# REGIONAL RECHARGE PLAN

## TUCSON ACTIVE MANAGEMENT AREA
## INSTITUTIONAL AND POLICY ADVISORY GROUP

## EXECUTIVE SUMMARY

In order to reach its statutory goal of achieving safe-yield by the year 2025, the Tucson Active Management Area (Tucson AMA) must take steps to substantially reduce its dependence on groundwater. Groundwater has been used a faster rate than it is naturally replenished in the AMA since the 1940's. Groundwater use in the Tucson AMA in 1995 was nearly twice the rate of natural and incidental recharge. Mining of groundwater reserves has resulted in groundwater level declines in much of the AMA, with declines of up to 200 feet in the City of Tucson's Central Wellfield. Water level declines over the last 50 years have meant loss of riparian habitat, reduced stream flows, decreased well productivity, and increased pumping costs. The quality of groundwater pumped is expected to decrease over time as lower quality water is pumped from lower depths in the aquifer, and the potential for subsidence, or sinking of the earth's surface, in the areas of greatest groundwater declines is expected to increase.

Water supply augmentation, along with water conservation, is expected to be a key component of achieving the safe-yield goal. Use of renewable supplies, particularly Central Arizona Project (CAP) water, will help achieve long-term water balance in the AMA. However, when direct potable delivery of CAP water was initiated in 1992, it resulted in taste, appearance and odor problems as well as damaged pipes. As a result, direct CAP water delivery was partially halted in 1993 and completely discontinued in 1994. Plans for CAP water use have since shifted to artificial groundwater recharge, although other options are still being evaluated.

Principal responsibility for developing water supplies is carried by the region's water providers. However, the need to coordinate efforts at a regional level resulted in the development of this plan. Regional recharge planning efforts to date have focused on 1) clarifying legal issues related to recharge, 2) planning for adequate recharge capacity to meet regional water needs, 3) providing a forum to identify and help resolve institutional and inter-jurisdictional conflicts, 4) prioritizing regional investment in water storage facilities, and 5) assisting in the development of a facilities plan for the Arizona Water Banking Authority (AWBA).

### Regional Recharge Planing Process

The Regional Recharge Plan (RRP; the Plan) summarizes the work over two and a half years of the Tucson AMA Regional Recharge Planning Process (RRP Process). The RRP Process is a collaborative planning effort initiated by ADWR's Tucson AMA office and Groundwater Users Advisory Council. The RRP Process brings together water providers and all levels of

governmental jurisdictions to develop a coordinated approach to recharge activities in the Tucson AMA and incorporate these goals into a Regional Recharge Plan. The Plan addresses a number of needs identified by area water users, including 100-year assured water supply demonstrations, reliability of CAP water delivery, and increasing the use of renewable water supplies, principally CAP allocations. Recharge will play an important role in meeting these needs, but recharge projects are costly. Collaborative groundwater recharge planning will enhance the region's ability to take advantage of incentives, secure outside support, and improve the cost-effectiveness of regional recharge projects.

The RRP Process depended on the voluntary participation of two committees of representatives from a broad spectrum of interests. The Regional Recharge Committee (RRC), which was made up entirely of technical experts in fields related to recharge, produced the RRC Technical Report in September 1996 identifying the technical issues related to recharge in the Tucson Basin. The Institutional and Policy Advisory Group (IPAG) was composed of policy-oriented representatives whose roles were to shape and direct the planning process and be instrumental in communicating the results to their respective publics.

The following specific objectives were identified for the RRP Process:

- Provide a forum for regional cooperation regarding recharge activities
- Maximize the use of renewable water supplies in the Tucson AMA
- Optimize sharing of recharge, pumping and transmission facilities
- Expedite selection, testing and construction of groundwater recharge facilities
- Facilitate equitable access to recharge capacity
- Provide a background document for the facilities plan that is required by the AWBA

In order to provide a background document for development of the AWBA's facilities plan, IPAG submitted a Report to the Arizona Water Banking Authority in November 1997. This document contained advice on meeting groundwater management objectives in the Tucson AMA and included much of the analysis of recharge sites contained in the Regional Recharge Plan. Major conclusions and issues discussed in documents produced at other stages of the RRP Process, such as the RRC Technical Report and the Report of the RRP to the AWBA, have been incorporated into the RRP in order to have important information developed in the RRP Process available in one document.

**Facility Types**

Two types of recharge facilities are authorized in Arizona: Underground Storage Facilities (USFs)

and Groundwater Savings Facilities (GSFs). USFs are commonly referred to as direct recharge facilities and can include "constructed" projects, such as spreading basins or injection wells, and "managed" projects using natural stream channels. GSFs are commonly referred to as "in-lieu" recharge facilities - meaning that a renewable water supply is used on a gallon-for-gallon substitute basis in lieu of groundwater that would otherwise have been pumped. GSFs usually involve agricultural facilities that use CAP water in lieu of groundwater.

**Sources of Recharge Water**

The primary source water for recharge in the Tucson AMA is the Central Arizona Project. The City of Tucson's CAP allocation is the largest municipal and industrial (M&I) allocation in the state: 138,920 acre-feet (AF), after accounting for the recent settlement agreement between Metropolitan Domestic Water Improvement District (Metro Water District) and the City of Tucson. Allocations to other municipal providers, Indian Nations, and the State Land Department within the AMA bring the total amount of CAP allocated to entities in the AMA to 215,333 AF. More than 250,000 AF per year of CAP water could be available for storage in the AMA if excess CAP water potentially available to the AWBA and Central Arizona Groundwater Replenishment District (CAGRD) for recharge in the Tucson AMA is included.

There is also a growing supply of effluent available for use in the Tucson AMA, and recharge of effluent is becoming an important option, especially in meeting local groundwater management needs. However, a separate Regional Effluent Planning Process is underway, so effluent recharge options will be considered through that effort.

**Subsidence**

Subsidence is the downward movement or sinking of the Earth's surface caused by compaction of aquifer materials. Most of the subsidence in Arizona results from pumping more groundwater than is naturally recharged to the aquifer (Slaff 1993). Subsidence can take place when the pressure of the water that fills the pore spaces between grains of aquifer material (gravel, sand, silt and clay) is decreased as water is removed. Observed land subsidence has been greatest where depressurization or dewatering has occurred in aquifer materials containing high concentrations of fine-grained sediments such as silt and clay. Damage associated with land subsidence may include the formation of fissures and sinkholes, the alteration of drainage patterns, and damage to structures caused by differential subsidence.

Potential for subsidence can be reduced when water level declines are stopped or reversed. This may be accomplished by 1) reducing the amount of pumping, and 2) recharging in the vicinity of the cone of depression. Artificial recharge may be used as a tool to mitigate land subsidence by increasing hydrostatic pressure. Recharge may reduce the amount of compaction and in some cases may result in some rebounding of the compacted layers. However, most aquifer compaction is "inelastic" and will not recover. To be most effective, water should be recharged as close as possible to the aquifer layer that is compacting. This indicates that well-injection recharge is

likely to be an effective tool in mitigating subsidence.

Surface methods of recharge may be less effective at mitigating subsidence than well injection, and in some circumstances they also may increase subsidence. The added weight of the water at and near the surface initially increases geostatic pressure above the compacting aquifer layer.

**Recharge Facility Capacity and Recharge Demand**

Recharge capacity in the Tucson AMA is growing, but recharge projects take time to develop. The time required to move from conceptual phase to full-scale implementation has been underestimated in virtually every recharge project that has been developed, primarily due to unforseen institutional, political, or regulatory constraints. In addition, actual project costs have often varied widely from original estimates. The first project to recharge CAP water in the Tucson AMA was a pilot injection well in the Tucson Central Wellfield, initiated in 1993. This project had to be discontinued when direct potable CAP deliveries were curtailed. A second pilot injection well was discontinued in 1994. Two GSFs, Cortaro Marana Irrigation District (CMID) GSF and BKW Farms GSF, also began storage in 1993. As is shown in the table below, the amount of water stored through recharge projects in the Tucson AMA nearly tripled compared to 1995 levels by the end of 1997, to approximately 36,000 AF.

However, storage capacity in the Tucson AMA is still severely lacking, given that up to 250,000 AF of CAP water is available annually for storage, and given that direct delivery of CAP water

**WATER DELIVERED TO RECHARGE PROJECTS IN THE TUCSON AMA**

| Recharge Facility | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|
| Avra Valley Recharge Project (CAP) | --- | --- | --- | 2,794 AF | 5,555 AF |
| CAVSARP Pilot (CAP) | --- | --- | --- | 154 AF | 2,209 AF |
| Cortaro Marana ID GSF (CAP) | 2,650 AF | 0 AF | 5,902 AF | 9,581 AF | 9,746 AF |
| BKW GSF (CAP) | 250 AF | 2,014 AF | 4,235 AF | 7,080 AF | 8,648 AF |
| Kai Picacho GSF (CAP) | --- | --- | --- | 0 AF | 6,701 AF |
| 1st TW Pilot Injection Well (CAP) | 2,394 AF | --- | --- | --- | --- |
| 2nd TW Pilot Injection Well (CAP) | 2 AF | 1,574 AF | --- | --- | --- |
| Sweetwater Annual Storage and Recovery (Effluent) | 2,427 AF | 3,209 AF | 2,654 AF | 2,572 AF | 3,207 AF |
| **TOTAL** | **7,723 AF** | **6,797 AF** | **12,791 AF** | **22,181 AF** | **36,066 AF** |

AF - acre-feet, AMA - Active Management Area, CAP - Central Arizona Project, ID - Irrigation District, GSF - Groundwater Savings Facility
CAVSARP - Central Avra Valley Storage and Recovery Project, TW - Tucson Water

appears unlikely in the near future. Demand for recharge in the Tucson AMA is growing, and will depend on several factors including City of Tucson usage of its CAP allotment, how designated municipal providers and certificated subdivisions use their groundwater allowances, the price of alternative supplies of water, and the cost to the AWBA of recharging at Tucson AMA facilities.

**Scenarios for Future Demand for Recharge Capacity**

Three scenarios were developed to explore possible future demand for recharge. The scenarios are not meant to represent specific anticipated utilization patterns, but rather to frame the possible range of demand based on differing assumptions. Scenarios were developed for target years 2000 and 2007 to represent low, medium and high demand for recharge capacity. The scenarios differ according to the method for City of Tucson use of CAP water (direct potable delivery for the low scenario, blending for the medium scenario, all recharge for the high scenario), phase-in of annual storage and recovery for other municipal providers, varying accrual rates for long-term storage credits, and different average prices for AWBA recharge in the Tucson AMA. Storage capacity required in the year 2000 based on the scenario analysis could range from 77,100 AF for the low demand scenario to 158,000 AF for the high demand scenario. By 2007, the required capacity could range from 74,300 AF for the low demand scenario to 173,500 AF for the high demand scenario.

**Recharge Participant Needs Assessment and Categorization of Projects**

In accordance with the objectives and principles of the RRP planning process, an inclusive assessment of recharge-related needs was conducted to reveal common goals and highlight points of contention so they could be resolved. A needs assessment survey was conducted from November 1996 through January 1997 to obtain information about goals, concerns, operating constraints, and recharge project interest and involvement, and to assess the relevant issues associated with recharge. Most of the entities initially identified as likely participants provided some information in response to the survey.

Besides the discussion of issues, the main products of the needs assessment were lists of the goals of potential recharge participants and concerns about the risks of recharge. The goals and concerns of potential participants formed the basis for developing criteria on which individual projects and the Regional Recharge Plan could be evaluated.

Rather than rank projects numerically on the basis of the assessments, the IPAG elected to categorize projects qualitatively. To develop categories of projects, the IPAG needed to prioritize the criteria and condense the information in the assessments. These tasks were accomplished by combining individual criteria into three groups: 1) feasibility, 2) capacity, and 3) water management and related benefits.

The “feasibility” criteria group allowed the relative ordering of projects based on IPAG’s analysis

of the likelihood each would be built. "Capacity" criteria included total planned capacity and capacity in excess of projected short-term and long-term needs of the sponsors. "Water management and related benefits" comprised the long-term, location-specific objectives and additional benefits of multiple-use projects. To help assess potential water management benefits, IPAG considered groundwater level decline and subsidence maps to identify areas threatened by continued or increased pumpage without recharge.

The graph on the following page summarizes the assessment of projects based on the three categories of criteria. These assessments are expected to change over time as projects develop. The water management benefit assessment for the Central Avra Valley Storage and Recovery Project (CAVSARP) is dependent on full-scale implementation of the project, which would allow operation of the project to offset use of groundwater wells in the Central Wellfield.

The project assessments conducted by the IPAG indicated that 13 projects could be identified as having sponsorship commitment and were not disqualified on the basis of IPAG's selection criteria. Analysis of potential capacity available from these projects reveals that it is only possible to utilize all of the CAP water available if virtually all of the projects are constructed, including those on Indian reservations. This would require massive capital investment, and it is probably overly optimistic to assume it could be done by 2007, the last year of the AWBA's ten year planning period. The "high end" recharge scenario presents a more probable maximum developable capacity of 173,500 AF by 2007.

**Conclusions**

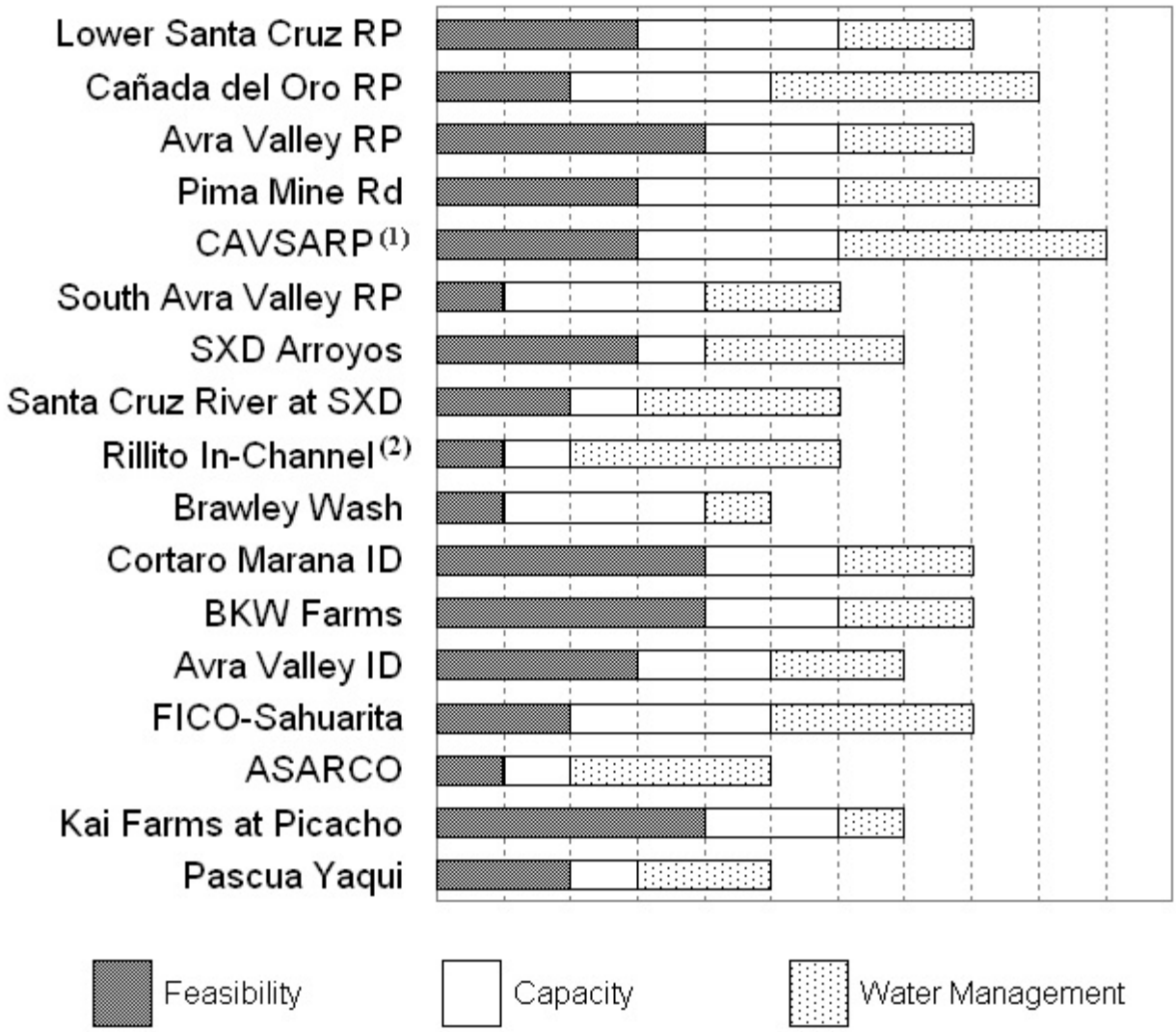
In order to facilitate regional cooperation in groundwater recharge in the Tucson basin, not only do participants need a complete understanding of the institutional and legal setting and the potential demand for recharge, but also the associated technical issues. Although the mechanisms of recharge are conceptually simple, the technical aspects are relatively complex. Several of the most important conclusions from the RRC Technical Report are included here. These are followed by the general conclusions of the IPAG and its recommendations to the AWBA.

**Conclusions from the RRC Technical Report (September 1996):**

- Recharge capacity within the Tucson AMA is growing, and numerous sites have been identified as possible candidates for the development of additional capacity in the AMA. However, the opportunities for recharge in the central Tucson basin have been overstated and oversimplified. The primary limitations of in-channel recharge of the central basin are: 1) the differences between short-term (at the surface) infiltration rates and long-term (at the regional aquifer) recharge rates, 2) the limitations imposed by landfills and existing areas of groundwater contamination, and 3) the lack of infrastructure to deliver CAP water to the area of the Central Wellfield or further upgradient.High infiltration rates in the riverbeds in the Tucson basin do not necessarily mean that vast quantities of water can be recharged in these areas. The real constraint to recharging large quantities of water in

# Recharge Project Assessment

(as of July 1998*)




Projects were selected from a longer list of 35 and are considered most likely to meet regional objectives.

* Project assessments are expected to change in absolute and relative terms over time as projects develop.

(1) CAVSARP rates highly from a water management perspective because the project is intended to offset use of groundwater wells in the Central Wellfield.

(2) The Rillito In-Channel Project evaluated in this report includes portions of Rillito Creek and the Pantano and Tanque Verde washes and is not the same as the pilot project currently being considered by the City of Tucson, although the two project proposals share a stream segment in common.

ID - Irrigation District, RP - Recharge Project, CAVSARP - Central Avra Valley Storage and Recovery Project, SXD - San Xavier District (of the Tohono O'odham Nation)

the riverbeds, and elsewhere, is not the surface infiltration rate--it is the rate at which the water can move from the surface alluvial materials down into the regional aquifer. The long-term infiltration rate is difficult to estimate without long-term field testing. Other factors that affect the amount of water that can be recharged at a site include depth to groundwater and the ability of the aquifer to transmit water from the recharge site. The existence of impeding layers in the vadose zone can also affect recharge rates. Recharge is a complicated process which requires site-specific studies and pilot tests to assess effectiveness, cost and environmental impacts.

- There appear to be some misconceptions regarding the costs associated with recharge. The energy requirements of both delivery to the site and recovery of the recharged water are often overlooked. Releasing effluent or CAP water into riverbeds may be relatively inexpensive if there are existing delivery systems to deliver the water and there are no regulatory, institutional or water quality concerns. However, the cost and time associated with preliminary site investigations and pilot tests to ensure that there are no negative environmental effects, the hydrologic studies and permitting costs, and the costs associated with ongoing monitoring are frequently overlooked.

- Key cost factors to consider for recharge projects include: 1) proximity to source water (i.e. distance from CAP canal), 2) short and long-term recharge rates at the site, 3) ability to utilize existing infrastructure, 4) land acquisition costs, and 5) regulatory considerations.

- Water quality impacts of recharge of CAP water depend on a number of site-specific factors, such as soil type, aquifer materials, and quality of the ambient groundwater. From the perspective of regulated constituents (primary maximum contaminant levels (MCLs) for drinking water regulated by the U.S. Environmental Protection Agency (EPA)) there are no implications associated with recharging CAP water, other than the higher natural organic content. CAP water, like most other surface water, does exceed primary MCLs for bacteria and turbidity. Given sufficient time and travel through soils and aquifer materials, these pollutants are usually filtered out of the water when it is recharged.

- CAP water also contains certain organic compounds, referred to as precursors, which can, in combination with chlorine, react to form trihalomethanes (THMs). THMs have been shown to cause cancer in laboratory animals. The implications of the presence of organic material in CAP water and the fate of such materials and THMs in recharge projects is the subject of an ADWR consultant report. In general, the report concludes that both direct potable delivery through the Hayden-Udall Treatment Plant and CAP water recharge can be managed to ensure compliance with the EPA's proposed more stringent standards for THMs.

- Recharge of untreated CAP water is likely to increase the dissolved mineral content and hardness of the water in the aquifer, though there are some native groundwater wells with higher total dissolved solids (TDS, also called salinity) than CAP water. CAP water has

roughly twice the TDS of the average groundwater pumped in the AMA. Recharge in the Tucson AMA is not likely to reduce the TDS of the source water, except through dilution. In general, water that is pumped from wells in the area of the recharge site will have a higher TDS than the groundwater. Like direct potable CAP water delivery, delivery of recharged and recovered CAP water will translate into the need to replace water-using appliances more frequently and increase the maintenance of irrigation and evaporative cooling systems.

- It is important to note that TDS brought in with the CAP water will be spatially distributed in the aquifer differently depending on how the CAP water is used. If the water is recharged, the TDS will be distributed in the vicinity of the recharge facilities and could migrate over time to surrounding aquifer materials unless recovery facilities are in the same location as the recharge facilities. Once TDS are introduced into the aquifer, enhanced treatment (utilizing membrane technology) would be required to remove them from recovered water. The long-term effect of multiple recharge projects scattered over the AMA would be wide variability in water quality due to TDS introduction.

**Conclusions of the Institutional and Policy Advisory Group**

- IPAG has determined that in the short term, the goal of the Regional Recharge Plan should be to maximize the total amount of CAP water delivered to the Tucson AMA each year. However, over the longer term, it is imperative that achieving water management goals become the primary consideration in siting new facilities.

- From a water management perspective, the City of Tucson's Central Wellfield is probably the most significant area of concern in the Tucson AMA. Recharge in central streambeds is limited by landfills located along stream channels and there are questions about the effectiveness of recharge in the streambed in mitigating overdraft in the Central Wellfield. The City of Tucson Mayor and Council has voted to pursue a pilot recharge project in Rillito Creek to help answer some of these questions. Additionally, the CAVSARP, when fully operational, will allow the City to reduce and perhaps eliminate Central Wellfield pumping except during peak demand periods by substituting water recovered on an annual basis from CAVSARP and delivered to the City of Tucson service area for groundwater pumped from the Central Wellfield.

- There is uncertainty regarding the long-term need for additional storage capacity due to a lack of consensus regarding the City of Tucson's CAP water use. The City of Tucson is the state's largest municipal contractor for CAP water. One of the projects designed to help use the City's CAP allocation is the CAVSARP. The full-scale version of this project is planned to have an estimated capacity of 60,000 AF - enough to significantly reduce or replace pumping in the City's Central Wellfield. In the long-term, other options for CAP water utilization may significantly reduce the City's need for recharge at this facility and others, possibly adding to capacity available for other storers.

- The Green Valley/Sahuarita area is another geographic area of concern where additional storage may help achieve groundwater management objectives. Recharge in this area could help offset existing groundwater withdrawals as well as projected increases in demand. Representatives of the San Xavier District and the Tohono O'odham Nation have indicated interest in recharge on or near the reservation to raise the groundwater level, restore riparian habitat, and possibly generate credits that could be transferred off of the reservation for use elsewhere in the AMA.

- Another geographic area of concern where additional storage may substantially increase the likelihood of attaining groundwater management objectives is the Cañada del Oro basin. There are on-going investigations of the possibilities for direct recharge in this area, primarily because of projected increases in demand. At this time, the groundwater table is largely stable in this area, except in the lower reaches of the watershed. Bringing "wet water" to the region is a top priority for Metro Water District, the Town of Oro Valley, and the Town of Marana.

- The relative benefits of direct recharge at USFs compared to in-lieu recharge at GSFs must be analyzed on a site-by-site basis. There are some weaknesses of in-lieu recharge relative to direct recharge. GSFs are perceived by some local water interests as postponing rather than preventing groundwater level declines, because after the GSF contracts are completed, water users are likely to resume pumping groundwater. However, the benefits of some GSFs may outweigh those of some USFs due to lower cost or local contributions to water management goals.

- Considering the "high" scenario projections of recharge demand developed in this report, there appears to be no need to identify and study additional potential recharge sites beyond those identified in this report for the *sole purpose of increasing total available recharge capacity*. The projected storage capacity in the year 2007 resulting from construction of all recharge projects identified in this report exceeds the potential demand for recharge identified in the "high demand" scenario. However, several of the identified projects are only in the conceptual phase, and, if projects on Indian reservations do not move forward, more capacity will have to be developed off the reservations.

- Recharge projects involving well injection were not included in the list of recharge projects evaluated, primarily because the Water Consumer Protection Act (Proposition 200 of 1995) precludes the City of Tucson from using CAP water for well injection unless it is treated to the same quality as Avra Valley groundwater and is free of disinfection by-products. Although well injection was eliminated from consideration, it must be recognized that well injection may be the most effective recharge method in terms of mitigating subsidence and certainty of hydrologic effect of the project. Entities other than Tucson Water are not precluded from utilizing this option.

**Recommendations to the AWBA (IPAG 1997):**

- There are three geographic areas where additional storage may substantially increase the likelihood of attaining groundwater management objectives:

  - **Tucson's Central Wellfield**
    AWBA participation in the CAVSARP will help address groundwater management objectives in the Central Wellfield, provided that the full-scale version of the project is constructed and operated as planned to significantly reduce or replace pumping in the Central Wellfield, and provided that the City of Tucson does not fully utilize CAVSARP storage capacity.

  - **CAP terminus near Green Valley**
    AWBA participation in the FICO-Sahuarita Groundwater Savings Facility would be especially beneficial in this area of concern. Recharge in this area could help offset existing groundwater withdrawals as well as projected increases in demand. The AWBA could also participate in other direct or in-lieu projects in this area.

  - **Cañada del Oro Basin**
    AWBA participation in the project proposed for the Cañada del Oro Basin could help achieve local groundwater management objectives.

- The assumption that all agricultural users are unwilling to pay the AWBA price for GSF water should be re-examined. There may be opportunities for negotiating prices for GSF water which would be beneficial to both the AWBA and agricultural users. Options such as adding a facilities charge for in-lieu facilities similar to charges paid to direct recharge facilities may help in reaching a suitable price.

- The AWBA should work on developing facilities within the Tucson AMA which might not otherwise be built, or at least focus on facilities within the AMA which have storage capacity that is not currently spoken for, in order to avoid the possibility of competing with local interests for storage capacity.

- Ability to recover water should be a factor in selecting AWBA facilities. If the objective of storage is to firm municipal supplies, the specific needs of those providers for "wet water" during times of shortage should be considered. If other management objectives are to be pursued, different recovery criteria will apply.

**Future Directions**

At this time, it is anticipated that the Regional Recharge Plan will be updated in response to new projects, new interests of participating entities, new participants, and changes in institutional, legal and political conditions in the Tucson AMA. Implementation of the RRP and participation in the

process is entirely voluntary.

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