

## **4B.8 Aquifer Storage and Recovery (ASR)**

In the development of Brazos G water management strategies, Aquifer Storage and Recovery (ASR) is considered for (1) the Seymour Aquifer in Knox and Haskell Counties where the aquifer is recharged with water from the Salt Fork Brazos River by infiltration and recovered with existing irrigation wells, and (2) the Trinity Aquifer in Johnson County where new, dual-purpose wells are used to inject potable water from the SWATS water treatment plant on Lake Granbury into the aquifer for storage and recovery by public supply wells.

The ASR management strategy is useful to water suppliers who periodically have surplus water and water shortages. For example, ASR can be used to inject and store water in aquifers during the fall, winter, and spring when demands are low and to recover the water during the summer when demands are high. This strategy better utilizes the available capacity of the water treatment plant and supply and transmission system, and commonly delays the need for expanding water treatment and distribution facilities. In most all cases, the water utility's operating plan would call for balancing injection and recovery or possibly recovering slightly less than the amount injected.

### **4B.8.1 Seymour Aquifer in Knox and Haskell Counties**

#### **4B.8.1.1 Description of Option**

A proposed ASR water management option for irrigation water supplies in Knox and Haskell Counties is based on diverting a portion of runoff during relatively high flow conditions from the Salt Fork Brazos River to an off-channel reservoir for temporary storage, transporting the stored water to spreading basins in the target recharge area in the Seymour Aquifer, and recovering some or all the water with existing irrigation wells. The project area was selected on the basis of the local proximity of potentially suitable surface water reservoirs for temporary storage, the Salt Fork Brazos River, and areas of the Seymour where the aquifer is rather thick and productive, water level declines are significant, and there is extensive agricultural irrigation with groundwater. The selected ASR area of the Seymour Aquifer is in a region along the Haskell-Knox County line and between the towns of Munday and Knox City; the selected off-channel reservoir is Lake Davis, which is located about 5 miles north of the ASR area. The Salt Fork is between the off-channel reservoir and the target ASR area. The strategy is intended to supplement the natural recharge to the Seymour and benefit irrigated agriculture. This area is shown in Figure 4B.8.1-1.

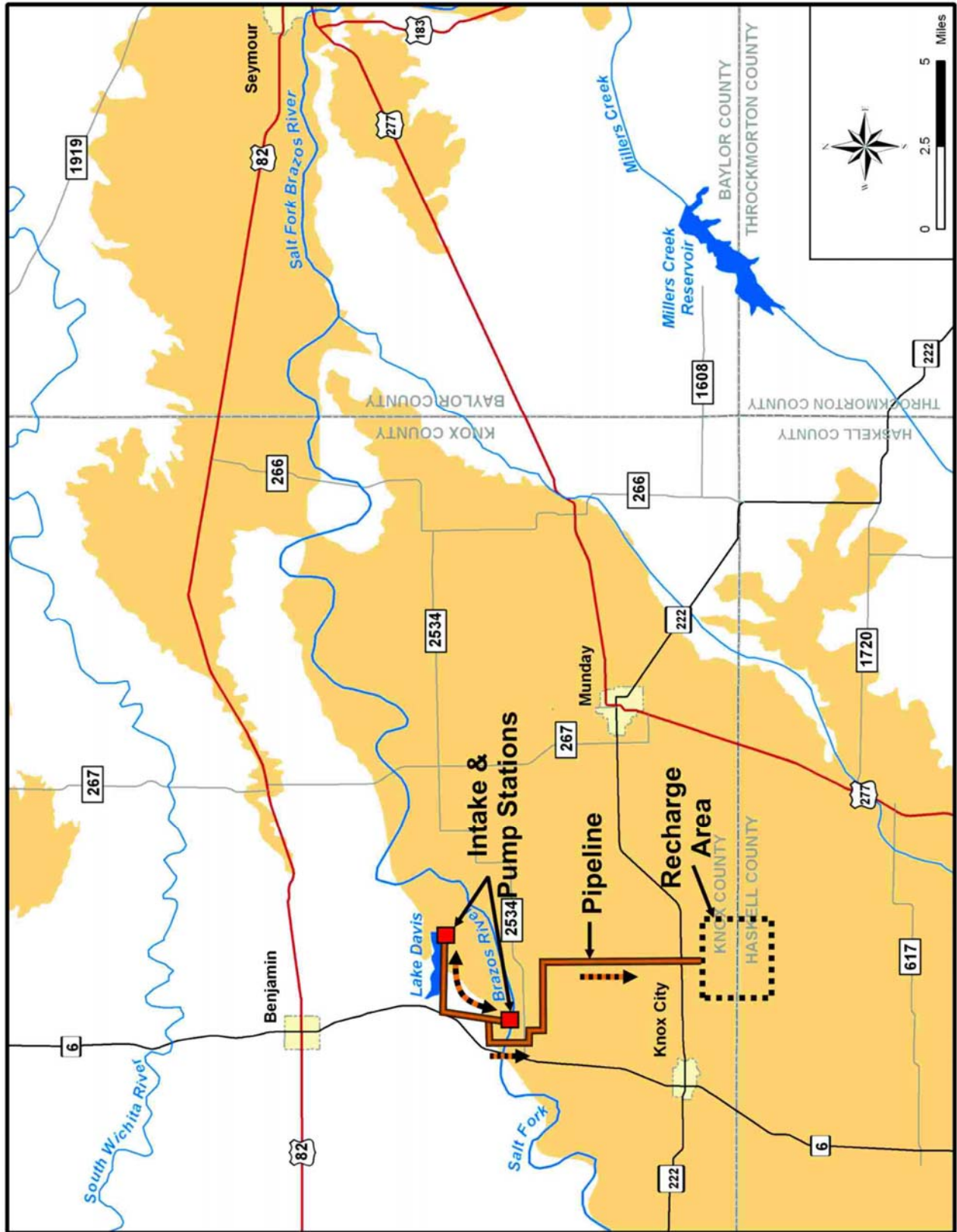


Figure 4B.8.1-1. Location and Features of Seymour ASR Project

### **4B.8.1.2 Available Yield**

#### 4B.8.1.2.1 Source and Supply of Surface Water

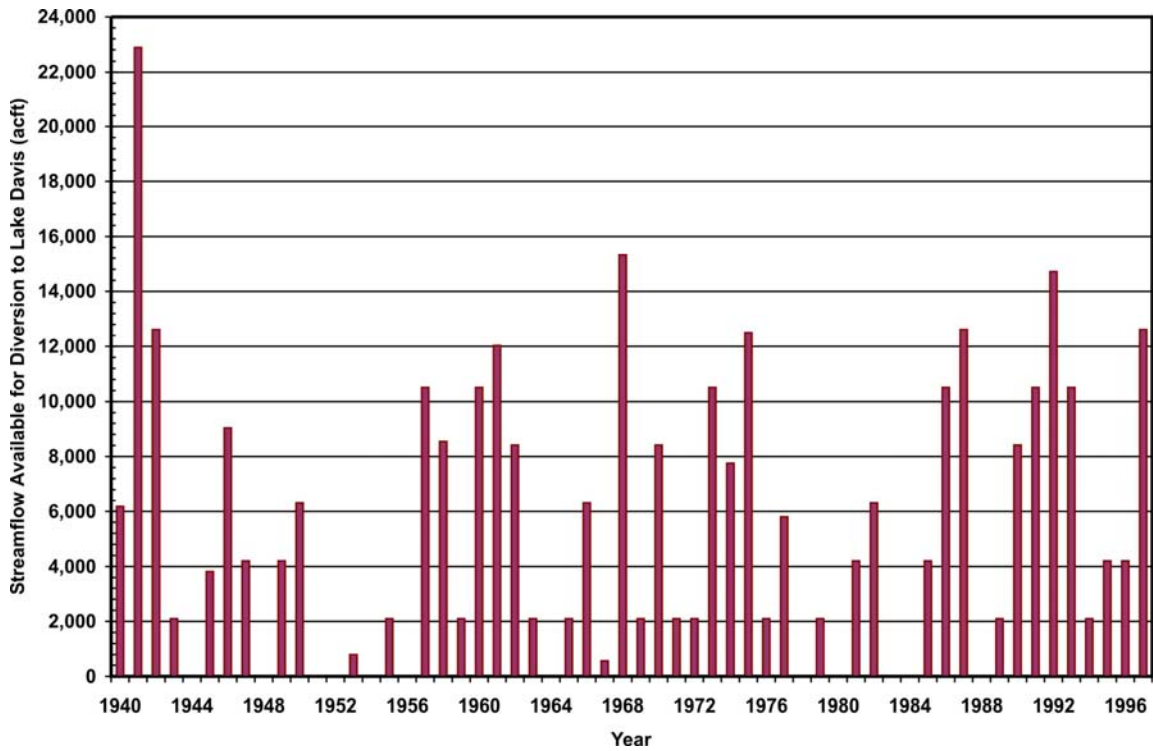
The source of water for the Seymour ASR project is the Salt Fork Brazos River. During seasons of high flow available water from the Salt Fork would be diverted to Lake Davis. Later, some or all the water would be delivered to the target area for recharging the Seymour Aquifer.

The Brazos G WAM was used to evaluate the availability of water in the Salt Fork and potential operation of Lake Davis. Operational settings to the Brazos G WAM included:

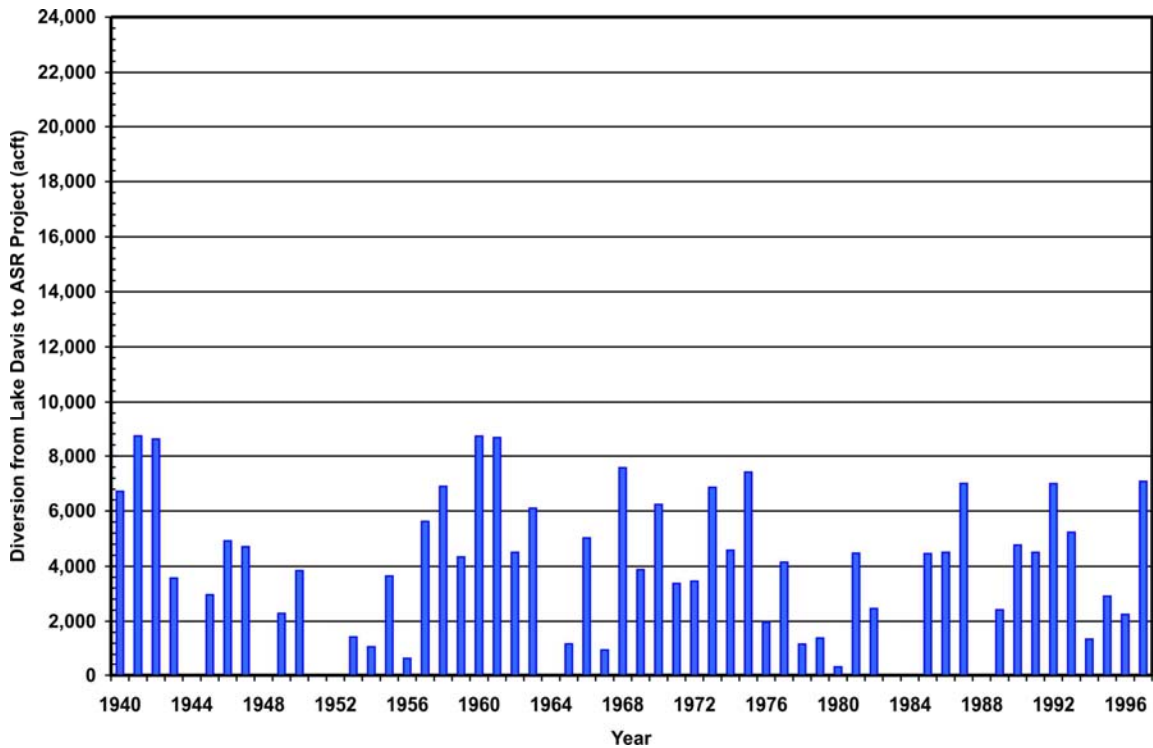
- No diversions to ASR unless at least 350 acft of storage remained in Lake Davis;
- Adjustment of the water diversion patterns from Lake Davis to allow existing irrigation water rights to continue from May through August and ASR diversions from September through April;
- When water in the Salt Fork is available and needed by the ASR project, the filling rate of Lake Davis is 2,100 acft/month (equivalent of a 36-in. pipe transporting water at a velocity of 5 cfs from the Salt Fork to Lake Davis); and
- ASR diversions are limited to 9,000 acft/yr.

In addition to these WAM settings, the project approach to operations assumes available water in Lake Davis is to be diverted to the recharge area over eight months. If a maximum of 9,000 acft/yr was available for diversion, 1,125 acft could be diverted each month to the recharge area.

Using the planned operations described above, the Brazos G WAM model shows that the yield of Lake Davis for irrigation increases from 125 acft/yr to 325 acft/yr. With subordination of Possum Kingdom to Lake Davis, the yield of Lake Davis for irrigation increases to 850 acft/yr. Figure 4B.8.1-2 shows the annual available flow from the Salt Fork to Lake Davis, and Figure 4B.8.1-3 shows the simulated annual diversions to the ASR recharge area from Lake Davis. The year with the most available flow in the South Fork is 1941, and the year with the most diversions to the ASR system is 1992. Several incidents of no water availability and, consequently, zero diversion to the ASR system, occur in 1944, 1952, 1956, 1964, 1983, and 1984. Based on these settings and assumptions, the long-term average diversion to Davis Lake is about 5,440 acft/yr and the diversion to ASR is about 3,750 acft/yr.

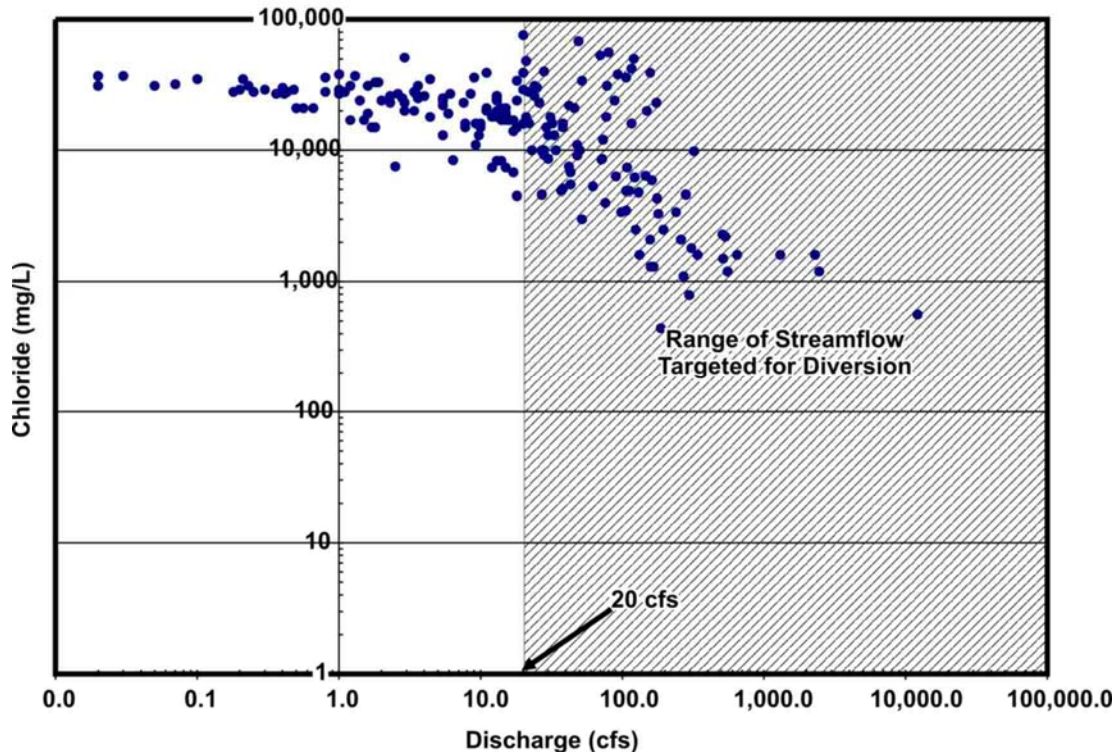


**Figure 4B.8.1-2. Annual Availability of Water from the Salt Fork Brazos River for Storage in Lake Davis**



**Figure 4B.8.1-3. Annual Availability of Water from the Lake Davis for ASR Recharge**

Water quality in the Salt Fork was considered in the study of the ASR system. For this analysis, chloride concentrations and streamflow records at USGS gaging station 08082000 Salt Fork Brazos River near Aspermont, Texas, were analyzed. Figure 4B.8.1-4 shows the concentration of chloride versus streamflow. The shaded area indicates the range of discharges at which the most scalping of high flows in the Salt Fork would occur. The chart shows that chloride concentration decreases significantly as discharge increases.



**Figure 4B.8.1-4. Relation of Chloride Concentrations to Streamflow at 08082000 Salt Fork Brazos at Aspermont**

4B.8.1.2.2 Seymour Aquifer

The Seymour Aquifer is composed of alluvial clay, silt, sand, and gravel deposited during the Pleistocene era and can be up to several tens of feet thick. Originally, the geologic material was laid down as a continuous unit; however, natural erosion has dissected the geologic material into several disconnected “pods.” The targeted ASR area is in a relatively large and hydraulically transmissive pod of the Seymour Aquifer and has been utilized for irrigation and local municipal supplies during the last several decades. Unconfined (water table) conditions exist throughout the

aquifer. Infiltration of precipitation and excess irrigated water serve as the primary sources of recharge.

Historical water level data in the vicinity of the target recharge area show significant declines in saturated thickness during the last 20 years. For example, a decline of about 30 feet was recorded between 1987 and 2003 at TWDB's monitoring well 2134902, which is near Knox City. This is about a 70 percent reduction in saturated thickness. These declines suggest that well yields from this area have declined in the past and, if the historical trend in declining water levels persists, well yield declines will continue. The reductions in saturated thickness also indicate that storage space for ASR recharge exists within the aquifer. Because the Seymour is an unconfined aquifer, any surplus recharge added through ASR must be contained within the sediment pore spaces.

#### 4B.8.1.2.3 ASR Modeling

To better evaluate the potential benefits of an ASR system in the region, a groundwater flow model was developed from the TWDB's Seymour Aquifer Groundwater Availability Model (SAGAM). The original SAGAM was modified for use in this study to better simulate the potential application of ASR. The modifications included:

- Clipping the Seymour GAM to cover only the Seymour in Haskell and Knox Counties;
- Refining the model grid by a factor of 5, this resulted in cells dimensions of 1,056 feet by 1,056 feet; the increase in cell density allowed for greater resolution of the smaller-scale effects produced by the simulated ASR well field;
- Assigning the elevation of the upper surface of the Seymour to land surface (as recorded in the National Elevation Dataset distributed by the USGS);
- Engaging MODFLOW's Evapotranspiration (ET) package;
- Disengaging regional pumpage; and
- Adjusting average recharge rates until the modeled saturated thickness closely matched the most recent values recorded by the TWDB for wells in the area of the proposed ASR site (these conditions are believed to represent quasi-steady-state conditions).

Assignment of ground level and subsequent engagement of the ET package was necessary to ensure that water table rises from recharge did not go above ground level throughout the simulations. The removal of regional pumpage allowed a straightforward assessment of the likely regional effects of the simulated ASR wells.

Two modeling scenarios were then conducted to assess the benefits of the ASR system. These scenarios are intended to represent the extremes of water availability for recharge which were selected during the period 1940 through 1997 and for continuous 10-year periods. The first scenario assumed the volume available for ASR injection corresponded to the 10-year period when the most surface water was available. This “wettest” period was from 1985 to 1994 and is expected to provide a supply of about 3,600 acft/yr and recovery of about 3,000 acft/yr. The second scenario assumed that the volume available for injection corresponded to 10-year period when the least amount of surface water is available. The “driest” period began in 1944 and provided approximately 1,360 acft/yr recharge and 1,000 acft/yr of pumpage. On the basis of water levels and changes in water levels, the estimated recovery is about 75 to 80 percent of the water injected.

Recharge to the Seymour was simulated utilizing a cyclic approach in order to illustrate the water level fluctuations that may occur during operation of the ASR system. For this study, it is assumed that injection of water takes place during a 4-month period each year. Similarly, recovery of groundwater from the Seymour is assumed to occur during an 8-month period each year. The model evaluations applied to each scenario extended through a 10-year period, simulating the magnitude, extent, and distribution of the water level increases that may occur following the implementation of an ASR system in the region.

#### 4B.8.1.2.4 Simulated ASR Impacts on the Seymour Aquifer

The ASR project impact on water levels of interest include: (1) magnitude of water level fluctuations over the injection and recovery cycle, and (2) extent of water table mounding and drawdown. As shown in Figure 4B.8.1-5, water level fluctuations in the center of the ASR area are approximately 18 feet for the “wet” scenario. During the “dry” scenario when smaller amounts of water are stored and recovered from the aquifer, the graph shows the total water table fluctuations are about 8 feet.

The water table maps representing conditions at the end of the recharge and recovery cycles of the 10-year simulations are shown for the wettest scenario in Figure 4B.8.1-6. These maps indicate that the location of the well field and the layout of wells do not significantly impact the overall distribution of the simulated water level increases. This is primarily due to the relatively high transmissivity of the Seymour Aquifer in the vicinity of the selected recharge

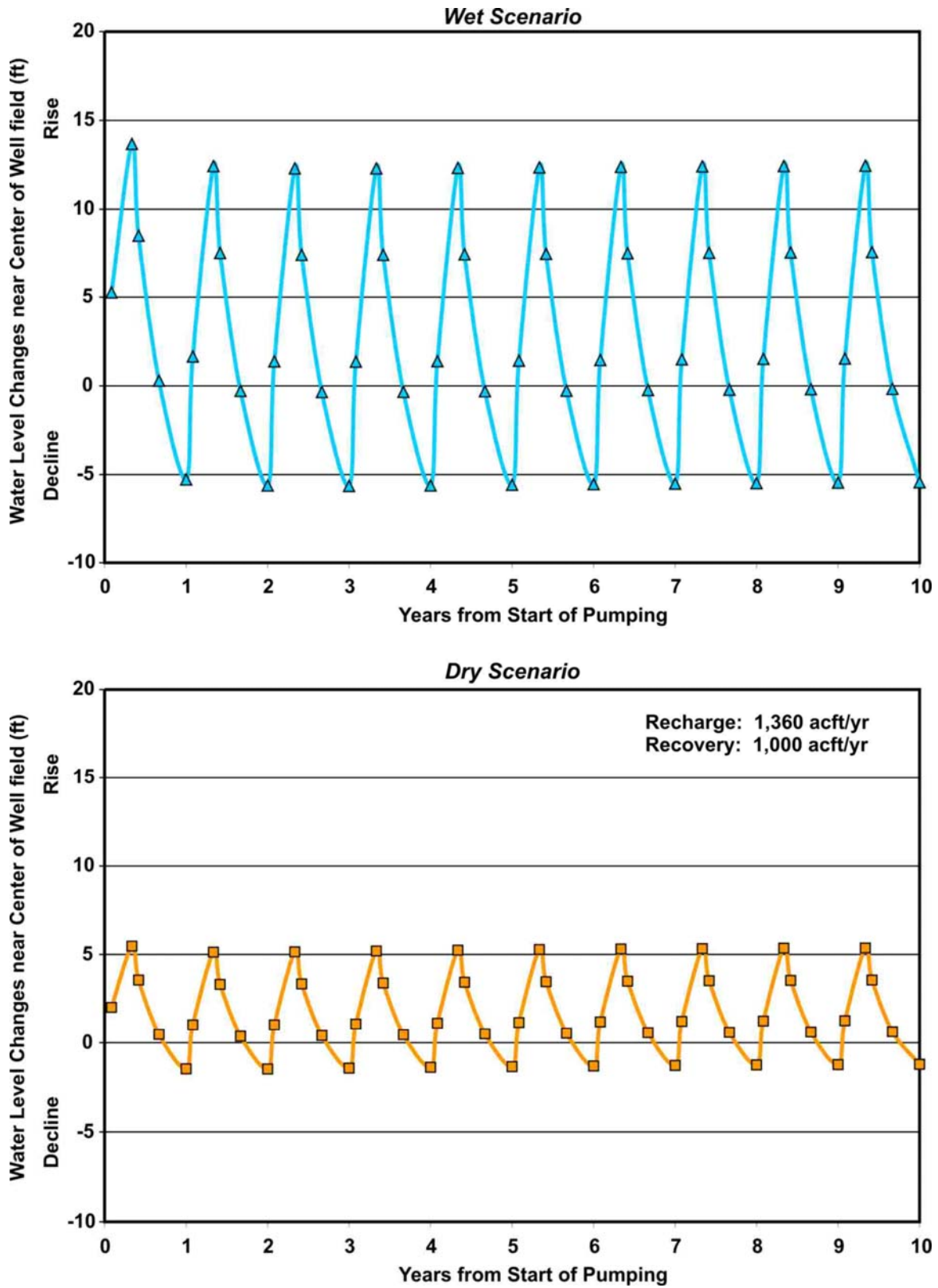
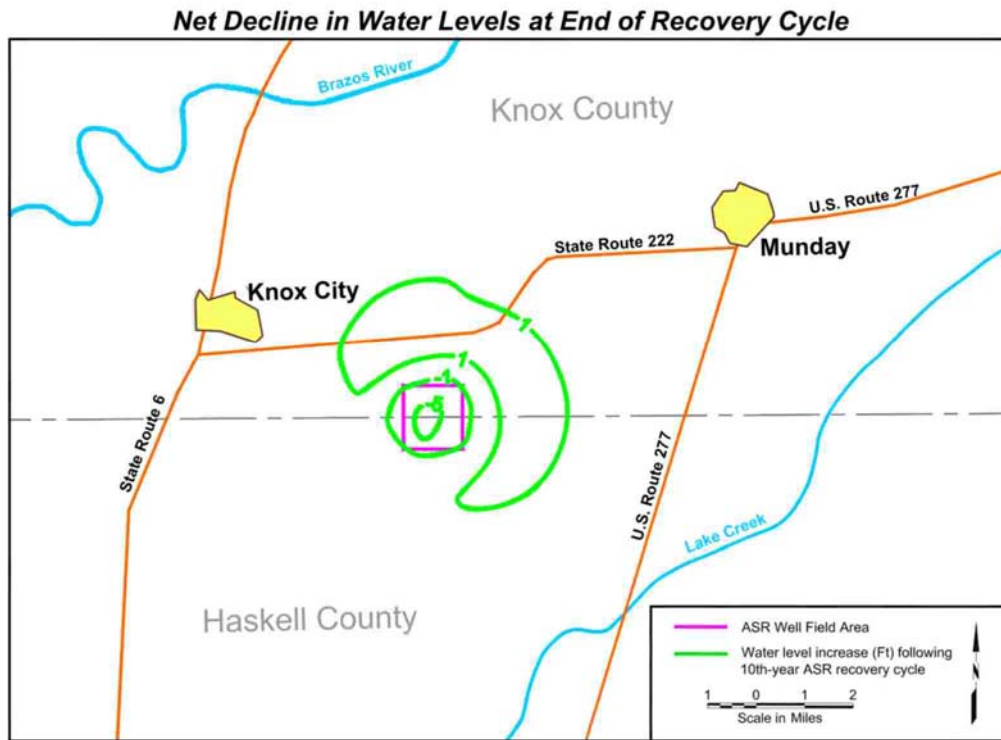
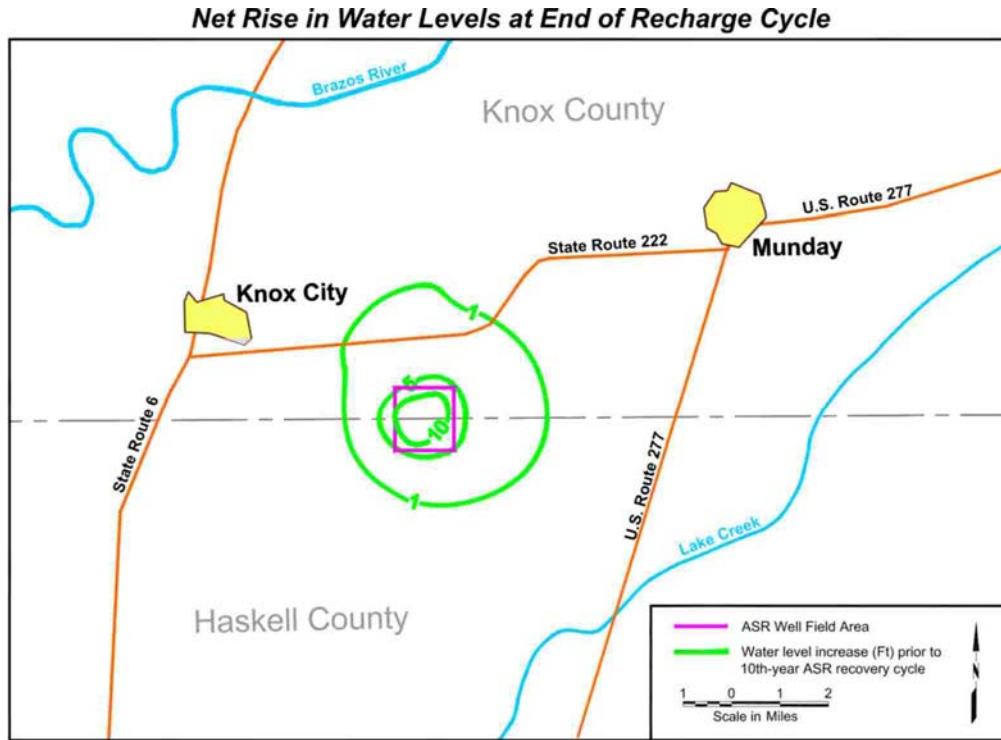


Figure 4B.8.1-5. Water Level Fluctuations at Center of ASR Recharge Area



**Figure 4B.8.1-6. Net Change of Water Level During 10<sup>th</sup> Year of Simulation for Wettest Scenario**

area. When 3,600 acft/yr is recharged and 3,000 acft/yr is pumped for a period of 10 years during an extended “wet” scenario, the area exhibiting at least a 1-foot water level increase extends about 1.5 to 2 miles from the recharge area. When 1,360 acft/yr is recharged and 1,000 acft/yr is pumped for 10 years, the 1-foot water level increase extends only about 0.5 miles from the recharge area. In both scenarios, the simulation results indicate that the increases in water levels around the ASR well field are not entirely symmetrical; slightly greater increases are seen to the north and northwest of the well field. These results are consistent with the general north-northwest direction of groundwater flow reported in the region.

#### 4B.8.1.2.5 Potential Seymour ASR Design

The proposed method of recharge is the use of spreading basins instead of wells. The spreading basins are expected to be shallow swales in the more permeable areas and along topographic contours. The spreading basins have the advantage of allowing the use of recharge water with some sediment concentrations, high application rates, and limited maintenance. It has the disadvantage of some water loss. This probably will be overcome with the retention of rainfall that may otherwise runoff. Site-specific information on soil infiltration characteristics and aquifer properties would be needed to design the recharge system and to identify the prime recovery wells.

#### 4B.8.1.2.6 Important Seymour ASR Assumptions

Important issues relating to the applicability of a Seymour ASR project include annual recharge and recovery cycles and suitable quality and quantity of surface water for aquifer compatibility and local groundwater use.

The recovery cycle must soon follow the injection cycle, or the recharge may dissipate into the regional aquifer system. While benefiting the aquifer on a more regional basis, specific project benefits for participants may be minimal. Additional studies concerning water quality from the Salt Fork would need to be conducted if the project appears feasible from cost/benefit studies.

#### **4B.8.1.3 Environmental Issues**

Diversion facilities on the Salt Fork with a pump station and pipeline to Lake Davis and then to the recharge area, which would cover a relatively small surface area of 57 acres, would probably result in:

- Negligible impacts on environmental water needs, instream flows, and bays and estuaries;
- Improved fish and wildlife habitat conditions in Lake Davis;
- Low to moderate impacts to wildlife habitat along pipeline crossing of Salt Fork;
- Low to moderate impacts to fish and wildlife, including endangered species; and
- Low impacts on cultural resources.

#### **4B.8.1.4 Engineering and Costing**

The engineering facilities for the ASR project consist of an intake and pump station on the Salt Fork Brazos River, a 36-in pipeline to Lake Davis, an intake and pump station at Lake Davis, a 24-in pipeline from the river to the ASR recharge area, distribution pipelines to several delivery points, and swales in the fields. The pipeline from the Salt Fork to Lake Davis would be used for filling the lake and diverting water from the lake to the recharge area. The river intake and pump station would be located near State Hwy 6. The Lake Davis discharge, intake and pump station facilities would be located near the dam. These facilities were shown in Figure 4B.8.1-1. The major facilities required for this option is:

- River Diversion to Off-Channel Storage
  - River Intake;
  - Pump Station;
  - Pipeline; and
  - Outlet works.
- Lake Diversion to Recharge Area
  - Lake Intake;
  - Pump Station;
  - Pipeline;
  - Outlet works; and
  - Terraces or swales.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, water purchases, power, land, and environmental mitigation. These costs are

summarized in Table 4B.8.1-1. The project costs, including capital, are estimated to be \$18,826,000. The annual costs, including debt service, operation and maintenance, and power are estimated to be \$1,776,000. This water management option produces water at estimated costs of \$474 per acft/yr for a long-term average delivery of 3,750 acft/yr. Because of relatively large fixed cost, unit rates would be less for relatively wet conditions and more for relatively dry conditions.

**Table 4B.8.1-1.  
Seymour Aquifer ASR Water Supply Project Option  
Second Quarter 2002 Prices**

<i>Item</i>	<i>Estimated Costs for Facilities</i>
<b>Capital Costs</b>	
Intake and Pump Stations (23 MGD to Davis and 12 MGD to ASR)	\$6,133,000
Transmission Pipeline (36-in to Davis and 24-in to ASR)	6,102,000
Recharge Facilities in Fields	<u>250,000</u>
<b>Total Capital Cost</b>	<b>\$12,485,000</b>
Engineering, Legal Costs and Contingencies	\$4,065,000
Environmental & Archaeology Studies and Mitigation	368,000
Land Acquisition and Surveying (57 acres)	513,000
Interest During Construction (30 years)	<u>1,395,000</u>
<b>Total Project Cost</b>	<b>\$18,826,000</b>
<b>Annual Costs</b>	
Debt Service (6 percent for 30 years)	\$1,368,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	214,000
Pumping Energy Costs (3,226,476 kWh @ \$0.06/kWh)	<u>194,000</u>
<b>Total Annual Cost</b>	<b>\$1,776,000</b>
<b>Available Project Yield (acft/yr)</b>	<b>3,750</b>
<b>Annual Cost of Water (\$ per acft)</b>	<b>\$474</b>
<b>Annual Cost of Water (\$ per 1,000 gallons)</b>	<b>\$1.45</b>

#### **4B.8.1.5 Implementation**

Implementation of the described ASR water management strategy for the Seymour Aquifer includes the following issues:

- Availability of suitable water quantities and water quality from the Salt Fork Brazos River;
- Contractual arrangements can be made with owner of Lake Davis or another nearby reservoir for use of the unused storage capacity of the reservoir;
- Contractual arrangements with land owners where the infiltration basins are to be constructed;
- Pipeline right-of-way from Salt Fork diversion to Lake Davis, and from Lake Davis to ASR site;
- Entity who is willing and capable of funding and operating the facilities and capable of developing and administering a management plan to efficiently use the facilities and to balance injection and recovery cycles.
- Controlling the loss of the injected water by the participants in the project;
- Initial cost; and/or
- Experience in operating water facilities.

It will be necessary to obtain these permits:

- TCEQ water rights permit to divert from Salt Fork Brazos River
- U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings
- General Land Office Sand and Gravel Removal Permits
- Texas Parks and Wildlife Department Sand, Gravel and Marl permit for river crossings

The impacts of the ASR option for the Seymour Aquifer in Knox and Haskell Counties has been compared to the plan development criteria, as shown in Table 4B.8.1-2.

**Table 4B.8.1-2.  
Comparison of ASR –Seymour Option in Knox and Haskell Counties  
to Plan Development Criteria**

<i>Impact Category</i>	<i>Comment(s)</i>
A. Water Supply 1. Quantity 2. Reliability 3. Cost	1. Sufficient in most years 2. Low 3. Moderate to expensive for irrigation use
B. Environmental factors 1. Environmental Water Needs 2. Habitat 3. Cultural Resources 4. Bays and Estuaries 5. Threatened and Endangered Species 6. Wetlands	1. Low impact 2. Low impact 3. Low impact 4. None 5. Low impact 6. Low impact
C. Impact on Other State Water Resources	• Potential negative impacts on water quality of Seymour; no effect on navigation
D. Threats to Agriculture and Natural Resources	• None
E. Equitable Comparison of Strategies Deemed Feasible	• Option is an attempt to meet agricultural irrigation needs
F. Requirements for Interbasin Transfers	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

## **4B.8.2 Trinity Aquifer in Johnson County**

### **4B.8.2.1 Description of Option**

For purposes of this option, the ASR project of the Trinity Aquifer in Johnson County is considered to be the use of dual-purpose wells to inject potable water into the aquifer for storage and recovery of the water at a later date. This management strategy is useful to water suppliers who periodically have surplus water and water shortages. For example, ASR can be used to inject and store water in aquifers during the fall, winter, and spring when demands are low, and to recover the water during the summer when demands are high. This strategy better utilizes the available capacity of the water treatment plant and supply and transmission system, and

commonly delays the need for expanding water treatment and distribution facilities. In most cases, the water utility's operating plan would call for balancing injection and recovery or possibly recovering slightly less than the amount injected.

For Johnson County, the ASR option is considered to be a potential water management option on the basis of more fully utilizing the available water transmission capacity from the SWATS facility on Lake Granbury to Johnson County customers (Figure 4B.8.2-1). As shown in Figure 4B.8.2-2, the July and August demands are expected to exceed the pipeline capacity by year 2010. However, with a fully operational ASR system, the annual average demand does not exceed the capacity of the pipeline until nearly 2020. This surplus of available capacity occurs during the fall, winter, and spring; however, the surplus diminishes with time as water demands gradually increase. Facilities required for this option are the installation of ASR wells, well field, pipelines, and booster station.

The area selected for potential implementation of an ASR well field is located in the northeast part of the county between the towns of Godley and Joshua and covers about 16 square miles. For purposes of this study, it is assumed that SWATS water is chemically compatible with the Trinity Aquifer and native Trinity water.

#### **4B.8.2.2 Available Yield**

##### 4B.8.2.2.1 Trinity Aquifer System

In Johnson County, the Trinity Aquifer system is composed of three sandy aquifer units that are confined and separated by relatively impermeable clay units. These aquifer units include, from youngest to oldest: the Paluxy, Hensell, and Hosston (Figure 4B.8.2-3). In the proposed ASR well field, the water-bearing units are confined with artesian pressures generally rising several hundred feet above the top of the aquifer(s). The geometry and hydraulic properties of the hydrogeologic units of the Trinity Aquifer units vary throughout Johnson County. In general, the most hydraulically transmissive (i.e., sand-rich) portions of the aquifers vary from 50 to 100 feet in thickness. High-capacity production wells typically yield from 150 to 250 gallons per minute (gpm).

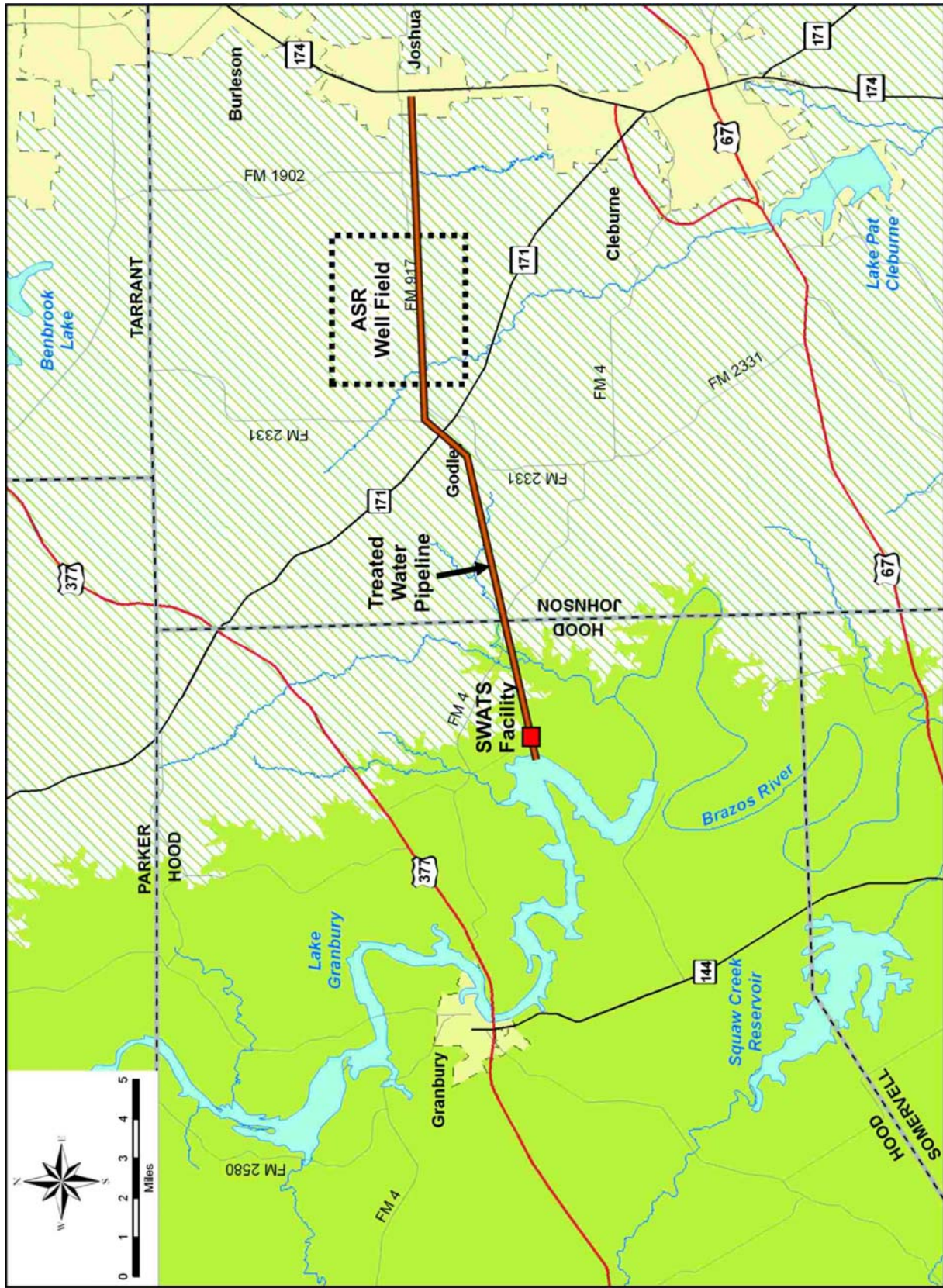


Figure 4B.8.2-1. Location of Johnson County ASR Project

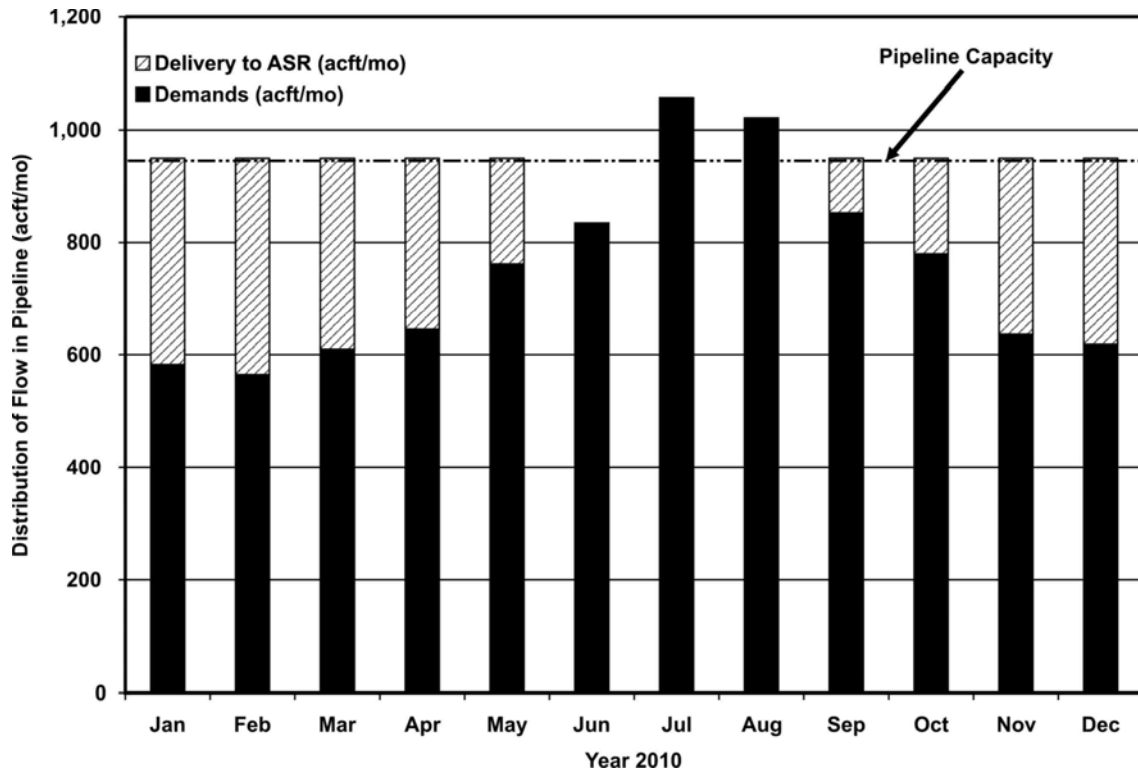


Figure 4B.8.2-2. Johnson County ASR Operations

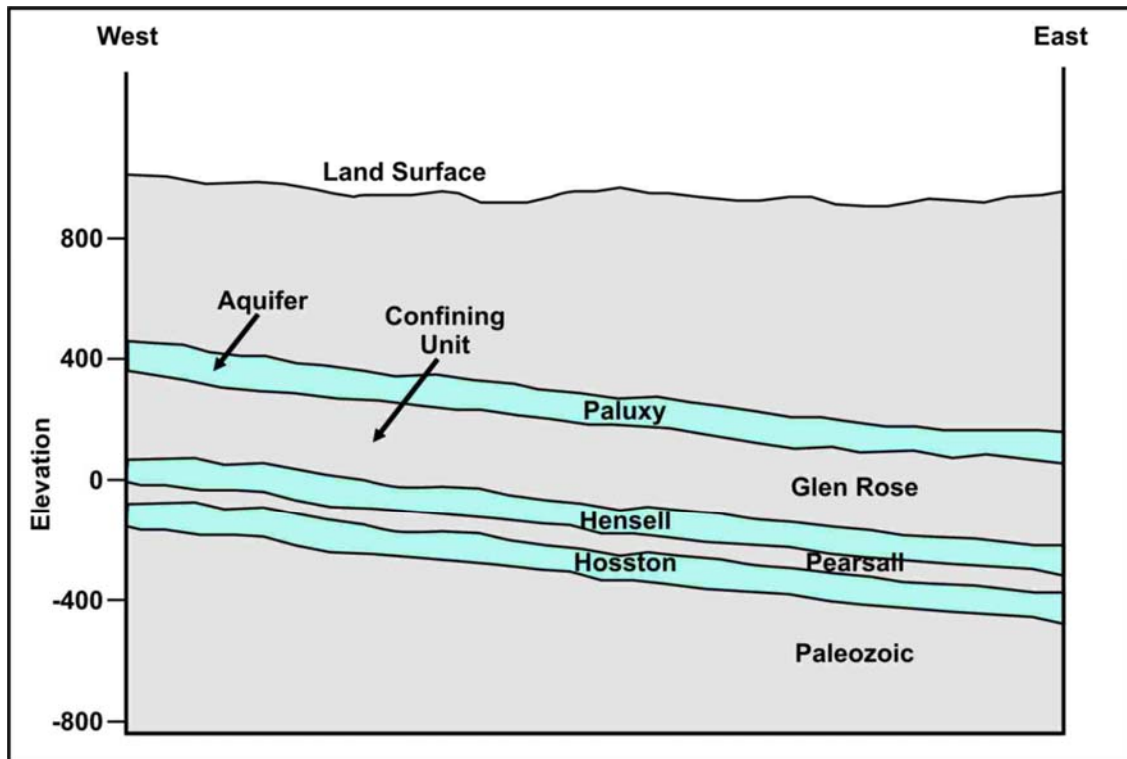


Figure 4B.8.2-3. Hydrogeologic Profile in ASR Well Field

#### 4B.8.2.2.2 Modeling ASR Operations in the Trinity Aquifer

To estimate the likely impacts of ASR operations on the aquifer system, the TWDB's Northern Trinity/Woodbine Groundwater Availability Model (NTWGAM) was utilized. The GAM subdivides the Trinity Aquifer system in the study area into three discrete aquifer units: (1) Paluxy, (2) Hensell, and (3) Hosston. For this study, all ASR injection and recovery is simulated in wells that penetrate the Hosston, the deepest and generally the most transmissive aquifer in the local region. With the exception of predictive pumpage, original GAM input parameters were retained for all simulations. Recharge was held constant at a rate corresponding to the average estimated during 1980 to 2000.

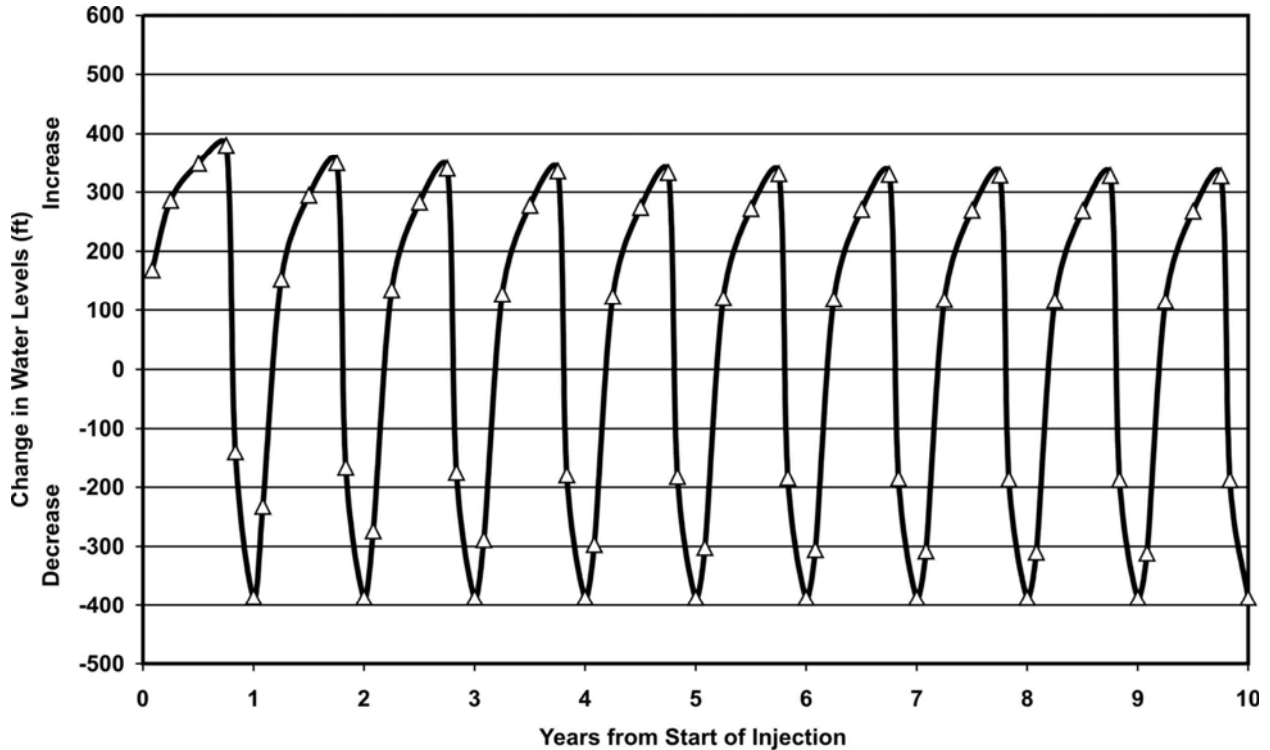
Several entities have forecasted significant declines in the rate of withdrawal from the Trinity for the next half-century, and these rate reductions were included in the predictive pumpage set included with the NTWGAM. However, it is unclear whether reductions in pumpage will actually occur given the projected population growth within the region and the lack of alternative water supplies. Because of the uncertainty in future use of the Trinity, the regional pumpage estimated during the year 1999 was held constant throughout the simulations in an effort to minimize the underestimation of regional drawdown should a planned reduction in future pumpage not occur and to simplify the analysis.

Injection of water into the Hosston member of the Trinity Aquifer was simulated utilizing a cyclic approach in order to illustrate the water level fluctuations that may occur during operation of the ASR system. For this study, it is assumed that injection of about 2,600 acft/yr of water takes place during a 9-month interval within each 1-year period of the simulation. Following the injection cycle, recovery of groundwater is assumed to occur during a 3-month interval in the course of a 1-year simulation.

The test scenario was conducted on the basis of 2,600 acft/yr of ASR recharge followed by full recovery. To test for trends, the model simulations extended through a 10-year period, simulating the magnitude, extent, and distribution of the water level increases that may occur following the implementation of an ASR system in the region.

Figure 4B.8.2-4 shows the well field water level fluctuations caused by ASR operations for 10 years. Conceptually, the injection would begin in September and last through May, and the recovery would be from June through August. During these simulations, 2,600 acft/yr of annual ASR injection with full recovery will likely result in yearly water level (artesian pressure) oscillations of about 750 feet. As shown, the water levels slowly decline over time because the

water levels for background pumping have not stabilized. As shown in Figure 4B.8.2-5, the model results also indicate that significant fluctuations in artesian pressure may be expected to extend several miles from the well field. At the end of the injection cycle in the 10th year, water level rises range from about 300 feet in the center of the well field to about 10 feet at a distance of 7 miles. At the end of the recovery cycle in the 10th year, the declines are more than 10 feet within about 6 miles of the well field.



**Figure 4B.8.2-4. Water Level Fluctuations in Center of ASR Well Field**

It should be noted that the magnitude and extent of the modeled water level fluctuations are heavily dependent on the assumed hydraulic characteristics of the aquifer in the region, and that the actual water level changes will likely vary with the conditions found at specific well sites.

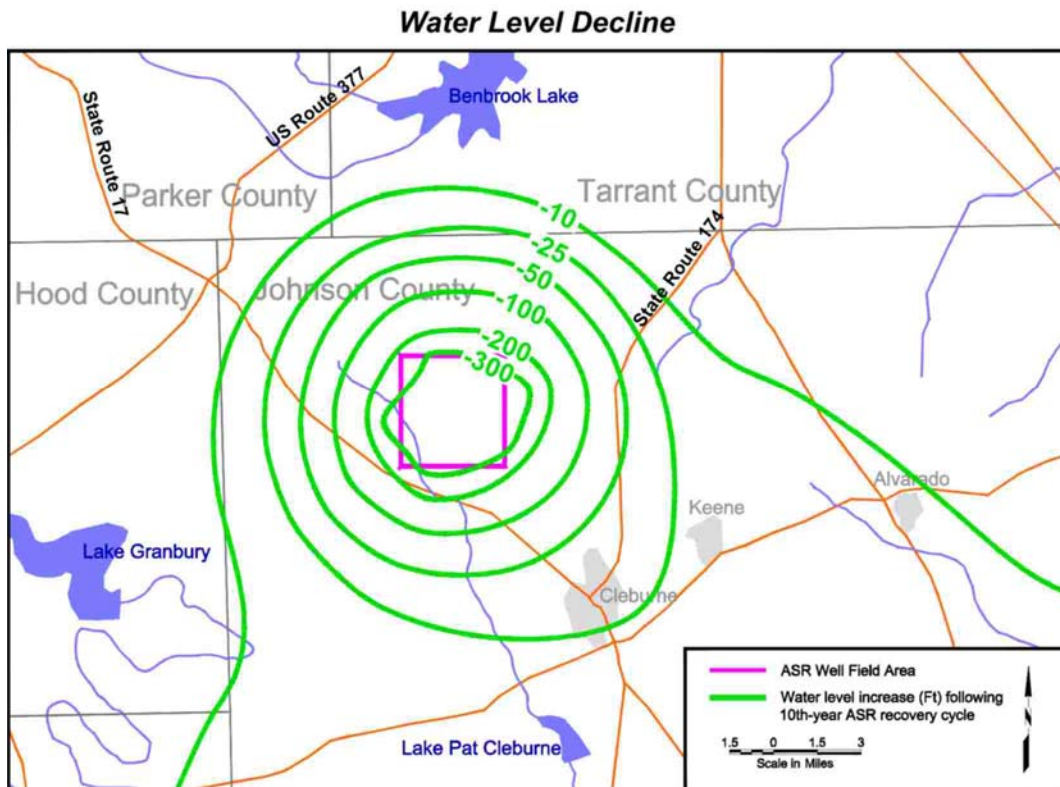
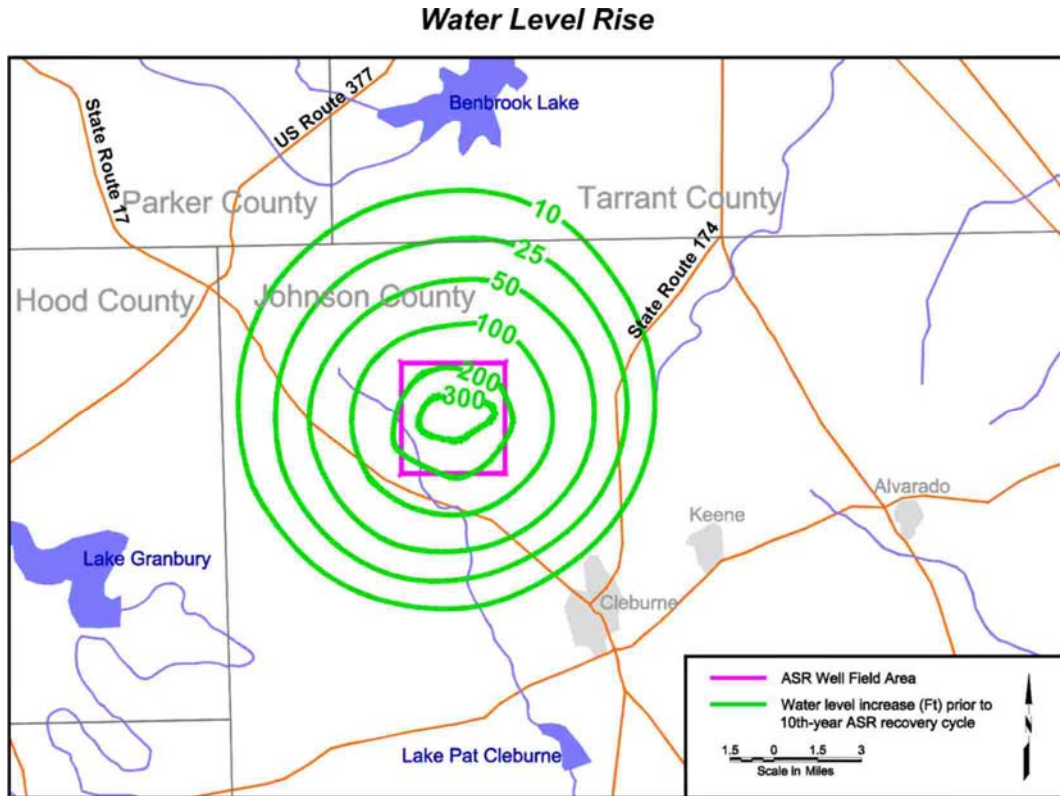
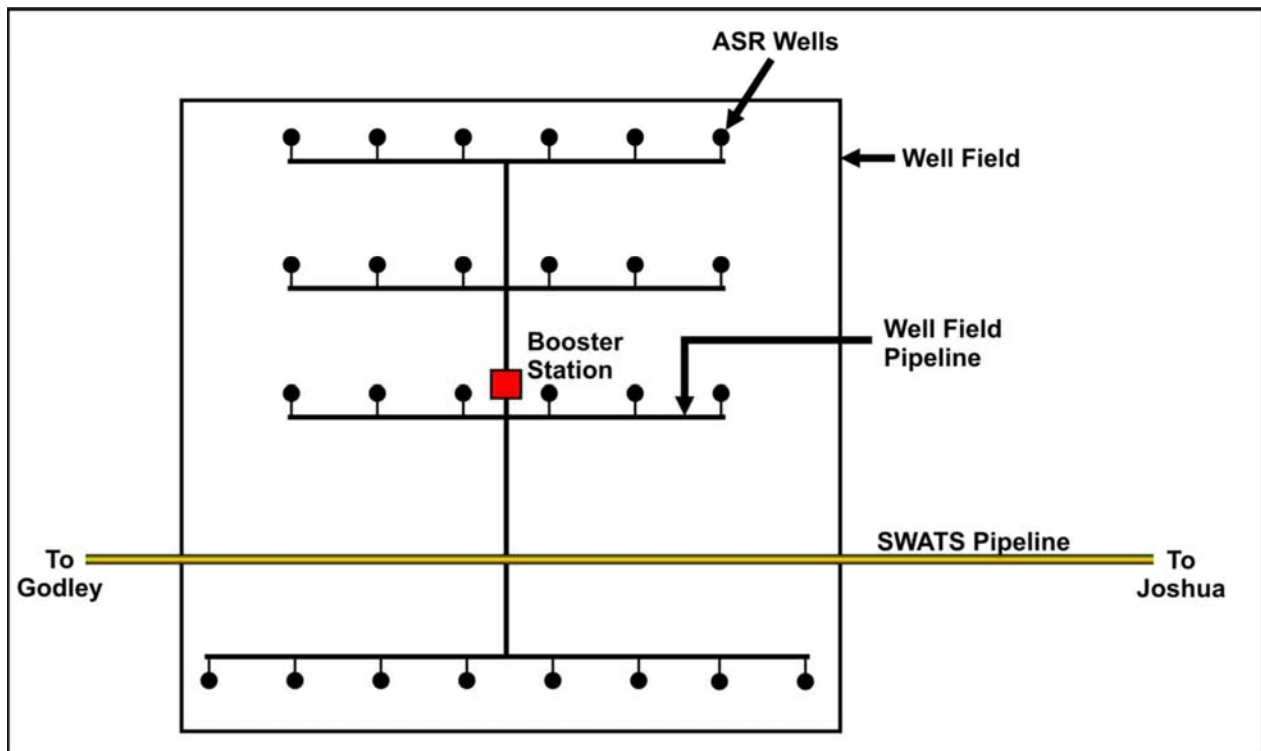


Figure 4B.8.2-5. Water Levels During 10th Year of Operations

4B.8.2.2.3 Potential Trinity ASR Well Field Design

The actual number of wells and land required for the well field is dependent upon local depth to water, and the thickness and character of sands present at each well field site. This site-specific information would need to be acquired through a test drilling and field testing program prior to implementation of an ASR system in the region.

Available records indicate that wells constructed in the area will average between 1,100 and 1,200 feet in depth. Based on existing wells in the area, the maximum injection and recovery rates per well is about 250 gpm. Given this restriction, it is estimated that about 26 wells would accommodate the recovery rate assumed for this study. A schematic of a potential well field design is shown in Figure 4B.8.2-6.



**Figure 4B.8.2-6. Schematic of Potential ASR Well Field Design**

#### 4B.8.2.2.4 Important Assumptions

Important issues relating to the applicability of a Johnson County ASR project include: (1) annual injection and recovery cycles, (2) availability of suitable quality and quantity of water, (3) the aquifer and imported water are compatible, and (4) limited local groundwater use.

The recovery cycle must soon follow the injection cycle, or local artesian pressures generated during the injection phase will dissipate. While losing the annual pressure benefit, the project may provide water quality improvements even without a subsequent recovery cycle. As noted, it is assumed that injection water quality is compatible with the Trinity Aquifer. Additional studies concerning water quality would need to be conducted to determine if the project is feasible.

#### **4B.8.2.3 Environmental Issues**

The development of ASR facilities in the Johnson County includes the construction of wells, collector pipelines, and water treatment facilities would involve relatively low environmental impacts:

- Operation of ASR wells is expected to have no effect on streams in the area.
- Construction of wells, collector pipelines and pump station would have little or no effect on wildlife habitat or in disturbed areas. No streams or wetlands are expected to be encountered.

#### **4B.8.2.4 Engineering and Costing**

The ASR well field would be developed by constructing water wells capable of injection and recovery, well field pipelines for distribution and collection of water, a booster station for injection, and terminal storage. The well field is about midway between the towns of Godley and Joshua and will extend north and south of the SWATS pipeline, as shown in Figure 4B.8.2-1. During the injection cycle, a pump station and terminal storage is needed to provide sufficient pressure to the northern part of the ASR well field. In all, 26 dual-purpose wells constructed to public water supply standards are required. Eight would be south of the SWATS pipeline and 18 would be north, spaced at 5,000 feet. Well pumps will be large enough to produce sufficient head to force the recovered water directly into the SWATS pipeline. The major facilities required for these options are:

- Well Field and Collection and Conveyance System to the SWATS pipeline along State FM 917

- Wells;
- Pipelines;
- Booster Station; and
- Terminal Storage.

The approximate locations of the well fields, pipeline routes, and pump station were shown earlier in Figures 4B.8.2-1 and 4B.8.2-6.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, water purchases, power, land, and environmental mitigation. These costs are summarized in Table 4B.8.2-1. The annual costs, including debt service, operation and maintenance, power, and purchase of treated water, are estimated to be \$5,245,600. This water management option initially produces water at estimated costs of \$2,025/acft/yr with about \$1,140/acft/yr for the purchase of treated water. Later, as the SWATS pipeline has less and less capacity for recharge, the unit cost would increase.

#### **4B.8.2.5 Implementation**

The ASR water management strategy described above has been compared to the plan development criteria, as shown in Table 4B.8.2-2, and the option meets each criterion. Implementation of the ASR water management strategy for Johnson County includes the following issues:

- Contractual arrangements can be made with the Brazos River Authority for a supply of raw water and expanded use of the SWAT facility;
- Permits from TCEQ for ASR operations and for storage of surface water in the Trinity Aquifer can be obtained;
- Lack of experience to develop confidence in the ability to inject and recover water from an aquifer, which includes the uncertainty about the compatibility of the injected water with native groundwater and aquifer materials;
- Controlling the loss of the injected water by the funding agency;
- Initial cost;
- Experience in operating the facilities; and/or
- Development of a management plan to efficiently use the ASR wells with a balance of injection and recovery cycles.

**Table 4B.8.2-1.  
Johnson County ASR Water Supply Project Option  
Second Quarter 2002 Prices**

<i>Item</i>	<i>Estimated Costs for Facilities</i>
<b>Capital Costs</b>	
Transmission Pump Station(s)	\$1,400,000
Well Fields	<u>14,397,000</u>
<b>Total Capital Cost</b>	<b>\$15,797,000</b>
Engineering, Legal Costs and Contingencies	\$5,527,000
Environmental & Archaeology Studies and Mitigation	823,000
Land Acquisition and Surveying (107 acres)	1,006,000
Interest During Construction (2 years)	<u>1,853,000</u>
<b>Total Project Cost</b>	<b>\$25,006,000</b>
<b>Annual Costs</b>	
Debt Service (6 percent, 30 years)	\$1,817,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	170,000
Pumping Energy Costs (5,106,032 kWh @ \$0.06/kWh)	306,000
Purchase of Treated Water (2,590 acft/yr @ \$1,140/acft)	<u>2,952,600</u>
<b>Total Annual Cost</b>	<b>\$5,245,600</b>
<b>Available Project Yield (acft/yr)</b>	<b>2,590</b>
<b>Annual Cost of Water (\$ per acft)</b>	<b>\$2,025</b>
<b>Annual Cost of Water (\$ per 1,000 gallons)</b>	<b>\$6.21</b>

**Table 4B.8.2-2.  
Comparison of Johnson County ASR-Trinity Water Supply Project  
to Plan Development Criteria**

<b>Impact Category</b>	<b>Comment(s)</b>
A. Water Supply 1. Quantity 2. Reliability 3. Cost	1. Improves balance of winter and summer demands 2. High 3. Moderately expensive
B. Environmental factors 1. Environmental Water Needs 2. Habitat 3. Cultural Resources 4. Bays and Estuaries 5. Threatened and Endangered Species 6. Wetlands	1. Low impact 2. Low impact 3. Low impact 4. None 5. Low impact 6. Low impact
C. Impact on Other State Water Resources	• No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	• Low to none
E. Equitable Comparison of Strategies Deemed Feasible	• Option is considered to meet municipal and "County-Other" shortages
F. Requirements for Interbasin Transfers	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

(This page intentionally left blank.)