Conceptual Modeling of Salt Management Problems in the Western San Joaquin Valley of California

(Funded 2001-2002)

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Executive Summary:
Problem Statement
California's Western San Joaquin Valley is experiencing a variety of irrigation-induced problems ranging from water scarcity, deteriorating water quality, and salinization of agricultural soils. Various management plans have been proposed to deal with these problems, including sequential reuse, in which high-quality water is used to grow a salt-sensitive crop, and the drainage from this operation is collected by tile lines and subsequently used on a more salt-tolerant crop. This drainage in turn is collected and used on a very tolerant species such as Eucalyptus, whose drainage is used on halophytes. The final residual is collected and sent to evaporation ponds. While this idea has considerable promise for reducing drainage volumes and managing salt, design of a system to apply the concept will require knowledge of the response time of the soil to a change in surface management. This project will develop a conceptual-mathematical model of water and chemical movement through the soil and to the tile drain that can be used to represent the sequential reuse system and calculate the buildup of salinity in the soil and drainage water over time.

A second aspect of drainage management receiving substantial discussion in recent years is water table height control. The Western San Joaquin Valley is underlain by a low permeability clay barrier that separates the unconfined upper aquifer from the confined lower aquifer. Use of imported drainage water since the 1950s has resulted in steadily rising water tables in the unconfined zone, which are causing waterlogging in the lower regions of the Valley and salt buildup from evaporation in a number of locations with shallow water tables. Among the management schemes proposed for water table control are land retirement in regions with poor drainage and reducing tile drainage interception in conjunction with crop extraction from the water table to promote leakage through the lower clay layer and reduce tile drainage volume. While numerical simulations of regional flow in the subsurface have shed some light on possible ways of managing this problem, some fundamental conceptual problems remain. The high water table is a consequence of the agricultural drainage water, but the water table is also a driving force for seepage through the clay layer into the confined aquifer, and the slope of the water table is a driving force for moving water laterally through the unconfined aquifer out of the Western Valley Basin. Drainage extraction by tile lines decreases the amount of seepage moving to the water table, but creates a disposal problem at the surface for the drainage water. Partial land retirement in the salt affected areas at lower elevation will reduce water requirements and subsurface flow to the water table, but any alter hydraulic gradients and attract flow from higher points in the system. Increasing and decreasing drainage below the farms will change the water table position, but it is not clear by how much, since lateral flow and leakage through the clay layer will also change. This proposal will develop a conceptual model of this flow system to understand the dynamics of the basin and the effects of changes in water use. Specific land and water management strategies will be analyzed to determine their effect on water table height, land salinization, and water flow through various components of the system.

Objectives:

1. To study the implementation of the sequential reuse salt-management strategy on tile drained fields of different characteristics using both numeric and analytic methods. Conditions studies in the calculations will include: drain spacing, soil layering, leaching fraction, and subsurface permeability below the tile line.

2. To study by numerical simulations the effect of farm location and irrigation management changes on the extent of salinization of lower-lying lands and on the water table depth.

Methods and Procedures

For the sequential reuse problem a two-dimensional water and solute transport model together with analytic modeling will be used to calculate water flow and chemical transport from the bottom of a root zone to the tile drain outlet for different field-drain-barrier geometry, soil properties, and water management procedures. The outflow of a given field will become the input to the second field and so forth, up to a maximum of four fields.

A multi-dimensional water and solute transport program will be used in the basin-scale calculations to represent water flow and chemical transport for the western San Joaquin Valley. Surface management changes such as tile-drainage interception of seepage and land retirement will be simulated to see their effect on downstream salinity and water table position. The emphasis in the conceptual modeling will be on studying the simultaneous response of all parts of the hydrologic system (seepage from the vadose zone, later groundwater flow, leakage through the clay layer, evaporation) and in identifying the relationships between the vertical and lateral flows.