UNIVERSITY OF IDAHO

College of Agriculture

Water Quality Study in the Boise Valley

G. C. LEWIS

Department of Agricultural Chemistry

IDAHO Agricultural Experiment Station

Bulletin No. 316
December 1959

ANALYSIS of well water sources in the Boise Valley has shown that approximately one-half of this water is satisfactory for use in its present form and the other half could be made satisfactory by dilution with existing surface water supplies. The use of well water for irrigation purposes would lower the water table and at the same time release water for possible use elsewhere. Changes in the ground water composition might occur as a result of increased domestic, industrial, and agricultural use. It is important that changes in ground water composition be monitored and that appropriate adjustments be made to prevent an excessive deterioration in water quality.

Water Quality Study in the Boise Valley

G. C. LEWIS[1]

A STUDY was initiated by the Idaho Agricultural Experiment Station in April 1957, to determine the water quality of certain water sources, including wells and surface water supplies in the Boise Valley. There were two principal reasons for making this study. First, the Bureau of Reclamation wished to have information on the quality of ground-water sources and certain surface sources in a portion of the Boise Valley.[2] This information was desirable in order to judge the suitability of these sources for irrigation use. The second purpose was to gain more extensive information on the quality of water being used and proposed for use in the Boise Valley area as a part of the Idaho Experiment Station program. The data thus obtained may be used as a basis for delineating water sources which are not acceptable for irrigation use in their present form and for making recommendations for improving the quality. This work is a continuation of a research program previously conducted on the characteristics of irrigation waters in Idaho (1).

Knowledge of the quality of ground water and surface supplies in the Boise Valley is important in several aspects. Excess water and a deficiency of drainage outlets in the valley have produced a high water table with accompanying water-logged soils and saline conditions in many places. One of several means for relieving this water-logged condition is the use of drainage wells. If this drainage water could be used more extensively, either directly or diluted with surface supplies for irrigation, this might help alleviate the drainage problem and at the same time provide another source of irrigation water. The Bureau of Reclamation is investigating the possible exchange of some of this pumped water for Boise River water now being used in the valley, which could then be used in irrigating some of the nearby Mountain Home desert area.

Drainage and water quality are important for the future of the Boise Valley. The area is one of the most populous in the State with approximately 22 per cent of the State's population at the time of the 1950 census. The Boise Valley has more than 370,000 irrigated acres, of which approximately 100,000 acres are affected

---

[1] Assistant Agricultural Chemist, Department of Agricultural Chemistry.

[2] This water quality study was initiated at the request of Region 1, Bureau of Reclamation, U. S. Department of the Interior. The water samples were taken by Bureau of Reclamation personnel and funds were made available to the University of Idaho to aid in the cost of labor for running the water analyses, shipping costs and supplies. The author gratefully acknowledges the helpful cooperation of the many Bureau employees who aided in conduct of the work, especially Messrs. Anderson, Bushnell, Hart and Poulson for technical advice and review of the report. The assistance of Jack C. Chugg of the Idaho Experiment Station in the preparation of maps and description of soils is gratefully acknowledged.

by a high ground-water table. The irrigated lands are devoted to cash crops, dairying and production of beef cattle. Basic industries for processing agricultural products, such as the sugar factories, packing plants, canneries, feed yards, seed plants, cheese factories, and dehydrating plants, depend almost entirely upon the production from the irrigated acreage.

Description of Area

The geology of the Boise Valley area is very complex. Southwestern Idaho has been described by Savage (2) as being a region of broad flood plains, dissected lava plateaus, mesas, buttes, cinder cones, minor faults and faultline scarps, badland piedmont hills, and mountains of uplifted crystalline rock. The Boise Valley within this area has been described in a recent report by Nace, **et al.** (3) as a broad alluvial plain lying adjacent to the Boise River. On the south a series of terraces rises to the level of the Mountain Home plateau. The northern edge of the valley is bounded by foothills while in the west it merges with the valley of the Snake River. Drainage is a problem in the irrigated area despite construction of 325 miles of drains and use of about 200 wells, some pumped and others artesian.

The following description of the geology of the area as related to ground water and drainage has been abstracted from the report by Nace, **et al.** (3).

"The Boise Valley is underlain by a trough-like impermeable floor of ancient consolidated rocks. Within the trough there is a great thickness of stream-and-lake-deposited sediments (Payette formation) and volcanic rocks (Owyhee rhyolite and Columbia River basalt), all having generally low permeability. Resting on these materials is a younger group of sediments, the Idaho formation, which is a lake-laid deposit. This formation is quite varied in permeability, but generally is somewhat more permeable than the older sediments. The Idaho formation, consisting chiefly of clay, silt, and sand, is a source of moderately deep artesian water in the Boise and Snake River valleys. Streams spread a thick sheet of rather permeable terrace gravel on the ancient land surface of the Idaho formation. Lava flows formed the Snake River basalt which lies on the lower part of the gravel in some places and at others is covered by the upper part of the gravel. The present course of Snake River resulted as the river cut a deep canyon through the basalt and sediments. Meanwhile, the Boise Valley developed by alternate stream erosion and deposition, resulting in terraces underlain by permeable younger terrace gravel, and the bottom land occupied by highly permeable recent alluvium. Recent local basalt flows are interbedded with terrace gravels at a few places. The younger, variable, but more permeable, deposits in the Boise Valley thus occupy a partly closed basin that was eroded in the older terrace gravel and Idaho formation.

"The valley is enclosed on the north and east by mountains, and on the south by the Mountain Home plateau. On the west the valleys of the Boise and Snake Rivers intersect at grade. Outflow occurs only to the westward on the surface and at shallow depth. Under natural water conditions, the water table was at shallow depth in the bottom lands and not more than 100 to 200 feet deep under the terraces and lowland slopes. Under irrigation development, with much of the irrigated area on the terraces and surface application of large amounts of water, a great deal of water which formerly was discharged in the river now enters the ground and must be discharged westward through the ground. Earth materials to the west, however, are generally less permeable than those to the east. As a result, the water table has risen to the east to develop enough hydraulic gradient to move the water westward. Consequently, drainage problems have been encountered through most of the length of the valley, and, due to the lenticular character of much of the alluvium, trouble spots still develop."

Another type of drainage problem encountered in the Boise Valley is related to the recent basalt flows which are interbedded with the terrace gravels. Water migrating westward in the gravels becomes confined under the basalt, sometimes under considerable head. Leakage occurs upward through the basalt, and where fine silty or clay soils rest upon the basalt local seepage areas develop. Drainage of these areas has been accomplished through excavation of outlet drains and drilling of wells through the basalt.

The area has a semi-arid climate with a mean annual precipitation of 8 to 11 inches including 1.5 to 2 feet of snow, dry summers, a mean annual temperature of approximately 51°F, and an average frost-free season of 145 to 170 days.

Methods of Investigation

WATER SAMPLING

In March 1957, Bureau of Reclamation personnel selected 60 water sampling sites. These included 50 drainage and domestic wells and 10 surface water sources. Table A of the appendix gives the location and depth of wells and the location of the surface water sampling sites. Figure 1 shows the distribution of sampling sites, both wells and surface supplies.

Approximately one-half of the sites were sampled weekly from the middle of April until the first part of September. Two samples per month were taken at these sites during October and November, and one sample in December. The remainder of the sites were sampled at random during May, June, July, August and September.

The samples were taken by Bureau of Reclamation personnel in one-quart polyethylene bottles, stoppered tightly, placed in a specially constructed box and shipped the day they were sampled by railway express to the laboratory at Moscow. They arrived at

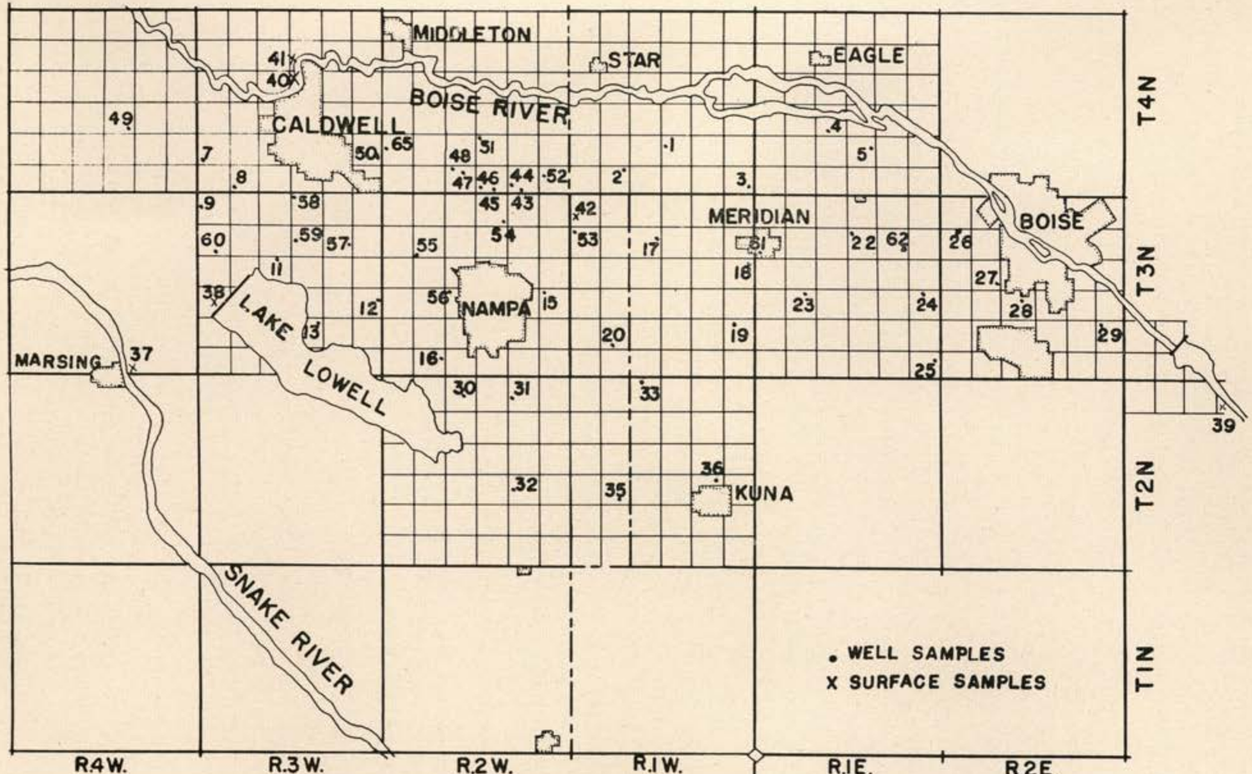

Figure 1 — Distribution of sampling sites in the Boise Valley.

the laboratory the next morning and were immediately stored in a refrigerator until the analyses were started.

WATER ANALYSIS

The pH of the water was determined using a Beckman glass electrode pH meter. Electrical conductivity was determined with an RD Solu-bridge, using a pipette-type cell (4). The analysis for calcium was made by titrating the oxalate with a standard cerate solution (4). Magnesium was determined indirectly by titrating the sample with standard versenate solution for calcium plus magnesium and then subtracting the calcium concentration (4). Sodium and potassium were run on a Perkin-Elmer flame photometer (4). Carbonates and bicarbonates were titrated with a standard sulfuric acid solution and chlorides with a standard silver nitrat solution (4). Sulphates were determined gravimetrically as barium sulphate (4).

Data and Discussion

The interpretation of water quality as it influences the permanence of land productivity must be considered along with ease of drainage, soil characteristics, the type of crops that are grown and the management practices. Water can have an adverse effect on soils, and different kinds of soils and drainage conditions may require slightly different kinds of irrigation water. The main criteria for judging water quality in this area are the concentration of salts and the amounts of sodium and bicarbonate ions.

A salinity problem can develop if the water used has a high salt concentration. The method of evaluating salt concentration in this study was to determine the electrical conductivity (E. C.) of the samples. Electrical conductivity is the ease with which the water can conduct an electric current and can be related to salt concentration in parts per million, tons of salt per acre foot of water, or other values more readily visualized. Some of these conversion factors are found in the glossary.

The amount of salts which can be tolerated in the water depends to a large extent upon the characteristics of the soil on which the water is to be applied, crop tolerance, and to the ease of drainage. The U. S. Salinity Laboratory (4) has divided water into four classes based on salinity. The classification of water in this report makes use of these criteria. The following is the classification of water for salinity (expressed in millimhos per centimeter):

Classification of Water	Electrical Conductivity mmhos/cm. at 25°C
C-1 — Low-salinity water can be used for irrigation with most crops on most soils, with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.	0 to 0.25
C-2 — Medium-salinity water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control.	0.25 to 0.75
C-3 — High-salinity water cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required, and plants with good salt tolerance should be selected.	0.75 to 2.25
C-4 — 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.	2.25 to 5.00

The sodium status of the irrigation water is dependent on the ratio of this element to the calcium plus magnesium concentrations. If the relationship of sodium to calcium plus magnesium is high the soils usually will not absorb water readily and may become sticky and difficult to till. This ratio of sodium to calcium plus magnesium is known as the sodium-absorbtion-ratio (4) and is as follows:

$$\text{Sodium absorption ratio (SAR)} = \frac{\text{sodium}}{\sqrt{\dfrac{\text{calcium} + \text{magnesium}}{2}}}$$

The ion concentrations are expressed in milliequivalents per liter.

The sodium status of the water is then judged according to the diagram in Figure 2:

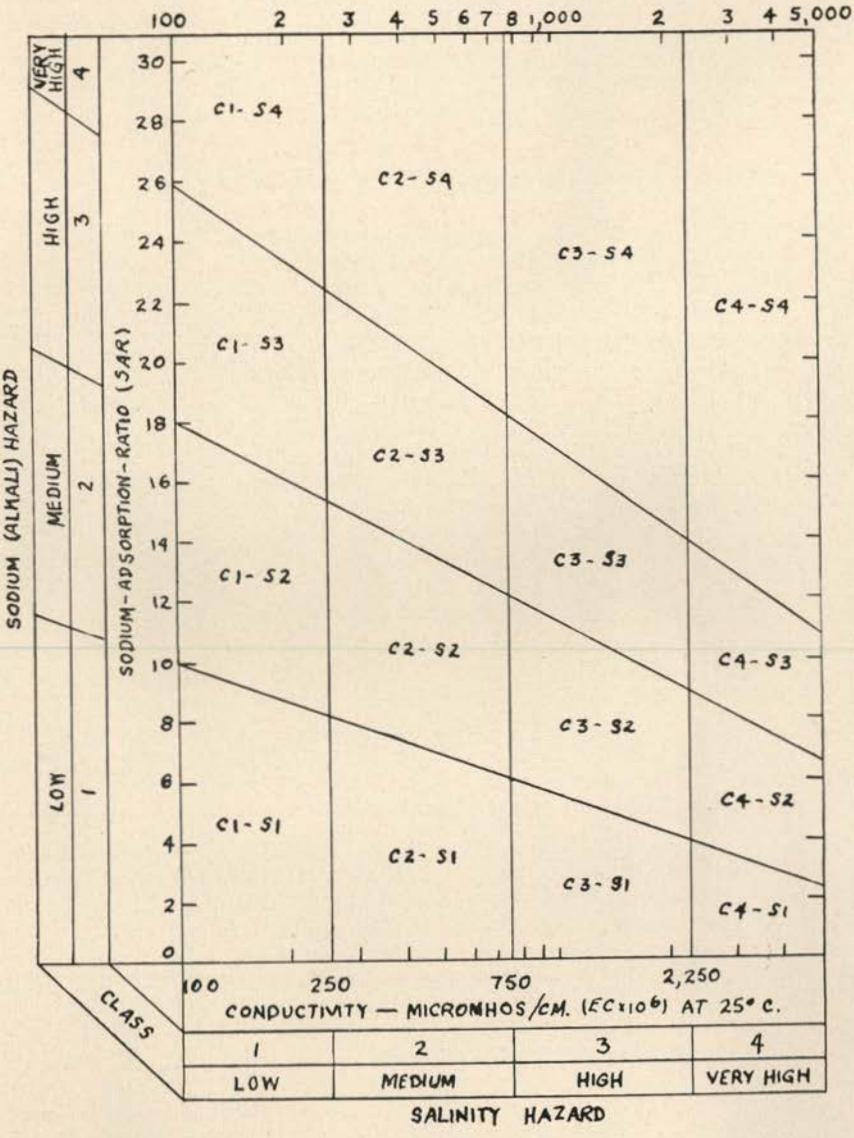

Figure 2 — U. S. Department of Agriculture diagram for the classification of irrigation waters.

The interpretations of the sodium status are as follows:

S-1 — Low-sodium water can be used for irrigation on almost all soils, with little danger of the development of a sodium problem.

S-2 — Medium-sodium water may present a moderate sodium problem in fine-textured (clay) soils unless there is gypsum in the soil. This water can be used on coarse-textured (sandy) or organic soils that take water well.

S-3 — High sodium water may produce troublesome sodium problems in most soils and require special management, — good drainage, high leaching and additions of organic matter. If there is plenty of gypsum in the soil, a serious problem may not develop for some time. If gypsum is not present, it or some similar material may have to be added.

S-4 — Very high-sodium water is generally unsatisfactory for irrigation except at low or medium-salinity levels where the use of gypsum or some other amendment makes it possible to use such water.

The amount of carbonate plus bicarbonate ions in water is also important from the standpoint of irrigation use. The soil solution becomes more concentrated as the soil dries after an irrigation. Under these conditions there may be a tendency for the less soluble compounds to precipitate from solution. Calcium and magnesium carbonates are much less soluble than sodium carbonate and may precipitate on drying if present in large enough quantities. The precipitation of calcium and magnesium results in a corresponding increase in the proportion of sodium in the soil solution. The extent to which calcium and magnesium carbonates will precipitate under these conditions has not been accurately determined. This excess of carbonate plus bicarbonate ions is called "residual sodium carbonate" and is calculated by subtracting the calcium plus magnesium ion concentration from the carbonate plus bicarbonate ion concentration. Waters containing 0 to 1.25 meq./l. are probably safe, 1.25 to 2.50 meq./l. are probably marginal, and in excess of 2.5 meq./l. are probably unsafe for irrigation usage (3).

Previous research in the Boise Valley area by the Idaho Experiment Station[1] has shown that C-1 and C-2 waters (Figure 2) could be grouped together for irrigation usage on the soils of southwestern Idaho.

To evaluate the data from the Boise Valley study, the salt, sodium and residual sodium carbonate status was grouped together to arrive at an "index of quality." This index of quality and its interpretation is found in Table 1.

[1] Unpublished data, Idaho Agricultural Experiment Station.

Table 1: Index of Quality Used for Classification of Irrigation Water

Index of Quality	U. S. Salinity Lab. Classification	Residual Sodium Carbonate meq./l.
1	C1S1 and C2S1	0-1.25
2	C3S1	0-1.25
3	C2S1	1.26-2.50
4	C3S1	1.26-2.50
5	C2S1	>2.51
6	C3S1	>2.51
7	C2S2	>2.51

The evaluation of the average quality of water from each of the sources sampled can be found in Table C of the appendix. Based on the "index of quality" the water sources analyzed in this study are summarized in Table 2.

Table 2: Summary of the Number of Water Sources in Each Classification Based on the Index of Quality

Index of Quality	No. of Sources	Reasons for Classification
1	31	Good Quality.
2	17	Medium to high salinity.
3	1	Marginal residual sodium carbonate.
4	7	Medium to high salinity and marginal residual sodium carbonate.
5	1	High residual sodium carbonate.
6	2	Medium to high salinity and high residual sodium carbonate.
7	1	High sodium and high residual sodium carbonate.

The 31 sources of good quality water can be used for irrigation purposes with most crops on most soils with little chance that a salinity or sodium problem will develop. Some leaching is required but this will occur under normal irrigation practices.

The 17 sources of number 2 water can probably be used with success where a moderate amount of leaching occurs. They should not be used where there is restricted drainage. The mixing of this water with any good water would improve its quality, as shown later in this report.

.Waters with an "index of quality" of 3, 4, 5, 6 and 7 can be used if mixed with good quality water to overcome the objectionable residual sodium carbonate.

A very complex system of stratification and dissection of the Idaho-Payette formation with the intrusion of Snake River basalt makes it difficult to predict areas of a certain water quality.

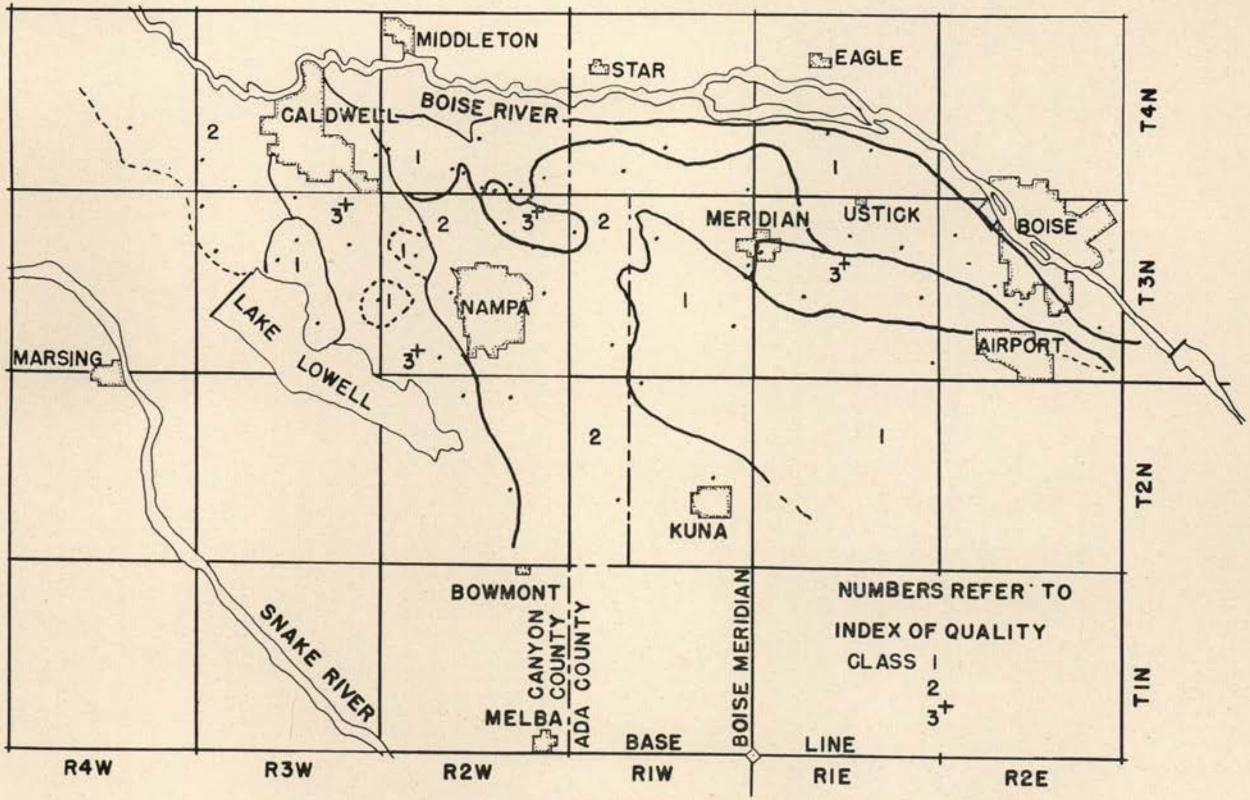

Figure 3: — Arbitrary division of water quality by areas in the Boise Valley area.

Figure 3 shows an arbitrary division of water quality areas. Note the complex pattern of distribution.

It can be generalized that the areas of better quality water are found adjacent to the Boise River and on the higher terraces at the eastern end of the valley. Except for a small area on the northern edge of Lake Lowell, the ground water quality becomes poorer moving from southeast to northwest towards the confluence of the Boise and Snake Rivers.

Marginal to unsatisfactory waters from the standpoint of residual sodium carbonate seem to occur along the Indian Creek drainage area north of Lake Lowell and the 5-and 10-Mile Creek drainage area between Meridian and Caldwell, with a smaller area between Boise and Meridian. Coincident with these poorer waters are soils with indurated hardpans and mixed soil associations.

There is no consistent relationship between the height of existing water tables and the quality of the water. In the area adjacent to the Boise River where the water table is higher, there appears to be considerable mixing of the underground sources, making these sources more satisfactory for irrigation.

The depth to the acquifers supplying a well does not have a consistent relationship to the quality of the water found in the well.

The surface water supplies included in the study are all satisfactory for irrigation use. The average analysis of each individual sample is found in Table D of the appendix. With the exception of the Snake River, which is not being used at present, the sources are being used successfully for irrigation in the Boise Valley.

MIXING WATER

To use some of the marginal quality well waters, it may be possible to use Boise River water or other good quality water to mix with these well waters and produce a satisfactory irrigation supply. To illustrate this possibility, dilution studies were made on well sources as mixed with water from the Phyllis Canal, a canal running approximately through the middle of the study area. One of the sampling stations was on lateral 8.25, a short distance below the turnout from the Phyllis Canal. This water contains from 10 to 30 percent drainage water effluent and is slightly more saline than the Boise River at Diversion.

A series of actual dilutions was made along lateral 8.25. Water from the 0. Frost well was pumped in the lateral, then sampled, followed with water from the N. Frost well, then sampled, and finally water from the Christenson well, followed by sampling. The results are shown in Table 3. Although the N. Frost and Christenson wells were number 4 and 2 quality waters, respectively, the dilution with the Phyllis Canal changed them to number 1 water. In this case, both salinity and high residual sodium carbonate were overcome by the dilution.

Table 3: Effect of Mixing Well Water with Surface Water along Lateral 8.25 of the Phyllis Canal

No.	Description	E.C. mmhos.	Ions in meq./l. Ca+ Mg	Na	CO_3+ HCO_3	Cl	SO_4	Water Class.
42	Lateral 8.25 at Phyllis Canal	0.24	1.17	0.65	1.34	0.35	0.13	1
43	O. Frost Well	0.66	3.58	2.62	4.22	0.56	1.49	1
44	Lateral below Frost well	0.26	1.30	0.84	1.62	0.46	0.11	1
45	N. Frost well	0.86	3.99	4.85	5.52	1.59	1.74	4
46	Lateral below N. Frost well	0.29	1.44	1.16	1.90	0.27	0.44	1
47	Christenson well	0.96	5.02	5.03	2.87	3.15	4.04	2
48	Lateral below Christenson well	0.38	2.04	1.80	1.75	0.60	1.45	1

All of the water sources having a rating of Class 2, 3, 4, 5, 6 and 7 could be improved in quality by dilution with surface water sources. Using the Phyllis Canal at lateral 8.25 as a surface water source, Table 4 was prepared showing the dilution ratios necessary to produce a class 1 water from each of the well sources of lower quality. Inspection of the table shows that mixing of surface water in proportions of from as little as one-sixth to as much as twice the quantity of well water raised all sources to good quality water. Of the sources requiring dilution with two parts surface water to one part ground water, 4 were class 2 waters, 1 was class 3, 1 class 6, and 1 class 7.

Each marginal quality well water source would have to be considered separately, along with the supply of surface or other water available. Knowing the analysis of both sources, a simple calculation could be used to evaluate the recommended mixture ratio by calculating the dilutions necessary to lower the total salts, sodium, and residual sodium carbonate to a satisfactory level.

Recommended dilution ratios are satisfactory only if the quality of the well or surface source does not change significantly. If increased draft on ground water lowers the water table or materially decreases the total amount of surface water recharging the ground water acquifiers, then the quality of an individual well may change and new dilution ratios might be required. It is impossible to predict the equilibrium quality of the ground water. In some locations removal of large quantities of ground water might increase salt concentrations, in other locations drainage conditions would be improved with resultant decrease in salt concentration due to improved leaching (or due to underground mixing with better quality water).

Table 4: Recommended Dilution of Marginal Well Water with Surface Water

	Characteristics of Existing Source			Recommended Dilution			
Source No.	Class	E.C. mmhos	Res.Na meq./l.	Ratio Well:Surface	Combined Class	E.C. mmhos	Res.Na meq./l.
2	2	0.85	0-1.25	5:1	1	0.75	0-1.25
3	2	0.83	0-1.25	5:1	1	0.75	"
7	2	1.07	0-1.25	1:1	1	0.65	"
8	2	1.40	0-1.25	1:2	1	0.66	"
9	2	1.45	0-1.25	1:2	1	0.66	"
15	2	1.28	0-1.25	1:2	1	0.59	"
18	2	0.84	0-1.25	5:1	1	0.74	"
20	2	1.02	0-1.25	1:1	1	0.63	"
31	2	1.07	0-1.25	1:1	1	0.65	"
35	2	1.20	0-1.25	1:1	1	0.72	"
36	2	1.09	0-1.25	1:1	1	0.66	"
47	2	0.96	0-1.25	2:1	1	0.72	"
49	2	1.03	0-1.25	1:1	1	0.64	"
52	2	0.79	0-1.25	6:1	1	0.73	"
56	2	0.80	0-1.25	6:1	1	0.72	"
60	2	1.36	0-1.25	1:2	1	0.61	"
70A	2	0.95	0-1.25	1:1	1	0.71	"
50	3	0.60	1.26-2.50	4:1	1	0.53	"
16	4	0.89	1.26-2.50	2:1	1	0.67	"
23	4	1.03	1.26-2.50	2:1	1	0.72	"
24	4	0.87	1.25-2.50	4:1	1	0.74	"
45	4	0.86	1.26-2.50	4:1	1	0.74	"
53	4	0.85	1.26-2.50	2:1	1	0.65	"
58	4	1.03	1.26-2.50	1:1	1	0.64	"
61	4	0.85	1.26-2.50	1:1	1	0.55	"
32	5	0.41	2.50	1:2	1	0.30	"
54	6	0.92	2.50	1:2	1	0.47	"
57	6	0.78	2.50	4:1	1	0.53	"
30	7	0.35	2.50	1:2	1	0.28	"

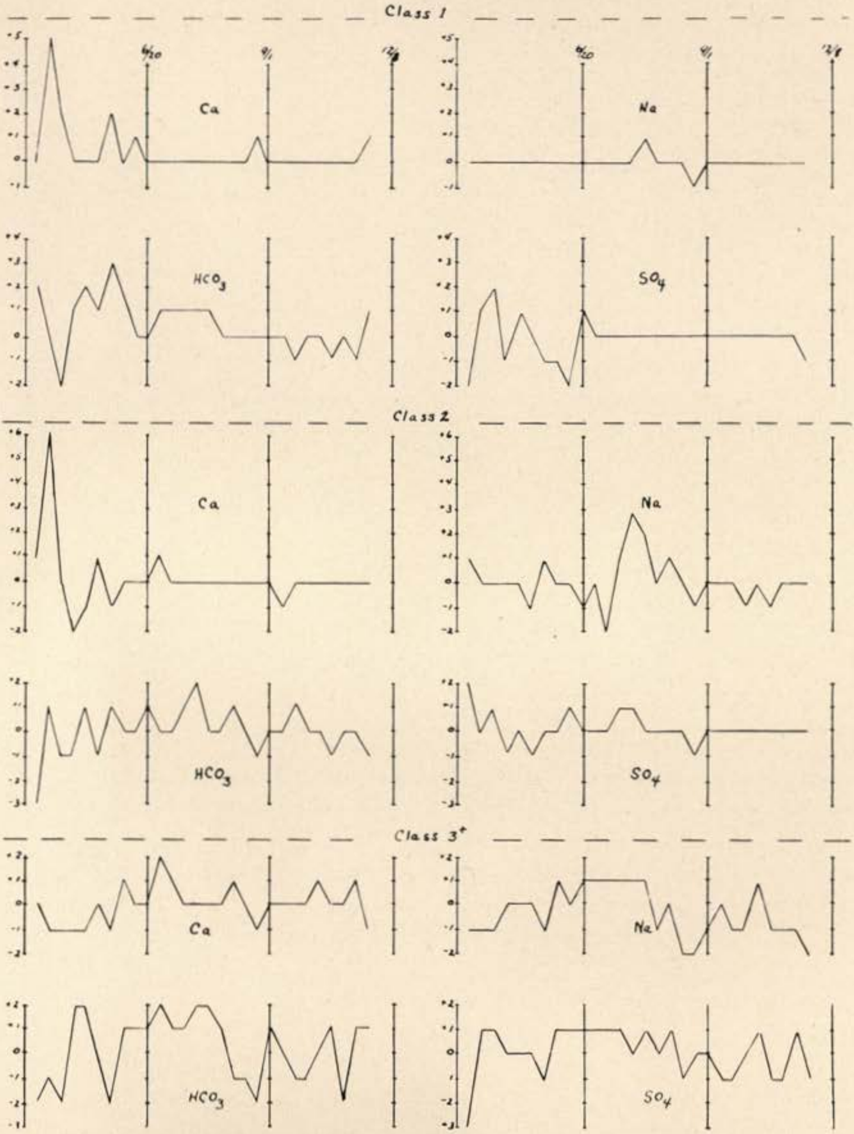

Figure 4 — Number of fluctuations in excess of 0.5 meq./l., below and above the average concentration during the sampling period.

FLUCTUATIONS OF WATER QUALITY

The fluctuations of well water quality during the irrigation season had little practical importance since the soils received the average quality during this period. However, there are several interesting aspects directly and indirectly related to this fluctuation. These include the pattern of fluctuation, such as an increase or decrease in salts or ions during the irrigation season, or change of well water class during the irrigation season.

The pattern of ion fluctuation was somewhat different for each water source. Since it would be of no particular importance to show the curve of fluctuation for each source, the waters of each class were considered together and a study was made to determine the frequency of fluctuations during the sampling season. Only fluctuations in excess of 0.5 meq/liter were considered in water sources which were sampled on approximately the same date.

The class number 1 water showed considerable fluctuation in excess of 0.5 meq/liter of calcium, bicarbonate, and sulphate from April 15 to June 20, with relatively small change for the rest of the season. These data are shown graphically in Figure 4. There was very little fluctuation in the sodium content.

Class 2 water showed more seasonal fluctuation than Class 1, as shown in Figure 4. This was especially true with bicarbonate, sulfate and sodium ions. In the case of sodium ions, the concentration was higher in July during the peak irrigation season. Calcium ions again fluctuated the least after June 20.

The classes of water of Class 3 and higher showed the most fluctuation of the ions, as shown in Figure 4. The sodium, bicarbonate and sulfate ions were generally higher in July and the first part of August, which reflects recharge of ground water supplies with high irrigation rates.

It is interesting to note the changes of classification which occur in certain water sources during the irrigation season. These changes are shown in Table 5. This would be important if single samples alone had been taken from each source and used as a basis for classifying the water quality. For example: Wells numbered 23 and 24 could have Class 1, 2, or 3+, depending on when they were sampled. The Snake River, Boise River at Caldwell Notus Canal and Reynolds Creek changed quality classification during the sampling period.

SOILS

It is difficult to evaluate the quality of water for irigation use unless something is known of the soils to which this water is to be applied. For example: Heavy-textured soils such as clays or clay loams are more likely to become less permeable due to the presence of sodium ions in the irrigation water than light-textured soils such as sandy loams. The heavy-textured soils would be more deflocculated by sodium ions making free passage of water through them more difficult.

A high concentration of salt in the irrigation water can do more damage to plants in heavy soils than light soils. On heavy

Table 6: Changes in Water Quality Classification of Individual Wells During Irrigation Season

Source No.	No.of Class 1	No.of Class 2	No.of Class 3+	Source No.	No.of Class 1	No.of Class 2	No.of Class 3+
1	27	1	0	36	0	27	1
2	3	25	0	37	24	5	8
3	4	24	0	38	26	1	0
4	6	7	0	39	28	0	0
5	6	0	0	40	27	0	1
6	1	27	0	41	8	5	0
7	1	3	0	42	16	0	0
8	0	27	1	43	5	1	3
9	0	4	0	44	15	0	0
11	4	0	0	45	0	17	2
12	27	1	0	46	16	0	0
13	26	0	0	47	0	7	0
15	0	24	4	48	9	0	0
16	0	3	25	49	0	2	0
17	27	0	1	50	5	0	0
18	1	27	0	51	12	4	0
19	28	0	0	52	0	10	2
20	1	27	0	53	0	3	16
22	1	27	0	54	0	0	18
23	1	5	22	55	15	0	0
24	2	8	18	56	2	12	0
25	4	0	0	57	0	0	7
26	25	0	0	58	0	0	4
27	28	0	0	59	10	0	0
28	1	0	0	60	0	14	14
29	13	0	0	61	0	0	15
30	0	0	28	62	28	0	0
31	0	3	0	65	28	0	0
32	1	0	27	70A	0	7	0
33	24	0	4	70B	3	1	4
35	0	25	3				

soils where permeability is low and field capacity is quite high compared with the wilting percentage, the concentration of the soil solution near the wilting point may be 100 times that of the irrigation water. This increases the osmotic pressure of the soil solution to the point where the plants are unable to obtain sufficient water for growth.

In some cases, a very low concentration of salts in irrigation water may decrease soil permeability. The degree of clay swelling in saline-alkali soils of arid regions remains low as long as the salt concentration remains relatively high in the soil solution. If such soils are leached with low salt content water, dispersion and swelling of the clay upon salt removal may essentially seal off further water movement.

The soils of the Boise Valley area lie in the Sierozem soil zone. Differences in age, parent material, topography, climate, vegetation associated with variations in drainage and salinity have produced a number of soils which occur in a complex pattern. In general, there is an accumulation of fine materials in the B horizon, with the silt and sand left in the A or surface horizon. This, along with the continued weathering of materials, has contributed to an accumulation of clay in the B horizon. All of these soils contain lime in the lower part of the profile or in the C horizon. The soil profiles may or may not contain gypsum, depending on the amount of leaching it has undergone. Some of the soils are underlaid by a caliche hardpan.

This study of irrigation water quality in the Boise Valley area did not include a study of the effects of irrigation water quality on the soil characteristics. However, data from other research projects [1] have indicated that, with good drainage, the surface waters used at present were not having an adverse effect on the soils. This was true despite the wide variation in the amount of salts found in the irrigation water and the presence of clay subsoils.

A high water table is one of the more important problems associated with irrigation of the Boise Valley area. In successful irrigated agriculture it is important that enough water, in excess of plant use and evaporation losses, should be applied to remove approximately as much salt as is transported onto the land by the irrigation water. Otherwise, there will be a gradual increase in the salinity of the soil.

[1] Unpublished data, Idaho Agricultural Experiment Station.

Summary and Conclusions

Approximately one-half of the water sources sampled were of good quality for irrigation usage without dilution. This included the surface water supplies with the exception of Sproat Springs.[1] The remainder of the water sources can be used for irrigation if they are mixed with good quality water, and many of them can be used on some soils without dilution. Most of these sources were of poorer quality because of high salt content or high residual sodium carbonate.

In the case of poor quality well water, if the quality of the available surface supply is known, it is possible to determine a satisfactory mixture of these two sources. A recommended dilution ratio would be satisfactory only if the quality of the sources remained reasonably constant.

A very complex system of stratification and dissection of the area by Snake River basalt flows makes it difficult to predict areas of a certain water quality. There is no well defined pattern of distribution of water quality by areas. Moreover, the depth to the acquifier has no consistent relationship to the quality of water found.

Many water sources showed a change in quality during the irrigation season. This suggests that periodic checks should be made on the quality of the well water during the irrigation season so that changes in dilution requirements can be made when required.

If the drainage problem of the Boise Valley can be alleviated by drainage wells, it appears feasible to reuse much of this water for irrigation purposes. This may lower the water table to a desirable depth and at the same time release water for other uses.

It should be emphasized, however, that a change in ground water salinity can be anticipated as a result of increased domestic, industrial and agricultural ground water use. The direction and extent of change cannot be forecast without a detailed hydrological study. It is important that changes in ground water composition be monitored and that appropriate adjustments be made to prevent an excessive deterioration in water quality.

[1] It is probable that most of the discharge from the Springs is return flow from irrigated lands to the east.

Literature Cited

1. Jensen, Max C., Lewis, Glenn C., and Baker, G. O. 1951 Characteristics of Irrigation Waters in Idaho. Ida. Agr. Exper. Sta. Res. Bul. No. 19.

2. Savage, C. N. 1958 Geology and Mineral Resources of Ada and Canyon Counties. County Report No. 3, Idaho Bureau of Mines and Geology.

3. Nace, R. L., West, S. W., and Mower, R. W. 1957 Feasibility of Ground-Water Features of the Alternate Plan for the Mountain Home Project, Idaho. Geological Survey Water Supply Paper 1376.

4. U. S. Salinity Laboratory Staff. 1954 Diagnosis and Improvement of Saline and Alkali Soils. Handbook No. 60, U. S. Dept. of Agr.

Appendix

GLOSSARY

Anion — A negative ion. For example: Carbonates ($CO_3^{=}$), bicarbonates (HCO_3^-), sulphates ($SO_4^{=}$), and chlorides (Cl^-).

Alluvium — Materials moved and deposited by water. It consists of sediments deposited by streams.

Caliche hardpan — Gravel, sand and silt cemented together by calcium carbonate and silica compounds to form a hard mass. When thick and continuous, it restricts the entry of water.

Cation — A positive ion. For example: Calcium (Ca^{++}), sodium (Na^+), magnesium (Mg^{++}), and potassium (K^+).

Deflocculated soil — Soil in which the clay readily forms a colloidal sol. These soils have a low permeability and tend to shrink, crack, and become hard on drying and to slake and become plastic on wetting.

Electrical conductivity — The reciprocal of the electrical resistivity. The resistivity is the resistance in ohms of a conductor, metallic or electrolytic, which is 1 cm. long and has a cross-sectional area of 1 cm^2. Hence, electrical conductivity is expressed in reciprocal ohms per centimeter, or mmhos per centimeter. Electrical conductivity can be converted to parts per million by multiplying E.C. x 10^3 x 640 for irrigation waters in the range of 0.1 to 5.0 mmhos per cm.

Field capacity — The moisture content of the soil in the field two or three days after a thorough wetting of the soil profile by rain or irrigation water.

Ground water — Water in soil beneath the surface where the voids or spaces between the soil particles are filled with water.

Ion — As used in this paper refers to salts dissolved in water which have broken up into atoms or groups of atoms carrying positive or negative charges of electricity. For example: Ca^{++}, Mg^{++}, Na^+, $CO_3^{=}$, HCO_3^-, Cl^-, and $SO_4^{=}$ are ions.

Milliequivalents per liter (meq./l.) — As used in this paper it is a method of expressing the concentration of an ion in a liter of water. For example: A concentration of 1 meq./l. of calcium is equal to 0.02 gram per liter or 20 parts per million.

Water table — The upper surface of the ground water.

Table A: Location of Well and Surface Water Sampling Stations

Ident.No.	Name	Location	Depth of Well—Feet
1	Stan Records	SW-NW-1/4 sec. 27 T 4 N, R 1 W	180′
2	Chas. Hart	NE-NE-1/4 sec. 32 T 4 N, R 1 W	112′
3	Harold Greason	NE-SE-1/4 sec. 36 T 4 N, R 1 W	184′
4	Joe H. Patterson	SE-SW-1/4 sec. 21 T 4 N, R 1 E	161′
5	Chas. Silliman	SE-NE-1/4 sec. 27 T 4 N, R 1 E	70′
7	Chas. Peterson	SW-SW-1/4 sec. 30 T 4 N, R 3 W	135′
8	Lloyd Schmitt	SW-SW-1/4 sec. 32 T 4 N, R 3 W	147′
9	C. W. Browning	NW-SW-1/4 sec. 6 T 3 N, R 3 W	178′
11	E. M. Carter	NW-NE-1/4 sec. 16 T 3 N, R 3 W	140′
12	Pauline Svehlak	SE-NE-1/4 sec. 24 T 3 N, R 3 W	110′
13	K. W. Baker	NE-NE-1/4 sec. 27 T 3 N, R 3 W	375′
15	E. R. Roberts	NW-NW-1/4 sec. 24 T 3 N, R 2 W	155′
16	Isaac Young	SE-NE-1/4 sec. 32 T 3 N, R 2 W	100′
17	E. Grosso	SE-NE-1/4 sec. 9 T 3 N, R 1 W	212′
18	H. Van Hees	NE-NE-1/4 sec. 14 T 3 N, R 1 W	150′
19	V. Sundall	NE-NW-1/4 sec. 25 T 3 N, R 1 W	142′
20	G. L. Epperly	SE-SW-1/4 sec. 29 T 3 N, R 1 W	90′
22	Cloverdale Park Cemetry	NW-NW-1/4 sec. 10 T 3 N, R 1 E	110′
23	Lant Hartman	NW-NE-1/4 sec. 20 T 3 N, R 1 E	80′
24	G. C. Wilson	NE-NW-1/4 sec. 24 T 3 N, R 1 E	167′
25	M. S. Ayers	SE-NE-1/4 sec. 36 T 3 N, R 1 E	310′
26	C. A. Nyberg	NW-NE-1/4 sec. 7 T 3 N, R 2 E	250′
27	H. F. Miner	SE-SE-1/4 sec. 17 T 3 N, R 2 E	73′
28	W. C. Swank	SW-NE-1/4 sec. 21 T 3 N, R 2 E	86′
29	Ada Co. Drainage District No. 3 T	NW-NW-1/4 sec. 25 T 3 N, R 2 E	65′
30	Fred Trask	NW-SE-1/4 sec. 4 T 2 N, R 2 W	175′
31	B. S. Gottier	NW-SW-1/4 sec. 2 T 2 N, R 2 W	44′
32	G. A. Swartz	NW-SW-1/4 sec. 23 T 2 N, R 2 W	281′
33	Perry Kasel	NE-NW-1/4 sec. 4 T 2 N, R 1 W	100′

(Continued on next page)

Table A: Location of Well and Surface Sampling Stations

(Continued from page 23)

Ident.No.	Name	Location	Depth of Well—Feet
35	C. Bachman	SW-SE-1/4 sec. 20 T 2 N, R 1 W	163′
36	C. Tucker	SW-NE-1/4 sec. 23 T 2 N, R 1 W	110′
37	Snake River	Snake River at Marsing (N. end of bridge)	
38	Outlet of Lake Lowell	Outlet of Lake Lowell	
39	Boise River	Boise River at Diversion Dam at head of New York Canal	
40	Boise River	Boise River at Caldwell, near the head of the Farmers' Co-Op Canal at the old Highway Bridge	
41	Notus Canal	Near Caldwell, crossing at U.S. 30, north of river	
42	Lateral 8.25 from Phyllis Canal	SW corner, sec. 6 T 3 N, R 1 W, 500′ north of the corner	
43	O. Frost	SE-SW-1/4 sec. 35 T 4 N, R 2 W	90′
44	Lateral 8.25 below O. Frost well	West of O. Frost well near 16/4 corner	
45	North Frost well	Near 16/16 corner of sec. 34, T 4 N, R 2 W	108′
46	Lateral 8.25 below N. Frost well	1/2 mi. W of North Frost well between 16/4 corner and the W 1/4 cor. of sec. 34	
47	M. M. Christenson	At the 16/10 corner sec. 33, T 4 N, R 2 W	123′
48	Lateral 8.25 below the Christenson well	Between the 16/2 and the N 1/4 corner of sec. 33	
49	Street well (owner Walter Griffiths)	SE-SE-1/4 sec. 22 T 4 N, R 4 W	60′
50	Grace Horton	NE-SE-1/4 sec. 25 T 4 N, R 3 W	80′
51	Walter Guinn	NW-NW-1/4 sec. 27 T 4 N, R 2 W	120′
52	J. Betts well (owner V. E. Booth)	SW-NW-1/4 sec. 36 T 4 N, R 2 W	116′
53	Tiegs well (owner H. Krieger)	NW-NW-1/4 sec. 7 T 3 N, R 1 W	61′
54	Franklin Road (Owner N. A. Burns)	SE-SE-1/4 sec. 3 T 3 N, R 2 W	130′
55	Karcher Road well	SW-SW-1/4 sec. 8 T 3 N, R 2 W	143′
56	Orchard Ave. well	NW-NW-1/4 sec. 21 T 3 N, R 2 W	135′
57	Maple Grove (owner H. R. Vinson)	NE-SE-1/4 sec. 11 T 3 N, R 3 W	95′
58	G. E. Steelman	NW-NW-1/4 sec. 3 T 3 N, R 3 W	71′
59	U of I Experiment Station near Caldwell	East Side of 10th Ave. South	
60	Weeks well (owner James Watson)	Sec. 7, T 3 N, R 3 W	150′
61	Nampa Meridian Irrigation District Drainage Well	East side of road S. of RR tracks in Meridian, SW-SW-1/4 sec. 7, T 3 N, R 1 E	
62	V. Lundstrum	Sec. 11, T 3 N, R 1 E	316′
65	W. D. Hickman	W-1/4 cor., sec. 30 T 4 N, R 2 W	180′
70A	Sproat Springs		
70B	Reynolds Creek		

Table B: Average Chemical Composition of Wells and Surface Water Supplies in the Boise Valley[1]

Source	Sample Site No.	E.C. mmhos.	Ions in meq./L							
			Ca	Mg	Na	K	HCO_3	CO_3	Cl	SO_4
Records (28)[2]	1	0.40	2.09	0.64	0.65	0.03	1.92	0.00	0.62	0.87
Hart (28)	2	0.85	5.34	2.03	1.80	0.05	4.24	0.00	1.77	3.12
Greason (28)	3	0.83	5.62	1.11	1.60	0.05	4.12	0.09	1.38	2.75
Patterson (13)	4	0.75	2.31	2.18	3.47	0.04	3.62	0.00	0.94	3.41
Silliman (6)	5	0.58	2.23	1.16	2.87	0.05	4.22	0.00	0.84	1.19
Peterson (28)	7	1.07	5.50	1.39	3.89	0.18	3.71	0.00	3.80	3.33
Schmitt (28)	8	1.40	5.07	1.22	8.09	0.15	6.19	0.00	3.48	4.73
Browning (4)	9	1.45	6.95	3.12	4.71	0.15	4.31	0.00	4.86	5.89
Carter (4)	11	0.49	0.86	1.45	2.24	0.09	2.89	0.00	0.70	0.90
Svehlak (28)	12	0.31	1.37	0.39	1.17	0.07	1.69	0.00	0.40	0.90
Baker (26)	13	0.40	0.87	0.94	1.92	0.09	2.02	0.00	0.55	1.20
Roberts (28)	15	1.28	4.86	2.13	6.47	0.08	6.33	0.00	1.56	5.47
Young (28)	16	0.89	2.16	1.57	5.72	0.13	5.35	0.07	0.55	3.63
Grosso (28)	17	0.29	1.35	0.45	0.91	0.03	1.62	0.00	0.62	0.50
Van Hees (28)	18	0.84	3.40	2.73	2.24	0.05	3.36	0.00	1.81	3.41
Sundall (28)	19	0.58	2.22	1.57	1.82	0.05	2.69	0.03	0.91	2.06
Epperly (28)	20	1.02	4.76	2.28	3.99	0.10	6.90	0.07	1.06	3.10
Cloverdale (28)	22	0.65	2.18	2.58	2.35	0.07	5.10	0.00	0.38	1.68
Hartman (28)	23	1.03	3.42	1.91	6.27	0.04	6.90	0.04	0.70	3.98
Wilson (28)	24	0.87	2.68	1.70	4.67	0.04	5.69	0.07	0.73	2.54
Ayers (4)	25	0.23	0.46	0.17	1.40	0.03	1.57	0.00	0.38	0.14
Nyberg (25)	26	0.56	2.42	1.82	1.31	0.06	4.08	0.01	0.79	0.67
Miner (28)	27	0.41	1.41	0.37	2.43	0.03	2.44	0.00	0.33	1.47
Swank (1)	28	0.25	0.90	1.08	1.00	0.02	1.96	0.00	1.19	0.80
Ada Co. Drain. Dist. (13)	29	0.22	1.14	0.27	0.31	0.03	1.49	0.00	0.20	0.06
Trask (28)	30	0.35	0.37	0.14	2.88	0.04	3.19	0.00	0.20	0.05
Gottier (3)	31	1.07	3.16	2.71	4.95	0.16	6.80	0.00	1.11	3.04
Swartz (28)	32	0.41	0.50	0.26	3.37	0.03	3.64	0.04	0.46	0.03
Kasel (28)	33	0.45	0.88	0.96	2.49	0.04	2.36	0.10	0.58	1.30
Bachman (28)	35	1.20	4.38	1.66	6.66	0.24	5.79	0.09	1.65	5.38
Tucker (28)	36	1.09	4.95	1.51	5.03	0.23	5.80	0.02	1.35	4.50
Snake River (28)	37	0.69	2.97	1.02	2.84	0.17	4.60	0.07	0.83	1.40
Outlet Lake Lowell (27)	38	0.39	1.59	0.43	1.55	0.05	2.60	0.01	0.43	0.53
Boise River above Boise (28)	39	0.11	0.40	0.16	0.16	0.03	0.40	0.00	0.20	0.14
Boise River at Caldwell (28)	40	0.32	1.46	0.42	1.21	0.07	2.41	0.00	0.41	0.31
Notus Canal	41	0.70	2.35	1.50	3.34	0.12	4.58	0.00	0.98	1.67
Lateral, 8.25 (16)	42	0.24	0.90	0.27	0.65	0.04	1.34	0.00	0.35	0.13
O Frost (9)	43	0.66	2.42	1.16	2.62	0.05	4.22	0.00	0.56	1.49
Lateral West of O. Frost (15)	44	0.26	1.12	0.18	0.84	0.04	1.62	0.00	0.46	0.11
N. Frost (19)	45	0.86	2.44	1.55	4.85	0.05	5.52	0.00	1.59	1.74
Lateral, Sugar Factory Rd. (16)	46	0.29	1.33	0.11	1.16	0.04	1.90	0.00	0.27	0.44
Christenson (7)	47	0.96	3.83	1.19	5.03	0.05	2.87	0.00	3.15	4.04
Lateral Below Christenson Well (9)	48	0.38	1.49	0.55	1.80	0.05	1.75	0.00	0.60	1.45
Street (2)	49	1.03	3.16	2.15	5.86	0.09	3.97	0.00	3.80	3.29
Horton (5)	50	0.60	2.05	0.48	3.31	0.03	3.86	0.00	0.48	1.56
Guinn (16)	51	0.73	3.06	1.92	2.38	0.07	4.04	0.00	0.73	2.65
Betts (12)	52	0.79	2.59	1.42	4.90	0.05	5.07	0.00	1.27	2.60
Tiegs (20)	53	0.85	1.89	1.87	4.76	0.06	5.40	0.00	0.97	2.17
Franklin Rd. (18)	54	0.92	2.20	1.68	5.51	0.05	6.77	0.00	0.84	1.80
Karcher Rd. (15)	55	0.52	1.76	0.72	2.47	0.09	2.97	0.00	0.80	1.21
Orchard Ave. (14)	56	0.80	3.19	1.78	3.12	0.13	5.38	0.00	1.09	1.74
Maple Grove (7)	57	0.78	2.47	0.69	4.96	0.10	6.21	0.00	0.58	1.46
Steelman	58	1.03	3.20	1.75	5.87	0.07	6.47	0.00	0.98	3.47
U. I. Exp. Sta. Caldwell (10)	59	0.53	1.50	1.15	2.44	0.10	2.98	0.00	0.98	1.28
Weeks (28)	60	1.36	3.27	2.33	8.60	0.21	4.92	0.19	3.74	5.51
Nampa-Meridian Irri. Dist. (15)	61	0.85	2.32	1.92	4.55	0.05	6.59	0.00	0.74	1.39
Lundstrum (28)	62	0.33	1.77	0.60	1.13	0.03	2.78	0.02	0.34	0.42
Hickman (28)	65	0.21	0.73	0.22	1.04	0.03	1.23	0.00	0.60	0.19
Sproat Springs (8)	70A	0.95	3.36	1.90	4.50	0.16	3.90	0.00	3.68	2.35
Reynolds Creek (8)	70B	0.64	1.71	1.93	2.97	0.13	4.88	0.00	0.65	1.21

[1] The analyses data on each individual water sample are on file in the Agricultural Chemistry Department of the Idaho Agr. Exper. Sta.

[2] Number of water samples taken from each source.

Table C: Evaluation of the Quality of Water Sources and U.S.D.A. Classification

Source	Sample Site No.	Index of Quality	U.S.D.A. Classification C_1S_1	C_2S_1	C_3S_1	C_2S_2	Residual Sodium meq./l. 0-1.25	1.26-2.50	>2.51
Records	1	1		X			X		
Hart	2	2			X		X		
Greason	3	2			X		X		
Patterson	4	1		X			X		
Silliman	5	1		X			X		
Peterson	7	2			X		X		
Schmitt	8	2			X		Tr		
Browning	9	2			X		X		
Carter	11	1		X			X		
Svehlak	12	1		X			Tr		
Baker	13	1		X			X		
Roberts	15	2			X		Tr		
Young	16	4			X			X	
Grosso	17	1		X			Tr		
Van Hees	18	2			X		X		
Sundall	19	1		X			X		
Epperly	20	2			X		Tr		
Cloverdale	22	1		X			X		
Hartman	23	4			X			X	
Wilson	24	4			X			X	
Ayers	25	1	X				X		
Nyberg	26	1		X			Tr		
Miner	27	1		X			X		
Swank	28	1	X				X		
Ada Co. Drain District	29	1	X				X		
Trask	30	7				X			X
Gottier	31	2			X		X		
Swartz	32	5		X					X
Kasel	33	1		X			X		
Bachman	35	2			X		Tr		
Tucker	36	2			X		Tr		
Snake River	37	1		X			X		
Outlet - Lake Lowell	38	1		X			X		
Boise River above Boise	39	1	X				X		
Boise R. above Caldwell	40	1		X			X		
Notus Canal	41	1		X			X		
Lateral 8.25	42	1	X				X		
O. Frost	43	1		X			X		
Lateral W. of O. Frost	44	1		X			X		
N. Frost	45	4			X			X	
Lateral - S. Factory Rd.	46	1		X			X		

(Continued on next page)

Table C: Evaluation of the Quality of Water Sources and U.S.D.A. Classification

(Continued from page 26)

Source	Sample Site No.	Index of Quality	U.S.D.A. Classification				Residual Sodium meq./l.		
			C_1S_1	C_2S_1	C_3S_1	C_2S_2	0-1.25	1.26-2.50	>2.51
Christenson Well	47	2			X		X		
Lateral below Christenson	48	1		X			X		
Street	49	2			X		X		
Horton	50	3		X				X	
Guinn	51	1		X			X		
Betts	52	2			X		X		
Tiegs	53	4			X			X	
Franklin Rd.	54	6			X				X
Karcher Road	55	1		X			X		
Orchard Ave.	56	2			X		X		
Maple Grove	57	6			X				X
Steelman	58	4			X			X	
U. of I. Exp. Station	59	1		X			X		
Weeks	60	2			X		X		
Nampa-Meridian	61	4			X			X	
Lundstrom	62	1		X			X		
Hickman	65	1	X				X		
Sproat Springs	70A	2			X		X		
Reynolds Creek	70B	1		X			X		

3M—12-59

OTHER UNIVERSITY OF IDAHO AGRICULTURAL PUBLICATIONS DEALING WITH IRRIGATION

Costs of Sprinkler Irrigation on Idaho Farms, Exp. Bul. 0287

Evaluation of Some Irrigation Water Control Devices, Exp. Bul. 319

Farm Water Measurement, Ext. Bul. 170

Irrigated Pastures For Idaho Farms, Ext. Bul. 190

Irrigation Development in Idaho Under the Desert Land Act, Exp. Bul. 292

Irrigation of Field Beans in Idaho, Exp. Res. Bul. 37

Irrigation of Hay and Pasture Crops, Exp. Bul. 249

Irrigation of Russet Burbank Potatoes in Idaho, Exp. Bul. 246

Operating and Maintaining Your Sprinkler System, Farm Elec. Leaf. 37

Production Requirements for Major Enterprises on Southern Idaho Irrigated Farms, Exp. Mim. 116

Sprinkler Irrigation, PNW 3

Sprinkler Irrigation in Idaho, Farm Elec. Leaf. 10

Use the Farm Land for Better Irrigation and Soil Conservation, Ext. Bul. 171

Water Quality Study in the Boise Valley, Exp. Bul. 316

Copies of these and other University of Idaho and U. S. Department of Agriculture publications may be secured from County Agent offices or by writing to the University of Idaho, College of Agriculture, Moscow, or to the Agricultural Extension Service, University of Idaho, 317½ North 8th St., Boise, Idaho.