertical Leakage Downward	553	7,653	1	99	--	--	--	--	427	219	0	3,071	0	10,623
Queen City														
Storage	3,443	136	60	0	--	--	127	7	203	0	6,262	6,605	7,949	1,449
Reservoirs (River Package)	0	0	0	0	--	--	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	--	--	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	--	--	0	0	0	0	0	0	0	0
Wells	0	4,378	0	0	--	--	0	328	0	0	0	0	0	8,001
Rivers and Streams (Stream Package)	3,579	1,554	0	0	--	--	198	86	0	0	9,409	4,004	7,537	2
Recharge	5,166	0	0	0	--	--	1,144	0	0	0	11,146	0	13,821	0
Evapotranspiration	0	0	0	0	--	--	0	0	0	0	0	0	0	0
Vertical Leakage Upward	7,972	442	64	0	--	--	--	--	97	346	3,850	5	11,804	0
Lateral Inflow	2,121	991	3	4	--	--	13	921	4	25	1,755	3,862	981	4,339
Vertical Leakage Downward	0	14,780	0	123	--	--	0	142	257	190	0	17,947	0	28,299

Table A-1. (continued)

	Atascosa		Bee		Bexar		Caldwell		De Witt		Dimmit		Frio	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Carrizo														
Storage	20,803	216	48	0	5,760	159	1,368	3	158	0	4,553	28	29,072	96
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	52,419	0	99	0	7,971	0	3,961	0	1	0	19,708	0	118,630
Rivers and Streams (Stream Package)	1,461	3	0	0	2,537	0	75	0	0	0	841	0	545	0
Recharge	8,119	0	0	0	4,350	0	5,531	0	0	0	5,490	0	1,811	0
Evapotranspiration	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Upward	18,107	0	176	0	135	0	1,635	0	182	230	19,362	0	33,871	0
Lateral Inflow	25,928	19,550	325	520	2,287	7,114	974	5,474	220	11	2,032	4,533	55,191	6,672
Vertical Leakage Downward	2,165	4,395	71	0	458	283	158	304	611	0	2,266	6,727	9,231	4,322
Upper Wilcox														
Storage	274	0	68	0	7	14	3	14	301	0	2,670	10	239	0
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	36	0	99	0	0	0	0	0	0	0	8,933	0	7,188
Rivers and Streams (Stream Package)	0	0	0	0	0	0	0	0	0	0	236	28	0	0
Recharge	0	0	0	0	434	0	0	0	0	0	345	0	0	0
Evapotranspiration	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Upward	4,395	2,165	0	71	283	458	304	158	0	611	6,727	2,266	4,322	9,231
Lateral Inflow	344	396	29	19	9	133	1	33	130	84	2,308	2,960	2,223	194
Vertical Leakage Downward	1,834	4,251	91	0	112	240	2	105	265	0	2,898	986	9,921	92

Table A-1. (continued)

	Atascosa		Bee		Bexar		Caldwell		De Witt		Dimmit		Frio	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Middle Wilcox														
Storage	5,523	127	86	0	3,401	5	1,959	0	115	47	2,185	1	1,438	0
Reservoirs (River Package)	0	0	0	0	1,668	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	105	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	11,487	0	99	0	5,461	0	4,025	0	0	0	1,270	0	4,859
Rivers and Streams (Stream Package)	642	0	0	0	3,241	122	1,079	5,805	0	0	275	0	0	0
Recharge	622	0	0	0	2,816	0	4,423	0	0	0	724	0	0	0
Evapotranspiration	0	0	0	0	0	12	0	0	0	0	0	0	0	0
Vertical Leakage Upward	4,251	1,834	0	91	240	112	105	2	0	265	986	2,898	92	9,921
Lateral Inflow	2,190	689	54	0	313	2,290	3,735	1,500	22	26	875	1,751	4,440	284
Vertical Leakage Downward	3,152	2,243	50	0	154	3,724	822	790	201	0	2,732	1,857	9,117	21
Lower Wilcox														
Storage	2,311	0	140	0	3,245	47	840	89	218	0	1,710	8	1,280	0
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	48	0	72	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	15,340	0	99	0	5,715	0	7,491	0	0	0	338	0	83
Rivers and Streams (Stream Package)	0	0	0	0	4,510	382	1,374	382	0	0	193	0	0	0
Recharge	0	0	0	0	5,308	0	4,665	0	0	0	268	0	0	0
Evapotranspiration	0	0	0	0	0	165	0	230	0	0	0	0	0	0
Vertical Leakage Upward	2,243	3,152	0	50	3,724	154	790	822	0	201	1,857	2,732	21	9,117
Lateral Inflow	14,719	781	104	96	1,527	11,803	2,434	1,016	233	250	3,383	4,332	9,081	1,182

Table A-1. (continued)

	Gonzales		Guadalupe		Karnes		La Salle		Lavaca		Live Oak		Maverick	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Sparta														
Storage	466	0	--	--	201	0	3,895	0	21	0	203	0	--	--
Reservoirs (River Package)	0	0	--	--	0	0	0	0	0	0	0	0	--	--
Springs (Drain Package)	0	5	--	--	0	0	0	0	0	0	0	0	--	--
Lateral Inflow (GHB Package)	1,302	2,928	--	--	1,042	574	14,910	3,043	256	615	57	370	--	--
Wells	0	3,748	--	--	0	0	0	1,403	0	0	0	0	--	--
Rivers and Streams (Stream Package)	0	926	--	--	0	0	0	1,663	0	0	0	0	--	--
Recharge	3,081	0	--	--	0	0	1,923	0	0	0	0	0	--	--
Evapotranspiration	0	1	--	--	0	0	0	420	0	0	0	0	--	--
Lateral Inflow	573	35	--	--	167	157	3,224	1,150	19	103	22	10	--	--
Vertical Leakage Downward	2,881	660	--	--	214	893	98	16,372	558	136	197	99	--	--
Queen City														
Storage	1,644	154	0	12	468	0	2,239	0	38	0	528	0	--	--
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Springs (Drain Package)	0	0	0	0	0	0	0	0	0	0	0	0	--	--
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	2	0	0	0	--	--
Wells	0	7,503	0	0	0	0	0	421	0	0	0	0	--	--
Rivers and Streams (Stream Package)	671	1,710	0	0	0	0	0	0	0	0	0	0	--	--
Recharge	6,094	0	39	0	0	0	0	0	0	0	0	0	--	--
Evapotranspiration	0	27	0	0	0	0	0	0	0	0	0	0	--	--
Vertical Leakage Upward	1,268	2,415	--	--	772	46	16,700	39	45	520	116	71	--	--
Lateral Inflow	2,698	57	1	8	498	207	6,611	1,240	16	96	23	60	--	--
Vertical Leakage Downward	1,067	1,576	0	21	0	1,485	0	23,850	524	9	0	535	--	--

Table A-1. (continued)

	Gonzales		Guadalupe		Karnes		La Salle		Lavaca		Live Oak		Maverick	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Carrizo														
Storage	2,132	0	4,228	458	418	0	1,044	0	24	0	300	0	9	685
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	831	0	0	0	0	0
Wells	0	28,421	0	2,184	0	1,803	0	23,884	0	1	0	2,398	0	144
Rivers and Streams (Stream Package)	785	0	288	0	0	0	0	0	0	0	0	0	447	94
Recharge	1,406	0	7,210	0	0	0	0	0	0	0	0	0	2,108	0
Evapotranspiration	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Upward	3,920	600	633	0	1,740	0	25,818	0	0	606	879	0	46	0
Lateral Inflow	20,117	792	51	9,551	3,389	5,051	9,979	12,336	1,121	1,899	1,523	1,096	4	820
Vertical Leakage Downward	1,511	59	220	436	1,321	13	1,784	2,404	529	0	793	0	26	898
Upper Wilcox														
Storage	33	0	2	0	299	0	1,569	0	90	0	420	0	0	106
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	499	0	0	0	0	0
Wells	0	1	0	0	0	0	0	10,931	0	0	0	0	0	136
Rivers and Streams (Stream Package)	0	0	0	0	0	0	0	0	0	0	0	0	84	24
Recharge	0	0	0	0	0	0	0	0	0	0	0	0	85	0
Evapotranspiration	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Upward	59	1,511	436	220	13	1,321	2,404	1,784	0	529	0	793	898	26
Lateral Inflow	123	3	3	95	37	73	5,593	1,053	17	147	53	279	16	150
Vertical Leakage Downward	1,314	14	87	212	1,045	0	4,202	0	70	0	599	0	34	675

Table A-1. (continued)

	Gonzales		Guadalupe		Karnes		La Salle		Lavaca		Live Oak		Maverick	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Middle Wilcox														
Storage	536	0	1,460	1	465	0	1,945	0	20	115	400	0	68	75
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	109	0	0	0	0	0
Wells	0	497	0	5,391	0	0	0	0	0	0	0	0	0	259
Rivers and Streams (Stream Package)	873	0	3,822	2,430	0	0	0	0	0	0	0	0	981	19
Recharge	125	0	5,508	0	0	0	0	0	0	0	0	0	591	0
Evapotranspiration	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Upward	14	1,314	212	87	0	1,045	0	4,202	0	70	0	599	675	34
Lateral Inflow	1,335	2,022	1,018	3,872	26	117	566	710	71	141	22	63	438	860
Vertical Leakage Downward	948	0	434	674	671	0	2,401	0	127	0	240	0	23	1,529
Lower Wilcox														
Storage	258	0	621	216	948	0	2,004	0	19	0	595	0	334	267
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	22	0	0	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	266	43	0	0	0	0
Wells	0	0	0	2,806	0	0	0	0	0	0	0	0	0	992
Rivers and Streams (Stream Package)	0	0	1,187	317	0	0	0	0	0	0	0	0	408	49
Recharge	0	0	4,644	0	0	0	0	0	0	0	0	0	1,353	0
Evapotranspiration	0	0	0	61	0	0	0	0	0	0	0	0	0	195
Vertical Leakage Upward	0	948	674	434	0	671	0	2,401	0	127	0	240	1,529	23
Lateral Inflow	2,317	1,626	929	4,199	936	1,213	2,747	2,349	210	325	247	602	35	2,132

Table A-1. (continued)

	McMullen		Medina		Uvalde		Webb		Wilson		Zavala	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Sparta												
Storage	481	0	--	--	--	--	217	2,884	1,220	0	3	1,183
Reservoirs (River Package)	0	0	--	--	--	--	0	0	0	0	0	0
Springs (Drain Package)	0	0	--	--	--	--	0	0	0	107	0	0
Lateral Inflow (GHB Package)	3,342	193	--	--	--	--	6,009	188	2,075	2,243	0	0
Wells	0	600	--	--	--	--	0	0	0	980	0	0
Rivers and Streams (Stream Package)	0	0	--	--	--	--	4,074	2,077	176	341	247	62
Recharge	0	0	--	--	--	--	3,201	0	2,403	0	4,362	0
Evapotranspiration	0	0	--	--	--	--	0	2,198	0	6	0	0
Lateral Inflow	632	119	--	--	--	--	357	861	69	475	34	148
Vertical Leakage Downward	24	3,567	--	--	--	--	172	5,823	184	1,975	0	3,253
Queen City												
Storage	1,956	0	--	--	--	--	1,623	14,828	4,178	99	1,872	14,075
Reservoirs (River Package)	0	0	--	--	--	--	0	0	0	0	0	0
Springs (Drain Package)	0	0	--	--	--	--	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	--	--	--	--	0	0	0	0	0	0
Wells	0	1,103	--	--	--	--	0	0	0	5,652	0	0
Rivers and Streams (Stream Package)	0	0	--	--	--	--	22,004	6,791	1,543	2,234	16,906	0
Recharge	0	0	--	--	--	--	10,787	0	7,482	0	10,722	0
Evapotranspiration	0	0	--	--	--	--	0	1,485	0	0	0	0
Vertical Leakage Upward	3,800	3	--	--	--	--	6,716	59	3,135	97	2,634	0
Lateral Inflow	1,476	62	--	--	--	--	1,147	3,124	98	1,686	1,116	1,163
Vertical Leakage Downward	0	6,063	--	--	--	--	0	15,994	0	6,667	0	18,011

Table A-1. (continued)

	McMullen		Medina		Uvalde		Webb		Wilson		Zavala	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Carrizo												
Storage	605	0	5,364	203	--	--	745	4	13,000	147	11,782	362
Reservoirs (River Package)	0	0	0	0	--	--	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	--	--	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	--	--	0	0	0	0	0	0
Wells	0	7,868	0	2,054	--	--	0	16,812	0	31,247	0	31,563
Rivers and Streams (Stream Package)	0	0	1,460	37	--	--	153	0	11,190	76	2,633	0
Recharge	0	0	8,726	0	--	--	529	0	8,696	0	6,558	0
Evapotranspiration	0	0	0	0	--	--	0	124	0	0	0	0
Vertical Leakage Upward	6,599	0	8	0	--	--	18,184	0	9,314	0	21,178	4
Lateral Inflow	2,572	4,250	1,604	14,867	--	--	68	2,685	6,894	19,745	5,675	15,574
Vertical Leakage Downward	2,375	33	0	0	--	--	2,638	2,694	2,589	469	7,246	7,570
Upper Wilcox												
Storage	1,357	0	89	42	0	0	2,114	0	53	0	334	96
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	24	0	42	0	0	0	242	0	72	0	8,294
Rivers and Streams (Stream Package)	0	0	0	0	0	0	58	102	0	0	0	0
Recharge	0	0	0	0	1,323	0	82	0	0	0	348	0
Evapotranspiration	0	0	0	0	0	0	0	69	0	0	0	0
Vertical Leakage Upward	33	2,375	1,509	656	0	0	2,694	2,638	469	2,589	7,570	7,246
Lateral Inflow	571	1,224	74	538	0	411	685	4,534	122	18	1,009	979
Vertical Leakage Downward	1,661	0	506	900	0	912	2,073	120	2,156	122	8,877	1,522

Table A-1. (continued)

	McMullen		Medina		Uvalde		Webb		Wilson		Zavala	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Middle Wilcox												
Storage	1,238	0	4,393	45	1,298	4	1,760	0	1,110	0	3,028	304
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	8	0	1,361	0	1,846	0	104	0	1,448	0	4,901
Rivers and Streams (Stream Package)	0	0	932	28	197	0	3,152	2,754	1,169	888	1,417	4
Recharge	0	0	2,619	0	83	0	82	0	968	0	1,006	0
Evapotranspiration	0	0	0	0	0	0	0	150	0	0	0	0
Vertical Leakage Upward	0	1,661	900	506	912	0	120	2,073	122	2,156	1,522	8,877
Lateral Inflow	50	194	337	2,945	34	309	457	823	1,947	1,172	1,784	940
Vertical Leakage Downward	575	0	127	4,422	0	366	657	324	1,134	785	8,837	2,570
Lower Wilcox												
Storage	1,352	0	3,557	246	3,143	23	1,526	0	922	0	1,696	440
Reservoirs (River Package)	0	0	0	0	0	0	0	0	0	0	0	0
Springs (Drain Package)	0	0	0	0	0	0	0	0	0	0	0	0
Lateral Inflow (GHB Package)	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	0	0	2,364	0	1,755	0	17	0	1,086	0	440
Rivers and Streams (Stream Package)	0	0	113	193	329	0	0	100	207	0	790	83
Recharge	0	0	1,975	0	421	0	15	0	69	0	537	0
Evapotranspiration	0	0	0	273	0	0	0	42	0	0	0	0
Vertical Leakage Upward	0	575	4,422	127	366	0	324	657	785	1,134	2,570	8,837
Lateral Inflow	491	1,268	477	7,342	658	3,140	1,747	2,796	6,393	6,156	5,883	1,677