GAM Run 07-14

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October 15, 2007

EXECUTIVE SUMMARY:

We ran the groundwater availability model for the central part of the Gulf Coast Aquifer using a specified pumpage annually for a 60-year predictive simulation along with average recharge rates, evapotranspiration rates, and initial streamflows. The results of this model run indicated that using the specified pumpage in the model results in large areas of water level declines over the 60-year model run. These areas of water level declines are present for all three aquifers and are due to the increased pumpage throughout most of the model area.

REQUESTOR:

Mr. Mike Mahoney from the Evergreen Underground Water Conservation District (on behalf of Groundwater Management Areas 15 and 16).

DESCRIPTION OF REQUEST:

Mr. Mahoney asked for a baseline model run using the groundwater availability model for the central part of the Gulf Coast Aquifer. This model run would be a 60-year simulation using initial water levels from the end of the historic calibration simulation and average recharge conditions. Each year of the model run would use a pumpage approved by members of Groundwater Management Areas 15 and 16.

METHODS:

Recharge and evapotranspiration rates and initial streamflows were averaged for 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 baseline pumpage. Resulting water levels and drawdowns were then evaluated and are described in the "Results" section below.

PARAMETERS AND ASSUMPTIONS:

The groundwater availability model for the central part of the Gulf Coast Aquifer was used for this model run. The parameters and assumptions for this model are described below:

- We used Version 1.01 of the groundwater availability model for the central part of the Gulf Coast Aquifer. This model assumes partial penetrating wells in the Evangeline Aquifer due to a lack of data for aquifer properties in the lower portion of the aquifer.

- See Chowdhury and others (2004), and Waterstone and others (2003) for assumptions and limitations of the groundwater availability model for the central part of the Gulf Coast Aquifer.

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the entire model for 1999 is 26 feet, which is 4.6 percent of the hydraulic head drop across the model area (Chowdhury and others, 2004).

- The model includes four layers representing: the Chicot Aquifer (Layer 1), the Evangeline Aquifer (Layer 2), the Burkeville Confining Unit (Layer 3), and the Jasper Aquifer (Layer 4).

- Recharge rates, evapotranspiration rates, and initial streamflows are averages from the 1981 to 1999 calibration and verification time period.

- Pumpage used for each year of the 60-year predictive simulation was specified by members of Groundwater Management Areas 15 and 16. Details on this pumpage are given below.

Specified Pumpage

The pumpage specified by the members of Groundwater Management Areas 15 and 16 was based on the baseline pumpage constructed for GAM Run 07-12 (Donnelly, 2007). The assumptions used to create the baseline pumpage are detailed in the GAM Run 07-12 report (http://www.twdb.state.tx.us/gam/GAMruns/GR07-12.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 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, for five counties (Bee, Jim Wells, Kleberg, Live Oak, and Nueces), a total county pumpage specified by individual members of Groundwater Management Areas 15 or 16 was used. The total amount of pumpage used in each county in this simulation is shown in Table 1. Also included in Table 1 is the amount of pumpage assigned to each of the three aquifers (Chicot, Evangeline, and Jasper) within the Gulf Coast Aquifer System. The amount assigned to each individual aquifer was determined based on the percentages pumped from each aquifer in the baseline pumpage data set, unless the pumpage to each aquifer was specified by members of the Groundwater Management Areas 15 or 16.

Table 1. Specified pumpage used in this model simulation. Pumpage is reported in acre-feet per year.

County	GAM Run 07-12 baseline pumpage	GAM Run 07-14 specified pumpage	Additional pumpage	Additional Chicot pumpage	Additional Evangeline pumpage	Additional Jasper pumpage
Aransas	1,827	1,827	0	0	0	0
Bee	4,694	24,000	19,306	5,694	12,356	1,351
Brooks	4,040	4,040	0	0	0	0
Calhoun	1,517	2,940	1,423	1,387	36	0
Colorado	33,236	47,857	14,621	7,448	6,898	275
Dewitt	4,587	15,866	11,279	3,384	6,767	1,128
Duval	7,749	14,039	6,290	338	3,585	2,390
Fayette	2,197	8,697	6,500	0	715	5,785
Goliad	6,143	12,810	6,667	706	5,961	0
Jackson	53,615	87,876	34,261	24,979	9,282	0
Jim Hogg	981	4,880	0	0	0	0
Jim Wells	4,761	50,000	45,239	11,310	33,929	0
Karnes	2,897	15,200	12,303	0	1,107	11,196
Kenedy	104	250	0	0	0	0
Kleberg	8,634	50,000	41,366	4,137	37,229	0
Lavaca	11,376	38,123	26,747	4,060	16,583	6,152
Live Oak	8,693	16,000	7,307	97	2,192	5,042
Matagorda	35,000	49,221	14,221	11,254	2,967	0
McMullen	29	300	271	0	3	268
Nueces	3,097	50,000	46,903	14,071	32,832	0
Refugio	1,063	42,320	41,257	6,257	35,000	0
San Patricio	3,748	6,002	2,254	1,446	808	0
Victoria	13,872	41,129	27,257	15,091	12,166	0
Webb	143	3,000	2,857	0	2,716	141
Wharton	180,000	182,793	2,793	1,734	1,059	0

In addition to the total county pumpage, members of Groundwater Management Areas 15 and 16 also had the option of specifying where the new pumpage would be allocated. The following specifications were made on where and how pumpage should be allocated.

- Bee County—ninety percent (90%) of the total pumpage was placed in the shaded area in the southern half of Bee County, as shown in Figure 1. Pumpage was allocated to the three aquifers within the Gulf Coast Aquifer System based on the percentage in the baseline pumpage data set.

- Jim Wells County—seventy-five percent (75%) of the total pumpage was allocated to the Evangeline Aquifer in the shaded area shown in Figure 2.

- Kleberg County—ninety percent (90%) of the total pumpage was allocated to the Evangeline Aquifer in the shaded area shown in Figure 2.

- Live Oak County—eighty percent (80%) of the total pumpage was placed in the shaded area in the southern half of Live Oak County, as shown in Figure 1. Pumpage was allocated to the three aquifers within the Gulf Coast Aquifer System based on the percentage in the baseline pumpage data set.

- Refugio County—35,000 acre-feet per year of pumpage was allocated to the Evangeline Aquifer and placed in two areas, shown in green in Figure 3. The remainder of the pumpage for the county, approximately 6,257 acre-feet per year, was allocated to the Chicot Aquifer and placed in the three red areas shown in Figure 3.

If locations for pumpage were not specified by members of either Groundwater Management Area the additional pumpage was distributed evenly across the entire active portion of each aquifer within each county.

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. 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 using the MODFLOW Well package.

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

- Recharge—simulates areally distributed recharge due to precipitation falling on the outcrop 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 aquifers. This flow is controlled by the 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.

- 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 using the MODFLOW Evapotranspiration 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 using the MODFLOW Stream package.

- General-Head Boundary—the model uses general-head boundaries to simulate the movement of water out of the Chicot Aquifer at the coast.

The results of the model run are described for the three aquifers in the model area; the Chicot (layer 1 in the model), the Evangeline (layer 2), and the Jasper (layer 4) aquifers. Results for the Burkeville Confining Unit (layer 3) are not discussed because this is not a major source of water in the region.

Initial water levels (which are from the end of the transient calibration run- the end of 1999) for the Chicot, Evangeline, and Jasper aquifers are shown in Figures 4, 5, and 6, respectively. 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 farthest from the coast, and that water levels decrease as groundwater flows downdip towards the coast. A cone of depression (an area of decreased water levels around an area of heavy pumpage) can be observed in the Evangeline Aquifer in south-central Wharton County, as well as around the cities of Victoria and Kingsville in Victoria and Kleberg counties, respectively (Figure 5). Small cones of depression can also be observed in the Jasper Aquifer in southern Duval County, central Live Oak County, central DeWitt County, and central Lavaca County.

Water levels at the end of the 60-year predictive simulation for the Chicot, Evangeline, and Jasper aquifers are shown in Figures 7, 8, and 9, respectively. Water levels at the end of the 60-year runs show the impact of the increased pumpage in many parts of the model area (Figures 4 to 6). Large new areas of drawdown are evident in the water level map for the Chicot Aquifer (Figure 7) in Kleberg County, and an area of drawdown in Jackson and Wharton counties that was present in the initial water level map (Figure 4) has expanded because of the additional pumpage in Jackson County.

Water levels in the Evangeline Aquifer (Figure 8) also show the impact of the additional pumpage in some areas of the model. Significant areas of depression in the water levels can be seen in Figure 8 in Jim Wells and Kleberg counties. The impact of the additional pumpage in Refugio County in the two designated areas of the Evangeline can also be seen in Figure 8.

In the Jasper Aquifer, differences initial water levels (Figure 6) and water levels after 60 years (Figure 9) are harder to discern because less pumpage was added to this aquifer than either the Chicot or Evangeline Aquifers. One area of decline can be seen in Figure 9 in southern Karnes County, where the largest concentration of Jasper pumpage is located.

In addition to water level maps, maps of water level changes for each aquifer were made. A water level change map shows the difference between the initial water levels and the water levels at the end of the 60-year run. These figures will help evaluate the impact of pumpage on the water levels over the length of the model run. Water level changes over the 60-year predictive simulation for the Chicot, Evangeline, and Jasper aquifers are shown in Figures 10, 11, and 12, respectively.

Water levels in the Chicot Aquifer (Figure 10) show a decline (drawdown) throughout most of the model area, including an area in Jackson and Wharton counties where the declines are in excess of 50 feet. Declines can also be observed in Bee, Colorado, Jim Wells, Matagorda, and Nueces counties where pumpage in the Chicot Aquifer was significantly increased. Although pumpage in Victoria County was also increased in this model run, water levels show an increase across the county. This is due to the response of the aquifer to the decrease in pumpage from the City of Victoria that was incorporated into the baseline pumpage. An increase in water levels can also be observed at the southern edge of the model in Brooks, Jim Hogg, and Kenedy counties. However, this is an unavoidable artifact of the way the model was constructed and should be ignored for management decisions.

In the Evangeline Aquifer (Figure 11) decreases in water levels are observed across most of the model area. Extremely high drawdowns are observed in Jim Wells and Kleberg counties where large concentrations of pumpage from the Evangeline were placed in limited areas. Other areas of higher water level declines can be seen in Refugio County in the two areas where pumpage was added to the Evangeline. Throughout most of the rest of the model area water level declines in the Evangeline Aquifer are less than 25 feet. Water levels are predicted to recover in Victoria County due to the decrease in pumpage from the Evangeline for the City of Victoria. As with Figure 10, water level increases at the southern edge of the model are a result of the model construction and are not considered to be accurate.

In the Jasper Aquifer (Figure 12) significant declines in water levels can be observed throughout the model area. Several areas of significant decline in Fayette, Karnes, Lavaca, and Live Oak counties can be observed in Figure 12, all due to pumpage added to the Jasper Aquifer for this model run. Water-level declines of up to 30 feet can be observed in Figure 12 for much of the rest of the model area. An area of higher drawdown in southern Duval County can be seen, however this was also observed in the baseline model run (GAM Run 07-12) and is not due to additional pumpage used in this model run. A localized area of recovery can also be observed in Bee County, which was also observed in the baseline model run and is not due to pumpage used in this simulation. As with Figures 10 and 11, water level increases at the southern edge of the model are a result of the model construction and are not considered to be accurate.

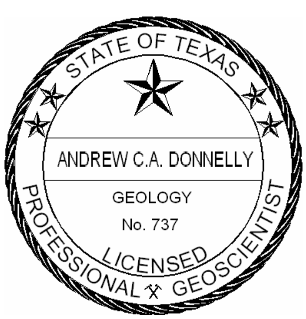
Because some of the desired future conditions for the groundwater management area may be based on discharge to springs or baseflow to rivers and streams, we also pulled the water budgets for each of these components for each county in the model area. These budgets are provided in Appendix A. The components 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:

Chowdhury, A.H., Wade, S., Mace, R.E., and Ridgeway, C., 2004, Groundwater Availability Model of the Central Gulf Coast Aquifer System: Numerical Simulations through 1999- Model Report, 114 p.

Donnelly, A.C.A., 2007, GAM Run 07-12, Texas Water Development Board GAM Run Report, 39 p.

Waterstone Engineering, Inc., and Parsons, Inc., 2003, Groundwater Availability of the Central Gulf Coast Aquifer: Numerical Simulations to 2050 Central Gulf Coast, Texas- Final Report: contract report to the Texas Water Development Board, 158 p.



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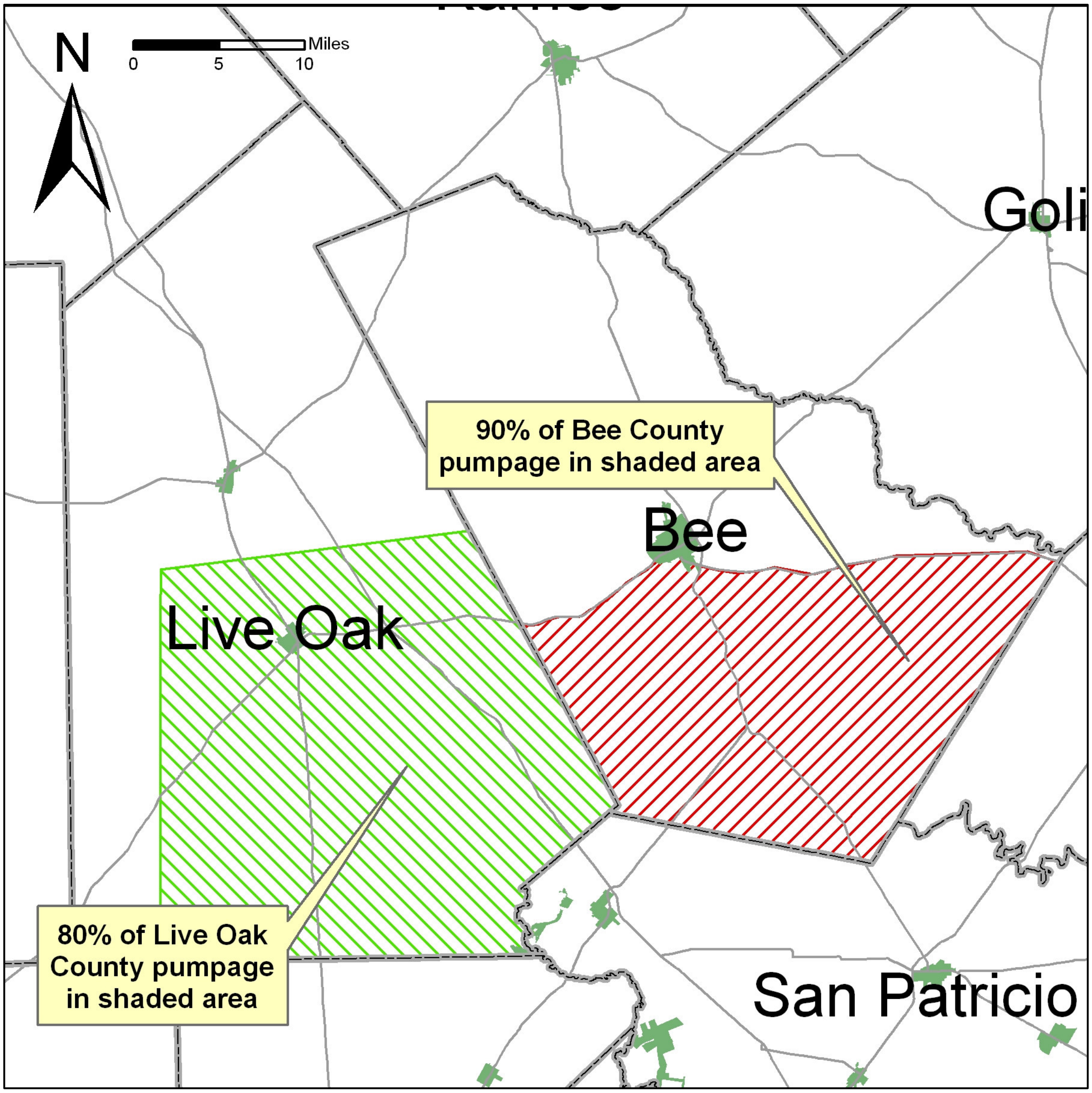

Figure 1. Location of additional pumpage in Bee and Live Oak counties. Pumpage in each county is concentrated in the shaded areas.

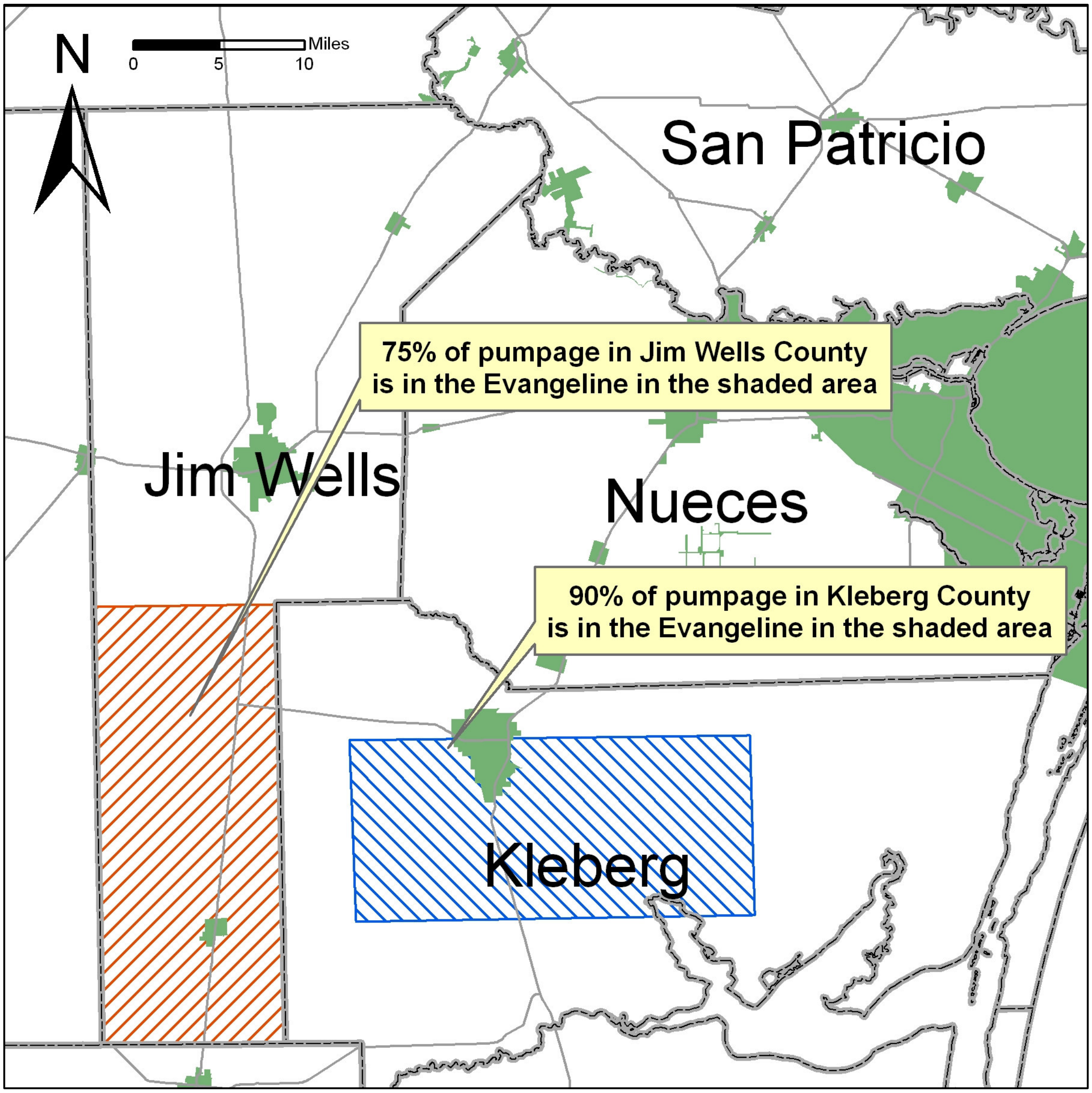

Figure 2. Location of additional pumpage in Jim Wells and Kleberg counties. Pumpage in each county is concentrated in the Evangeline Aquifer in the shaded areas.

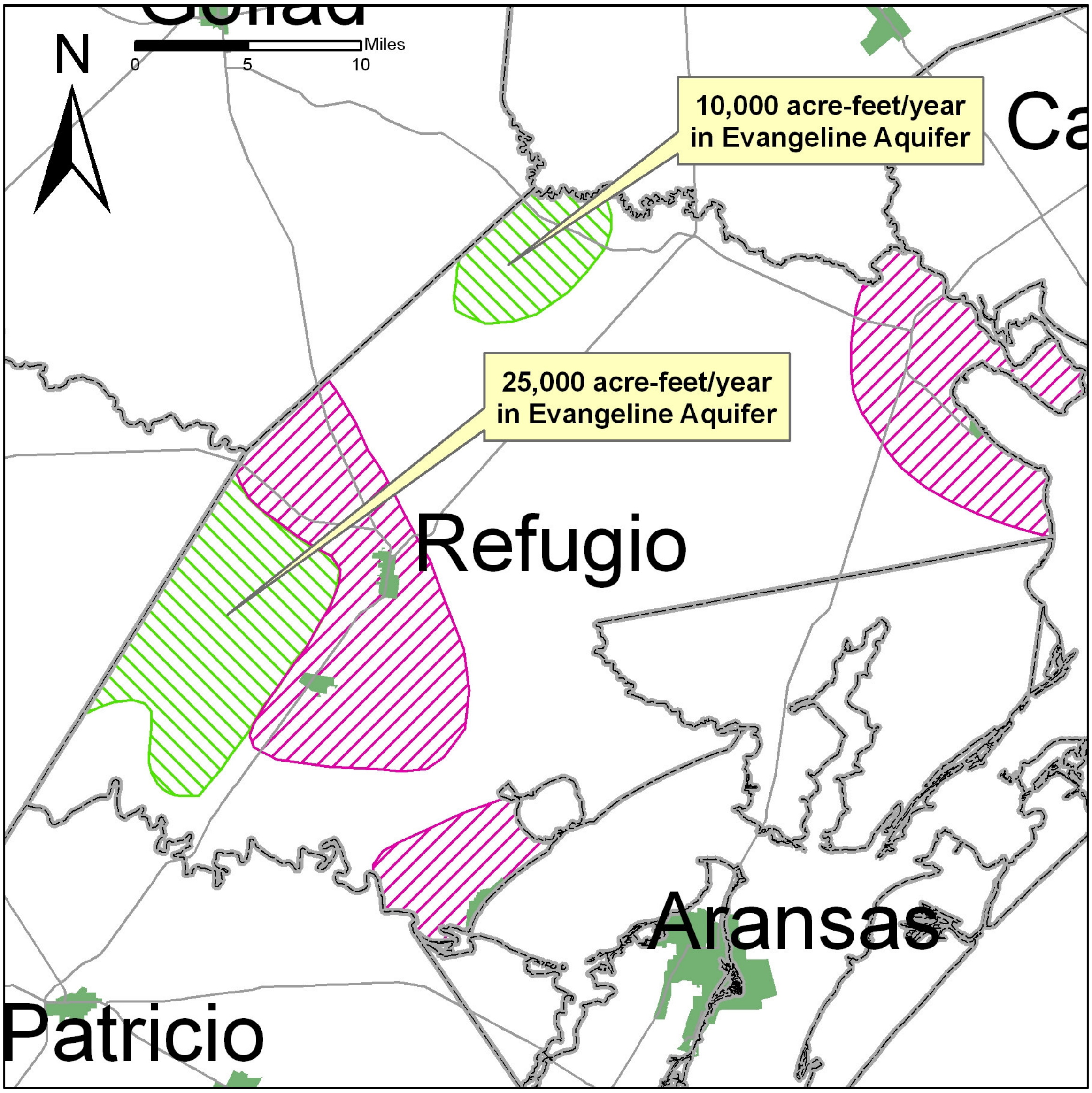

Figure 3. Location of additional pumpage in Refugio County. Pumpage in the Evangeline Aquifer is shown in the green areas, and pumpage in the Chicot Aquifer is shown in the red areas.

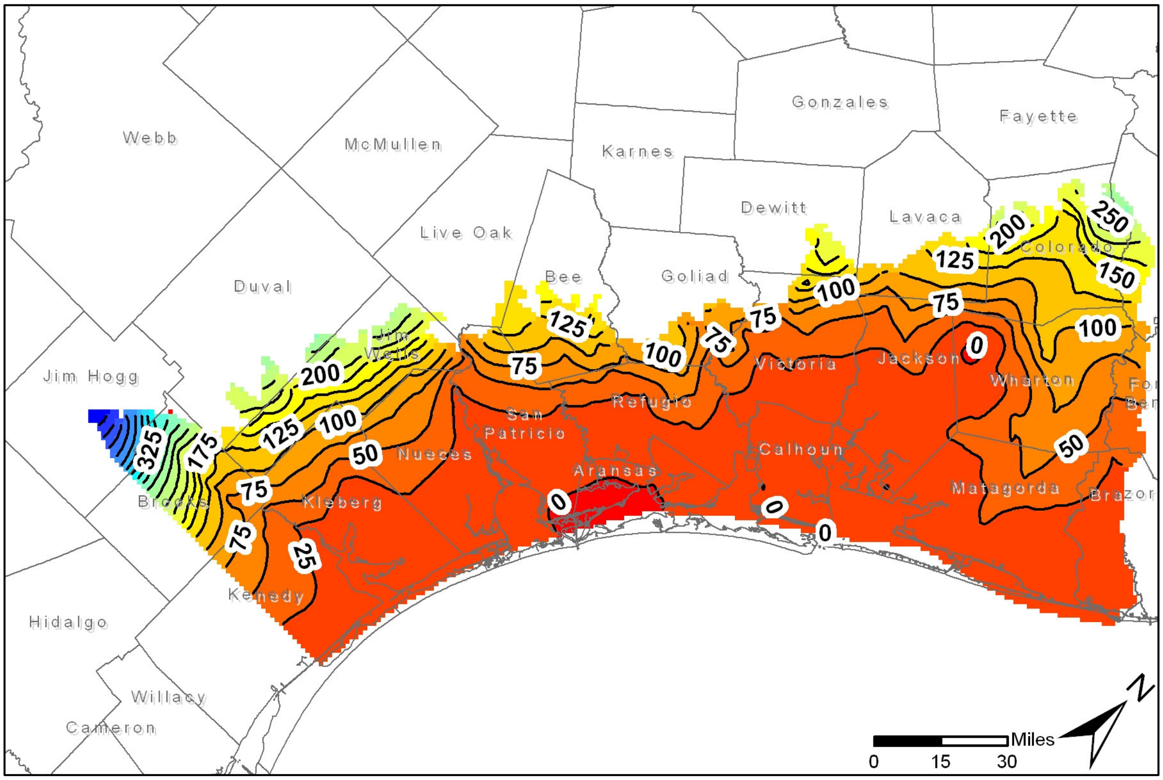

Figure 4. Initial water level elevations for the predictive model run in the Chicot Aquifer from the groundwater availability model for the central part of the Gulf Coast Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet.

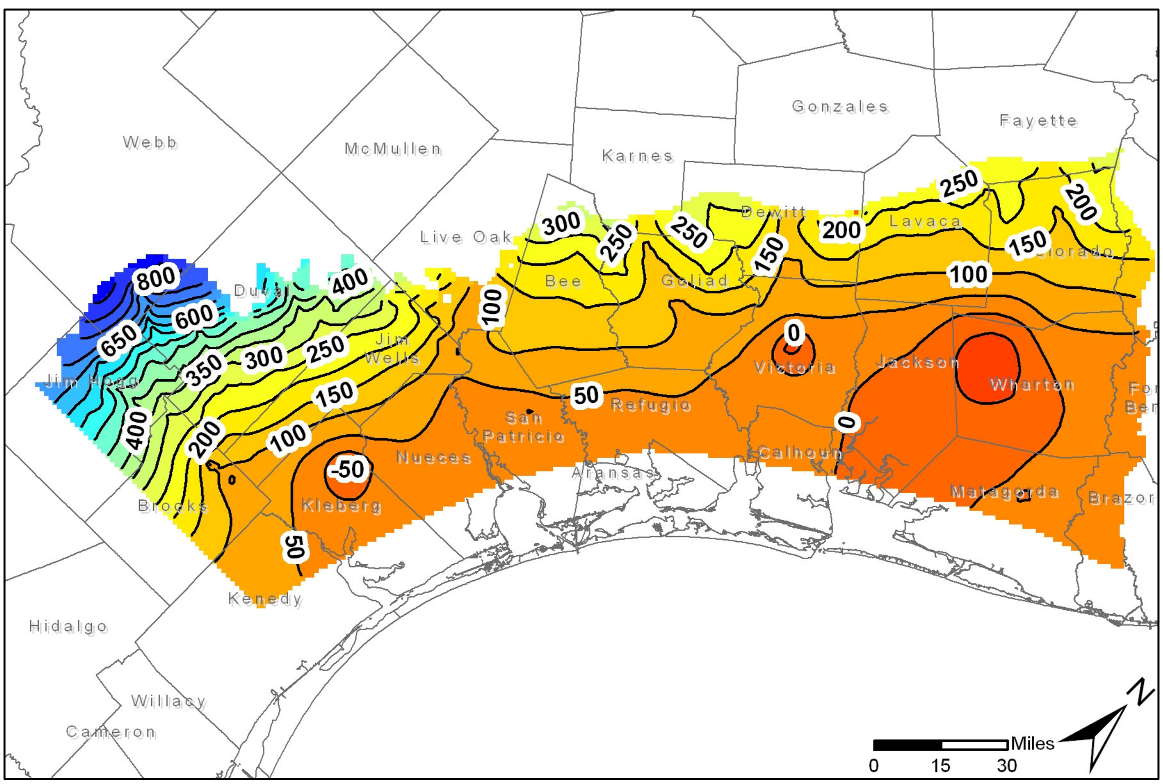

Figure 5. Initial water level elevations for the predictive model run in the Evangeline Aquifer from the groundwater availability model for the central part of the Gulf Coast Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 50 feet.

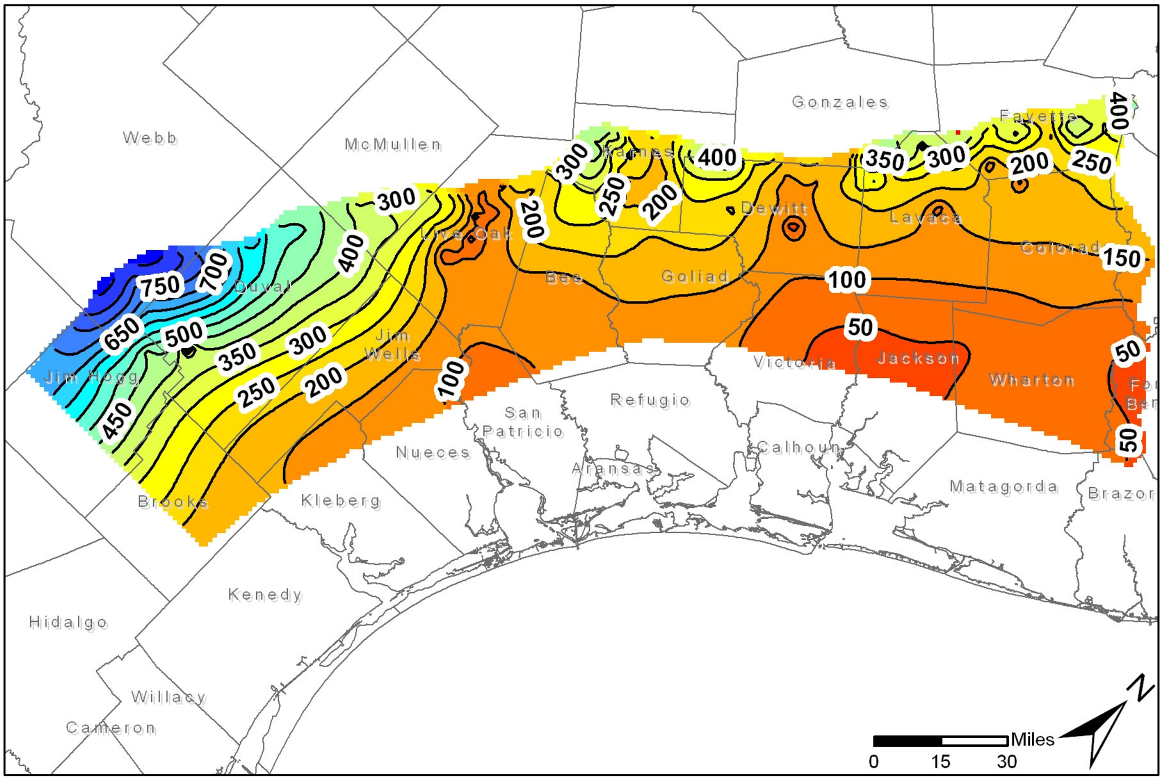

Figure 6. Initial water level elevations for the predictive model run in the Jasper Aquifer from the groundwater availability model for the central part of the Gulf Coast Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 50 feet.

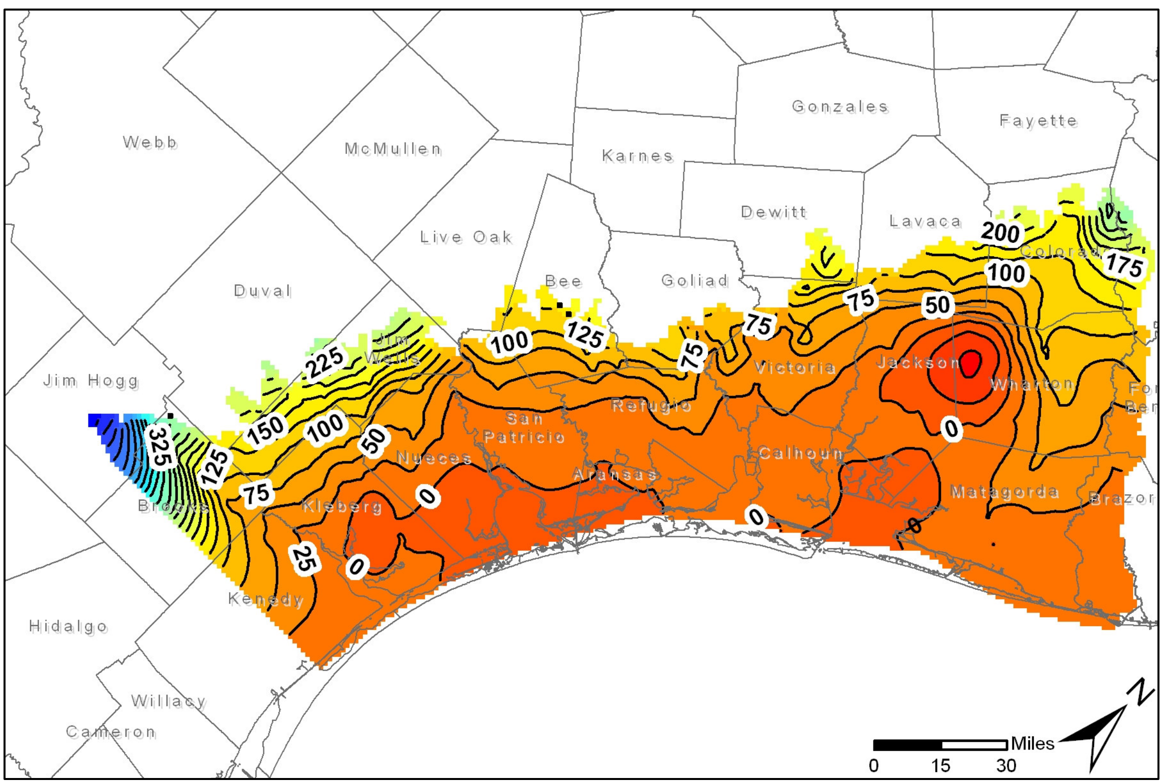

Figure 7. Water level elevations after 60 years using baseline pumpage in the Chicot Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 25 feet.

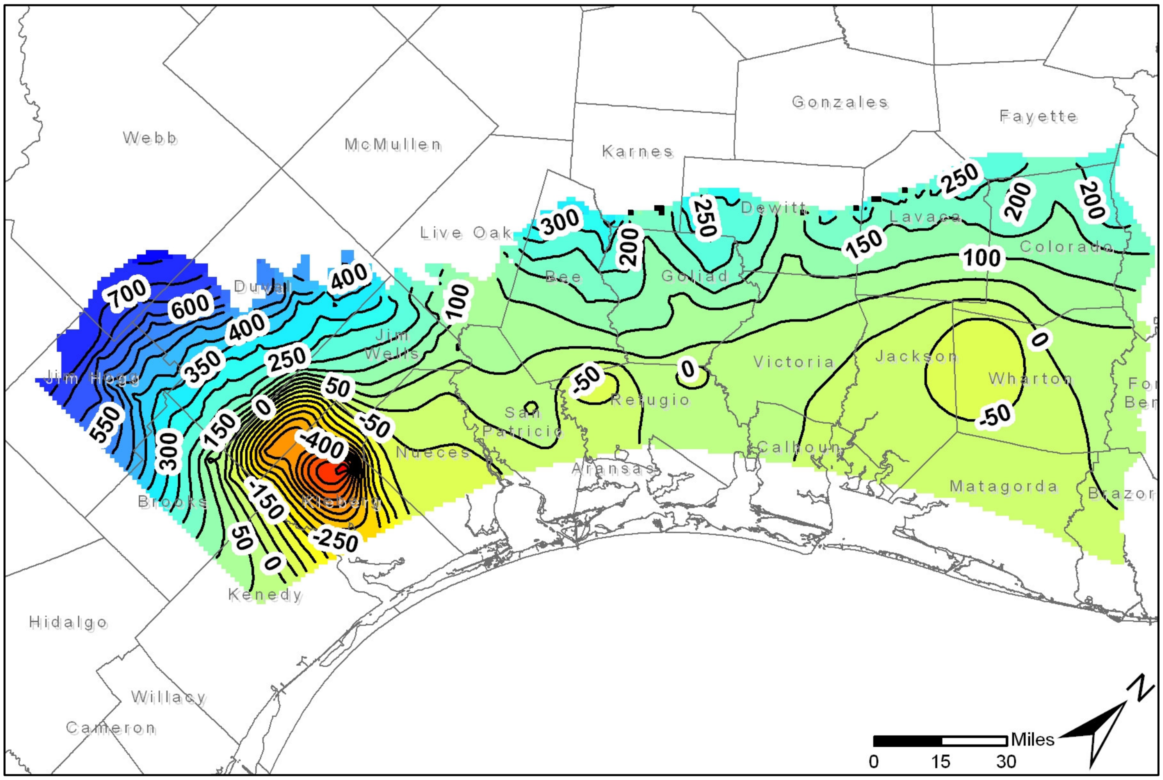

Figure 8. Water level elevations after 60 years using baseline pumpage in the Evangeline Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 50 feet.

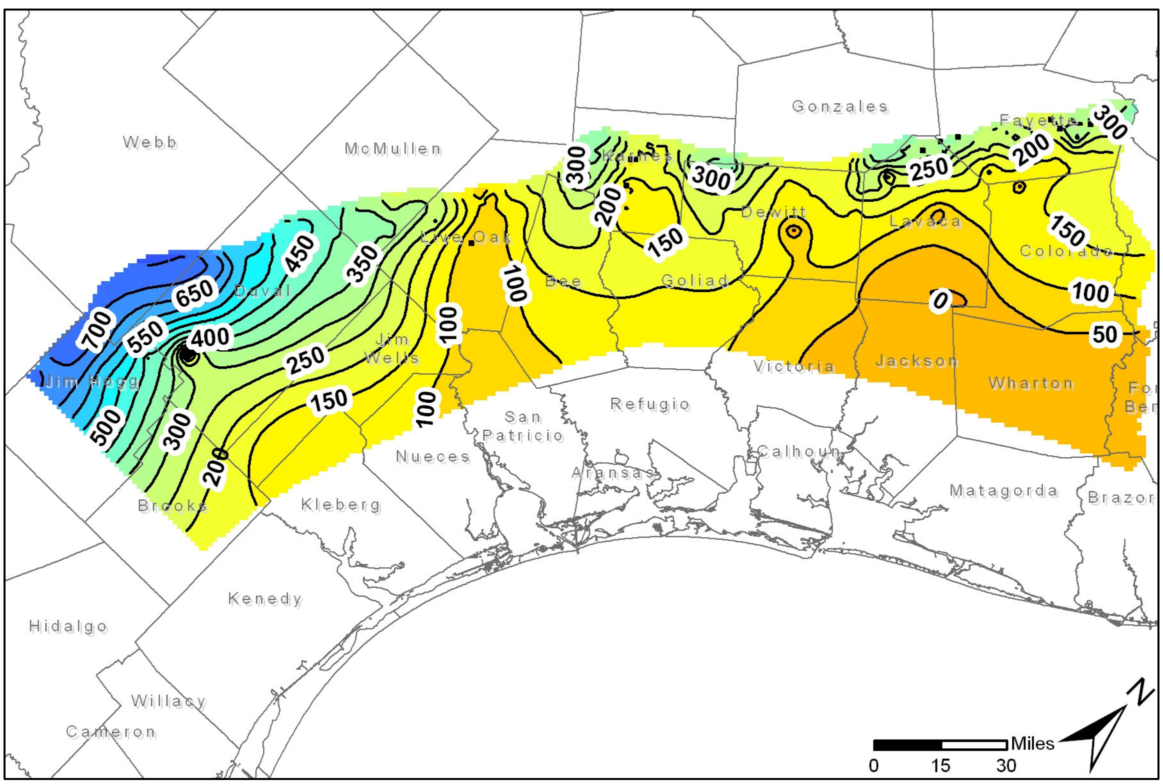

Figure 9. Water level elevations after 60 years using baseline pumpage in the Jasper Aquifer. Water level elevations are in feet above mean sea level. Contour interval is 50 feet.

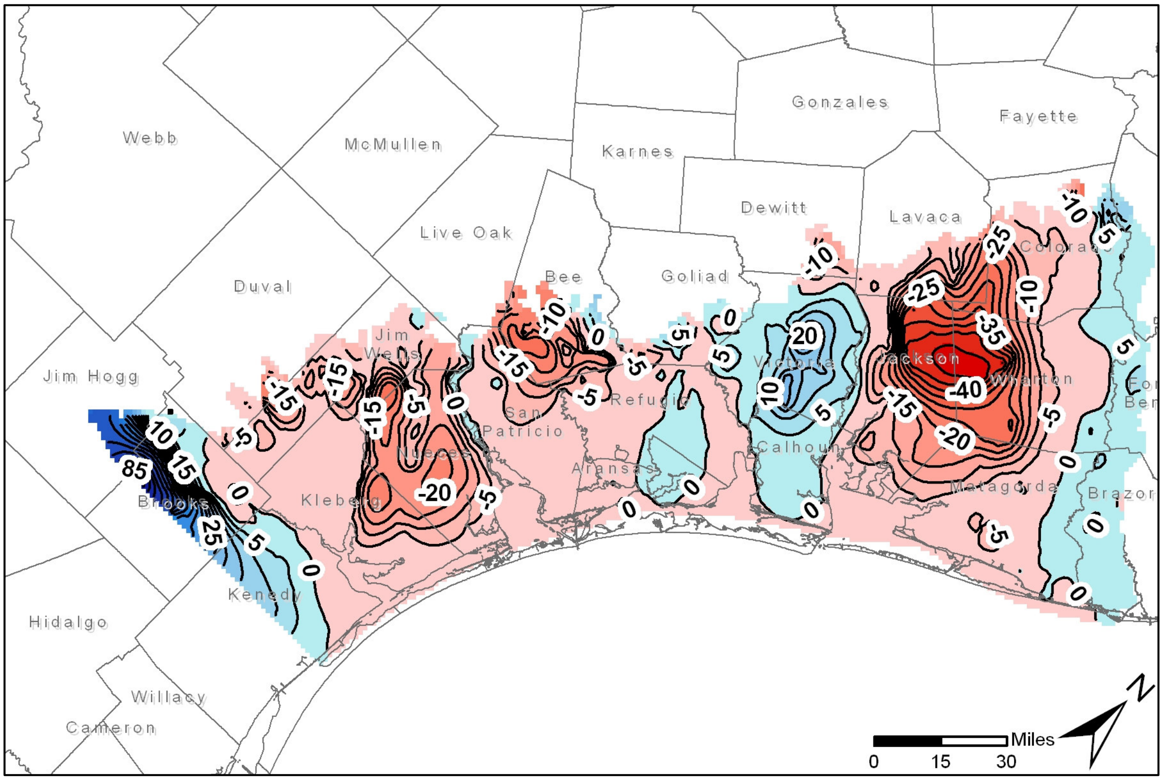

Figure 10. Changes in water levels after 60 years using baseline pumpage in the Chicot Aquifer. Drawdowns are in feet. Contour interval is 10 feet. Decreases in water levels (drawdowns) are shown in red. Increases in water levels are shown in blue.

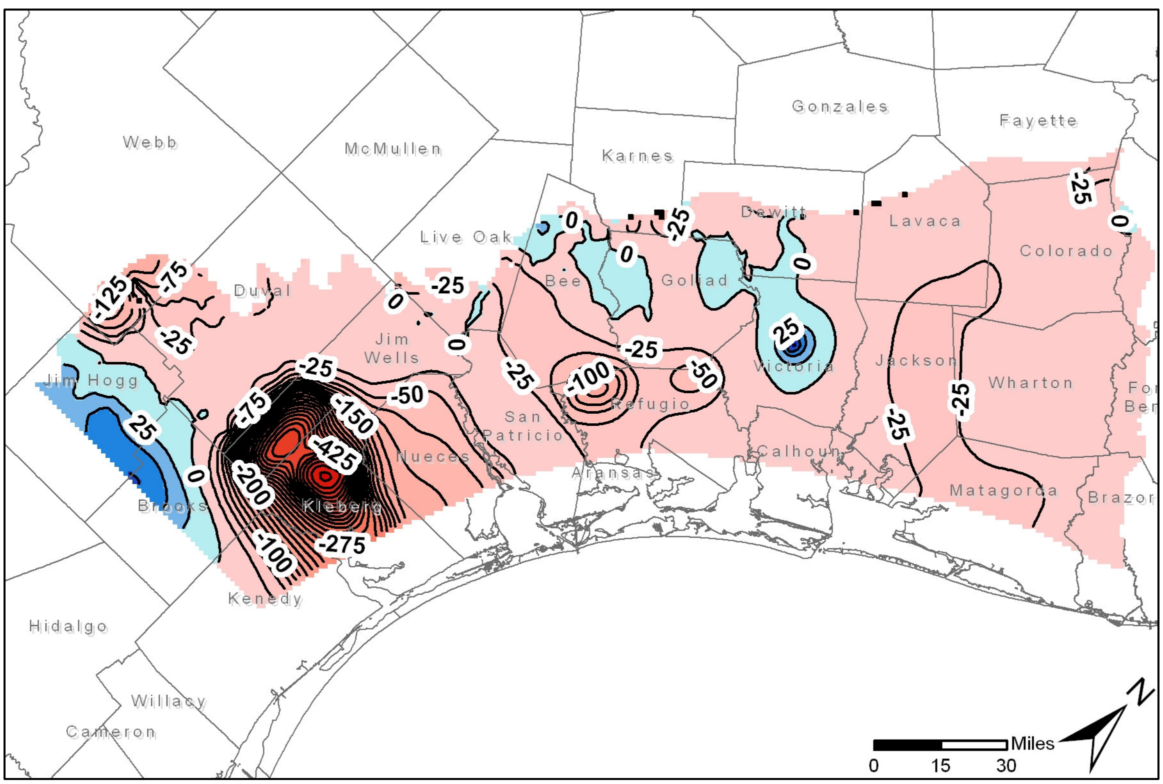

Figure 11. Changes in water levels after 60 years using baseline pumpage in the Evangeline Aquifer. Drawdowns are in feet. Contour interval is 10 feet. Decreases in water levels (drawdowns) are shown in red. Increases in water levels are shown in blue.

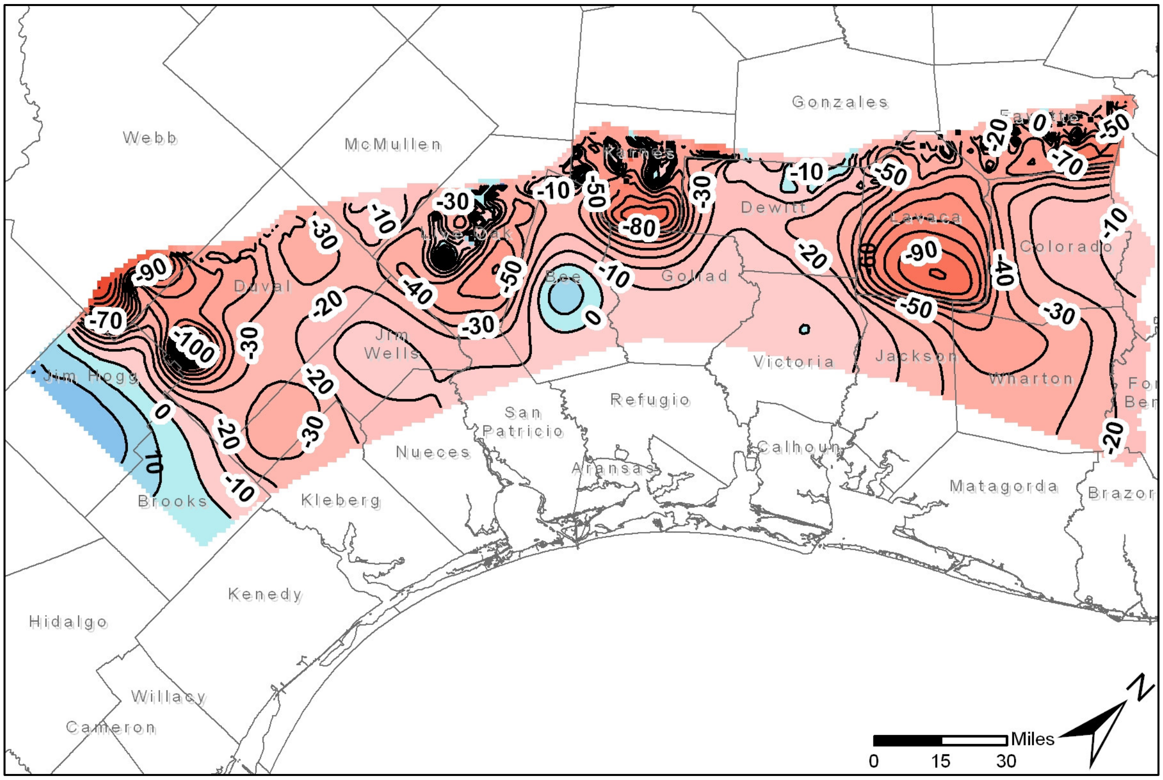

Figure 12. Changes in water levels after 60 years using baseline pumpage in the Jasper Aquifer. Drawdowns are in feet. Contour interval is 10 feet. Decreases in water levels (drawdowns) are shown in red. Increases in water levels are shown in blue.

Appendix A

Summary of Water Budgets After 60 Years

Table A-1. Annual water budgets for each county at the end of the 60-year predictive model run using the specified pumpage in the groundwater availability model for the central part of the Gulf Coast Aquifer (in acre-feet per year). Budgets for Jim Hogg, Brooks, Kenedy, Brazoria, Fort Bend, and Austin counties represents only the portions of those counties located in the active portion of the model.

	Aransas		Austin		Bee		Brazoria		Brooks		Calhoun	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Chicot												
Storage	1	0	8	0	1,424	0	7	0	98	0	23	0
Reservoirs (River package)	0	0	0	0	0	0	341	0	3,431	0	3,269	0
Springs (Drain package)	0	11	0	0	0	0	0	63	0	0	0	1,021
General Head Boundaries	1,417	3,111	0	0	0	0	0	1,138	0	0	1,694	8,289
Wells	0	1,827	0	3,118	0	9,620	0	8,727	0	359	0	2,853
Streams and Rivers	2,456	646	6,782	1,164	7,027	975	9,872	18,989	1,349	19,705	3,899	2,066
Recharge	164	0	6,758	0	18,825	0	15,152	0	23,402	0	3,039	0
Evapotranspiration	0	729	0	17	0	45	0	1,320	0	1,763	0	1,224
Lateral Inflow	3,670	1,355	2,300	4,190	972	5,568	11,885	5,069	4,674	4,580	9,871	4,707
Vertical Leakage Downward	0	30	0	7,359	0	12,041	0	1,950	507	7,051	13	1,648
Evangeline												
Storage	0	0	9	0	173	0	10	0	574	0	7	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
General Head Boundaries	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	0	0	3,931	0	13,553	0	284	0	3,681	0	64
Streams and Rivers	0	0	0	0	6,758	2,190	0	0	5	828	0	0
Recharge	0	0	90	0	5,089	0	0	0	340	0	0	0
Evapotranspiration	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Upward	30	0	7,359	0	12,041	0	1,950	0	7,051	507	1,648	13
Lateral Inflow	136	166	1,263	4,707	5,104	13,006	543	2,347	3,308	7,610	190	1,773
Vertical Leakage Downward	--	--	35	118	612	1,023	126	0	1,562	214	4	0

Table A-1. (continued)

	Aransas		Austin		Bee		Brazoria		Brooks		Calhoun	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Burkeville												
Storage	--	--	23	0	525	0	85	0	531	32	4	0
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
General Head Boundaries	--	--	0	0	0	0	0	0	0	0	0	0
Wells	--	--	0	6	0	74	0	0	0	0	0	0
Streams and Rivers	--	--	0	0	101	0	0	0	0	0	0	0
Recharge	--	--	0	0	1	0	0	0	0	0	0	0
Evapotranspiration	--	--	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Upward	--	--	118	35	1,023	612	0	126	214	1,562	0	4
Lateral Inflow	--	--	5	11	40	123	8	0	65	24	0	0
Vertical Leakage Downward	--	--	27	121	270	1,152	33	0	998	188	--	--
Jasper												
Storage	--	--	48	0	594	0	44	0	282	58	--	--
Reservoirs (River package)	--	--	0	0	0	0	0	0	0	0	--	--
Springs (Drain package)	--	--	0	0	0	0	0	0	0	0	--	--
General Head Boundaries	--	--	0	0	0	0	0	0	0	0	--	--
Wells	--	--	0	23	0	658	0	0	0	0	--	--
Streams and Rivers	--	--	0	0	159	58	0	0	0	0	--	--
Recharge	--	--	0	0	24	0	0	0	0	0	--	--
Evapotranspiration	--	--	0	0	0	0	0	0	0	0	--	--
Vertical Leakage Upward	--	--	121	27	1,152	270	0	33	188	998	--	--
Lateral Inflow	--	--	83	203	453	1,395	0	11	1,399	813	--	--

Table A-1. (continued)

	Colorado		De Witt		Duval		Fayette		Fort Bend		Goliad	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Chicot												
Storage	1,463	0	11	0	106	0	--	--	13	0	15	0
Reservoirs (River package)	1,408	0	0	0	0	0	--	--	0	0	1,547	0
Springs (Drain package)	0	5	0	0	0	0	--	--	0	0	0	5
General Head Boundaries	0	0	0	0	0	0	--	--	0	0	0	0
Wells	0	24,378	0	3,482	0	733	--	--	0	5,921	0	1,383
Streams and Rivers	33,916	8,349	4,183	246	3,451	1,230	--	--	8,309	5,980	3,297	6,652
Recharge	35,074	0	4,569	0	5,270	0	--	--	884	0	10,556	0
Evapotranspiration	0	54	0	0	0	17	--	--	0	17	0	163
Lateral Inflow	8,743	20,894	89	1,214	666	3,184	--	--	10,552	4,473	773	3,406
Vertical Leakage Downward	322	27,245	0	3,910	40	4,368	--	--	0	3,368	105	4,684
Evangeline												
Storage	70	0	63	0	859	0	43	0	8	0	59	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
General Head Boundaries	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	22,580	0	7,662	0	7,949	0	884	0	2,882	0	11,457
Streams and Rivers	5,238	1,978	12,430	5,692	6,070	4,955	803	59	0	0	18,789	9,515
Recharge	2,515	0	5,773	0	14,506	0	1,737	0	0	0	7,979	0
Evapotranspiration	0	0	0	56	0	28	0	0	0	0	0	31
Vertical Leakage Upward	27,245	322	3,910	0	4,368	40	--	--	3,368	0	4,684	105
Lateral Inflow	8,880	18,816	1,143	7,413	1,769	12,000	51	565	2,281	3,015	4,612	14,976
Vertical Leakage Downward	565	813	43	2,539	1,032	3,632	0	1,126	240	0	574	613

Table A-1. (continued)

	Colorado		De Witt		Duval		Fayette		Fort Bend		Goliad	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Burkeville												
Storage	762	0	137	0	941	0	147	0	37	0	372	0
Reservoirs (River package)	0	0	0	0	0	0	271	0	0	0	0	0
Springs (Drain package)	0	0	0	0	0	0	0	0	0	0	0	0
General Head Boundaries	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	0	0	145	0	76	0	109	0	0	0	0
Streams and Rivers	0	0	398	2	113	14	348	0	0	0	0	0
Recharge	0	0	28	0	259	0	3	0	0	0	0	0
Evapotranspiration	0	0	0	0	0	12	0	19	0	0	0	0
Vertical Leakage Upward	813	565	2,539	43	3,632	1,032	1,126	0	0	240	613	574
Lateral Inflow	30	71	4	55	25	80	5	12	2	2	28	64
Vertical Leakage Downward	59	1,029	--	--	431	4,188	9	1,769	202	0	287	663
Jasper												
Storage	481	0	1,326	0	2,131	0	3,693	0	206	0	355	0
Reservoirs (River package)	0	0	0	0	0	0	201	0	0	0	0	0
Springs (Drain package)	0	0	0	0	0	0	0	0	0	0	0	0
General Head Boundaries	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	900	0	3,801	0	5,283	0	7,308	0	0	0	0
Streams and Rivers	0	0	1,053	454	0	0	1,241	19	0	0	0	0
Recharge	0	0	243	0	189	0	354	0	0	0	0	0
Evapotranspiration	0	0	0	0	0	371	0	5	0	0	0	0
Vertical Leakage Upward	1,029	59	2,934	72	4,188	431	1,769	9	0	202	663	287
Lateral Inflow	268	819	459	1,688	2,127	2,550	361	278	49	53	376	1,107

Table A-1. (continued)

	Gonzales		Jackson		Jim Hogg		Jim Wells		Karnes		Kenedy	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Chicot												
Storage	--	--	3,128	0	0	2	281	0	--	--	110	0
Reservoirs (River package)	--	--	4,213	0	0	0	0	0	--	--	0	0
Springs (Drain package)	--	--	0	36	0	0	0	5	--	--	0	0
General Head Boundaries	--	--	1,733	142	0	0	0	0	--	--	0	17,601
Wells	--	--	0	64,067	0	14	0	13,567	--	--	0	41
Streams and Rivers	--	--	53,223	8,086	0	2,009	14,515	6,284	--	--	952	4,947
Recharge	--	--	11,805	0	6,440	0	25,328	0	--	--	25,221	0
Evapotranspiration	--	--	0	385	0	442	0	157	--	--	0	2,169
Lateral Inflow	--	--	24,456	10,085	377	3,261	3,316	8,293	--	--	3,919	2,580
Vertical Leakage Downward	--	--	0	15,760	310	1,399	209	15,340	--	--	0	2,859
Evangeline												
Storage	--	--	77	0	30	17	4,994	0	61	3	158	0
Reservoirs (River package)	--	--	0	0	0	0	562	0	0	0	0	0
Springs (Drain package)	--	--	0	0	0	0	0	0	0	0	0	0
General Head Boundaries	--	--	0	0	0	0	0	0	0	0	0	0
Wells	--	--	0	23,697	0	371	0	36,421	0	1,147	0	62
Streams and Rivers	--	--	0	0	412	3,655	1,019	3,410	486	3	0	0
Recharge	--	--	0	0	7,165	0	2,234	0	839	0	0	0
Evapotranspiration	--	--	0	0	0	584	0	5	0	0	0	0
Vertical Leakage Upward	--	--	15,760	0	1,399	310	15,340	209	--	--	2,859	0
Lateral Inflow	--	--	14,774	8,214	321	2,037	18,266	7,387	358	305	1,406	4,983
Vertical Leakage Downward	--	--	1,296	1	408	2,761	5,254	237	0	286	623	0

Table A-1. (continued)

	Gonzales		Jackson		Jim Hogg		Jim Wells		Karnes		Kenedy	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Burkeville												
Storage	--	--	950	0	7	67	3,287	0	141	17	617	0
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
General Head Boundaries	--	--	0	0	0	0	0	0	0	0	0	0
Wells	--	--	0	0	0	0	0	4	0	31	0	0
Streams and Rivers	--	--	0	0	0	0	2	16	472	0	0	0
Recharge	--	--	0	0	13	0	14	0	46	0	0	0
Evapotranspiration	--	--	0	0	0	2	0	0	0	1	0	0
Vertical Leakage Upward	--	--	1	1,296	2,761	408	237	5,254	286	0	0	623
Lateral Inflow	--	--	20	10	8	76	55	47	42	3	11	4
Vertical Leakage Downward	--	--	385	51	392	2,628	1,971	245	0	936	--	--
Jasper												
Storage	451	0	461	0	51	269	1,410	0	7,538	21	--	--
Reservoirs (River package)	0	0	0	0	0	0	0	0	0	0	--	--
Springs (Drain package)	0	1	0	0	0	0	0	0	0	0	--	--
General Head Boundaries	0	0	0	0	0	0	0	0	0	0	--	--
Wells	0	4	0	0	0	594	0	7	0	12,607	--	--
Streams and Rivers	20	160	0	0	0	0	0	0	2,239	0	--	--
Recharge	139	0	0	0	155	0	0	0	417	0	--	--
Evapotranspiration	0	68	0	0	0	162	0	0	0	1	--	--
Vertical Leakage Upward	--	--	51	385	2,628	392	245	1,971	936	0	--	--
Lateral Inflow	21	398	101	228	865	2,284	1,625	1,302	1,877	379	--	--

Table A-1. (continued)

	Kleberg		Lavaca		Live Oak		Matagorda		McMullen		Nueces	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Chicot												
Storage	431	0	1,349	0	63	0	337	0	--	--	1,217	0
Reservoirs (River package)	0	0	0	0	0	0	804	0	--	--	0	0
Springs (Drain package)	0	0	0	0	0	0	0	189	--	--	0	59
General Head Boundaries	3,803	7,454	0	0	0	0	2,496	8,702	--	--	4,137	467
Wells	0	5,086	0	5,784	0	88	0	38,931	--	--	0	15,935
Streams and Rivers	26,367	7,961	12,585	1,454	177	0	65,190	25,697	--	--	36,234	1,836
Recharge	4,486	0	18,276	0	1,194	0	23,061	0	--	--	4,795	0
Evapotranspiration	0	933	0	1	0	4	0	2,981	--	--	0	281
Lateral Inflow	12,126	5,964	1,176	16,680	92	301	11,547	15,560	--	--	10,109	5,722
Vertical Leakage Downward	0	19,816	4	9,469	0	1,133	0	11,374	--	--	5	32,198
Evangeline												
Storage	6,479	0	61	9	123	0	36	0	--	--	88	0
Reservoirs (River package)	0	0	0	0	2,890	0	0	0	--	--	0	0
Springs (Drain package)	0	0	0	0	0	0	0	0	--	--	0	0
General Head Boundaries	0	0	0	0	0	0	0	0	--	--	0	0
Wells	0	44,910	0	23,405	0	4,140	0	10,207	--	--	0	33,913
Streams and Rivers	0	0	21,548	1,624	1,106	5,915	0	0	--	--	0	0
Recharge	0	0	6,051	0	4,205	0	0	0	--	--	0	0
Evapotranspiration	0	0	0	2	0	38	0	0	--	--	0	0
Vertical Leakage Upward	19,816	0	9,469	4	1,133	0	11,374	0	--	--	32,198	5
Lateral Inflow	15,229	4,062	3,892	13,715	1,550	693	3,057	4,569	--	--	6,217	6,302
Vertical Leakage Downward	7,448	0	73	2,331	30	251	303	0	--	--	1,715	0

Table A-1. (continued)

	Kleberg		Lavaca		Live Oak		Matagorda		McMullen		Nueces	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Burkeville												
Storage	6,347	0	936	8	376	0	309	0	45	0	1,150	0
Reservoirs (River package)	0	0	0	0	134	0	0	0	0	0	0	0
Springs (Drain package)	0	0	0	0	0	0	0	0	0	0	0	0
General Head Boundaries	0	0	0	0	0	0	0	0	0	0	0	0
Wells	0	0	0	80	0	1,269	0	0	0	9	0	0
Streams and Rivers	0	0	334	0	1,249	141	0	0	288	0	0	0
Recharge	0	0	43	0	220	0	0	0	13	0	0	0
Evapotranspiration	0	0	0	0	0	19	0	0	0	0	0	0
Vertical Leakage Upward	0	7,448	2,331	73	251	30	0	303	--	--	0	1,715
Lateral Inflow	12	1	32	27	135	24	6	11	4	8	2	4
Vertical Leakage Downward	1,089	0	14	3,502	268	1,151	--	--	0	333	567	0
Jasper												
Storage	817	0	3,021	0	2,949	0	--	--	624	0	265	0
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
General Head Boundaries	0	0	0	0	0	0	--	--	0	0	0	0
Wells	0	0	0	8,533	0	7,705	--	--	0	286	0	0
Streams and Rivers	0	0	879	0	997	90	--	--	465	520	0	0
Recharge	0	0	169	0	528	0	--	--	249	0	0	0
Evapotranspiration	0	0	0	0	0	39	--	--	0	105	0	0
Vertical Leakage Upward	0	1,089	3,502	14	1,151	268	--	--	333	0	0	567
Lateral Inflow	321	48	1,278	302	2,684	207	--	--	190	950	396	93

Table A-1. (continued)

	Refugio		San Patricio		Victoria		Washington		Webb		Wharton	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Chicot												
Storage	58	0	623	0	165	0	--	--	--	--	2,450	0
Reservoirs (River package)	0	0	0	0	1,056	0	--	--	--	--	537	0
Springs (Drain package)	0	92	0	250	0	1,383	--	--	--	--	0	8
General Head Boundaries	19	6,266	654	2,651	0	389	--	--	--	--	0	0
Wells	0	6,800	0	3,877	0	22,769	--	--	--	--	0	114,552
Streams and Rivers	36,727	21,749	3,593	6,015	50,301	24,469	--	--	--	--	127,760	12,631
Recharge	14,669	0	12,704	0	24,830	0	--	--	--	--	21,792	0
Evapotranspiration	0	1,725	0	440	0	875	--	--	--	--	0	233
Lateral Inflow	10,226	8,717	4,558	3,439	7,198	19,289	--	--	--	--	34,606	19,369
Vertical Leakage Downward	34	16,385	44	5,503	56	14,434	--	--	--	--	0	40,353
Evangeline												
Storage	9	0	21	0	12	0	--	--	372	0	81	0
Reservoirs (River package)	0	0	823	0	0	0	--	--	0	0	0	0
Springs (Drain package)	0	0	0	0	0	0	--	--	0	0	0	0
General Head Boundaries	0	0	0	0	0	0	--	--	0	0	0	0
Wells	0	35,465	0	2,110	0	18,360	--	--	0	2,786	0	69,980
Streams and Rivers	0	0	0	584	2,021	2,465	--	--	79	32	0	0
Recharge	0	0	148	0	743	0	--	--	2,996	0	0	0
Evapotranspiration	0	0	0	10	0	26	--	--	0	0	0	0
Vertical Leakage Upward	16,385	34	5,503	44	14,434	56	--	--	--	--	40,353	0
Lateral Inflow	19,299	751	1,116	5,408	9,909	6,952	--	--	72	81	30,172	3,062
Vertical Leakage Downward	559	0	546	1	778	37	--	--	13	632	2,429	0

Table A-1. (continued)

	Refugio		San Patricio		Victoria		Washington		Webb		Wharton	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Burkeville												
Storage	516	0	229	0	254	2	--	--	8	0	1,825	0
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
General Head Boundaries	0	0	0	0	0	0	--	--	0	0	0	0
Wells	0	0	0	0	0	0	--	--	0	0	0	0
Streams and Rivers	0	0	0	0	0	0	--	--	0	0	0	0
Recharge	0	0	0	0	0	0	--	--	13	0	0	0
Evapotranspiration	0	0	0	0	0	0	--	--	0	0	0	0
Vertical Leakage Upward	0	559	1	546	37	778	--	--	632	13	0	2,429
Lateral Inflow	46	3	9	9	37	15	--	--	1	2	66	12
Vertical Leakage Downward	--	--	320	5	516	48	--	--	12	651	595	45
Jasper												
Storage	--	--	157	0	150	0	21	0	141	0	1,277	0
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
General Head Boundaries	--	--	0	0	0	0	0	0	0	0	0	0
Wells	--	--	0	0	0	0	0	6	0	148	0	1,062
Streams and Rivers	--	--	0	0	0	0	0	0	0	0	0	0
Recharge	--	--	0	0	0	0	1	0	46	0	0	0
Evapotranspiration	--	--	0	0	0	0	0	0	0	59	0	0
Vertical Leakage Upward	--	--	5	320	48	516	--	--	651	12	45	595
Lateral Inflow	--	--	280	122	556	238	0	17	190	810	370	35