Surface irrigation return flows vary

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Much attention is being focused on irrigation return flows as a result of recent legislation on water quality and pollution control and the concern for water and energy conservation. Statewide, surface irrigation return flows are nearly nonexistent where water normally is scarce or expensive. This report describes the variations in flow and quality characteristics of surface drainage waters from two irrigation districts in California's Central Valley, and the factors that contribute to such variations.

Irrigation return flows and quality characteristics

The major components of surface return flows include surface runoff (irrigation tail water, rainfall runoff, and operational spills from distribution systems) and collected subsurface drainage (effluents from tile drainage and drainage wells, and subsurface waters intercepted by natural and man-made open channels).

With some exceptions, the various components of surface return flows are collected in the same drain regardless of their origin (surface or subsurface, point source or nonpoint source). A part of these drain waters is reused, either by plan or incidentally, at the site of production or downstream. The remainder is discharged with no readily apparent beneficial uses.

Table 1 shows expected differences in quality characteristics for collected irrigation return flows. These are described relative to the supply water, because actual concentrations in both supply and discharge waters are highly variable from place to place.

District supply water vs. drain water

Figure 1 is a schematic diagram of supply and drain waters for the Glenn-Colusa Irrigation District (GCID) in the west side of the Sacramento Valley; figure 2 is for the Panoche Drainage District (PDD) in the west side of the San Joaquin Valley. The dominant crop in GCID is rice, which is usually contour flooded throughout the growing season; the major crops in PDD are tomato, cotton, and other row and field crops, which are normally furrow irrigated.

GCID captures and reuses about 44 percent of its drain waters within the district and discharges the rest into the Colusa Basin Drain (CBD), where it is reused downstream before final discharge back into the Sacramento River. PDD and the neighboring Central California Irrigation District capture and reuse about 20 percent of PDD's surface drainage (not counting reuse at farm levels) and discharge the remainder into the Grasslands Water District, where it is reused in irrigated pastures and waterfowl habitats. A small part eventually enters the middle reaches of the San Joaquin River.

Table 2 presents the flow-weighted average quality of supply and drain waters from CGID and PDD. The implications of these data are of considerable importance. In CGID, the 2-fold increase in concentration of total dissolved solids (TDS) relative to supply water can be attributed to the usual 2- to 4-fold increase by evapotranspiration by crop plants. In PDD, however, the increase is 9.6-fold and must be attributed to the pickup of salts from the chemical weathering (dissolution) of native soil salts and minerals (primarily gypsum). This is confirmed by soil and tile drain water analyses.

The increase in concentration of suspended solids (SS) in drain water relative to supply water is 1.5-fold in GCID, and again much larger (3.9-fold) in PDD. This may be attributed to two major factors: (1) the flooded rice fields of GCID tend to act as settling basins for suspended matter, and (2) because of their physical and chemical properties, surface soils in the PDD are more susceptible to erosion under surface irrigation methods.

However, on a mass basis, only slightly more sediments were discharged by PDD than were brought in by the supply water (15,487 vs. 13,135 tons). The impact of pollutants on possibilities of water use often is appraised in terms of concentrations only; mass emission of pollutants also should be considered.

Rice fields vs. tile-drained farm

Table 3 summarizes data obtained from four commercial rice fields in GCID. The supply (inflow) and the surface runoff (outflow) waters were continuously monitored over the whole growing season, and various quality parameters were measured at weekly to twice-monthly intervals. The average amount of water applied was 7.64 acre-feet per acre (ac-ft/ac), of which 1.91 ac-ft/ac were discharged as spill water. (An estimated 3.37 ac-ft/ac were used in evapotranspiration, and 2.36 ac-ft/ac were lost by seepage.)

Although the concentration of TDS in the spill water increased 1.7-fold, the unit mass emission rate (lb/ac) was only 44 percent of that brought in by the supply water, which is in line with the district-wide 61 percent mass emission of salts. Note that concentration of suspended solids was reduced by about one-half, and the mass by nearly one-tenth.

As for nutrients, the nitrogen concentration in the drain water was about 1½ times greater, but only 38 percent of the nitrogen brought in by the water was discharged. It should be noted that about 90 percent of the total nitrogen was in the form of organic nitrogen, which implies only small losses of chemical nitrogen fertilizers in runoff waters.

Table 4 contains water quantity and quality data for a tile-drained farm cropped to cotton, tomato, and wheat in the PDD. The grower blended drain waters captured from the Panoche Drain with fresh water obtained from the Delta-Mendota Canal (DMC). Quality parameters are given for the waters and for the tile effluents collected in two tile sumps. The extremely high salinity level, high boron content, and low sediment concentration of the tile effluents are due more to the dissolved salts, gypsum, and boron native to the soil than they are to the supply water.

A computer model predicted the total dissolved salts of tile effluents in PDD would be 7,150 mg/liter, which agrees with the 6,700 to 8,900 mg/liter (flow-weighted average of 7,380 mg/liter) reported in table 4. The model predicted the concentration of total dissolved solids in the surface irrigation return flow would be 1,820 mg/liter (and that it would have been only 460 mg/liter if gypsum were not present in the PDD soils). The measured concentration was 2,050 mg/liter (table 2).

In summary, the ranges of variations in the quality and quantity of surface irrigation return flows are highly site-specific, and are affected by the parameters presented here and by many other factors. Quantity is influenced by: availability and cost of supply water; irrigation application methods and efficiencies; extent of reuse at the on-farm, district, and basin levels; special cultural practices; and constraints on reuse due to the presence of excess boron, sodium, and chloride. Quality is influenced by: the supply water; presence of salts, boron, and nitrogen native to the soils; leaching fraction and salt pickup/salt deposition phenomenon; use of agricultural chemicals and wastes, such as animal manures; erodibility of surface soils and open drain channel banks; and discharges into irrigation drains by other sectors of society.

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TABLE 1. Collected Surface Irrigation Return Flow Components and Their Expected Quality Characteristics as Related to Applied Waters

Quality parameters	Operational spills	Irrig. tail water	Subsurface drainage
General quality	0	+	+ +
Salinity	0	0, +	+ +
Nitrogen	0	0, +, + +	+ +, +
Oxygen-demanding organics	0	+, 0	0, −, − −
Sediments	0, +, −	+ +	− −
Pesticide residues	0	+ +	0, −, +
Phosphorus	0	+ +	0, −, +

0 = not expected to be much different than supply water.
+, − = some slight increase/pickup or decrease/deposition may occur.
+ + = usually expected to be significantly higher due to concentrating effects, application of agricultural chemicals, erosional losses, pickup of natural geochemical sources, etc.
− − = usually expected to be significantly lower due to filtration, fixation, microbial degradation, etc.

TABLE 2. Quality of Supply and Surface Drain Waters in Glenn-Colusa Irrigation District (GCID) and Panoche Drainage District (PDD) for the 1975 Irrigation Season

Quality Parameter	Supply water GCID	Supply water PDD	Drain water GCID	Drain water PDD
Electrical conductivity (EC), micromhos/cm	180	363	391	3,070
Total dissolved solids (TDS), mg/liter	116	215	244	2,053
Turbidity, Jackson Turbidity Units (JTU)	15	34	22	126
Suspended solids (SS), mg/liter	24	90	36	348

TABLE 3. Summary of Selected Quality Parameters from Four Rice Fields in Glenn-Colusa Irrigation District During the 1975 Irrigation Season

Quantity and quality	Inflow	Outflow	Percent emission
Water, ac-ft/ac	7.64	1.91	25
TDS, mg/liter	106	184	--
TDS, lb/ac	2,204	962	44
SS, mg/liter	68	36	--
SS, lb/ac	1,414	187	13
Total nitrogen, mg N/liter	1.16	1.74	--
Total nitrogen, lb/ac	24	9.0	38

TABLE 4. Quality of Blended Supply Water and Tile Effluents from a 1,675-acre Tile-drained Farm in the Panoche Drainage District During the 1975 Irrigation Season

Quantity and quality	DMC water	Captured drain water	Mixed supply water	Tile effluents
Quantity, ac-ft	2,344	1,837	4,181	72; 163
EC, micromhos/cm	268	1,963	1,386	11,588; 8,540
TDS, mg/liter	206	1,266	880	8,897; 6,713
Turbidity, JTU	24	59	38	5; 1
SS, mg/liter	54	139	58	24; 7
Boron, mg/liter	0.2	2.4	1.3	23; 9

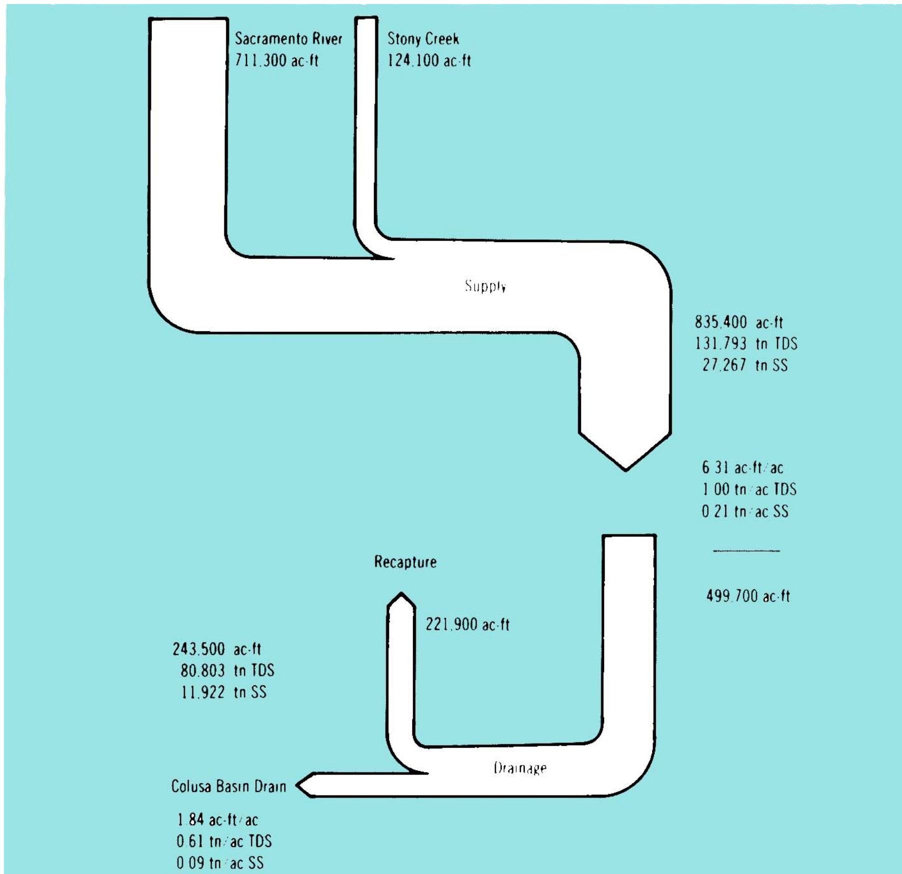

Fig. 1. Irrigation and surface drainage in Glenn-Colusa Irrigation District during the 1975 irrigation (April-October) season. Water is reported in terms of acre-feet (ac-ft) and acre-feet per acre (ac-ft/ac); total dissolved solids (TDS) and suspended solids (SS) in tons (tn) and tons per acre (tn/ac).

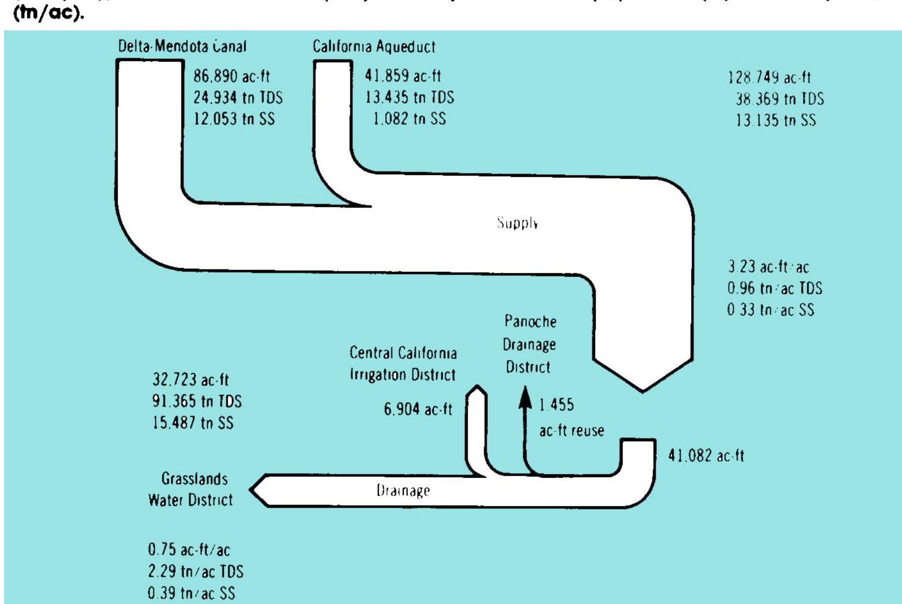

Fig. 2. Irrigation and surface drainage in Panoche Drainage District during the 1975 irrigation (January-December) season.