

EVALUATION AND UPDATE OF DRAINAGE WATER MANAGEMENT
OPTIONS ON THE WESTSIDE SAN JOAQUIN VALLEY, CALIFORNIA

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ABSTRACT

Over one million acres of irrigated lands on the westside of the San Joaquin Valley are affected by shallow water tables, salinity, and toxic trace elements such as selenium. The San Joaquin Valley Drainage Program developed a management plan in 1990 to manage agricultural subsurface drainage and related problems. A review of the present status and information on the SJV drainage problem since adoption of the 1990 Plan is under way. Three subarea committees comprised of growers and water district staff representing the drainage problem area prepared reports on the implementation status of the 1990 Plan recommendations. Eight technical committees comprised of university scientists, government agency staff, water district staff, growers, and other stakeholders reviewed the latest information on drainage management options. The committee reports present detailed information on eight drainage management measures. The current status of knowledge on each of the eight measures is summarized in this paper.

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INTRODUCTION

California's San Joaquin Valley is one of the world's most vital and productive farming areas. The westside of the San Joaquin Valley is a fertile yet arid landscape where commercial agriculture is viable only with irrigation. A low permeability clay layer underlies most agricultural lands of the westside SJV. The clay layer does not allow for adequate percolation of leachate, causing the water table to rise toward the soil surface. Water logging of the crop root zone and evapotranspiration of soil water from the shallow water table results in the accumulation of salts and potentially toxic trace elements in the crop root zone. High concentrations of naturally occurring trace elements, such as selenium, in drainage water may pose a hazard to fish and wildlife when agricultural drainage waters are discharged to surface water bodies.

Salinization

The San Joaquin Valley Drainage Program Study Area on the westside SJV is about 2.3 million acres (Figure 1).

Using 1980-85 data to demonstrate the extent of salt accumulation in the Study Area, SJVDP estimated the annual increase in total dissolved solids in the upper aquifer to be about 6.115 million tons. The sources of this salt accumulation are shown in Table 1.

Table 1 - Estimated Salt Contributions

Source	Salt input (tons)
Native salt solubilization	2,825,000
Imported water from the Delta	1,766,000
Groundwater pumped from the confined aquifer	968,000
Local stream diversions	301,000
Lateral groundwater inflow and local stream inflow	155,000
Canal seepage and precipitation	100,000

Water Table and Water Quality

The depth of the shallow groundwater table below the ground surface in the Study Area is monitored at over 1,000 locations twice each year. The water table is shallowest in

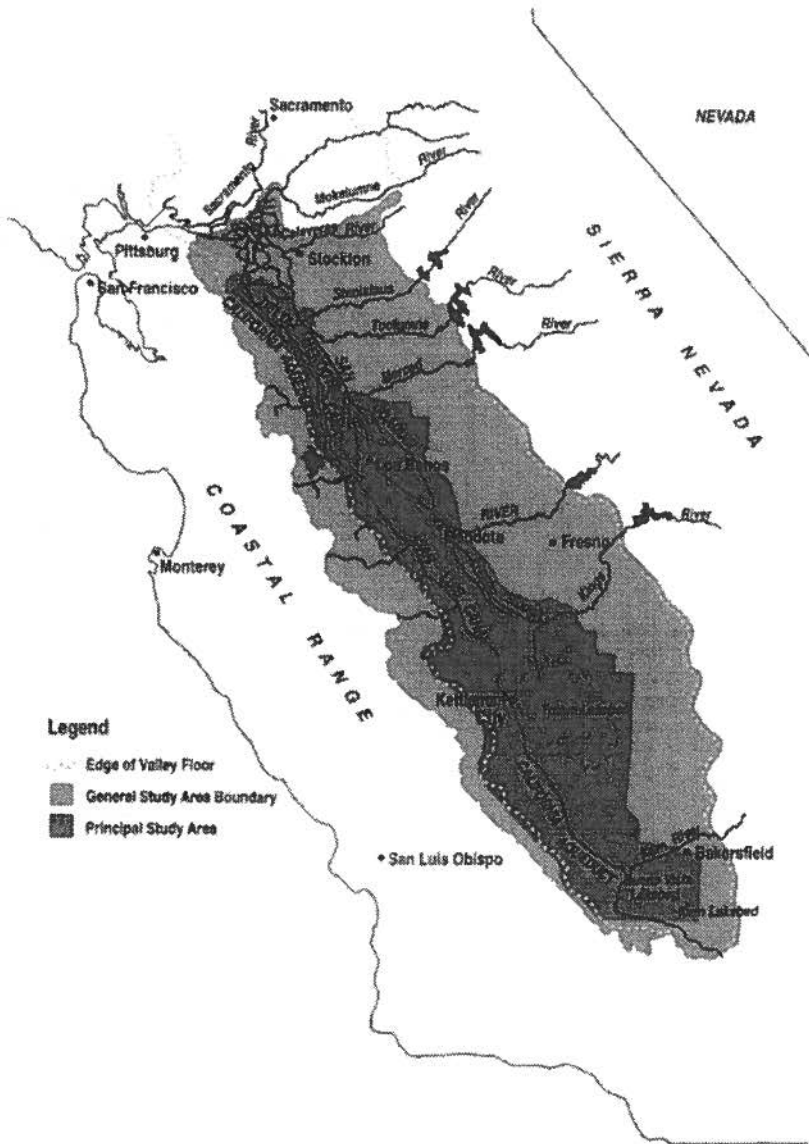


Figure 1
Program Study Area

early spring as a result of winter rainfall and preplant irrigations. In many areas, depth to the water table increases with time during the growing season due to reduced percolation (caused by decreasing infiltration rates), increased shallow groundwater use by crops, and limited natural and artificial drainage. Areas having shallow water depths from 0-5 feet during 1991-1997, varied from a minimum of 311,000 acres in 1991 to a maximum of 749,000 acres in 1997. SJVDP conducted a regional water quality evaluation of key constituent concentrations from 1984-1990 (Table 2).

Table 2. Areas with Shallow Water Table Between 0-5 Feet and Salinity, Selenium, and Boron Concentrations in Shallow Groundwater, 1984-1990 Data

Constituent concentration	Area (acres)
Salinity >2500 ppm	661,700
Boron > 2 ppm	882,200
Selenium > 5 ppb	553,800

In 1995, DWR conducted a one-time monitoring of electrical conductivity in shallow groundwater (Table 3).

Table 3. 1995 San Joaquin Valley Shallow Groundwater Area for Groundwater Electrical Conductivity Ranges

EC Range Microsiemens/cm	Area (acres)
0 to 2,000	188,800
2,000 to 4,000	337,300
4,000 to 10,000	257,200
10,000 to 20,000	50,600
greater than 20,000	31,000

Table 2 indicates that salinity is high in over 660,000 acres and boron and selenium are also present in significant concentrations in shallow groundwater. Table 3 shows the area and range over which salinity affects irrigated lands.

San Joaquin Valley Drainage Implementation Program

Four federal and four State agencies signed a Memorandum of Understanding in December 1991. The agencies agreed to use SJVDP's 1990 Plan as the guide

to manage the Valley's subsurface drainage problems. They agreed to work together to identify specific tasks and associated responsible parties, seek needed funding and authority, and set schedules to implement all components of the 1990 Plan. Those signing the MOU recognized that the success of the program depended on local districts and irrigators to carry out effective drainage management measures. Key components of the SJVDP 1990 Plan are: source reduction, drainage reuse, land retirement, evaporation ponds, groundwater management, river discharge, water for fish and wildlife protection, and institutional changes. Recommendations were made for the various subareas.

SJVDP Drainage Management Update Process and Results

In 1997, the SJVDIP in cooperation with the University of California and water and drainage districts in the Valley began to evaluate and update the 1990 Plan. This process is intended to remove the constraints to implementation of the 1990 Plan and foster cooperation among stakeholders in resolving long-term drainage problems for the benefit of both agriculture and the environment in the Valley.

This activity is being carried out in three phases by the SJVDIP. The first phase in updating the 1990 Plan consisted of two concurrent tasks. One task was formation of three subarea committees consisting of growers and district staff. The subarea committees' task was preparation of status reports that assessed the progress toward adopting the recommendations of the 1990 Plan. The three subareas were Grasslands, Westlands, and Tulare-Kern. The second task was a technical and economic evaluation of the management options proposed in the 1990 Plan, with the addition of salt and selenium utilization. In total, eight technical committees consisting of university scientists, government agency staff, and stakeholder representatives reviewed and evaluated information on eight separate drainage management measures. These two tasks were completed in early 1999 (SJVDIP, 1999a-1999k).

The second phase is a synthesis of the information gathered in the first phase into a report that identifies interactions and trade-offs between drainage management options. The report also makes recommendations based on technical and economic considerations. This task was accomplished by an Ad Hoc Coordination Committee and was completed in January 2000.

The third phase will use the recommendations from the second phase along with input from stakeholders to formulate acceptable processes and means for further implementation of drainage management measures.

CURRENT STATUS OF KNOWLEDGE ON DRAINAGE MANAGEMENT MEASURES

Drainage Reuse

Demonstration projects to reuse drainage water on salt tolerant crops and halophytes and discharge brine to a solar evaporator at a rate equal to daily evaporation have been established. Substantial progress has been made in the development of these sequential reuse systems with an endpoint of salt separation in solar evaporators. Additional research is needed on selection and marketability of halophytic crops, and management of selenium and boron within the reuse system. Long-term sustainability has not been established.

Drainage Treatment

Opportunities exist to apply reverse osmosis membrane technology for the recovery of drinking-quality water and concentration of brine and selenium. Desalinization of drainage is now being considered for implementation. Biological treatments currently under development also hold promise.

Land Retirement

A 15,000-acre land retirement pilot project is being initiated by the USBR, and a corollary program is being initiated by the Westlands Water District. The 1990 Plan purpose for land retirement, environmental isolation of selenium, has been expanded to include habitat restoration for recovery of special-status species, and water transfers. Management techniques are needed to prevent soils from becoming salinized and seleniferous. Use of limited irrigation and rotational fallowing are alternatives to complete cessation of irrigation and permanent retirement. These alternatives could achieve the objectives of increased water conservation and reduced drainage volume while minimizing soil salinization.

Evaporation Ponds

Evaporation ponds play a major role as a terminal point for disposal of drainage water in closed basins. However, the impacts of selenium on water birds using the ponds have to be mitigated. Substantial reductions in bird use of ponds and bird impacts have been observed after pond configurations were modified and mitigation habitats were provided. For example, for 740 acres of evaporation ponds where average selenium concentration in drainage water was about 7 ppb, 145 acres of compensation habitat and 640 acres of demonstration habitat were established to mitigate adverse impacts. Continued research is needed to provide additional data regarding the effectiveness of mitigation measures.

Source Reduction

Improved irrigation systems and management plays a major role in the reduction of drainage water volume. Subsurface drainage can be reduced by shortening furrow lengths, installing drip and linear-move irrigation systems, modifying irrigation schedules and managing groundwater levels to encourage crop use of shallow groundwater, and generally improving management of irrigation systems.

Groundwater Management

Although groundwater continues to be pumped in portions of the Study Area, especially in years of limited surface supply, a systematic pumping plan to lower shallow groundwater tables, as recommended in the 1990 Plan, has not been implemented over concerns of poor water quality. The technical committee has determined that it is possible to reduce the volume of drainage water by managing groundwater tables. The drawback in lowering shallow groundwater tables by pumping from deeper aquifers is gradual degradation of the aquifers.

River Discharge

Discharge of drainage water containing conservative constituents to the San Joaquin River can be timed to coincide with periods of high flows and high assimilative capacities in the River. This requires a real-time management system for drainage discharge, and thus cooperation and coordination among water users,

dischargers, and reservoir operators. Currently, discharge of drainage water containing selenium is subject to regulation of water column concentration of selenium as well as selenium load limits. Research should continue on the determination of site-specific ecotoxicity criteria for selenium, based on a better understanding of exposure pathways for at-risk biota. Such site-specific ecotoxicity criteria may allow for real-time management of selenium discharge.

Salt and Selenium Utilization

Industrial and commercial markets for salt and selenium, as well as human and animal health and nutrition uses for selenium, already exist. A research and development program is recommended for the separation, harvesting, purifying, manufacturing, and marketing of salt and selenium products made from San Joaquin Valley drainage salts.

IMPLEMENTATION ANALYSIS

The selection of a combination of drainage management options depends on the feasibility and applicability for specific conditions in the Valley. In this analysis we consider two regions, one with access for discharge to the River (Region A), and one without discharge to the River (Region B). In selecting a mix of options to meet regulatory requirements (for example, load limits), the cost of each option must be evaluated. The combination of options that meet the requirements at a minimum cost should be selected. Assuming that discharge to the River is subject to water quality objectives (SJVDIP, 1999g), and discharge to evaporation ponds is subject to Waste Discharge Requirements (SJVDIP, 1999d and 1999h), we offer the following strategy for in-valley drainage management.

Regions A and B

Initial Drainage Reduction: Source control, on-farm and district-wide drainage reuse, and active land management should be taken as the first step in managing drainage water in both regions. However, these actions alone may not be sufficient to eliminate the volume of drainage requiring management. Therefore the following further actions may be needed.

Region A

Discharge to the River: After initial drainage reduction measures have been taken, the remaining drainage water can be discharged to the River provided it meets river discharge requirements.

Discharge to Ponds: If discharge to the River exceeds the load limits or water quality objectives, then discharge to evaporation ponds (standard, modified, or accelerated rate) could be selected. When selenium in drainage is less than 2 ppb, standard evaporation ponds are sufficient. When selenium concentrations are high, modified ponds, and pond site-specific management measures, are necessary to reduce impacts to water birds. Compensation habitat is also necessary for unavoidable impacts. These additional management measures add to the costs of drainage management.

In an experimental study, drainage is used on halophytes and brine is discharged to solar evaporators at a rate less than daily evaporation. When managed properly, these evaporators have shown promise. Selection of solar evaporators versus evaporation ponds depends on site-specific conditions. For example, solar evaporators require installation of tile drains in halophytes, and dedication of agricultural land to halophytes as well as the evaporators. Since water can not be ponded in a solar evaporator, for a given amount of drainage water, more land is required compared to an evaporation pond. Evaporation ponds and mitigation habitat can be created on poor soils. Thus the economics of pond modifications, management, and compensation habitats vs. costs of solar evaporators have to be analyzed before selecting a drainage discharge system.

Secondary Drainage Reduction Measures: If evaporation ponds are not a viable option, drainage treatment, groundwater management, and land retirement should be considered in a mix of options with minimum costs.

Region B

In Region B, River discharge is not an option. After initial drainage reduction measures are implemented, remaining drainage can be discharged to evaporation ponds. If evaporation pond requirements reduce the feasibility of this option, secondary drainage

reduction measures can be implemented.

CONCLUSIONS

Shallow groundwater, salinity, and selenium are three major drainage problems in the Valley impacting agriculture and the environment. Drainage management measures including source reduction, drainage reuse, evaporation ponds, and limited discharge to the River, as recommended in the 1990 Plan, appear to be effective in managing the drainage problem. Drainage treatment may still be limited by cost. Groundwater management may contribute to some water quality degradation, and may have limited potential. Salt separation and utilization is currently under development. Further research, monitoring, and field experiments are needed to develop an optimal mix of efficient, cost effective, and environmentally protective drainage management measures.

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