GROUNDWATER RECHARGE WITH SEWAGE EFFLUENT

by

Herman Bouwer, Director
U. S. Water Conservation Laboratory
U.S. Dept. of Agriculture

INTRODUCTION

The Salt River Valley is in an irrigated agricultural area with a rapidly expanding urban population. Groundwater furnishes about one-third of all the water used in the area served by the Salt River Project, which is the local irrigation district. The rest comes from the Salt and Verde Rivers which are dammed in the mountains, causing the Salt River below Granite Reef Dam east of Mesa to be normally dry. This reduces groundwater recharge and, consequently, water tables have been dropping, sometimes as much as 10 ft. per year. Ironically, groundwater pumping in the Salt River Valley began in the 1920’s to lower the water table, which had risen so much due to irrigation that low areas became water-logged. The urbanization of the valley produces an increase in the amount of sewage effluent (about 5 to 6 mgd each year). If this sewage could be reused for agriculture or other purposes, the overdraft on the groundwater could be reduced.

Large-scale reuse of sewage effluent for agriculture requires treatment beyond that normally applied in a conventional treatment plant. For the Salt River Valley, the additional treatment can be effectively obtained if the effluent from the treatment plant is used for groundwater recharge, letting it percolate from infiltration basins to the underlying groundwater, and using the vadose zone and aquifer as natural filters to “renovate” the sewage water. The infiltration basins should be located in relatively permeable soils, such as the loamy sand, sand, and gravel found in the Salt River bed, to obtain high infiltration rates. After the sewage effluent has percolated down to the groundwater, it can be pumped as renovated water from wells located some distance from the infiltration basins.

Presently, Phoenix and surrounding cities produce about 100 mgd of sewage effluent. This is a little more than 100,000 acre-feet per year and sufficient to irrigate about 30,000 acres.

Unlike conventional sewage-treatment plants for which standard designs are available, the design and management of a groundwater recharge system for renovating sewage effluent requires local experimentation before the best design can be formulated. This is because the performance of an infiltration-recharge system for sewage effluent depends very much on local conditions of climate, soil, and groundwater hydrology. For the Salt River Valley, such an experimental system, called the Flushing Meadows Project, was installed in 1967. The system consists of six parallel infiltration basins, 20 by 70 feet each. It is located in the Salt River bed at about 103rd Avenue and uses secondary effluent from the 91st Avenue Sewage Treatment Plant. The soil consists of about 3 feet of loamy sand underlain by sand and gravel layers to a depth of 240 feet where a clay layer begins. The water table is at a depth of about 10 feet. Wells, 20 to 30 feet deep, were installed between the basins and at various distances from the basins to obtain samples of the renovated sewage water and to follow the quality improvement of the effluent water as it moves down to the groundwater and laterally through the aquifer. Almost 10 years of research with this project has shown that:

1. The largest capacity or hydraulic loading is obtained with 2- to 3-week flooding periods alternated with 2-week drying periods. At this schedule, 300 to 400 feet of effluent move into the ground per year. At these high hydraulic loading rates, however, only about 30 percent of the nitrogen is removed from the sewage water as it percolates through the soil.

2. Quantity and quality of renovated water are optimized with a hydraulic loading of about 200 feet per year, which is obtained by a schedule of 9 days flooding and 12 days drying. At this hydraulic loading rate, nitrogen removal is about 60 percent. At a loading rate of 200 feet per year, about 500 acres of basins are required to infiltrate the sewage effluent from one million people.

3. Viruses cannot be detected in renovated water sampled at a depth of 20 to 30 feet below the basins. This renovated water still contains some fecal coliform bacteria, which are completely removed after an additional lateral movement of about 200 feet in the aquifer.

4. Phosphate removal increases with increasing distance of underground movement of the renovated water and exceeds 90 percent after 200 feet.

5. The renovated water is essentially free from suspended solids and biodegradable material as expressed by the biochemical oxygen demand (BOD). Some residual organic carbon persists in the renovated water at an average concentration of 4 to 5 mg/l. Possible toxicity (carcinogenity, mutagenity, teratogenity, etc.) of these refractory organics presently is the main concern in potable use of the renovated water.
STOP NO. 1. 23RD AVENUE RECHARGE PROJECT.

The groundwater recharge project to be visited on the field trip is a larger system that was installed in the Salt River bed by the City of Phoenix in 1975 to produce renovated sewage water for unrestricted irrigation by a local irrigation district. The system consists of four 10-acre infiltration basins (fig. 1) that are intermittently flooded with secondary effluent from the 23rd Avenue Sewage Treatment Plant. The material below the basins is mostly sand and gravel, which continues to a great depth, similar to the Flushing Meadows Project. The static water table is at a depth of about 70 feet. Renovated water is to be pumped from three wells on the center dike. The first well (fig. 2), installed in 1975, is 200 feet deep, perforated from 100 to 180 feet, and delivers about 2,000 gpm. The other wells should be deeper, for example, about 300 feet and perforated from 150 to 300 feet. The renovated water has been certified by the State Health Department for unrestricted irrigation and eventually will be discharged in the Roosevelt Irrigation District canal north of the project.

Spread of renovated water in the aquifer outside the basin area is undesirable for legal and health reasons. To avoid such spread, infiltration of sewage effluent and pumping of renovated water must be managed so that groundwater levels along the project perimeter are maintained at the same height as those in the aquifer outside the system. To monitor groundwater levels at the perimeter of the system, observation wells have been installed on the north and south sides of the infiltration area (fig. 3).

Originally, the infiltration basins received effluent that had passed through an 80-acre oxidation pond. This was undesirable, however, because algae growing in the pond doubled and sometimes even quadrupled the suspended solids content of the effluent. These algae then accumulated on the bottom of the infiltration basins, causing soil

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**BIBLIOGRAPHY**


clogging and producing low infiltration rates. The situation will be remedied by constructing a bypass channel in the 8-acre pond to transport secondary effluent directly into the infiltration basins.

STOP NO. 2. GRAVEL PIT
Gravel excavation northeast of the infiltration basins offers an excellent opportunity for examining the local geologic profile to a depth of about 30 feet (fig. 4). The gravel-pit walls show typical “river run” sand and gravel layers, microstratification, imbrication, and layers of manganese-oxide coated gravel indicative of past water-table positions. Analysis of the response of the water table to infiltration at the Flushing Meadows Project showed that the sand and gravel layers as a whole had a hydraulic conductivity of 282 ft. per day horizontally and 17.6 ft. per day vertically. Hence, the medium was anisotropic with a horizontal to vertical hydraulic conductivity ratio of about 16.
Figure 4. Wall of gravel pit northwest of infiltration basins showing sand and gravel layers.