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ARTIFICIAL RECHARGE IN THE LAS VEGAS VALLEY:
AN OPERATIONAL HISTORY 1997

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ARTIFICIAL RECHARGE IN THE LAS VEGAS VALLEY: AN OPERATIONAL HISTORY

Abstract

Artificially recharging the Las Vegas Valley (Valley) ground-water system with treated Colorado River water is one water resource management option employed by the Las Vegas Valley Water District (District) to help meet future long-term and short-term peak water demands. The District began operation of an artificial ground-water recharge program in 1988 in order to bank water for future use and to slow declining water levels. Artificial recharge occurs in the winter months, typically from October to May, when there is excess capacity in the Southern Nevada Water System (SNWS), currently a 400 Million Gallon per Day (MGD) treatment and transmission system.

Treated Colorado River water is recharged into the principal aquifer through the District's existing distribution system, to a network of production wells or dual-use wells for both recharge and production. The water is then stored until recovered from the wells, during the high demand summer months. The water recovered is injected Colorado River water, however, this water is accounted against the District's ground-water rights. Credits in the artificial recharge account accrue until needed to cover pumpage in excess of permitted ground-water rights.

Wells used in the program were drilled and constructed in a variety of ways, and have responded differently to artificial recharge operations. The majority of the wells now used for artificial recharge and production were completed prior to 1980, using the cable-tool drilling method, perforated in place and naturally developed. Other wells were installed using the reverse-circulation drilling method with filter packs. The District commenced drilling dedicated injection wells in 1993, to address operational concerns observed in some of the production wells. Several types of installation and drilling methods have been used to optimize injection. The types of drilling methods used for the injection wells include, reverse circulation, air-foam, cable tool and dual-rotary.

In 1988, two dual-use wells were used for production and artificial recharge, injecting an annual total of 1,153 acre feet of water. Since 1988 the artificial recharge program has expanded, using up to 40 wells with eight dedicated injection wells. Total water banked for future use, as of January 1, 1997 is 114,126 acre feet of water. Static water levels in the principal aquifer have risen from 10 to 40 feet in the main area of artificial recharge. Water levels in other areas of the Valley also show increases, indicating that the rise is not isolated, but is occurring throughout the principal aquifer. The artificial recharge program is currently expanding to utilize 31 dual use and 19

injection wells, for a potential capacity of 62,000 gallons per minute of injection or 45,000 acre feet per year of recharge by the fall of 1999.

Introduction

Most of the potable water used in the Valley comes from the Southern Nevada Water System, a 400 MGD treatment and transmission facility located on the shore of Lake Mead. The remaining supply is obtained from the principal alluvial aquifer in the Valley. Prior to importation of Colorado River water through SNWS in 1971, the principal aquifer was the sole source of potable water in the Valley. As a result, the ground-water system was over drafted and water levels in the aquifer have declined up to 280 feet by 1990 in some areas of the Valley (Morgan and Dettinger, 1994). The ground-water gradient of the aquifer is from the northwest part of the valley towards the southeast. Currently, (1997) 85 percent of the water supply for the Valley is obtained from the Colorado River. Ground water contributes 15 percent of the annual supply, but wells are pumped only during the summer months, to meet peak water demands. During the months of May through September, ground water accounts for nearly 33 percent of the Valley's water supply. In order to optimize available water supplies, and to help meet future anticipated demands, the District, the largest member of the Southern Nevada Water Authority (SNWA), has incorporated artificial recharge of ground water as part of the overall water management program. Up to 50 MGD has been injected during the cooler, winter months, when demand for water declines below the capacity of SNWS.

Description of Study Area

The Las Vegas Valley Hydrographic Basin is located in Southern Nevada, about five miles west of Lake Mead and the Colorado River (Figure 1). The basin is a structurally formed, alluvial-filled depression rimmed by bedrock uplifts during Ccnozoic extension of the Basin-and-Range Physiographic Province. The alluvial sediments are made up of primary clastic rocks eroded from surrounding mountains. The principal alluvial aquifers contain clastic sediments ranging from fine-grained silts and clays in the central part of the basin, to coarse-grained sands, gravels, pebbles, and boulders (Donovan, 1996). The thickness of the alluvial sediments in most of the areas of the Valley is at least 1,000 feet. In the central and southeastern areas of the Valley, thicknesses reach 3,000 to 5,000 feet (Plume, 1989). The Valley floor elevation ranges from 3,000 feet above mean sea level (asl) in the west to 1,500 feet asl in the east. This low elevations, combined with the Valley's location in the Mojave Desert results in a mean annual precipitation to the Valley floor of four inches per year. Surrounding mountain peaks reach of maximum elevation of nearly 12,000 feet asl and receive over 20 inches of precipitation annually.

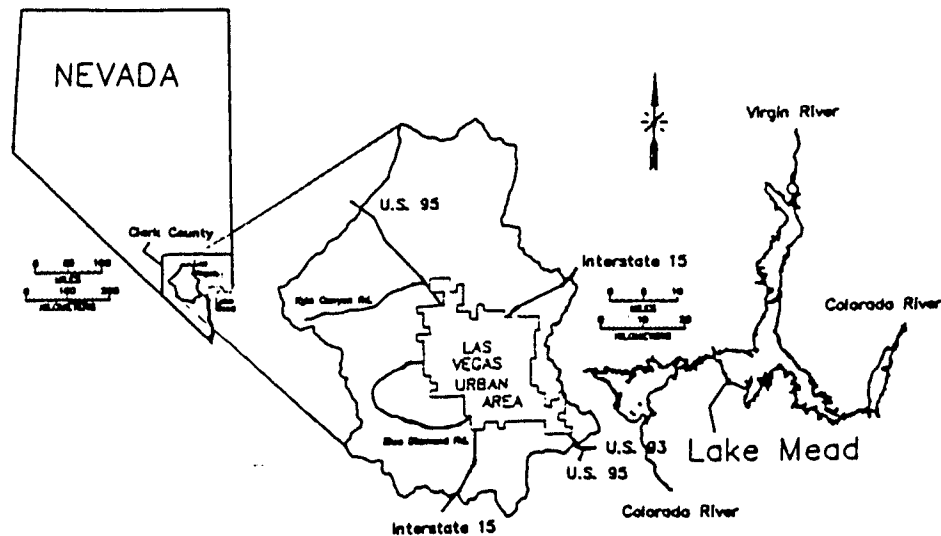


Figure 1.—Location of Las Vegas Valley Hydrographic Basin and Lake Mead.
(Modified from Danovos, 1986)

Pilot and Demonstration Project

To assess the feasibility of Artificial Recharge the District first conducted a pilot project in 1987 using existing unused production Well 21. During the pilot project 5000 gallons of treated Colorado River water were injected. The results of the pilot project are described by Katzer and Brothers (1989). After successfully testing the feasibility in the pilot program, two production wells were selected for the Demonstration project injection. Production wells 16 and 17 were selected because of the close proximity to the main field to prove recovery of the injection water for compliance with Nevada water law. The chemical compatibility and aquifer hydraulics of the demonstration project are summarized by Brothers and Katzer (1990). The demonstration project proved that artificial recharge was feasible in the Valley.

Expansion of Artificial Recharge

Figure 2 displays the relative location of the District wells and documents the expansion of the program through time. Retrofitting of existing production wells for recharge/recovery operation occurred from 1989 to 1991 in proximity to the District's main well field. The wells used for recharge were predominately drilled prior to 1980 by the cable tool method. The casing was perforated in place and the wells were naturally developed. The existing wells were retrofitted with minimal modifications. Pump impellers were prevented from rotating, check valves opened up to allow water

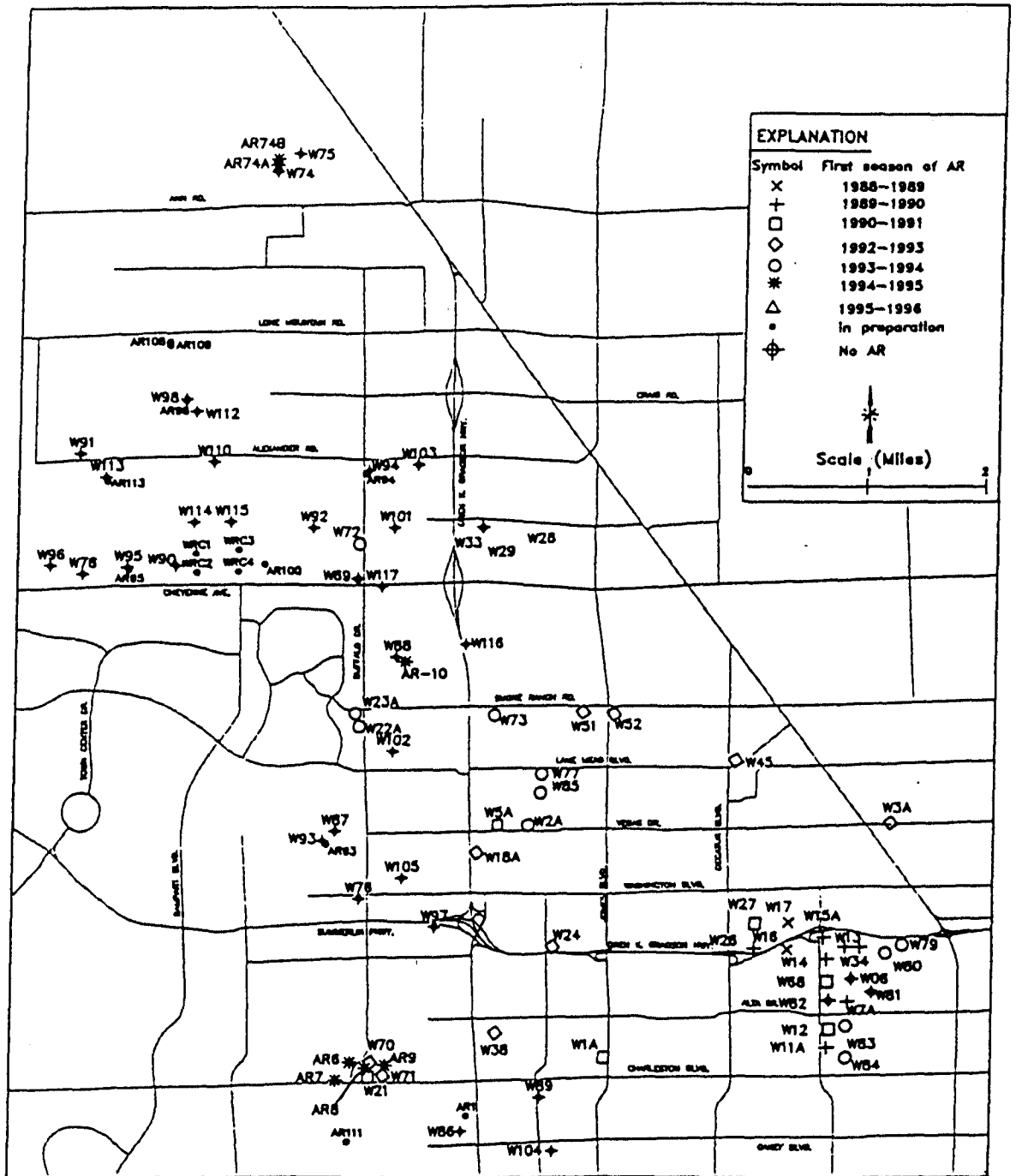


Figure 2. -- Location of District Wells Used for Artificial Recharge

down: the pump column and flow meters manually reversed to monitor injection rates. Stationary pump impellers provided sufficient friction loss to fill the pump column, preventing air entrainment. During this time period, 15 wells were used for artificial recharge.

During the 1992 to 1993 artificial recharge season, 10 more wells were added to the program. The majority (seven) of these wells were like previous wells used in the program -- constructed more than 20 years ago by cable-tool methods. Three of the wells were recently drilled by reverse circulation drilling methods and gravel packed. During the following season (1993-94), eight more of the recently, reverse circulation drilled wells were brought on-line as dual use wells.

As each well was added to the program, its performance, both as an injecting and pumping well, was closely monitored and it became apparent that the two types of wells responded quite differently to artificial recharge operations. Figure 3 displays the performance of a subset of the dual-use wells located in the main well field. Of seven total wells, three of the wells are the older cable-tool (CT) drilled type and the other four are the newer reverse-circulation (RC) wells. Figure 3 compares the recharge water level recorded in the artificial recharge wells over the 1993-94 injection with the rising static water level. In three of the older CT wells the recharge water level rise approximates that observed in the static well - indicating the recharge water level rise is a result of reservoir filling. All four of the newer RC wells, however, show recharge water level rises much steeper than the static water level rise, suggesting near well bore clogging.

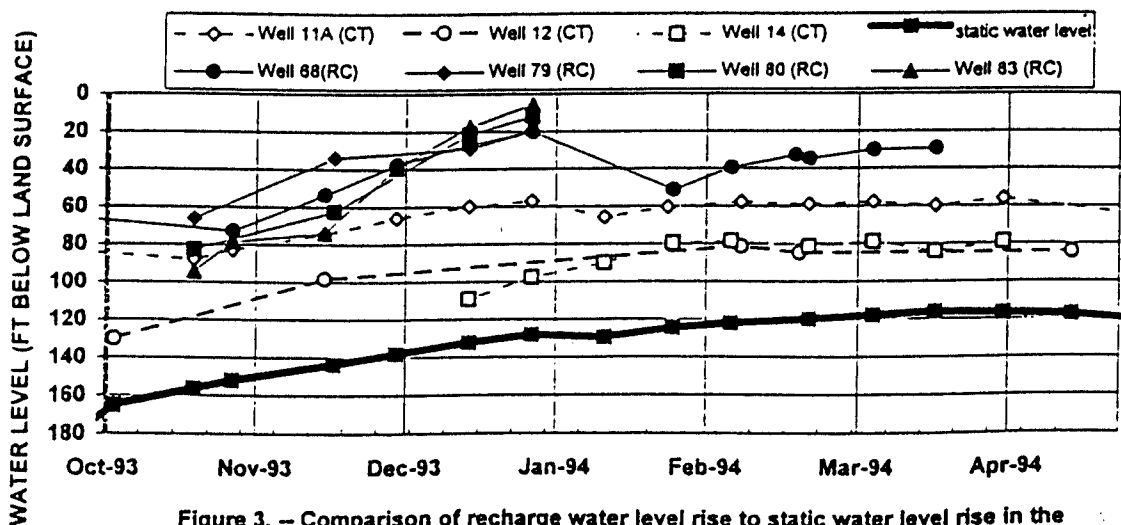


Figure 3. -- Comparison of recharge water level rise to static water level rise in the main well field during the 1993-94 season. (CT) wells are older cable-tool drilled wells; (RC) are newer reverse circulation drilled wells.

The clogging observed in the newer wells when they were operated for artificial recharge also became apparent when the newer wells were pumped during the following summer production season. Flow rate declines and production specific capacity reductions occurred in all 11 wells, and the reductions were significant (from 30 to 60 percent). Because the District was so dependant on the water supply in the summer from these wells, they were removed from the artificial recharge program and the challenge focused on how to expand the artificial recharge program without incurring significantly increased well maintenance and operational costs on the rapidly clogging wells.

Instituting a program of re-development at each well has been recommended and is common practice at other aquifer storage and recovery programs in the United States (Pyne, 1994; Bay and Bowser, 1993). However, instituting such a program would significantly increase operational costs of these newer wells and there was no guarantee that the benefits of re-development would be cost-effective. Two other options were also examined: 1) constructing gravel-packed single use injection wells with reverse circulation or air foam drilling methods (addressing the "particle rearrangement" hypothesis of clogging (Pyne, 1994)) and 2) constructing injection-only or dual-use wells with cable tool methods and natural development.

To investigate the "particle rearrangement" hypothesis, five gravel packed wells were constructed and equipped for use as injection only wells (wells AR-6, AR-7, AR-8, AR-9, and AR-10). These wells were placed into operation during the 1994-95 injection season. Specific injection capacity declines recorded in these wells was also much greater than that anticipated from rising static water level.

Use of the cable-tooled drilling method to construct injection-only and dual-use wells began late in 1996. Currently three wells are under construction using the cable-tool drilling method and natural development (AR-94, AR-95 and AR-100). Another well (AR-93) will employ the dual rotary method of well construction. These methods were selected to minimize the "damage-zone" of the aquifer that occurs during drilling, and also to eliminate the need for a gravel pack in the annulus of the well bore. It is anticipated that these types of wells will have a smaller clogging potential than the reverse-circulation drilled, gravel-packed wells numbered 68 through 85 and the dedicated artificial recharge wells AR-6 through AR-10.

System Operations

Distribution system operations at the District changed significantly due to the continued expansion of the artificial recharge program. Maximizing artificial recharge requires certain regional pumping stations and parts of the distribution system to be operating near full capacity year round. Traditionally during the winter months maintenance of both production wells and pumping facilities occurred. Maximizing artificial recharge meant that routine maintenance was rescheduled. The continual

maintenance of both production wells and pumping facilities occurred. Maximizing artificial recharge meant that routine maintenance was rescheduled. The continual pumping of distribution facilities resulted in stresses not anticipated when they were designed.

During the early years of the artificial recharge program all valving changes at the wells and related system facilities were accomplished manually. The lack of automatic control at the recharge sites meant that system demand had to drop and stay down before a field crew was sent out to preform the site modifications to bring the well online for artificial recharge. To make artificial recharge operation more efficient, valving at recharge sites were automated to minimize the turn time between injection and production. Automated bypass valve were installed to route water around the check valve. Magnetic flow meters were installed on all wells so that flow measurements were possible without having to manually reverse flow meters. With the automated system in place, artificial recharge operations can be initiated from the central computer any time there is excess capacity available from SNWS.

Results of Artificial Recharge

The volume of water injected by the artificial recharge program on a monthly basis is summarized in Figure 4. The volume of recharge increased steadily from 1989 to 1994. The maximum volume of artificial recharge occurred from October 1993 to May of 1994. During this time period, a monthly maximum of 5,200 acre feet of water was injected in January 1994. Since 1994 artificial recharge volumes have declined as a result of increased demands on the SNWS system. Total volume of water banked as of January 1, 1997 is 114,126 acre-feet. With the expansion of the SNWS system schedule for completion in June 1997, artificial recharge volumes are anticipated to exceed the 5000 acre feet of water per month. System modeling predicts that for the 1998 recharge season up to 38,000 acre feet may be available for injection.

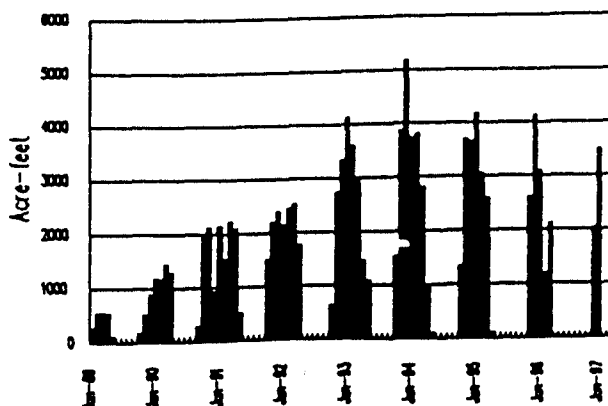


Figure 4.-- Artificial Recharge Volume by Month from January 1989 to January 1997.

Figure 5 shows the change in the potentiometric surface in the principal aquifer from October 1990 to October 1996. Evaluation of the October water levels annually are critical to observing impacts to the Valley ground-water system. Generally, District production occurs from May through September. October represents a static condition following up to five months of maximum pumping stress. Changes observed in the October potentiometric surface are conservative measurement of the positive effect the recharge program is having on the water levels in the valley. Static water levels have risen from ten to forty feet in areas surrounding the District's artificial recharge program. Water levels in other areas of the Valley also show increases, indicating that the rise is not isolated, but is occurring throughout the principal aquifer.

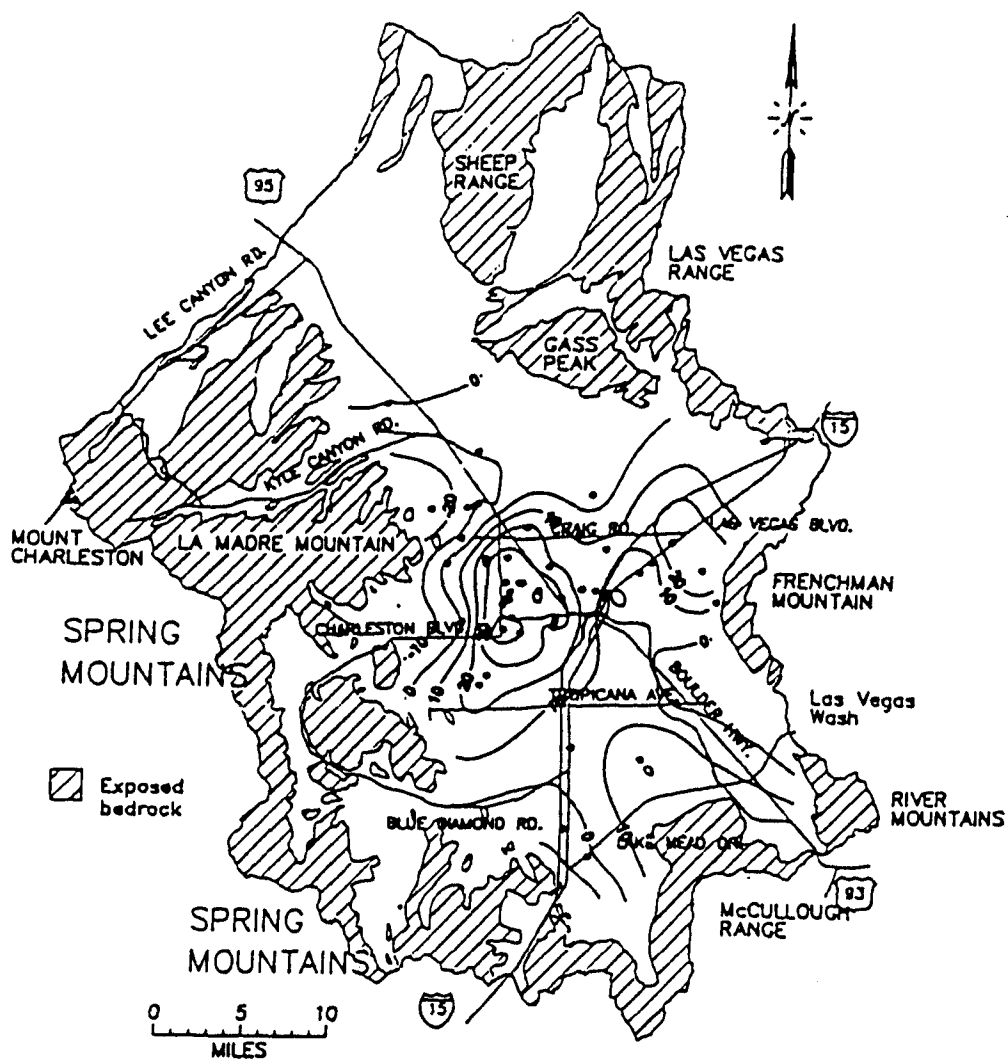


Figure 5.— Difference in Potentiometric Surface of the Principal Aquifer: October 1990 to October 1996.

Summary

Since the start of artificial recharge in the Valley with the pilot and demonstration projects, many modifications have occurred to the well operations and the distribution system. Different types of well completions have been used by the District throughout the project to optimize recharge. The primary method of injecting water has been through dual use wells drilled by the cable tool method. In 1994 single purpose injection wells were added to the program to address impacts of plugging in the gravel envelope wells. Major distribution systems changes have occurred as the project has evolved. The system has been automated to more efficiently recharge when ever sufficient capacity is available from SNWS. With the expansion of system capacities in 1997, the artificial recharge program should expand accordingly. Water levels throughout much of the principal aquifer are rising as a result of the program.

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