GAM Run 06-17

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EXECUTIVE SUMMARY:

The Groundwater Availability Model (GAM) for the Igneous and parts of the West Texas Bolsons (Salt Basin) aquifers was used to estimate drawdowns over a fifty year time period in Jeff Davis and Presidio counties when pumping at the year 2000 rates. Drawdowns for average and drought-of-record recharge conditions were also compared. The following conclusions can be drawn from the results of this modeling study.

- The use of drought-of-record recharge has negligible impact on the results of the modeling in the Salt Basin aquifer when compared to the use of average recharge. This is because the GAM assumes that the Salt Basin aquifer receives no direct recharge from precipitation; therefore, drought-of-record recharge has virtually no effect on water levels in this aquifer.

- The use of drought-of-record recharge has minimal impact on the results of the modeling in the Igneous aquifer when compared to the use of average recharge. The difference in water levels and drawdowns between the average and drought-of-record recharge runs was less than ten feet for most of the area, except in the heart of the Davis Mountains where there is no pumpage in the model.

- Drawdowns in the Salt Basin aquifer were much higher in Jeff Davis County than in Presidio County. This is because of pumpage in Culberson County which impacted water levels in the northern portion of the Salt Basin aquifer in Jeff Davis County.

REQUESTOR:

Ms. Janet Adams on behalf of the Jeff Davis County Underground Water Conservation District (UWCD) and the Presidio County UWCD (Districts).

DESCRIPTION OF REQUEST:

Ms. Adams requested a GAM run to evaluate the impact of the 2000 estimated pumpage on average and maximum drawdowns after 50 years using the GAM for the Igneous and parts of the West Texas Bolsons aquifers. Ms. Adams also requested that the difference in drawdowns between average and drought-of-record recharge conditions be evaluated. This GAM run is a baseline that will be used to set up additional GAM runs to evaluate desired future conditions for the Districts.

METHODS:

To determine the impact of the 2000 estimated pumping on drawdowns in Jeff Davis and Presidio counties, we used the GAM for the Igneous and parts of the West Texas Bolsons aquifers. The portions of the West Texas Bolsons aquifer included in the GAM are Wildhorse Flat, Michigan Flat, Ryan Flat, and Lobo Flat and are locally referred to as being part of the Salt Basin aquifer. To avoid confusion with other parts of the West Texas Bolsons aquifer, we refer to the West Texas Bolsons aquifer in this GAM as the Salt Basin aquifer in this report. We used both average and drought-of-record recharge for the runs. The water levels in the year 2000 were used as the baseline or reference point to calculate water level declines or increases in the predictive simulation. The year 2000 pumpage, both the volume and spatial distribution, remained constant throughout the predictive simulation.

PARAMETERS AND ASSUMPTIONS:

- See Beach and others (2004) for assumptions and limitations of the GAM for the Igneous and West Texas Bolsons 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 1990 to 2000 is 64 feet, or four percent of the range of measured water levels (Beach and others, 2004).

- The model includes three layers, representing the Salt Basin aquifer (Layer 1), the Igneous aquifer (Layer 2), and the underlying Cretaceous and Permian units (Layer 3).

- We simulated a 50-year time period for the predictive model run.

- We used both average annual recharge based on recharge determined through the calibration of the transient model covering the years 1950 to 2000 and the drought-of-record recharge. The drought-of-record recharge consists of 43 years of average recharge followed by seven years of recharge representing the drought-of-record. The drought-of-record for this region was defined as the years 1951 to 1957, where precipitation was 42 to 80 percent of normal, averaging 65 percent of normal (Beach and others, 2004).

- The GAM uses the MODFLOW recharge package to model both recharge from alluvial fans/stream beds and precipitation. It is assumed that precipitation recharge directly to the Salt Basin aquifer is zero; therefore, all recharge included in the recharge package to Layer 1 is from alluvial fan/stream bed infiltration. Recharge applied with the recharge package to the Igneous aquifer (Layer 2) is both direct precipitation recharge and alluvial fan/stream bed recharge.

- Pumpage is included in the model for all three layers, although pumpage in Layer 3, representing the underlying Cretaceous and Permian units, is minimal, and only occurs in Jeff Davis County on the northeastern margins of the aquifer. No pumpage is present in Presidio County from Layer 3 in the model.

- Pumpage for each year of the 50-year predictive model run was the estimated historic pumpage for the year 2000. Historic pumpage for Jeff Davis County is shown in Figure 1, and for Presidio County in Figure 2. This scenario assumes no changes to the amount of groundwater used in response to recharge conditions or in the distribution pattern of wells over the 50-year predictive simulation.

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

- The GAM uses the MODFLOW drain package to simulate discharge to streams and springs. Drains are included in both the Salt Basin aquifer and Igneous aquifer layers of the model. Drains were used as a simplified approach that allowed water to be removed from the groundwater system but do not allow water to flow in the stream to downstream locations that would then recharge the aquifer (Beach and others, 2004). Streams in the region are intermittent. Drain parameters were held at conditions representing the year 2000 stress period for the predictive simulations.

- The GAM uses the MODFLOW general-head boundaries (GHB) package to simulate cross-formational flow into and out of layer 3, which represents the Cretaceous and Permian units underlying the Igneous aquifer. GHB parameters were held at conditions representing the year 2000 stress period for the predictive simulations.

- The GAM uses the MODFLOW evapotranspiration package (ET) to simulate discharge of water due to evaporation and transpiration. ET parameters were held at conditions representing the year 2000 stress period for the predictive simulations.

RESULTS:

The Salt Basin aquifer is present in limited extent in both Jeff Davis and Presidio counties (Figure 3). Active cells in the GAM do not cover the entire extent of the Salt Basin aquifer due to the relatively small saturated thicknesses in these areas, generally less than 50 feet (Beach and others, 2004). Initial (2000) water levels range from approximately 4,500 feet above mean sea level at the southern end of Ryan Flat to less than 3,900 feet above mean sea level where Ryan Flat crosses the Jeff Davis-Culberson county line (Figure 4). As shown in Figure 4, portions of the aquifer were dry at the start of all of the predictive model runs (black cells are dry areas). In MODFLOW, when the water level in a model cell falls below the bottom of the cell, the cell goes dry. Because the cell no longer has water in it, MODFLOW turns the cell off. When a cell goes dry, the model is indicating that there is not enough water flowing into the cell (for example, recharge) or there is too much water being removed from the cell (for example, pumping) to keep water in the cell. If pumping is the primary factor, the model is saying that the pumping may be too great for the aquifer in this area. When MODFLOW shuts a cell off, that cell is off for the rest of the simulation unless the rewetting option is used. However, the MODFLOW rewetting option is difficult to use, and it is usually better to identify why the cell went dry and address the causes rather than use the rewetting option. In reality, the aquifer will probably not go dry because pumping will become uneconomical before the aquifer goes dry in any particular area. However, the GAM is suggesting that these areas may experience water supply problems sometime in the next 50 years.

Water levels in the Salt Basin aquifer after 50 years of pumping using the 2000 estimated pumpage and average recharge are shown in Figure 5, and the drawdown from 2000 to 2050 is shown in Figure 6. These figures indicate that drawdowns are between 0 and 60 feet over the 50-year predictive model run. Water-level declines were the smallest in the southern end of the aquifer in Presidio County and were the greatest at the Jeff Davis-Culberson county border. This is due to the large amount of pumpage included in the 2000 estimated pumpage in Culberson County.

Water levels and drawdowns in the Salt Basin aquifer were virtually identical when using the drought-of-record pumpage compared to average recharge. Differences in drawdowns between average and drought-of-record recharge are shown in Figure 7. This figure indicates that for most of the Salt Basin area the differences are negligible (less than one foot). This is because the GAM assumes that the Salt Basin aquifer receives no direct recharge from precipitation. The only locations where some difference between average and drought-of-record recharge can be observed are discrete points where alluvial fan/streambed recharge is added.

Average and maximum water-level drawdowns in the Salt Basin aquifer for both average and drought-of-record recharge are summarized in Table 1. As indicated in this table, differences in drawdowns between average and drought-of-record recharge is small. The drawdown in the Salt Basin aquifer in Jeff Davis County is much higher than in Presidio County, with an average drawdown for the county of approximately 23 feet and a maximum of more than 60 feet. This is due to the impact of pumpage included in Culberson County in the year 2000 estimated pumpage data set in this aquifer. If this pumpage were not present, drawdowns in Jeff Davis County would probably be similar to those in Presidio County.

The Igneous aquifer is present in much of Jeff Davis and Presidio counties (Figure 8). Initial (2000) water levels range from nearly 6,000 feet above mean sea level in the Davis Mountains to less than 3,000 feet above mean sea level in southern Presidio County (Figure 9). As shown in this figure, portions of the aquifer were dry at the start of all of the predictive model runs (black cells are dry areas).

Table 1. Average and maximum water-level drawdowns in the Salt Basin aquifer in Jeff Davis and Presidio counties from 2000 to 2050 when pumping at the year 2000 rates and using average and drought-of-record recharge.

	Average recharge	**Drought-of-record recharge**
Average drawdown in Jeff Davis County	23.0 feet	23.1 feet
Maximum drawdown in Jeff Davis County	60.5 feet	60.5 feet
Average drawdown in Presidio County	6.8 feet	7.4 feet
Maximum drawdown in Presidio County	17.4 feet	17.9 feet

Water levels in the Igneous aquifer after 50 years of pumping using the year 2000 estimated pumpage are shown in Figure 10, and the drawdown from 2000 to 2050 is shown in Figure 11. These figures indicate that water levels decline very little over the 50-year predictive model run over most of the two county area. Drawdowns are less than ten feet throughout most of Jeff Davis and Presidio counties. Higher drawdowns are observed in Jeff Davis County near the Culberson County line due to pumpage included in Culberson County in the year 2000 estimated pumpage. Drawdowns between ten and twenty feet can also be seen near the Jeff Davis-Presidio-Brewster county intersection. Some areas in Jeff Davis and Presidio counties show an increase (recovery) in water levels over the 50-year predictive model run. This is due to higher amounts of pumpage during the historic model run in the mid-1970s to early 1980s compared to pumpage in the year 2000 (Figure 1), which was used in the predictive model runs. This is especially notable in an area in south-central Jeff Davis County, where more than forty feet of recovery of water levels is projected to occur.

Drawdowns from 2000 to 2050 when using the drought-of-record recharge are shown in Figure 12. This figure indicates that the use of drought-of-record recharge results in similar drawdowns as using average recharge for most of the study area. Differences between average and drought-of-record recharge simulations are shown in Figure 13. Additional drawdowns when using drought-of-record recharge are less than ten feet for most of Jeff Davis and Presidion counties. Additional drawdowns of more than ten feet can be observed in the mountainous portions of the Davis Mountains where no pumpage is located, and around discrete points where alluvial fan/streambed recharge occurs.

Average and maximum drawdowns in the Igneous aquifer for both average and drought-of-record recharge are summarized in Table 2 below. As indicated in this table, differences between average and drought-of-record recharge is only a few feet. The large difference in the maximum drawdown in Presidio County is an artifact of the use of the MODFLOW recharge package to model water entering the aquifer from alluvial fan/streambed recharge, and is restricted to only two cells. The average drawdown is more reflective of the difference between average and drought-of-record recharge in Presidio County.

It should be noted that the GAM is a regional model with a grid spacing of a half mile. Drawdowns and recovery of water levels are averaged over this distance. Therefore, the drawdown observed at a particular well may actually be higher or lower due to the spatial scale of the model. Noting the trends in the water levels, as opposed to the exact values described in this report, is important to remember.

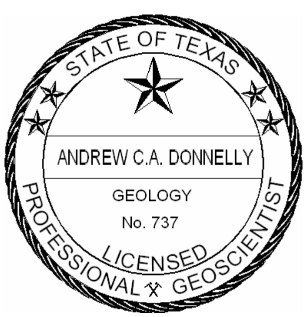
Table 2. Average and maximum water-level drawdowns in the Igneous aquifer in Jeff Davis and Presidio counties from 2000 to 2050 when pumping at the year 2000 rates and using average and drought-of-record recharge.

	Average recharge	**Drought-of-record recharge**
Average drawdown in Jeff Davis County	3.9 feet	9.5 feet
Maximum drawdown in Jeff Davis County	65.4 feet	67.1 feet
Average drawdown in Presidio County	2.9 feet	4.6 feet
Maximum drawdown in Presidio County	17.6 feet	55.5 feet*

* The high maximum drawdown for the drought-of-record in Presidio County is an artifact of the use of the MODFLOW recharge package for alluvial fan/streambed recharge.

REFERENCES:

Beach, J. A., Ashworth, J. B., Finch, Jr., S. T., Chastain-Howley, A., Calhoun, K., Urbanczyk, K. M., Sharp, J. M., and Olson, J., 2004, Groundwater availability model for the Igneous and parts of the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) aquifers: Contract report to the Texas Water Development Board, 208 p.



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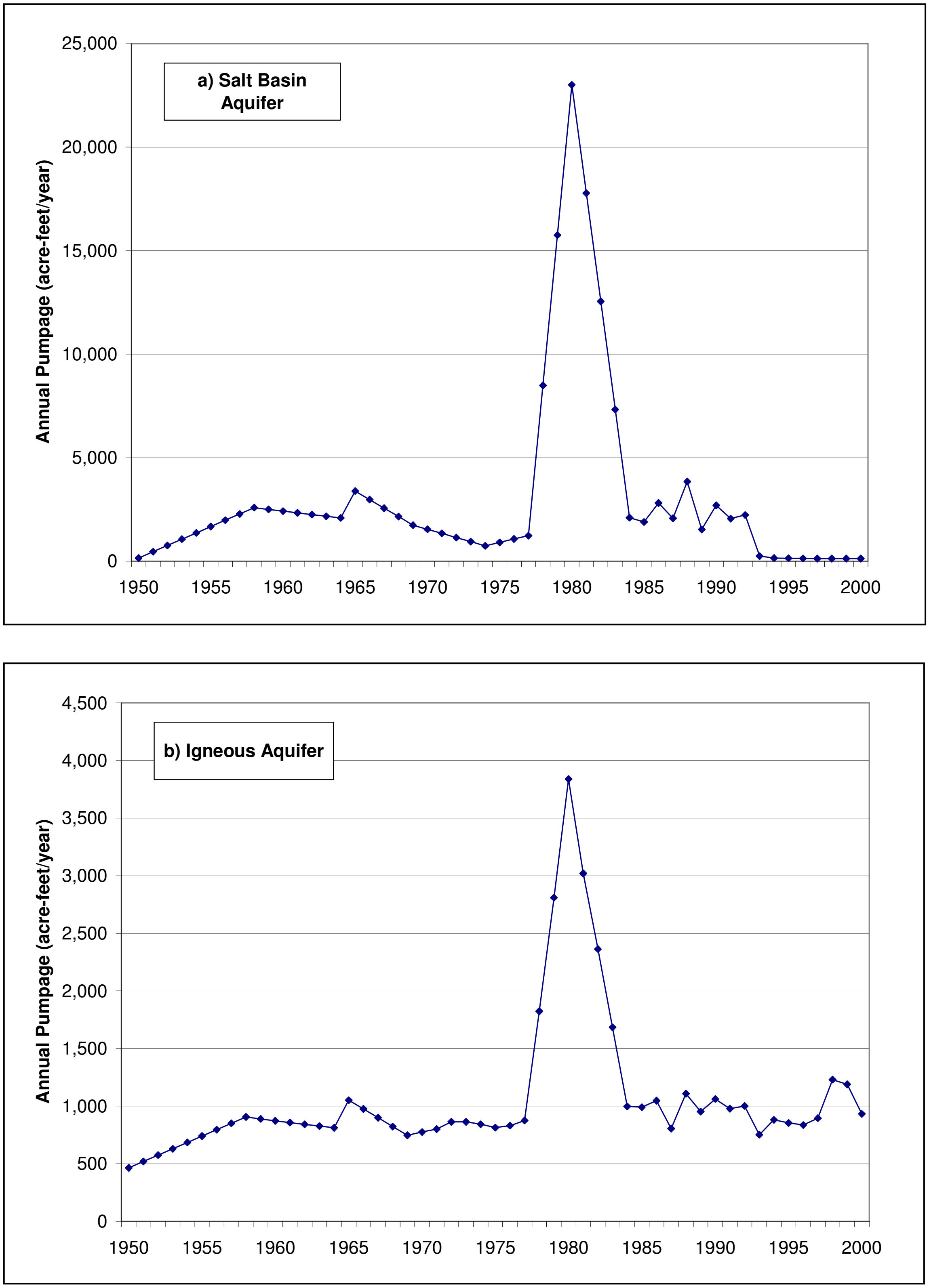

Figure 1. Annual historic pumpage in Jeff Davis County from a) the Salt Basin aquifer and b) the Igneous aquifer.

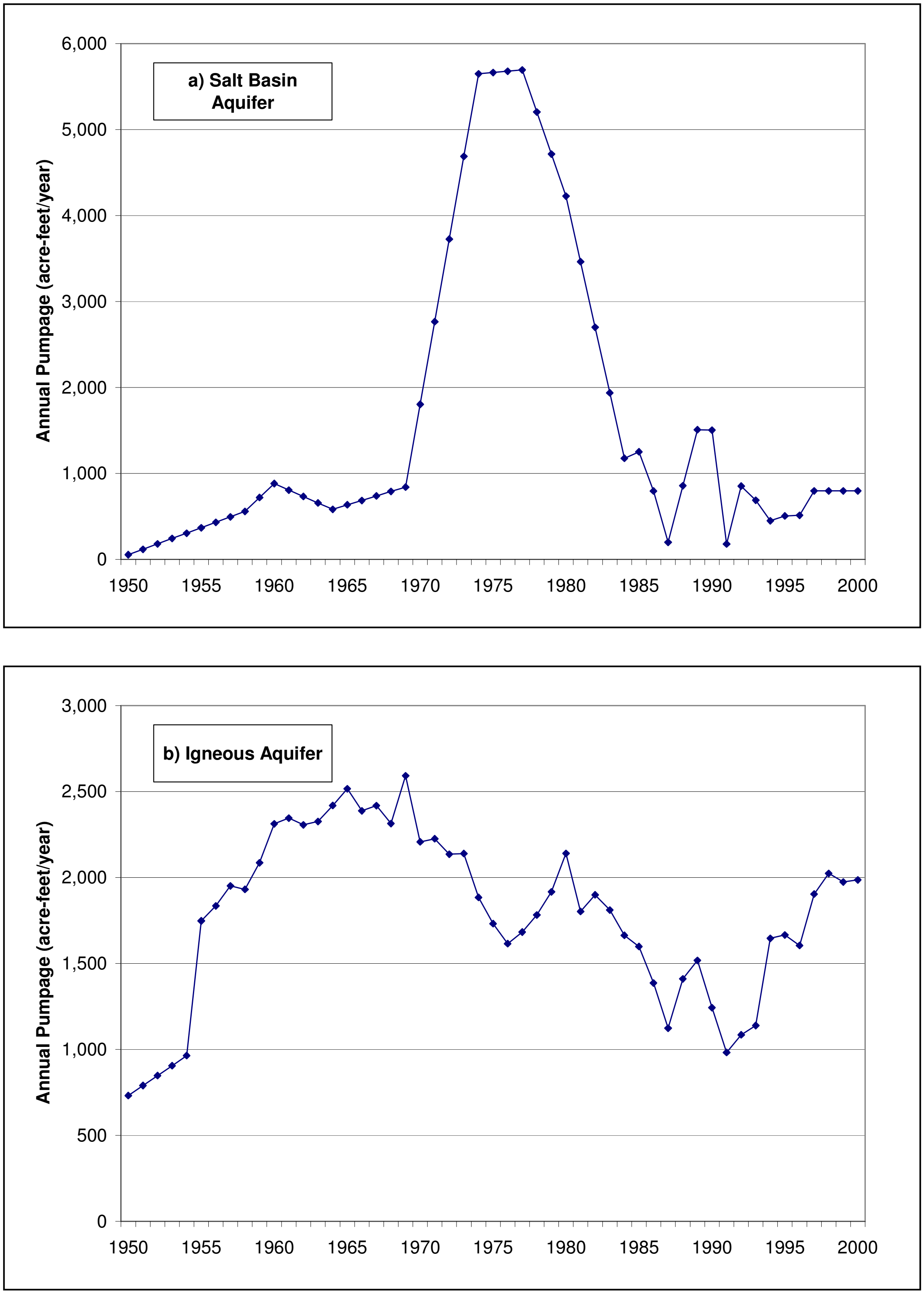

Figure 2. Annual historic pumpage in Presidio County from a) the Salt Basin aquifer and b) the Igneous aquifer.

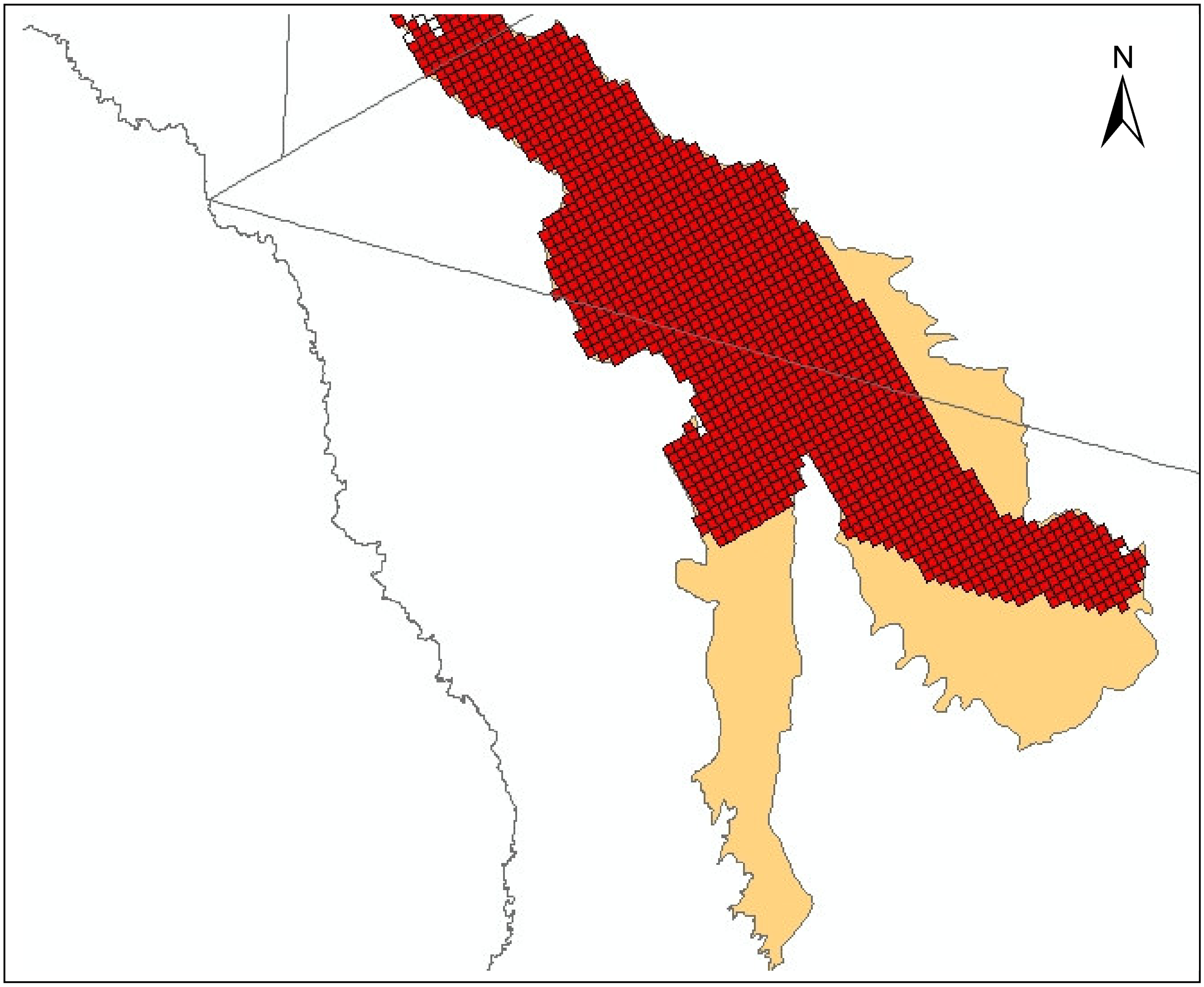

Figure 3. Extent of the Salt Basin aquifer in the GAM. Model cells in red are active cells that contain pumpage in 2000. Model cells in white are active cells without pumpage. The actual extent of the Salt Basin aquifer is shown in tan.

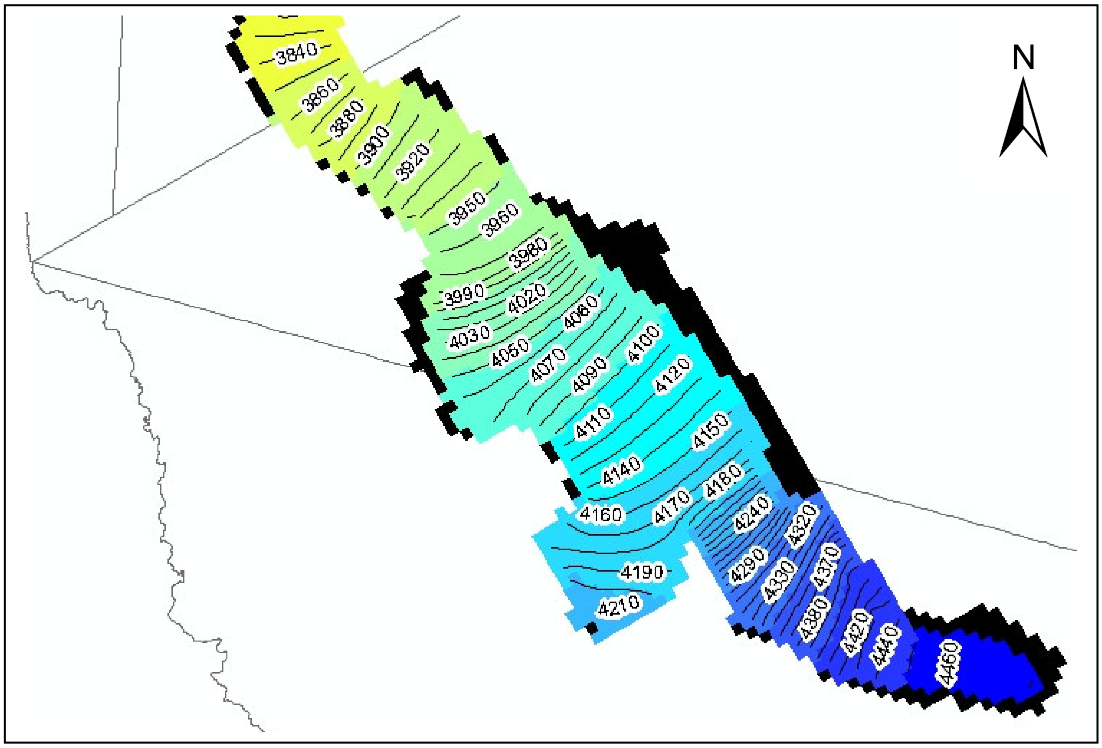

Figure 4. Initial water levels in the Salt Basin aquifer in the year 2000. Contour interval is 10 feet. Black areas are where the GAM showed the aquifer is dry.

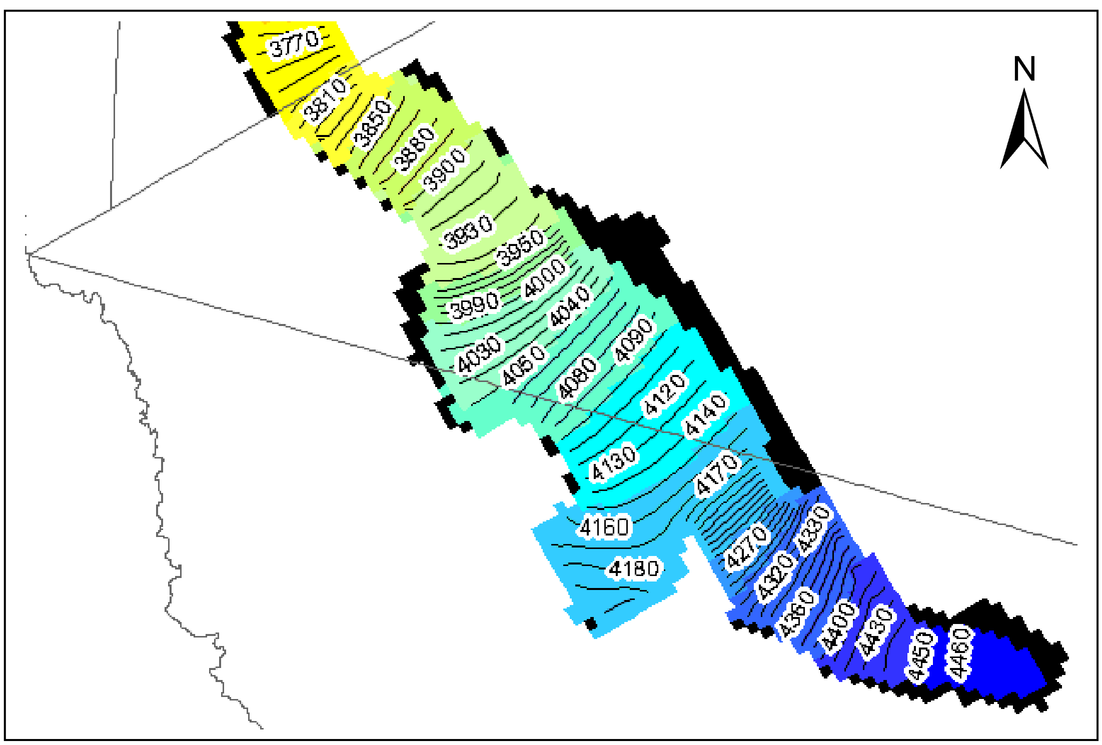

Figure 5. Water levels in the Salt Basin aquifer after 50 years of pumping using the 2000 estimated pumpage with average recharge. Contour interval is 10 feet. Dry model cells in the model run are shown in black.

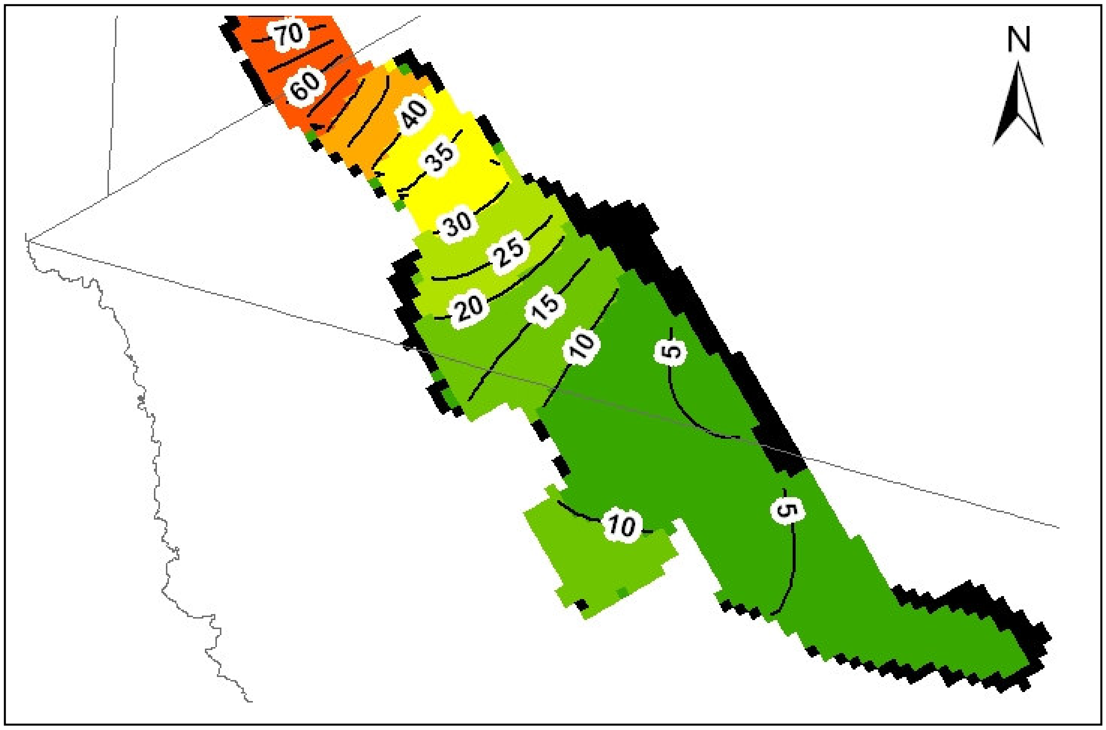

Figure 6. Drawdowns in the Salt Basin aquifer after 50 years of pumping using the year 2000 estimated pumpage with average recharge. Contour interval is 5 feet. Dry model cells in the model run are shown in black.

Figure 7. Difference in drawdowns in the Salt Basin aquifer after 50 years of pumpage when using average compared to drought-of-record recharge. The difference is minimal in most of the study area. The only locations with significant differences are at discrete points where alluvial fan/streambed recharge is added to the Salt Basin aquifer. Contour interval is 1 foot.

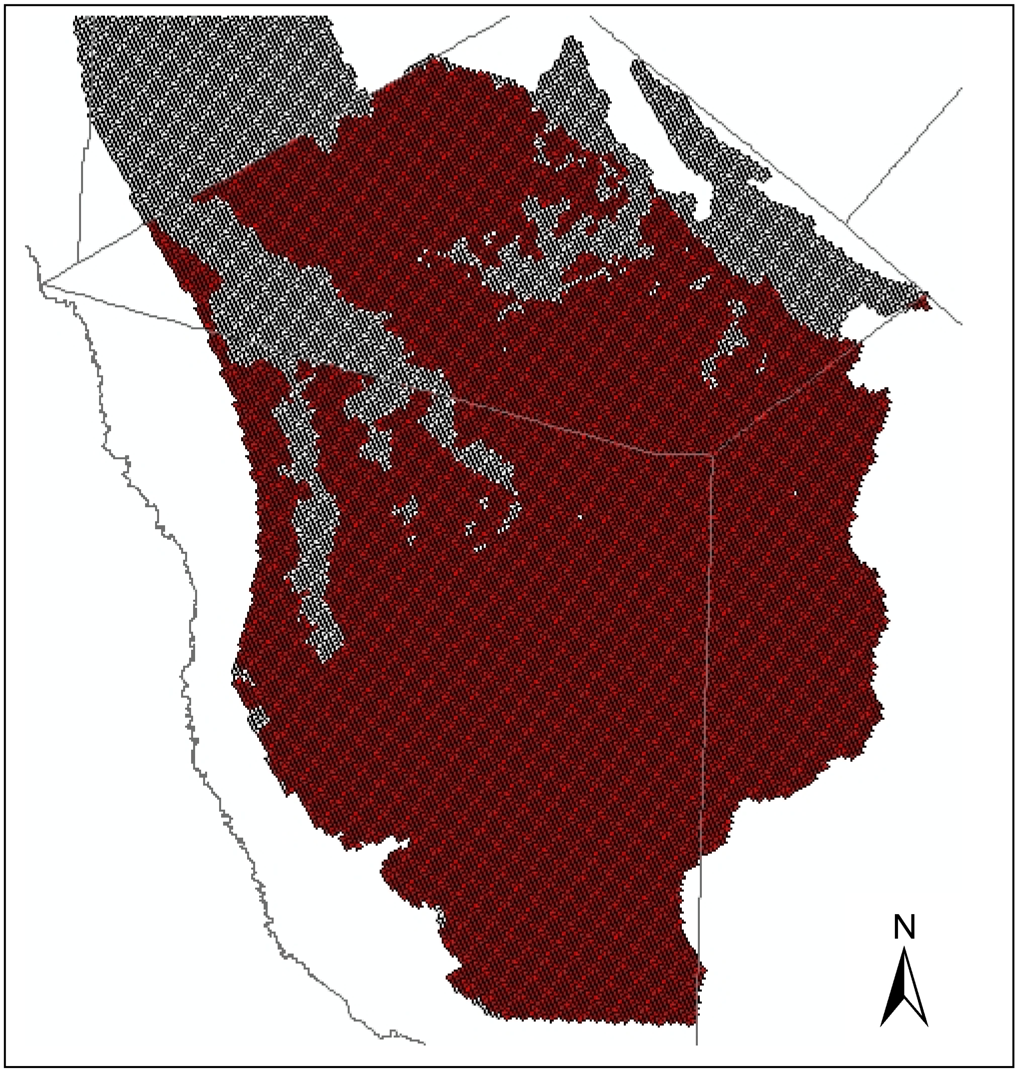

Figure 8. Extent of the Igneous aquifer in the GAM. Model cells in red are active cells that contain pumpage in 2000. Model cells in white are active cells without pumpage. The scale of this figure makes it difficult to see individual model cells.

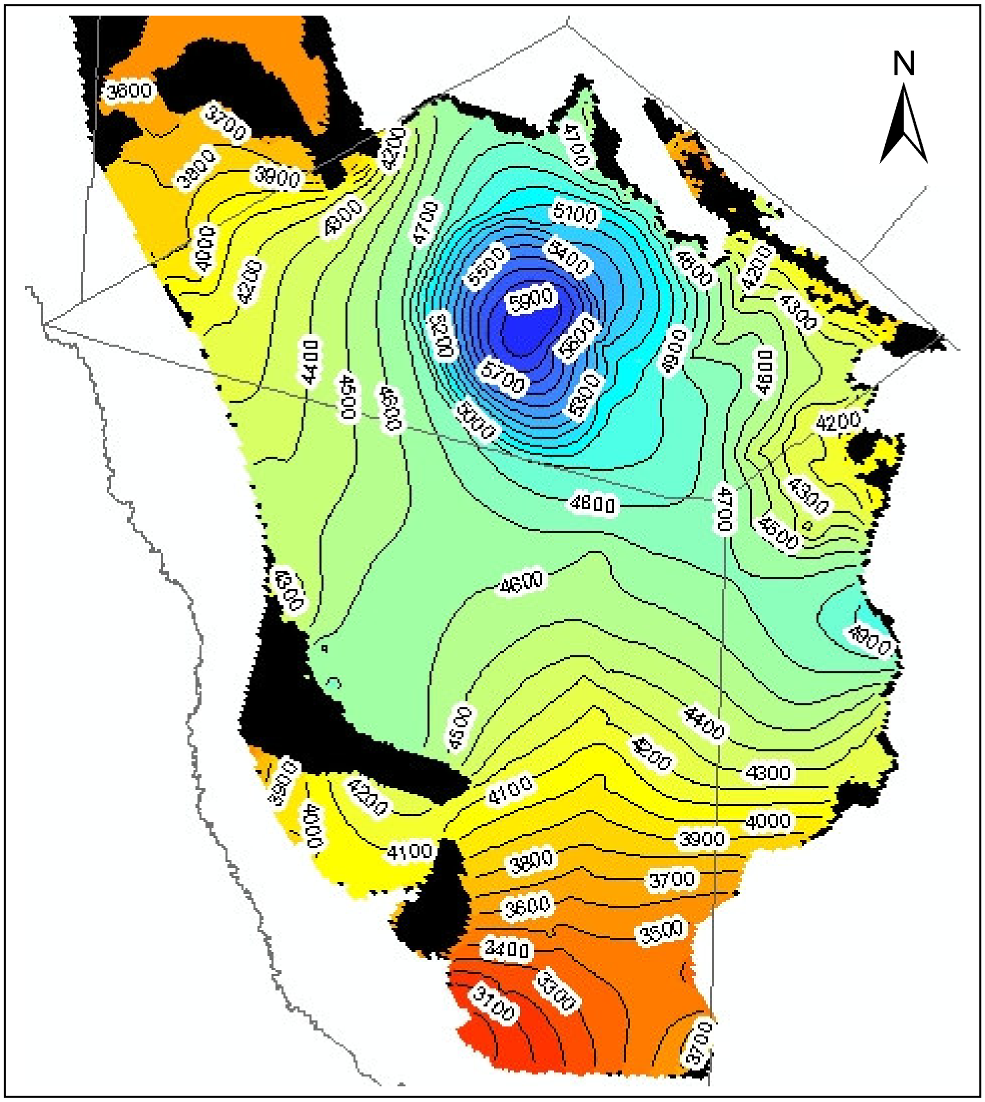

Figure 9. Initial water levels in the Igneous aquifer in the year 2000. Contour interval is 100 feet. Black areas are where the GAM showed the aquifer is dry.

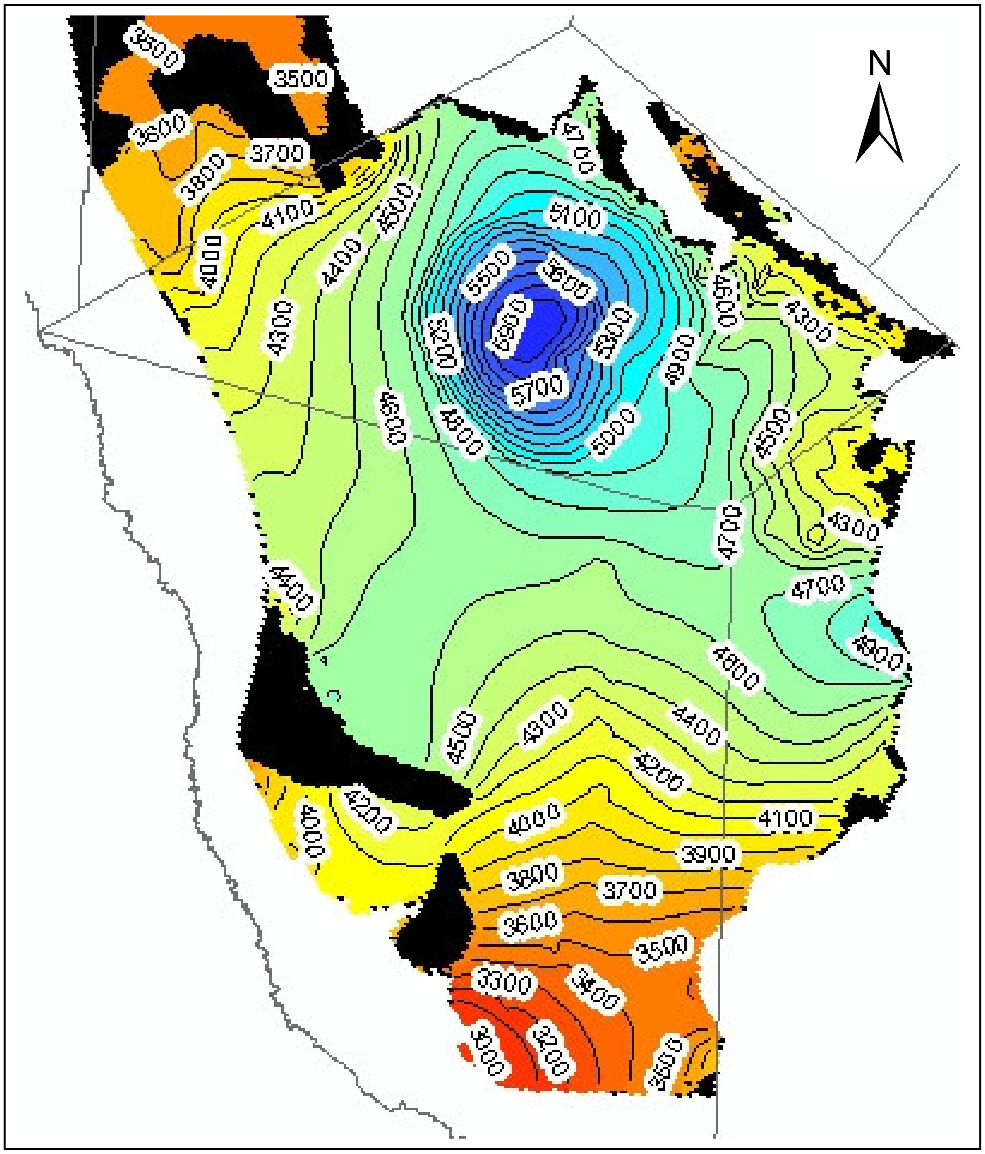

Figure 10. Water levels in the Igneous aquifer after 50 years of pumping using the 2000 estimated pumpage with average recharge. Contour interval is 100 feet. Dry model cells in the model run are shown in black.

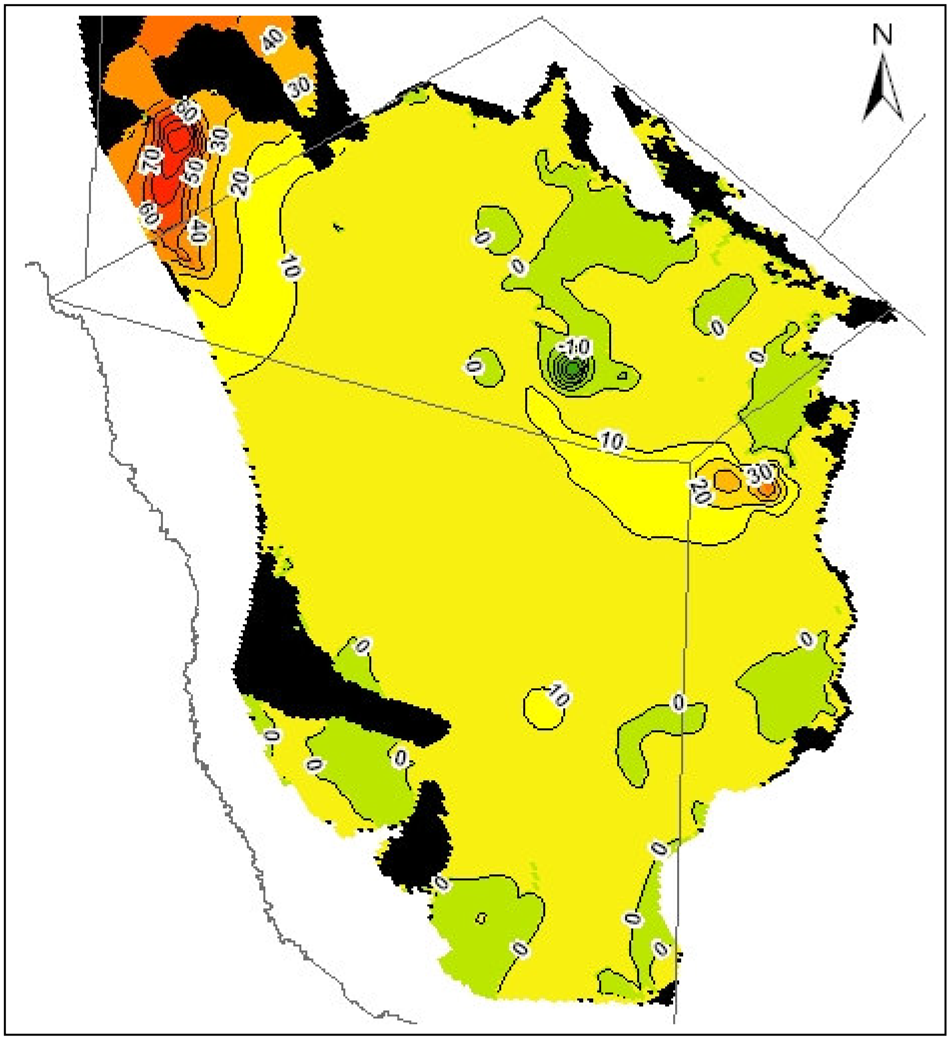

Figure 11. Drawdowns in the Igneous aquifer after 50 years of pumping using the 2000 estimated pumpage with average recharge. Contour interval is 10 feet. Areas in green are showing recovery (and therefore have negative drawdowns); areas in yellow and orange are showing drawdown. Dry model cells in the model run are shown in black.

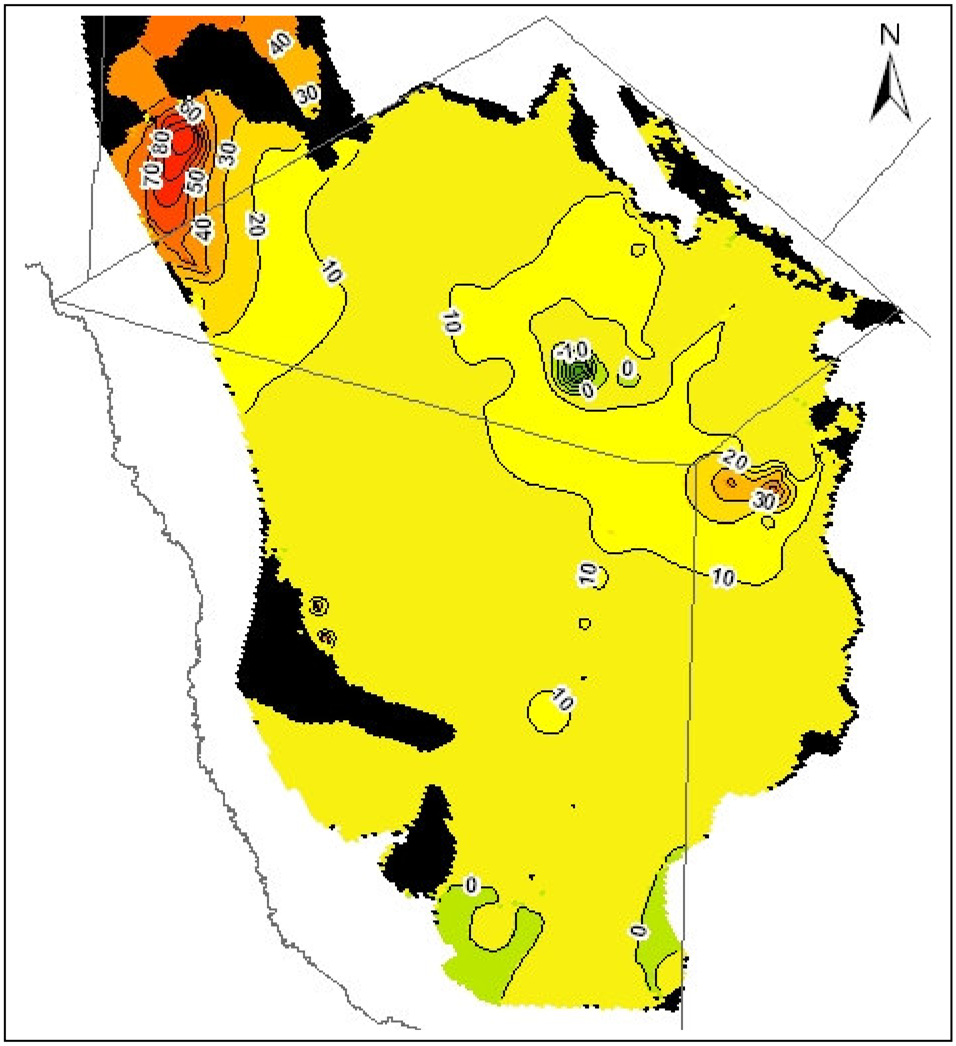

Figure 12. Drawdowns in the Igneous aquifer after 50 years of pumping using the 2000 estimated pumpage with drought-of-record recharge. Contour interval is 10 feet. Areas in green are showing recovery (and therefore have negative drawdowns); areas in yellow and orange are showing drawdown. Dry model cells in the model run are shown in black.

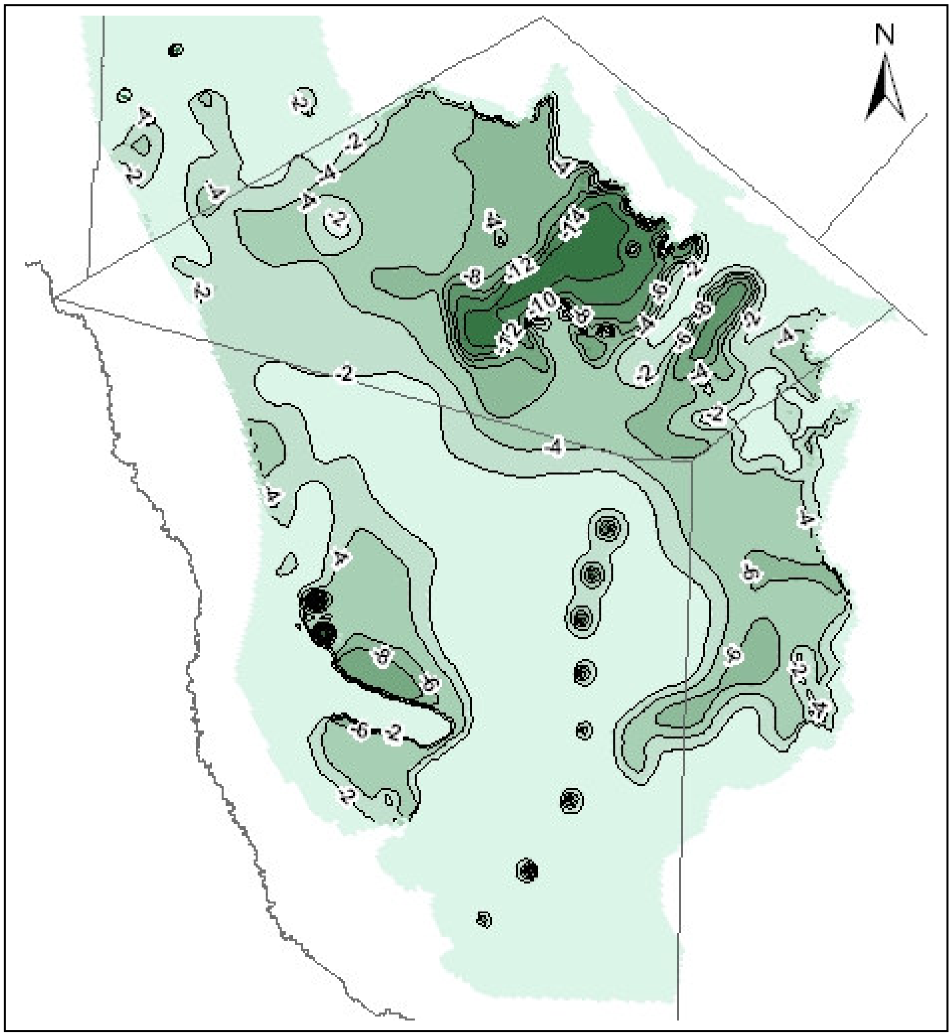

Figure 13. Difference in drawdowns in the Igneous aquifer after 50 years of pumping when using average compared to drought-of-record recharge. Water levels are lower, and therefore drawdowns are greater, throughout most of the aquifer area. However, except in the mountainous portions of the Davis Mountains, where no pumpage is located, the difference between average and drought-of-record recharge is less than 10 feet. Contour interval is 2 feet.