eight times at 24 to 36 inches, and averaging nearly six times for the soil profile as a whole.

Not surprisingly, the dependence of soil Cl on applied water Cl shows a similar relationship to that of Na (fig. 7), though the increases in soil Cl at applied water values greater than about 5.5 meq/L across the soil subprofiles are less than those for Na. This likely reflects the greater mobility of Cl in the soil compared to Na. It is of major concern that at applied water Cl values more than 5.5 meq/L, soil Cl concentrations increased across all depths.

Soil SAR values roughly match those of the applied water SAR values up to about 4, after which soil SAR values are about 1.5 times greater than the values of the applied water, though the correlation of soil SAR and applied water SAR was less than significant (CL < 95%).

These results indicate that the effect of the quality of applied water on soil salinity is dependent on the level of salts present in the applied water. It is important to note that there may be other factors responsible for the variation in soil salinity parameter values, including growers' use of soil amendments, and the combined effects of applied water and winter rainfall leaching must be considered. A second paper in this issue contains an analysis of the data from the perspective of soil water balance and addresses these effects (Platts and Grismer 2014, page 75).

Accumulation of chloride

As competition for water supplies intensifies and associated sea water intrusion affects the use of well water in coastal California areas, the long-term effects on soil salinity from use of recycled water are important to investigate. Our primary objective was to quantify the changes in salinity in Monterey County fields under intensive production and determine whether the long-term use of recycled water there has been deleterious to the types of soils in the area.

Our analysis of study data from 2000 to 2012 supports the general conclusions of the MWRSA in the 1980s: The use of recycled water has caused an increase in soil salinity in the area; however, SAR values are not deleterious and Na has shown little accumulation in the rooting zone (1 to 12 inches).

Can irrigation with municipal wastewater conserve energy?

Water conservation and energy costs were concerns 35 years ago, just as they are today. This study looked at whether reuse of wastewater on farmland would require less energy than discharging it to the ocean. If so, would it require more or less energy than importing fresh water for irrigation? In 1977, the energy costs came out about even. Would today's energy costs and irrigation/wastewater technologies yield a different result?

1977 "Approximately 80 percent of the potential for reclamation in California is in basins where wastewater is being discharged to brackish or saline water — mainly the Pacific Ocean.

"One of the expected benefits of wastewater reuse is energy savings in those situations where reuse is an alternative to importation of fresh water. . . . . Two important questions, then, are: (1) Would reuse of wastewater on farmland require less energy than discharge to the ocean? (2) If so, would it require more or less energy than importation of fresh water for irrigation?

"Municipal wastewater discharged to the Pacific Ocean requires considerable energy for secondary treatment (biological oxidation and assimilation of organic matter) and pumping through a long ocean outfall. Since wastewater reused for irrigation of fodder, fiber, and seed crops requires only primary treatment (screening and settling processes), each acre-foot reused could save about 200 KWH in direct energy requirements — compared to ocean disposal — by eliminating the secondary treatment and ocean outfall pumping.

"Under current health regulations wastewater reused for pasture irrigation and surface irrigation of food crops requires secondary treatment. Therefore reuse instead of ocean disposal would save only the approximately 50 KWH otherwise required for outfall pumping. Wastewater reused for sprinkler irrigation of food crops requires secondary treatment plus chemical coagulation and filtration. Such reuse would require slightly more direct energy — possibly 10 KWH/AF — than ocean disposal of the wastewater.

"When only these direct energy requirements are considered, it appears that irrigation with wastewater could save very large amounts of energy compared with importing fresh water. However, elevation and quality differences tend to offset the benefits."

Roberts EB, Hagan RM. 1977. Energy: Can irrigation with municipal wastewater conserve energy? Calif Agr 31(5):45.

Robert Hagan served the UC Davis community as professor of water science from 1948 until his retirement in 1987. In addition to his expertise on agricultural water use under arid conditions, Hagan sought to increase constructive communication between growers and environmental groups on issues of water and resource use. The UC Davis Robert M. Hagan Endowed Chair in Water Management and Policy was established in his honor.

Co-author Edwin B. Roberts served as a staff research associate at UC Davis, working with Professor Hagan.

—W. J. Coats