GAM Run 07-13

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EXECUTIVE SUMMARY:

We ran the groundwater availability model for the Lipan Aquifer for a sixty-year period using 1998 pumping rates and pumping locations along with average recharge rates, evapotranspiration rates, and initial streamflows. The results show a cone of depression with water level declines in excess of 160 feet in east central Tom Green County.

REQUESTOR:

Mr. Allan Lange of the Lipan-Kickapoo Water Conservation District.

DESCRIPTION OF REQUEST:

Mr. Lange requested we use the groundwater availability model for the Lipan Aquifer to make a baseline run for a 60-year predictive simulation.

METHODS:

To address the request, we:

- used the 1998 estimated pumpage from the transient calibration-verification model as the baseline pumpage,
- ran the model for 60 years,
- extracted county water budgets after 60 years of simulation time,
- generated maps of initial water levels in 1998, and
- generated maps of water levels and water level differences after 60 years.

PARAMETERS AND ASSUMPTIONS:

- We used version 1.01 of the groundwater availability model for the Lipan Aquifer.
- See Beach and others (2004) for assumptions and limitations of the groundwater availability model for the Lipan Aquifer.

- The model includes one layer representing the Quaternary Leona Formation, the underlying Permian Formations, and the Edwards-Trinity (Plateau) Aquifer to the west, south, and north.

- The mean absolute error (a measure of the difference between simulated and actual water levels during model calibration) in the groundwater availability model is 18 feet for the calibration period (1980-1989) and 17 feet for the verification period (1990-1999,Beach and others, 2004).

- Recharge rates are based on average (1960 – 2000) precipitation (Beach and others, 2004).

- Evaporation rates and initial streamflow rates are the average long-term values used in the predictive model for the Lipan Aquifer (Beach and others, 2004).

- Baseline pumpage is 1998 pumping rates and pumping locations. Tables and graphs of the total pumping by county used in the transient calibration are shown in Appendix A.

RESULTS:

The components of the water budget (Table 1) are described below.

- Storage—This component is 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 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).

- Reservoirs – This is water that leaks from reservoirs into the aquifer or from the aquifer into the reservoir. This component can be shown as "Inflow" or "Outflow" in the budget. Reservoirs in this model are simulated with the river package.

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

- General-Head Boundary (GHB)—The model uses general head boundaries to simulate the eastern and western aquifer boundaries.

- Wells—This is water produced from rural domestic, municipal, industrial, irrigation, and livestock wells in the aquifer. For this model, this component is always shown as “Outflow” from an aquifer, because all wells included in the model produce (rather than inject) water. Wells are simulated in the model using the MODFLOW Well package.

- Rivers and Streams—This is 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 simulated in the model using the MODFLOW Stream package.

- Recharge—This component simulates areally distributed recharge due to precipitation falling on the outcrop areas of aquifers. Recharge is always shown as “Inflow” into an aquifer. This component does not include runoff from precipitation events that may later recharge an aquifer as stream losses, which is included in the model using the stream (or river) package. Recharge is simulated in the model using the MODFLOW Recharge package.

- Evapotranspiration—This is 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 simulated in the model using the MODFLOW Evapotranspiration (EVT) package.

- Lateral flow between counties—This component describes lateral flow within the aquifer between adjacent counties.

It is important to note that sub-regional water budgets for individual counties 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.

Simulated water levels in the aquifer in 1998 (Figure 1) generally slope towards the east with at gradient of about 10 feet per mile. At the end of the 60 year pumping period a cone of depression has formed in east central Tom Green County (Figure 2). Water level declines in excess of 160 feet occur at the center of the cone of depression (Figure 3). The cone of depression is mostly caused by irrigation pumping in the Lipan Flats area, Beach and others (2004).

REFERENCES:

Beach, J.A., Burton, S. and Kolarik, B., 2004, Groundwater availability model for the Lipan Aquifer in Texas: contract report to the Texas Water Development Board.

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Table 1. Annual water budgets for each county in the Lipan Aquifer model area at the end of the 60-year model run using 1998 pumpage. Values are reported in acre-feet per year.

	Coke		Concho		Irion		Runnels		Schleicher		Tom Green	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Sparta												
Storage	0	0	477	0	0	0	4	0	3	0	4,357	0
Reservoirs	0	0	0	0	0	0	0	0	0	0	0	0
Springs and seeps	0	0	0	0	0	0	0	0	0	0	0	2,753
General Head Boundary	285	102	680	776	6,158	0	77	0	50	0	7,627	0
Well	0	1	0	2,130	0	13	0	49	0	1	0	48,935
Rivers and Streams	0	0	173	5,158	1,077	0	0	0	0	0	23,466	4,099
Recharge	1,459	0	13,909	0	2,659	0	2,194	0	600	0	36,461	0
Evapotranspiration	0	0	0	7,101	0	6,838	0	3	0	3	0	23,788
Lateral Inflow	0	1,641	3,060	3,142	120	3,162	1,442	3,664	60	709	10,298	2,660

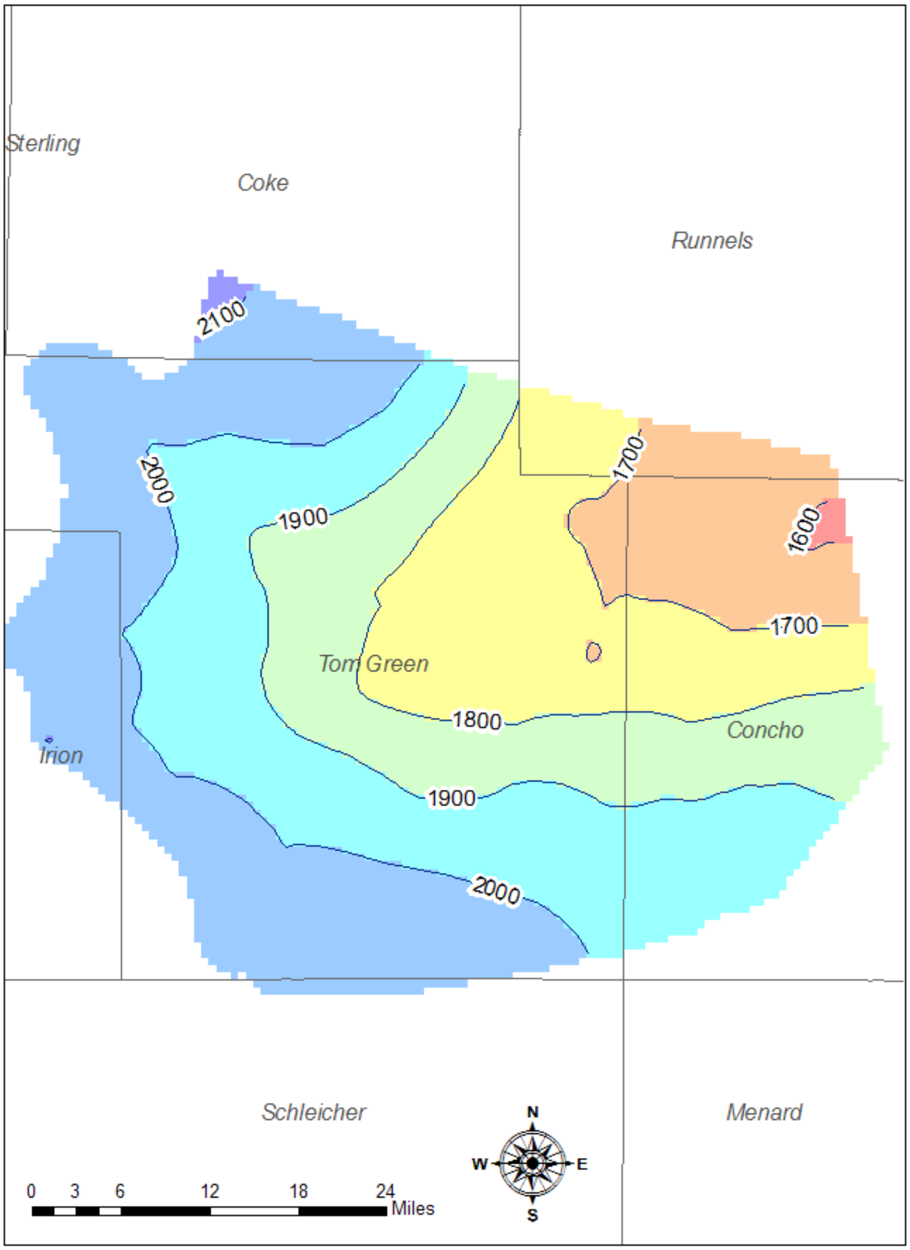

Figure 1: Water levels in feet in the Lipan Aquifer in 1998. Contour interval is 100 feet.

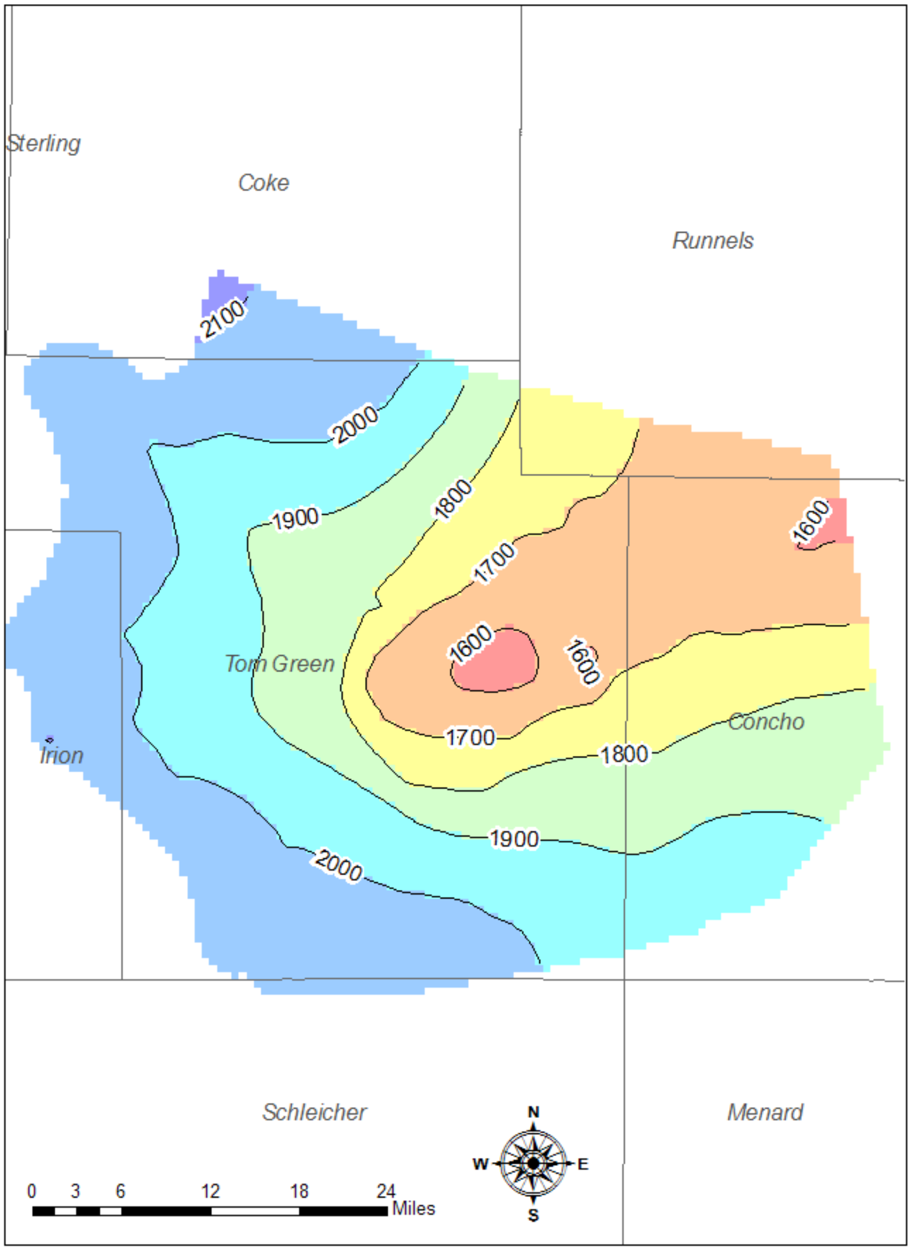

Figure 5: Water levels in feet in the Lipan Aquifer after 60 years of 1998 pumpage. Contour interval is 100 feet.

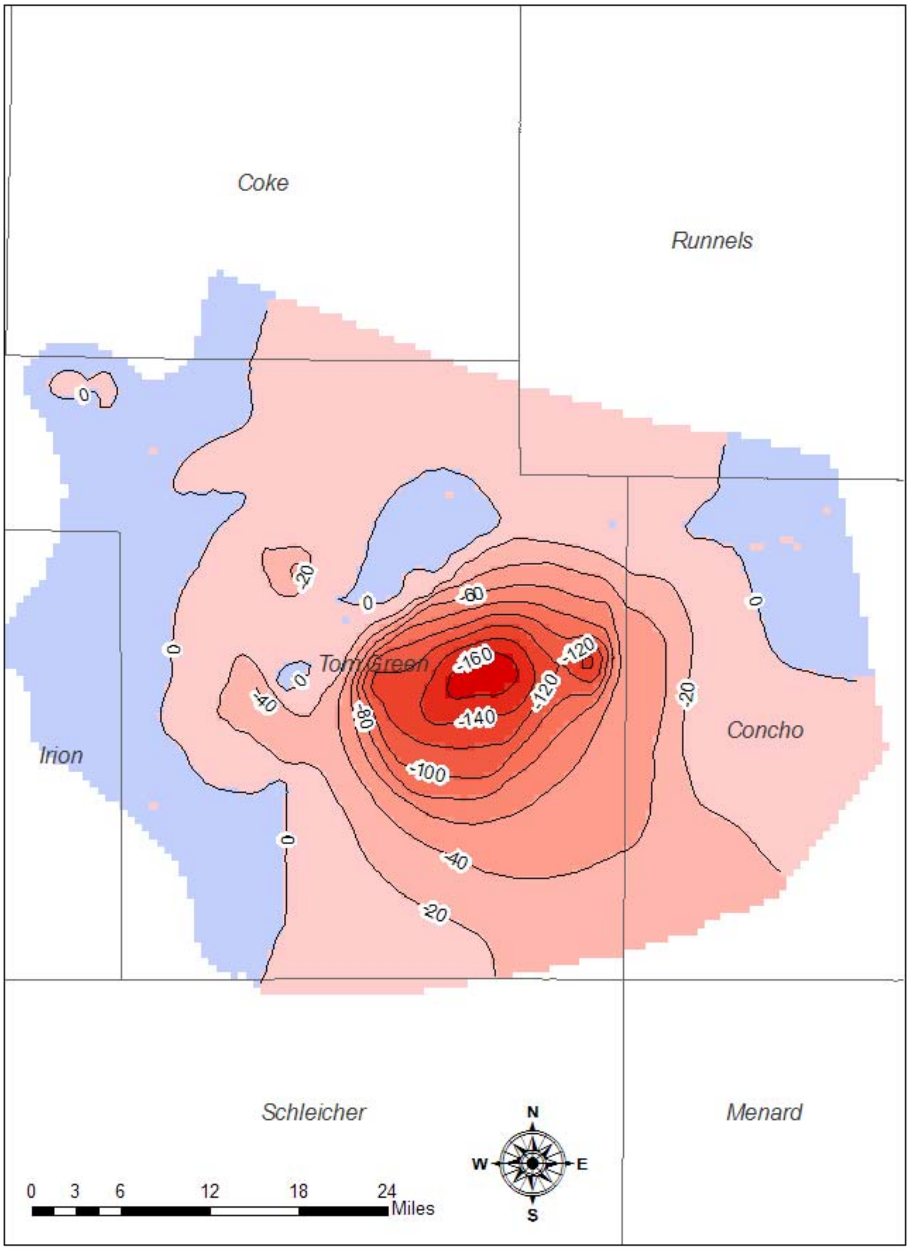

Figure 9: Water level differences in feet in the Lipan Aquifer after 60 years of 1998 pumpage. Blue areas indicate areas where water levels increase and red areas show water level declines. Contour interval is 20 feet.

Appendix A

Summary of Historic Pumpage in the Groundwater Availability Model for the Lipan Aquifer

Table A-1. Summary of estimated historic pumpage included in the groundwater availability model for the Lipan Aquifer (in acre-feet per year).

Year	Total	Coke	Runnels	Tom Green	Concho	Irion	Schleicher
1980	10,788	0.6	54	10,253	471	8.8	0.1
1981	13,935	0.6	57	13,030	839	9.1	0.1
1982	17,099	0.6	58	15,827	1,204	9.5	0.1
1983	20,229	0.7	60	18,587	1,570	11.1	0.1
1984	23,383	0.7	62	21,370	1,936	13.1	0.2
1985	20,269	0.7	61	17,009	3,183	14.6	0.2
1986	18,088	0.6	59	15,463	2,552	13.3	0.2
1987	15,386	0.6	59	12,104	3,208	13.9	0.2
1988	23,457	0.6	60	20,610	2,771	14.9	0.1
1989	25,268	0.7	57	22,076	3,123	11.4	0.2
1990	26,579	0.8	63	25,428	1,074	13.3	0.2
1991	22,450	0.8	61	21,479	896	12.5	0.2
1992	15,843	0.8	61	15,158	610	12.4	0.2
1993	65,900	0.9	63	63,042	2,781	11.9	0.2
1994	62,361	0.9	64	59,658	2,624	13.5	0.2
1995	78,090	0.9	65	74,704	3,307	13.8	0.2
1996	37,290	0.9	67	35,681	1,528	13.7	0.2
1997	68,299	0.9	52	65,355	2,877	13.4	0.2
1998	51,129	0.9	52	48,932	2,130	13.4	0.2

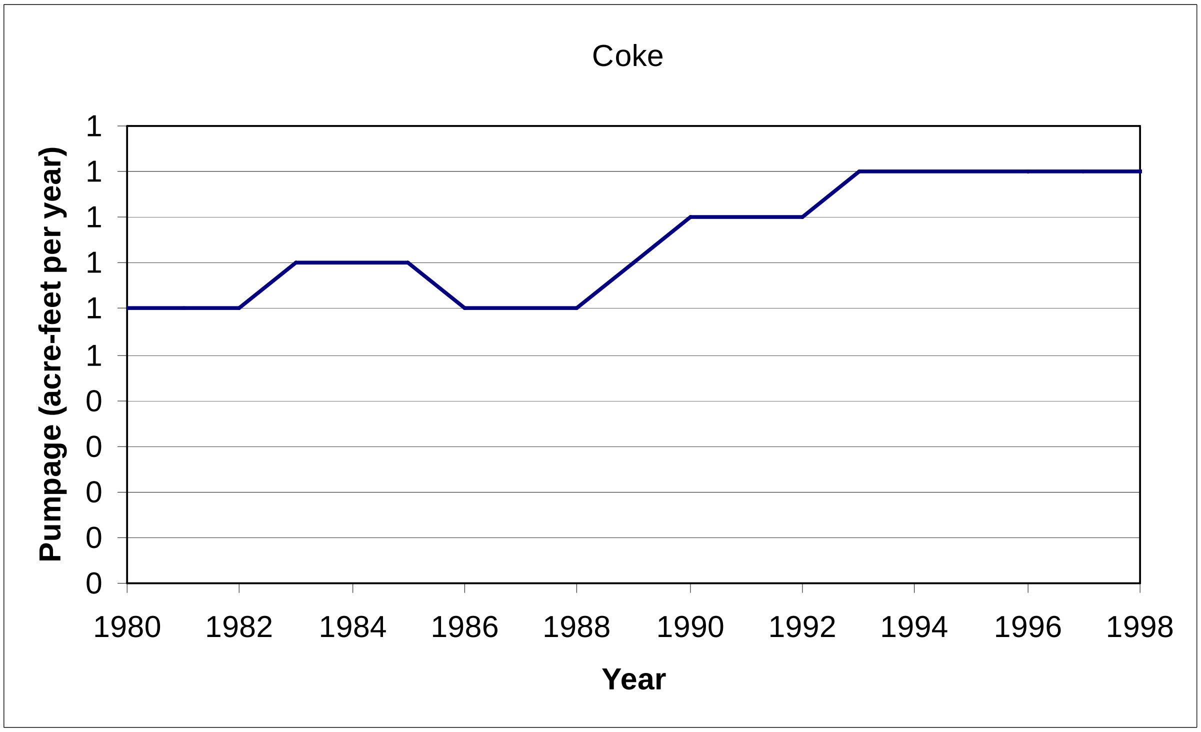

Figure A-1- Pumpage in Coke County included in the model for the Lipan Aquifer.

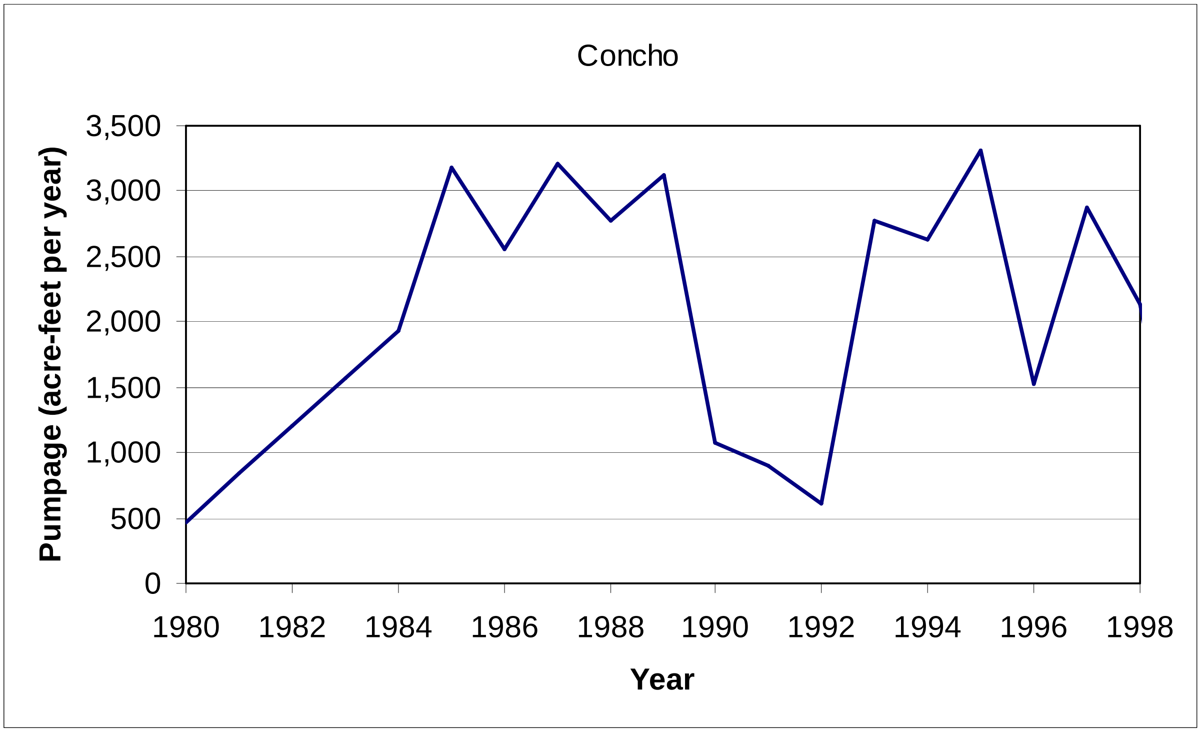

Figure A-2- Pumpage in Concho County included in the model for the Lipan Aquifer.

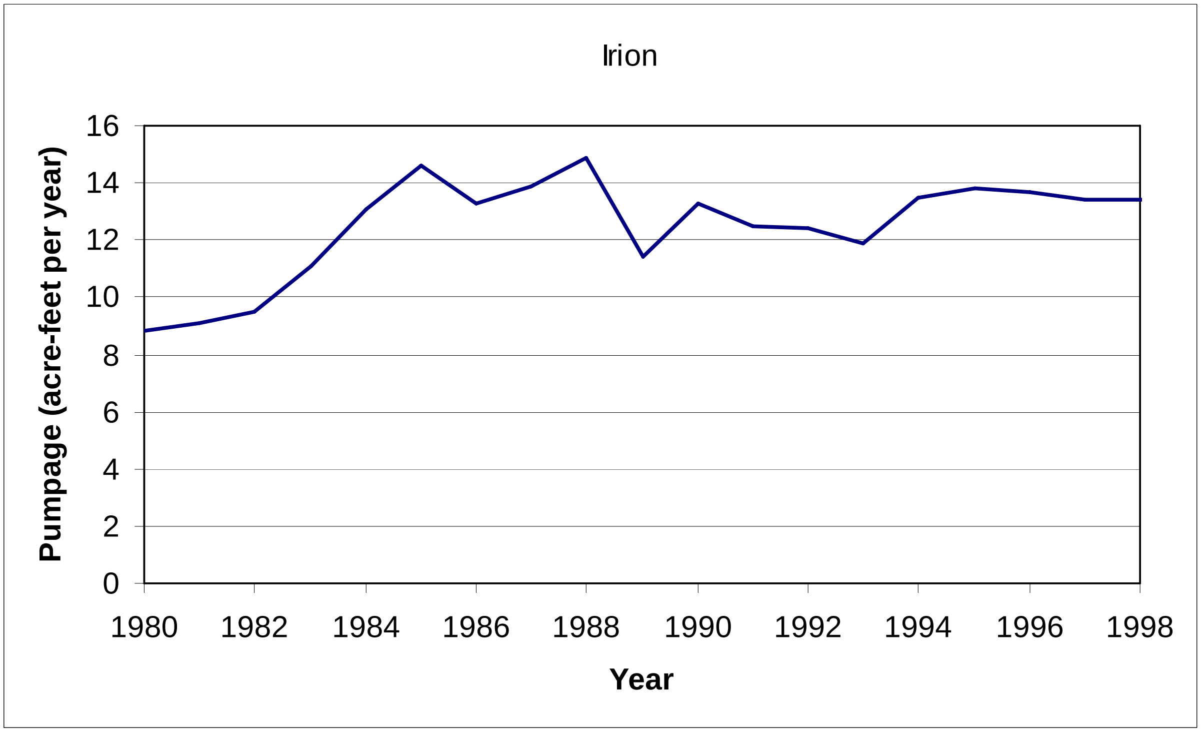

Figure A-3- Pumpage in Irion County included in the model for the Lipan Aquifer.

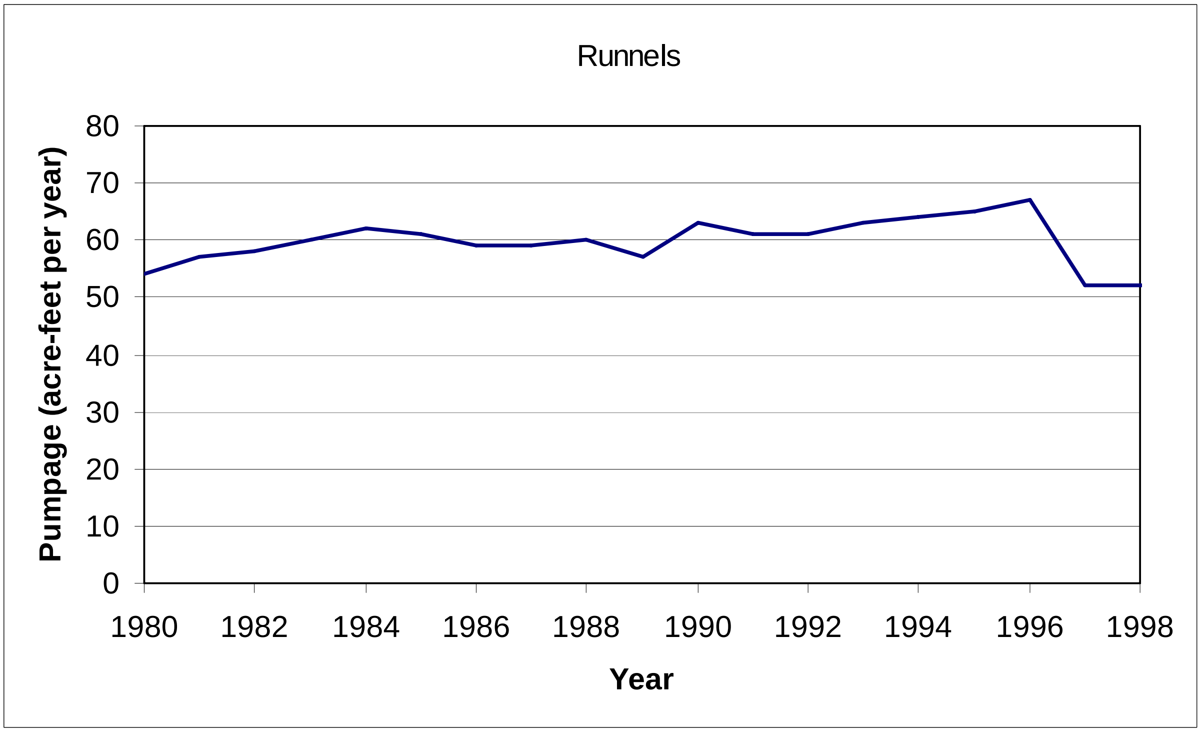

Figure A-4- Pumpage in Runnels County included in the model for the Lipan Aquifer.

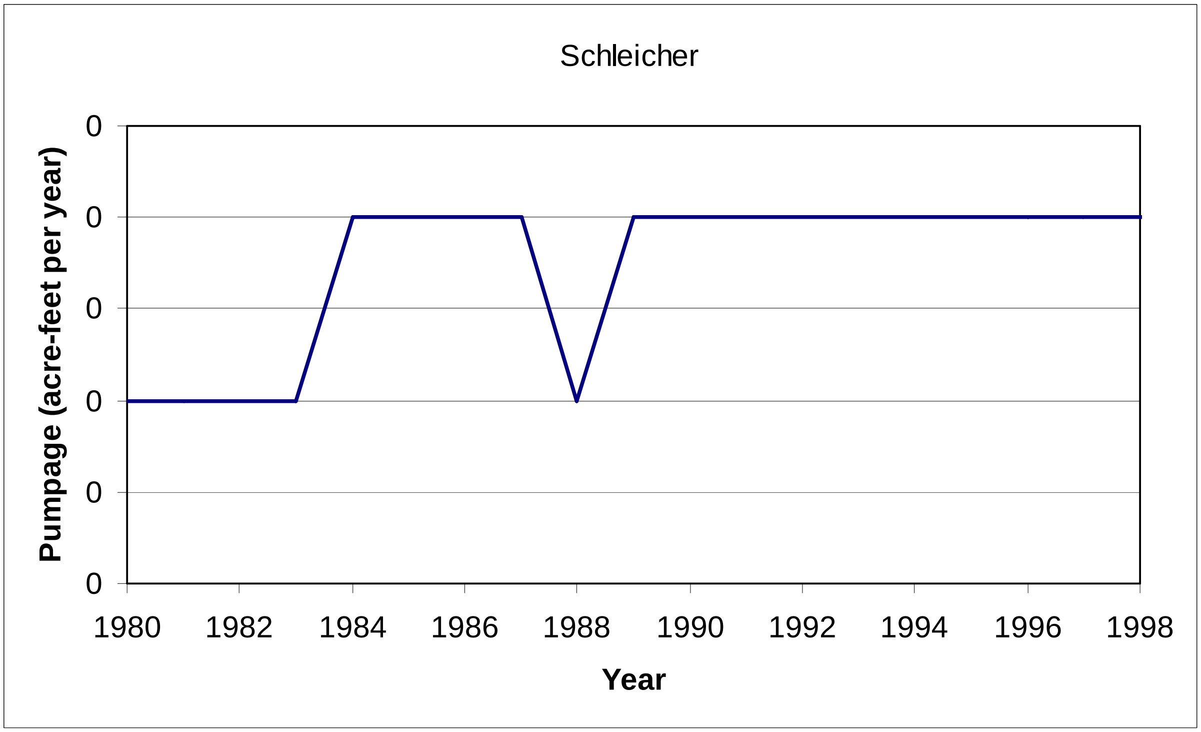

Figure A-5- Pumpage in Schleicher County included in the model for the Lipan Aquifer.

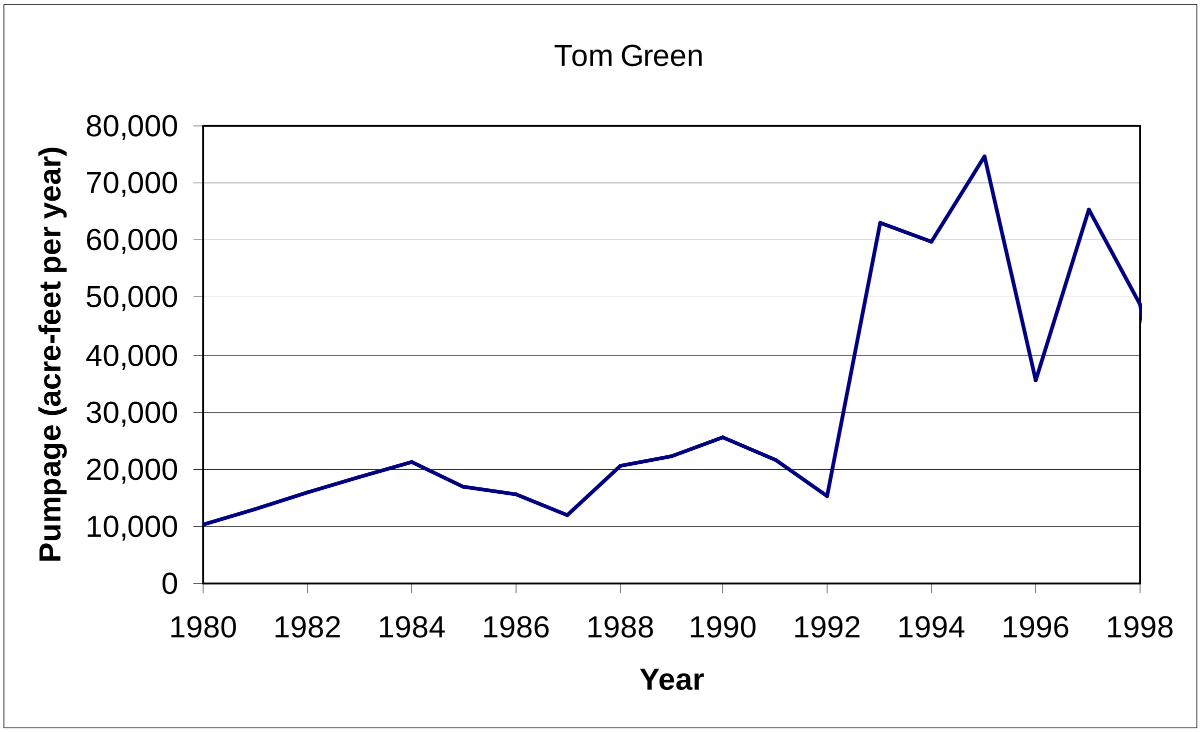

Figure A-6- Pumpage in Tom Green County included in the model for the Lipan Aquifer.