HYDRAULIC ANALYSIS of IRRIGATION CANAL SYSTEMS in SALT LAKE COUNTY

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Salt Lake County 208
Water Quality Project
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I. INTRODUCTION

A. Background

In the past, agriculture was a major industry in the Salt Lake Valley. With growth and expansion, much of the land used for agriculture has been converted to residential or commercial use. However, irrigation canal flows have not decreased accordingly. The excess water remains in the canal and floods irrigated land and returns to the canals or to the Jordan River. Thus, a water and agricultural use imbalance has been created.

The remaining agricultural return flows to the Jordan River are a major problem with the water quality during the summer months. In the past, very little investigation has been undertaken to determine points of agricultural return flows and to investigate the agricultural water balance in the valley. With the lack of available information, the need to investigate quality, quantity, and location of return flows becomes even more apparent.

An accurate description of the canal systems and the surrounding lands is necessary in developing any future use patterns for these lands. A surveillance of the general patterns of development near a canal was made to gather some data concerning present use.

This study has focused its attention on prime agricultural land west of the Jordan River. All data that has been collected to date are limited in coverage and intensive study is indicated.

B. Objectives

The overall objective of this report is to provide information on the nature, use and efficiency of the west side canal system in the valley.

One of the specific goals in this analysis is to pinpoint agricultural returns, not only to the Jordan River, but to the various canal systems traversing the valley. The second specific goal is to investigate the irrigation water balance of the canals on the west side of the Jordan River.

C. Scope of Investigation

With the help of NASA U-2 infrared photography, an investigation of actual farmed acreages (as of September 1972) was undertaken. Plots of land were placed in one of the following categories:

1) heavy irrigation

2) intermediate irrigation

3) light irrigation (see Table 1)

For a comparison, the State Engineer's Office[1] was contacted to obtain available information (maps) on each canal system. The maps contained information on irrigation rights for each canal and actual irrigated acreages. The same consumptive use figures that were used in the U-2 information were applied to obtain quantities of water that are desirable for irrigation purposes.

Optimum irrigation and actual practices were compared to the annual flow in acre-feet per year for each canal system. The canal annual flow data were obtained from Utah Lake and the Jordan River Distribution Reports of 1972.[2] A factor of 15 percent loss of water due to seepage and evaporation in the canal distribution system was applied to all canal systems. From the State Engineer's information, return flows to each canal and the Jordan River were located.

To give a general description of the canal system, the access road for Utah and Salt Lake Canal was followed. The lands surrounding the canal were observed and the location of all storm drains recorded. Due

to variations in water rights days, agriculture return flows were not recorded. However, it can be assumed that most irrigated lands return used or excess water somewhere along the banks of the canals.

The field survey included just one canal but other descriptions were obtained from Salt Lake County Planning District Maps.

II. SUMMARY OF RESULTS

Information from the NASA U-2 photography and the State Engineer's maps indicates that the amounts of water diverted to the canal systems are between 80 percent and 34 percent in excess of amounts needed for irrigation with 75 percent efficiency. With a substantial drop in irrigation efficiency (to 50 percent) this study shows that a water excess of between 2 percent and 70 percent still exists.

The North and South Jordan Canals showed the highest percentages of excess irrigation water, thus substantiating the fact that as urbanization has taken place, canal intakes have not been diminished accordingly. In other words, as expected, the canal districts closer to the Jordan River and with higher demand for urbanization have the highest percentages of excess irrigation water.

The surveillance of the Utah and Salt Lake Canal showed a growing urbanization along the banks of the canal. With this growth, an increase in storm drainage inputs occurred.

III. REVIEW OF PREVIOUS/RELATED INVESTIGATIONS

In December 1975, Mr. Robert Sperling completed his Master's thesis which investigated the effects of irrigation return flow on the lower Jordan River and compared the return flows to the effects of urban stormwater runoff and wastewater treatment plant effluents. The study concludes that:

1) irrigation regurn flows degrade the quality of the applied water
2) irrigation return flows meet stated criteria for most beneficial uses
3) Total Dissolved Solids (TDS) is the only quality parameter which presents problems.

No previous investigations or surveillances have been made on the canal character or excess flows.

IV. INVESTIGATIVE METHODOLOGY

The major task was the accumulation of irrigation water rights information and comparison of this information with another reliable source.

The U. S. Department of Agriculture is in charge of NASA infrared photography. A flight of September 14, 1972, using false color infrared was one of the major sources of information for this study. It was felt that a September flight would provide a realistic sample of actual irrigation practices, eliminating any false interpretations due to the seasonal variations in precipitation. Photos from more recent years were obscured by cloud cover and could not provide reliable results. From this mapping, the acreage of irrigated land for each canal system west of the Jordan River was tabulated (see Table 1).

The State Engineer's Office Maps showed irrigated land with respect to actual water rights for each parcel. These maps were obtained and reviewed for information on canal return flows and total irrigated land. The acreages served by each canal system were tabulated and compared with information obtained from the NASA photography (Table 1).

Data on crop water requirements were obtained from the U. S. Department of Agriculture and the Soil Conservation Service "Irrigated Crop Consumptive Use Index" (Table 2).[3]

The surveillance of Utah and Salt Lake Canal was performed by car. The access road was driven and locations of storm drains recorded. The description of the additional canals was obtained from Salt Lake County Valley, Magna and West Jordan Planning District maps.

V. RESULTS

A comparison of the U. S. Department of Agriculture data (NASA U-2) and the State Engineer's information indicates a good comparison of agriculture acres, although there is a time differential between the two sources. It is expected that the NASA information would give the best representation of the actual information.

The first step in analyzing excess diverted water is to compute the minimum water requirements at different irrigation efficiencies(Table 3). The leaching requirement was computed using a factor directly related to irrigation efficiency and consumptive use.

$$E = \frac{CU}{TU}$$

and

$$TU = CU + LR$$

therefore

$$E = \frac{CU}{CU + LR}$$

By multiplying both sides by CU + LR/E you obtain

$$CU + LR = \frac{CU}{E}$$

$$LR = \frac{CU}{E} - CU$$

$$LR = CU\left(\frac{1}{E} - 1\right)$$

where

TU = total water used
LR = leaching requirement
CU= = consumptive use requirement
E = irrigation efficiency

Excess canal flows are found by subtracting minimum water requirements from actual canal flows for 1972. A factor of 15 percent loss of water due to seepage and evaporation was applied to canal flow (Table 4).

Assuming an optimum irrigation efficiency of 75 percent, analysis of the canal systems on the west side of the Jordan River indicate that between 34 percent and 80 percent excess water is presently being diverted into the canal systems. If an irrigation efficiency of 50 percent is assumed, excesses of between 2 percent and 70 percent are obtained. It is concluded that exact knowledge of overall iriigation efficiencies is not necessary to show that substantial excess diversions are taking place.

As expected the canals that are closest to the Jordan River have the highest percentage of excess irrigation water. This study indicates that as urbanization has taken place, little or no reduction in water diversions has taken place. Excesses of irrigation return flow to adjacent canals and to the Jordan River are the result.

As part of the agricultural return flow study a preliminary analysis was undertaken to pinpoint locations of agricultural return flows both to irrigation canals and to the Jordan River (Table 5). This list of agricultural return flow locations that were obtained during the process of this study were gathered through the State Engineer's Office and only indicate a partial list of the existing agricultural return flows. It is expected that as the 208 study progresses, the actual observations along with additional published information will augment this report along with additional return flow locations.

The general description of Utah and Salt Lake Canal along with the list of storm drain inputs into this canal are found in Figure 1 and Table 6. Again, this list of inputs is preliminary and not complete. The general description of South Jordan, North Jordan, Utah Lake Distributing and Provo Reservoir lands is also found in Figure 1 and Table 7.

VI. GENERAL DISCUSSION

The review of the surrounding lands of the canals and their excess flows clearly indicate an increase in the development of residential and commercial areas on agricultural land. As this trend continues, excess flows will increase and the necessity for adjustments in canal flows will be necessary. By applying the excess factors from west-side canals at 50 percent irrigation efficiency to the east-side canal system, a value of 31,214 excess acre-feet of diverted water is obtained.

FLOWS FOR EAST-SIDE CANALS[2]

Canals	Flow(acre-feet)
East Jordan Canal	54,599
Jordan and Salt Lake Canal	14,116
Draper Canal	12,542
Brighton Canal	19,435
Totals	100,692

This conservative estimate when combined with the west-side canals produces a total excess of 73,182 acre-feet of unused diverted irrigation water. This excess canal water violates water resource management practices for flood control purposes and decreases irrigation efficiencies thus increasing return flows to other canals and the Jordan River.

TABLE 1

COMPARISONS OF IRRIGATION ACREAGE--208 STUDY RESULTS (NASA) VERSUS DATA FROM STATE ENGINEER'S OFFICE

Canal District	NASA U-2 Flight (September 15, 1972)				State Engineer 1967
	Heavy (acres)	Intermediate (acres)	Light (acres)	Total (acres)	Total (acres)
Provo Reservoir	1724	994	1133	3851	3712
Utah Lake Distributing	2024	651	1259	3934	4680
Utah and Salt Lake	1838	2222	2777	6837	8817
South Jordan	1307	1597	989	3893	5710
North Jordan	170	194	290	654	2324

TABLE 2

CROP CONSUMPTIVE USES

Crop	Heavy to Intermediate 1972 NASA U-2/red & green (inch/year)	Light 1972 NASA U-2/yellow (inch/year)
Alfalfa	36.8	
Corn (silage)	26.4	
Grass (pasture)	32.0	
Sugar Beets	33.5	
Orchards		
Spring Grains		21.4
Small Vegetables		20.0
Spring Wheat		17.1
Average	32.4	19.5

TABLE 3

COMPUTATION OF IRRIGATION WATER REQUIREMENTS

Canal District	Irrigated Area[1] (acres)		Consumptive Uses Requirement		Leach. Requirement @ 33% Consumptive Use (acre ft/yr)	Minimum Water Requirement (acre ft/yr)
75 Percent Irrigation Efficiency						
Provo Reservoir	L	1133	1847	9186	3062	12,248
	H & I	2718	7339			
Utah Lake Distributing	L	1250	2052	9275	3092	12,367
	H&& I	2675	7223			
Utah and Salt Lake	L	2777	4527	15489	5163	20,652
	H & I	4060	10962			
South Jordan	L	989	1612	9453	3151	12,604
	H & I	2904	7841			
North Jordan	L	290	473	1456	485	1,941
	H & I	364	983			

(1) From Table I--NASA U-2 Flight Imagery Interpretation, 14 September 1972
(2) From Table II--Light Irrigation,1.63 ft/yr; Intermediate & Heavy, 2.70 ft/yr

TABLE 3

COMPUTATION OF IRRIGATION WATER REQUIREMENTS

Canal District	Irrigated Area[1] (acres)		Consumptive Uses Requirement		Leach. Requirement @ 60% Consumptive Use (acre ft/yr)	Minimum Water Requirement (acre ft/yr)
62.5 Percent Irrigation Efficiency						
Provo Reservoir	L	1133	1847	9186	5512	14,698
	H & I	2718	7339			
Utah Lake Distributing	L	1259	2052	9275	5565	14,840
	H & I	2675	7223			
Utah and Salt Lake	L	2777	4527	15489	9293	24,782
	H & I	4060	10,962			
South Jordan	L	989	1612	9453	5672	15,125
	H & I	2904	7841			
North Jordan	L	290	473	1456	874	2,330
	H & I	364	983			

(1) From Table I--NASA U-2 Flight Imagery Interpretation, 14 September 1972
(2) From Table II--Light Irrigation,1.63 ft/yr; Intermediate & Heavy, 2.70 ft/yr

TABLE 3

COMPUTATION OF IRRIGATION WATER REQUIREMENTS

Canal District	Irrigated Area[1] (acres)	Consumptive Uses Requirement		Leach. Requirement @100% Consumptive Use (acre ft/yr)	Minimum Water Requirement (acre ft/yr)
50 Percent Irrigation Efficiency					
Provo Reservoir	L 1133 H & I 2718	1847 7839	9186	9186	18,372
Utah Lake Distributing	L 1259 H & I 2675	2052 7223	9275	9275	18,550
Utah and Salt Lake	L 2777 H & I 4060	4527 10,962	15489	15489	30,978
South Jordan	L 989 H & I 2904	1612 7841	9453	9453	18,906
North Jordan	L 290 H & I 364	473 983	1456	1456	2,912

(1) From Table I--NASA U-2 Flight Imagery Interpretation, 14 September 1972
(2) From Table II--Light Irrigation,1.63 ft/yr; Intermediate & Heavy, 2.70 ft/yr

TABLE 4

CANAL EXCESS FLOWS

Canal District	Canal Flow 1972 less 15% water lost (acre-ft)	Minimum Water Requirement (acre ft/yr)	Excess Flow (acre ft/yr)	Percent Excess
75 Percent Irrigation Efficiency				
Provo Reservoir	23,800.0	12,248.0	11,552.0	48.5
Utah Lake Distributing	18,842.0	12,367.0	6,475.0	34.4
Utah and Salt Lake	47,388.3	20,652.0	26,736.3	56.4
South Jordan	31,821.4	12,604.0	19.217.4	60.4
North Jordan	9,834.5	1,941.0	7,893.5	80.3
Total	131,686.5	59,812.0	71,874.2	

TABLE 4

CANAL EXCESS FLOWS

Canal District	Canal Flow 1972 less 15% water lost (acre-ft)	Minimum Water Requirement (acre ft/yr)	Excess Flow (acre ft/yr)	Percent Excess
62.5 Percent Irrigation Efficiency				
Provo Reservoir	23,800.0	14,698.0	9,102.0	38.2
Utah Lake Distributing	18,842.0	14,840.0	4,002.0	21.2
Utah and Salt Lake	47,388.3	24,782.0	22,606.3	47.7
South Jordan	31,821.4	15,125.0	16,696.4	52.5
North Jordan	9,834.5	2,330.0	7,504.5	76.3
Total	131,686.5	71,775.0	59,911.2	

TABLE 4

CANAL EXCESS FLOWS

Canal District	Canal Flow 1972 less 15% water lost (acre-ft)	Minimum Water Requirement (acre ft/yr)	Excess Flow (acre ft/yr)	Percent Excess
50 Percent Irrigation Efficiency				
Provo Reservoir	23,800.0	18,372.0	5,428.0	22.8
Utah Lake Distributing	18,842.0	18,550.0	292.0	1.5
Utah and Salt Lake	47,388.3	30,978.0	16,410.3	34.6
South Jordan	31,821.4	18,906.0	12,915.4	40.6
North Jordan	9,834.5	2,912.0	6,922.5	70.4
Total	131,686.5	89,718.0	41,968.2	

TABLE 5

SALT LAKE COUNTY IRRIGATION RETURN FLOWS
(Preliminary list)

1. Rose Creek (as it crosses all major canals)
2. 3300 ft. south of 12600 South on Utah & Salt Lake Canal
3. 2300 ft. south of 12600 South on Utah & Salt Lake Canal
4. 320 ft. south of 12600 South on Utah & Salt Lake Canal
5. 1000 ft. north of 11800 South on Utah & Salt Lake Canal
6. 1920 ft. north of 7000 South on Utah & Salt Lake Canal
7. 850 ft. south of 7000 South on Utah & Salt Lake Canal
8. 1650 ft. south of 7000 South on Utah & Salt Lake Canal
9. 2300 ft. south of 7000 South on South Jordan Canal
10. 1300 ft. south of 7000 South on South Jordan Canal
11. 1500 ft. north of 7000 South on South Jordan Canal
12. Across Utah & Salt Lake Canal at 3600 West just north of 5400 South
13. 1200 ft. south of 10400 South and 850 ft. east of 2200 West on Utah & Salt Lake Canal
14. 1825 ft. east of 1700 West and 3200 ft. north of 10400 South on the South Jordan Canal
15. 3400 ft. south of 7800 South and 2650 ft. east of 2700 West on the South Jordan Canal
16. 4000 ft. south of 5400 South and 1650 ft west to Redwood Road on South Jordan Canal
17. 1200 ft. south of 5400 South and 1200 ft. east of 2700 West on South Jordan Canal
18. 700 ft. west of 3600 West and 600 ft. south of 4400 South on South Jordan Canal
19. 400 ft. west of 3200 West and 1300 ft. south of 4700 South on South Jordan Canal
20. South Jordan Canal ends at 4000 West and irrigation water drops into the Kearns/Chesterfield storm drain

TABLE 5 (cont'd)

21.	Bingham Creek
22.	600 ft. north of the North Jordan diversion from the Jordan River on the North Jordan Canal
23.	1300 ft. north of 6200 South and 2200 ft. east of 1700 West on North Jordan Canal
24.	2500 ft. east of 1700 West and 1400 ft. south of 5400 South on North Jordan Canal
25.	1000 ft. north of 5400 South and 2300 ft. east of 1700 West on North Jordan Canal
26.	800 ft. south of 7800 South on the Jordan River
27.	6200 ft. south on the Jordan River
28.	2000 ft. north of 6200 South on the Jordan River
29.	1000 ft. north of Bullion Street on the Jordan River
30.	200 ft. south of 4800 South on the Jordan River-Barneys Creek
31.	300 ft. north of 4800 South on the Jordan River
32.	1000 ft. south of 4800 South on the Jordan River
33.	Combination storm drain, irrigation return flow at 4800 South from the Jordan River

TABLE 6

SURVEILLANCE OF SALT LAKE COUNTY IRRIGATION CANALS

Location	Description
Utah and Salt Lake Canal	
13400 South to Jordan Narrows at diversion--2450 W. and 13800 S.	Storm Drain
13200 South to 13400 South	Residential Area
12600 South to 13200 South	Cultivated Land
12220 South to 12600 South	Residential Area
2300 West and 12280 South	Storm drain
2280 West and 12320 South	Storm Drain
2275 West and 12500 South	Storm Drain
11600 South to 12220 South	Residential Area-east Cultivated Area-west
9000 South to 11600 South	Cultivated Area
1800 West and 10400 South	3 Storm Drains
2210 West and 11400 South	2 Gutter Drainages
8650 South to 9000 South	Residential Area
2650 West and 8650 South	Storm Drain
2600 West and 8750 South	Storm Drain
2550 West and 9000 South	2 Storm Drains
8400 South to 8650 South	Cultivated Land
8315 South to 8400 South	Cultivated Land
8200 South to 8315 South	Residential Area
3000 West and 8200 South	Storm Drain
7700 South to 8200 South	Cultivated Land
6600 South to 7700 South	Residential Area
3005 West and 7000 South	Storm Drain
*6240 South to 6600 South	Cultivated Land

* Elbow in canal, so it flows northwest. Numbering system switches to west coordinates.

TABLE 6 (cont'd)

Location	Description
2300 West to 2000 West	Residential Area
2260 West and 6130 South	Storm Drain
2230 West and 6170 South	Storm Drain
2200 West and 6245 South	2 Gutter Drainages
2100 West and 6300 South	Storm Drain
2050 West and 6340 South	Storm Drain
2700 West to 2300 West	Cultivated Lands-south Residential area-north
2350 West and 6040 South	Storm Drain
3200 West to 2700 West	Residential Area
2760 West and 5780 South	Storm Drain
2700 West to 2300 West	Storm Drain
3780 West to 3200 West	Residential Area
3685 West and 4930 South	Storm Drain
3600 West and 4995 South	2 Storm Drains
3580 West and 5000 South	2 Storm Drains
3500 West and 5100 South	Storm Drain
3450 West and 5160 South	Storm Drain
3400 West and 5200 South	Storm Drain
3325 West and 5275 South	Storm Drain
3280 West and 5325 South	Storm Drain
4000 West to 3780 West	Residential Area-south Cultivated lands-north
4150 West to 4000 West	Commercial Area
4060 West and 4700 South	Storm Drain
4000 West and 4740 South	Storm Drain
4300 West to 4150 West	Residential Area
4540 West to 4300 West	Residential Area-south Cultivated Lands-north
4360 West and 4590 South	Storm Drain
4320 West and 4600 South	Storm Drain

TABLE 6 (cont'd)

Location	Description
4800 West to 4540 West	Residential Area
4540 West and 4530 South	Storm Drain
5050 West to 4800 West	Cultivated Lands-south Residential Areas-north
5000 West and 4300 South	Storm Drain
4910 West and 4325 South	Storm Drain
4800 West and 4400 South	2 Storm Drains
5300 West to 5050 West	Cultivated Lands
5600 West to 5300 West	Residential Area-south Cultivated Lands-north
5565 West and 4130 South	Storm Drain
5530 West and 4150 South	Storm Drain
5480 West and 4180 South	Storm Drain
5400 West and 4200 South	Storm Drain Storm Drain
6200 West to 5600 West	Cultivated Lands
6400 West to 6200 West	Residential Area-south Cultivated Lands-north
6500 West to 6400 West	Cultivate. Lands
6400 West to 3950 South	Gutter Drainage
6580 West to 6500 West	Cultivated Lands-south Residential area-north
6800 West to 6580 West	Cultivated Lands
7200 West to 6800 West	Cultivated Lands-south Residential Area-north
8850 West to 7200 West	Cultivated Lands
8920 West to 8850 West	Residential Area
9200 West to 8920 West	Cultivated Lands
Kennecott Copper Corporation Land	Canal runs to Kennecott Smelter and is used for dust settling purposes

TABLE 6 (cont'd)

Location	Description
Provo Reservoir Canal	
Enters Salt Lake County above Jordan Narrows to terminus point near 9400 South	Cultivated Lands
Utah Lake Distributing Canal	
Enters Salt Lake County above Jordan Narrows to 12600 South	Cultivated Lands
12600 South to 12200 South	Residential Area-west Cultivated Lands-east
12200 South to 7000 South	Primarily cultivated areas with small residential areas at 10700, 10400 and 8600 South Streets
7000 South to 6250 South	Residential Area-east Cultivated Land-west
6250 South to 6200 South	Cultivated Land
6200 South to 5850 South	Residential Area
5850 South to 5300 South	Cultivated Land
5300 South to 4700 South	Residential and Commercial Areas
4700 South to terminus point near 4100 South	Cultivated Land

TABLE 6 (cont'd)

Location	Description
South Jordan Canal	
Diversion at Jordan Narrows to 12800 South	Cultivated Land
12800 South to 12500 South	Cultivated Land-east Residential area-west
12500 South to 8200 South	Cultivated Land
8200 South to 7400 South	Residential Areas
7400 South to 7000 South	Cultivated Lands
7000 South to 6850 South	Residential Areas
6850 South to 6600 South	Cultivated Lands
*1600 West to 1700 West	Residential Area-east Cultivated Land-west
1700 West to 1850 West	Cultivated Land-east Residential Area-west
1850 West to 2450 West	Cultivated Land
2450 West to 2700 West	Cultivated Land-east Residential Area-west
2700 West to 3200 West	Cultivated Land
3200 West to 4600 West	Residential Area
4600 West to terminus point near 4800 West	Cultivated Land

* Elbow in canal. Canal flows northwest; numbering system switches to west coordinates.

TABLE 6 (cont'd)

Location	Description
North Jordan Canal	
Diversion near 9200 South to 5600 South	Cultivated Lands
5600 South to entrance into Riter Canal near 3000 South	Residential or commercial area with a few irrigated lands interspersed.
3000 South to 2900 South	Riter Canal Flows through residential area
Kennecott Copper Corporation Land	Flow used for flotation purposes at Kennecott Smelter.

REFERENCES

1. Utah Lake and Jordan River Adjudication, Office of State Engineer, State of Utah, 1967.

2. Gardner, Brad, "Utah Lake and Jordan River Water Distribution," Utah State Engineer, 1972.

3. Irrigated Crop Consumptive Use Index, U. S. Department of Agriculture and the Soil Conservation Service, 1967.

IRRIGATION CANAL SYSTEM
(WEST OF JORDAN RIVER)

DEVELOPED LAND

AGRICULTURAL LAND

MAJOR ROAD

CANAL

APPROXIMATE 5200 FT. ELEVATION

0 .5 1.5
.25 1 MILES

NORTH

SLD

OCTOBER 1976