3-1955

Great Salt Lake Diking Project, Large Plan, Hydrology and Quality of Water Study

United States Department of Interior, Bureau of Reclamation

UNITED STATES
DEPARTMENT OF INTERIOR
BUREAU OF RECLAMATION

Weber Basin Projects, Utah

GREAT SALT LAKE DIKING PROJECT

LARGE PLAN

HYDROLOGY AND QUALITY OF WATER STUDY

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Weber Basin Projects Office
Ogden, Utah
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GREAT SALT LAKE DIKING PROJECT

HYDROLOGY AND WATER QUALITY STUDY

Introduction

Purpose of Study

The purpose of this study was to determine the feasibility of diking a portion of the Great Salt Lake for purposes of using the fresh water for irrigation, industrial uses, and recreation. This study approached the problem only from a hydrologic and quality of water standpoint.

Discussion of Plan

The present plan, like that proposed in the past, is to dike off the part of the Great Salt Lake lying east of Antelope and Fremont Islands. The dikes would extend from Promontory Point to the north end of Fremont Island, from the south end of Fremont Island to the north end of Antelope Island, and from the south end of Antelope Island to the adjacent land area by the most direct route. See map, Frontispiece. All previous investigations available have been reviewed, and some of the facts and figures incorporated in this study. It is not the purpose of this study to lean toward either side of the project, but to present as factual a picture as possible with the information available.

Summary of Results

It has been found that during periods of drouth conditions, the content and surface area of proposed fresh water reservoir would decrease to a very great extent, causing the salinity of the reservoir to greatly increase.

The results of the study from thequality of water standpoint are as follows:

SAR(Sodium-Absorption Ratio) Average 6.49

	Electrical Conductivity E.C.	Total Dissolved Solids T.D.S PPM
Average Year	$4356x10^6$	2760
Low Year	$2357x10^6$	1509
High Year	$14864x10^6$	9513

Indication - total dissolved solids (Salinity) too great for normal irrigation.

Hydrology

Area-Capacity Curves

The map, Frontispiece, of this report was obtained from a previous report prepared by J. J. Lillie for the Committee on Great Salt Lake Diking Project in 1932. The area-capacity curves were drawn using the information obtained from the map and from the table accompanying the map which is reproduced on page 3. A correction of the area-capacity curves was made to exclude the areas and capacities of the Bear River Bird Refuge, Ogden Bay Bird Refuge, and the Farmington Bay Bird Refuge. The area-capacity curves for the proposed reservoir are found on Page 4.

Evaporation and Transpiration of Fresh Water Reservoir

The evaporation from the proposed fresh water lake was taken from data compiled by R. E. Van Liew in 1933, and reproduced on page 5. The average annual fresh water evaporation is 4.12 feet. The evaporation was divided into fill-up and drawdown seaso ns according to the average fill-up

TABLE I

CAPACITY AND SURFACE AREA OF PROPOSED RESERVOIR

Elevation (feet)	Area (acres)	Capacity (acre-feet)
4184	51	26
4185	127	115
4186	710	534
4187	1,622	1,700
4188	2,991	4,007
4189	4,132	7,568
4190	7,123	13,195
4191	8,746	21,129
4192	10,697	30,750
4193	14,129	43,163
4194	22,368	61,461
4195	35,075	90,282
4196	50,917	133,278
4197	66,691	192,082
4198	93,462	273,158
4199	113,492	377,635
4200	134,196	501,479
4201	154,603	645,879
4202	172,793	809,527
4203	192,000	985,000
4204	216,000	1,190,000
4205	243,000	1,422,000

The above information was taken from the map for the proposed project which is included in Mr. J. J. Lillie's report on the Field Surveying work.

The area and capacity figures from elevation 4203 to 4205 have been changed to exclude Bear River, Ogden Bay, and Farmington Bay Bird Refuges.

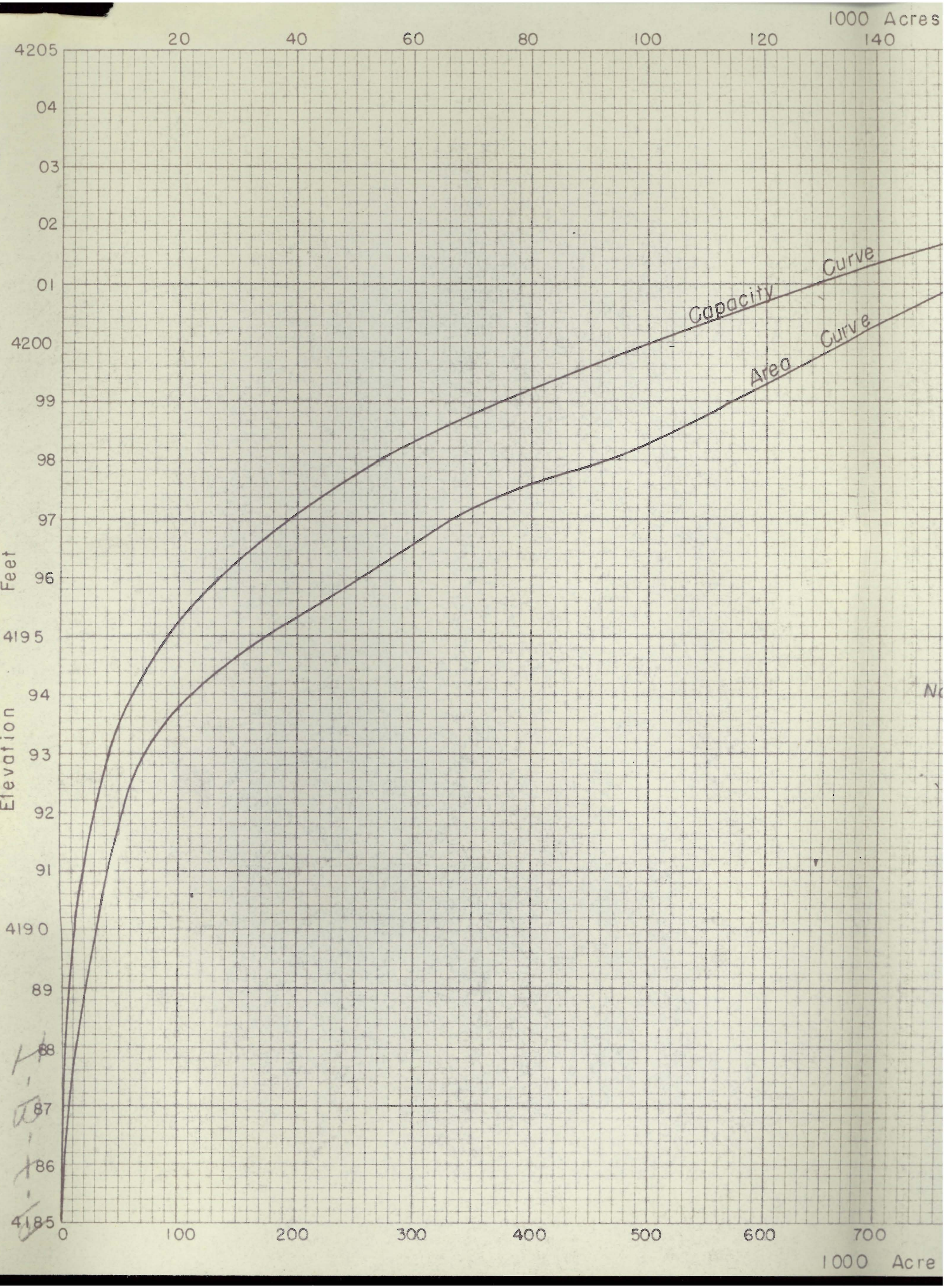

1000 Acres
20
40
60
80
100
120
140
4205
04
03
02
01
4200
99
98
97
96
4195
94
93
92
91
4190
89
88
87
86
4185
Elevation Feet
Capacity Curve
Area Curve
0
100
200
300
400
500
600
700
1000 Acre
EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340DH-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

Fig. 2

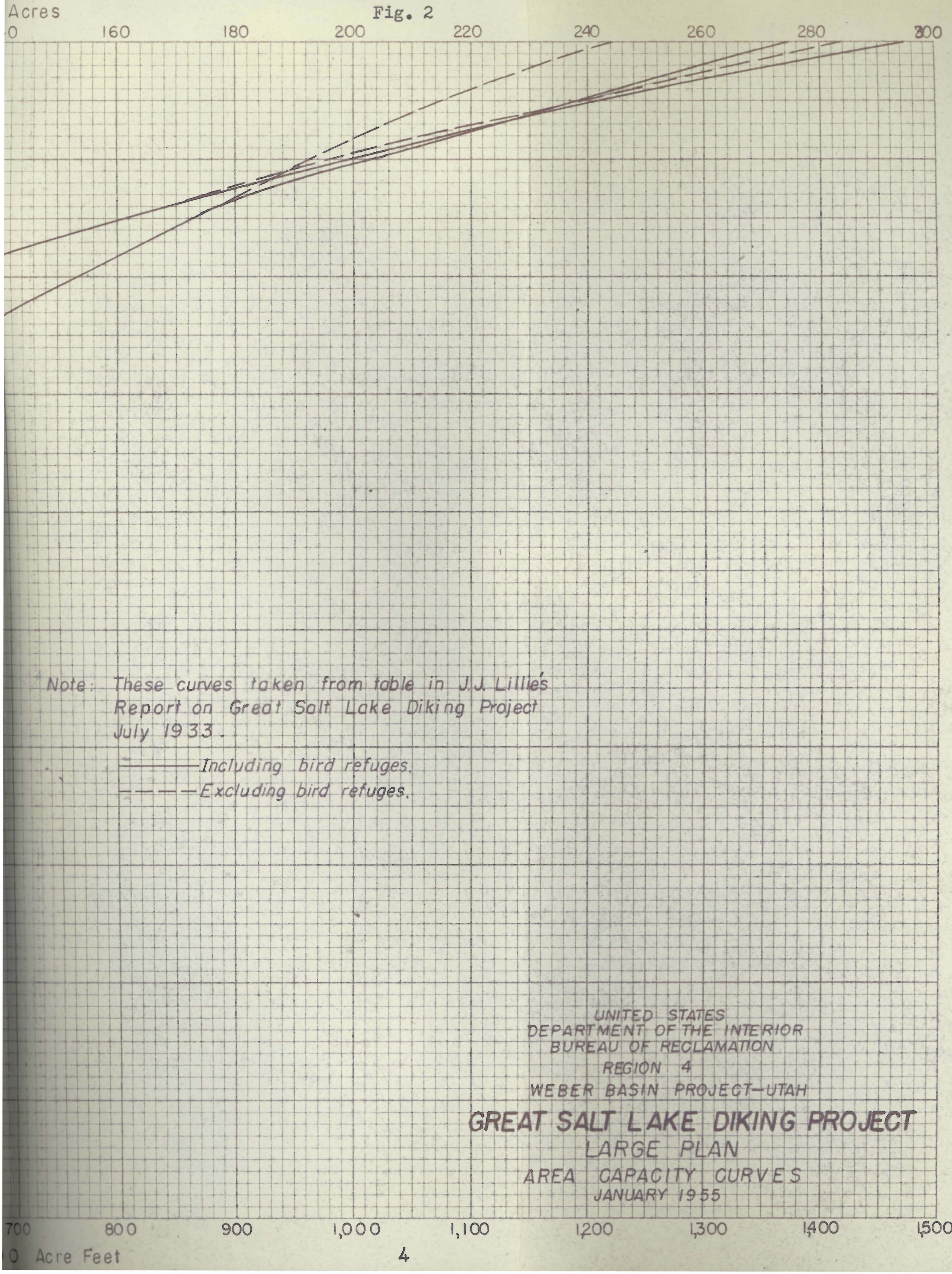

Acres
0
160
180
200
220
240
260
280
300
Note: These curves taken from table in J.J. Lillie's Report on Great Salt Lake Diking Project July 1933.
Including bird refuges.
Excluding bird refuges.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGION 4
WEBER BASIN PROJECT—UTAH
GREAT SALT LAKE DIKING PROJECT
LARGE PLAN
AREA CAPACITY CURVES
JANUARY 1955
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
0 Acre Feet

Table 2

EVAPORATION FROM THE GREAT SALT

LAKE MEAN MONTHLY EVAPORATION IN INCHES FROM

FRESH WATER SURFACE

YEAR	1928	1929	1930	1931	1932	FRESH AVERAGE	SALT AVERAGE
JAN.	0.65	0.65	0.65	0.65	0.65	0.65	0.65
FEB.	1.46	1.46	1.50	1.30	1.40	1.42	1.15
MAR.	3.25	2.40	4.03	2.92	3.18	3.15	2.56
APR.	4.98	2.36	4.55	4.40	3.99	4.06	3.38
MAY.	6.05	3.27	5.57	6.28	6.25	5.88	4.77
JUNE	6.48	8.01	8.01	9.26	6.61	7.67	6.44
JULY	8.95	7.55	9.45	10.60	8.64	9.04	7.41
AUG.	8.26	7.60	6.45	8.17	8.22	7.74	6.27
SEPT.	6.16	4.17	5.74	6.30	5.32	5.54	4.52
OCT.	3.10	3.38	2.41	3.45	3.18	3.10	3.30
NOV.	0.56	0.56	0.65	0.78	0.65	0.64	0.52
DEC.	0.48	0.48	0.48	0.56	0.50	0.50	0.41
						49.39	41.26

49.39 equals 4.12 feet of fresh water annually
41.26 " 3.44 " " salt " "

The above data was obtained from the U. S. Department of Agriculture Weather Bureau's records of evaporation station at the Salt Lake Airport and corrected to meet the evaporation conditions over the Lake. The correction factor used was 0.65 to correct for differences of humidity between the airport and over the lake. The evaporation factor used to change fresh water data to salt water was 0.815.

Compiled by R. E. Van Liew - July 15, 1933 and drawdown seasons of the fresh water average evaporation from 1928 to 1944. The fill-up season was selected as the period from Oct. 1 to May 31, and the drawdown season, the period from June 1, to Sept. 30. The average evaporation during the fill-up season is 1.62 feet and during the drawdown season 2.50 feet. A table showing the average evaporation losses for various surface areas is shown on page 7.

The effect of transpiration of shoreline vegetation, which would grow in the fresh water, has been estimated at 72,000 A.F. annually for a full reservoir. This figure was obtained by comparison with Utah Lake (considered to have the same type vegetation) and corrected to the conditions of the proposed reservoir area. The figures for average transpiration losses are included in the table on page 7.

The net evaporation and transpiration on the proposed fresh water reservoir was then computed for various surface areas each year. The total evporation and transpiration taken from the table on page 7, minus the precipitation over the same area for each year of the study, results in the net annual evaporation on the proposed reservoir area. The net evaporation for various surface areas is shown on table 4, page 8.

Precipitation

The mean annual precipitation on the proposed reservoir area, used in deriving net evaporations, was obtained from the isohyetal map reproduced from the U. S. Department of Agriculture, Weather Bureau, Climatological Data, Utah Section. This map is shown on page 10.

TABLE 3

GREAT SALT LAKE DIKING PROJECT STUDY

Loss of Water Due to Evaporation and Transpiration of Shoreline Vegetation

(1)	1,000 Acres	243	240	229	217	206	194	184	172	161	147	134
(2)	Reservoir Content 1,000 AF	1,422	1,400	1,300	1,200	1,100	1,000	900	800	700	600	500
(3)	Drawdown Period, June-Sept. 2.50 Avg. Ann. Evap.	608	600	573	543	520	485	460	430	402	368	335
(4)	Fillup period Oct-May 1.62 Avg. Ann. Evap.	394	389	371	352	337	314	298	279	261	238	217
(5)	Total Avg. Annual Evap. 4.12	1,002	989	944	895	857	799	758	709	663	606	552
(6)	Transpiration 1,000 AF Fillup Period	16	13	15	15	14	11	11	12	13	15	22
(7)	Transpiration 1,000 AF Drawdown period	56	45	51	51	46	37	37	40	43	49	74
(8)	Total Annual Transpiration 1,000 AF	72	58	66	66	60	48	48	52	56	64	96
(9)	Total Lines 4+6	664	645	624	594	566	522	497	470	445	417	409
(10)	Total lines 3+7	410	402	386	367	351	325	309	291	274	253	239
(11)	Total lines 5+8	1,074	1,047	1,010	961	917	847	806	761	719	670	648

(1) Reservoir Surface Area
(2) Reservoir Capacity
(3) (1) Multiplied by Avg. Annual Evaporation during drawdown period. (Page 6 .).
(4) (1) Multiplied by Avg. Annual Evaporation during fillup period. (Page 6 .).
(5) Total line (3) plus (4).
(6) & (7) Ratio of 1:3 of total transpiration
(8) Total transpiration is equal to area in 1,000's acres times 2 ft. Estimated average depth of growth of vegetation is 2 ft. Width of shoreline area (area of growth of water plants) was considered as distance from water's edge to a depth of 2 feet of water.

1000 ACRE-FEET

		Wet	Dry	Wet Dry	Wet Dry	Wet Dry	Wet Dry	Wet Dry	Wet Dry	Wet Dry
Area A		243	0	240 3	229 14	217 26	208 35	194 49	172 71	147 96
Cont. AF		1422	0	1400 22	1300 122	1200 222	1100 322	1000 422	800 622	600 822
1928	F	302	0	278.22	279.35	264.21	246.87	220.21		
	D	602	0	590.88	566.45	536.99	513.63	476.09		
1929	F	231	0	216.88	210.75	198.25	181.87	157.62		
	D	551	0	540.62	517.25	489.75	467.63	431.88		
1930	F	303	0	288.34	279.92	266.28	249.30	223.12		
	D	504	0	492.46	472.48	445.32	424.70	391.18		
1931	F	323	0	308.37	300.08	284.57	266.69	239.77		
	D	605	0	593.91	569.56	540.19	516.91	479.47		
1932	F	270	0	256.12	248.87	235.32	219.67	192.54		
	D	585	0	573.80	550.09	521.32	497.73	461.82		
1933	F	273	0	258.13	251.92	237.43	221.81	195.73		
	D	607	0	595.91	570.60	541.25	517.99	480.59		
1934	F	370	0	362.65	353.35	335.93	317.87	288.22	260.00	232.00
	D	574	0	563.75	539.85	510.87	488.13	451.98	391.88	345.00
1935	F	222	0	206.87	201.74	189.22	173.84	150.58	130.00	113.00
	D	609	0	598.83	573.66	544.38	521.16	482.82	420.00	371.00
1936	F	248	0	234.00	227.35	214.37	198.38	173.73	152.00	133.00
	D	583	0	571.80	548.05	519.23	496.62	459.67	398.00	351.00
1937	F	210	0	194.81	189.46	177.70	163.14	139.60		
	D	597	0	586.87	562.38	532.86	509.46	472.84		
1938	F	229	0	214.91	208.90	196.54	181.26	156.16		
	D	602	0	590.89	566.50	537.06	513.74	477.24		
1939	F	228	0	213.91	207.89	195.50	180.22	156.11	136.00	118.00
	D	579	0	567.77	543.95	515.06	492.38	456.33	395.00	348.00
1940	F	265	0	251.09	243.74	230.10	214.36	189.10	166.00	146.00
	D	566	0	554.71	531.66	503.50	480.64	444.30	384.00	339.00
1941	F	202	0	187.77	182.28	170.37	156.69	131.97	114.00	98.00
	D	532	0	521.55	498.88	472.07	449.71	415.59	356.00	312.00
1942	F	184	0	170.69	165.89	154.64	140.71	117.60		
	D	598	0	586.87	562.39	533.88	510.49	472.88		
1943	F	310	0	295.31	286.77	272.01	254.94	227.71		
	D	570	0	558.73	535.75	506.67	484.86	448.61		
1944	F	244	0	229.98	223.26	210.19	195.14	170.40		
	D	530	0	551.70	528.58	500.37	477.46	442.04		
1944	F	269	0	254.11	246.83	234.26	217.58	192.42		
	D	513	0	503.45	481.45	454.26	432.62	398.06		
1946	F	251	0	236.02	230.41	217.48	201.53	175.95		
	D	604	0	593.90	568.55	539.16	515.87	478.41		
1947	F	219	0	204.86	198.67	186.10	171.67	147.34		
	D	515	0	504.46	482.49	456.34	434.73	400.22		

The total evaporation (Line 11, page 7) for each area minus the total precipitation (Table 5 , page 11) each year for the corresponding areas, is equal to the net evaporation.

The average annual precipitation on the reservoir area was computed to be 12 inches.

The precipitation at Ogden, Utah, was tabulated for a 20-year period from 1928 to 1947, and the ratio or percentage of each year to the 20-year average precipitation determined. The average annual precipitation on the lake (12) inches) was distributed yearly according to the percent of the mean precipitation at Ogden, Utah.(Col 1 & 2, Table 5)

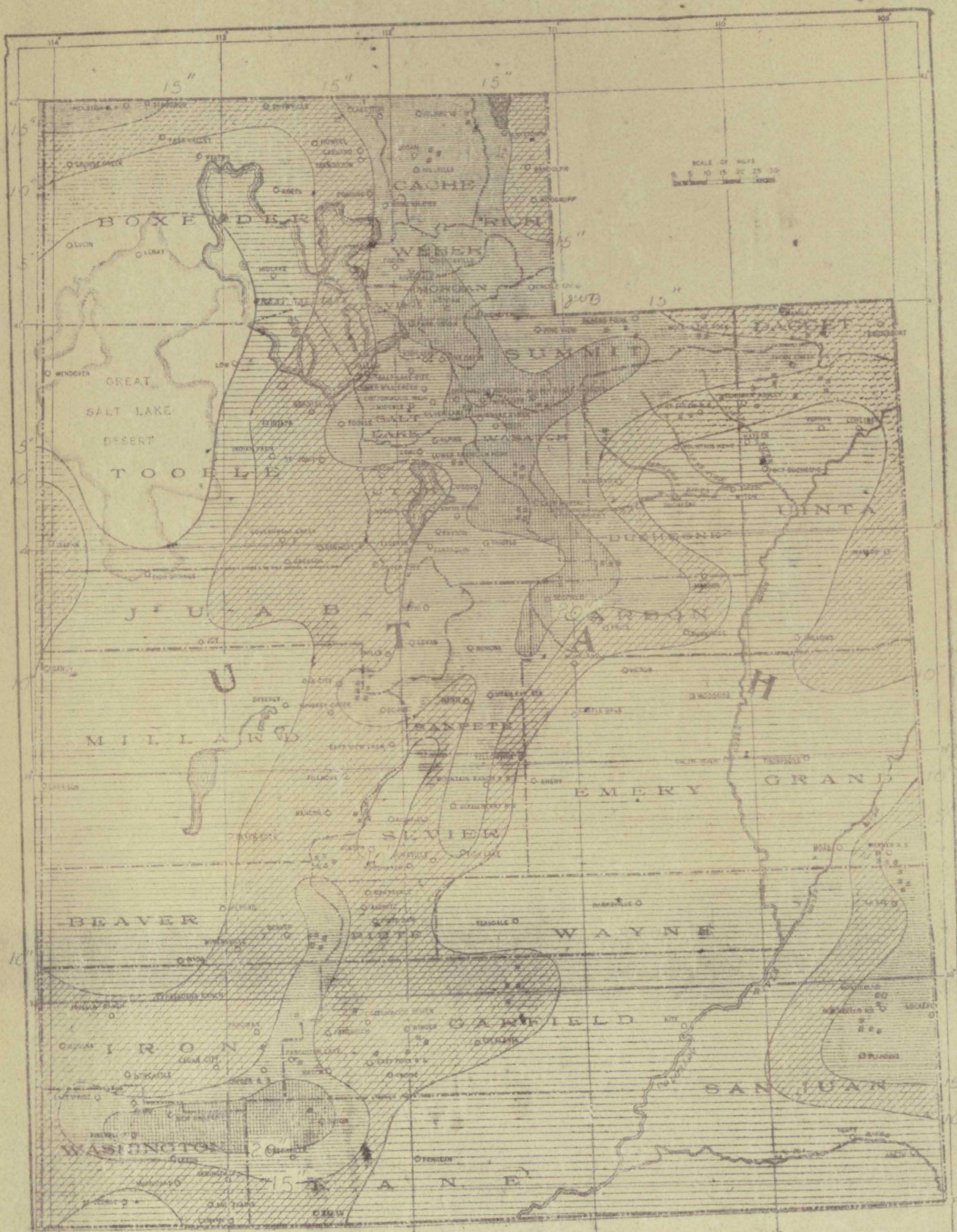
The precipitation, effective in increasing the content of the reservoir, was estimated to equal the rainfall on the reservoir water surface area, plus 40% of the rainfall on the exposed ground surface of the reservoir. This table of direct precipitation on proposed lake area for various reservoir areas, is found on page 11. This was the method used in determing net evaporations of Willard Reservoir (Water Supply Appendix, Definite Plan Report, Weber Basin Project, Utah). The effective precipitation at regular intervals of surface elevations was determined in this manner and subtracted from the gross evaporation and transpiration to obtain net evaporations, with the results shown on Table 5.

<u>Inflow from Main Tributaries</u>

The main tributaries contributing to the inflow of the proposed reservoir are the Bear, Weber and Jordan Rivers.

Inflow records on the Bear River were obtained from the Bureau of Reclamation, Logan, Utah, and on the Weber River from the Bureau of Reclamation, Ogden, Utah. These inflows consist of estimated post-project flows from the Bear River Project and the Weber Basin Project, including the flows that would be supplied to the Willard Reservoir under the Weber Basin Project. (The irrigation requirements from Willard Reservoir under this study were supplied from the proposed fresh water reservoir). The

NORMAL ANNUAL PRECIPITATION AND LOCATION OF COOPERATIVE STATIONS.



SCALE OF SHADES—IN INCHES.

Less than 5 | 5 to 10 | 10 to 15 | 15 to 20 | more than 20

DIRECT PRECIPIT

100

Year	Effective Precip. ft. for Res. Water Sur. Area (1)	Res. Dry Sur. 40% Inflow (2)		Fillup & Drawdown Precip. Percentages (3)	Wet 243 1422	Dry 0 0	Wet 240 1400	Dry 3 22	Ar Wet 229 1300	Dry 14 122
			F	87	148	0	146	.78	139	3.65
1928	.7	.3	D	13	22	0	22	.12	21	.55
			F	75	219	0	216	1.12	206	5.25
1929	1.2	.5	D	25	73	0	72	.38	69	1.75
			F	55	147	0	145	.66	139	3.08
1930	1.1	.4	D	45	120	0	120	.54	113	2.52
			F	87	127	0	125	.63	119	2.92
1931	.6	.24	D	13	19	0	19	.09	18	.44
			F	82	180	0	177	.88	169	4.13
1932	.9	.36	D	18	39	0	39	.20	37	.91
			F	91	177	0	175	.87	166	4.08
1933	.8	.32	D	9	17	0	17	.09	17	.40
			F	59	72	0	71	.35	67	1.65
1934	.5	.20	D	41	50	0	49	.25	47	1.15
			F	94	228	0	226	1.13	215	5.26
1935	1.0	.40	D	6	15	0	14	.07	14	.34
			F	83	202	0	199	1.00	190	4.65
1936	1.0	.40	D	17	41	0	41	.20	39	.95
			F	90	240	0	238	1.19	227	5.54
1937	1.1	.44	D	10	27	0	26	.13	25	.62
			F	91	221	0	218	1.09	208	5.10
1938	1.0	.40	D	9	22	0	22	.11	21	.50
			F	83	222	0	219	1.09	209	5.11
1939	1.1	.44	D	17	45	0	45	.23	43	1.05
			F	76	185	0	182	.91	174	4.26
1940	1.0	.40	D	24	58	0	58	.29	55	1.34
			F	73	248	0	245	1.23	234	5.72
1941	1.4	.56	D	23	92	0	91	.45	87	2.12
			F	91	266	0	262	1.31	250	6.11
1942	1.2	.48	D	9	26	0	26	.13	25	.61
			F	72	140	0	138	.69	132	3.23
1943	.8	.32	D	28	54	0	54	.27	51	1.25
			F	77	206	0	203	1.02	194	4.74
1944	1.1	.44	D	23	61	0	61	.30	58	1.42
			F	62	181	0	179	.89	171	4.17
1945	1.2	.48	D	38	111	0	109	.55	104	2.55
			F	91	199	0	197	.98	187	4.59
1946	.9	.36	D	9	20	0	19	.10	19	.45
			F	68	231	0	228	1.14	218	5.33
1947	1.4	.56	D	32	109	0	108	.54	103	2.51

(1) Water year precipitation-feet-Water Supply Appendices,
(2) Precipitation available to water area of reservoir fro
Definite Plan Report, Willard Bay, page 171.
(3) Percentage of precipitation for fillup and drawdown pe
(4) Acre-ft. of water from precipitation over total reserv

Precipitation on Wet = (3)X(1)X(Wet Area) Precipitation

TABLE 5
ATION ON PROPOSED LAKE AREA
) Acre-Feet

ea in 1000's Acres - Capacity 1000 AF (4)

Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
217	26	208	35	194	49	172	71	147	96-Area 1000 Ac.
1200	222	1100	322	1000	422	800	622	600	822-Content 1000 A. F.
132	6.79	127	9.13	118	12.79				
20	1.01	19	1.37	18	1.91				
195	9.75	188	13.13	175	18.38				
65	3.25	62	4.37	58	6.12				
131	5.72	126	7.70	117	10.78				
108	4.68	103	6.30	96	8.82				
113	5.43	109	7.31	101	10.23				
17	.81	16	1.09	15	1.53				
160	7.68	153	10.33	144	14.46				
35	1.68	34	2.27	31	3.18				
158	7.57	151	10.19	141	14.27				
16	.75	15	1.01	14	1.41				
64	3.07	61	4.13	57	5.78	51	8.26	44	11.21
45	2.13	43	2.87	40	4.02	35	5.94	30	8.00
204	9.78	196	13.16	182	18.42	162	26.69	138	36.10
13	.62	12	.84	12	1.18	10	1.71	9	2.30
180	8.63	173	11.62	161	16.27	143	23.57	122	31.87
37	1.77	35	2.38	33	3.33	29	4.83	25	6.53
215	10.30	206	13.86	192	19.40				
24	1.14	23	1.54	21	2.16				
197	9.46	189	12.74	177	17.84				
20	.94	19	1.26	17	1.76				
198	9.50	190	12.78	177	17.89	157	25.93	134	35
41	1.94	39	2.62	36	3.67	32	5.31	28	7.0
165	7.90	158	10.64	147	14.90	131	21.58	112	29
52	2.50	50	3.36	47	4.70	41	6.82	35	9
222	10.63	212	14.31	199	20.03	176	.29	150	39
82	3.93	79	5.29	73	7.41	65	11	56	15
237	11.36	228	15.29	212	21.40				
23	1.12	22	1.51	21	2.12				
125	5.99	120	8.06	112	11.29				
49	2.33	46	3.14	43	4.39				
184	8.81	176	11.86	164	16.60				
55	2.63	53	3.54	49	4.96				
161	7.74	155	10.42	144	14.58				
99	4.74	95	6.38	89	8.94				
177	8.52	170	11.47	159	16.05				
18	.84	17	1.13	16	1.59				
207	9.90	198	13.33	185	18.66				
97	4.66	93	6.27	87	8.78				

} Effective Precip. 1000 AF

, Definite Plan Report.
om dry area of reservoir is 40% of total precipitation on dry area.

eriods based on actual measured precipitation of like periods each year.
voir yearly for different capacities within the reservoir.

n on Dry= (3)X(2)X(Dry Area)

Jordan River and the Surplus Canal flows were taken from the U.S.G.S Water Supply Papers. The Jordan River gage is one mile downstream from the bridge over the Jordan River on 21st South, Salt Lake City, and the Surplus Canal 1/8th of a mile downstream from the same point.

<u>Inflow from Other Sources</u>

The inflow from sources other than the Bear, Weber and Jordan Rivers and precipitation (considered in net evaporation) was computed as follows:

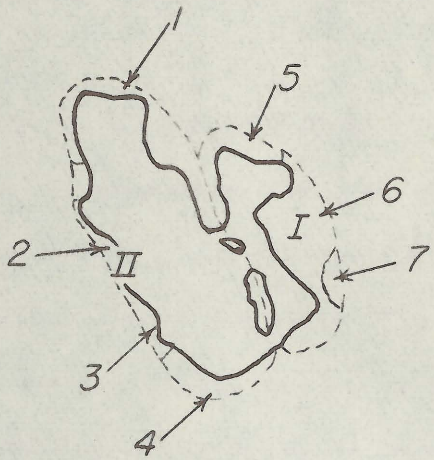
The historical change in content of the Great Salt Lake was added to the past salt water evaporation to give the total inflow into the lake. The total inflow minus the precipitation and the flows of the Bear, Weber, and Jordan Rivers gives the net inflow from ground water and other sources. It was estimated from the U. S. Department of Agriculture, Weather Bureau Climatological Data Map on page 10, and reproduced in part on page 13, that the precipitation ratio of the east to the west side of the lake, with Fremont and Antelope Islands being the dividing line, was two to one. As inflow is the direct result of precipitation, the inflow of ground water and other sources was distributed in the ratio of two to one and thus the flow from the east side determined. The salt water historical evaporation used in this determination of inflows from other sources was derived as follows: Evaporation curves were drawn, using the information page 14, taken from E. L. Peck's "Hydrometeorological Study of Great Salt Lake". The evaporation ratio of the fill-up season (Nov. 1 to June 1) and the drawdown season (June 1 to Sept. 30) was established at 40:60 from N. T. Olsen's report on the Great Salt Lake Diking Project

Fig. 3

Precipitation Ratio Over Great Salt Lake

Taken From

U. S. Dept. of Agriculture, Weather Bureau Climatological Data Utah Section, Year 1919, Page 114



	East of Island	West of Island
Land Area Ratio	1	1
Precipitation ratio	2	1

Land Total Area	East 150 mi^2	West 144 mi^2	Average Precipitation Inches		
(1)		82	7.5	615	
(2)		12	5.0	60	
(3)		12	7.5	90	
(4)		38	12.5	475	West
					1240
(5)	35		12.5	438	
(6)	97		17.5	1698	
(7)	18		20.0	360	East
					2496

Table ~~2~~ 6

Total Average Annual Evaporation from Great Salt Lake
(Table recomputed after Adams)

Stage gage at Saltair (feet)	Area of Lake (million acres)	Salt content (percent)	Evaporation ratio due to salt	Depth of Evaporation (feet)	Total evaporation (million acre-ft)
14	-	14.0	.86	3.80	-
12	1.46	15.2	.85	3.76	5.49
10	1.42	16.5	.84	3.71	5.27
8	1.36	18.1	.82	3.63	4.94
6	1.27	20.2	.80	3.51	4.46
4	1.15	22.2	.78	3.45	3.97
2	.99	25.3	.75	3.32	3.29
0	.84	27.0	.71	3.14	2.64
-2	.72	27.0	.71	3.14	2.26
-4	.64	27.0	.71	3.14	2.01
-6	.59	27.0	.71	3.14	1.85

in 1943. The evaporation curves on page 16 show the evaporation from the surface areas between the elevations 4191 and 4205.

The historical change in content of the Great Salt Lake was obtained by changing the gage heights(listed in the U.S.G.S. Water Supply Papers) at the end of the fill-up and drawdown seasons to elevations and applying these to the area andcapacity curves reproduced from E. L. Peck's Hydrometeorlogical Study on Great Salt Lake, pages 17 and 18. The complete study of inflow from other sources is found on page 19.

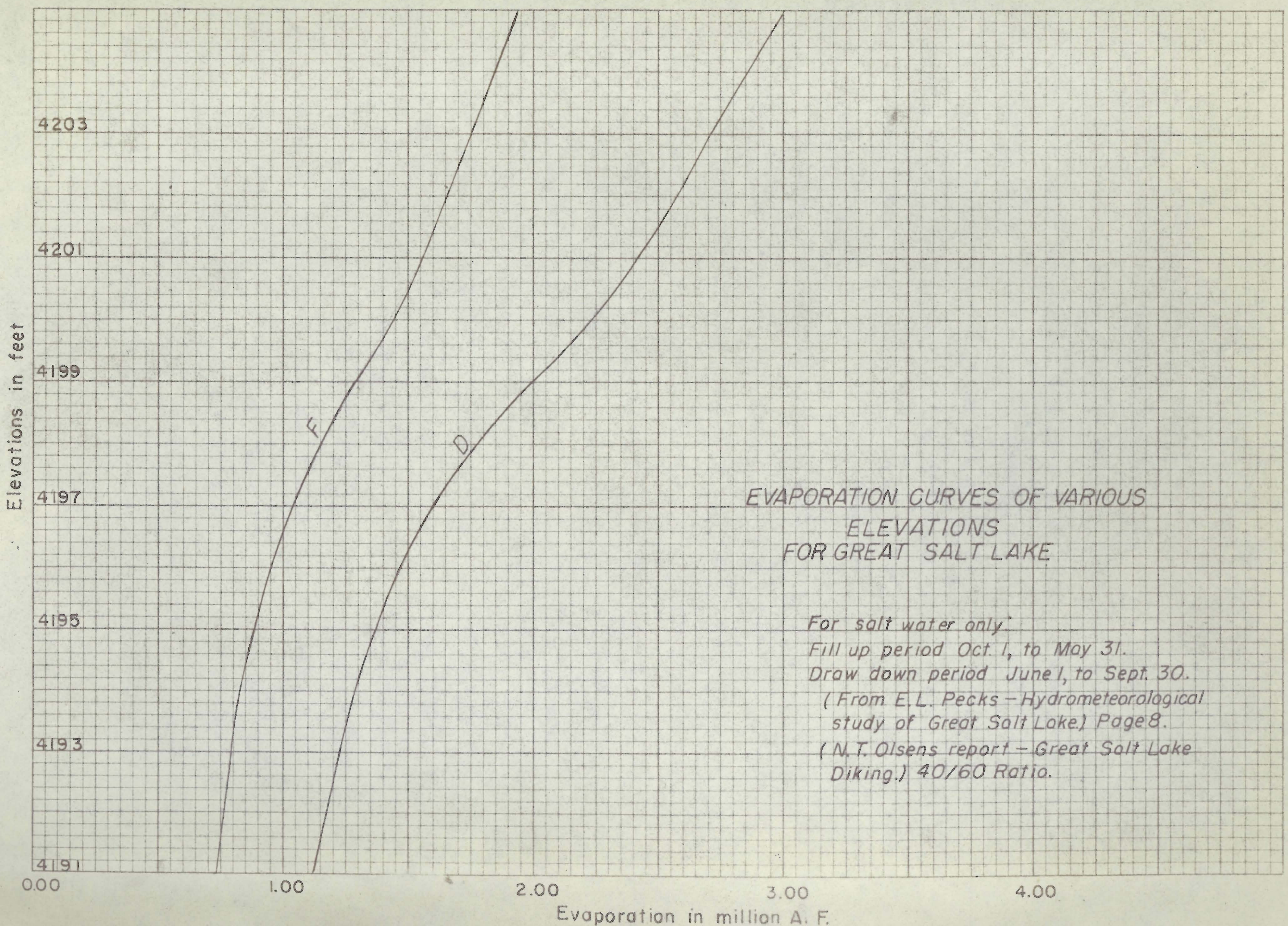
Irrigation Requirements

In determining irrigation requirements, the pumping demands from the proposed Willard Reservoir were used along with the estimated ultimate water requirements west of Salt Lake City in the "Terminal Tract" area. It was assumed in this study that the Willard Reservoir requirements under the Weber Basin Project would be supplied from the new reservoir.

The demands from the Willard Bay were taken from the operation study in the "Definite Plan Report", Weber Basin Project, Utah, 1952,

The estimated ultimate water requirements west of Salt Lake City around the area known as the "Terminal Tract" was taken from information in N. T. Olson's report on Great Salt Lake Diking Project, Utah, 1943. The original investigation and report, which is included in N. T. Olson's report, was made in 1925 by A. T. Strahorn, U. S. Department of Agriculture, Bureau of Soils. He concluded that only 8700 acres were arable and 25,700 acres more could be made arable through drainage and irrigation.

As no better information was available, it was assumed that an acreage of 8,700 plus 25,700 or 34,400 acres requiring a full supply of 3.27 A.F./acre or an average of 112,500A.F./yr. will be required in this



EVAPORATION CURVES OF VARIOUS ELEVATIONS FOR GREAT SALT LAKE
For salt water only.
Fill up period Oct. 1, to May 31.
Draw down period June 1, to Sept. 30.
(From E. L. Pecks - Hydrometeorological study of Great Salt Lake) Page 8.
(N. T. Olsens report - Great Salt Lake Diking.) 40/60 Ratio.
F
D
Elevations in feet
4203
4201
4199
4197
4195
4193
4191
0.00
1.00
2.00
3.00
4.00
Evaporation in million A. F.

Fig. 4

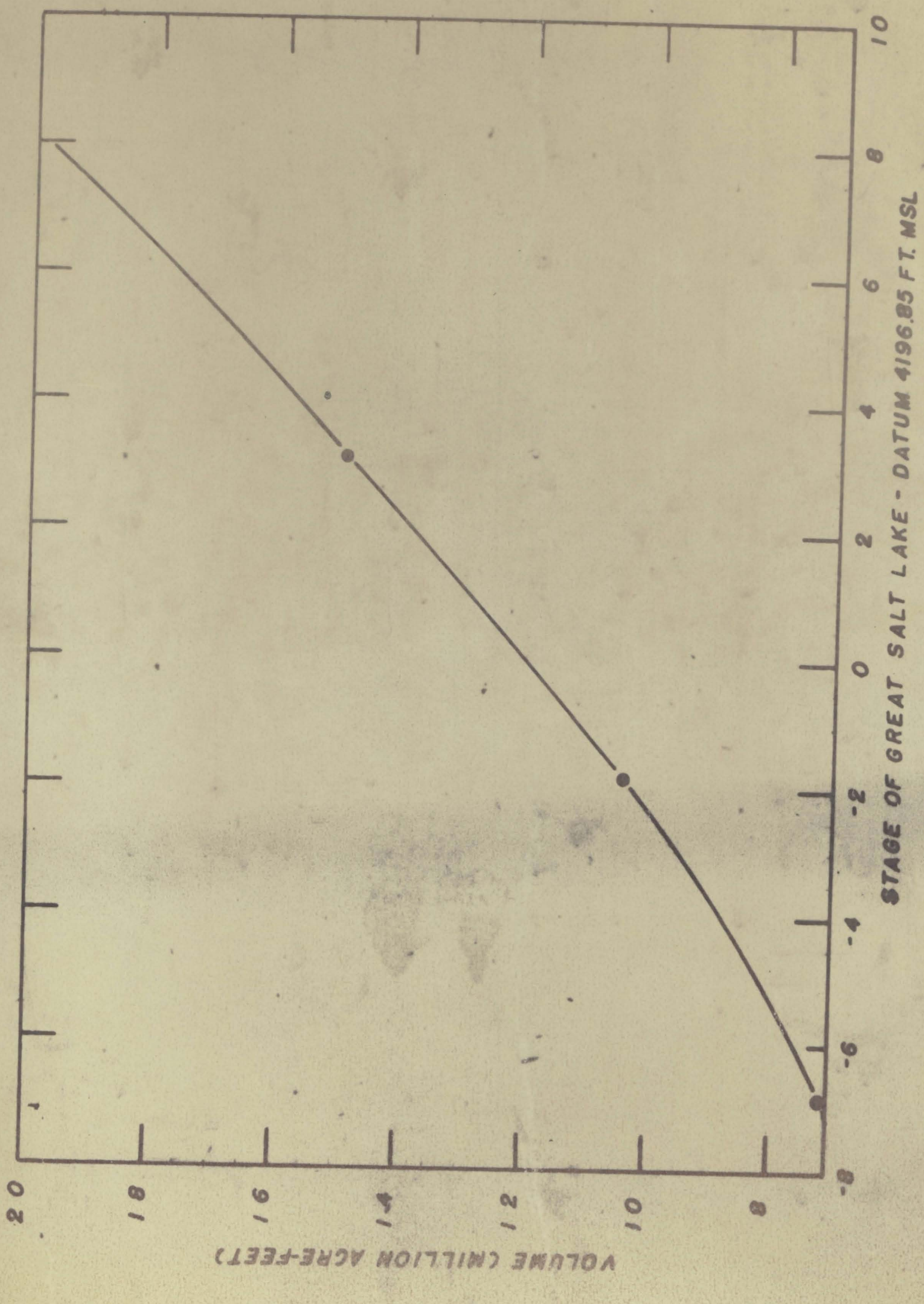


Fig.2. Stage-volume relation, Great Salt Lake

Fig. 6

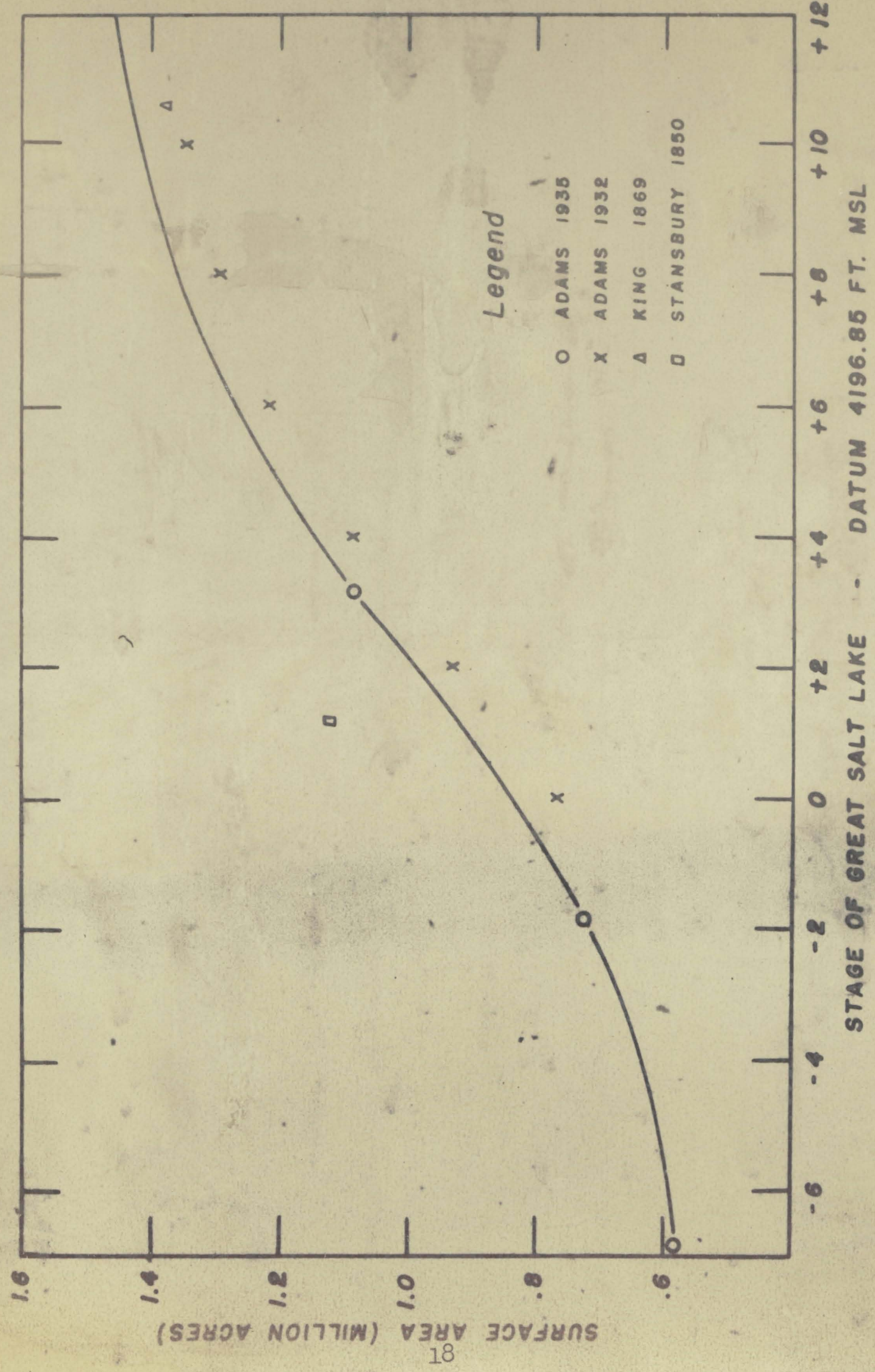


Fig. 1. Stage-area relation, Great Salt Lake

DETERMINATION OF INFLOW TO GREAT SALT LAKE EXCLUDIN JORDAN RIVER FLOWS

		1	2	3	4	5	6	7	8
Water Year		Elev. at Saltair	Content in Million A.F.	Change in Content Million A.F.	Mean Elev.	Total Evap. Million A.F.	Gross Inflow Million A.F.	Mean Lake Surface Area	Precip ft.
1928	F	4201.85	16.6	+.6	4202.15	1.68	2.28	1.22	.51
	D	4202.46	17.2	-1.8	4201.55	2.50	.70	1.18	.08
1929	F	4200.65	15.4	+1.3	4201.30	1.59	2.89	1.17	.73
	D	4201.95	16.7	-1.3	4201.27	2.45	1.15	1.17	.24
1930	F	4200.60	15.4	+ .4	4200.88	1.55	1.95	1.14	.48
	D	4201.15	15.8	-1.4	4200.40	2.30	.90	1.10	.40
1931	F	4199.65	14.4	+..5	4199.90	1.42	1.92	1.07	.44
	D	4200.15	14.9	-2.0	4199.07	2.02	.02	.99	.06
1932	F	4198.00	12.9	+1.3	4198.67	1.25	2.55	.96	.62
	D	4199.35	14.2	-1.4	4198.65	1.92	.52	.96	.14
1933	F	4197.95	12.8	+ .9	4198.37	1.20	2.10	.94	.58
	D	4198.80	13.7	-1.7	4197.90	1.77	.07	.91	.06
1934	F	4197.00	12.0	- .4	4196.78	1.02	.62	.82	.28
	D	4196.55	11.6	-1.3	4195.75	1.44	.14	.76	.19
1935	F	4194.95	10.3	+ .9	4195.47	.93	1.83	.75	.79
	D	4196.00	11.2	-1.6	4195.07	1.38	assume0	.73	.05
1936	F	4194.15	9.6	+1.3	4194.95	.88	2.18	.72	.69
	D	4195.75	10.9	-1.2	4195.02	1.37	.17	.73	.14
1937	F	4194.30	9.7	+1.8	4195.35	.92	2.72	.74	.86
	D	4196.40	11.5	-1.2	4195.65	1.43	.23	.76	.09
1938	F	4194.90	10.3	+1.3	4195.70	.94	2.24	.76	.79
	D	4196.50	11.6	-1.4	4195.66	1.43	.03	.76	.08
1939	F	4194.83	10.2	+1.1	4195.52	.93	2.03	.75	.77
	D	4196.22	11.3	-1.3	4195.46	1.42	.12	.75	.16
1940	F	4194.69	10.0	+ .6	4195.03	.89	1.49	.73	.62
	D	4195.37	10.6	-1.3	4194.56	1.43	.13	.69	.20
1941	F	4193.75	9.3	+1.4	4194.62	.86	2.26	.70	.87
	D	4195.50	10.7	-1.2	4194.75	1.35	.15	.70	.46
1942	F	4194.00	9.5	+2.1	4195.25	.90	3.00	.73	.90
	D	4196.50	11.6	-1.4	4195.65	1.43	.03	.76	.09
1943	F	4194.80	10.2	+1.1	4195.47	.92	2.02	.75	.49
	D	4196.15	11.3	-1.3	4195.42	1.42	.12	.74	.19

Col. 1 Elevation in feet above Sea Level at Saltair, taken from U. S.G. S. Water Supply pa

Col. 2 Content in million A. F. of Col. 1 from Fig. 5 , page 17.

Col. 3 Difference in lake content at beginning of each season on Col. 2.

Col. 4 The mean elevation during each season or elevation beginning of fillup season plus

Col. 5 Evaporation from surface area at mean elevation from Fig. 4 , page 16.

Col. 6 Algebraic sum of Cols. 3 & 5.

Col. 7 Surface Area as related to Col. 4.

Col. 8 Precipitation in feet based on the percent mean precipitation at Ogden plus percent

Col. 9 Col. 8 changed to million A. F.

Col. 10 Col. 6 minus Col. 9

Col. 11 Col. 10 minus inflow of Bear, Weber and Jordan Rivers (Taken from U.S. G. S. Water S diverted to the refuges.

Col. 12 Col. 10 minus Col. 11

Col. 13 The fillup and drawdown seasons of Col. 12 based on the 2:1 ratio as determined from

7

T LAKE EXCLUDING BEAR, WEBER, AND
R FLOWS

7	8	9	10	11	12		13 Net Inflow Million A. F.	
Mean Lake urface Area	Precip. ft.	Precip. Million A.F.	Inflow Million A.F.	Minus Inflow Bear Weber and Jordan River	Net Inflow Million A.F. - Water Other Sources		Fresh Water Side of Dike 67%	Salt Water Side of Dike 33%
1.22	.51	.62	1.66	1.39	.27	.88	.18	.09
1.18	.08	.09	.61		.61		.41	.20
1.17	.73	.85	7.04	1.50	.54	1.41	.36	.18
1.17	.24	.28	.87		.87		.58	.29
1.14	.48	.55	1.40	.99	.41	.87	.27	.13
1.10	.40	.44	.46		.46		.31	.15
1.07	.44	.47	1.45	.69	.76	.76	.51	.25
.99	.06	.06	.06	0	0		0	0
.96	.62	.60	1.95	1.25	.70	1.09	.47	.23
.96	.14	.13	.39		.39		.26	.13
.94	.58	.55	1.55	.99	.56	.58	.38	.18
.91	.06	.05	.02		.02		.01	.01
.82	.28	.23	.39	.45	.06	-	0	0
.76	.19	.14	0		0		0	0
.75	.79	.59	1.24	.65	.59	.59	.40	.19
.73	.05	.04	0		0		0	0
.72	.69	.50	1.68	1.37	.31	.38	.21	.10
.73	.14	.10	.07		.07		.05	.02
.74	.86	.64	2.08	1.25	.83	.99	.56	.27
.76	.09	.07	.16		.16		.11	.05
.76	.79	.60	1.64	1.25	.39	.39	.26	.13
.76	.08	.06	0		0		0	0
.75	.77	.58	1.45	.99	.46	.46	.31	.15
.75	.16	.12	0		0		0	0
.73	.62	.45	1.04	.69	.35	.35	.23	.12
.69	.20	.14	0		0		0	0
.70	.87	.61	1.65	.73	.92	.97	.62	.30
.70	.46	.32	0		0		0	0
.73	.90	.66	2.34	1.15	1.19		.80	.39
.76	.09	.07	0		0	1.19	0	0
.75	.49	.37	1.65	1.20	.45	.45	.30	.15
.74	.19	.14	0		0		0	0

S. Water Supply papers.

illup season plus elevation beginning of drawdown season (Col. 1), divided by two.
ge 16.

Ogden plus percent fillup and drawdown yearly over Great Salt Lake.

U.S. G. S. Water Supply papers). All flows during the drawdown period are

as determined from Fig. 3 , page 13.

area. The 3.27 A.F./acre rate was used for the lake shore area of the Weber Basin Project.

Operation Study

Assuming that the reservoir was completely empty, it would take approximately 4 years for the reservoir to fill with an average annual inflow of 910,000 A.F./yr. With the reservoir full at the end of the fill-up season of 1928, an operation study was started. There is sufficient inflow to the reservoir during the fill-up seasons to fill and spill for the years 1928 to 1933, 1937 and 1938, and 1942 and 1943. From the end of the fill-up season of 1933 to sometime during the fill-up season of 1937, there is insufficient inflow to fill the reservoir. The reservoir content drops to a low of 181,000 A.F. during the drawdown season of 1934, and the surface area is reduced to 63,000 acres. This is again the case from the end of the fill-up season of 1938 to sometime during the fill-up season of 1942. The reservoir content drops to 452,000 A.F. during the drawdown season of 1940 and the reservoir surface area is reduced to less than 130,000 acres. These is no instance during the drawdown seasons of any of the years of the operation study that there is sufficient inflow to spill or even to maintain the elevation of the lake due to the heavy demands by pumping and the high evaporation during this season. The operation study is shown on page 21.

Quality of Water

Basic Data

Using the reservoir operation study of the Great Salt Lake Diking Project previously explained, a quality of water study was made.

Table 8

OPERATION STUDY
GREAT SALT LAKE DIKING

1,000 AF

		Total Inflow								
		Bear River	Weber River	Jordan & Surplus Canal	Other Tributaries	Total	Total Demands by Pumping	Net Evap.	Res. Content	Spills
1928	F		0			0	21.2		1,422	
	D		0		410	410	191.1	546	1,095	0
1929	F	330	261	170	360	1,121	24.5	208	1,422	561
	D		0		580	580	141.3	534	1,327	0
1930	F	160	92	135	270	657	19.6	286	1,422	256
	D		0		310	310	161.3	460	1,111	0
1931	F	85	83	110	510	788	23.5	292	1,422	161
	D		0		0	0	216.4	500	706	0
1932	F	385	280	96	470	1,231	31.1	208	1,422	276
	D		0		260	260	187.1	520	975	0
1933	F	260	161	110	380	911	21.1	235	1,422	208
	D		0		10	10	209.9	505	717	0
1934	F	60	38	79	0	177	78.4	230	586	0
	D		0		0	0	148.5	256	181	0
1935	F	150	80	65	400	695	9.3	88	778	0
	D		0		0	0	176.8	330	271	0
1936	F	400	365	83	210	1,058	25.5	140	1,163	0
	D		0		50	50	163.3	433	617	0
1937	F	335	229	102	560	1,226	13.9	144	1,422	263
	D		0		110	110	183.1	515	834	0
1938	F	355	219	113	260	947	11.6	186	1,422	161
	D		0		0	0	217.4	500	705	0
1939	F	240	119	115	310	784	33.5	156	1,299	0
	D		0		0	0	198.6	454	646	0
1940	F	150	89	113	230	582	50.0	171	1,007	0
	D		0		0	0	180.0	375	452	0
1941	F	175	112	80	620	987	21.2	127	1,291	0
	D		0		0	0	185.4	419	687	0
1942	F	310	213	100	800	1,423	8.8	130	1,422	549
	D		0		0	0	209.5	496	716	0
1943	F	420	188	80	300	988	31.2	246	1,422	5
	D		2		0	2	161.2	460	803	0

The samples used were taken from points as close to the lake as possible so as to get as truly a representative chemical analysis of the inflow to the lake as possible. The study follows the procedure and outline as set forth in Bureau Manual, Volume IV, Chapter 2.4.

Samples 1, 2, and 3 from the Bear River were taken east of Corinne, Utah, and the information was taken from page 26 and 27 of Bulletin 346, June 1951, Agricultural Experiment Station, Utah State Agricultural College. Sample 4 on the Bear River was taken at the Bear River Bird Refuge Headquarters.

All of the samples (5) used from the Weber River were taken at the U.S.G.S. gage at Plain City, Utah

Jordan River sample 1 was taken at the pump ditch to the Bonneville Canal. Sample 2 and 3 were taken at the Jordan River intake' to Unit No. 1, Farmington Bay Bird Refuge. Sample 4 was taken on the Jordan River at the Salt Lake Fairgrounds. Samples 5 and 6 were taken at the intersection of 2100 South Street and Utah Highway 201. Sample 7 was taken at the intersection of North Temple Street and U.S. Highway 40.

The slough samples were taken at the respective U.S.B.R. gages on the Hooper, Walker and Howard sloughs, and a representative stream sample was obtained from Bulletin 346, June 1951, Agricultural Experiment Station, Utah State Agricultural College, For Farmington Creek. These samples from the sloughs and Farmington Creek were considered as representative samples of inflow from other sources.

The sample analyses were obtained from Bureau of Reclamation files, U.S.G.S. records and from the Utah State Health Department Laboratory at Ft. Douglas, Utah. The dates, analyses, places taken, and extended

Sample Number	Date	Sample Location	e.p.m. Ca	Mg	Na
BEAR RIVER					
1	6-14-49	East of Corinne	2.59	1.89	5.92
2	8- 5-49	East of Corinne	3.19	4.44	19.58
3	9- 7-49	East of Corinne	2.59	4.27	10.27
4	3-31-50	Bear River Bird Refuge Hdgtes.	3.08	4.19	7.39
WEBER RIVER					
1	6-14-49	U.S.G.S. Gage - Plain City	2.34	1.07	1.17
2	9- 7-49	U.S.G.S. Gage - Plain City	3.29	1.56	2.48
3	4- 4-50	U.S.G.S. Gage - Plain City	3.31	1.37	.87
4	9-29-50	U.S.G.S. Gage - Plain City	2.73	2.75	2.20
5	7-12-54	U.S.G.S. Gage - Plain City	3.70	2.05	2.96
JORDAN RIVER					
1	8-14-47	Pump Ditch - Bonneville Canal			
2	4- 7-50	Intake to Unit #1			
3	3-27-47	Intake to Unit #1			
4	6-23-49	At Fairgrounds			
5	4- 5-50	2100 South St., Utah Hwy. 201			
6	11-22-50	2100 South St., Utah Hwy. 201			
7	8-17-48	North Temple St., U. S. Hwy. 40			
HOOPER SLOUGH					
1	11-3-43	U. S. B. R. Gage - Hooper Slough	3.09	2.88	3.39
WALKER SLOUGH					
1	11- 4-43	U. S. B. R. Gage - Walker Slough	2.78	3.21	8.60
HOWARD SLOUGH					
1	11- 3-43	U. S. B. R. Gage - Howard Slough	2.35	2.86	3.27
FARMINGTON CREEK					
1	6- 6-49	Below Diversions - Bull. #346 Utah Agricultural Exp. Station	.35	.16	.22

TABLE 9 GREAT SALT LAK

	P.P.M.				$ECx10^6$		Discharge c.f.s.		
Ca	Mg	Na	TDS						Ca
51.8	23.1	136.2	618		1130		588		2500
63.8	54.2	450.0	1581		2900		118		618
51.8	52.1	236.2	1022		1750		233		990
61.5	51.1	169.9	833				2150		10853
46.8	13.1	26.9	257		460		1550		5954
65.8	19.0	57.0	441		790		74		400
66.2	16.7	20.0	287				779		4233
54.6	33.5	50.7	446				42		188
74.0	25.0	68.0	464		860		27		164
107.5	60.9	170.0	1227				190		1676
103.2	63.3	275.5	1154				87		736
152.1	18.6	606.5	892				107		1335
95.9	43.0	134.0	912		1400		152		1197
139.0	64.0	160.2	1160		1780		200		2281
156.0	80.0	198.0	1400		2170		354		4533
128.0	73.0	202.0	1260		1940		222		2332
61.8	35.1	77.9	614		88		9.4		48
55.6	39.2	197.8	874		141		.77		4
47.0	34.9	75.2	506		83		22.8		88
7.0	1.9	5.1	118		100		24.0		14

Results in T/mo.				Flow AF/mo.		Tons/AF			
Mg	Na	TDS				Ca	Mg	Na	TDS
1115	6573	29826		35455		.0706	.0313	.0185	0.8405
836	4358	15312		7155		.0870	.0735	.6129	2.1502
996	4517	19545		14049		.0706	.0707	.3215	1.3899
9017	29982	147000		129,641		.0837	.0696	.2313	1.1320
1666	3422	32696		93462		.0638	.0177	.0366	.3495
115	346	2678		4462		.0896	.0258	.0775	.5997
1068	1279	18351		46972		.0901	.0227	.0626	.3906
115	175	1537		2533		.0742	.0454	.0691	.6070
55	151	1028		1628		.1007	.0338	.0927	.6314
950	2651	19135		11457		.1460	.0830	.2314	1.6687
452	1967	8240		5246		.1400	.0860	.2396	1.5694
163	5326	7834		6452		.2070	.0250	.8254	1.2131
536	1672	11378		9165		.1310	.0580	.1824	1.2403
1051	2626	19042		12060		.1890	.0870	.2177	1.5776
2324	5753	40678		21346		.2120	.1090	.2695	1.9040
1330	3680	22959		13386		.1740	.0990	.2749	1.7136
27	60	473		566		.0840	.0477	.1059	.8350
3	12	55		46		.0756	.0533	.2690	1.1886
65	141	947		1375		.0639	.0475	.1023	.6882
4	10	232		1447		.0095	.0026	.0069	.1605

Ca	Mg	Na	TDS	
Tons/AF Average from each source				
.07818	.0615	.2941	1.3880	
.0843	.0294	.0682	.5160	
.1710	.0781	.3201	1.5540	
.0582	.0378	.1210	.7181	

computations are shown on page 23 of this report.

It must be realized that the number of samples available were limited, but that the study contains all of the sample analyses taken at the most representative locations which were complete.

Following are the formulas and conversion factors used in the extended computations on table 9, page 23, and table 12, page 29.[1]

$$\text{Equivalent parts per million} = \frac{\text{parts per million}}{\text{Equivalent Weight}}$$

Tons per Acre-ft. = parts per million x 0.00136

Tons per month = Flow c.f.s. x ppm x 0.0027x average number day/mo.

Acre-ft./mo = Flow c.f.s. x 1.9835 x average number days/mo.

Ion concentration in reservoir in epm

Ca tons per af x 36.765

Mg tons per af x 60.270

Na tons per af x 31.969

$$\text{Sodium Absorption Ratio} = \frac{Na}{\sqrt{\frac{Ca\ Mg}{2}}}$$

$$\text{Conductivity-Micromhos/cm.} = \frac{\text{Total dissolved Solids in ppm}^{2/}}{.64}$$

Using the chemical analyses from each source the average tons per acre-foot inflow were derived for each ion, Ca, Mg, Na, and the TDS (total dissolved solids). These constants were applied to the annual inflow, page 25, in 1000 A.F. from each respective source to arrive at an ion concentration in 1000 tons. The tonnages were added together to get the total ion inflow in tons.

1/ "Bureau Manual" Volume IV, Chapter 2.4

2/ "Diagnosis and Improvement of Saline and Alkali Soils", U.S. Dept. Agriculture Handbook No. 60

Date Year	Bear River Inflow 1000 AF	Bear River 1000 Tons Ca 0.07818	Mg 0.0615	Na 0.2941	TDS 1.388	Weber River Inflow 1000 AF	Weber River 1000 Tons Ca 0.0843	Mg 0.0294	Na 0.0682
1928									
1929	330	25.79	20.29	97.05	458.04	261	22.00	7.67	17.80
1930	160	12.51	9.84	47.05	222.08	92	7.76	2.70	6.27
1931	85	6.64	5.23	24.99	117.98	83	7.00	2.44	5.66
1932	385	30.10	23.68	113.23	534.38	280	23.60	8.23	19.10
1933	260	20.33	15.99	76.47	360.88	161	13.57	4.73	10.98
1934	60	4.69	3.69	17.65	83.28	38	3.20	1.12	2.59
1935	150	11.73	9.22	44.11	208.20	80	6.74	2.35	5.45
1936	400	31.27	24.60	117.64	555.20	365	30.77	10.73	24.89
1937	335	26.19	20.60	98.52	464.98	229	19.30	6.73	15.62
1938	355	27.75	21.83	104.40	492.74	219	18.46	6.44	14.93
1939	240	18.76	14.76	70.58	333.12	119	10.03	3.50	8.11
1940	150	11.73	9.22	44.11	208.20	89	7.50	2.62	6.07
1941	175	13.68	10.76	51.47	242.90	112	9.44	3.29	7.64
1942	310	24.23	19.06	91.17	430.28	213	17.95	6.26	14.53
1943	420	32.83	25.83	123.52	582.96	188	15.85	5.53	12.82
1944									

Total Ion Inflow = Inflow from each source multiplied b
Average Ion Concentration = Derived from the chemical a

TABLE

TDS 0.516	Inflow 1000 AF	Jordan & Surplus Canal 1000 Tons Ca 0.1710	Mg 0.0781	Na 0.3201	TDS 1.554	Fillup and Drawdown Seasons	Inflow 1000 AF	Other Tributar 1000 Tons Ca 0.0582	Mg 0.0378
						D	410	23.86	15.50
134.68	170	29.07	13.28	54.42	264.18	F	360	20.95	13.61
						D	580	33.76	21.92
47.47	135	23.08	10.54	43.21	209.79	F	270	15.71	10.21
						D	310	18.04	11.72
42.83	110	18.81	8.59	35.21	170.94	F	510	29.68	19.28
						D	0	0	0
144.48	96	16.42	7.50	30.73	149.18	F	470	27.35	17.77
						D	260	15.13	9.83
83.08	110	18.81	8.59	35.21	170.94	F	380	22.12	14.36
						D	10	.58	.38
19.61	79	13.51	6.17	25.29	122.77	F	0	0	0
						D	0	0	0
41.28	65	11.11	5.08	20.81	101.01	F	400	23.28	15.12
						D	0	0	0
188.34	83	14.19	6.48	26.57	128.98	F	210	12.22	7.94
						D	50	2.91	1.89
118.16	102	17.44	7.97	32.65	158.51	F	560	32.59	21.17
						D	110	6.40	4.16
113.00	113	19.32	8.82	36.17	175.60	F	260	15.13	9.83
						D	0	0	0
61.40	115	19.66	8.98	36.81	178.71	F	310	18.04	11.72
						D	0	0	0
45.92	113	19.32	8.82	36.17	175.60	F	230	13.39	8.69
						D	0	0	0
57.79	80	13.68	6.25	25.61	124.32	F	620	36.08	23.44
						D	0	0	0
109.91	100	17.10	7.81	32.01	155.40	F	800	46.56	30.24
						D	0	0	0
97.01	80	13.68	6.25	25.61	124.32	F	300	17.46	11.34
						D	2	.12	.07

the average ion concentration.
lyses of water samples from each respective source, Table 9, page 23.

es			1000's Tons			
Na 0.1210	TDS 0.7181	Total Inflow 1000 AF	Total Ca Inflow	Total Mg Inflow	Total Na Inflow	Total TDS Inflow
49.61	294.42	410	23.86	15.50	49.61	294.42
43.56	258.52	1121 81	97.81	54.85	212.83	1115.42
70.18	416.50	580	33.76	21.92	70.18	416.50
32.67	193.89	657	59.06	43.13	129.20	673.23
37.51	222.61	310	18.04	11.72	37.51	222.61
61.71	366.23	788	62.13	35.54	127.57	697.98
0	0	0	0	0	0	0
56.87	337.51	1231	97.47	57.18	219.93	1165.55
31.46	186.71	260	15.13	9.83	31.46	186.71
45.98	272.88	911	74.83	43.67	168.64	887.78
1.21	7.18	10	.58	.38	1.21	7.18
0	0	177	21.40	10.98	45.53	225.66
0	0	0	0	0	0	0
48.40	287.24	695	52.86	31.77	118.77	637.73
0	0	0	0	0	0	0
25.41	150.80	1058	88.45	49.75	194.51	1023.32
6.05	35.91	50	2.91	1.89	6.05	35.91
67.76	402.14	1226	95.52	56.47	214.55	1143.79
13.31	78.99	110	6.40	4.16	13.31	78.99
31.46	186.71	947	80.66	46.92	186.96	968.05
0	0	0	0	0	0	0
37.51	222.61	784	66.49	38.96	153.01	795.84
0	0	0	0	0	0	0
27.83	165.16	582	51.94	29.35	114.18	594.88
0	0	0	0	0	0	0
75.02	445.22	987	72.88	43.74	159.74	870.23
0	0	0	0	0	0	0
96.80	574.48	1423	105.84	63.37	234.51	1270.07
0	0	0	0	0	0	0
36.30	215.43	988	79.82	48.95	198.25	1019.72
.24	1.44	2	.12	.07	0.24	1.44

It was assumed that the reservoir was empty and was to be filled from the vatous sources. An average yearly inflow of 910,000 A.F. per year was determined over a period of 16 years and this figure was used as an annual inflow to fill the lake as previously explained. As the evaporation varies with reservoir surface area during this period, the evaporation was taken from the net evaporation table on page 8. Since average conditions were assumed for the initial fill-up period, an average evaporation based on reservoir content was also used. It was found that the reservoir would fill in the fourth year, and the concentration of ions was determined on this basis as the starting concentration for a full reservoir (see following computatinns).

Assuming an average yearly inflow of 910,000 A.F./yr:

Year	1000 AF Inflow	1000 AF Evaporation	End of Year Resv. Content 1000 AF
1	910	340	570
2	910	620	840
3	910	700	1050
4	700	348	1422 Full reservoir at Elev. 4205'

Average yearly inflow from each source as part of total average inflow of 910,000 A.F., multiplied by the average ion constant from each source gives 1000's of tons of ions per year inflow while filling from each source.

Source	1000 AF	CA	1000's Tons Mg	1000's Tons Na	TDS
Bear River	250	19	15	74	347
Weber River	170	14	5	12	88
Jordan River	105	18	8	34	163
Other Sources	385	22	14	46	276
Total Ion Concentration		73	42	166	874

Total ion concentration in the reservoir when full was computed as total tons per year ion inflow, times years or part of years to fill the reservoir.

Tons		Years		
73	x	3.77	=	275,000 tons Ca
42	x	3.77	=	158,000 tons Mg
166	x	3.77	=	626,000 tons Na
~~184~~ 874	x	3.77	=	3,295,000 tons TDS

These concentrations were used as the starting concentrations at the end of the fill-up period to begin the quality of water study.

Quality of Water Study

The study was divided into two periods, each year, the fill-up period and the drawdown period as was used in the operation study. Taken into consideration during the fill-up period were the inflow, spills, evaporation, and the amount pumped for irrigation. The latter is relatively small or zero during the fill-up season. During the drawdown season, the inflow, evaporation and that amount pumped for irrigation are the only factors taken into consideration. There are no spills during the drawdown season. An explanation of the columns is given on page 28, preceding the quality of water study, page 29.

Results

The sodium absorption ratio (SAR) and the conductivity from the quality of water study are then aligned in the diagram for use in interpreting the analysis of irrigation water. (Bur. Man Vol. IV, Chap 2.4, Illustration 1). Using the lowest SAR and Conductivity in the study gives a C4-S2 irrigation water. The results are shown in table 12 on page 29 and under the summary page 2.

TABLE 11

Column Explanation
for
Table ~~22~~ 12

Col. Number	
1	Years of Study
2	Designation of fillup and drawdown seasons
3, 4, 5, & 6	Columns 28, 29, 30 & 31 plus Columns 40,41, 42, & 43 minus Columns 45, 46, 47, & 48. Water pumped from reservoir is at 100% reservoir concentration due to ~~concentration due to~~ lack of spills during drawdown season.
7	Inflow to reservoir during fillup season taken from Operation Study page 21.
8, 9, 10 & 11	Taken from table 10, page 25.
12	From Operation Study, page 21.
13	Column 12 divided by Column 7.
14	100% minus Column 13
15, 16, 17 & 18	50% of Column 13 times Columns 8, 9, 10 & 11
19, 20, 21 & 22	50% of Column 14 times Columns 35, 36, 37 & 38 (Use previous season concentrations)
23	Taken from Operation Study, page 21.
24, 25, 26, & 27	50% of Column 22 times Columns 52, 53, 54 & 55 (Use previous season concentrations)
28, 29,30, & 31	Columns 3, 4, 5, & 6 plus Columns 8, 9, 10 & 11 minus Columns 15, 16, 17, & 18 minus Columns 19, 20,21,&22 minus Columns 24, 25, 26, & 27.
32	Taken from Operation Study, page 21
33	Taken from Operations Study, page 21
34	Col. 32 plus Column 7 minus Column 12 minus Column 23.
35, 36,37, & 38	Same as Columns 28, 29, 30, & 31
39	Taken from operation Study, page 21.
40, 41, 42 & 43	Taken from table 10, page 25
44	Taken from Operation Study, page 21
45, 56, 47, & 48	Column 44 times Columns 52, 53, 54, 55. (Use Previous season concentrations)
49	Taken from Operation Study, page 21
50	Taken from Operation Study, page 21
51	Column 34 plus Column 39 minus Column 44.
52, 53, 54 & 55	Columns 3, 4, 5, & 6 times Column 32 for drawdown season, and Columns 28, 29, 30, 31 times Column 34, for fillup season.
56, 57 & 58	Columns 52, 53, & 54 changed to epm's
59	Column 56 plus Column 57
60	Total of Columns 56, 57, & 58
61	Column 58 divided by $\sqrt{\frac{Ca\text{-}mg}{2}}$
62	Column 55 changed to ppm
63	Column 62 divided by 0.64

1	2	3	4	5	6		7		8
Year	Fillup & Drawdown Season	Ions Retained in Reservoir at Beginning of Fillup Season 1000's Tons					Inflow to Res. during Fillup Season 1000's AF		Io du
		Ca	Mg	Na	TDS				Ca
1928	F								
	D								
1929	F	262	152	592	3147		1121		98
	D								
1930	F	273	159	606	3249		657		59
	D								
1931	F	278	170	614	3289		788		62
	D								
1932	F	264	160	575	3091		1231		97
	D								
1933	F	269	164	574	3191		911		75
	D								
1934	F	260	157	562	3082		177		21
	D								
1935	F	199	119	430	2342		695		53
	D								
1936	F	192	114	417	2262		1058		88
	D								
1937	F	236	139	515	2768		1226		96
	D								
1938	F	241	143	528	2839		947		81
	D								
1939	F	247	145	547	2913		784		66
	D								
1940	F	260	152	582	3082		582		52
	D								
1941	F	248	144	554	2922		987		73
	D								
1942	F	271	159	601	3193		1423		106
	D								
1943	F	211	124	465	2487		988		80
	D								
1944	F	254	150	577	3051				

9	10	11		12	13	14		15	16
n Inflow to Reservoir ring Fillup Season 1000's Tons				Spills during Fillup Season 1000's AF	Percent Inflow Spilled	Percent Inflow Retained in Reservoir		Ions Spille Inflow Conc 1000	
Mg	Na	TDS						Ca	Mg
55	213	1115		561	50	50		25	14
43	129	673		256	39	61		11	8
36	128	698		161	20	80		6	4
57	220	1166		276	22	78		11	6
44	169	888		208	23	77		8	5
11	46	226		0	0	100		0	0
32	119	638		0	0	100		0	0
50	195	1023		0	0	100		0	0
56	215	1144		263	21	79		10	6
47	187	968		161	17	83		6	4
39	153	796		0	0	100		0	0
29	114	595		0	0	100		0	0
44	160	870		0	0	100		0	0
63	235	1270		549	39	61		21	12
49	198	1020		5	1	99		0	0

17	18		19	20	21	22		23	
d (50%) at entration			Ions Spilled (50%) at Reservoir Concentration					Pumped from Res. for Irri. during Fillup 1000 AF	
's Tons Na	TDS		Ca	1000's Tons Mg	Na	TDS			
53	279		67	39	151	805		25	
24	128		26	15	58	313		20	
13	70		20	12	44	237		24	
24	128		52	31	132	604		31	
18	98		29	17	61	340		21	
0	0		0	0	0	0		78	
0	0		0	0	0	0		9	
0	0		0	0	0	0		26	
24	126		50	29	109	588		14	
15	77		23	14	51	272		12	
0	0		0	0	0	0		34	
0	0		0	0	0	0		50	
0	0		0	0	0	0		21	
47	254		108	63	240	1273		9	
1	5		1	1	2	9		31	

24	25	26	27		28	29	30	31		
Ions Pumped from Reservoir for Irrigation during Fillup Season (50% at Reservoir Concentration) 1000's Tons					Ions Retained in Reservoir end of Fillup Season 1000's Tons					Re ti o3 d0 so
Ca	Mg	Na	TDS		Ca	Mg	Na	TDS		
					275	158	626	3295	F D	
3	2	6	34		265	152	595	3144	F D	
2	1	4	24		293	178	649	3457	F D	
3	2	7	35		311	188	678	3645	F D	
6	3	14	66		292	177	625	3459	F D	
3	2	6	33		304	184	658	3608	F D	
14	8	31	168		267	160	577	3140	F D	
4	3	9	52		248	148	540	2928	F D	
9	5	20	108		271	159	592	3177	F D	
3	1	6	31		269	159	591	3167	F D	
2	1	4	20		291	171	645	3438	F D	
6	4	13	70		307	180	687	3639	F D	
10	6	22	119		302	175	674	3558	F D	
5	3	12	65		316	185	702	3727	F D	
1	1	3	18		247	146	546	2918	F D	
4	3	10	52		286	169	650	3441	F D	

32	33	34		35	36	37	38		39
es.con-ent end f Draw-own Sea-n 1000AF	Evapora-tion los dur.Fill-up Season 1000 AF	Res.Con-tent end of Fillup Season 1000 AF		Ions In Reservoir Beginning of Drawdown Season 1000's Tons Ca	Mg	Na	TDS		Inflow to furing Dra down Seaso 1000 AF
		1422							
1095				275	158	626	3295		410
	208	1422							
1327				265	152	595	3144		580
	286	1422							
1111				293	178	649	3457		310
	292	1422							
706				311	188	678	3645		0
	208	1422							
975				292	177	625	3459		260
	235	1422							
717				304	184	658	3608		10
	230	586							
181				267	160	577	3140		0
	88	778							
271				248	148	540	2928		0
	140	1163							
617				271	159	592	3177		50
	144	1422							
834				269	159	591	3167		110
	186	1422							
705				291	171	645	3438		0
	156	1299							
646				307	180	687	3639		0
	171	1007							
452				302	175	674	3558		0
	127	1291							
687				316	185	702	3727		0
	130	1422							
716				247	146	546	2918		0
	246	1422							
803				286	169	650	3441		2

Res. ..- ..n	40	41	42	43		44		45	46
	Ion Inflow to Reservoir during Drawdown Season 1000's Tons					Pumped from Res. for Irri. during Drawdown Season 1000 AF		Ions Pumped for Irri. du... (100% at Rese... 10...	
	Ca	Mg	Na	TDS				Ca	Mg
	24	15	50	294		191		37	21
	34	22	70	417		141		26	15
	18	12	38	223		161		33	20
	0	0	0	0		216		47	28
	15	10	31	187		187		38	23
	1	0	1	7		210		45	27
	0	0	0	0		149		68	41
	0	0	0	0		177		56	34
	3	2	6	36		163		38	22
	6	4	13	79		183		34	20
	0	0	0	0		217		44	26
	0	0	0	0		199		47	28
	0	0	0	0		180		54	31
	0	0	0	0		185		45	26
	0	0	0	0		210		36	22
	0	0	0	1		161		32	19

47	48		49	50	51		52	53	54	55	
from Reservoir ing Drawdown Season rvoir Concentration) 0's Tons			Res.Content of end Fillup Season 1000 Af	Evapo. loss dur DD Season 1000 AF	Res.Content of end DD Season 1000 AF		Ion Concentration in Reservoir at end of Fillup and Drawdown Seasons Tons/AF				
Na	TDS						Ca	Mg	Na	TDS	
		F	1422				.193	.111	.440	2.317	
84	442	D		546	1095		.239	.139	.541	2.874	
		F	1422				.186	.107	.418	2.211	
59	312	D		534	1327		.206	.120	.457	2.448	
		F	1422				.206	.125	.456	2.431	
73	391	D		460	1111		.250	.153	.553	2.960	
		F	1422				.219	.132	.477	2.563	
103	554	D		500	706		.374	.227	.956	4.378	
		F	1422				.205	.124	.440	2.432	
82	455	D		520	975		.276	.168	.589	3.272	
		F	1422				.214	.129	.463	2.537	
97	533	D		505	717		.363	.219	.784	4.298	
		F	586				.456	.273	.985	5.358	
147	798	D		256	181		1.099	.657	2.376	12.939	
		F	778				.319	.190	.694	3.763	
123	666	D		330	271		.708	.421	1.539	8.346	
		F	1163				.233	.137	.509	2.732	
83	445	D		433	617		.382	.225	.835	4.486	
		F	1422				.189	.112	.416	2.227	
76	407	D		515	834		.289	.171	.633	3.404	
		F	1422				.205	.120	.454	2.418	
98	525	D		500	705		.350	.206	.776	4.131	
		F	1299				.236	.139	.529	2.801	
105	557	D		454	646		.402	.235	.901	4.770	
		F	1007				.300	.174	.669	3.533	
120	636	D		375	452		.549	.319	1.226	6.464	
		F	1291				.245	.143	.544	2.887	
101	534	D		419	687		.394	.231	.875	4.647	
		F	1422				.174	.103	.384	2.052	
81	431	D		496	716		.295	.173	.649	3.473	
		F	1422				.201	.119	.457	2.420	
73	390	D		460	803		.316	.187	.718	3.800	

55		56	57	58	59	60		61
Fillup		Ion Concentration In Reservoir E.P.M.'s				Total E.P.M.'s		Sodium Absorption Ratio =
TDS		(36.765) Ca	(60.270) Mg	(31.969) Na	Ca+Mg		(Ca+Mg) / 2	NA ÷ √((Ca+Mg)/2)
2.317		7.096	6.690	14.066	13.786	27.852	2.625	5.36
2.874		8.787	8.377	17.295	17.164	34.459	2.930	5.90
2.211		6.838	6.449	13.363	13.287	26.650	2.577	5.18
2.448		7.573	7.232	14.610	14.805	29.415	2.721	5.37
2.431		7.573	7.534	14.578	15.107	29.685	2.748	5.30
2.960		9.191	9.221	17.679	18.412	36.091	3.003	5.89
2.563		8.052	7.956	15.249	16.008	31.257	2.829	5.39
4.378		13.750	13.681	30.562	27.431	57.993	3.703	8.25
2.432		7.537	7.473	14.066	15.010	29.076	2.739	5.13
3.272		10.147	10.125	18.830	20.272	39.102	3.184	5.91
2.537		7.868	7.775	14.802	15.643	30.445	2.797	5.29
4.298		13.346	13.199	25.064	26.545	51.609	3.643	6.88
5.358		16.765	16.454	31.489	33.219	64.708	4.075	7.73
12.939		40.405	39.597	75.958	80.002	159.600	6.324	12.01
3.763		11.728	11.451	22.186	23.179	45.365	3.404	6.52
8.346		26.030	25.374	49.200	51.404	100.604	5.069	9.71
2.732		8.566	8.257	16.272	16.823	33.095	2.900	5.61
4.486		14.044	13.561	26.694	27.605	54.299	3.715	7.19
2.227		6.949	6.750	13.299	13.699	26.998	2.617	5.08
3.404		10.625	10.306	20.236	20.931	41.167	3.235	6.25
2.418		7.537	7.232	14.514	14.769	29.283	2.717	5.34
4.131		12.868	12.416	24.808	25.284	50.092	3.555	6.98
2.801		8.676	8.377	16.912	17.053	33.965	2.920	5.79
4.770		14.780	14.163	28.804	28.943	57.747	3.804	7.57
3.533		11.030	10.487	21.387	21.517	42.904	3.280	6.52
6.464		20.184	19.226	39.194	39.410	78.604	4.439	8.83
2.887		9.007	8.619	17.391	17.626	35.017	2.968	5.86
4.647		14.485	13.922	27.973	28.407	56.380	3.769	7.42
2.052		6.397	6.208	12.276	12.605	24.881	2.510	4.90
3.473		10.846	10.427	20.748	21.273	42.021	3.261	6.36
2.420		7.390	7.172	14.610	14.562	29.172	2.698	5.42
3.800		11.618	11.270	22.954	22.888	45.842	3.383	6.79
							Avg.	6.49

62	63			
TDS in PPM of Col. 55	$\frac{EC \times 10^6}{TDS_{PPM}}$ .64			
1704	2662			
2113	3300			
1626	2540			
1800	2812			
1787	2791			
2176	3399			
1884	2943			
3219	5028			
1718	2793			
2406	3758			
1865	2913			
3160	4936			
3939	6153			
9513	14864	C4-S4		
2766	4320			
6136	9584			
2009	3138			
3298	5151			
1637	2557			
2503	3910			
1778	2777			
3037	4744			
2059	3216			
3507	5478			
2597	4057			
4752	7423			
2122	3315			
3416	5336			
1509	2357	C4-S2		
2553	3988			
1779	2779			
2794	4364			
Avg.	4356			

50% Sodium

C4 (very high-salinity water) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt-tolerant crops should be selected

S2(Medium-Sodium) water will present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, especially under low leaching conditions unless gypsum is present in the soil. The water may be used on coarse-textured or organic soils with good permeability.

The sodium and salinity hazards range upward from C4-S2 to the maximum of C4-S4. The average sodium and salinity hazards fall on the high side of the C4-S2 quadrant in the interpretation diagram. With this type of water, the problem becomes complicated. If this water is used on soils adjacent to the lake, with a small pump lift, which already have their own alkaline and salinity problems, it would not be long (2 or 3 years) until that soil would be non-arable. If the water is pumped to soils which are more permeable and are better drained, there will be the increased cost of pumping, and also the probability that the water would return underground to the soils adjacent to the reservoir.

The results of the reservoir operation study show that the lake, during periods of drouth, would decrease in area and volume to the extent that for purposes of recreation the boundaries of the lake surface would be too far from the present shore, and the intervening area would most likely be a sea of mud. The salinity during these periods would also restrict the waters use for industrial purposes.