

## 5.0 PAST VIEWS OF GROUNDWATER SUPPLY

### 5.1 Muller and Price (1979)

Section 3 of this report summarized three key investigations of the El Paso portion of the Hueco from 1921 to 1976 as they related to the understanding of the interaction between groundwater and surface water. The discussion ended with a description of the results of a 1976 US Geological Survey investigation that presented a quantification of the impact of pumping to the overall groundwater budget.

In 1979, the Texas Department of Water Resources (a predecessor agency of the Texas Water Development Board) prepared an assessment of groundwater availability in all the major groundwater areas of Texas, including the Hueco Bolson (Muller and Price, 1979). The assessment of the Hueco relied heavily on the US Geological Survey investigation discussed earlier (Meyer, 1976), as well as a companion Texas Department of Water Resources investigation (Knowles and Alvarez, 1979), which used the model developed by Meyer (1976) to simulate future groundwater conditions.

Muller and Price (1979) used the results of these modeling investigations and specific assumptions related to future groundwater pumping to develop conclusions related to groundwater availability in the El Paso portion of the Hueco. Specifically, Muller and Price (1979) concluded that fresh groundwater in the El Paso portion of the Hueco would be depleted by 2030.

The approach of the Muller and Price (1979) analysis was as follows:

- Groundwater storage in 1974 was 10.6 million acre-feet
- The model simulations showed that groundwater storage was declining as a result of an imbalance between total inflow and total outflow, resulting in groundwater “mining”
- As the mining continues, only 75% of the storage would be “available” for pumping due to the proximity of poor quality groundwater

In summary, Muller and Price (1979) used the results of Knowles and Alvarez (1979) along with specific assumptions to estimate when cumulative storage decline would reach the threshold level. The threshold can be defined as either:

- Cumulative storage depletion reaches 7.95 million acre-feet (75% of the initial storage of 10.6 million acre-feet)
- Remaining storage is 2.65 million acre-feet (25% of the initial storage of 10.6 million acre-feet)

The assumptions used in the analysis can be grouped into water supply and demand assumptions (i.e. amounts of pumping), and assumptions that are derived from the model (hydrogeologic assumptions). These hydrogeologic assumptions include the natural recharge, the amount of inflow induced into the flow system due to pumping, and the rate of storage decline.

### *5.1.1 Water Supply and Demand Assumptions*

The El Paso water supply and demand assumptions used by Muller and Price (1979) can be summarized as follows:

- Total water demand was 111,900 AF in 1974, and would increase to 431,400 AF in 2030
- Surface water supply was 14,200 AF in 1974, and would increase to 20,100 AF in 2030.
- Groundwater supply was 97,700 AF in 1974, and would increase to 411,300 in 2030.

The total water demand assumptions are presented in Figure 5-1 along with the actual total demand from 1967 to 2002. Similarly, Figure 5-2 presents the assumed surface water supply with the actual from 1967 to 2002, and Figure 5-3 presents the assumed groundwater supply with actual pumping from 1967 to 2002. It is clear from an examination of these comparisons that the supply and demand assumptions made in 1979 did not “come true”. Total demand in 2002 was about 120,000 AF, surface water diversions were about 58,000 AF, and EPWU Hueco pumping was about 39,000 AF.

In 1979, EPWU still used a flat rate pricing structure. In 1980, this flat rate was terminated, and per capita use dropped (Figure 2-3). In 1990, an “excess rate structure” or increasing block rate structure was adopted as well as a water conservation ordinance. These policies were instrumental in reducing water demand.

Surface water use assumptions were based on the fact that, in 1979, EPWU had 40 mgd of surface water treatment capacity at the Robertson/Umberhauer plant (sometimes referred to as the “canal plant”) near downtown El Paso. In 1993, the Jonathan Rogers plant became operational and the total surface water treatment capacity was doubled to 80 mgd. In 2002, the Rogers plant was expanded, and the total capacity of surface water treatment was increased to 100 mgd.

As a result of the combined reduction in per capita demand, and the increased capacity of surface water treatment plants, the pumping in the Hueco Bolson was reduced. This reduction, as noted earlier, has resulted in stabilization of groundwater elevations in some areas of El Paso.

This analysis of Muller and Price (1979) could lead to criticism of their water supply and demand assumptions. This would be unfair since the deviations observed in Figures 5-1, 5-2 and 5-3 were the result of fundamental changes that occurred after the completion of their report. Furthermore, it is not a coincidence that these changes occurred after the Muller and Price (1979) report. Their work provided the impetus for EPWU to act in a positive manner to improve its overall water supply situation.

The true conclusion of Muller and Price (1979) was that if pumping in the El Paso portion of the Hueco continued at the rate that had been experienced in the 1970s, a

problem would occur several years or decades later. As a result of this information, EPWU took positive action that resulted in the reduction of Hueco pumping.

### *5.1.2 Hydrogeologic Assumptions*

A comparison of the hydrogeologic assumptions of Muller and Price (1979), and the “actual” conditions from 1979 to 2002 demonstrate that the underlying model used in the Muller and Price (1979) analysis were quite good. These assumptions can be summarized as follows:

- “Natural” recharge is about 6,000 AF/yr
- “Induced” inflow varied with pumping (i.e. higher pumping resulted in more induced inflow)
- Groundwater storage change was calculated based on a comparison of total inflow and total outflow

For purposes of this discussion, the Muller and Price (1979) assumptions of “natural” recharge, “induced” inflow, and storage change and “actual” was based on a more recent groundwater flow model of the area developed by the US Geological Survey (Heywood and Yager, 2003). The details of that model are discussed later in this report.

Figure 5-4 presents a comparison of the Muller and Price (1979) natural recharge and the “natural” recharge of Heywood and Yager (2003). Figure 5-5 presents a comparison of “induced” inflow estimated by Muller and Price (1979) and Heywood and Yager (2003). Finally, Figure 5-6 presents a comparison of groundwater storage change estimated by Muller and Price (1979) and Heywood and Yager (2003).

It can be seen that the estimated natural recharge of about 6,000 AF/yr estimated by Muller and Price (1979) is essentially the same as that estimated by Heywood and Yager (2003). The “induced” inflow estimates from the two investigations are in reasonable agreement until the late 1980s. After the late 1980s, Muller and Price estimates are much higher than Heywood and Yager’s (2003) estimates. Note that the induced inflow is a function of pumping: the higher the pumping, the higher the induced inflow. Also note that EPWU pumping in the Hueco began to decrease after 1989. It is reasonable to conclude that the underlying model used in Muller and Price (1979) is consistent with the more updated model of Heywood and Yager (2003) since the pre-1989 estimates of induced inflow are similar. The divergence after 1989 can be attributed to the high pumping assumptions of Muller and Price (1979) discussed earlier in this section of this report.

Similar to the induced inflow estimates, the storage change estimates of Muller and Price (1979) and the storage change estimates of Heywood and Yager (2003) are in reasonable agreement until the 1980s. However, the divergence in the estimates in storage change occurs earlier than the induced inflow estimates.

Based on these comparisons, it appears that the underlying model that was used in the Muller and Price (1979) analysis and the more recent model developed by Heywood and

Yager (2003) yield similar results. The “over-estimation” of induced inflow and storage decline of Muller and Price (1979) are not due to an inadequate model, but can be attributed to their assumptions of post-1979 pumping. As was discussed earlier, the estimates made by Muller and Price (1979) regarding demand, surface water diversions and groundwater pumping were not erroneous. Action by EPWU that was taken by EPWU in the 1980s and 1990s resulted in reduced pumping.

### **5.1.3 Assessment of Muller and Price (1979)**

This comparative analysis of Muller and Price (1979) with the most recent groundwater flow model of the area (Heywood and Yager, 2003) is strong evidence that the hydrogeology of the El Paso portion of the Hueco Bolson was well understood by 1976 when Meyer (1976) published his report. Knowles and Alvarez (1979) used that model to simulate future conditions, and their results were used as the foundation of the Muller and Price (1979) work.

In conclusion, the assumptions of supply and demand made by Muller and Price (1979) did not “come true” due to positive action by EPWU to reduce pumping. Unfortunately, the conclusion that the Hueco would be depleted of fresh groundwater by 2030 was often quoted and used in subsequent years without a full understanding of the underlying assumptions associated with the conclusion. Moreover, the conclusion that the Hueco would be depleted of fresh groundwater by 2030 was repeated even after pumping had been reduced.

## **5.2 Boyle (1991)**

In 1991, Boyle Engineering completed a report entitled “Water Resource Management Plan, 1991 – 2040” for EPWU. It defined the quantities and costs of new water supplies and facilities projected to be required over the planning period. The report was to be a guide for management policy and actions, and the authors intended for the report to be periodically reviewed and updated (i.e. every 5 years).

Regarding the Hueco Bolson as a water supply, Boyle (1991, pp. 36-37) wrote:

*“Continued withdrawals from the Hueco Bolson under the present trends by both El Paso and Cd. Juarez is projected to deplete the recoverable freshwater in the Texas portion of the bolson in the mid 2020’s. Accordingly, while the Hueco Bolson is currently a viable source of additional groundwater supplies, a basic objective of this Management Plan is to reduce withdrawals from the Hueco Bolson in Texas to a sustained yield level. Initially, the Hueco Bolson will continued to be relied on to supply water to the EPWU at rates decreasing from the present level of extraction of about 75,000 AF/year to no withdrawals after the year 2005, except for supplemental pumping in surface-water short years.”*

It is clear that the approach outlined in this plan was followed: surface water diversions were increased and pumping from the Hueco was reduced. However, it is also clear that

Boyle (1991) simply restated the conclusion from Muller and Price (1979) without quoting them, or reviewing the underlying assumptions.

Recall from Figure 2-3 that per capita demand was decreasing after 1980 due to changes in the pricing of water (i.e. the end of the flat rate). It can be seen in Figure 5-3 that the pumping trend from 1980 to 1990 was different from that prior to 1980. However, Boyle (1991) did not appear to evaluate the significance of the change in trend relative to the Muller and Price (1979) conclusion.

More significant was the trend after 1990 (i.e. after adoption of the plan outlined by Boyle (1991), the adoption of a increasing block rate structure, and the adoption of the water conservation ordinance). Since 1990, pumping has been decreasing each year, with the commensurate stabilization of groundwater elevations noted in hydrographs (Figures 4-2 to 4-5), previously discussed.

### **5.3 Fahy and Sheng (2000)**

In 2000, Fahy and Sheng (2000) prepared a report entitled: “Management Strategies for the Hueco Bolson”. On pages 6 and 7 of that report, the following summarized their assessment of the condition of the Hueco:

*“The fresh groundwater depletion of the Hueco Bolson aquifer in 1999 was estimated at 184,106 AF/yr ... due to pumping in Texas, New Mexico and Mexico. Several cones of depression have been observed, which have resulted from the overwithdrawal of groundwater in the Hueco Bolson aquifer. ... The overall margins of cones of depression continue to widen and the center of the cones continue to deepen due to the historic stresses and continuous pumping, even though EPWU has reduced annual pumping from 70,000 to 50,000 ac-ft since 1990 because of conservation and completion of the Jonathan Rogers Water Treatment Plant in 1993. The water quality deterioration rate has not been measurably reduced because the depression gradient still induces the migration of the brackish water into the fresh water zones. If the current deterioration trend continues, the economically recoverable fresh water in the Texas portion of the Hueco Bolson will still be depleted by 2020-25 without the Regional Sustainable Water Project.”*

The key points from this assessment are as follows:

- The conclusion that the El Paso portion of the Hueco Bolson would be depleted of fresh groundwater by 2020 to 2025 is once again repeated. It is interesting to note that Muller and Price (1979) estimated 2030, Boyle (1991) estimated “mid 2020s”, and Fahy and Sheng (2000) estimated 2020 to 2025. Neither Boyle (1991) nor Fahy and Sheng (2000) referenced Muller and Price (1979), but it is apparently the origin of the estimate.
- Fahy and Sheng (2000) appeared to rely on “the water quality deterioration rate” to support their conclusion. However, no data or analyses are presented to explain what the rate was or where it was most acute.

- The reduction in pumping since 1990 is noted, but, based on the subsequent statements, Fahy and Sheng (2000) appeared to have concluded that groundwater elevations continued to decline. This is particularly confusing since the historic groundwater level data in many of the EPWU wells contradict the conclusion (e.g. Figures 4-2 to 4-5).
- The groundwater storage decline for 1999 was estimated to be 184,106 AF. In their analysis, pumping in 1999 in Texas, New Mexico, and Mexico was estimated to be 191,508 AF. The recharge, however, was estimated to be 7,402 AF. Recharge estimates were limited to “natural recharge” of 5,640 AF and injection of 1,762 AF of reclaimed water from the Fred Hervey Water Reclamation Plant. Noticeably absent from this analysis was the induced inflow from the surface water system and the increased inflow from New Mexico caused by the depressed groundwater levels in El Paso and Juarez. Interestingly in another portion of the report, Fahy and Sheng (2000, pg. 5) acknowledged the increased inflow from New Mexico, but failed to include it in their summary groundwater budget for 1999.

Although the groundwater model developed by the USGS (Heywood and Yager, 2003) was not yet finalized and released to the public, Fahy and Sheng (2000, pg. 1) noted that, as cooperators, EPWU had received a working version of the model in December 1999. Therefore, they had access to the groundwater storage decline estimates of the model when the estimate of groundwater storage decline for 1999 was developed. While not acceptable to release the actual estimates of the USGS model prior to final approval, the working model could have provided a basis for comparison of the independently prepared 1999 groundwater budget.

EPWU (2002) summarized the groundwater budget components of the USGS model, and the storage change estimates from 1903 to 1996 are presented in Figure 5-7. Note that the maximum groundwater level decline was estimated at about 134,000 AF/yr in 1989. From 1989 to 1996, the rate of groundwater storage decline was reducing in response to decreasing EPWU pumping.

An analysis of actual groundwater level data between 1998 and 1999 suggests that the estimate of 184,106 AF decline in 1999 is high. The area of maximum groundwater level decline in El Paso and Juarez is shown in Figure 5-8, and covers 213,479 acres. In order to estimate the liquid water storage change, the 184,106 AF estimate is divided by the 213,479 acres to yield an estimate of 0.86 feet. This represents the liquid water decline (as if it represented the storage decline in a tank). In order to translate this into a reasonable estimate of groundwater level decline, the value must be divided by an estimate of aquifer storativity. Storativity is defined as the amount of water taken into or released from storage under a unit (i.e. one foot) change in groundwater level over a unit area (i.e. one acre).

Previous estimates of aquifer storativity in the Hueco Bolson range from 0.12 to 0.17. Table 5-1 summarizes the expected groundwater level decline under the assumed 184,106 AF storage decline.

**Table 5-1**  
**Estimated Groundwater Level Decline Assuming 184,106 AF**  
**Storage Change over a 213,479 acre area (El Paso and Juarez)**

Storativity	Decline in Groundwater Level (ft)
0.12	7.19
0.13	6.63
0.14	6.16
0.15	5.75
0.16	5.39
0.17	5.07

Figure 5-9 presents an analysis of the actual groundwater level changes between 1998 and 1999. The wells used in this analysis are shown in Figure 5-10 and include mostly wells in the high pumping areas. Based on an analysis of actual groundwater level data in 1998 and 1999, the average decline is less than one foot, which suggests that the estimate of 184,106 AF is unreasonably high.

In summary, Fahy and Sheng (2000) did not consider induced inflow in their estimate of the 1999 groundwater budget, and did not evaluate their estimate of storage decline in the context of the actual groundwater level data in EPWU wells. As a result, they overestimated the groundwater storage decline in 1999.

#### **5.4 Conclusions Regarding Past Views**

- The analysis completed by Muller and Price (1979) included specific and well-articulated assumptions regarding water demand and supply. The underlying models used in the analysis appear to have been appropriate and, based on a comparative analysis with more recent modeling efforts, suggest that the hydrogeology of the Hueco was well understood at the time of the analysis.
- Boyle (1991) developed a water management plan that, when implemented in conjunction with other strategies, resulted in reductions in EPWU pumping in the Hueco. Unfortunately, the plan did not recognize the role of induced inflow in the management of the Hueco, and thus recommended that EPWU pumping be reduced to zero by 2005.
- Fahy and Sheng (2000) did not consider induced inflow in their estimate of the 1999 groundwater budget, and did not evaluate their estimate of storage decline in the context of the actual groundwater level data in EPWU wells. As a result, their estimate of groundwater storage decline was unreasonably high.

- Both Boyle (1991) and Fahy and Sheng (2000) repeated the conclusion of Muller and Price (1979) without an analysis of the changed assumptions, which were significant.



Figure 5-1  
Total Water Demand

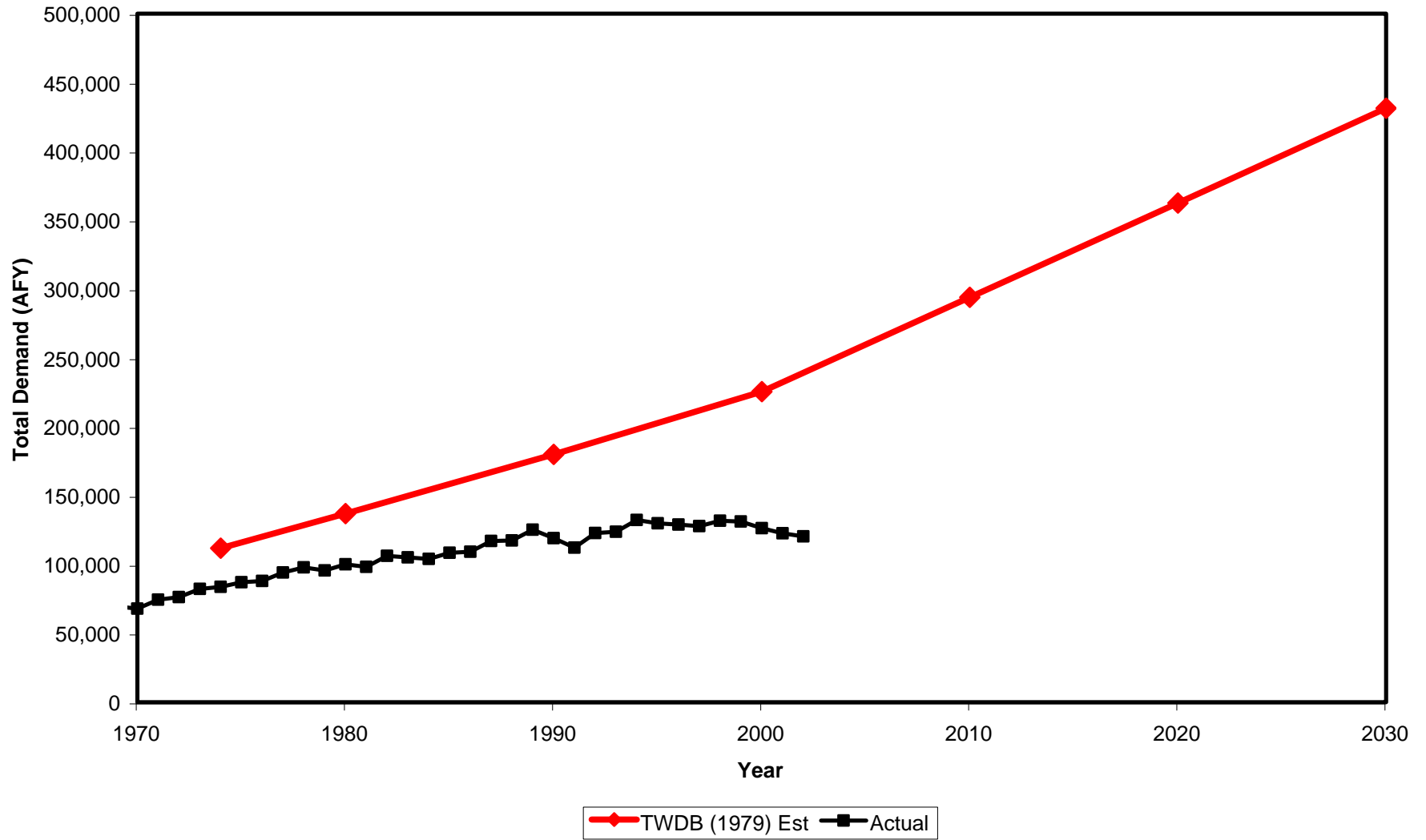


Figure 5-2  
Surface Water Use

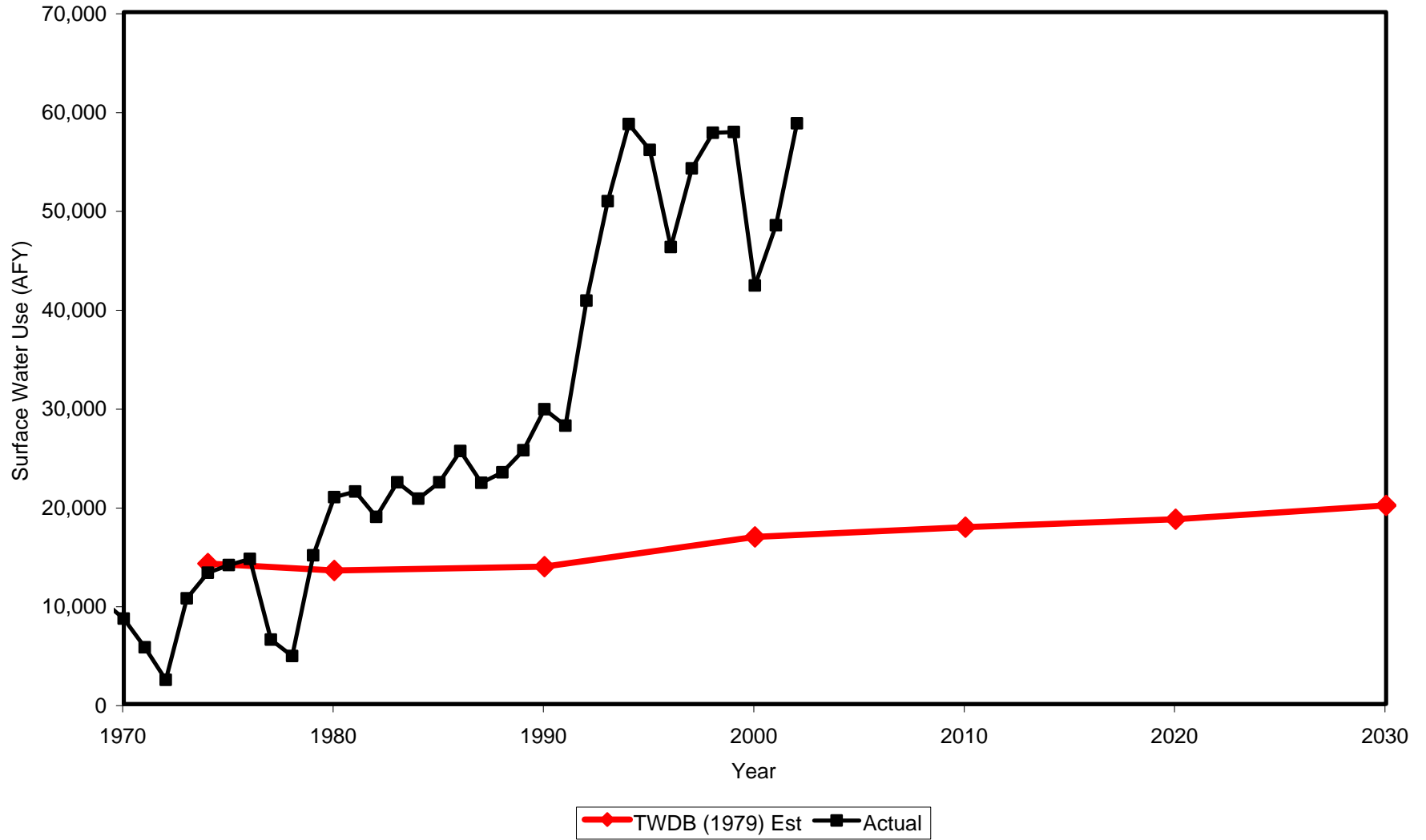


Figure 5-3  
Groundwater Use

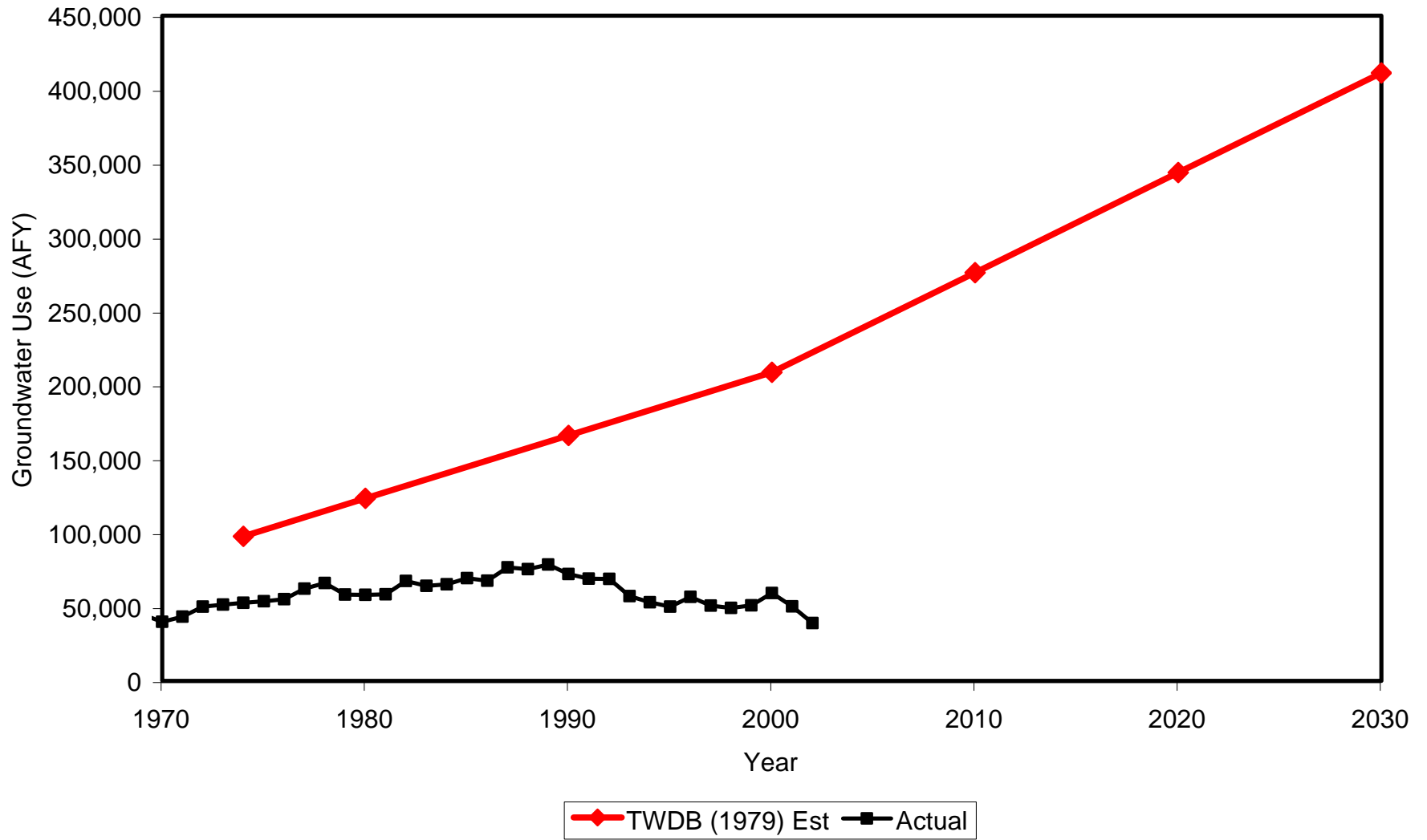


Figure 5-4  
"Natural" Recharge

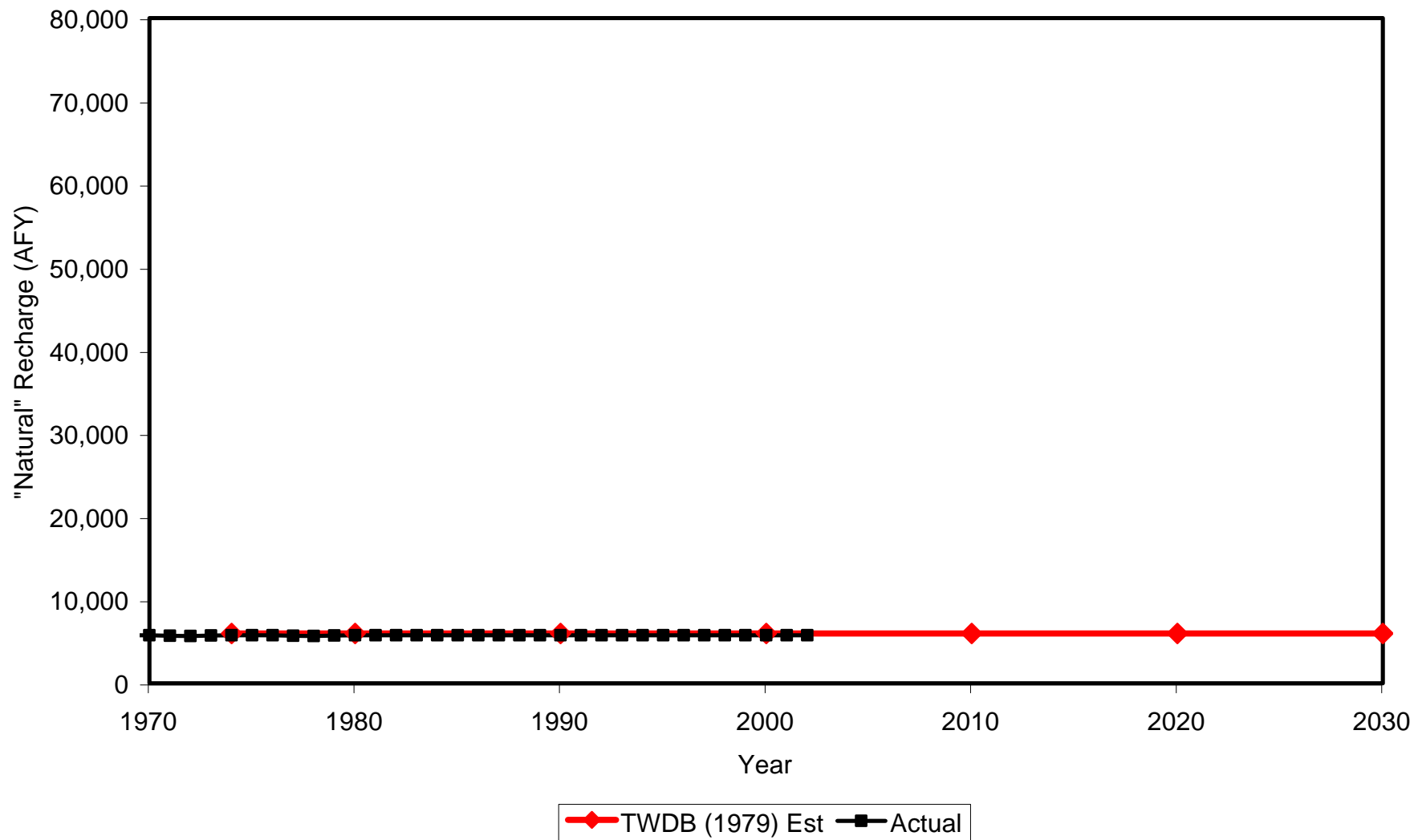


Figure 5-5  
"Induced" Recharge

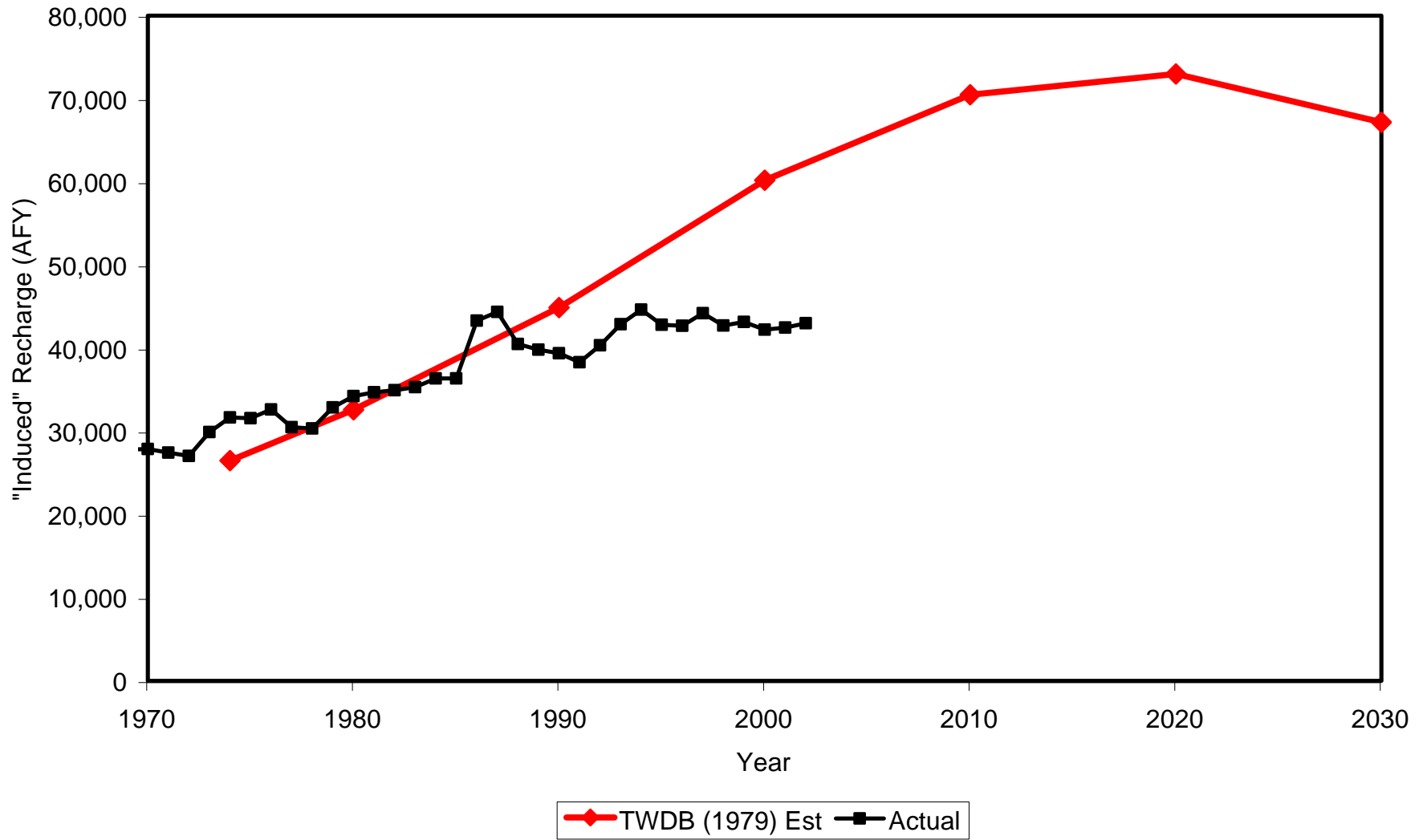


Figure 5-6  
Storage Decline

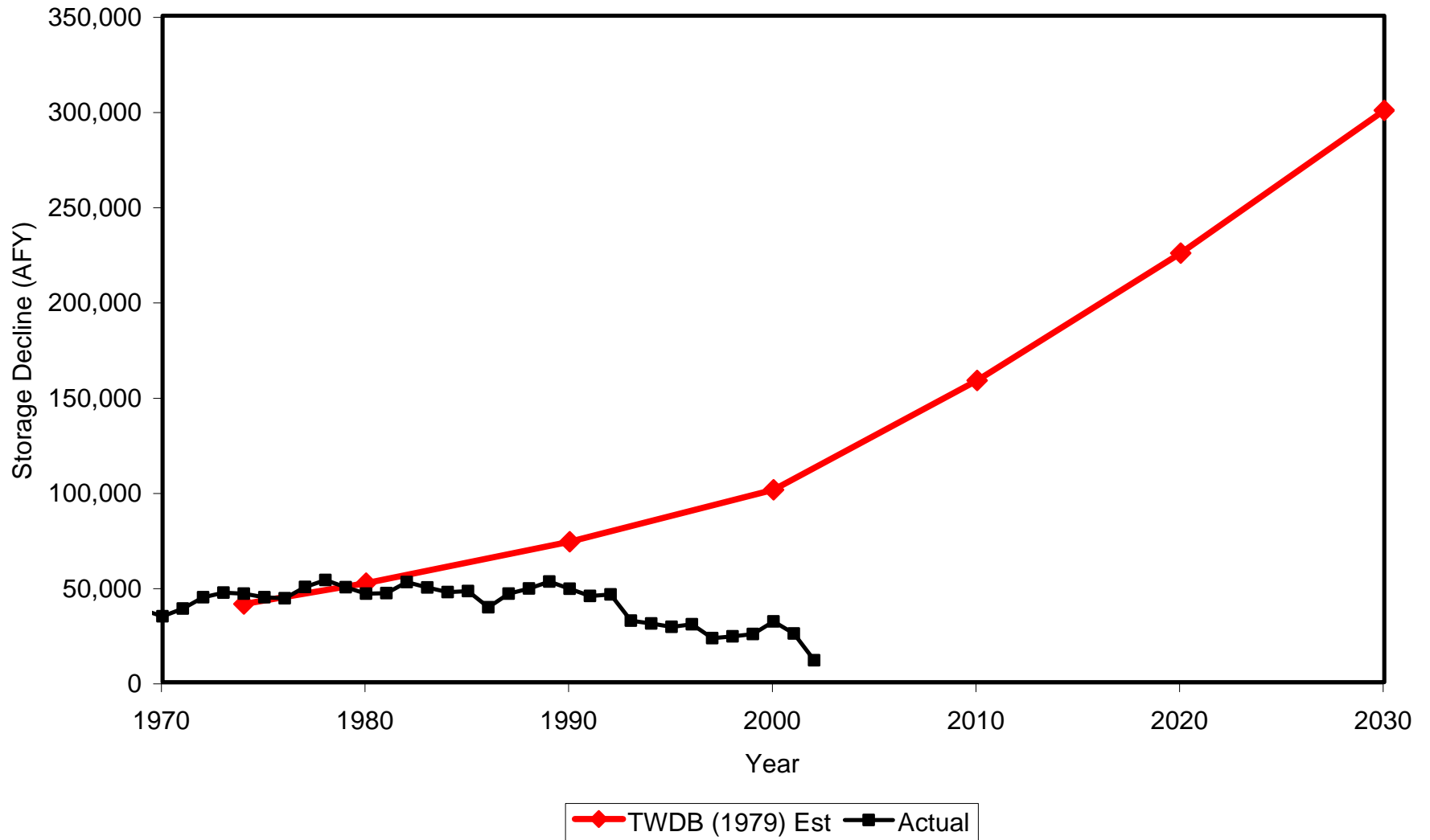
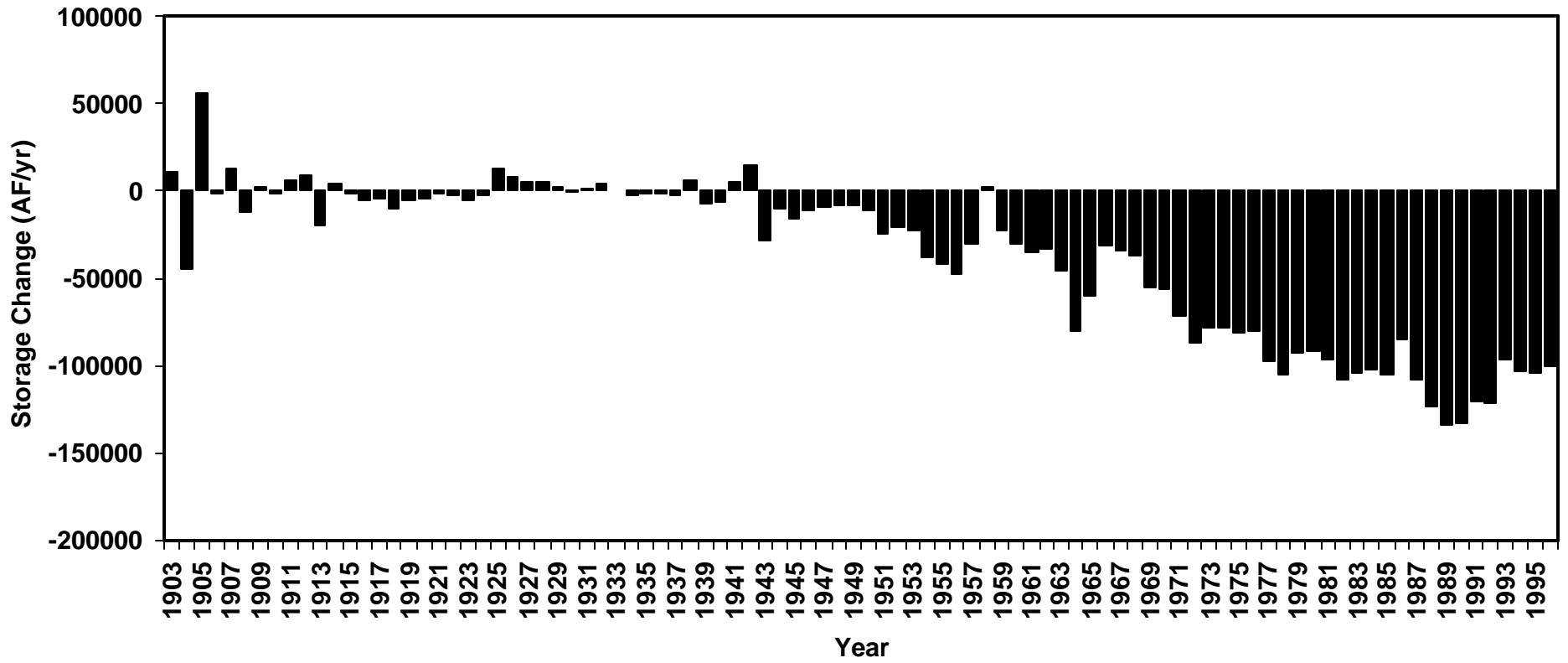
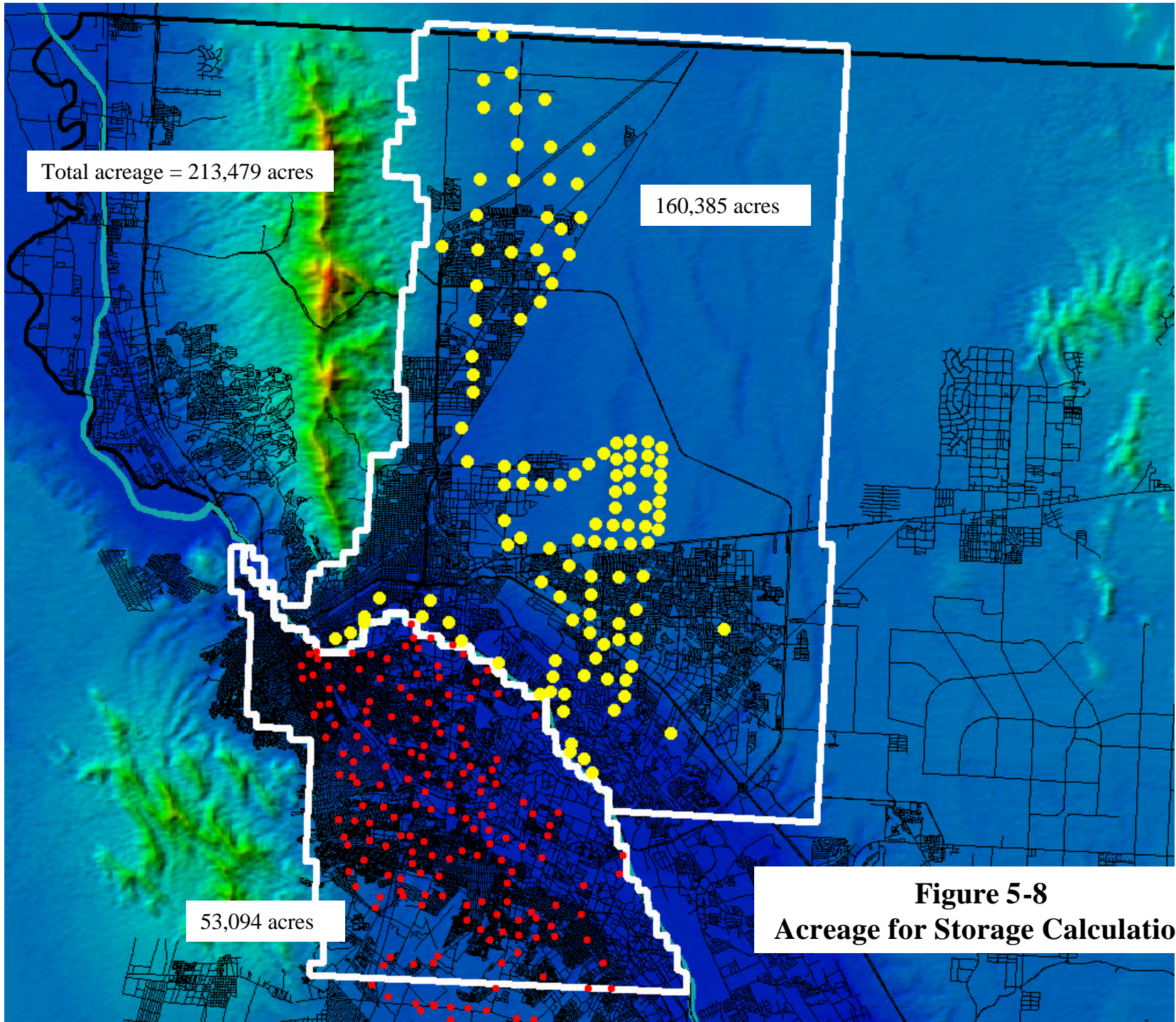


Figure 5-7  
Model Estimated Groundwater Storage Change  
(Entire Model Area)

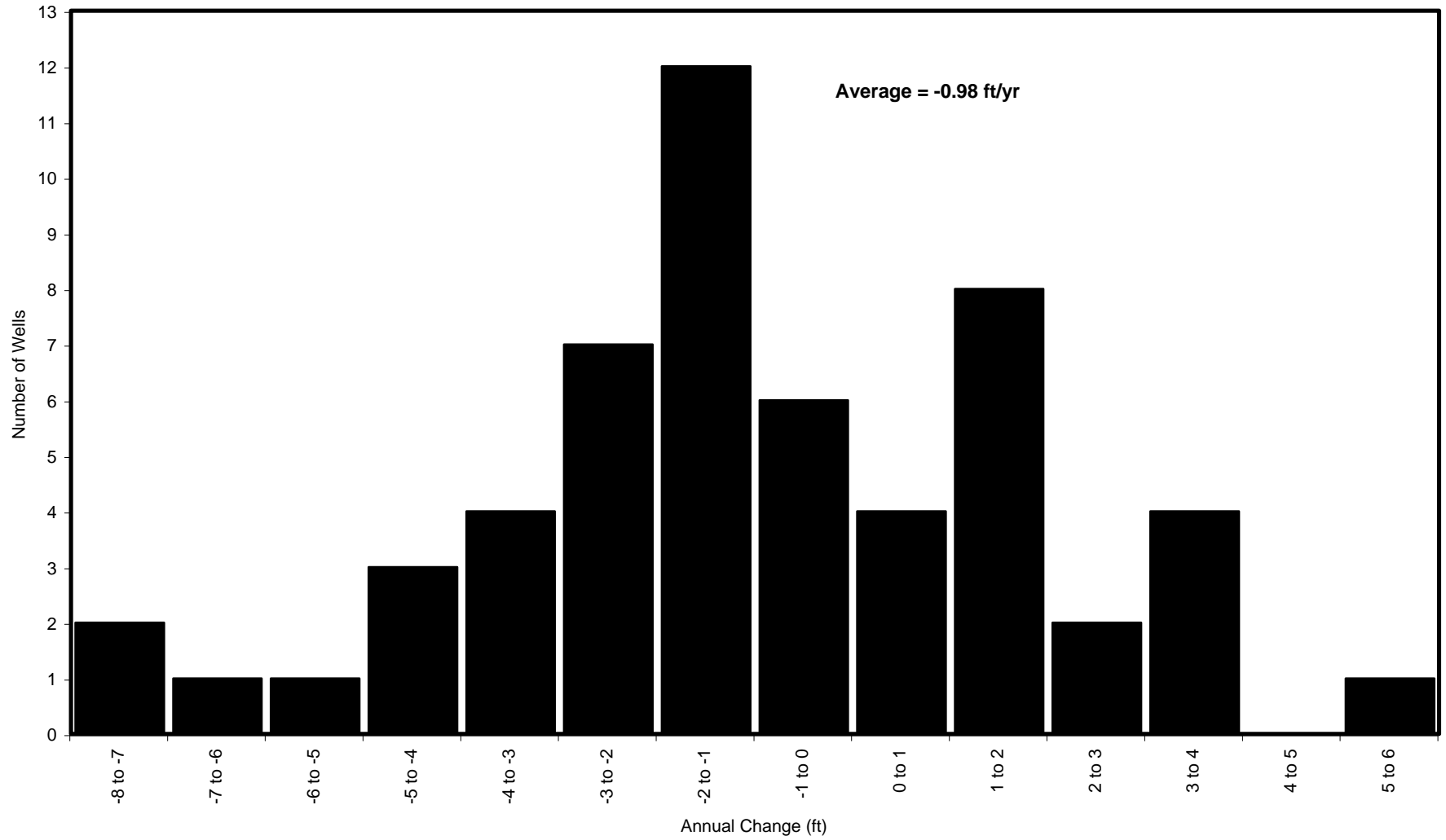


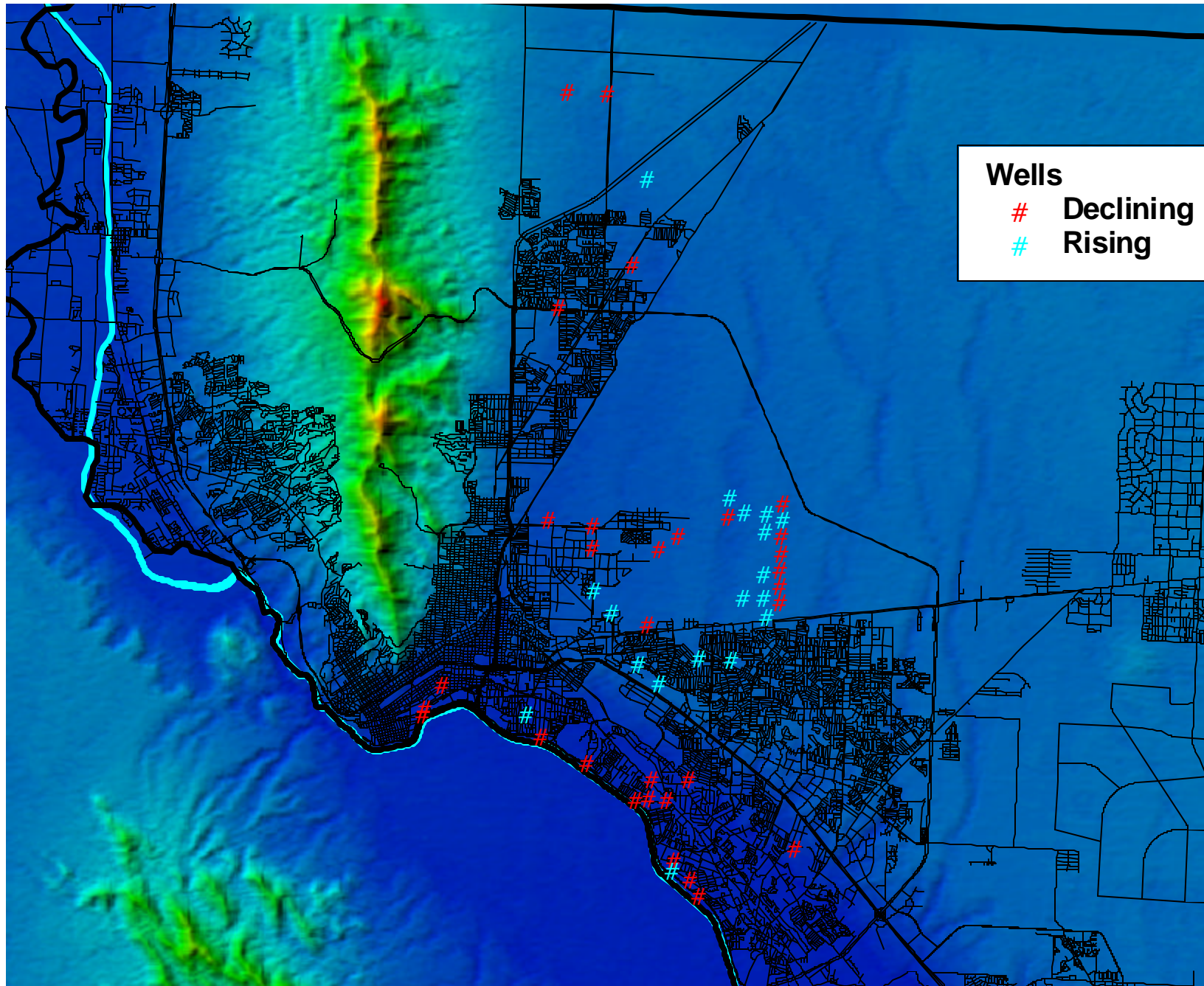


**Figure 5-8**  
**Acreage for Storage Calculation**



Figure 5-9  
Annual Groundwater Elevation Change (1999)  
55 EPWU Wells





**Figure 5-10**  
**1999 Groundwater**  
**Elevation Changes**

0 5 10 15 Miles