WATER SUPPLY AND USE

STATUS AND OUTLOOK IN SALT LAKE COUNTY

SALT LAKE COUNTY 208 WATER QUALITY PROJECT

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208 Study

WATER SUPPLY AND USE, STATUS AND OUTLOOK IN SALT LAKE COUNTY

Prepared by

Dr. Bard Glenne
Associate Professor of Civil Engineering
University of Utah
Salt Lake City, Utah 84112

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D.W. Eckhoff, Ph.D., P.E.
Project Manager

Kenneth W. Watson, P.E.
Deputy Project Manager
and
Water Resource Specialist

Steven F. Jensen
Land Use Planner

The Following Individuals Served as
Report Review Team

Terry Holzworth
Salt Lake County Water
Conservency District

Barry Saunders
Utah Division of Water Resources

Ed Feldt
Utah Division of Water Rights

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1. INTRODUCTION

It is generally agreed that the population of Salt Lake County will increase by 250,000 - 300,000 people in 1975 - 1995. This 50 percent population increase will mean an expansion of the developed acreage necessary for residential, commercial and industrial activities. A good share of this acreage will have to come from what is presently agricultural land. Generally this development will mean increased water demand over the next twenty years for residential, commercial, and industrial use while a decrease in water demand is expected from the agricultural (irrigation, stock, fur-bearing) sector of society.

It is the purpose of this report to examine past and present water supplies, uses and diversions in Salt Lake County and to assess their expected developments in the period 1975 - 1995 using the demographic information available. The study considers surface streams, reservoirs, aqueducts, canals, and groundwater (wells and springs) supplies along with residential, municipal, commercial, industrial, and agricultural (irrigation, stock, fur-bearing) uses of water. In the final instance economic and legal constraints are also included.

Water use is broken down as follows:

* Municipal & Industrial use (M&I) which basically includes the water delivered by the various water departments and municipal companies. This water is of culinary quality and includes;

- Residential use (personal use as well as lawn and garden watering)
- Municipal use (park watering, street cleaning, municipal and state office use, etc.)
- Commercial use (shops, offices, etc.)
- Industrial use (water delivered by companies to various smaller industries)

* Special Industrial water use is the water especially delivered to or diverted by larger industries (Kennecott Copper Corporation, Utah Power & Light, etc.)

* Irrigation water use is the water used for irrigation purposes by the agricultural sector.

* Stock use refers to the water used for stock watering, mink farms, turkey farms, etc. Undoubtedly some of this water is also used for other purposes since most of it comes from groundwater sources.

Theoretical use, actual use, and diversion of water are three terms used repeatedly in this report. Diversion of water is normally the largest of the terms and designates the quantity of water diverted at the source (well, spring, stream or reservoir). Actual use is the amount of water used by the consumer (industry, resident, farmer, stock). Theoretical use, or need, is the net amount of water needed to sustain normal or near normal conditions, such as encountered during time of drought.

For ease of communications water needs or uses are often quantified on a per capita basis. Unfortunately, this simplification of an intricate problem often leads to confusion and disagreements. In order to assess Salt Lake County's future water needs or uses the following factors need be considered:

* Irrigation Demand
  - Irrigated area (dependent on degree of urbanization)
  - Type of crops grown (potential consumptive use)
  - Climatic Sensitivity
  - Irrigation Efficiences (flood & sprinkling, canal losses, etc.)
  - Water availability (water rights, price, administration)
* Industrial Demand
  - Degree of industrial development
  - Type of industries
  - Environmental constraints (discharge permits, etc.)
  - Water availability (water rights, price, legislation)
  - Climatic Sensitivity
* Residential & Municipal Demand
  - Population
  - Population density (per capita use)
  - Climatic sensitivity
  - Water quality considerations (treatment, discharge)

This report attempts to evaluate the above factors and develop the water budget for Salt Lake County for 1970-75 and for 1995. The technique used specifically consists of calibrating the procedure (and physical factors) to 1975 land use and population conditions and then extrapolating with demographic data to 1995 conditions.

A certain variability of water use and water diversion exists from year to year. Generally data on water supplies and water diversion are reported from the last five years (1970-75). When long-term records are non-existent or unobtainable, data for 1975 are used. 1975 precipitation in Salt Lake County was 14.6% above the long-term average while the 1970-75 precipitation at Salt Lake Airport was 14.3% above the long-term record.

Data are generally precise to not more than three significant figures. Where more than three figures have been reported the data should probably be rounded off to three figures.

Extensive use has been made of published and non-published reports as well as information obtained through personal communications with officials and agency personnel. Two reports, namely: "Water Resources of Salt Lake County, Utah", Tech, Pub. No. 31, Department of Natural Resources, Utah 1971, and "Utah Lake - Jordan River Hydrologic Basins Water Quality Management Planning Study" by Templeton, Linke, and Alsup and Engineering-Science, Inc., Salt Lake City, Utah, 1975 have been consulted extensively. Attempts have been made to acknowledge data sources in the bibliography as well as on table depictions and in the text.

Appreciation is hereby expressed to Cheryl Contant, Steve Jensen and Raymond Larsen who have helped produce the tables herein. The author also acknowledges the help of Mr. Terry Holzworth, Salt Lake Water Conservancy District, Mr. Barry Saunders, Utah Division of Water Resources, and Mr. Ed Feldt of the Utah Division of Water Rights.

2. SUMMARY

The following observations are pertinent regarding the present (1970-1975) water situation in Salt Lake County:

* The period of 1970-76 has been used to arrive at the general water budget for Salt Lake County. This period was approximately 14% wetter than 'normal' which resulted in irregular spilling conditions from Utah Lake. A fraction of the industrial and irrigation diversions from the Jordan River during 1970-75 may therefore, be due to spilling conditions from Utah Lake. The climatic sensitivity analysis shows low correlations however, between irrigation, industrial and municipal diversions and annual precipitation and/or temperature.

* In 1970-75 approximately 625,000 acre-feet per year of water was diverted for agricultural, industrial and municipal use on Salt Lake County. This is enough water to cover the County to a depth of 15 inches or to supply each inhabitant with about 1,150 gallons of water per day[1].

* Salt Lake County is not self-sufficient in water supply. Each year approximately 50,000 acre-feet are improted from the Provo River, which in turn imports water from the Duchesne and Weber Rivers, while about 10,000 acre-feet come from Tooele County. About 72% of the average annual flow in the Wasatch Front Streams is diverted prior to the water reaching the Jordan River. During 1970-75 about 94% of the average annual flow at Jordan Narrows was diverted. About half of the water diverted from the Jordan River is returned (as irrigation returns or groundwater), some is re-used for recreation, bird refuges, and industry on the Lower Jordan River.

* The 625,000 acre-feet of water diverted in 1970-75 in Salt Lake County came from the following sources:

Jordan River	51%	323,000 acre-feet/year
Wells and Springs	32%	142,000 acre-feet/year
Wasatch Front Streams	17%	108,000 acre-feet/year
Provo River	8%	50,200 acre-feet/year
Tooele County	1.5%	9,500 acre-feet/year

* The 625,000 acre-feet of water diverted in 1970-75 in Salt Lake County were intended for the following uses: (Diversions to or use for recreation or bird refuges on the Lower Jordan have not been included.)

Irrigation	47.4%	296,600 acre-feet/year
Industrial	25.6%	160,100 acre-feet/year
Residential & Municipal	21.6%	135,300 acre-feet/year
Stock (Cattle, horses, etc.)	5.4%	33,500 acre-feet/year

* A large difference exists in Salt Lake County as to water diversions and water use. For 1975, measurements and calculations yield a total water use of about 508,000 acre-feet per year, yet about 625,000 acre-feet per year were diverted.

* In 1970-75 the following approximate annual quantities of water were diverted for irrigation purposes:

From Jordan River	75%	221,000 acre-feet
From Wasatch Front Streams	13.5%	40,000 acre-feet
From Provo River	10%	30,000 acre-feet
From Wells and Springs	1.5%	5,000 acre-feet
TOTAL		296,000 acre-feet

* Stipulating an annual irrigation use of 5 acre-feet per year per acre results in an annual irrigation use for the estimated 35,000 acres of irrigated land in the County (excluding lawns and gardens) of about 175,000 acre-feet. The calculated use is approximately 120,000 acre-feet less than the amount of water actually diverted for irrigation in 1970-75.

* Well and Spring withdrawals in Salt Lake County have increased slowly over the last decade (about 1.5% per annum) to about 144,000 acre-feet per year in 1975. Well and Spring water use is as follows:

Public Water Supply	35%	50,900 acre-feet/year
Industrial Use	37%	53,900 acre-feet/year
Domestic and Stock Use	23%	33,500 acre-feet/year
Irrigation Use	4%	4,700 acre-feet/year

* Of the 160,000 acre-feet of water diverted for industry in 1970-75 in Salt Lake County 143,000 acre feet, or about 89 percent, went to Kennecott Copper Corporation.

* The per capita municipal system water use as monitored by Salt Lake City Water Department was an average of 0.264 acre-feet per capita per year in 1970-75. Linear regression analysis of per capita residential and municipal water consumptions for 1950-75 shows a slight downward trend with time.

* Typical costs of irrigation water in Salt Lake Valley are $2-$5 per acre-foot not including canal depreciation (canals are fully paid), water rights cost and some hidden administrative charges (special counsel, courts commission).
  Typical costs of residential and municipal water (M&I) in Salt Lake Valley are $100-$110 per acre-foot ($0.32 per 1,000 gallon) at the tap.

The following observations pertain to the water situation in Salt Lake County as it will develop over the next twenty years:

* In 1975-1995 the population in Salt Lake County is expected to increase by about 270,000 persons. Estimates are that the residential area population densities will decrease slightly except in certain communities (i.e., Sandy and West Jordan).

* By 1995 the increasing population in Salt Lake County will require development of an additional 50,000 acres of land for residential, commercial, and industrial use. This development will probably reduce the irrigated land in Salt Lake County from the present 35,000 acres to about 22,000 acres by 1995.

* The expected reduction in irrigated land from 35,000 acres to about 22,000 acres by 1995 should decrease irrigation diversions by about 65,000 acre-feet per year. How readily this water may be used for other purposes depends primarily on water quality, water rights and economic considerations.

* If one assumes a constant per capita use of residential and municipal water of 0.264 acre-feet per year per capita the additional population of 269,000 will need an extra culinary water supply of about 71,000

acre-feet per year by 1995.

* Future industrial use of water in Salt Lake County is difficult to estimate. However, if Kennecott Copper Corporation's use stays constant, the industrial use will probably increase by about 7 percent (an additional 10,500 acre-feet per year) by 1995.

3. RECOMMENDATIONS

In view of the foregoing conclusions the following recommendations are made:

* It is becoming increasingly important for irrigators, industries, and municipalities as well as private individuals to conserve our water for the most essential uses. Conservation is a vital step in increasing the efficiency of water utilization in Salt Lake County.

* Population growth will demand an additional culinary water supply of about 70,000 acre-feet per year by 1995. Steps need be taken to plan and construct the necessary facilities.
  Most likely this supply will come from several sources. Prospective sources and methods of supply include:

  -Little Dell Reservoir and improved utilization of Big and Little Cottonwood Creek waters,
  -Jordanelle Reservoir on the Provo River,
  -Increased pumping of groundwaters in the County,
  -Conversion of high quality irrigation waters.

* As irrigation water demands decrease, provisions need to be made to convert old irrigation water rights more rapidly to use for municipal and residential purposes. This is especially important regarding irrigation water rights to high quality waters (e.g., Provo River, Big and Little Cottonwood Creeks).

* To upgrade the Jordan River water quality to State standards and to maintain the quality of our water supplies, it is necessary to improve the integration of water quantity and water quality planning.

* Water supply planning in Salt Lake County needs to be an integral part of development planning. A greater coordination of city, county and private efforts is needed for a better approach to this problem. In addition the coordination between municipal, irrigation and self-supplied industrial users need be strengthened.

* Groundwater supplies are important in Salt Lake County especially during times of drought. The use of these supplies need be integrated with the use of surface water supplies. To accomplish this it is necessary to improve our knowledge of groundwater aquifers, their hydraulic characteristics, and their recharge areas. Artificial recharge of aquifers needs to be explored as an additional method of water storage.

* To conserve our water for beneficial uses requires better knowledge of our water needs as contrasted with water uses or water diversions. Information is needed on specific water needs (e.g., irrigation, industrial and municipal) in Salt Lake County and the factors (population density, canal conditions, climatic conditions, etc.) which effect the water needs.

* Salt Lake County should resume its support of the United States Geological Survey in publishing the annual "Hydrologic and Climatologic Data" for Salt Lake County. Without these publications, it becomes a major negotiating task to obtain the records of the various water supplies and diversions taking place in Salt Lake County.

4. COUNTY DEVELOPEMENT PATTERN

Table 1 which contains most of the pertinent demographic data used in this study is based on information from: "Economic and Demographic Futures 1975-1995", Salt Lake County 208 Water Quality Project, as well as personal communications with Salt Lake County Planning Department personnel.

From 1975 to 1995 a population growth of 51% is expected (about 2% per annum). This population increase will mean an increase of the developed acreage in the County of about 53,000 acres, of the residential acreage of about 24,000 acres, and of the industrial and commercial acreage of about 8,000 acres. The largest population increases are expected in Sandy and West Jordan.

It is often thought that the rapidly escalating construction costs are bringing higher population densities due to smaller lots and planned unit developments (PUD). The data in Table 1 do not support this argument. As a matter of fact, in Salt Lake County the number of persons per residential acre is expected to go from 16.9 in 1975 to 14.3 in 1995. Sandy, Riverton, West Jordan, and South Jordan look to be candidates for density increases among the residential population.

Since residential population densities are exceedingly difficult to forecast due to economics and legislative changes this report assumes that the population density in Salt Lake County will essentially remain constant to 1995.

Table 1A gives the available data on irrigated areas in Salt Lake Valley for the thirties, the late sixties and for 1972. Although the

	Salt Lake City	South S.L.	Murray	Midvale	West Jordan	South Jordan	River-ton	Sandy	All Cities	Unincorp. Areas	County Total
1975 Totals:											
Population	175,580	7,700	23,710	8,790	18,890	3,790	4,360	32,360	275,200	251,800	527,000
Dev. Acreage	25,190	2,005	3,672	1,134	4,206	755	882	6,457	44,301	41,323	85,624
Res. Acreage	7,589	341	1,492	477	1,288	375	344	2,003	13,909	17,210	31,119
Ind. & Comm. Acr.	3,891	559	700	207	393	58	22	285	6,115	4,318	10,433
Pers./Res. Acr	23.1	22.6	15.9	18.4	14,7	10.1	12.7	16.2	19.8	14.6	16.9
1975-1995 Additions:											
Population	5,460	-0-	11,980	5,120	46,700	10,300	9,080	87,700	176,400	92,300	268,700
Dev. Acreage	4,462	-0-	1,204	650	3,875	915	780	6,100	17,986	~33,000	~51,000
Res. Acreage	411	-0-	813	323	2,600	652	576	4,160	9,595	14,797	24,392
Ind. & Comm. Acr.	4,005	-0-	300	270	750	100	60	900	6,385	~ 1,800	~ 8,200
Pers./Res. Acr.	13.3	-0-	14.7	15.9	17.6	15.8	15.8	21.1	18.4	6.24	11.0
1995 Totals:											
Population	181,000	7,700	35,900	13,900	65,600	14,100	13,400	120,100	451,600	344,100	795,700
Dev. Acreage	29,652	2,005	4,876	1,784	8,081	1,670	1,662	12,557	62,287	~74,000	~137,000
Res. Acreage	8,000	341	2,305	800	3,948	1,027	920	6,163	23,504	32,007	55,511
Ind. & Comm. Acr.	7,896	559	1,000	477	1,143	158	82	1,185	12,500	~ 6,100	~ 18,600
Pers./Res. Acr.	22.6	22.6	15.5	17.4	16.6	13.7	14.6	19.5	19.2	10.7	14.3

[1]Data from: "Economic and Demographic Futures 1975-1995." Salt Lake County 208 Water Quality Project, Salt Lake County, January 1977 and Salt Lake County Planning Department (Personal Communications).

numbers in Table 1A indicate a decrease with time of the irrigated area in Salt Lake Valley the discrepancies in the estimates make it difficult to forecast an irrigated acreage for 1995. The acreages do not include lawns and gardens.

To remedy this situation a method was devised which estimates irrigated acreages by taking into account the developed acreages resulting from the population growths. The method subtracts a fraction of the developed acreage from the land area which at one time or another has been under irrigation. The results which in this manner incorporate the non-linearity of the situation are shown in Table 1B.

Using a factor of 30% for the developed land which comes from formerly irrigated land the method gives an irrigated acreage estimate of 22,000 acres for 1995.

This means that about 13,000 acres of presently (1975) irrigated land will be used for development by 1995. The majority of the 13,000 acres will probably come from land on the east side of the Jordan Valley. Some of the land on the east side is presently being irrigated with high quality water from Big and Little Cottonwood Creeks while most of the land on the west side (except the high west bench) is irrigated with Jordan River water.

TABLE 1A.

IRRIGATED AREAS IN JORDAN VALLEY

Year & Data Source	East Side (acres)	West Side (acres)	Total (acres)
1935: (Israelson & Clyde)	21,400	26,300	47,700
1967-69: (Div. of Water Rights)	14,000	29,600	43,600
1972: (208 Study)	5,200	22,500	27,700

TABLE 1B.

PROJECTED IRRIGATED AREAS IN JORDAN VALLEY

	1935	1955	1975	1995
Population	203,000	322,000	527,000	796,000
Developed Area (acres)	30,000	50,000	85,600	137,000
Land which has been Irrigated (acres)	57,000	59,000	61,000	63,000
Dev. area on land which has been Irrig.	30%	30%	30%	30%
Land under Irrigation (acres)	48,000	44,000	35,000	22,000

Irrigated acreages do not include lawns and gardens.

5. COUNTY WATER SOURCES

The U.S. Geological Survey (1971) assessed the 1964-68 water budget for the Jordan Valley to have an inflow of 1,066,000 AF/Yr of which 464,000 AF/Yr came from precipitation, 463,000 AF/Yr from streamflow and 139,000 AF/Yr from subsurface inflows. Outflows were given as: evapo-transpiration 735,000 AF/Yr, streamflows 324,000 AF/Yr and subsurface outflows 4,000 AF/Yr.

Surface Sources

Figure 1 gives a view of the most important streams and canals in Salt Lake County. Many of the canals date back to the last century.

The particular water sources utilized for water supply in Salt Lake County are given in Table 2. Two of the water sources, Provo River and Kennecott Pipeline, are outside the County. The Provo River which receives some of its water from the Colorado River drainage via the Duchesne Tunnel supplies water to Salt Lake County via the Salt Lake Aqueduct, the Utah Lake Distributing Canal (most of this flow comes from the Jordan River above the Jordan Narrows), and the Provo Reservoir Canal. The Salt Lake Aquaduct and the Utah Lake Distributing Canal drain from Deer Creek Reservoir while the Provo Reservoir Canal diverts water from the Provo River near Olmstead.

Two of the Wasatch Front streams namely, City Creek and Parleys Creek are extensively utilized as domestic water supplies while most of the water in Mill Creek goes unused. Big and Little Cottonwood Creek, the two largest Wasatch Front streams, are diverted near their canyon mouths, however, lack of storage facilities limit their usefulness.

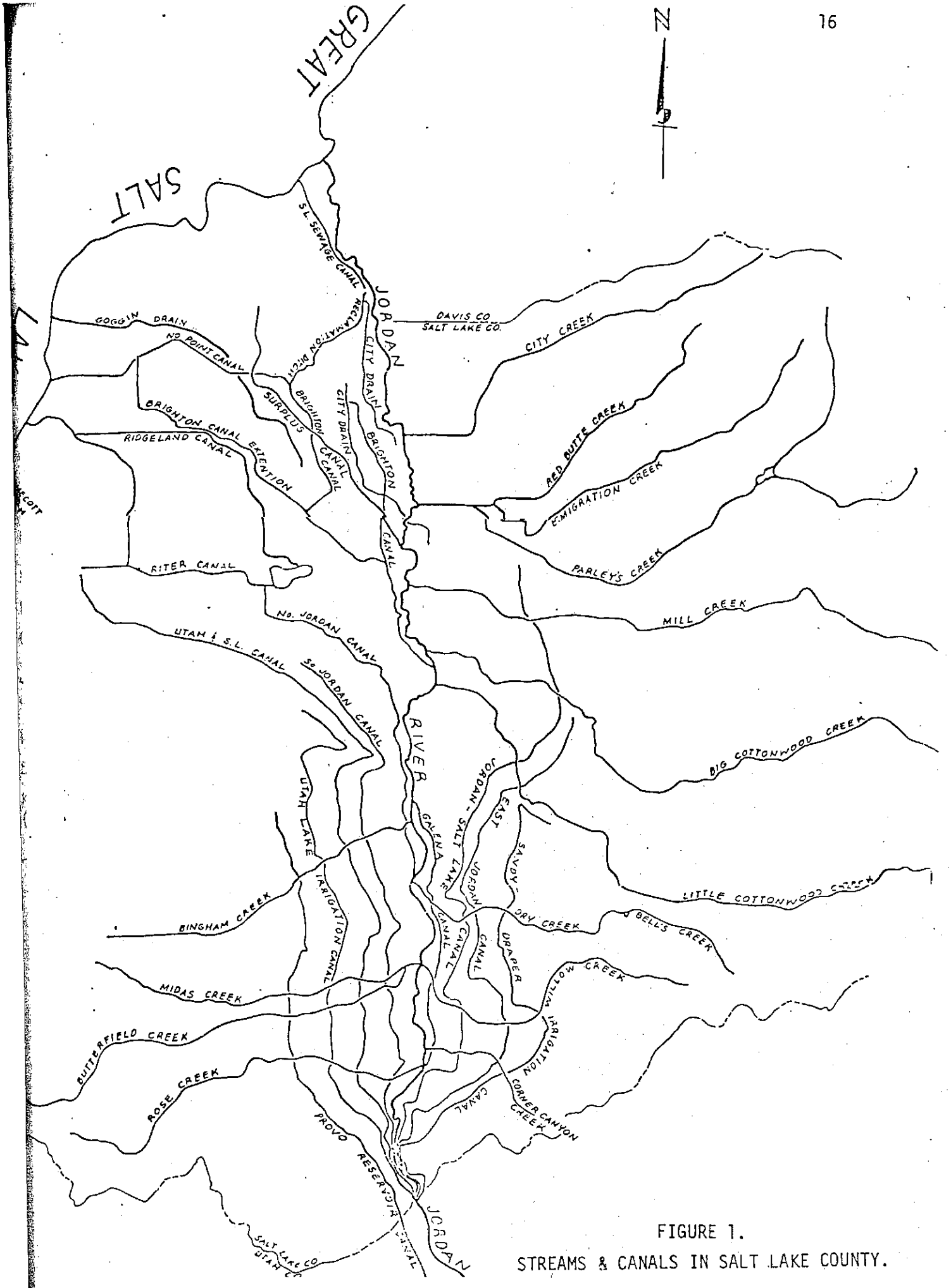


FIGURE 1.
STREAMS & CANALS IN SALT LAKE COUNTY.

TABLE 2

SALT LAKE COUNTY WATER SOURCES

	Reservoir Name	Reservoir Usable Cap. (acre-feet)	Reservoir Detention Times (days)	Average Annual Flows (AF/Yr)	1970-75 Diversion to S.L. Co. (AF/Yr)
Provo River Aquaduct & Two Canals	Deer Creek Jordanelle[1]	150,000 325,000	202 561	273,000[4] (1953-75)	50,200[2]
Little Cottonwood Creek				48,200[3]	38,200
Big Cottonwood Creek	Twin Lakes Lake Mary Argenta[1]	937 742 12,000		53,100[3]	37,700
Mill Creek				10,900[3]	3,600
Parleys Creek	Mountain & Little Dell[1]	3,200 30,000	63 560	18,600[3]	15,920
Emigration Creek				5,900[3]	2,380
Red Butte Creek	Red Butte	307	42	2,700[3]	640
City Creek				11,600[3]	9,650
Jordan River (at Jordan Narrows)	Utah Lake Lampton[1] Riverton[1]	830,000 19,500 23,200	1,150	280,000[4] (1930-75)	323,000[6] (inc. re-use)
Wells					123,000[5]
Springs				19,000	19,000
Kennecott Pipeline (from Tooele County)				9,500	9,500[7]

[1] Proposed Reservoirs
[2] Includes flows to SLC aquaduct, Provo Reservoir Canal and Utah Lake Distributing Canal.
[3] Data from: Glenne, Hadley, Borg & Eckhoff, "Water Pollution and Recreational Use in Little Cottonwood Canyon", Civil Engineering Department, University of Utah, 1973.
[4] Data from: "Water Resources Data for Utah", U.S. Geological Survey, 1975.
[5] Data from: "Developing a State Water Plan, Groundwater Conditions in Utah, Spring of 1976", Utah Division of Water Resources, 1977.
[6] Data from: "Annual Report, Utah Lake & Jordan River Distribution for the Year 1974", Brad Gardner.
[7] Data from: "Water Resources of Salt Lake County", Tech. Pub. No. 31, Department of Natural Resources, Utah, 1971.

The Jordan River is extensively diverted for irrigation and industrial purposes at Jordan Narrows. During the summer this diversion may leave the River almost dry at Bluffdale and return-flows and groundwater inflows make up most of the streamflow through Salt Lake City. Reuse of the Jordan River water takes place. Pollution from return-flows and storm runoff is a problem in the Lower Jordan River.

Table 3 gives a breakdown of water supplies and diversions in Salt Lake County during 1975. About 76% of the water came from surface sources. In the case of irrigation diversions from the Provo River and Wasatch Front streams data could only be obtained for the period 1964-68.

Table 4 gives the annual streamflows for Jordan River (Jordan Narrows and 2100 South), Big Cottonwood and Little Cottonwood Creeks (at canyon mouths) during the last forty-five years. To illustrate the sensitivity of the annual flows in these streams to drought and wet periods frequency analyses have been performed on the data in Table 4 and the results are plotted in Figure 2. The 100-year drought flows in Little and Big Cottonwood Creeks are about 50% and 43% respectively of the mean annual flows while the 100-year drought flow in the Jordan River at the Jordan Narrows is about 82,000 AF/Yr or about 35% of the mean annual flow.

Groundwater Sources

Groundwater sources are becoming increasingly important as supplies of domestic water in Salt Lake County, especially during times of drought. Groundwater supplies however, are vulnerable to paving and canalization of its recharge areas. Since the recharge areas of many of the aquifers in the Jordan Valley lie along the east-bench area care must be taken to prevent urbanization from blocking the recharge of the aquifers.

TABLE 3.

1975 SALT LAKE COUNTY MAJOR WATER SUPPLIES

(Water Quantities are in AF/Yr)

Source	Canal	Residential & Municipal Diversions	Irrigation Diversions			Industrial Diversions	Domestic & Stock Diversions	Total Diversions
			East Side	West Side	Total			
Provo River	Utah Lake Dist.			5,800[2]	5,800[2]			5,800
	Provo Reservoir			23,800	23,800			23,800
	SLC Aquaduct	20,600[1]						20,600
Little Cottonwood		13,250[7]	24,900[2]		24,900[2]			38,200
Big Cottonwood		25,100[7]	12,600[2]		12,600[2]			37,700
Mill Creek		1,350[7]	2,270[2]		2,270[2]			3,600
Parleys Creek		15,920[7]						15,920
Emigration Creek		2,380[7]						2,380
Red Butte Creek		640[7]						640
City Creek		9,650[7]						9,650
Jordan River	Galena		1,380		1,380	5,800		7,180
	Jordan & Salt Lake		9,700		9,700			9,700
	East Jordan		50,575		50,575			50,575
	Draper		11,100		11,100			11,100
	Utah & Salt Lake			50,000	50,000	26,100		76,100
	South Jordan			35,000	35,000			35,000
	Beckstead			900	900			900
	North Jordan			11,000	11,000	42,800		53,800
	Brighton			19,435	19,435			19,435
	Utah Lake Dist.			12,450	12,450			12,450
	Utah Power & Light					1,410		1,410
Tooele County	Kennecott Pipeline					9,500[2]		9,500
Wells		43,300	550	4,050	4,600	43,400	33,500	125,000[5]
Springs		7,600	950		950	10,500		19,000
		139,790[3]	114,050[6]	162,435[6]	276,485[6]	139,510[4]	33,500	589,200

[1] SLC Water Department holds water rights to 56,800 AcFt/Yr from Deer Creek Reservoir.
[2] Data from: "Water Res. of Salt Lake County", Tech. Pub. No. 31, Dept. of Natural Resources, Utah, 1971.
[3] Includes approx. 10,500 AF/Yr of water used for commercial and industrial purposes.
[4] Includes approx. 113,000 AF/Yr to Kennecott Copper Corporation.
[5] Data from: "Developing a State Water Plan, Groundwater Conditions in Utah, Spring 1976", Utah Div. of Water Resource, 1977
[6] Data from: "Annual Report, Utah Lake & Jordan River Dist. for 1975", Brad Gardner, Comm.
[7] SLC Water Department Data for 1975 personal communications).

TABLE 4.

AVERAGE ANNUAL STREAMFLOWS (AF/Yr)

Water Year	JORDAN RIVER		Big Cottonwood Creek	Little Cottonwood Creek
	Jordan Narrows	2100 South (above diversion)		
1930	247,000			
1	169,000		30,100	26,100
2	157,000		49,900	47,800
3	129,000		46,900	34,900
4	89,100		20,200	20,600
1935	75,500		39,600	40,200
6	140,200		46,100	43,400
7	197,600		39,100	40,600
8	210,300		49,200	55,500
9	229,900		35,800	45,100
1940	203,800		31,600	38,200
1	173,800		47,300	48,500
2	205,200		54,400	48,000
3	218,800		44,300	39,400
4	201,100	197,800	49,500	45,600
1945	197,600	180,400	46,900	47,800
6	241,800	180,100	48,400	33,100
7	218,600	202,500	53,900	40,600
8	269,800	220,500	54,600	47,100
9	252,100	235,000	50,900	48,800
1950	266,300	226,600	50,800	48,800
1	252,600	215,800	52,500	44,400
2	418,800	476,900	69,200	92,500
3	509,600	489,700	54,000	47,100
4	325,700	264,300	34,500	35,300
1955	205,300	191,100	41,200	39,400
6	222,900	204,500	43,600	42,700
7	186,000	223,900	58,500	42,900
8	255,000	252,100	59,600	46,300
9	233,300	220,800	39,600	33,100
1960	205,200	180,700	41,800	38,400
1	118,100	132,100	24,600	25,900
2	174,100	168,100	52,400	49,400
3	164,400	157,900	40,100	40,600
4	165,400	199,300	49,400	46,400
1965	169,900	239,800	58,600	59,100
6	250,400	231,100	39,100	34,400
7	214,100	240,300	50,500	53,900
8	231,600	278,100	51,300	52,700
9	346,600	373,400	66,300	63,700
1970	360,900	389,000	55,000	47,800
1	341,300	378,800	61,900	55,600
2	347,800	374,300	58,400	48,300
3	297,400	260,000	55,200	57,800
4	417,000	430,400	61,300	52,400
1975	287,400	388,100	66,200	62,300
MEAN	235,000	266,000	48,300	45,600
STD. DEV.	86,600	97,400	10,700	11,600

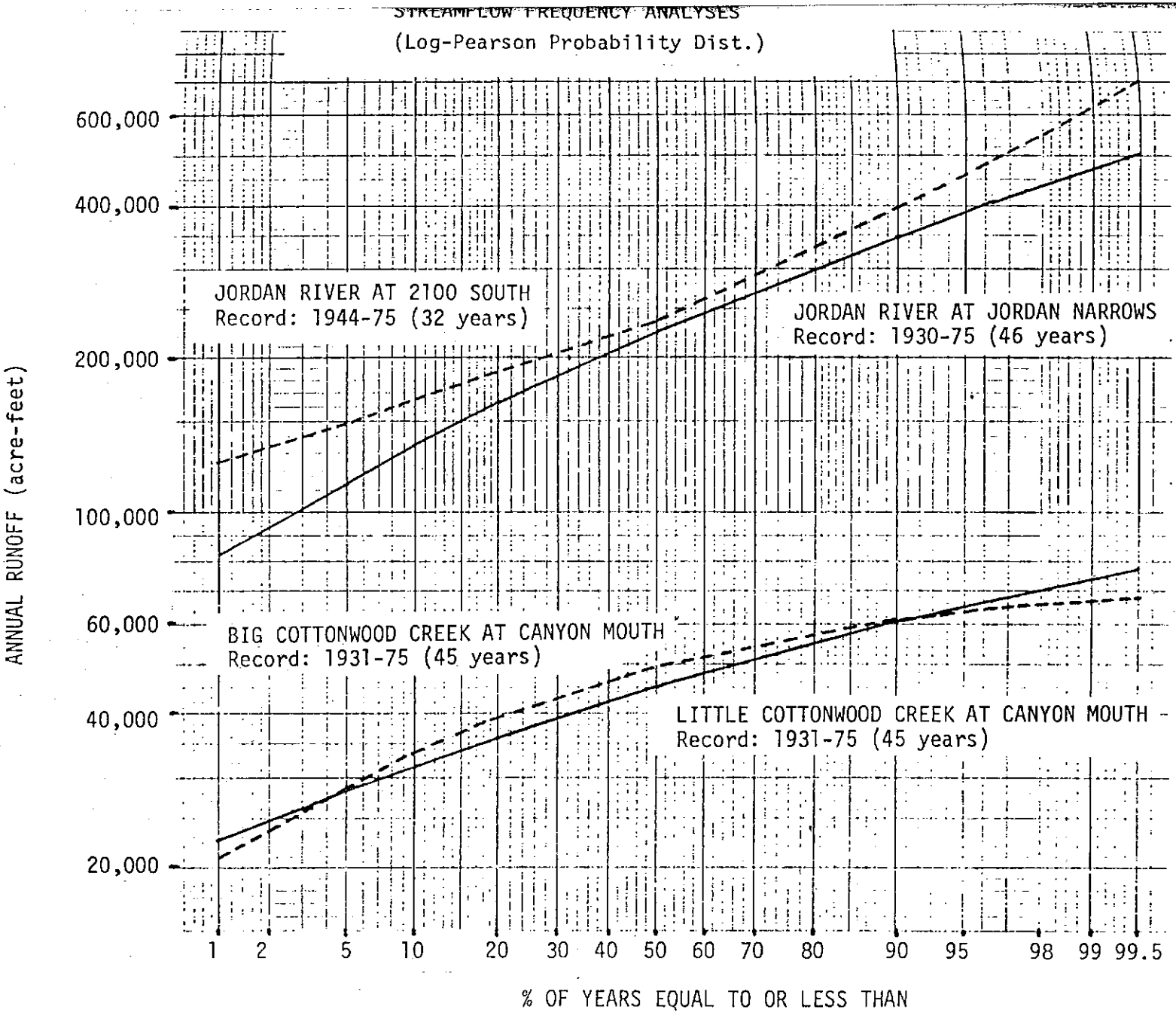

STREAMFLOW FREQUENCY ANALYSES
(Log-Pearson Probability Dist.)
ANNUAL RUNOFF (acre-feet)
600,000
400,000
200,000
100,000
60,000
40,000
20,000
JORDAN RIVER AT 2100 SOUTH
Record: 1944-75 (32 years)
JORDAN RIVER AT JORDAN NARROWS
Record: 1930-75 (46 years)
BIG COTTONWOOD CREEK AT CANYON MOUTH
Record: 1931-75 (45 years)
LITTLE COTTONWOOD CREEK AT CANYON MOUTH
Record: 1931-75 (45 years)
1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5
% OF YEARS EQUAL TO OR LESS THAN

Table 5 shows the wells and spring withdrawals in Jordan Valley for 1965-1976. The withdrawals have been increasing at a rate of about 1.5% per annum and presently about 125,000 AF/Yr, or about 20% of Salt Lake County's water diversions, are being pumped. The annual recharge to subsurface water in the Jordan Valley has been estimated at 367,000 AcFt/Yr by the U.S. Geological Survey (1971). Mr. Ted Arnow of the U.S. Geological Survey in Salt Lake City has stated that groundwater aquifers in Jordan Valley may be pumped for another 40,000 AF/Yr as long as recharge is not hindered.

Water Quality

Table 6 gives an overview of typical water qualities of water sources in Salt Lake County. The high quality water sources are the Wasatch Front streams, with the exception of Emigration Creek, the Provo River and the east-side wells. These high quality water sources presently furnish about 37% of the water diverted for use in Salt Lake County. Approximately 60% of the high quality water is used for residential and municipal purposes.

The quality of the water in the Jordan River at the Jordan Narrows is such that considerable water treatment would be necessary to remove the dissolved constituents and bacteria and render the water suitable for the culinary purposes.

The dissolved solids content of groundwater in Jordan Valley is generally lowest (100-250 mg/l) in the aquifers which have their recharge area in the Cottonwood region. This is because the recharge water in this area is of high quality and the bedrock is primarily crystalline and relatively insoluble. Along the Jordan River and the northern part of the East Bench the dissolved solids content of the groundwater runs 500-1000 mg/l. Near the Oquirrh mountains and Great Salt Lake the dissolved solids content of the

groundwater usually is above 1000 mg/l.

An account of the occurrance of the major ions (Ca^{++}, Mg^{++}, Na^{+} & K^{+}, HCO_3^{-}, SO_4^{--}, Cl^{-}) and minor constituents (nitrate, fluoride, boron) of Jordan Valley groundwater is contained in; "Water Resources of Salt Lake County, Utah", Tech, Pub. No. 31, Department of Natural Resources State of Utah, 1971. A more detailed description of the Valley's groundwater aquifers may be found in this report and the annual reports on "Ground-water Conditions in Utah", published by the Division of Water Resources.

TABLE 5.

WELLS AND SPRING WITHDRAWALS IN JORDAN VALLEY

(AF/Yr)

	Irrigation	Industry	Public Supply	Domestic & Stock	Total
1960					
1					
2					
3	8,000	48,400	36,200	37,200	129,000
4					129,000
5	4,000	50,800	32,500	34,200	121,000
6	8,500	51,500	52,400	32,900	145,000
7	5,400	40,100	43,500	32,900	121,900
8	5,200	43,400	44,800	32,900	126,300
9	5,600	50,800	38,400	33,200	128,000
1970	4,200	48,800	47,900	33,500	134,400
1	5,400	49,000	46,800	33,800	135,000
2	6,100	51,000	52,900	33,500	143,500
3	5,100	53,500	55,700	33.500	147,800
4	5,600	51,200	59,000	33,500	149,300
5	5,600	53,800	50,900	33,500	144,000
6	5,600	46,600	57,500	33,500	143,200

Source: Ground Water Conditions in Utah, Annual Reports, USGS & DWR.

Personal Communication with R.W. Mower USGS, Salt Lake City, Utah.

TABLE 6.

TYPICAL WATER QUALITY OF WATER SOURCES

	MPN Coliforms no./100ml	Suspended Solids mg/l	Total Dissolved Solids mg/l	Biochemical Oxygen Demand mg/l	Dissolved Chloride mg/l
Little Cottonwood[1]	266	71	130	1.1	23
Big Cottonwood[1]	135	50	180	2.3	12
Mill Creek[1]	250	17	340	1.8	13
Parleys Creek[1]	25		400	3	
Emigration Creek[1]	3,000	5	470	2.6	45
Red Butte Creek[1]	36		390	2	13
City Creek[1]	25		280	2	18
Provo River -Deer Creek Res.	41		240	2	12
Jordan River -Jordan Narrows	2,000	10	950	4	222
-Cudahy Lane	17,000	67	855	6	172
Groundwater -Holladay Area			100-500		5-20
-Draper Area			500-1000		50-300
-Magna Area			1000-2000		100-400

[1]Data for Wasatch Front streams near canyon mouths.

6. COUNTY WATER DIVERSIONS

Table 7 quantifies the major water diversions in Salt Lake County during 1970-75. With the exception of residential and municipal water the amounts of water diverted may be larger than those actually used due to losses and by-passing of water.

The total amount diverted, about 625,500 AF/Yr is enough water to cover the entire Salt Lake County to a depth of 15 inches or to supply each inhabitant with about 1,150 gallons per day. When compared with similar communities in the U.S.A. the amount diverted for use is high.

Irrigation, with 47% of the diverted water, is the highest user. Industry with 26% is second closely followed by residential and municipal use with 22%. These numbers suggest that it may be somewhat futile during times of drought to concentrate one's efforts on conserving domestic waters, especially as long as high-quality (culinary quality) water is also being diverted by irrigation and industry (Provo Reservoir Canal, Utah Lake Distributing, Little Cottonwood Creek, etc.).

Residential and Municipal Use

Table 8 shows the total water deliveries made by municipal systems in Salt Lake County during 1970-75. The average use of 135,000 AF/Yr during 1970-75 represents about 22% of the water diverted. Of the 135,000 AF/Yr approximately 10,000 AF/Yr go to industrial uses (bottling plants, etc.) The maximum summer day use is approximately 240% of the average day use.

TABLE 7

SALT LAKE COUNTY WATER USES AND DIVERSIONS 1970-1975

(AF/Yr)

Year	Residential and Municipal Use [1]	Irrigation Diversions [2]	Special Industrial Diversions [3]	Stock Use (Groundwater)	Total Diversions
1970	119,000	304,900	153,000	33,500	610,500
1971	124,000	300,500	157,800	33,800	616,100
1972	142,000	305,600	162,700	33,500	643,800
1973	138,000	280,600	177,400	33,500	629,500
1974	148,000	311,400	170,400	33,500	663,300
1975	141,000	276,500	139,400	33,500	590,400
Average	135,300	296,600	160,100	33,500	625,500
%	21.6%	47.4%	25.6%	5.4%	100%

[1] Data includes; Salt Lake City Water Department, Salt Lake County Water Conserv. Dist., and other municipal systems. Approximately 10,000 AF/Yr go to industrial uses. Data for 1970 and 1975 are estimated.

[2] Includes 39,800 AF/Yr from Wasatch Front streams, 23,800 AF/Yr from Provo Reservoir Canal, and 19,400 AF/Yr from Brighton Canal.

[3] Includes 9,500 AF/Yr from Tooele County (Kennecott Pipeline) and 1,400 AF/Yr to Utah Power and Light as well as 10,400 AF/Yr from Adamson Spring.

RESIDENTIAL AND MUNICIPAL WATER USE IN SALT LAKE COUNTY

	Salt Lake City Water Department[1]		Salt Lake County Water Cons. Dist.[2]	Other Municipal Systems[2]	TOTAL
	Total Use AF/yr	Per Capita AF/cap/yr	AF/yr		
1950	50,700	0.246			
1	51,300	0.241			
2	59,100	0.276			
3	61,500	0.279			
4	63,200	0.279			
5	63,400	0.268			
6	67,200	0.268			
7	61,700	0.240			
8	70,500	0.268			
9	61,700	0.229			
1960	66,300	0.241			
1	66,500	0.237			
2	66,900	0.235			
3	63,700	0.221			
4	66,300	0.224			
5	59,800	0.213			
6	77,300	0.254			
7	70,000	0.229			
8	68,600	0.222			
9	73,400	0.235			
1970	75,400	0.241	13,400	16,200[3]	105,000[3]
1	76,500	0.250	17,200	30,300	124,000
2	92,000	0.296	19,900	30,100	142,000
3	82,700	0.262	21,400	33,900	138,000
4	86,900	0.261	24,900	36,200[4]	148,000[4]
5	93,400	0.271	23,900	33,700[4]	141,000[4]
6			26,000		

1 Data from: Report on Engineering Study Water Distribution System Salt Lake City, Utah 1976. The Pitometer Assoc. Engrs. New York, 1977

2 Data from: Salt Lake County Conservancy District (Personal Communications).

3 Does not include data from: Sandy, West Jordan, Taylorsville, Bennion, Magna.

4 Incomplete data; estimated quantity.

The per capita domestic water consumptions have been calculated from the Salt Lake City Water Department data for 1950-1975. When regressed against time the per capita water consumptions show a slight declining trend during 1950-1975. These results are in agreement with those obtained by Kirkpatrick (1976).

The average per capita water consumption for 1970-75 as measured by the Salt Lake City Water Department was 0.264 AF/Yr/Cap or 236 gall/cap/day. This figure is used in this report as being representative of the per capita residential and municipal water use in Salt Lake County during 1975-1995.

Figure 3 attempts to correlate domestic water use with population density. Generally speaking the per capita domestic water use can be seen to decrease as the population density increases. A minimum use of about 100 gallons per capita per day was found to exist irregardless of population density. The records of the various municipal water companies in Salt Lake County measure a higher per capita water use than indicated in Figure 3. This is due to a considerable amount of water going to irrigation, commercial and industrial use.

Table 9 which is taken from Bishop (1975) as revised by Mr. Terry Holzworth of the Salt Lake County Water Conservancy District details the water deliveries by the various municipal systems in Salt Lake County. The many systems involved testify to the water delivery complexities and to the difficulty in coordinating development and obtaining efficiency. Table 9 also gives the status of the various water systems in regard to Utah State Division of Health approval. Only two systems, Salt Lake City Corp. and Salt Lake County Conserv. District, are fully approved.

FIGURE 3.

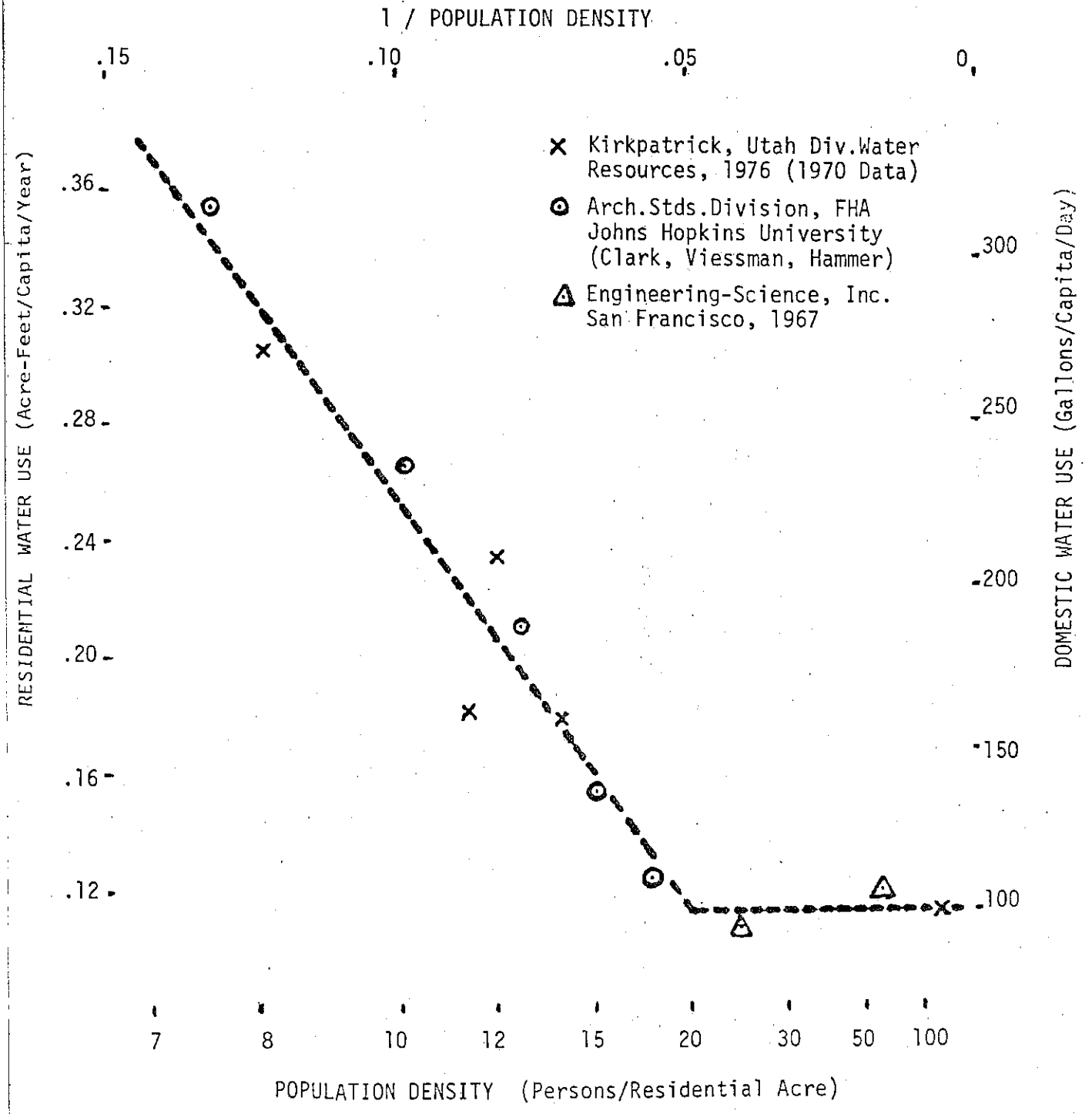
AVERAGE PER CAPITA RESIDENTIAL WATER USE IN SALT LAKE CITY

1.0 Acre-Feet/Capita/Year ≅ 893 Gallons/Capita/Day

B. Glenne, Civil Engineering Department, University of Utah
April 1977

$$\text{Water Use (AF/Cap/Yr)} = \frac{2.73}{\text{Pop.Density}} - 0.0184$$ (Correlation Coeff. = 0.94)

(The equation above is valid for a Pop.Density less than 20 per acre)



Kevin Brown

{ D.O.W.
  Our Drinking Water

Av. Household Usage
250 per person

TABLE 9.
MUNICIPAL WATER SYSTEM SUPPLIES IN SALT LAKE COUNTY
(AF)

	1970	1971	1972	1973	1974	1975	1976	Approval Status (Ut. Div. of Health
Bell Canyon	-	130	-	220	340	360	-	Not Approved
Chesterfield Imp. District	410	410	350	350	380	430	400	Classification Pending
Copperton Imp. District	-	260	-	-	-	-	-	Provisionally Approved
County Water System	-	2,200	-	-	-	-	-	
Draper Irrigation Company	-	740	-	760	920	840	900	Class. Pending
Granger/Hunter	7,300	8,500	8,900	8,500	9,200	9,600	-	Prov. Approved
Harriman Pipeline Co.	100	90	100	100	120	-	-	Class. Pending
Holladay Water Co.	2,400	2,500	2,800	2,400	3,000	-	-	Prov. Approved
Kearns Imp. District	3,200	3,500	3,800	3,500	4,100	3,700	3,100	Prov. Approved
Lark	270	270	190	120	120	-	-	Prov. Approved
Magna	-	1,300	1,800	1,300	1,900	-	-	Prov. Approved
Midvale City	2,400	2,400	2,500	3,100	3,200	-	-	Prov. Approved
Murray City	5,100	5,400	6,100	6,600	7,300	5,900	-	Prov. Approved
Riverton	-	350	650	740	1,100	-	-	Prov. Approved
Salt Lake City Corp.	75,200	76,600	91,900	82,900	86,800	83,400	-	Fully Approved
Salt Lake County Water Conserv. Dist. (Direct Deliveries only)	4,400	5,000	5,800	5,700	6,900	6,300	7,100	Fully Approved
Sandy City	-	4,600	6,500 est.	9,900	8,800	7,900	-	Prov. Approved
South Jordan	370	530	520	510	690	670	-	Prov. Approved
So. Salt Lake	2,400	2,300	2,800	3,000	2,900	3,000	-	Prov. Approved
Spring Creek Irrig. Company	540	540	610	520	620	-	-	Prov. Approved
Taylorsville - Bennion Impr. Dist.	-	2,300	3,000	3,200	4,600	4,400	-	Prov. Approved
Union - Jordan	-	1,500	-	-	-	-	-	
West Jordan	-	1,300	1,900	2,800	3,100	2,700	3,800	Prov. Approved
White City	1,000	1,200	1,300	1,400	1,800	1,700	-	Prov. Approved
Totals:	105,000[1]	124,000	142,000	138,000	148,000	130,900[2]		

[1] Incomplete data

[2] Incomplete data; total estimated at 141,000 af/yr (0.268 af/cap/yr).

The cost for residential and municipal water as delivered at the tap in Salt Lake City is about $0.32 per 1,000 gallon, or $100-$110 per acre foot. This cost does not seem to deter people from using extensive amounts of water for irrigation of lawns, flowers, trees, etc. The average personal residential use of water is believed to be 130-150 gallons/cap/day which means that on the average we use 85-105 gallons/cap/day for "other" purposes.

Irrigation Diversions

The exact quantities of water diverted for irrigation use in Salt Lake County are difficult to determine due to the complex canal system and the number of people and agencies which hold water rights and/or operate diversion structures. Based on consumptive uses and irrigated acreages, it appears that an extremely large quantity of irrigation water is being diverted in Salt Lake County.

Table 7 gives the average irrigation diversion during 1970-75 as 296,600 AF/Yr, or 47.4% of the total diverted water in Salt Lake County. Table 7 gives a breakdown of the various water diversions and canal flows during 1975 while Table 10 gives an overview of the irrigation diversions during 1962-75. During 1970-75 Utah Lake was full and some of the irrigation diversions from the Jordan River may have been flood spill rather than irrigation water.

The Division of Water Rights has estimated that in 1967-69 about 43,600 acres of land were under irrigation in Salt Lake County with about 32% being on the east side of the Jordan River (see Table 1A). This estimate does not include lawns and gardens. The land under irrigation in 1935 was approximately 47,700 acres with about 45% on the east side of the Jordan

TABLE 10.

1962-1975 IRRIGATION DIVERSIONS TO SALT LAKE COUNTY

(Water Quantities in Acre-Feet per Year)

Year	Jordan River (excluding Brighton Canal)[1]	Brighton Canal[2]	Provo Reservoir Canal[3]	Wasatch Front Streams[3]	Wells & Springs	Total
1962	197,800	19,400	23,800	39,800		280,800
3	179.600	19,400	23,800	39,800	8,000	270,600
4	188,700	19,400	19,530	48,300		275,900
1965	191,100	19,400	34,400	54,000	4,000	302,900
6	264,700	19,400	23,750	42,300	8,500	358,700
7	209,700	19,400	30,460	47,800	5,400	312,800
8	207,400	19,400	23,800	39,800	5,200	295,600
9	223,200	19,400	23,800	39,800	5,600	311,800
1970	217,700	19,400	23,800	39,800	4,200	304,900
1	212,100	19,400	23,800	39,800	5,400	300,500
2	216,500	19,400	23,800	39,800	6,100	305,600
3	192,500	19,400	23,800	39,800	5,100	280,600
4	222,800	19,400	23,800	39,800	5,600	311,400
1975	188,000	19,400	23,800	39,800	5,600	276,600

[1] Approximately 5,800 AF/Yr in the Utah Dist. Canal comes from Deer Creek Reservoir.

[2] Data for one year from: "An Analysis of the Water Balance in the Jordan River", Civil Eng. Dept., University of Utah, 1973.

[3] Data for 1964-68 from: "Water Resources of Salt Lake County, Utah", Tech. Pub. No. 31, Dept. of Natural Resources, Utah 1971. Data for 1962, 1963, and 1968-75 are flows for 1964-68 obtained from said document.

[4] Incomplete data.

river. Planimetering of infra-red photographs taken by NASA during 1972 produced an irrigated acreage of about 28,000 acres in Salt Lake County. Table 1B estimates the irrigated acreage in Salt Lake County in 1975 at 35,000 acres.

To estimate the total irrigation water requirement in Salt Lake Valley it is necessary to know the irrigation requirement per acre for the crop in question as well as the expected transmission losses. The Utah State Division of Water Rights in its adjudication proceedings uses a figure of 10% for canal losses and about 5.0 AF/Yr per acre for its irrigation requirement for alfalfa in Salt Lake Valley. A figure of 5.0 AF/Yr per acre for a diversion requirement (irrigation requirement plus canal losses) was decided upon after consultation with the Division of Water Resources.

By multiplying 5.0 AF/Yr per acre by 35,000 acres a total irrigation diversion requirement of 175,000 AF/Yr is obtained. A difference of about 120,000 AF/Yr is found between the measured and calculated irrigation diversions. This large amount of water which apparently is diverted for irrigation purposes but not utilized for crop growth on land classified as being irrigated, may be either used elsewhere, lost by canal seepage, used to leach the land, or bypassed and returned to the Jordan River. Under the last three alternatives the water becomes an irrigation return-flow and a pollution source to the Jordan River.

Assuming that 30% of the irrigated acreage is situated on the east-side of the Jordan River (see Table 1A) gives an excess diversion of about 70,000 AF/Yr for the east-side and about 50,000 AF/Yr for the west-side. In other words, 58% of the excess irrigation diversion seems to occur on the east-side over 30% of the irrigated acreage in the Valley. However, it should

be considered that a sizeable portion of the excess diversion may be going onto land which is no longer classified as irrigated land.

The rate, of about $2-$5 per acre-foot, now being paid for irrigation water by canal companies in Salt Lake Valley places virtually no economic incentive on the irrigator to use less water. Since irrigation diversions are a substantial part of Salt Lake County's water budget it is important that the irrigators be encouraged to divert only what they need.

About 76% of the water diverted for irrigation comes from the Jordan River and about 23% is high-quality water from Wasatch Front streams and the Provo River. Most of the irrigation water diverted from the Provo River goes into the Provo Reservoir Canal which irrigate land on the western-most side of the Jordan Valley.

Industrial Diversion

As with irrigation diversions considerable variance exists in regards to estimates of industrial water diversions. U.S. Geological Survey (1971) lists total industrial withdrawals in Salt Lake County, 1974-68 as 122,000 AF/Yr. Templeton, Linke & Alsup (1975) shows industrial water use in Salt Lake County in 1972 as 188,511 AF/Yr. The estimates arrived at in this study are shown in Table 11 and generally lie between the two quoted studies.

For 1970-75 the average special industrial water diversion was about 160,000 AF/Yr or about 25.6% of the total diverted. Approximately 143,000 AF/Yr or about 89% of the total industrial diversion seems to have gone to Kennecott Copper Corporation during 1970-75. Most of Kennecott's water was diverted from the Jordan River via Utah & Salt Lake Canal (51,200 Af/Yr) and North Jordan Canal (40,000 AF/Yr).

TABLE 11.

1962-75 INDUSTRIAL WATER DIVERSIONS IN SALT LAKE COUNTY

(Water quantities in acre-feet)

	Galena Canal	South Jordan Canal	Utah & Salt Lake Canal	North Jordan Canal	Wells & Springs	Kennecott Pipeline[1]	Utah Power & Light[2]	Total
1962	8,860	2,680	21,900	20,000		9,500	1,400	64,300[3]
3	9,160	3,490	17,100	20,400	48,400	9,500	1,400	109,500
4	5,810	5,140	9,300	21,200		9,500	1,400	52,400[3]
1965	5,790	4,300	21,300	20,500	50,800	9,500	1,400	113,600
6	5,790	4,080	26,200	20,600	51,500	10,400	1,400	120,000
7	5,790	3,980	45,000	23,500	50,100	6,680	1,400	126,500
8	5,810	3,350	44,800	34,600	43,400	9,500	1,400	142,900
9	5,790	3,790	55,000	32,100	50,800	9,500	1,400	158,400
1970	5,790	4,300	56,200	27,000	48,800	9,500	1,400	153,000
1	5,790	1,380	49,200	41,500	49,000	9,500	1,400	157,800
2	5,810	0	57,100	37,900	51,000	9,500	1,400	162,700
3	5,790	0	64,100	43,000	53,500	9,500	1,400	177,300
4	5,790	0	54,500	48,000	51,200	9,500	1,400	170,400
1975	5,790	0	26,100	42,800	53,800	9,500	1,400	139,400

[1] Data for 1964-68 from: "Water Resources of Salt Lake County, Utah", Tech. Pub. No. 31, Dept. of Nat. Res., Utah, 1971.

[2] Data for 1975 only (personal communications).

[3] Incomplete data.

Industrial diversions generally seem to have been steadily increasing from 1963 to 1973. 1975 was a year of low industrial diversion with most of the flow reduction taking place in the Utah & Salt Lake Canal. Because the high proportion of industrial diversions being for Kennecott Copper Corporation future total industrial diversion in Salt Lake County is highly dependent on Kennecott's water utilization.

7. 1975-1995 WATER USE PROJECTIONS

The data obtained in connection with this study and which is tabulated in this report allows one to construct a model for water use in Salt Lake County. The model, presented on the next pages, is verified using 1970-75 conditions and then extended to cover typical 1995 conditions. It should be understood that 1995 water use projections obtained through such a model are approximate and that unusual conditions (i.e., climatic severities, Kennecott Copper Corporation operation changes, etc.) are not incorporated in the projections.

The model is developed for <u>water use</u> in Salt Lake County and can be expressed as follows:

$$\begin{bmatrix}\text{Total}\\ \text{Water}\\ \text{Use}\end{bmatrix} = \begin{bmatrix}\text{Irrigation}\\ \text{Water}\\ \text{Use}\end{bmatrix} + \begin{bmatrix}\text{Industrial}\\ \text{Water}\\ \text{Use}\end{bmatrix} + \begin{bmatrix}\text{Residential}\\ \text{\& Municipal}\\ \text{Water Use}\end{bmatrix} + \begin{bmatrix}\text{Stock}\\ \text{Water}\\ \text{Use}\end{bmatrix} \qquad (1)$$

$$\begin{bmatrix}\text{Irrigation}\\ \text{Water}\\ \text{Use}\end{bmatrix} = \left(\frac{PCU - P_e}{E_f\, E_c}\right) A_i \qquad (2)$$

where: PCU = potential consumptive use of crop (ft/yr)

P_e = effective precipitation (ft/yr)

E_f = farm efficiency (decimal)

E_c = conveyance loss (decimal)

A_i = irrigated acreage (acres)

$\left(\frac{PCU - P_e}{E_f\, E_c}\right)$ = water diversion requirement (af/yr per acre)

For the Jordan Valley a common value for the water diversion requirement for alfalfa is 5.0 AF/Yr per Acre. This value corresponds to the following approximate values:

PCU = 3.0 feet/yr, P_e = 0.67 ft/yr, E_f = 0.55, and E_c = 0.85.

$$\left[\begin{array}{c}\text{Industrial}\\ \text{Water}\\ \text{Use}\end{array}\right] = \left(\begin{array}{c}\text{Kennecott}\\ \text{Water}\\ \text{Use}\end{array}\right) + K_d A_d \qquad (3)$$

where: K_d = specific industrial use (AF/Yr per Acre)

A_d = industrial acreage (acres)

For lack of specific data an overall value of 1.0 AF/Yr acre has been used for K_d in this report. Kennecott's water use evaluated at 133,000 AF/Yr for the 1970-75 period. It is assumed herein that this use will stay approximately constant during 1975-95.

$$\left[\begin{array}{c}\text{Residential}\\ \text{\& Municipal}\\ \text{Water Use}\end{array}\right] = \left(\frac{2.73}{P_d} - 0.0184\right) P \qquad (4)$$

where: P_d - residential population density (persons/res. acre)

P = population served

From the records of Salt Lake City Water Department a value of 0.264 AF/Yr/Cap was calculated for the per capita residential and municipal water use in 1970-75. This value was used for the bracket on the right hand side of equation (4) although the value also includes a fair amount of industrial water supply.

Domestic and stock use was estimated to decrease slightly by 1995 to about 30,000 AF/Yr. This trend seem reasonable and is supported by the data in Table 5.

Using the model above and the coefficient values outlined allows calculations for 1995 water use in Salt Lake County. The results are shown in Table 12. Generally the model shows an increase in residential and municipal water use (70,900 AF/Yr) and special industrial water use (10,000 AF/Yr). A decrease is shown in irrigation use (65,000 AF/Yr) and stock use (3,500 AF/Yr). The net overall water use shows an increase of 12,000 AF/Yr or an increase of about 2 percent.

The figure calculated for residential and municipal water use in 1995 (210,000 AF/Yr) is in close agreement with projections made by the Salt Lake County 208 Water Quality Study. Possible sources for the additional 71,000 AF/Yr of culinary water include:

* Little Dell Lake Project	11,000 AF/Yr
* Big and Little Cottonwood Creeks	21,000 AF/Yr
* Provo Reservoir Canal exchange	13,000 AF/Yr
* Jordanelle Reservoir (Provo River)	70,000 AF/Yr
* Groundwater (without artificial recharge)	40,000 AF/Yr
* Jordan River (converted irrigation water)	125,000 AF/Yr

The sources presently being used for irrigation purposes may be difficult to obtain (buy) because of the water rights problem. The last source (Jordan River waters) would also require extensive treatment and may best be used for artificial recharge of groundwater aquifers.

It should be kept in mind that the results from the model will change if different values are used for the various constants and coefficients. It is hoped that additonal information will gradually allow better evaluations of the coefficients and constants and in this way improve the water use projections for Salt Lake County.

TABLE 12.

1975 - 1995 WATER USE IN SALT LAKE COUNTY

	MUNICIPAL & INDUSTRIAL USE					IRRIGATION DIVERSIONS					
	SALT LAKE CITY	OTHER CITIES	UNINCORP. AREAS	TOTAL	SPECIAL INDUSTRIAL USE	EAST SIDE	WEST SIDE	TOTAL	STOCK WATERING	GRAND TOTAL	1975-1995 INCREASE
1970-1975 Measured Water Diversions (AF/Yr)	84,500[1]	22,100	28,600	135,000[2]	160,000[3]	125,000	171,600	296,000	33,500	625,600	
Pers/Acre	23.0	15.8	14.6	16.9	25						
Gall/Cap/Day	236	236	236	236	35						
AF/Yr/Cap	0.264	0.264	0.264	0.264	0.04						
AF/Yr per Acre	6.07	4.17	3.85	4.46	1.0	5.0	5.0				
Population	175,580	99,600	251,800	527,000						527,000	
Acreage	7,589	6,320	17,210	31,119	10,433	11,000	24,000	35,000		488,700	
1975 Calculated Water Use (AF/Yr)	46,400	26,300	66,500	139,100[2]	160,000[3]	55,000	120,000	175,000	33,500	508,000	
1995:											
Pers/Acre	22.6	17.5	10.7	14.3	25						
Gall/Cap/Day	236	236	236	236	35						
AF/Yr/Cap	0.264	0.264	0.264	0.264	0.04						
AF/Yr per Acre	5.97	4.62	2.82	3.78	1.0	5.0	5.0				
Population	181,043	270,545	344,066	795,650						795,650	268,650
Acreage	8,000	15,504	32,007	55,511	18,403	5,000	17,000	22,000[4]		488,700	
Calculated Water Use (AF/Yr)	47,800	71,400	90,800	210,000	170,000[5]	25,000	85,000	110,000	30,000	520,000	12,000

[1] Water deliveries from Salt Lake City Water Department to a population of 320,000.
[2] Includes approx. 10,000 AF/Yr of industrial water use.
[3] Includes approx. 143,000 AF/Yr to Kennecott Copper Corporation.
[4] Assumes approx. 13,000 of developed acreage added in 1975-1995 to come from irrigated acreage.
[5] Assumes an increase of 10,000 AF/Yr in special industrial use in 1975-1995.

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APPENDIX

CLIMATIC SENSITIVITY ANALYSIS

The question is often asked; "how sensitive are water uses and diversions to climatic fluctuations?" To attempt to answer this question the 1962-75 average annual irrigation diversions, industrial diversions and Salt Lake City Water Department supplies have been tabulated along with average annual temperature and precipitation at Salt Lake City Airport in Table A1. Included are also the average annual streamflows in Little Cottonwood Creek and the Jordan River. The industrial diversions and the SLC Water Department supplies have been normalized by dividing by the population to produce per capita diversion and deliveries.

To quantify possible correlations between the flows, diversions and water supply and the climatic parameters linear regression analyses were run on a PDP 11/35 computer between all the columns of data in Table A1. The results in the form of correlation coefficients are shown in Table A2. To investigate if higher correlations would result when flows, diversions and water supply were lagged one-year behind the temperature and precipitation the analyses were re-run with "one-year lags" for flows, diversions and water supply. These results are tabulated below the diagonal in Table A2.

In Table A2 a correlation coefficient of ±1.00 means perfect correlation while 0.00 means no correlation. A positive value means that when one variable increases the other can be expected to increase as well (i.e. precipitation and streamflow). A negative value means that when one variable increases the other can be expected to decrease and vice versa (i.e. temperature and precipitation).

TABLE A1.

AVERAGE ANNUAL TEMPERATURES, PRECIPITATIONS, STREAMFLOWS, WATER SUPPLIES AND DIVERSIONS IN SALT LAKE COUNTY

(Avg. annual temperature and avg. annual precipitation at Salt Lake Airport)

	Avg. Ann. Temp (°F)	Avg. Ann. Precip (in)	Little Cottonwood (AF/Yr)	Jordan River (AF/Yr)	Irrigation Diversions (AF/Yr)	Industrial Diversions (AF/Yr)	SLC Water Dept. Supply (AF/Cap./Yr)
1962	50.6	14.90	49,000	183,000	281,000	0.244[1]	0.235
3	50.9	14.09	40,900	167,000	263,000	0.244	0.221
4	48.3	17.87	46,300	165,000	276,000	0.244[1]	0.224
1965	50.5	18.43	60,000	168,000	299,000	0.244	0.213
6	52.3	8.99	32,900	256,000	350,000	0.256	0.254
7	51.8	16.52	54,300	211,000	307,000	0.265	0.229
8	50.2	21.11	54,200	257,000	290,000	0.299	0.222
9	51.9	16.09	62,600	364,000	306,000	0.327	0.235
1970	51.5	19.87	49,500	345,000	301,000	0.310	0.241
1	50.4	18.79	54,800	339,000	295,000	0.310	0.250
2	52.3	15.74	48,900	297,000	300,000	0.315	0.296
3	51.3	20.39	57,900	336,000	276,000	0.342	0.262
4	52.8	14.46	50,500	380,000	306,000	0.320	0.261
1975	50.7	17.92	63,300	358,000	271,000	0.254	0.271

[1]Best estimate

TABLE A2.

CORRELATION COEFFICIENTS BETWEEN CLIMATE, STREAMFLOWS, DIVERSIONS AND WATER SUPPLY

(Based on data given in Table A1)

No. Lag / One Year Lag	Avg. Ann. Temp	Avg. Ann. Precip	Little Cottonwood	Jordan River	Irrigation Diversions	Industrial Diversions	Res. & Munic. Water Supply
Avg. Ann. Temp		-0.46	-0.10	0.51	0.58	0.46	0.51
Avg. Ann. Precip.	-0.46		0.68	0.17	-0.53	0.35	-0.16
Little Cottonwood	0.14	0.02		0.39	-0.35	0.33	0.01
Jordan River	0.45	0.49	0.38		0.18	0.79	0.63
Irrig. Diversions	-0.27	0.33	-0.37	0.13		0.14	0.14
Indust. Diversions	0.27	0.49	0.32	0.77	0.09		0.47
Res. & Munic. Supply	0.31	0.29	0.00	0.64	0.13	0.46	

Data below diagonal are for flows and diversions lagged one-year with respect to temperature and precipitation.

The results in Table A2 may be summarized as:

* No high correlations are evident between diversions and precipitation or temperature.
* The highest correlation (0.79) is between Jordan River flow and industrial diversion.
* A few surprisingly low correlations are evident, i.e.:
  Between precipitation and water supply.
  Between precipitation and Jordan River flow.
* The one-year lag model did not change the results significantly except in the case of precipitation and Jordan River flow.
* The relatively low correlations obtained between irrigation diversion and precipitation or temperature bears out the observation that a sizeable portion of the irrigation diversions is not used for irrigation.

The lack of high correlations observed does not negate the possibility that some high correlations may exist between water diversions in Salt Lake County and climatic conditions. Rather it proves that no high correlations exist between water diversions and climatic conditions as listed in Table A1.