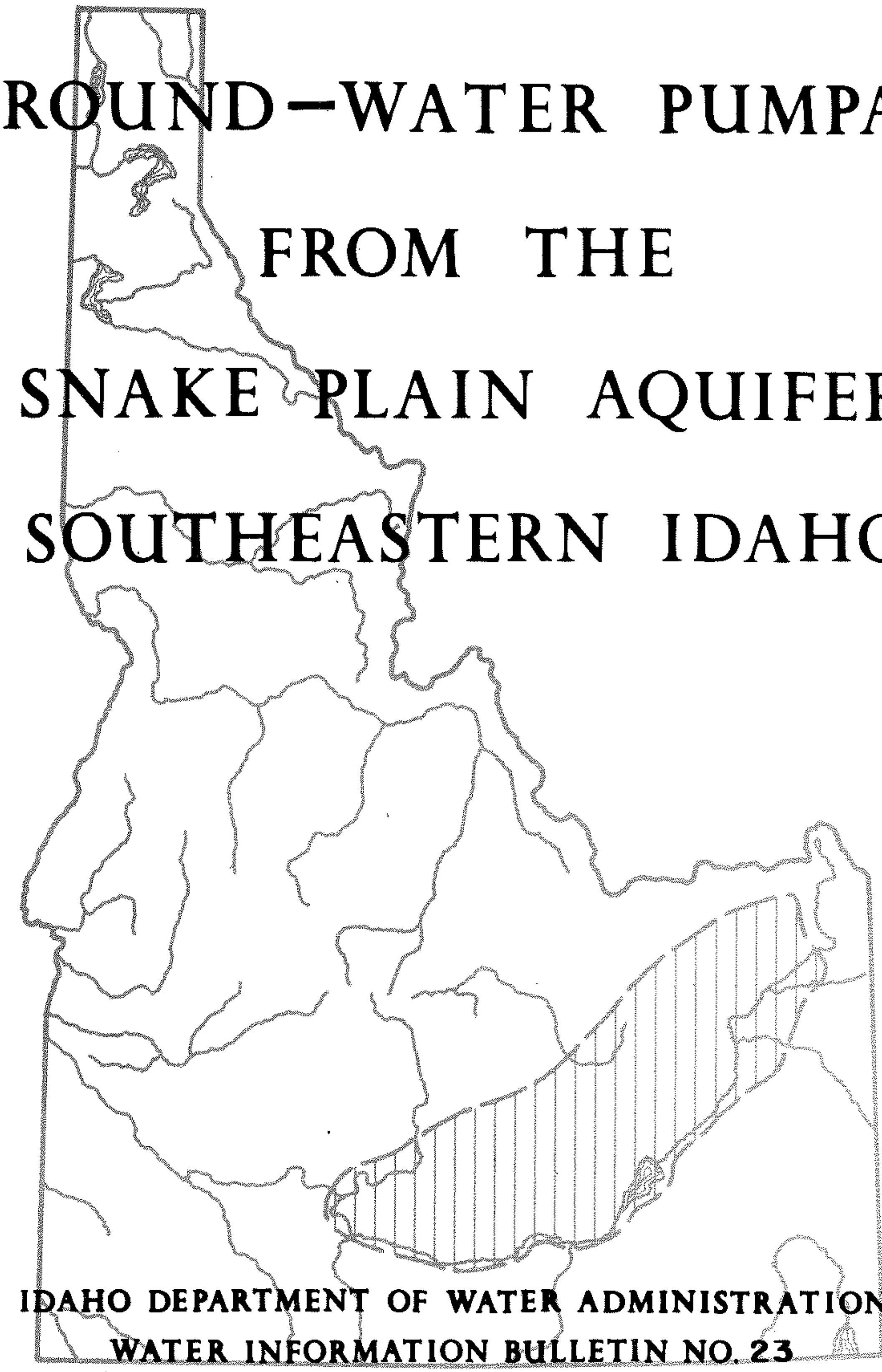
GROUND-WATER PUMPAGE FROM THE SNAKE PLAIN AQUIFER, SOUTHEASTERN IDAHO



IDAHO DEPARTMENT OF WATER ADMINISTRATION

WATER INFORMATION BULLETIN NO. 23

SEPTEMBER 1971

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by

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and

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Prepared by the United States Geological Survey

in cooperation with

Idaho Department of Water Administration

Published by

Idaho Department of Water Administration

R. Keith Higginson

Director

September 1971

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by

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ABSTRACT

This report estimates, by a method described herein, the amount of ground water pumped from the Snake Plain aquifer in southeastern Idaho. Emphasis is placed on the method used to estimate withdrawals for irrigation purposes.

Ground-water withdrawals for irrigation needs were computed using the average number of kilowatt-hours of electrical energy consumed per acre-foot of water pumped and the total kilowatt-hours used by irrigation wells. A statistical technique was employed to determine sample size and location and to evaluate the accuracy of the results.

A sample of 173 wells indicates that about 527 kilowatt-hours are used to pump 1 acre-foot of ground water from the Snake Plain aquifer. Using this coefficient and the total electrical power consumed by irrigation wells, irrigation pumpage is estimated to be about 1,000,000 acre-feet. Statistical evaluation of the sample population indicates that the results are accurate to within 10 percent of actual withdrawals.

Municipal ground-water pumpage is estimated to be about 34,000 acre-feet, industrial pumpage about 38,000 acre-feet, and rural-domestic pumpage about 7,000 acre-feet. Total ground-water pumpage from the Snake Plain aquifer in 1969 for irrigation, municipal, industrial, and rural-domestic uses is estimated to be about 1,079,000 acre-feet.

INTRODUCTION

The rapidly-expanding agricultural and industrial growth occurring on the Snake River Plain in Idaho is requiring the use of increasing amounts of ground water. Persons and agencies responsible for the planning needed to accommodate this growth often must forecast the amount of water that will be needed in the future. To do this, they first need accurate data indicative of the amount of ground water presently being pumped. An accurate estimate of present use will not only be of aid in existing and future planning studies, but it will also be useful in other types of investigations whose goals are to describe the availability and the effects of use of the ground-water resource.

Generally, the past estimates made by various workers of the amount of ground water pumped were based largely on reported information collected during short-term water-use studies or as a subsidiary part of other water-resource investigations. As a result, few measurements of the quantities pumped for irrigation and other uses were made. Previous workers have been discouraged from making an accurate estimate of pumpage because of the lack of a suitable method for making the estimate within reasonable time and cost limits. These workers, and others concerned with the water resources of Idaho, have long recognized the need for a better, more reliable, and quicker method of estimating pumpage than has previously been available.

Recently, the use of statistical techniques to guide the collection and analysis of pumpage data has served to provide a better method of estimating the quantity of water withdrawn in an area and for evaluating the accuracy of the withdrawal figure obtained. This method is described and applied in this report. In the first application of this method in Idaho, a statistically derived estimate for the quantity of ground water withdrawn for irrigation use from the Snake Plain aquifer of southeastern Idaho is obtained and its accuracy assessed. It is anticipated that future studies will be made using this method to obtain periodical estimates of ground-water withdrawals for the Snake Plain aquifer and for other parts of Idaho.

The study described in this report was accomplished within a program of water-resource investigations made by the U. S. Geological Survey in cooperation with the Idaho Department of Water Administration.

Location

The Snake Plain aquifer underlies approximately 9,600 square miles of the Snake River Plain in southeastern Idaho (fig. 1). The boundary of the aquifer, as defined by Norvitch, Thomas, and Madison (1969, p. 2), encompasses the area covered by this study and is shown in figure 2. As shown, this boundary was arbitrarily drawn along the foot of the mountains surrounding the Plain and across the mouths of tributary valleys. Generally, the boundary marks the contact of the Snake Plain aquifer with the usually less permeable surrounding material.

Centers of water use, of agricultural development, and of population are mostly near the Snake River, which flows along the eastern and southern margins of the Snake River Plain. The Snake River is the primary source of surface water for irrigation of croplands lying near the river. Ground water is used almost exclusively on the more recently developed irrigated lands extending out into the Plain away from areas irrigated with surface water. (See fig. 2.)

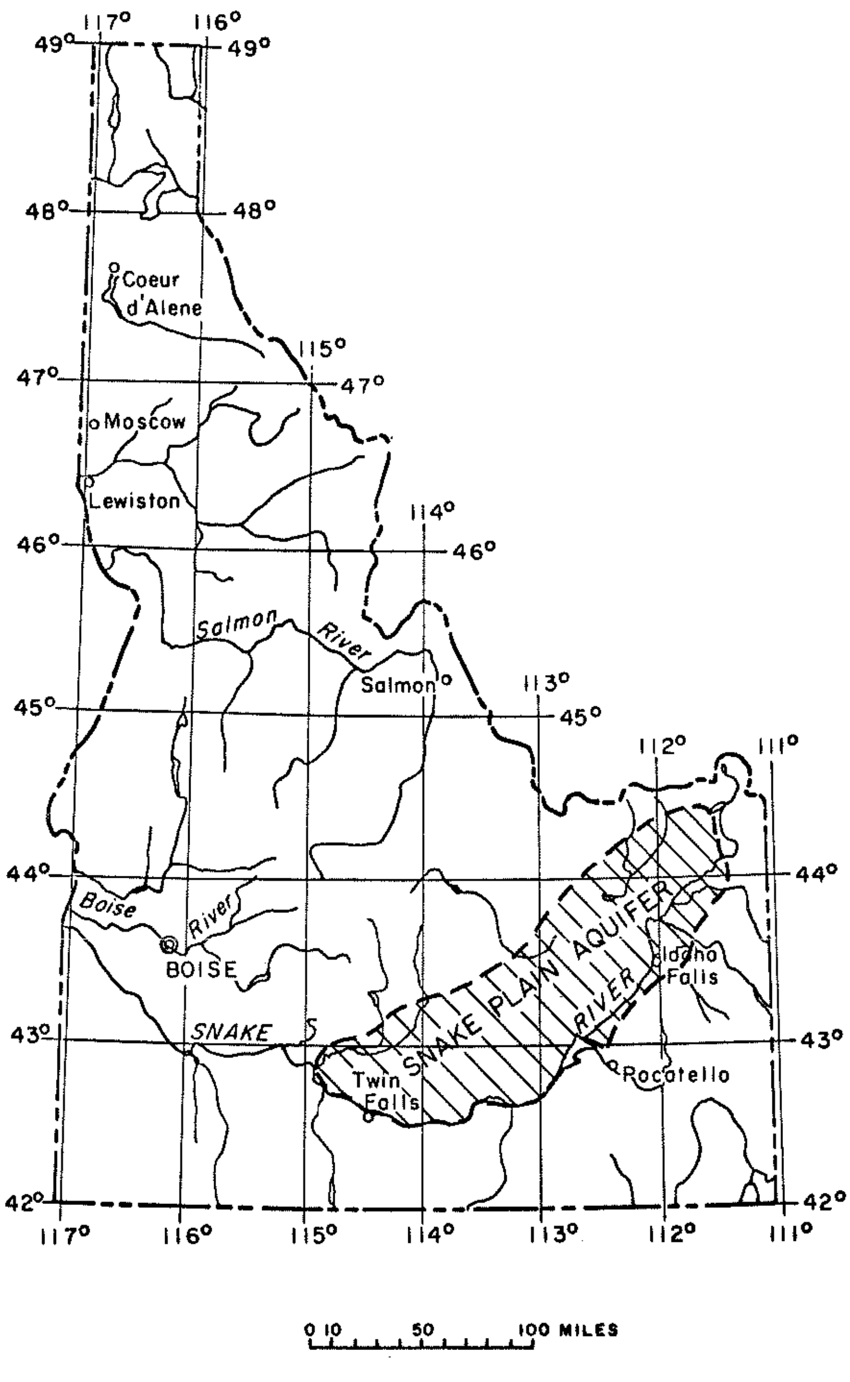

FIGURE 1. Index map showing area covered by this report.

Purpose and Scope

The purpose of this report is (1) to describe and to establish a procedure for estimating the quantity of ground water pumped annually from the Snake Plain aquifer in southeastern Idaho for irrigation, industrial, municipal, and rural-domestic use; and (2) to provide an evaluated estimate of the amount being pumped for these purposes. Because the amount of ground water pumped for irrigation use greatly exceeds the amount pumped for all other uses, and because of its large magnitude, the procedure for estimating this value is described in detail.

In attempting to establish a procedure for estimating the amount of ground water pumped for irrigation, several approaches were considered. If the number of acres irrigated with ground water and the average rate of application were known, a value for the total quantity of ground water pumped could be calculated. A search made of the information available indicated that these data could not be readily collected.

It was found, however, that the total amount of electrical energy used by all irrigation pumps could be obtained. These data, and information on the amounts of water pumped and energy consumed at randomly selected wells, were used to estimate the total amount of ground water pumped for irrigation. The following procedure to compute this estimate was established: the total number of kilowatt-hours of electrical energy consumed by 2,044 irrigation wells on the Plain was acquired and the discharge of and kilowatt-hours consumed in 173 randomly selected index wells on the Plain were measured. Using these data, the average kilowatt-hours consumed per acre-foot of water pumped was calculated and, by applying this figure to the total number of kilowatt-hours used, a total figure for irrigation pumpage was then computed.

The amount of ground water pumped for municipal and industrial purposes was estimated using data obtained from questionnaires, from previous investigations, and by interviewing owners of water-supply systems. The amount of ground water used for rural-domestic purposes was estimated using population data from reports of the U. S. Bureau of the Census and published per capita consumption figures.

Previous Investigations

Numerous estimates of the quantity of ground water pumped in all or parts of Idaho have been made. As a part of its continuing program of ground-water investigations, the U. S. Geological Survey has reported on quantities pumped in several water-use reports (MacKichan and Kammerer, 1961; and Murray, 1968). A report prepared for the Idaho Water Resource Board by the University of Idaho also contains pumpage data for Idaho (Water Resources Research Institute, University of Idaho, 1968).

Estimates of the amount of ground water pumped for irrigation on the Snake River Plain are contained in two published reports. Mundorff, Crosthwaite, and Kilburn (1964, p. 23) estimated that 920,000 acre-feet of ground water was pumped for irrigation needs in 1959. Norvitch, Thomas, and Madison (1969, p. 9) estimated that 2,100,000 acre-feet of ground water was pumped in 1965 to meet irrigation requirements.

All the pumpage estimates noted above were based largely on reported data that incorporated a sparse number of field observations. The authors of these estimates all recognized the lack of firm data and pointed out the need for an intensified study to determine ground-water pumpage, and for a means to substantiate and evaluate the final estimates.

Acknowledgments

The success of this study is largely owing to the excellent cooperation extended to the U. S. Geological Survey by the many well owners, private companies, municipalities, and governmental agencies who provided access to their wells and records. Individual well owners freely provided pertinent data regarding construction of their wells, size of pumps, and details of their irrigation distribution systems, and also allowed the discharges of and water levels in their wells to be measured. Data on well locations and on kilowatt-hours consumed at wells were provided by the Idaho Power Company, Lost River Electric Cooperative, Inc., and the Utah Power and Light Company; without these data, the amount of ground water used for irrigation could not have been calculated. All municipal officials contacted gave full cooperation by supplying pumpage data. The large amount of historical pumpage data collected and supplied by the U. S. Bureau of Reclamation enabled use of their Minidoka North Side Pumping Division as a test area for the method used in this report to determine irrigation withdrawals.

GROUND-WATER WITHDRAWALS

Irrigation Pumpage

Method Used

To determine with absolute accuracy the amount of ground water pumped annually for irrigation on the Snake River Plain would require that the exact quantity of water pumped at each and every irrigation well on the Plain be measured each year. Because there are several thousand irrigation wells on the Plain, the effort required to make these measurements would be prohibitively expensive and time consuming. Practically, then, it is to estimate irrigation pumpage using some other method.

A commonly accepted method for estimating the amount of water pumped in an area consists of using (1) average discharge values and values of consumed energy derived from a number of index wells considered representative of conditions in the area being studied and (2) the total energy consumed by all wells in the area, to obtain a total pumpage value. In the past, index wells were arbitrarily selected to represent different pumping lifts, types of irrigation systems (flood or sprinkler), well yields, topographic settings and infiltration capacities of the land irrigated, types of crops grown, and such other conditions as may have seemed pertinent to the individual making the study. The degree to which these items were considered and the number of wells selected depended entirely on the judgment of the individual making the selection.

In recent years, the use of statistical techniques to obtain an accurate measure of a population using a randomly selected sample has received widespread use. The statistical technique used in this report to aid in obtaining a measure of total pumpage was first applied to ground-water withdrawals by R. R. Luckey (written commun., 1969) who estimated the amount of ground water pumped in the Arkansas River Valley in Colorado. The benefits of using this technique are that it provides a means of determining the size of the random sample to be used, selecting the wells to be used, and evaluating the final pumpage figure obtained. Because application of this technique requires selection of the sample (index wells) on a random basis, it eliminates the problem of bias that may result from using individual judgment in selecting representative index wells.

Briefly, the technique consists of selecting a random sample (index wells) on the basis of the variance (an indicator for the total population of the amount of deviation of a variable of interest from its mean value) and the accuracy of the answer desired. The total quantity of water pumped is calculated using an average value of kwhr per acre-foot (kilowatt-hours per acre-foot) used by the index wells and the total kilowatt-hours consumed by all of the wells in the sampled population.

There are two basic requirements inherent to statistical evaluation and use of the random sample obtained as a part of this inventory of irrigation pumpage: (1) that the variable of interest (kilowatt-hours used per acre-foot of water pumped) have a normal or log-normal distribution with respect to all irrigation wells on the Plain and (2) that the variance of this variable be known or can be estimated. A graphic illustration of a normal distribution would appear as a bell-shaped curve that is symmetrical about the mean value of the variable of interest (see fig. 3). If the distribution were log-normal, a graph using logarithms of the variable on the ordinate would assume the same shape.

Test of Method

A preliminary investigation of the data available from about 178 wells used by the U. S. Bureau of Reclamation's Minidoka North Side Pumping Division located on the Snake

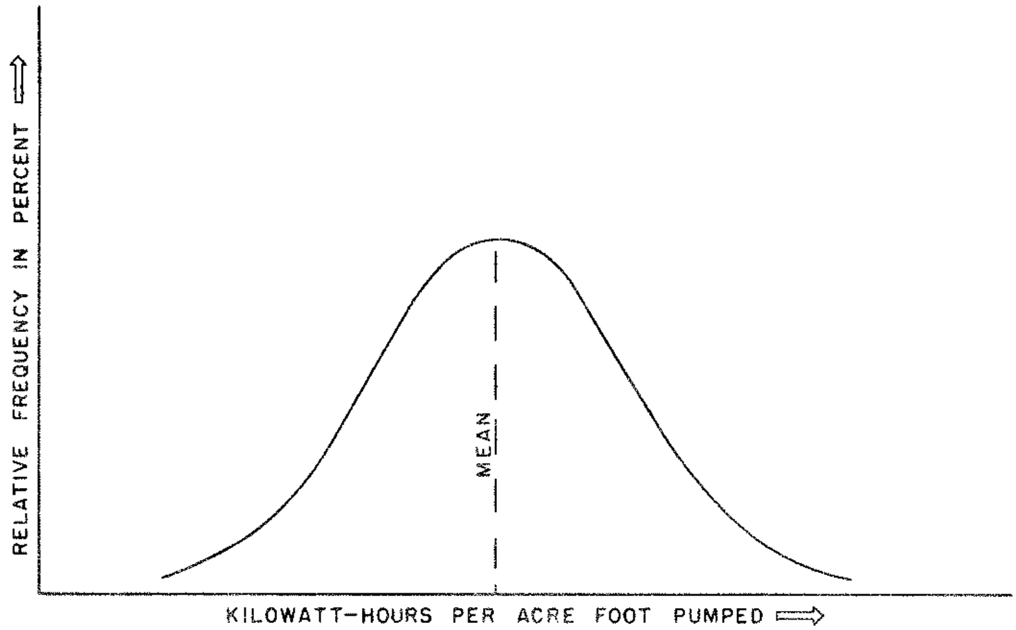

FIGURE 3. Graph showing a normal frequency distribution.

River Plain (fig. 2) indicated that this area could be used to test the applicability of the method. It was assumed that if satisfactory results could be obtained by applying the method in this area, they could also be obtained for the Plain as a whole. The test of the method was made as follows:

1. The average number of kwhr consumed per acre-foot of water pumped by each irrigation well in the project area during the 1968 irrigation season was calculated using data supplied by the U. S. Bureau of Reclamation.

2. A plot of the cumulative frequency of the data on log-probability paper showed that the calculated values of kwhr consumed per acre-foot of water pumped were distributed approximately log-normally among the wells.

3. An evaluation of the accuracy desired for the pumpage value to be calculated was made so that the number of index wells to be randomly selected among the wells pumped in this area could be determined.

Analysis of pumpage data available for the test area for the 9 years, 1960-1968, indicated that any pumpage value calculated should be within 10 percent of the actual pumpage. This accuracy would enable relating the effects of significant variations in climatic conditions, or number of acres irrigated, to the amount of ground water pumped annually.

The number of index wells needed to calculate a pumpage value that would be within 10 percent of the true value with a 95 percent probability of attaining that accuracy, was calculated to be 21, using the following formula of Luckey for sampling with replacement

$$n = \frac{b^2 \quad \sigma y^2}{\log \quad e^2 \quad (\alpha + 1)}$$

where

n = number of sample points (wells),

b = a constant (Natrella, 1963, p. T-3) depending on p

where

p = the probability that the statistic is within the confidence interval

σy^2 = variance of the natural logs of X

where

X = kwhr per acre-foot pumped

e = the base of the natural system of logarithms

α = maximum desired fractional error made in estimating mean kwhr per acre-foot.

Using the above formula and a variance of 0.05 log units, the number of sample points (21) needed to give any desired error (± 10 percent) with the corresponding probability (95 percent) of achieving that accuracy are shown below:

Probability (p) of Achieving Accuracy, in Percent

		95	90	80	70
Maximum	5	81	57	35	23
desired	10	21	15	9	6
fractional	20	6	4	3	2
error	30	3	2	1	1
(α),	40	1	1	1	1
in percent	50	1	1	1	1

4. Selection of the index wells was made from a tabulation giving the location of each well in the test area. Each well on the list was assigned a number, and a table of random numbers was used to select the index well.

5. A test of the natural logarithms of the measured values of kwhr consumed per acre-foot pumped, by both the index wells and all the wells in the test area, showed that these values were distributed normally and fit the curve shown in figure 3. The fact that a log-normal distribution of this variable was found among both the index wells and all the wells in the test area is used later as justification for assuming that the normal distribution found for the index wells used to sample the entire Snake River Plain is indicative of a normal distribution of this variable among all irrigation wells on the Plain.

6. The number of kwhr consumed per acre-foot of water pumped at each index well was calculated. These values were averaged to obtain, for the index wells, the average number of kwhr consumed per acre-foot pumped.

7. The total quantity of ground water pumped for the test area was calculated by dividing the computed average kwhr per acre-foot pumped by the index wells into the total number of kwhr used by all wells on the project.

Table 1 lists, for the period 1960-68, both the measured amount of water pumped annually by irrigation wells in the Minidoka North Side Pumping Division and the amount computed using the method just described. The pumpage computed for each year was estimated using a calculated average kwhr per acre-foot value for the index wells as computed from 1968 records. As shown, the percentage difference of the pumpage values shown for each year ranges from -5.9 to +5.1 percent and is within the estimated accuracy. Because of this close agreement between computed and actual ground-water withdrawals, and because conditions in this test area appear to closely approximate those on the Plain, it was decided that this statistical procedure could be used to obtain an accurate estimate of irrigation pumpage for the Plain.

Application of Method

The estimate of the amount of ground water pumped for irrigation on the Snake River Plain was made by applying, with some modification, the same technique tested in the Minidoka North Side Pumping Division. In the following discussion, several of the items entering into the technique used to obtain a pumpage figure are described more fully than was done previously.

Variance.--Because of a lack of data, it was necessary to make an initial estimate of the variance. This was accomplished, using a technique suggested by Natrella (1963), by making an estimate of the range of values of kwhr consumed per acre-foot of water pumped for the

Table 1

Ground-Water Pumpage by Irrigation Wells

in the Minidoka North Side Pumping Division

Year	Measured Pumpage (acre-feet)	Computed pumpage (acre-feet)	Percent error
1960	203,927	191,796	–5.9
1961	202,921	191,707	–5.5
1962	186,989	187,866	+.5
1963	177,481	177,444	0
1964	193,389	192,384	–.5
1965	190,719	200,356	+5.1
1966	226,254	230,649	+1.9
1967	200,607	201,867	+.6
1968	191,237	191,863	+.3

wells on the Plain. To do this, it was assumed that the average irrigation-well installation in use on the Plain has a pump efficiency of 65 percent and an electrical efficiency of 87.5 percent, and that 1.8 kilowatt-hours of electricity would be used to lift 1 acre-foot of water 1 foot. From a depth-to-water map of the area irrigated with ground water, it was estimated that 95 percent of the irrigation wells on the Plain were operating with lifts between 50 and 550 feet. Also, it was estimated that the average sprinkler system in use would have a pressure of 40 pounds per square inch, thus increasing the maximum lift by about 92 feet. Using these figures, it was estimated that values of kwhr per acre-foot pumped for 95 percent of the wells on the Plain would lie between 90 and 1,150 kwhr per acre-foot, and a variance of 0.41 (natural-log units) was calculated. The values of kwhr per acre-foot obtained from the index wells were found to range from 54 to 1,440, with 96 percent within the previously estimated range of 90 to 1,150, indicating that the method used to estimate the variance is valid.

Accuracy.–The accuracy of the final irrigation-pumpage value obtained, using this method, is primarily a function of the number of wells sampled. In this case, it can be shown that a sample size of 173 wells provides an answer which is accurate within 10 percent of the true value with a 95-percent chance of achieving that accuracy. Implicit in the above statement is the assumption that all measurements made at the index wells are accurate and that the measure of the total number of kilowatt-hours consumed is accurate. Tests of the accuracy of the measurements made at the index wells indicate that the values derived from these measurements are probably accurate to within 10 percent. Intuitively, it was considered that this 10-percent error is compensating and that, therefore, an average discharge value derived from these measurements is accurate. That is, although the individual measurements may be in error by plus or minus 10 percent, an average of these measurements can be used to calculate a total discharge for all wells. It was considered that the values obtained from power companies for the total number of kilowatt-hours consumed are 100 percent accurate.

Number of wells on Plain. –The total number of irrigation wells on the Plain whose pumps are powered by electrical motors was determined from records from the Idaho Power Company, Utah Power and Light Company, and the Lost River Electric Cooperative. These companies supply all the electrical power consumed by irrigation wells on the Plain. From these records, it was found that 2,044 irrigation wells used electric power. Data collected from companies supplying natural gas, butane, gasoline, and diesel fuel indicated that few wells, probably less than 10, used these sources of energy, and that these wells could be ignored without significantly affecting the accuracy of the final pumpage value sought.

Index wells.–The number of pumping irrigation wells to be sampled on the Plain was calculated to be 173 by applying the estimated variance and the accuracy desired to Luckey's formula. Selection of the index wells was made by assigning numbers to all wells and by use of a random number table. Because Luckey's formula requires sampling with replacement, several wells were drawn more than once from the random number table with the result that discharge measurements were needed at only 158 wells. See table 2 and figure 4.

Discharge measurements.–Distribution of the water pumped by irrigation wells on the Plain is accomplished using either a closed or an open system. Typically, in a closed system the water pumped is conveyed through aluminum pipes to a sprinkler system, whereas in an open system ditches are used to distribute the water from the well to the fields. Where discharge meters have been installed on wells, the measurement of discharge is readily obtainable for either type of system. Unfortunately, however, rarely have these meters been installed and, therefore, other means of measuring well discharge had to be used. To determine the discharge for closed sprinkler systems, the water pressure at the first and last sprinkler head on each line of sprinklers in the system was measured. Using the average of these values and the size and number of orifices used, the discharge of the well supplying the system was calculated. To determine the discharge of wells supplying open systems, the quantity of water flowing in the distribution canal at a point near the well was measured using standard measuring techniques. During the 1970 irrigation season, the discharge of each index well was measured at least once; a second measurement was made on as many wells as time permitted. The value or average value obtained was considered to be the average discharge rate of the well.

Measurements of the depth to water made in index wells showed that during the irrigation season pumping water levels fluctuated less than 10 feet. These measurements, in conjunction with the discharges measured, indicate that pumping rates were not

Table 2

Summary of Irrigation Index-Well Data

Irrigation method: S, sprinkler system; G, gravity system; S, G, sprinkler and gravity system.
Discharge measurements: Differences in sprinkler discharge measurements are due to the number of sprinkler heads operating and whether a booster pump was in use at the time of measurement. Gravity discharge measurements are considered accurate to within 10 percent.

		Static water level		Discharge measurements										
Well identification number	Irrigation method	Date	Feet below land surface	Date	Gallons per minute	Pumping level, feet below land surface	Date	Gallons per minute	Pumping level, feet below land surface	Average, gallons per minute	Horse power of pump	Total kwhr consumed 1970	Kilowatt demand	Kwhr consumed per acre-foot pumped
509	S	-	-	7-21-70	1,710	-	-	-	-	1,710	300	358,400	277	880
652	S	4- 9-70	312.30	7- 8-70	1,790	313.65	-	-	-	1,790	300 a50	228,960	302	916
489	S	3-29-70	439.61	7-20-70	1,860	-	-	-	-	1,860	300	597,120	336	981
1261	G	4-11-70	245.93	6-11-70	2,020	251.10	8-18-70	1,840	-	1,930	150	313,720	141	397
26	S	4- 1-70	415.91	7-16-70	2,940	-	-	-	-	2,940	400 a100	738.720	460	850
15	S	3-31-70	429.00	7-16-70	2,740	-	-	-	-	2,740	450	518,000	399	791
513	S	-	-	7-21-70	1,240	-	-	-	-	1,240	350	687,680	328	1,440
763	G	4- 7-70	67.40	7- 9-70	1,060	68.95	-	-	-	1,060	30	18,100	27	138
180	G	3-28-70	57.10	7-26-70	2,190	-	-	-	-	2,190	100	147,840	85	211
1196	G	-	-	6-10-70	1,370	-	-	-	-	1,370	125	229,120	107	424
779	G	-	-	7- 9-70	2,440	-	-	-	-	2,440	250	412,640	216	481
1664	S	-	-	6-18-70	893	-	8-26-70	819	-	856	60	83,210	50	317
1629	S	-	-	7- 7-70	2,250	-	8-26-70	2,000	-	2,130	250	233,440	246	627
1172	S	-	-	6-10-70	1,420	-	8-24-70	1,290	-	1,350	200	326,760	182	732
1860	G	-	-	6-19-70	520	-	8- 5-70	540	-	530	75	155,500	66	676
1980	G	-	-	6- 2-70	1,920	344.55	8- 5-70	1,940	344.00	1,930	200	471,240	182	512
1823	S	-	-	6-11-70	1,390	-	8- 6-70	1,580	-	1,480	250 a50	785,030	283	1,040
994	S	-	-	7- 9-70	2,160	-	-	-	-	2,160	200	223,360	177	445
640	S	4- 9-70	130.01	7- 8-70	2,300	143.70	9- 2-70	1,450	137.55	b2,090	200 a50	332,440	204	531
1777	S	-	-	6-17-70	1,060	-	9- 4-70	1,060	-	1,060	125	125,920	102	523
1073	G	-	-	6- 5-70	2,560	142.72	8- 7-70	2,490	138.79	2,520	200	302,400	192	414
1674	S	5- 2-70	156.49	6-18-70	1,400	154.80	8-26-70	1,790	156.35	b1,710	125 a100	244,720	141	448
743	G	4- 7-70	51.22	6-23-70	1,480	-	9- 2-70	1,620	-	1,550	30	40,600	28	98
648	S	4- 9-70	183.57	7- 8-70	590	185.30	-	-	-	590	100	147,420	79	727
855	G	-	-	6-24-70	950	-	8-27-70	950	-	950	50	95,690	37	212

Table 2 (Continued)

Summary of Irrigation Index-Well Data

Well identi- fication number	Irriga- tion method	Static water level: Date	Static water level: Feet below land surface	Discharge measurements: Date	Gallons per minute	Pumping level, feet below land surface	Date	Gallons per minute	Pumping level, feet below land surface	Average, gallons per minute	Horse power of pump	Total kwhr consumed 1970	Kilo- watt demand	Kwhr consumed per acre- foot pumped
754	S	4- 7-70	64.29	6-23-70	1,130	63.60	-	-	-	1,130	75	95,150	63	303
1322	G	4-12-70	79.44	6- 1-70	1,740	-	8- 4-70	1,800	78.08	1,770	50	103,240	57	175
389	S	-	-	7-14-70	1,860	-	-	-	-	1,860	400 a200	511,680	372	1,090
1550	S	5- 1-70	96.40	6-17-70	1,420	-	8-20-70	1,420	109.50	1,420	125	88,880	109	417
1577	S	5- 1-70	90.54	6-22-70	554	-	8-20-70	554	-	554	50	58,830	37	363
1515	G	-	150.50	-	-	159.10	-	-	-	-	100	184,400	-	c296
1120	G	-	-	6-11-70	1,960	-	8-18-70	1,970	-	1,960	200	372,720	172	477
996	S	4- 9-70	163.84	6-25-70	797	-	9- 3-70	976	-	886	100	169,760	93	570
352	S	9- 8-70	204.80	7-17-70	939	-	-	-	-	939	150	123,360	122	706
259	S	4-23-70	235.40	7-24-70	1,600	-	9- 9-70	1,760	-	1,680	200	411,200	176	569
111	S	3-26-70	122.76	7-27-70	2,270	125.17	-	-	-	2,270	125 a100	310,960	185	443
1423	G	-	234.70	-	-	236.70	-	-	-	-	75	154,580	-	c410
1248	G	4-11-70	243.65	6- 8-70	2,300	-	8-19-70	2,360	-	2,330	200	270,440	185	431
47	S	-	-	7-17-70	1,780	-	9-10-70	1,640	-	1,710	300	395,520	283	899
1464	G	-	216.80	-	-	217.10	-	-	-	-	75	115,400	-	c383
867	G	4- 8-70	59.62	6-24-70	1,370	60.50	9- 3-70	1,320	59.50	1,340	40	51,160	34	138
1224	S	4-11-70	275.00	6-10-70	950	282.85	-	-	-	950	125	161,360	124	709
192	S	3-27-70	57.75	7-24-70	1,320	144.30	-	-	-	1,320	200	284,480	172	708
1176	G	4-11-70	220.56	6-29-70	997	-	8-24-70	1,050	-	1,020	100	69,440	91	485
293	S	3-24-70	22.65	7-28-70	269	-	-	-	-	269	25	26,016	30	606
1700	G	4-28-70	71.25	6-26-70	1,070	79.50	8-20-70	1,060	80.50	1,060	40	62,740	33	169
17	S	-	-	7-23-70	2,980	-	-	-	-	2,980	600	702,240	559	1,020
1769	S	-	-	6-17-70	789	-	8-25-70	886	-	838	125	168,440	98	635
1862	G	5-20-70	353.52	6- 3-70	876	355.50	8- 6-70	983	351.17	930	125	258,520	112	654
1488	G	-	243.30	-	-	248.70	-	-	-	-	150	294,500	-	c415
655	S	4- 9-70	373.24	7-13-70	1,440	-	-	-	-	1,440	300 a60	492,320	333	1,260
477	S	3-29-70	294.40	7-23-70	1,160	316.70	-	-	-	1,160	200 a100	264,400	234	1,100
54	S	4- 1-70	412.48	7-14-70	2,160	418.11	-	-	-	2,160	400	360,680	339	852
1075	S	4-10-70	354.65	7- 6-70	1,760	358.23	9-21-70	1,830	360.73	1,800	250	261,680	257	775
633	S	4- 9-70	85.43	7-15-70	947	84.75	9- 2-70	822	85.00	884	100	120,840	96	590

Table 2 (Continued)

Summary of Irrigation Index-Well Data

Well identification number	Irrigation method	Static water level: Date	Static water level: Feet below land surface	Discharge measurements: Date	Gallons per minute	Pumping level, feet below land surface	Date	Gallons per minute	Pumping level, feet below land surface	Average, gallons per minute	Horse power of pump	Total kwhr consumed 1970	Kilo-watt demand	Kwhr consumed per acre-foot pumped
22	S	-	-	7-16-70	2,000	-	9-10-70	1,800	-	1,900	350	491,200	320	915
394	S	4- 2-70	214.79	7-13-70	731	218.57	9-16-70	701	210.97	716	75	123,200	77	584
833	S	-	-	7- 2-70	1,880	-	9-22-70	2,040	-	1,960	200	150,000	174	482
1754	S	4-30-70	162.72	6-18-70	1,000	-	-	-	-	1,000	125	139,040	105	570
121	S	3-25-70	39.96	7-27-70	4,040	45.05	-	-	-	4,040	250	185,600	230	309
1210	S	4-11-70	210.02	6-30-70	925	212.20	8-18-70	920	214.75	922	125	162,160	109	642
1677	G	-	-	6-22-70	1,290	-	9- 8-70	1,320	-	1,300	30	32,060	25	104
1876	S,G	5-18-70	302.44	6- 4-70	1,370	305.25	8- 6-70	1,380	301.86	1,380	150	339,520	169	665
											a40			
1044	S,G	4-10-70	296.41	6- 9-70	2,700	304.70	8-25-70	2,860	309.70	2,780	250	447,600	270	527
											a50			
250	G	-	-	7-26-70	3,540	-	9- 9-70	3,280	-	3,410	60	92,976	39	62
1260	S	4-11-70	236.14	6-11-70	750	239.50	8-18-70	731	242.30	740	100	123,920	93	683
854	S	-	-	7-15-70	1,700	-	-	-	-	1,700	150	218,560	134	428
1922	G	-	-	6- 1-70	700	-	8- 4-70	750	-	730	25	24,310	24	179
181	G	-	-	7-22-70	2,760	-	9-15-70	3,120	-	2,940	150	303,324	141	260
1792	S	-	-	6-22-70	1,060	-	8-20-70	1,010	-	1,040	125	124,680	97	507
764	G	4- 7-70	116.20	6-23-70	1,660	118.65	-	-	-	1,660	75	107,840	64	209
842	S,G	4- 7-70	155.44	6-24-70	1,310	155.60	-	-	-	1,310	75	126,000	84	348
											a30			
452	S	-	-	7-22-70	1,650	-	-	-	-	1,650	100	142,720	85	401
											a40	61,848		
1149	G	-	-	6- 8-70	2,360	267.70	8-31-70	2,390	265.70	2,380	200	255,920	182	415
568	S	4- 8-70	36.19	7- 7-70	1,080	-	-	-	-	1,080	60	60,930	54	272
1384	G	-	293.70	-	-	299.30	-	-	-	-	150	366,100	-	c521
174	G	4- 7-70	35.13	7-22-70	1,100	103.80	-	-	-	1,100	75	67,360	66	326
1015	G	4- 8-70	96.57	6-24-70	1,620	103.65	8-27-70	1,610	106.43	1,620	60	81,680	55	184
97	S	4- 7-70	30.10	7-26-70	1,150	34.68	9-16-70	987	34.35	b1,110	60	118,060	71	347
											a20			
1652	G	5- 1-70	61.44	6-16-70	1,320	64.70	9- 8-70	1,300	64.20	1,310	40	46,880	29	120

Table 2 (Continued)

Summary of Irrigation Index-Well Data

Well identification number	Irrigation method	Static water level: Date	Static water level: Feet below land surface	Discharge measurements: Date	Discharge measurements: Gallons per minute	Discharge measurements: Pumping level, feet below land surface	Discharge measurements: Date	Discharge measurements: Gallons per minute	Discharge measurements: Pumping level, feet below land surface	Average, gallons per minute	Horse power of pump	Total kwhr consumed 1970	Kilowatt demand	Kwhr consumed per acre-foot pumped
1998	G	-	-	8- 4-70	900	-	-	-	-	900	75	52,200	68	410
960	S	4-22-70	94.70	7- 1-70	932	95.85	-	-	-	932	75	62,960	75	437
1177	G	4-16-70	193.28	6-11-70	3,210	197.30	9-21-70	3,020	197.70	3,120	200	348,240	170	296
378	S	-	-	7-26-70	2,940	-	-	-	-	2,940	600	959,040	568	1,050
669	S	4-25-70	63.20	7-13-70	1,410	68.40	9- 2-70	1,170	66.75	1,290	150	208,360	117	493
588	S	4-21-70	36.72	7- 1-70	2,200	50.00	-	-	-	2,200	150	138,560	123	304
986	S	4-22-70	146.65	6-25-70	914	150.00	9- 1-70	730	148.65	b877	75	226,480	101	625
											a50			
1069	S	4-16-70	252.51	6- 9-70	623	255.10	8-24-70	670	258.10	647	150	199,520	128	1,070
1614	S	5- 1-70	161.62	6-17-70	1,070	164.00	8-20-70	924	164.20	997	100	118,940	80	436
1412	G	-	168.50	-	-	170.60	-	-	-	-	75	123,680	-	c298
185	S	-	-	7-24-70	1,480	-	-	-	-	1,480	200	184,160	185	679
1732	S	4-28-70	226.48	7-15-70	1,580	229.60	8-25-70	1,130	229.35	1,360	200	262,160	185	739
1832	G	5-20-70	377.28	6- 3-70	1,240	-	8- 6-70	1,230	-	1,240	150	376,160	136	596
1163	S	-	-	7- 6-70	1,150	-	-	-	-	1,150	150	155,680	140	661
1985	S	-	-	6- 4-70	1,110	228.90	8- 5-70	1,160	224.25	1,140	200	500,560	156	743
742	G	-	-	6-23-70	1,420	-	9-24-70	1,450	-	1,440	30	50,380	22	83
1467	G	-	179.20	-	-	179.70	-	-	-	-	100	224,200	-	c354
1320	G	4-20-70	83.04	6- 1-70	1,450	89.13	8-17-70	1,500	85.10	1,480	75	125,520	60	220
722	G	-	-	6-23-70	961	66.75	9- 2-70	947	65.80	954	30	47,820	21	120
794	S	4-25-70	154.18	7- 9-70	832	-	-	-	-	832	100	121,200	96	627
1632	S	5- 1-70	134.40	6-18-70	806	135.45	8-26-70	1,130	135.60	968	100	141,520	101	567
927	S	4-22-70	128.78	6-25-70	1,080	-	-	-	-	1,080	75	82,280	85	427
											a30			
1845	G	-	-	6- 3-70	1,830	371.60	8- 6-70	1,780	372.83	1,800	200	527,040	183	552
49	S	4-25-70	369.24	7-14-70	2,450	375.70	-	-	-	2,450	300	237,040	397	880
											a100			
1626	S,G	-	-	6-16-70	2,850	-	8-26-70	2,620	-	2,740	300	750,960	291	577
											a50			
920	S	-	-	7- 9-70	1,160	-	-	-	-	1,160	125	107,480	93	435
1074	S	4-16-70	292.15	6-19-70	2,980	-	8-31-70	2,950	-	2,960	400	463,200	368	675

Table 2 (Continued)

Summary of Irrigation Index-Well Data

Well identi-fication number	Irriga-tion method	Static water level: Date	Static water level: Feet below land surface	Discharge measurements: Date	Gallons per minute	Pumping level, feet below land surface	Date	Gallons per minute	Pumping level, feet below land surface	Average, gallons per minute	Horse power of pump	Total kwhr consumed 1970	Kilo-watt demand	Kwhr consumed per acre-foot pumped
1976	S	-	-	6- 2-70	1,230	-	8- 5-70	1,350	-	1,290	350	808,800	311	1,310
815	S	4-25-70	315.80	7- 1-70	1,230	318.10	9- 3-70	1,160	317.90	1,200	200	201,760	174	787
844	S	4-25-70	141.05	6-25-70	910	-	-	-	-	910	100	89,840	84	501
240	G	4-23-70	3.74	-	-	-	9-15-70	6,820	20.75	6,820	100	168,320	67	54
1787	S	-	-	6-22-70	859	-	8-20-70	883	-	871	100	108,880	80	499
78	S	4-22-70	103.03	7-28-70	923	101.30	-	-	-	923	75 a20	118,240	85	500
718	G	4-23-70	59.03	6-23-70	1,390	61.85	9- 2-70	1,510	60.70	1,450	30	60,100	31	116
1579	G	5- 1-70	95.52	6-18-70	720	102.90	8-25-70	720	103.80	720	25	48,980	22	166
1242	G	4-26-70	301.23	6- 9-70	4,110	-	8-21-70	4,440	-	4,320	450	884,800	378	475
915	S,G	4-22-70	76.30	7- 1-70	1,550	76.70	-	-	-	1,550	50 a20	58,020	56	196
765	S	4-23-70	88.43	6-23-70	1,510	94.00	8-27-70	1,290	94.00	1,400	100	108,640	96	372
918	G	-	-	6-24-70	1,980	-	8-27-70	2,080	-	2,030	100	79,160	86	230
359	S	4-25-70	247.41	7-16-70	2,000	246.65	9-10-70	2,040	233.95	2,020	250	277,440	229	616
57	S	-	-	7-17-70	4,650	-	-	-	-	4,650	700 a350	1,060,800	843	985
1059	G	-	-	6- 5-70	2,330	307.20	8- 7-70	2,140	313.45	2,240	250	419,760	220	533
1084	G	-	-	6- 8-70	1,900	-	8-19-70	1,850	-	1,800	250	467,360	200	578
744	G	-	-	6-23-70	2,340	-	-	-	-	2,340	50	62,470	47	109
985	S	-	-	6-25-70	1,670	-	-	-	-	1,670	150	198,640	126	410
1108	G	4-27-70	217.78	6-10-70	580	220.30	8-17-70	580	221.00	580	40	35,670	29	272
1768	S	-	-	6-17-70	1,100	-	8-25-70	1,450	-	1,280	200	190,960	179	759
270	S	-	-	7-22-70	1,150	-	-	-	-	1,150	100 a75	160,320	131	619
1318	S	4-27-70	253.02	6- 2-70	455	254.00	8- 4-70	511	247.29	483	75	133,000	63	708
1760	S	-	-	7-15-70	1,080	-	8-25-70	842	-	961	100	121,160	85	480
177	G	-	-	7-22-70	2,240	-	-	-	-	2,240	200	286,400	176	427
1458	G	-	202.80	-	-	204.40	-	-	-	-	200	522,100	-	c418
881	S	4-21-70	62.71	7- 1-70	649	62.82	8-27-70	728	63.40	688	60	69,500	52	410
1016	S	-	-	7-29-70	2,980	-	-	-	-	2,980	700 a200	909,600	632	1,150
400	S	4-21-70	209.80	7-14-70	1,530	215.20	9-11-70	1,260	208.05	1,400	200	288,640	171	663
747	S	4-22-70	45.05	6-24-70	459	52.10	9- 1-70	525	52.30	492	40	46,000	35	386
1218	S	4-26-70	323.18	6-11-70	1,670	-	8-18-70	1,690	-	1,680	250	318,760	235	760

Table 2 (Continued)

Summary of Irrigation Index-Well Data

Well identi-fication number	Irriga-tion method	Static water level: Date	Static water level: Feet below land surface	Discharge measurements: Date	Gallons per minute	Pumping level, feet below land surface	Date	Gallons per minute	Pumping level, feet below land surface	Average, gallons per minute	Horse power of pump	Total kwhr consumed 1970	Kilo-watt demand	Kwhr consumed per acre-foot pumped
1	S	4-21-70	288.65	7-28-70	1,700	289.40	9-15-70	1,680	288.40	1,690	200	136,320	189	607
905	S	5- 2-70	78.47	6-24-79	992	80.75	8-27-70	921	80.80	956	75	110,700	76	432
821	S	5-13-70	249.34	7- 9-70	1,100	-	-	-	-	1,100	150	178,280	138	681
1852	S	-	-	6- 4-70	2,270	-	8- 6-70	2,050	-	2,160	300	847,620	282	709
649	S	5-13-70	214.98	7- 8-70	1,460	-	9- 2-70	1,050	-	1,260	200	219,000	177	763
554	S	5- 2-70	39.40	7- 1-70	636	42.55	8-27-70	873	43.50	754	100	140,080	81	583
1166	S	5- 3-70	249.78	6-18-70	1,500	-	8-18-70	1,400	-	1,450	300	514,240	244	914
1923	S	5-19-70	115.98	6- 3-70	426	114.72	8- 4-70	413	111.58	420	20	112,650	37	478
											a20			
1145	S	-	-	6-30-70	1,850	-	9-18-70	1,700	-	1,780	200	252,000	163	497
1535	S	-	-	6-18-70	1,070	-	-	-	-	1,070	100	86,640	77	391
490	S	5-12-70	449.92	7-22-70	1,900	-	-	-	-	1,900	350	761,920	340	972
46	S	5-12-70	386.18	7-14-70	3,460	395.95	9-23-70	3,410	389.65	3,440	400	452,640	436	688
											a150			
1204	S	-	-	6-10-70	1,400	-	-	-	-	1,400	200	323,280	182	706
673	G	5-13-70	169.98	6-26-70	1,470	175.00	9-17-70	1,440	176.20	1,460	75	136,060	76	283
1706	S	4-30-70	232.44	6-16-70	686	242.40	8-25-70	429	243.75	558	150	167,320	104	1,010
523	S	5-12-70	178.78	7-21-70	611	166.60	-	-	-	611	100	119,040	96	853
1755	S	-	-	7- 7-70	1,990	-	8-20-70	2,120	-	2,060	200	283,040	193	509
1486	G	-	132.52	-	-	133.72	-	-	-	-	75	136,580	-	c205

[a] Horse power of booster pump.

[b] Weighted average discharge, weighted by portion of time booster pump operated.

[c] Annual pumpage and kilowatt-hours consumed reported by U. S. Bureau of Reclamation, Minidoka-North Side Pumping Division.

significantly affected by changes in ground-water levels (see table 2).

Total irrigation pumpage.--The total amount of irrigation water pumped on the Plain in 1969 was calculated as follows:

$$\text{Acre-feet pumped} = \frac{\text{kilowatt-hours used by all wells in 1969}}{\bar{X}}$$

where

$\bar{X}$ = average number of kilowatt-hours used per acre-foot pumped as determined in 1970.

Because the total number of kilowatt-hours of electrical energy consumed in 1970 by irrigation wells was not available in time for inclusion in this report, it was necessary to use 1969 energy data with pump discharge measurements made in 1970 to calculate total pumpage. As shown in table 1, the maximum error found using 1968 pump discharge data to calculate annual pumpage for the period 1960-68 in the Minidoka North Side Pumping Division test area was about 6 percent, which is well within the 10-percent accuracy desired. On this basis, therefore, it was reasoned that the discharge measurements made on the Plain in 1970 could be applied to the 1969 energy data and used to calculate total irrigation pumpage for 1969 without introducing any significant error.

The total number of kilowatt-hours used by irrigation wells on the Plain in 1969, as obtained from the Idaho Power Company, Utah Power and Light Company, and Lost River Electric Cooperative, Inc., is listed in table 3.

The average number of kilowatt-hours used per acre-foot of water pumped in 1970 ($\bar{X}$) by all the index wells (see table 2) was computed as follows: using the discharge measured and the corresponding kilowatts per hour demand figure obtained from the electric meter at each well, the average kilowatt-hours consumed per acre foot of water pumped at each well was calculated using the formula

$$X = \frac{5431a}{d}$$

where

X = energy used per volume of water pumped (kilowatt-hours per acre-foot)

5431 = constant converting rate of flow to volume

a = demand of motor (kilowatts)

d = discharge of pump (gallons per minute).

Table 3

Kilowatt-Hours Used by Irrigation Wells on the Plain, 1969

District	Kwhr
Utah Power and Light Company	
Ashton	1,529,256
Rexburg	50,411,952
Rigby	27,418,248
Shelley	69,425,321
St. Anthony	3,278,688
Lost River Electric Cooperative, Inc.	
Arco	1,178,740
Idaho Power Company	
Aberdeen	21,062,960
American Falls	21,272,620
Blackfoot	66,554,790
Gooding	5,424,280
Hazelton	35,068,280
Jerome	31,990,620
Rupert	95,651,550
NSPD Minidoka Project	86,834,362
Shoshone	1,670,980
Wendell	8,581,680
Total	527,354,327

The values of X from the 173 index wells were prepared for entry into a digital computer system so that a computer program could be used to compute the desired sample statistics and to test the values of X for goodness of fit to a normal distribution. The sample statistics computed from natural values of X are

$\overline{X}$ = 527 kilowatt-hours per acre-foot,

s^2 = 72,466 (kilowatt-hours per acre-foot)^2,

s = 269 kilowatt-hours per acre-foot,

where

$\overline{X}$ = mean of the sample values,

s^2 = the sample variance, a measure of the deviation from the mean,

s = standard deviation (square root of the variance);
two-thirds of the values lie within plus or minus one standard deviation.

The program used also provided Chi-square tests of goodness of fit for both the natural values and the log-transformed values of the data. From these tests, it was found that the natural values came closer to a normal distribution than did the logarithms of the values and that a normal distribution should be assumed (see fig. 5).

Since the mean ($\overline{X}$) is used to estimate total pumpage, a measure of its accuracy is needed. To derive this, it is first necessary to compute the standard error of the mean (s.e. $\overline{X}$) as follows:

$$\text{s.e. } \overline{X} = \frac{s}{\sqrt{n}} = 20.5 \text{ kwhr per acre-foot}$$

where

s = standard deviation of the sample (269 kwhr per acre-foot)

n = sample size (173 wells).

Using the standard error of the mean to compute a 95 percent confidence interval (C. I.) gives

$$\text{C. I. } 95\% = \overline{X} \pm b\,(\text{s.e. } \overline{X}), \text{ where } b = 1.96 \text{ (see p. 8)}$$

$$= \overline{X} \pm 40.2 \text{ kwhr per acre-foot } (\pm 8 \text{ percent}).$$

This figure is within the 10 percent accuracy at 95 percent probability sought in determining the sample size to be taken.

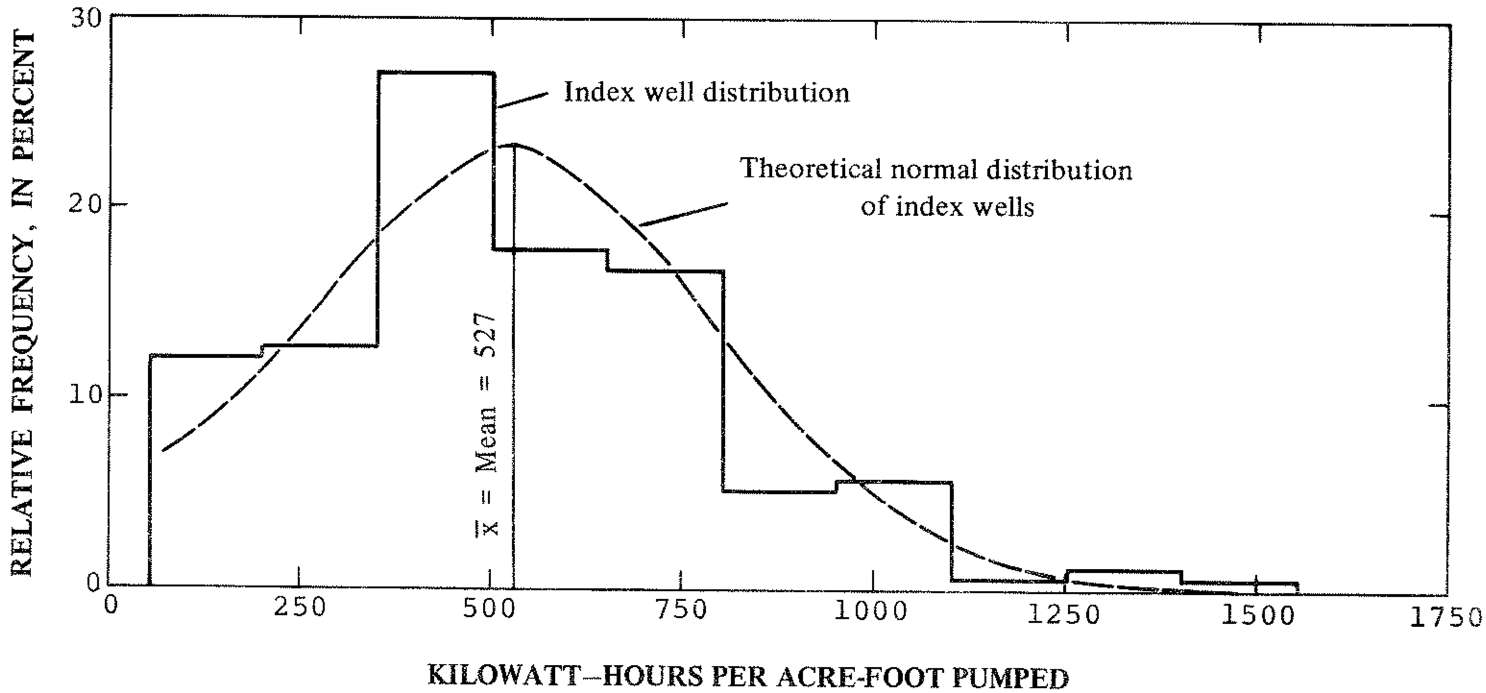

FIGURE 5. Frequency distribution of index wells.

Using the formula described on page 18, irrigation withdrawals from the Snake Plain aquifer in 1969 were estimated to be about 1,000,000 acre-feet.

Other Pumpage

Municipal

Wells open to the Snake Plain aquifer are the chief source of municipal water for communities located on the Snake River Plain. The municipal pumpage data presented in this report represent the total quantity of water pumped for all uses by each municipal supply system. Quantities of water used by industries or others having their own source of supply are not included in these data. The data were collected either by mailing questionnaires to, or visiting each municipality. In either case, each municipality was requested to furnish the following data: quantity of water pumped by their system in 1969; source of water; population served; and, quantity of water furnished to industry.

Table 4 is a compilation of the data obtained for municipal supplies. As indicated, a total of about 33,700 acre-feet of ground water was pumped by municipalities in 1969. The daily per capita use figures shown were obtained by dividing the average daily quantity of water supplied by the total population served. As shown, per capita use ranges from a high of 882 gpd (gallons per day) per person in Ririe (14 miles south of Rexburg) to a low of 40 gpd per person in Newdale (10 miles northeast of Rexburg) and averages 280 gpd per person.

Rural-Domestic and Livestock

The amount of water in 1969 used by individuals with private water systems was computed using a daily per capita use figure of 100 gpd per person (Murray, 1965, p. 3). To determine the population supplied by private systems, the population served by public water-supply systems in each county was subtracted from the total county population. The population used in counties only partially included in the study area was determined on the basis of an assumed uniform distribution of the rural population throughout the county and the percent of the county within the study area.

The livestock population of each county in 1969 was compiled using data supplied by the annual Idaho State Tax Commission report (State Tax Commission, 1969). The number of dairy cows, beef cattle, horses and mules, sheep, goats, hogs, and fowl were totaled by county. The daily per capita water requirements of these livestock were taken from Murray (1965, p. 9). The quantity of ground water pumped for livestock was computed using the per capita requirements and the assumption that 50 percent of the supply was derived from ground water. In counties partially in the study area, a percentage of the total livestock

Table 4

Municipal Ground-Water Pumpage, 1969.

City	County	Population Served	Number of Wells	Daily per Capita use (Gallons)	Industrial Usage (acre-feet)	Quantity Pumped (acre-feet)
Aberdeen	Bingham	1,494	2	48	32	80
Ammon	Bonneville	2,553	5	[a]280	None	[a]800
Arco	Butte	1,173	3	[a]280	None	[a]368
Ashton	Fremont	1,123	2	[a]280	40	[a]352
Atomic City	Bingham	20	2	685	None	15
Basalt	Bingham	343	1	[a]280	None	[a]108
Blackfoot	Bingham	8,558	6	242	580	2,319
Butte City	Butte	44	1	[a]280	None	14
Dubois	Clark	431	2	231	None	112
Eden	Jerome	339	1	42	2	16
Firth	Bingham	364	2	[a]280	11	[a]114
Gooding	Gooding	2,524	2	176	10	497
Hazelton	Jerome	399	2	[a]280	None	[a]125
Idaho Falls	Bonneville	35,318	11	495	3,327	19,570
Iona	Bonneville	899	2	[a]280	None	[a]282
Jerome	Jerome	4,158	2	247	115	1,149
Minidoka	Minidoka	124	2	[a]280	None	[a]39
Newdale	Fremont	264	2	40	None	12
Paul	Minidoka	845	1	276	None	261
Rexburg	Madison	8,265	3	180	166	1,663
Richfield	Lincoln	299	2	173	26	58
Rigby	Jefferson	2,311	2	811	105	2,098
Ririe	Bonneville	563	2	882	6	556
Roberts	Jefferson	388	1	[a]280	None	[a]122
Rupert	Minidoka	4,528	3	174	62	883
St. Anthony	Fremont	2,811	4	98	74	307
Shelley	Bingham	2,614	3	230	34	675
Shoshone	Lincoln	1,206	2	347	None	468
Sugar City	Madison	612	2	[a]280	60	[a]192
Teton	Fremont	387	1	[a]280	None	[a]121
Ucon	Bonneville	658	1	112	16	83
Wendell	Gooding	1,105	3	192	None	238
Total		86,720	80	[b]280	4,666	33,697

[a] Estimated from average reported daily per capita use.

[b] Average reported daily per capita use.

population was used.

The estimated total ground water pumped for rural-domestic and livestock needs in 1969 was 7,300 acre-feet (rounded); it is shown by county in table 5.

Industrial

The industrial pumpage data presented in this report were obtained only from users who are self-supplied and who rely on ground water as their chief source of supply. Because of the large number of companies and individuals involved, a canvass of users by mailed questionnaries was the only practical means of data collection within the time alloted for this effort. Industrial users were requested to furnish the following information: the quantity of water used by their company in 1969 and the source of their water supply (municipally supplied, private well(s), spring(s), or surface water).

Questionnarie response was about 60 percent with about 50 percent of these supplying usable data. To estimate the quantity of water used by nonrespondents, similar industries were assumed to use corresponding quantities of water. The source of the water used by nonrespondents was selected on the basis of their locations and of the source of water used by nearby industries.

As shown in table 6, about 38,000 acre-feet of water was pumped by industry in 1969. It should be noted that for the counties lying partially in the study area only the industrial pumpage within the study area is given.

Total Pumpage

Total ground-water pumpage from the Snake Plain aquifer in 1969 is estimated to be 1,079,000 acre-feet. Ground water for irrigation needs is estimated to be 1,000,000 acre-feet, or 93 percent of the total withdrawals. Municipal, rural-domestic, and industrial ground-water pumpage is estimated to be 79,000 acre-feet or 7 percent of the total.

Ground-water withdrawals for irrigation needs greatly exceed nonirrigation pumpage to the extent that the potential error, plus or minus 10 percent, in estimating irrigation pumpage is greater (100,000 acre-feet) than the total nonirrigation pumpage (79,000 acre-feet). It is, therefore, impractical to evaluate the accuracy of the the composite pumpage total with the present data.

Although no means were found to assess the accuracy of the nonirrigation pumpage estimate, the values attained agreed favorably with those found during some previous investigations. Although no attempt is made to compare or evaluate previous estimates of

Table 5

Rural-Domestic and Livestock Ground-Water Pumpage, 1969

County	Rural Population in Study Area	Domestic Pumpage (acre-feet)	Livestock Pumpage (acre-feet)	Domestic and Livestock Pumpage (acre-feet)
Bannock[a]	335	40	5	45
Bingham[a]	11,110	[b]1,780	265	2,045
Blaine[a]	828	90	40	130
Bonneville[a]	3,081	330	60	390
Butte[a]	628	65	30	95
Clark[a]	112	10	15	25
Fremont[a]	1,426	[c]680	35	715
Gooding[a]	2,046	220	65	285
Jefferson[a]	8,864	945	145	1,090
Jerome	5,456	580	190	770
Lincoln[a]	1,382	145	130	275
Madison[a]	1,410	160	30	190
Minidoka	9,975	1,060	130	1,190
Power[a]	589	65	25	90
Total		6,170	1,165	7,335

[a] Part of county lies outside of study area.

[b] Includes Fort Hall Indian Agency.

[c] Includes State Youth Training Center.

Table 6

Industrial Ground-Water Pumpage (self-supplied), 1969

County	Pumpage (acre-feet)
Bannock[1]	–
Bingham[1]	7,090
Blaine[1]	–
Bonneville[1]	4,090
Butte[1]	8,350
Clark[1]	45
Fremont[1]	445
Gooding[1]	140
Jefferson[1]	1,125
Jerome	560
Lincoln[1]	90
Madison[1]	2,670
Minidoka	10,130
Power[1]	3,200
Total	37,935

[1] Part of county lies outside of study area.

irrigation withdrawals with the present withdrawal figure, it should be noted that these previous estimates of total pumpage show 920,000 acre-feet in 1959 (Mundorff and others, 1964, p. 23) and 2,100,000 acre-feet in 1965 (Norvitch and others, 1969, p. 9). These estimates were based on the best data and methods available at the time they were made.

RECOMMENDATIONS

Using the method developed in this report, it is now possible, on either a monitoring or a one-time basis, to provide a value for the quantity of ground water withdrawn for irrigation use from the Snake Plain aquifer whose accuracy can be quantitatively evaluated. The same method is probably applicable to smaller areas of the aquifer, to tributary basins of the Snake River Plain, and to other parts of Idaho. However, improvement of this method for estimating irrigation pumpage will depend largely on the additional cooperation of the basic-data suppliers and on the refinement of existing well-discharge measuring procedures. For example, the valuable data on irrigation pumpage could be more simply and more reliably compiled if the irrigation-record systems of utility companies included identification of the type of pumping installation served. At the present time, their records do not distinguish between well, relift, or booster installations. Identification of these accounts as to use would greatly reduce possible errors in determining the number of wells in a study area and the total power consumption to be assigned to those wells.

In making future studies of this type, it is desirable that totalizing watermeters be used as a means of measuring the discharge of closed irrigation systems (sprinkler). Although the results attained by measuring the sprinkler head pressure and orifice size were very satisfactory, the time and manpower involved in making discharge measurements were considerable.

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE IDAHO

DEPARTMENT OF WATER ADMINISTRATION

EXPLANATION

U. S. Bureau of Reclamation Minidoka North Side Pumping Division

Lands irrigated by surface water

Lands irrigated by, or supplemented by, ground water pumped from wells

Boundary of Snake Plain aquifer

Irrigated land boundaries taken from U.S. Bureau of Reclamation and U.S. Soil Conservation Service preliminary field compilation data, 1966. Land classifications were not field checked for this report.

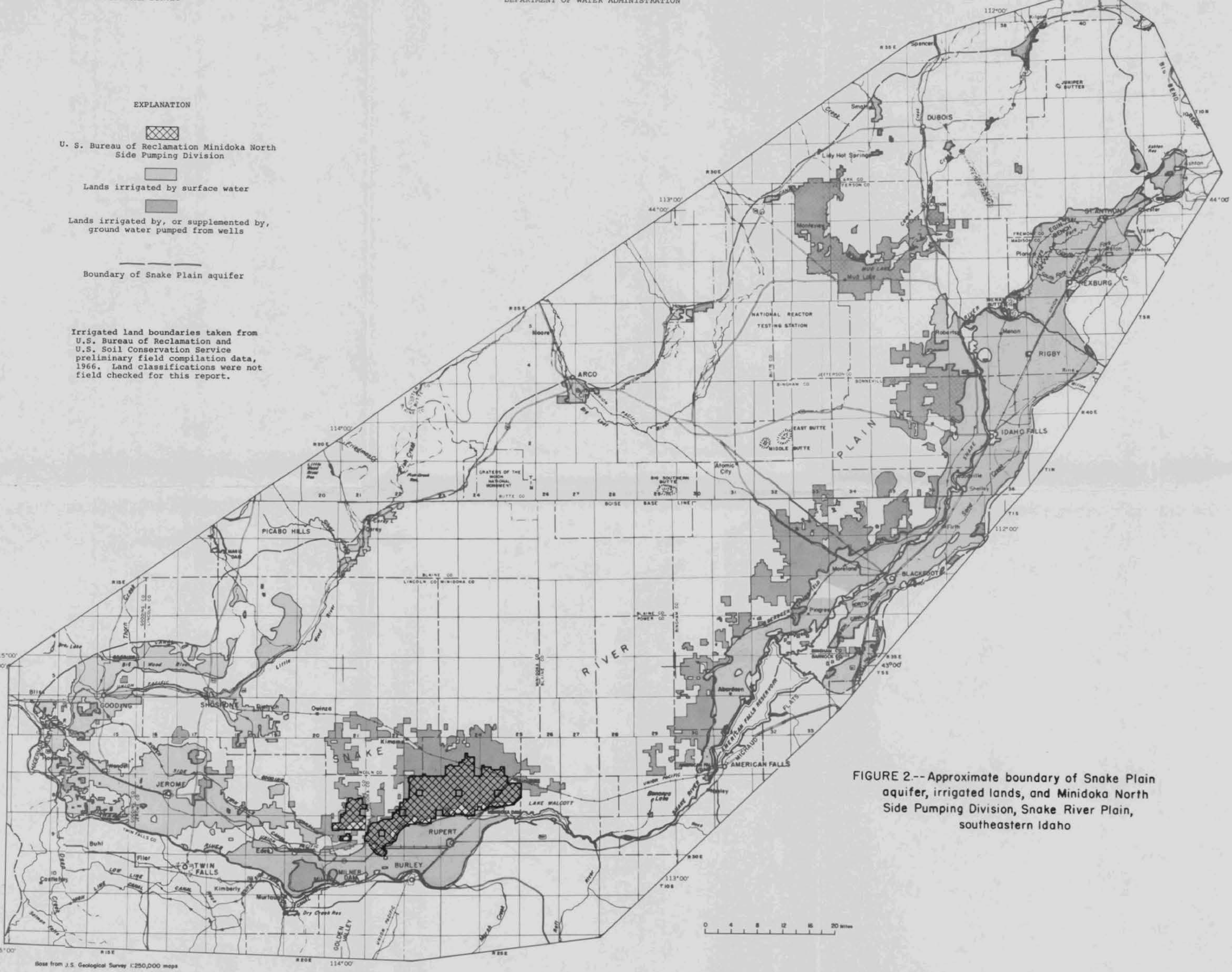

FIGURE 2.--Approximate boundary of Snake Plain aquifer, irrigated lands, and Minidoka North Side Pumping Division, Snake River Plain, southeastern Idaho

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EXPLANATION

Irrigation method

● Sprinkler

○ Gravity

◉ Combination (sprinkler and gravity)

○1320 Irrigation well and identification number

Lands irrigated by, or supplemented by, ground water pumped from wells

Boundary of Snake Plain aquifer

Irrigated land boundaries taken from U.S. Bureau of Reclamation and U.S. Soil Conservation Service preliminary field compilation data, 1966. Land classifications were not field checked for this report.

FIGURE 4.-- Areal distribution of index wells, Snake Plain aquifer, southeastern Idaho.

Base from U.S. Geological Survey 1:250,000 maps