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GIS Utilization for Analysis of District Drainage Water Recycling

Charles M. Burt[1] and Robert E. Walker[2]

Abstract

An ARC-INFO GIS system was used to identify physical drainage facilities in a 32,000 ha area of the San Joaquin Valley of California. Once the drainage facilities and linkages were established, it was possible to characterize the strategies used by various irrigation districts to control drainage outflows to the San Joaquin River. The motivation behind the study was the reduction of salt and selenium flows, via agricultural drainage, into the River.

Introduction

In 1992 the Irrigation Training and Research Center (ITRC) was requested by the Central Valley Regional Water Quality Control Board to expand on a previous study (Burt et al, 1991) of the district-level efficiencies in several irrigation districts in the west-central San Joaquin Valley. As shown in Figure 1, the 1992 study included Panoche WD, Pacheco WD, Firebaugh Canal WD, Broadview WD, and parts of the Charleston Drainage District and Central California Irrigation District. The total irrigated acreage of the 6-district study area is approximately 32,000 ha. This area, located between Los Banos and Firebaugh, has been identified as a major source of salinity and selenium discharges into the San Joaquin River.

Background

The study area is often referred to as the "Grassland Drainage Area" of the Westside of the San Joaquin Valley. It is the subject of considerable interest because much of the irrigated lands have sedimentary deposits which have high selenium contents. Deep percolation from irrigation and sparse rainfall picks up the selenium; the selenium then appears with the subsurface drainage water in

[1]Professor and Director, and [2]Professor, Irrigation Training and Research Center (ITRC), Dept. of Agricultural Engineering, Cal Poly State University, San Luis Obispo, CA 93407 (805) 756-2434.

farmer-and district-owned drain facilities. The San Joaquin River is the only natural outlet for drainage water in the region.

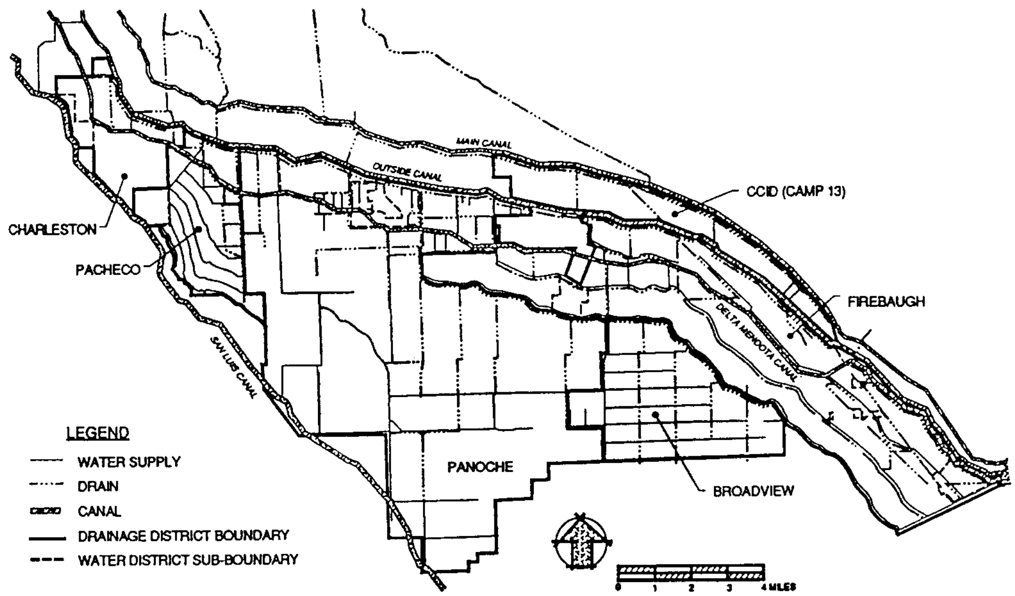

Figure 1. Study area.

The 1992 project (Burt et al, 1992) had the following objectives:

1. Develop district-level irrigation efficiency estimates for the period of 1985 - 1991.
2. Identify current on-farm and district-level drainage operation strategies and facilities.
3. Address various on-farm drainage water concerns, including sub-irrigation with drain plugs, and develop an estimate of the minimum required deep percolation component associated with good irrigation practices.

This paper addresses item (2) and the use of a Geographic Information System (GIS) to complete the work.

The high selenium content of subsurface drainage water, when released into the San Joaquin River, presents a potential threat to fish and wildlife in the River and in the Sacramento Delta. To decrease the impact of agricultural drainage discharges on downstream beneficial uses, the Regional Board adopted water quality objectives for selenium, boron, and molybdenum for the San Joaquin River. As part of this effort, the Regional Board worked with irrigation and drainage districts (rather than with individual farmers) to promote district and on-farm practices which reduce the discharge of salts in agricultural drainage from district boundaries.

Any effort to improve conditions requires a baseline of present and historical performance. In this case, it was deemed important to know the historical trends of district-level irrigation efficiencies. In addition, the district policies regarding releases into the San Joaquin River and their physical abilities to adopt various policies were of interest.

Complicating Factors

The study area encompasses six autonomous, older irrigation districts. An analysis of either the irrigation water supply or drainage management is complicated for a variety of reasons, including:

- Irrigation water is received by each district at a variety of points.
- Both formal and informal inter-district transfers have occurred in some instances.
- In some areas, farmers utilize water from drainage channels which convey drainage water from districts outside the study area boundaries.
- Drainage district boundaries are not always the same as irrigation district boundaries.
- There is no state or federal depository of maps showing correct district facilities and boundaries.
- Maps provided by one irrigation district may show a boundary overlap when compared with a map provided by an adjacent irrigation district.
- On-farm irrigation water wells are not required to be registered or recorded by the districts or the state.
- The recent drought in California caused considerable temporary (and sometimes permanent) modifications in physical facilities and water (irrigation and drainage) routing.
- There is no single outlet to a basin drain for most districts.
- Regional drains cross district boundaries.
- There is inflow, both surface and subsurface, from upslope areas.

The complexity of the hydraulic system was compounded by the recent and often undocumented changes in both on-farm and district-level hardware and operations related to irrigation and drainage. Additionally, an outsider trying to study the area must communicate with local employees and managers who have considerable knowledge regarding explanations and history of the water situation. Historically, these individuals have been charged with delivering water to farmers to meet farmer needs, but have not needed to verbalize a description of the details regarding irrigation and drainage operations. Furthermore, many of the decisions regarding drainage operations are new and confusing to these employees, and there may be differences between new official district policies and actual field practices.

In short, an engineering analysis must begin with a clear understanding from where irrigation and drainage water can originate and be delivered. A GIS system, which combines mapping of physical features with a data base associated with each point or line on the map, allows an analyst to organize data and discover discrepancies in information. Furthermore, with accurate maps showing the complete study area, an outside engineer and the local irrigation district staff personnel are able to discuss the operations intelligently and completely.

Compiling the GIS Database

Work in the study area prior to 1992 had shown the ITRC staff the complexity of the water situation. Therefore, the use of a GIS system to consolidate data was defined as being of major importance in the 1992 effort. Initially it was anticipated that the GIS component would be essential yet relatively simple to complete.

The ITRC was aware that the San Joaquin Drainage Program, funded by the US Bureau of Reclamation (USBR), placed key water facilities on an ARC-INFO GIS data base. The intent was to utilize that data base and make minor modifications based upon irrigation district maps, discussions with district employees, and some visual field verification. Once the physical points were identified, the GIS would allow addition of other database information such as pump capacities, canal dimensions, and other characteristics.

Using the GIS support capabilities of the Landscape Architecture Dept. at Cal Poly, the ITRC obtained the USBR GIS database. After some initial field checking, it was discovered that the GIS database used to study valley-wide problems did not have sufficient detail and accuracy for the smaller, regional study. The simple GIS component of the project suddenly became a major effort.

Ultimately, the development of the GIS database was done using 1:24000 scale maps (USGS quad sheet scale). The following information was placed on the basic quad data sheet, which included section boundaries, roads, and major canals:

- Irrigation district boundaries

- Drainage district boundaries
- On-farm tile drain lines
- On-farm irrigation wells
- On-farm and district-level surface drains
- Tile drain sumps
- District-operated irrigation pumps
- District-operated drainage pumps
- District-level irrigation supply canals and pipes
- District-level drainage holding ponds

All points (e.g., sumps and pumps) were tied into lines (e.g., drain ditches). The ARC-INFO GIS system assigns directions of flow to each line, as selected by the user.

In order to obtain this information, the ITRC relied upon a wide range of data sources. Almost all of the data was only available on paper maps; very few of the districts or government agencies had used some form of auto-cad to create maps. When auto-cad information was available, the scale was often skewed or the information was offset, requiring considerable effort to fit it into the common database.

After the development of an initial set of maps, the data went through four revision stages. During each stage, irrigation district employees and managers assisted the ITRC in adding, deleting, and modifying the maps. In all cases, the district personnel were very cooperative in organizing the information, even though this fell outside their normal scope of work requirements. At the end of the project, the ITRC made available the database for use by the districts and their engineers on future projects.

Use of the GIS Information

It was not until the GIS maps and databases were completed that the ITRC had a clear idea of the irrigation and drainage situation in the study area. The authors believe that without the GIS capability, the situation may have never been properly understood. The paths of water flow, water transfers, and changing facilities were so complicated that a multitude of studies spanning over six years had not yet organized the information.

The GIS allowed the ITRC to consolidate information and to clearly understand possible destinations of drainage water. In addition, it provided a means of organizing the tremendous amount of information regarding drainage water qualities and quantities which have been obtained by various agencies. The various pieces of the irrigation/drainage puzzle which had been analyzed by other prior studies could now be properly placed into the big picture.

The GIS capabilities of modeling interactions with flow rates and qualities were not utilized. This was partly due to the shortage of time, but was primarily due to the fact that the mandate for this project did not require such an analysis. The GIS did allow the ITRC to understand and analyze the various Drainage Operation Plans which the individual districts have adopted in concept.

Drainage Policies and Recycling of Various Districts

The study analyzed the extent of on-farm and district-level recycling of subsurface (tile) and surface (tail) water. It also examined how the districts managed their releases of drainage water from district boundaries in regards to San Joaquin River conditions.

The challenge of meeting strict San Joaquin River quality and quantity standards is necessary but is also rather brutal and sudden for most of these districts. Their operations were formerly oriented towards water supply and finding means of removing salt from farm land. Now they are faced with limitations of drainage water releases since standards are constantly changing in the political and environmental awareness environments. Compounding these factors are the effects of six years of drought, facilities which were not designed for recycling, and the difficulties of suddenly shifting the focus of board members, farmers, and employees towards meeting uncertain water standards.

The districts each have a unique situation and each have informally or formally adopted various drainage and recycling policies. Table 1 provides a summary.

Table 1. Summary of Drainage Policies and Recycling of Various Districts.

	Extent of Drainage Water Recycling Estimated. Percentage based on the total drain water.[1]			
	On-farm level recycling, % of total	District-level recycling, % of total		

District	Accept Tail/Tile	Separation of tile/tail	Tail	Tile	Tail	Tile	Holding External/ Internal	Assimilation Water[6]
Broad. WD[2]	accepts both	no separation	1	0	50	50	no holding policy or facility	no policy, now using River. Can add 10-25 CFS drain flows
CCID[5] CAMP 13	accepts both	no separation	8	0	10	10	no holding policy or facility	no policy, now using River
Charles. Drain D[3]	accepts both	sep. on upslope side of DMS, blend on downslope	0	0	0	0	no holding policy or facility	use River to maximum, not a supply District
Fire. CWD	accepts both	no separation	13	13	50	50	no holding policy or facility	no policy, now using River
Pan. DD[4]	policy is to accept tile only	no separation	90	5	1	4	100 acre holding pond	use River to maximum, not a supply District
Pach. WD	accepts both	attempts to keep separate	94	0	3	55	no holding policy or facility	use River to maximum, has used District Capacity in past

Notes:

1. On-farm estimates are based upon the acreage served with on-farm recycling systems, because on-farm return systems are rarely metered. Numbers will vary from year to year. Data generally reflects 1991 conditions.
2. Broadview WD provides drainage for the Firebaugh Drainage Association consisting of BWD and approximately 2230 acres (1991) laying outside of BWD.
3. Charleston Drainage District consists of lands laying in Central Calif. Irrig. District and San Luis Water District. (4275 acres supplied by SLWD; 500 acres supplied by CCID water).
4. Panoche Drainage District consist of Panoche, Oro Loma, Eagle Field, and Mercy Springs Water Districts.
5. Only one (1) of ten (10) active tile pumps recycles into outside Canal.
6. "Assimilation Water" refers to the origin of water which will or may be used by a District to blend or dilute the drainage water leaving the district boundaries so that the San Joaquin River water quality standards can be met .

The ITRC has made an initial recommendation regarding the decisions that a district must make regarding various forms of drainage water acceptance and disposal. Figure 2 illustrates that decision tree. An understanding of the decision tree structure enables districts to formulate a rational policy towards drainage water management. As more is information is acquired about the salt balances in these districts, the decision tree recommendations will undoubtedly be modified.

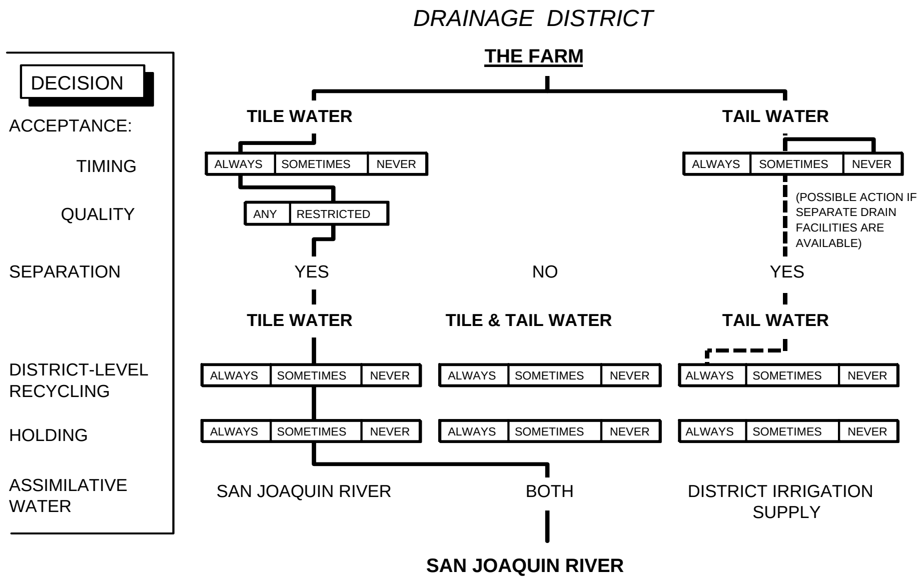

Figure 2. Recommended Drainage District Decision Tree.

Summary

This study pointed out the importance of obtaining and consolidating information in order to identify drainage problems and to make recommendations for drainage water management. It also brought into focus the tremendous duplication of efforts by various agencies and the districts themselves in obtaining and organizing information. Eventually the complexity of irrigation and drainage management, plus requirements by various environmental protection agencies, will probably result in the adoption of a common GIS database by all parties in California.

Once the information was obtained and organized, the ITRC was able to summarize the drainage and recycling policies of the various districts. Additionally, a decision tree was designed and recommended for the management of on-farm and district-level drainage waters and their disposal into the San Joaquin River.

References

Burt, C.M., P. Canessa, and J. Parrish. 1991. Irrigation Efficiencies in Parts of the Selenium Drainage Area on the Westside of the San Joaquin Valley. Contract #45902062 with the Central Valley Regional Water Quality Control Board. Irrigation Training and Research Center. California Polytechnic State Univ. San Luis Obispo, CA.

Burt, C.M., R.E. Walker, P. Canessa, and K. Robison. 1992. Irrigation and Drainage in the Grassland Area of the Westside of the San Joaquin Valley. Contract #10781501 with the Central Valley Regional Water Quality Control Board. Irrigation Training and Research Center. California Polytechnic State Univ. San Luis Obispo, CA.