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Irrigation Return Flows in Southern Idaho

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ABSTRACT

The quantity and quality of irrigation return flows from a 203,000-acre irrigation tract in southern Idaho were measured and compared to the quantity and quality of the irrigation water. Return flows for a typical water year amounted to 929,350 acre feet representing 64% of the total water input to the tract. The total salt concentration in the subsurface drainage water was more than twice that found in the irrigation water. The mean electrical conductivity of the subsurface drainage water was 1040µ mhos/cm which is as low as in some irrigation waters. The Na^+ concentration increased more than four times as water passed through the soil and became subsurface drainage water. Similar comparisons were made for other cations and anions. Surface runoff water did not differ from irrigation water in chemical quality. Surface drainage water from a 3,000-acre subregion contained up to 3.06 tons of sediment per acre foot during the midpart of the irrigation season.

INTRODUCTION

The quantity and quality of irrigation return flows depend upon the quantity and quality of water diverted for irrigation, the proportions of the return flow from surface runoff and subsurface drainage and other factors. Generally, water passing across the land surface picks up little salt or fertilizer elements except those associated with sediment picked up by erosion. Water passing through the soil reacts chemically with soil materials and dissolves soluble salts where contact is made. As soil water is used in evapotranspiration, salts are concentrated in the water that remains in the soil or drains from it. Thus subsurface drainage water usually differs markedly in quality from the irrigation water passing through the soil influences the quality of the subsurface drainage water and the outputs of total salts, specific ions and fertilizer elements.

Information is needed on the quality of irrigation return flows under various management systems as a basis for improving the quality of irrigation return flows. This paper presents information on the quality and quantity of irrigation return flows from a large irrigation tract in southern Idaho.

Methods and Materials

The study area (Figure 1) was a 203,000-acre tract developed by the Twin Falls Canal Company about 1905. Water is diverted from the Snake River and delivered to farmers at a con-

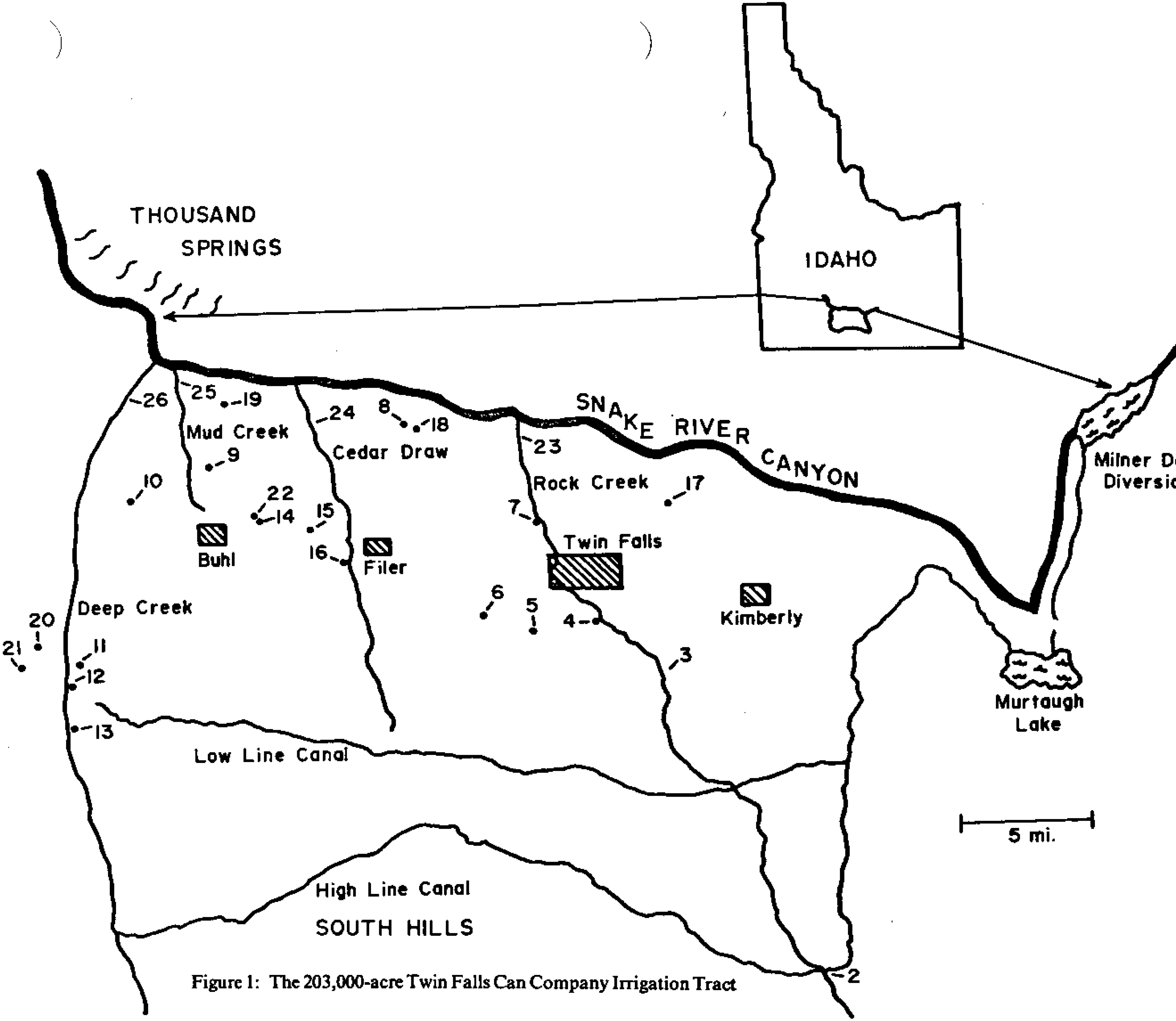

Figure 1: The 203,000-acre Twin Falls Can Company Irrigation Tract

stant rate of 0.5 cubic feet per second (cfs) for each 40 acres during the irrigation season when requested. Water is in the canal system from about April 1 to November 15 each year. Canal flows in the early spring and late fall are considerably lower than during the peak irrigation season of June, July, and August because many farmers have crops that do not require early spring or late fall irrigation.

Soils over most of the study area are moderately deep, uniformly textured silt loams derived from calcareous, wind deposited material, varying from a few inches to 50 feet in depth. These soils are generally well drained. They are underlain by fractured basalt to depths of several hundred feet. Most crops are irrigated by small furrows, and infiltration rates are fairly high. The mean, annual precipitation for the area is 8.5 inches.

The most important crops grown on the tract are alfalfa, dry beans, sugarbeets, small grain, corn and pasture.[1] Row crops are normally seeded in April and May, and harvest is usually completed by late October.

Soon after irrigation was initiated, high water tables appeared in localized areas throughout the tract. To alleviate this problem, the Canal Company used two drainage methods. For the larger areas, horizontal tunnels 4 feet wide by 7 feet high were excavated where test wells indicated significant amounts of water in basalt fractures. These tunnels effectively convey excess water to natural surface drains. The 49th and final tunnel was completed in 1948. The other method combined shallow drainage wells and tile lines in networks to drain smaller areas. The wells are connected by tile lines 3½ to 10 feet below the soil surface. The wells flow from hydrostatic pressure, and the water is conveyed to natural surface drains by tile lines. The practice has proved effective and is still used today. All surface and subsurface drainage returns to the Snake River which flows in a canyon about 500 feet deep, forming the northern boundary of the irrigation project.

Sampling sites were selected throughout the area (numbered on Figure 1) including the project diversion at Milner Dam on the Snake River, four main surface drains, 15 drainage tunnel outlets, five tile-relief well network outlets, and one small stream draining the South Hills watershed. Initially, water samples were collected from each site at two-week intervals and analyzed for total soluble salts, Na^+, K^+, Ca^{++}, Mg^{++}, Cl^-, HCO_3^-, SO_4-S, PO_4-P and NO_3-N concentrations.[3,4,5] Water temperature and pH were also measured at each site. Analysis over a few months showed that the concentrations of some components were nearly constant. Therefore, only PO_4-P, NO_3-N and total salt concentrations and water temperature determinations were continued at two-week intervals. Analyses for other components were made at four-week intervals.

The flow rate from each tunnel and tile-relief well network was measured. Weirs were used where possible. Parshall flumes existed at two sites, and the remainder were gaged periodically by current metering. Water stage recording stations were maintained on the main surface drains. Existing USGS gaging stations were utilized on Cedar Draw and Deep Creek. Flow hydrographs were developed from the data and the monthly flow volume computed for each site. Hydrograph separation techniques[2] were applied to the streamflow data to establish the amounts of surface runoff and subsurface drainage from the area for a typical water year, October 1, 1968 through September 30, 1969.[1]

A water balance for a typical water year of the Canal Company, October 1, 1968 through September 30, 1969, was computed.[1] Using this water balance along with the concentrations of total salts, PO_4-P and NO_3-N, input-output balances for these components were calculated and previously reported.[1] Input-output balances for specific ions and related information have also been calculated (submitted for publication).

The sediment concentration in the major surface drain waters was determined by removing the sediment from samples of known volume collected at two-week intervals during the 1971 irrigation season. The sediment was removed by allowing it to settle and by centrifuging. The sediment was then dried and weighed.

Results and Discussion

The mean concentrations of all ionic components except PO_4-P were higher in subsurface drainage water than in the irrigation water (Table 1). The concentration of each component was nearly constant at each sampling site even though the flow fluctuated with seasons at most

TABLE 1

Mean ionic concentrations at input and subsurface drainage sampling sites for the water year October 1, 1968 to September 30, 1969

No.	Name	Na^+ me/l	K^+ me/l	Ca^{++} me/l	Mg^{++} me/l	Cl^- me/l	HCO_3^- me/l	NO_3-N ppm	SO_4-S ppm	PO_4-P ppm
	Input Streams									
1	Milner	0.90	0.12	2.54	1.23	0.66	3.38	0.12	14	0.066
2	Rock Creek (HL)	0.22	0.12	1.09	0.34	0.17	1.79	0.11	4	0.015
	Drainage Tunnels									
3	Claar	3.65	0.10	5.22	3.62	1.33	6.66	4.02	69	0.013
4	Fish Hatchery	2.92	0.13	3.55	2.85	1.30	5.57	2.24	36	0.013
5	Grossman	3.01	0.10	3.99	2.81	1.18	5.97	2.25	45	0.014
6	Nye	3.64	0.11	3.81	3.02	1.54	5.91	2.44	55	0.009
7	Tolbert	4.06	0.12	4.95	3.23	1.65	6.45	3.30	68	0.012
8	Walters	3.86	0.14	4.47	3.98	1.52	6.67	3.47	56	0.008
9	Mendini	4.73	0.21	3.60	2.88	1.72	7.22	3.97	47	0.009
10	Neyman	4.06	0.23	5.42	2.71	1.55	7.52	3.40	50	0.011
11	Galloway	3.82	0.12	3.88	2.94	1.19	7.12	3.58	35	0.014
12	Cox	3.38	0.12	3.81	2.96	1.24	6.74	3.44	35	0.015
13	Herman	3.00	0.12	5.71	3.01	1.42	7.08	3.00	47	0.017
14	Harvey	3.70	0.13	3.64	2.84	1.37	6.93	3.39	31	0.008
15	Peavy	3.93	0.13	3.57	3.12	1.57	6.47	3.02	36	0.007
16	Padget	3.92	0.13	3.46	3.34	1.62	6.24	3.01	42	0.008
17	Hankins	4.49	0.18	4.27	3.11	1.63	6.62	3.55	53	0.012
	Tile-Relief Well Networks									
18	Brown	4.06	0.16	4.36	3.50	1.67	6.78	3.01	55	0.009
19	Hutchinson	4.38	0.21	4.15	3.06	1.61	7.65	3.20	44	0.012
20	Kaes	2.73	0.19	5.07	3.20	1.83	6.25	3.40	54	0.023
21	Molander	2.80	0.21	4.82	3.59	1.94	6.12	3.79	57	0.009
22	Harvey	3.67	0.14	3.59	3.10	1.42	6.27	3.30	36	0.023
Mean, Subsurface Drainage		3.69	0.15	4.27	3.14	1.52	6.61	3.24	48	0.012

sites. The concentration variation among sampling sites for subsurface drainage water was generally within 25% for any specific chemical component and for total salts.

The relative difference in individual cation concentrations between the irrigation water and the subsurface drainage water was greatest for Na^+ and least for K^+ (Table 2). For anions, the relative increase was greatest for NO_3-N and least for Cl^-. The PO_4-P concentration decreased so that the concentration in the drainage water was less than 1/5 of that in the irrigation water.

The water balance[1] showed that 50% of the total input water (diverted water plus precipitation) became subsurface drainage water, 14% returned to the Snake River as surface runoff and evapotranspiration accounted for the remaining 36% (Table 3). The net output of total salts amounted to approximately one ton per acre per year (Table 4). The portion of the water passing through the soil and the net salt output indicates that more leaching is taking place than is necessary to maintain a salt balance.[6]

During a typical water year, about 1 acre-foot of surface runoff per acre returned to the River,

TABLE 2

Specific ion concentrations in irrigation and subsurface drainage waters and the relative concentration change that occurred as water passed through the soil

Component	C units	Ci^a	Csd^b	$\frac{Csd}{Ci}$
Na^+	me/l	0.90	3.67	4.08
K^+	me/l	0.12	0.15	1.25
Ca^{++}	me/l	2.54	4.27	1.68
Mg^{++}	me/l	1.23	3.14	2.55
Cl^-	me/l	0.66	1.52	2.30
HCO_3^-	me/l	3.38	6.61	1.96
NO_3-N	ppm	0.12	3.24	27.00
SO_4-S	ppm	14.0	48.0	3.43
PO_4-P	ppm	0.066	0.012	0.18
Total Salt	μmhos/cm	460	1,040	2.26

[a]Ci is the concentration in the irrigation water.

[b]Csd is the concentration in the subsurface drainage water.

TABLE 3

The water balance for the 203,000-acre Twin Falls Tract for a typical water year[1]

	Acre-feet	%
Input		
Diverted from Snake River	1,290,100	89
Runoff from South Hills	32,000	2
Precipitation	130,000	9
City of Twin Falls	900	—
TOTAL	1,453,000	100
Output		
Evapotranspiration	523,650	36
Surface runoff	203,880	14
Subsurface drainage	725,470	50
TOTAL	1,453,000	100

and subsurface drainage amounted to more than 3.5 acre-feet per acre. Thus, the total quantity of return flow from the 203,000-acre tract amounted to 929,350 acre-feet, or 64% of the total input.

There was a net output of all chemical components measured excepting PO_4-P and K^+ (Table 4). The net K^+ input amounted to approximately 13 pounds per acre per year which is significant from the standpoint of fertilizer needs. More than 70% of the PO_4-P entering the tract in the irrigation water reacted with and remained in the soil. The total output of PO_4-P in the drainage water was only 28 tons compared to a total input of 116 tons in the irrigation water and 2,580 tons applied to the land as fertilizer. Results from this study show that applied phosphorus fertilizers remain associated with the soil. They are not dissolved into PO_4-P and leached away by drainage water.

The chemical quality of the subsurface drainage water from the Twin Falls tract is better than that of irrigation water diverted at some points from the lower reaches of the Colorado and Rio Grande Rivers and that from some

TABLE 4

Input-output balances for measured chemical components and total salts for a typical water year on 203,000 acres

Component	*Total Input*	*Total Output*	*Net Input*	*Net Output*
	Tons	Tons	Tons	Tons
Na^{+}	36,511	88,946	—	52,435
K^{+}	8,444	7,070	1,374	—
Ca^{++}	90,006	98,272	—	8,266
Mg^{++}	26,475	41,818	—	15,343
Cl^{-}	41,284	59,723	—	18,439
HCO_3^{-}	365,880	454,400	—	88,520
NO_3-N	210	3,226	—	3,016
SO_4-S	25,598	51,342	—	25,744
PO_4-P	116	28	88	—
Total salts	520,977	738,077	—	217,100

other sources. However, the total salt concentration in this subsurface drainage water was more than double that in the irrigation water. The quality of the irrigation water was high, and even though the salt concentration is increased by irrigation, the quality of the drainage water is still fairly high.

In some respects, the quality of the drainage water was superior to that of the irrigation water. For example, the PO_4-P load in the drainage water was less than in the irrigation water, and the temperature of the drainage water was lower than that of the irrigation water during midsummer when irrigation water temperatures exceeded 20°C.

The NO_3-N concentration was 27 times higher in the subsurface drainage water than in the irrigation water. This concentration increase coupled with the water balance represents a net NO_3-N output of 30 pounds per acre per year. However, the mean NO_3-N concentration was 3.24 ppm which is well below the 10 ppm set by the Public Health Service as a maximum for drinking water.

Surface runoff water quality did not differ from that of the irrigation water except that the runoff water had a much higher sediment concentration during part of the irrigation season. The four main surface drains from the area contained both surface runoff and subsurface drainage water. Therefore the quality of water in these drains was between the irrigation water and subsurface drainage water qualities. For example, the electrical conductivity of waters in Rock Creek, Cedar Draw, Mud Creek and Deep Creek (sites 23, 24, 25 and 26 respectively) ranged from about 600 to 800μ mhos/cm during the time that water was being diverted into the canal system and from 1,000 to 1,100μ mhos/cm during the winter months when essentially all water in these drains was from subsurface drainage. Concentrations of specific chemical components fluctuated similarly.

The sediment load in surface runoff water varied through the irrigation season. Our sediment data have not been summarized for all streams at this date, but preliminary results indicated that the surface runoff from a 3,000-acre subregion contained from about 0.25 to 3.00 tons of sediment per acre-foot during an irrigation season (Table 5). The amount of sediment removed from the 3,000 acres by erosion

TABLE 5

Sediment load in surface runoff water from 3,000 acres

Sampling Date	*Sediment load*	*Accumulative Sediment output*	*Accumulative runoff*
	Tons/acre-ft.	Tons	acre-ft.
May 25	0.97	—	—
June 2	.54	—	—
June 15	.28	620	1,000
June 29	.97	2,760	2,065
July 13	3.06	6,070	3,179
July 26	2.88	9,025	4,411
August 10	1.92	10,750	5,541
August 24	1.11	11,700	6,805
September 8	.37	12,500	8,791

during irrigation was over 12,000 tons or over 4 tons per acre per season.

In conclusion, irrigation return flows from a 203,000-acre irrigation tract in southern Idaho represented nearly 2/3 of the input water. Most of the return flow was subsurface drainage. The total salt concentration in subsurface drainage water was more than twice that in the irrigation water, but the concentration was lower than occurs in irrigation waters used in some areas of the U.S. The PO_4-P load in the drainage water was less than 30% of that in the irrigation water. Surface runoff water did not differ from irrigation water in chemical quality, but high sediment concentrations were measured during part of the irrigation season.

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