7.0 GROUNDWATER MANAGEMENT STRATEGIES

The USGS groundwater model was used to simulate alternative groundwater management strategies. The results of these simulations were evaluated in terms of groundwater elevation changes, groundwater flow pattern changes, and changes to the groundwater budget. The focus of these simulations was a comparative analysis. The results of the simulations were compared to each other, particularly the base case, in order to evaluate the potential benefits of pursuing a particular management strategy.

The simulations covered a 50-year period with initial conditions of December 2002, which represent the model output at the end of the update period. Drawdown was estimated based on a starting point of 2002. The 50-year period was assumed as follows: 20 years of normal river flow, followed by 10 years of low river flow, followed by 20 years of normal river flow. The normal and low river flows affect the simulations with regard to potential recharge from the surface water system and with regard to assumed EPWU pumping.

Four simulations were completed covering a range of potential management scenarios or options:

- Continuation of 2002 pumping conditions (base case)
- No pumping except in low river flow years
- Desalination of brackish water using the Joint Desalination Facility (JDF) currently in design. This project is being pursued cooperatively by EPWU and Ft Bliss
- JDF with artificial recharge

7.1 Base Case

7.1.1 Background

The base case assumes that the pumping in 2002 would continue both in total amount and distribution among the various EPWU wells during years with normal river flow. Pumping under a normal river flow condition would be 40,000 AF/yr, and pumping during low river flow years would be 75,000 AF/yr. During years with low river flow, the distribution of pumping was simulated to remain the same as in years with normal river flow, just increased a commensurate factor. Juarez pumping was assumed equal in amount and distribution to 2002 pumping. The Junta Municipal de Agua y Saneamiento de Juarez (JMAS) has stated that their goal is to cap Hueco pumping at current levels. Growth in demand in the future would be met with other sources (e.g. surface water conversion from agricultural to municipal and/or groundwater transfers from other areas in Chihuahua).

7.1.2 Results

Figures 7-1, 7-2, and 7-3 present the groundwater elevation drawdown after 20, 30 and 50 years (the end of the first "normal" river flow period, the end of the "low river flow period, and the end of the 50-year simulation). Note that drawdown is calculated using 2002 groundwater elevation as a starting point and that the drawdown continues throughout the period and extends far into the brackish groundwater area east of El Paso.

Figure 7-4 presents the groundwater flow pattern at the end of the 50-year simulation overlying the current groundwater quality. Flow patterns at the end of 20 years and 30 years are similar. Note that the trend of flow towards the wells in the airport area is from northeast to southwest. It can be seen that the flow that is moving towards the airport wells is essentially brackish water. Recall the analysis of water quality in wells around the airport demonstrated that chloride concentrations in several of these wells are expected to exceed 250 mg/l (the secondary drinking water standard) in the next few decades under current practices. This base case is strong evidence that brackish water intrusion will continue to be a management issue without some alteration of pumping patterns.

The groundwater budget for the base case is summarized in:

- Figure 7-5 (inflow from New Mexico)
- Figure 7-6 (inflow from the area east of El Paso)
- Figure 7-7 (inflow from the surface water system)
- Figure 7-8 (outflow to Juarez)
- Figure 7-9 (groundwater storage decline)

It can be seen that the inflow from New Mexico is relatively constant at about 18,000 AF/yr in years 1 to 20, increases to about 21,000 AF/yr by year 30 (low river flow and higher EPWU pumping), and returns to a constant, but higher level of 19,000 AF/yr in years 31 to 50.

Flow into the El Paso area from the east is relatively constant at about 8,300 AF/yr in years 1-20, increases to about 10,500 AF/yr by year 30, and remains at about 10,500 AF/yr.

Inflow from the surface water system is at about 33,000 AF/yr in years 1-20, drops to about 29,000 AF/yr in years 21-30, and returns to about 33,000 AF/yr in years 31-50. This pattern is consistent of the condition previously presented in Figure 3-5 (condition c) where the water table is disconnected from the bottom of the surface water channel. Inflow from the surface water system has reached an effective maximum, and varies only with the depth of water in the stream, canal, or ditch. It is obvious that in the years with low flows (i.e. years 21-30), the depth of water is lower than in the years with normal river flow.

Outflow to Juarez increases to about 37,000 AF/yr by year 20, drops to about 35,000 AF/yr by year 30, and increases again to about 38,000 AF/yr by year 50.

The storage decline by year 20 is about 16,000 AF/yr, jumps to about 42,000 AF/yr by year 30, and drops back to about 13,000 AF/yr by years 50.

Based on these results, the following can be concluded regarding the base case:

- Brackish groundwater will continue to intrude into the airport area
- Inflow from the surface water system appears to have reached a maximum apparently due to a "disconnected" water table/stream condition
- Storage decline in years with normal river flow is between 13,000 and 16,000 AF/yr, and is about 42,000 AF/yr in years with low river flow and high pumping

Based on the brackish groundwater intrusion issue, it is apparent that this alternative would not result in a sustainable supply.

7.2 No EPWU Pumping Scenario

7.2.1 Background

Boyle (1991) proposed this management approach in order to reverse groundwater storage declines. A key objective of simulating this scenario is to evaluate the potential for continued brackish groundwater intrusion.

The No EPWU Pumping Scenario assumes that the EPWU pumping would be zero during years with normal river flow, and pumping during low river flow years would be 75,000 AF/yr. During years with low river flow, the distribution of pumping was simulated to be the same as in the base case scenario. Juarez pumping was assumed equal in amount and distribution to 2002 pumping.

7.2.2 Results

Figures 7-10, 7-11, and 7-12 present the groundwater elevation drawdown after 20, 30 and 50 years (the end of the first "normal" river flow period, the end of the "low river flow period, and the end of the 50-year simulation). Note that groundwater levels would rise in relation to 2002 levels in a large portion of El Paso during years 1-20, decline in response to the high pumping of years 21 to 30, and recover again to a point higher than 2002 levels by year 50.

Figure 7-13, 7-14, and 7-15 present the groundwater flow pattern at the end of the 20, 30 and 50 years, respectively. Note that the trend of flow towards the wells in the airport area is from northeast to southwest, similar to the base case. Figure 7-16 presents the same flow pattern at the end of 50 years overlying the current groundwater quality. It can be seen that the flow that is moving towards the airport wells is essentially brackish water. Similar to the base case, this scenario would likely result in a situation where brackish water intrusion will continue to be a management issue.

The groundwater budget for the No EPWU Pumping scenario is summarized in:

- Figure 7-17 (inflow from New Mexico)
- Figure 7-18 (inflow from the area east of El Paso)
- Figure 7-19 (inflow from the surface water system)
- Figure 7-20 (outflow to Juarez)
- Figure 7-21 (groundwater storage decline)

It can be seen that the inflow from New Mexico drops from about 15,000 AF/yr to 10,500 AF/yr in years 1-20, increases to about 19,000 AF/yr by year 30, and drops to about 12,000 AF/yr by year 50.

Flow into the El Paso area from the east drops from about 8,000 AF/yr to about 4,200 AF/yr in years 1-20, rises to about 7,500 AF/yr by year 30, and drops to about 5,000 AF/yr by year 50.

Inflow from the surface water system is at about 33,000 AF/yr in years 1-20, drops to about 29,000 AF/yr in years 21-30, and returns to about 33,000 AF/yr in years 31-50. The amounts and patterns are nearly the same as the base case, which suggests that the historic pumping has disconnected the water table from the bottom of the stream, and shutting off EPWU wells will not make a significant difference in this historic depletion.

Outflow to Juarez increases to about 43,000 AF/yr by year 20, drops to about 37,000 AF/yr by year 30, and increases again to about 45,000 AF/yr by year 50.

As shown in the drawdown maps, when EPWU pumping is zero, storage declines are reversed, and storage increases are observed. During years 1-20, this increase ranges from about 20,000 AF/yr in year 1 to about 5,500 AF/yr in year 20. During years 21-30 (low river flow and high pumping), the storage declines return, with rates in excess of 50,000 AF/yr. When EPWU pumping returns to zero (years 31-50), the storage increases return at a rate of about 16,000 AF/yr in year 31 to about 6,000 AF/yr in year 50.

Based on these results, the following can be concluded regarding the No EPWU Pumping scenario:

- Brackish groundwater will continue to intrude into the airport area
- Inflow from the surface water system appears to have reached a maximum apparently due to a "disconnected" water table/stream condition
- Inflow from the surface water system appears to be unaffected by turning EPWU wells off in years with normal river flow. This is likely due to Juarez pumping.
- Turning off EPWU wells increases the outflow into Juarez slightly.
- Groundwater storage increases in years with normal river flow (ranging between 5,500 AF/yr and 20,000 AF/yr), and groundwater storage declines at a rate in excess of 50,000 AF/yr in years with low river flows and high EPWU pumping.

Although this scenario would improve groundwater level conditions in the El Paso portion of the Hueco, based on the brackish groundwater intrusion issue, it is apparent that this alternative would not result in a sustainable supply.

7.3 JDF Scenario

7.3.1 Background

As described in this report, the El Paso portion of the Hueco Bolson has a large volume of brackish groundwater. This brackish groundwater has intruded into fresh groundwater area, and several EPWU wells have not been operated in the last five years due to the fact that the wells do not meet drinking water standards. However, the brackish groundwater can be used as a potable supply after desalination. Technological advances in the last decade have made desalination a more economically viable water source. Integrating desalinated brackish groundwater resources into the overall EPWU water supply portfolio presents certain opportunities to manage the brackish groundwater intrusion.

EPWU and Ft. Bliss are working together to develop plans for a desalination plant that would be located on Ft. Bliss property. The project would consist of using fifteen existing EPWU wells in the Airport Well Field to supply the plant, referred to as "supply wells" or "feed wells". These wells would pump about 18.5 million gallons per day (mgd). The proposed desalination plant would use reverse osmosis (RO) to treat the water to below drinking water standards. It is expected that about 15.5 mgd of "permeate" (treated water) would be produced and about 3 mgd of "concentrate" (salty water) would require disposal. The permeate would be blended with about 12 mgd of "blend" water from 16 new wells that would be constructed along Loop 375 on Ft. Bliss property, referred to as "blend wells". Based on these expectations, a total of 27.5 mgd would be delivered into EPWU's distribution system, which includes Ft. Bliss.

Hutchison and others (2003) considered five alternative locations for blend wells, and recommended that the blend wells be located along Loop 375. The recommended locations of the blend wells and the location of the existing feed wells are presented in Figure 7-22.

The JDF Scenario assumes that the EPWU pumping would be 40,000 AF/yr during years with normal river flow, and pumping during low river flow years would be 75,000 AF/yr. Pumping would be distributed as follows:

Years	River Flow	Feed and Blend Well Pumping (AF/yr)	Other EPWU Wells (AF/yr)	Total EPWU Pumping (AF/yr)
1 to 20	Normal	34,200	5,800	40,000
21 to 30	Low	34,200	40,800	75,000
31 to 50	Normal	34,200	5,800	40,000

Note that the total pumping for EPWU is the same as in the base case. This approach allows for the comparison of results solely on well location, not total pumping. Juarez pumping was assumed equal in amount and distribution to 2002 pumping.

7.3.2 Results

Figures 7-23, 7-24, and 7-25 present the groundwater elevation drawdown after 20, 30 and 50 years (the end of the first "normal" river flow period, the end of the "low river flow period, and the end of the 50-year simulation). Note that a drawdown cone develops around the feed wells and blend wells and extends eastward in the first 20 years. The westward progression appears to be balanced by recovery associated with the low pumping in existing EPWU and Ft Bliss wells. During years of high pumping, the drawdown cones remain deepest around the JDF wells, but now extend to the west and south. Slight recovery is seen by year 50 in northeast El Paso due to the cessation of the high pumping during the assumed drought period.

Figure 7-26, 7-27, and 7-28 present the groundwater flow pattern at the end of the 20, 30 and 50 years, respectively. Note that the trend of flow towards the wells in the airport area is from northeast to southwest, similar to the base case. Figure 7-29 presents the same flow pattern at the end of 50 years overlying the current groundwater quality. It can be seen that in contrast to the base case and the No EPWU Pumping Scenario, the flow that the brackish groundwater northeast of the airport is intercepted by drawdown cone or trough caused by the feed and blend wells. The resulting flow pattern in the area of the existing EPWU and Ft Bliss wells would then become southerly rather than from the northeast. This would result in the movement of fresh groundwater into the area that would be relied on for drought pumping. Unlike the base case or the No EPWU Pumping Scenario, this scenario would likely result in a situation where brackish water intrusion is managed, and fresh water wells would be "protected" from brackish groundwater intrusion due to the trough that is formed by concentrating the pumping along Loop 375.

The groundwater budget for the JDF scenario is summarized in:

- Figure 7-30 (inflow from New Mexico)
- Figure 7-31 (inflow from the area east of El Paso)
- Figure 7-32 (inflow from the surface water system)
- Figure 7-33 (outflow to Juarez)
- Figure 7-34 (groundwater storage decline)

It can be seen that the inflow from New Mexico is about 15,000 AF/yr by year 20, increases to about 18,500 AF/yr by year 30, and drops to about 16,500 AF/yr by year 50.

Flow into the El Paso from the east area increases steadily to about 12,000 AF/yr through years 1-30, despite the increase in pumping after year 20. This is apparently due to the operation of the blend wells for the JDF. Pumping in the area is inducing flow across the eastern boundary of the El Paso Area, and increase in pumping west of the trough during years 21-30 does not impact this rate of flow as a result. During years 31-50, the flow rate is relatively steady at about 12,000 AF/yr, which suggests that the constant pumping of the blend wells has resulted in a near-equilibrium state with respect to induced flow after about 30 years.

Inflow from the surface water system is at about 33,000 AF/yr in years 1-20, drops to about 29,000 AF/yr in years 21-30, and returns to about 33,000 AF/yr in years 31-50.

Outflow to Juarez increases to about 38,000 AF/yr by year 20, drops to about 35,000 AF/yr by year 30, and increases again to about 38,000 AF/yr by year 50. These values and pattern of response are similar to the base case, but the rates are smaller than the No EPWU Pumping scenario. The base case and the JDF scenario represent the same amount of EPWU pumping, but different patterns of pumping. This particular change in the pumping pattern (base case to JDF) will have no affect on the amount of flow into Juarez.

The storage decline by year 20 is about 19,000 AF/yr, jumps to about 45,000 AF/yr during years 21-30, and drops back to about 15,000 AF/yr in years 31-50. The pattern is similar to the base case, but the magnitude of storage decline is slightly higher than in the base case (16,000 to 42,000 to 13,000 AF/yr). This is apparently due to the fact that the blend well pumping is in an area that had not historically been pumped. Presumably, much of this increase in storage decline is in the brackish groundwater area.

Based on these results, the following can be concluded regarding the JDF scenario:

- Brackish groundwater will be intercepted by the trough created by the operation of the blend wells and the feed wells
- Inflow from the surface water system appears to have reached a maximum apparently due to a "disconnected" water table/stream condition
- Inflow from the surface water system appears to be unaffected by concentrating the pumping along Loop 375 apparently due to Juarez pumping.
- Groundwater storage declines are slightly higher than the base case despite the fact that pumping under the JDF scenario and the base case are the same. This is apparently due to the fact that JDF pumping includes pumping in areas that have not been historically pumped. Much of this storage decline is likely in the brackish groundwater area.

The JDF will result in groundwater level conditions that are roughly equivalent to that of the base case, and result in interception of brackish groundwater. The interception of brackish groundwater will have the positive benefit of "protecting" the wells in the Ft Bliss and airport areas. Based on this analysis, it can be concluded that the JDF is an important step in managing the Hueco as a sustainable supply.

7.4 JDF with Artificial Recharge

7.4.1 Background

Artificial recharge has been previously identified as a potential project, most recently as part of the Sustainable Water Project. When proposed with the Sustainable Water Project, it was one component of an integrated strategy with the potential benefits of mitigating groundwater level decline, acting as a hydraulic barrier to brackish groundwater intrusion, and as a means of storing surface water for later use.

A future recharge supply could be from any one of a number of sources: reclaimed water, surface water (raw or treated), or imported water (raw or reclaimed). At present, limitations in supplies of reclaimed water and surface water have prevented a larger scale effort.

For this analysis, it was assumed that the artificial recharge supply would be 20,000 AF/yr. Recall that under the JDF scenario, groundwater storage declines in years with normal river flow would be about 15,000 AF/yr. Under the "static" response approach taken by some previous investigations, it would be erroneously concluded that recharging 20,000 AF/yr would result in a groundwater storage increase of 5,000 AF/yr. One of the objectives of this analysis, therefore, is to demonstrate the dynamic response of the groundwater basin using the USGS model.

The pumping assumptions for this scenario are the same as the JDF: EPWU pumping would be 40,000 AF/yr during years with normal river flow, and pumping during low river flow years would be 75,000 AF/yr (the same as the base case). Pumping would be distributed as follows:

Years	River Flow	Feed and Blend Well Pumping (AF/yr)	Other EPWU Wells (AF/yr)	Total EPWU Pumping (AF/yr)
1 to 20	Normal	34,200	5,800	40,000
21 to 30	Low	34,200	40,800	75,000
31 to 50	Normal	34,200	5,800	40,000

Juarez pumping was assumed equal in amount and distribution to 2002 pumping. The location of the spreading basin is presented in Figure 7-35. For this simulation, it was assumed that the recharge rate is 20,000 AF/yr. Recharge water was introduced into Layer 2 of the model due to the drying of Layer 1 towards the end of the calibration period of the model.

7.4.2 Results

Figures 7-36, 7-37, and 7-38 present the groundwater elevation drawdown after 20, 30 and 50 years (the end of the first "normal" river flow period, the end of the "low river flow period, and the end of the 50-year simulation). Note the area of groundwater level rise in the area of the spreading basin after 20 years of operation. The drawdown cone associated with the JDF wells still extends to the east. At the end of year 30, the recovery around the spreading basin is still present, and the drawdown cone extends west due to pumping of non-JDF wells. By year 50, the drawdown cone remains in a large area west of the JDF wells, and the spreading basin mound appears to have grown only slightly.

Figure 7-39, 7-40, and 7-41 present the groundwater flow pattern in Layer 2 of the model at the end of 20, 30 and 50 years, respectively. Figures 7-42, 7-43, and 7-44 present the groundwater flow pattern in Layer 5 of the model at the end of 20, 30 and 50 years, respectively. Note the mounding response of the recharge in Layer 2, and the maintenance of the JDF trough in Layer 5. The flow in the airport area would become more north to south, causing fresh groundwater to flow into this area. As in the JDF scenario, this scenario would likely result in a situation where brackish water intrusion is managed, and fresh water wells would be "protected" from brackish groundwater intrusion due to the trough that is formed by concentrating the pumping along Loop 375. Moreover, it is expected that the addition of 20,000 AF/yr would mitigate the declining groundwater levels and the groundwater storage decline.

The groundwater budget for the JDF with artificial recharge scenario is summarized in:

- Figure 7-45 (inflow from New Mexico)
- Figure 7-46 (inflow from the area east of El Paso)
- Figure 7-47 (inflow from the surface water system)
- Figure 7-48 (outflow to Juarez)
- Figure 7-49 (groundwater storage decline)

It can be seen that the inflow from New Mexico is about 13,000 AF/yr in year 1 and drops to about 8,000 AF/yr by year 20, then increases to 12,000 AF/yr in year 30, and finally drops to about 9,000 AF/yr by year 50. This response is primarily due to the proximity of the spreading basins to the New Mexico state line. The recharged water causes a local increase in groundwater levels, thus reducing the gradient and reducing the inflow.

Flow into the El Paso area from the east increases steadily to about 9,000 AF/yr by year 20, increases again to about 11,000 AF/yr by year 30, then drops slightly to about 10,500 AF/yr by year 50. This pattern is the result of a combination of the spreading basins and blend well operation. The rise in water levels caused by the spreading basins results in slightly less inflow than the JDF scenario. The constant pumping of the blend wells results in a near-equilibrium state with respect to induced flow after about 30 years.

Inflow from the surface water system is at about 33,000 AF/yr in years 1-20, drops to about 29,000 AF/yr in years 21-30, and returns to about 33,000 AF/yr in years 31-50.

Outflow to Juarez increases to about 38,000 AF/yr by year 20, drops to about 36,000 AF/yr by year 30, and increases again to about 39,000 AF/yr by year 50. These values and pattern of response are similar to, but slightly higher (about 1,000 AF/yr higher in years 21-50) than the JDF scenario. This suggests that EPWU pumping is effective in capturing the recharged water for the first 20 years. In years 21 to 50, the slight increase in outflow to Juarez appears to represent about 5% of the spread water.

The storage change in the first 20 years begins as a storage increase and then a decline that reaches about 6,500 AF/yr in year 20. During the high pumping years (21-30), the storage decline reaches a maximum of approximately 36,000 AF/yr. In years 31-50, the storage decline reaches a maximum of about 5,500 AF/yr. The pattern is similar to the JDF scenario, but the magnitude of storage decline is significantly less due to the additional recharge in northeast El Paso.

It should be noted that even though the operation of the spreading basins increased the recharge by 20,000 AF/yr, a small storage decline still exists. The dynamic response of the groundwater flow system to spreading basins is the decreased inflow from New Mexico, and slight changes to inflows from the area east of El Paso and outflows to Juarez.

Based on these results, the following can be concluded regarding the JDF with Artificial Recharge scenario:

- Brackish groundwater will be intercepted by the trough created by the operation of the blend wells and the feed wells
- Inflow from New Mexico is decreased as compared to the JDF scenario
- Inflow from the surface water system appears to have reached a maximum apparently due to a "disconnected" water table/stream condition
- Inflow from the surface water system appears to be unaffected by concentrating the pumping along Loop 375 apparently due to Juarez pumping.
- Groundwater storage declines are less than the JDF scenario, but are not completely eliminated due to the dynamic response of the groundwater flow system.

The JDF with artificial recharge scenario will result in groundwater level conditions that are improved when compared to the JDF scenario without impacting the benefits of brackish groundwater interception of the feed wells and blend wells. The interception of brackish groundwater will have the positive benefit of "protecting" the wells in the Ft Bliss and airport areas. Based on this analysis, adding an artificial recharge component would be an additional benefit to improving groundwater storage issues, if necessary.

7.5 Summary of Results

7.5.1 Comparison of Groundwater Budgets

Table 7-1 summarizes the groundwater budget components from all scenarios. As can be seen

- Inflow from New Mexico is most impacted by a spreading basin located in northeast El Paso
- Inflow from the east is most affected by the wells associated with the JDF
- Inflow from surface water is not affected by any of these management scenarios due to the disconnected water table that has resulted from years of high pumping in El Paso and Juarez
- Outflow to Juarez changes very little under each of the scenarios
- Storage decline is low in all scenarios compared to historic observations due to the decreased pumping that began in 1989.

Table 7-1
Summary of Groundwater Budget Terms from Simulations
All values in AF/yr

Inflow from New Mexico	Base Case	No EPWU Pumping	JDF	JDF + Artificial Recharge
Year 20	18	10.5	15	13
Year 30	21	19	18.5	8
Year 50	19	12	16.5	12

Inflow from East	Base Case	No EPWU Pumping	JDF	JDF + Artificial Recharge
Year 20	8.3	4.2	10	9
Year 30	10.5	7.5	12	11
Year 50	10.5	5	12	10.5

Inflow from Surface Water	Base Case	No EPWU Pumping	JDF	JDF + Artificial Recharge
Year 20	33	33	33	33
Year 30	29	29	29	29
Year 50	33	33	33	33

Outflow to Juarez	Base Case	No EPWU Pumping	JDF	JDF + Artificial Recharge
Year 20	37	43	38	38
Year 30	35	37	35	36
Year 50	38	45	38	39

Storage Decline	Base Case	No EPWU Pumping	JDF	JDF + Artificial Recharge
Year 20	16	-5.5	19	6.5
Year 30	42	50	45	36
Year 50	13	-6	15	5.5

7.5.2 Analysis of Sustainability of Hueco Groundwater

Table 7-2 summarizes the total storage decline for the entire 50-year simulation, and, presents the summary of an analysis that is analogous to the one completed by Muller and Price (1979). The assumptions for the analysis are as follows:

- The current storage is 9.4 million AF
- Only 25% of this storage is "economically recoverable" (i.e. 2.35 million AF)
- All storage decline is attributed to fresh groundwater (chloride less than 250 mg/l as defined in Table 4-1)
- The total storage decline of each 50-year simulation is expressed as an average annual rate of decline. This extends to an idealized assumption of a 10-year drought recurring in the middle of every 50-year period.
- Based on the average annual rate of decline and the threshold storage level of 2.35 million AF, the number of years to deplete 2.35 million AF is estimated

Two key assumptions make this analysis conservative: 25% recoverability and attributing all storage loss to the fresh groundwater. The Far West Texas Regional Plan (LBG-Guyton, 2001, pg 3-27) assumed that between 30 to 60 percent of stored groundwater was recoverable for planning purposes, and it termed that range "conservative". In order to assure the conservatism of this analysis, a value below the minimum value in the Regional Plan was used.

As can be seen in the drawdown maps for the all the scenarios in general and the JDF scenario in particular (Figures 7-23, 7-24 and 7-25), it can be seen that the drawdown cones include large areas of brackish groundwater as defined in Figures 4-6 to 4-14. However, without the aid of a solute transport model to assess the changes in chloride concentration, it is not possible to predict with any degree of confidence the storage changes in the fresh groundwater areas versus the brackish groundwater areas. Therefore, to assure a conservative estimate, the entire storage decline is attributed to fresh groundwater depletion.

Table 7-2
Storage Decline Analysis

Scenario	Cumulative Storage Decline for 50-Year Simulation (Million AF)	Average Rate of Storage Decline (AF/yr)	Years to Deplete 2.35 Million AF
Base Case	1.0	20,000	118
No EPWU Pumping	0.09	1,800	1306
JDF Scenario	1.1	22,000	107
JDF with Artificial Recharge Scenario	0.5	10,000	235

These estimates of the "life of the Hueco" should not be taken as precise estimates due to:

- The conservative nature of the assumptions related to recoverability and attribution of all storage change to fresh groundwater.
- The fact that current EPWU groundwater pumping is linked to river flows (higher pumping in years of low river flow). All simulations assume that a drought will occur in years 21 to 30 of each 50-year period. Clearly, this is an idealized assumption and is not made as a prediction, but rather to evaluate the response of the system to a prolonged drought of reasonable magnitude.
- Model uncertainty, the details of which are covered in Heywood and Yager (2003).

Instead, these estimates are presented in order to demonstrate the impacts of pumping on annual storage decline and total storage over an extended period of time. Moreover, they are presented to provide a working frame of reference to assess the effectiveness of groundwater management strategies embodied in each of the scenarios.

One important interpretation related to groundwater management, for example, is that while the Hueco would benefit from an artificial recharge project, it is not critical that such a project begin in the next 20 to 40 years under the assumed levels of pumping. If pumping were to increase in either El Paso or Juarez substantially above what is assumed in this analysis, an artificial recharge project should be considered sooner.

The caveat regarding assumed pumping is extremely important to consider in interpreting these results. The most significant interpretation of the data in Table 7-2 is that the assumed pumping amounts in the base case and the JDF scenarios are essentially at a sustainable level (i.e. no storage change) over any reasonable planning period (50 or 100 years). Moreover, it can be concluded that implementation of the JDF will also provide for sustainability in terms of groundwater quality. Managing the Hueco as a sustainable supply requires attention to both groundwater storage and groundwater quality. However, the completion of a solute transport (groundwater quality) model is needed to assess the effectiveness of this effort further.