UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE-RESEARCH

PROGRESS REPORT ON DRAINAGE INVESTIGATIONS

EMMETT VALLEY
GEM COUNTY, IDAHO

By

George B. Bradshaw
Drainage Engineer

(A report based on data gathered under cooperative agreement between the Soil Conservation Service, the Idaho Agricultural Experiment Station Gem County Board of Commissioners, Gem County Production and Marketing Administration, U. S. Bureau of Reclamation, and the U. S. Geological Survey) during 1951 and 1952.

Prepared Under the Direction of
George D. Clyde, Chief
Division of Irrigation Engineering and Water Conservation
Soil Conservation Service-Research

Boise, Idaho
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FOREWORD

This progress report by George B. Bradshaw contains a detailed account of the drainage and alkali reclamation studies that have been carried on in the Emmett Valley, Gem County, Idaho since the start of the investigation in August 1951.

The author has searched the records for all information gathered by previous investigators and has included some of the information along with his original data, so that when the investigation is completed there will be a comprehensive plan for the drainage and reclamation of these lands.

The procedures and results presented in this report, together with some of the conclusions reached in the Emmett Valley, can be used in solving drainage and reclamation problems in other areas.

Claude H. Pair
Project Supervisor

ORGANIZATION

The Gem County Drainage Investigation is being conducted under a memorandum of understanding between the Idaho Department of Reclamation, the Idaho Agricultural Experiment Station, the Bureau of Plant Industry, Soils, and Agricultural Engineering, the U. S. Regional Salinity Laboratory, Agricultural Research Administration, the Soil Conservation Service, U. S. Department of Agriculture and the Bureau of Reclamation, U. S. Department of Interior.

A joint working plan entitled "Payette Valley Drainage Investigations, Gem County, Idaho", describing the procedures to be used, was signed by the following cooperating agencies.

1. U. S. Department of Agriculture, Soil Conservation Service.
   (a) Division of Irrigation Engineering and Water Conservation.
   (b) Operations Division
2. Idaho Agricultural Experiment Station
3. Gem County Board of Commissioners
4. U. S. Bureau of Reclamation
5. Gem County Production and Marketing Administration.

Members of the Emmett Valley Drainage Committee were:

George D. Clyde, Chairman	Soil Conservation Service, Research.
R. N. Irving	Soil Conservation Service, State Conservationist.
Edwin J. Core	Soil Conservation Service, Regional Office
John E. Hull	Soil Conservation Service, Area Conservationist.
Victor Myers	University of Idaho
Keith Anderson	Bureau of Reclamation
Mark Kulp	State Commissioner of Reclamation
R. L. Nace	U. S. Geological Survey
Owen Dix	P.M.A., Gem County
Roy Knox	Gem County Board of Commissioners
Charles Pritzl	Canyon County Drainage District No. 1
Savis Stoher	Canyon County Drainage District No. 2
Irl Bishop	Gem County Drainage District No. 1

Over-all direction of the investigation was under the Division of Irrigation Engineering and Water Conservation, Soil Conservation Service.

UNITED STATES DEPARTMENT OF AGRICULTURE

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SUMMARY

The present Emmett Valley Drainage Investigation was started in August of 1951 as the result of recommendations made in May of 1951 by representatives of the Soil Conservation Service of the Department of Agriculture, Idaho Agricultural Experiment Station, Gem County Board of Commissioners, U. S. Bureau of Reclamation, U. S. Geological Survey and the Gem County Production and Marketing Administration.

The objectives of the drainage investigation have been:

1. To obtain basic physical data necessary to design drainage systems and reclaim water-logged and alkali-saline lands in the Emmett Valley.

2. To develop methods and techniques that might be applied to the solution of drainage and salt problems on lands in the intermountain and northwestern states.

The purpose of this report is to present a fairly detailed account of the significant work done to date and the results obtained since inception of the investigation.

The Emmett Valley, located in Southwestern Idaho, has an area of about 80 square miles of which about 50 are farmed under irrigation. (See Figure 1 for location)

The climate of Emmett Valley is characterized by fairly low annual rainfall, light snowfall and moderate winter temperatures.

The problem area is characterized by barren spots, native alkali or salt tolerant plants. Native plants found in the water-logged alkali area include saltgrass, salt brush, alkali weed, greasewood, poverty weed and foxtail. Stunted growth and off color plants can be observed in most of the affected area.

Practically all the farmland in Emmett Valley is irrigated. The principal crops are fruit, hay, grain, corn and sugar beets. Most of the hay and corn is grown on the valley benches; the major portion of the fruit is grown on the alluvial fans south of the river. The poorly drained land south and southwest of Emmett is used primarily as native pasture. Some of the water-logged areas have been reclaimed and are presently producing fairly good crops.

The problem soils of the Emmett Valley are generally characterized by high water table conditions, low salinity, high pH, high soluble and exchangeable sodium percentages and low rates of infiltration and permeability. Water-logging in the valley is probably due to an aggregation of the following water sources.

1. Artesian water rising from below the surface
2. Over-irrigation
3. Seepage from canals and ditches
4. Seepage from adjacent hills

The procedure followed during the investigation has been to initiate various studies and then follow through with sufficient routine observations so that reliable conclusions can be drawn. Observations on the major portion of the studies will be continued for a period of time to check the initial conclusions and to observe any beneficial or detrimental effects from the reclamation work.

Methods of securing data.

The methods of securing the basic data on the various studies were generally adapted from research in other areas. Additional needed techniques were developed as the investigation progressed. These techniques and methods have been modified and simplified to aid in deriving maximum production with limited personnel and equipment.

Topographic survey.

A topographic survey was made by Hays, Sloan and Lewis in 1920. The survey covered the southeastern portion of the valley. A copy of the survey, scale 8 inches to the mile, is filed in the Smoke Insurance Agency Office in Emmett.

Soil survey.

A soil survey of the Emmett Valley was made under a cooperative agreement between the Idaho Agricultural Experiment Station and the Division of Soil Survey, B.P.I.S. & A.E. The following major soil series were mapped in the Emmett Valley.

1. Power
2. Bramwell
3. Letha
4. Emerson
5. Cannon
6. Nolan
7. 91 Series
8. Reed
9. Moulton
10. Wardwell
11. Muck
12. Snow

Alkali salinity survey.

An alkali and salinity survey of the Emmett Valley area was made in conjunction with the soil survey. The various classes or degree of alkali concentration were based mainly on obvious conditions of alkali and salinity as evidenced by salt accumulation, natural vegetation, crop growth, and the morphology of the soils. These field observations were correlated by laboratory analysis - such as conductivity and pH tests. In the alkali salinity survey the following conditions were delineated:

1. Alkali free
2. Surface free - alkali in the sub-strata
3. Slightly alkali
4. Moderately alkali
5. Strongly alkali

Chemical analysis of selected soil samples.

During 1950 the U. S. Regional Salinity and Rubidoux Laboratories, Division of Soil Surveys and the Idaho Agricultural Experiment Station published a bulletin entitled, "Characteristics of Saline and Alkali Soils in the Emmett Valley Area, Idaho"; the location, chemical and physical characteristics of the 35 selected soil sample locations are included in the appendix of the report.

Artesian well survey.

The returns on a card questionaire mailed on April 7th indicates that the artesian aquifer underlies the water-logged-alkali area very closely.

Ground water survey.

A total of 91 wells were installed and observations have been made by the Bureau of Reclamation since 1936. A table of the high and low water table elevations, by years are given in appendix table 5. The ground water fluctuation varies with the wells. In some areas the fluctuation is very slight and in other areas the fluctuations may be 10 to 14 feet between the low and high ground water cycle.

Drainage investigations.

An investigation to determine the range of influence and the performance of open drains in five of the major soil series in the Emmett Valley was initiated during the past year. Drainage investigations were set up on seven farms in the valley.

The following tentative conclusions have been drawn from the data gathered to date.

1. The present drainage system is not adequate to completely reclaim all of the lands of the ranches investigated. Additional tile, open drains or wells will be required to complete the drainage job.

2. A rather close spacing of tile or open drains will be required to lower and maintain the ground water table at a safe depth of 4½ feet. Drains 6½ feet deep, spaced at 200 feet intervals may be required to adequately drain the slowly permeable soils and artesian areas having conditions similar to the Muck soils investigated. This spacing of drains will expand to 7 or 8 hundred feet depending upon the

depth to and the presence of the permeable gravel substrata.

3. A valley wide study of the irrigation efficiencies and length of run for furrows and borders should be initiated. A high irrigation efficiency will keep the amount of water lost to the ground water table at a minimum and aid in the over-all drainage problem.

Drainage installation in the Emmett Valley since 1927.

More than 100 miles of open drains have been installed in the Emmett Valley since 1927. Since 1944 more than 215 farms have had drainage systems installed. There is one tile drainage system in the valley and no vertical drains.

Crop increases due to drainage and reclamation.

With drainage good crop increases were generally obtained on the alkali free or very slightly alkali lands. Some of these lands were formerly very wet and supported bogs or tules. Drainage was all that was required on the farms that responded rapidly. Very slight crop increases, if any, were obtained on the moderately to strongly alkali soils following drainage.

Alkali reclamation investigations.

Observations to date indicate that artesian water is considerably better for reclamation than either the river or the drain water and that the over-all difference between river and drain water is very slight. The artesian water gave the best results, the river water second and the drain water gave the poorest results. The intake rate was influenced more by the application of gypsum than by the type of leaching water.

Vertical drainage investigations.

An estimate of the installation and operational costs of vertical drainage was obtained from the Pioneer Irrigation District at Caldwell, Idaho. The costs on 30 wells were assembled to obtain the estimates. The cost of installing drainage wells averaged about $6.58 an acre and the operational costs for power and maintenance averaged about 38 cents an acre per year for the area drained.

Future scope of the investigations.

Observations will be continued on the following:

1. Open drainage investigations.
2. Alkali reclamation
3. Continue and refine the artesian well location survey.

The following investigations are to be initiated during 1953.

1. Artesian aquifer survey.
2. Vertical drainage investigations.
3. Extending the U. S. Bureau of Reclamation observation well lines to the Payette River.

ACKNOWLEDGEMENTS

All work by the Division of Irrigation Engineering was under the direction of George D. Clyde, Chief, Division of Irrigation Engineering and Water Conservation, Soil Conservation Service, Research.

Credit is given to the following persons and agencies for their assistance and cooperation in initiating the Emmett Valley Drainage Investigation.

Mrs. Edith Florence, secretary of the Gem County Production and Marketing Administration, the local P.M.A. office staff and the county committee men for their assistance in making farmer contacts, assisting with field surveying, conducting farmer questionaires and making office space available in Emmett.

Mr. Lester Holmquist, Soil Conservation Service, for his assistance with the nearly 10,000 field measurements and observations that have been made since the investigation was initiated.

Mr. Morlan W. Nelson, Division of Irrigation Engineering and Water Conservation, for his assistance with both the general alkali problem and initiation of the alkali investigation.

Messrs. Sterling Davis, Dick Harpt, and John Rinard, Soil Conservation Service, for their assistance in making topographic and piezometric line and elevation surveys.

Mr. John Hull, Area Conservationist, Soil Conservation Service, for his assistance in making personnel available to assist with the field work.

Mr. John Turner, Armco Drainage and Metal Products, and the Pioneer Irrigation District for their assistance in assembling information on the 30 irrigation and drainage wells in the Pioneer Irrigation District.

Mr. Wallace Hart, Construction Contractor, for his assistance on orientation and his suggestions resulting from years of drain construction in the Emmett Valley.

The U. S. Bureau of Reclamation for making their ground water data available, adjacent to the Black Canyon Canal, the assistance on soil and water analysis, and other technical advice.

The University of Idaho for making the alkali and soil survey of the Emmett Valley available prior to publication.

The Gem County Commissioners and shop foreman for making automotive storage space and shop facilities available at Emmett.

The U. S. Geological Survey for making their well and soil log data available for analysis.

Mrs. Alice Hanley and Mrs. Ann Hicks for typing, editing and stenceling the report.

PROGRESS REPORT ON
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INTRODUCTION

The present Emmett Valley Drainage Investigation was started in August 1951 as the result of recommendations made in May 1951 by representatives of the Soil Conservation Service of the Department of Agriculture, Idaho Agricultural Experiment Station, Gem County Board of Commissioners, U. S. Bureau of Reclamation, U. S. Geological Survey and the Gem County Production and Marketing Administration. The investigation has been conducted by the Soil Conservation Service under the guidance of the Emmett Valley Drainage Committee, representing the above-named agencies.

The objectives of the drainage study in the Emmett Valley were set forth in the Joint Working Plan for the Payette Valley Drainage Investigations:

1. To obtain basic physical data necessary to design drainage systems and reclaim water-logged and saline-alkali lands in the Emmett Valley.

2. To develop methods and techniques that might be applied to the solution of drainage and salt problems on lands in the intermountain and northwestern states.

It is the purpose of this report to present a fairly detailed account of the work done and the results obtained since inception of the investigation.

1/ Prepared under the direction of George D. Clyde, Chief, Division of Irrigation Engineering and Water Conservation, Soil Conservation Service, U. S. Department of Agriculture. February 1953.

2/ Figures in parentheses refer to Literature Cited.

Description of the area.

The Emmett Valley, located in southwestern Idaho, has an area of about 80 square miles, of which about 50 square miles are farmed under irrigation. (See figure 1.) The valley is approximately 14 miles long and varies from 5 to 6 miles in width. The valley is fairly flat south of the river and slopes gently upward for about three miles to a low range of steep hills. The major part of this land lies a few feet above the level of the Payette River and is poorly drained. There is a narrow strip of bottom land between the river and the bench escarpment. This narrow strip is poorly drained and varies from slightly to severely water-logged. The steep escarpment is about 60 to 100 feet high. This escarpment is the southern boundary of the two to three miles of sloping river terraces.

Precipitation and temperature.

The climate of Emmett Valley is characterized by fairly low annual rainfall, light snowfall and moderate winter temperatures. The temperature, rainfall and frost-free periods of the Weather Bureau Stations at Emmett, Caldwell and Parma are presented in tables 1 and 2.

The average temperatures for January 1952 and July 1952 were slightly lower than the length of record normal for the three stations.

The precipitation records (table 2) show the annual precipitation (October 1, 1951 to October 1, 1952) at Emmett to be 41.8 percent above normal, at Caldwell to be 26.4 percent above normal and at Parma 4.3 percent above normal.

Crops of the Emmett Valley.

Practically all the farms in the Emmett Valley are under irrigation. The principal crops are fruit, hay, grain, corn and sugar beets. Most of the hay and corn is grown on the valley benches; the major portion of the fruit is grown on the alluvial fans south of the river. The poorly drained land south and southwest of Emmett is used primarily as native pasture. Some of the water-logged areas have been reclaimed and are presently producing fairly good crops.

A summary of the acreage planted and the production per acre or per tree from 1919 to 1949, in Gem County, is presented in table 3. This table was summarized from the U. S. Department of Commerce, Bureau of the Census Reports. The increases in yields for the various crops do not necessarily indicate an increase in soil productivity. Better crop breeding and more resistant types of plants contribute greatly to the increase in yields.

The increase in yields of wild hay from 0.98 in 1919 to 1.72 tons per acre in 1949 gives the best indication of increased production in the water-logged area south and southwest of Emmett.

FIGURE 1

EMMETT VALLEY
LOCATION MAP

GEM COUNTY, IDAHO

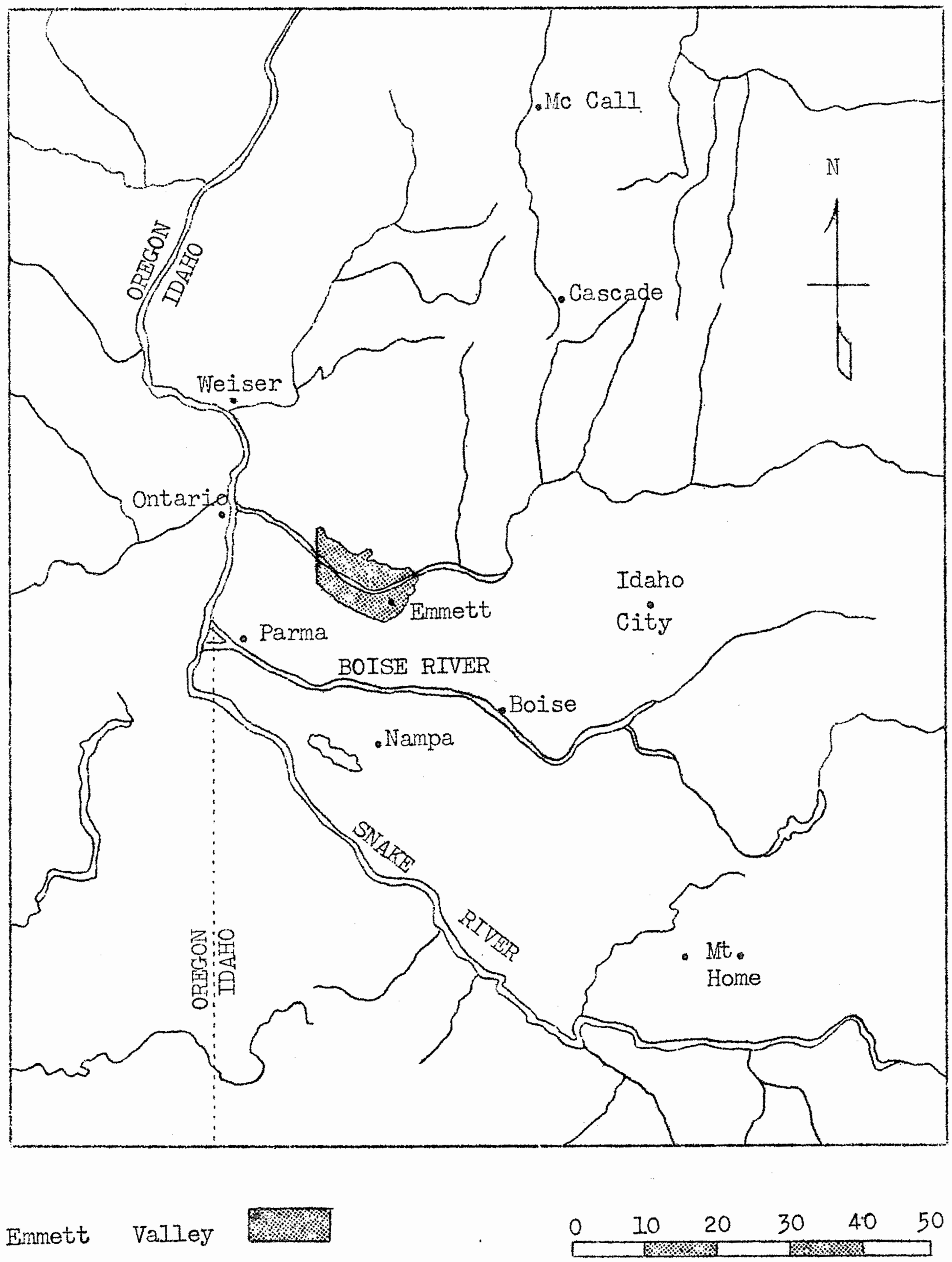


Table 1. Temperatures, frost-free periods, and frost dates from Weather Bureau Stations in and near the Emmett Valley.

	Caldwell, Idaho		Emmett, Idaho		Parma, Idaho	
	47-year period	1952	45-year period	1952	29-year period	1952
Jan. avg. temp. °F.	28.3	26.0	29.1	27.7	27.8	26.5
July avg. temp. °F.	73.5	72.0	75.0	71.0	74.1	72.9
Maximum temp. °F.	107.0	99.0	109.0	100.0	111.0	102.0
Minimum temp. °F.	-34	-2.0	-35	-1.0	-27	1.0
Date of last spring killing frost (lower than 32°)	5/7	4/11	4/30	4/29	4/24	4/11
Date of first fall killing frost (lower than 32°)	10/3	10/14	9/26	10/15	10/9	10/15
Length of growing season in days	149	186	149	169	168	187

Table 2. Monthly precipitation at three locations in and near the Emmett Valley.

	Caldwell, Idaho		Emmett, Idaho		Parma, Idaho	
	1951-52	Length of record average	1951-52	Length of record average	1951-52	Length of record average
	Inches	Inches	Inches	Inches	Inches	Inches
October	1.76	0.78	2.73	0.90	1.25	0.77
November	1.39	1.14	2.36	1.31	0.90	0.98
December	2.52	1.14	3.63	1.39	1.38	1.00
January	1.12	1.26	1.55	1.38	0.72	1.13
February	1.06	1.14	1.60	1.20	0.89	0.89
March	1.25	1.04	1.30	1.20	0.59	0.74
April	1.00	0.94	0.72	1.04	0.94	0.83
May	0.88	0.98	1.35	1.02	0.91	0.69
June	1.43	0.77	1.00	0.94	1.05	0.79
July	0.37	0.33	Trace	0.28	0.08	0.13
August	0.00	0.22	Trace	0.21	0.06	0.23
September	0.13	0.47	0.00	0.58	0.22	0.44
Annual	12.91	10.21	16.24	11.45	8.99	8.62

Table 3. Crop acreages and production figures for Gem County, Idaho from 1919 to 1949. 1/

	1919	1924	1934	1939	1944	1949
Corn						
Acres	1127	1459	1582	1943	962	1087
Bu. Ac.	28	29	34	45	36	56
Wheat Winter						
Acres			1306	689	1452	2085
Bu Ac.			15	18	23	23
	6887	2677				
	13	18				
Wheat Spring						
Acres			2948	2350	1438	2107
Bu. Ac.			41	31	38	32
Oats						
Acres	935	1426	2661	2318	2863	3630
Bu. Ac.	55	34	37	33	50	43
Barley						
Acres	1267	1240	1579	1825	3528	2106
Bu. Ac.	17	27	36	35	35	32
Alfalfa						
Acres	17365	12265	18665	16785	12932	12345
Tons Ac.	2.85		2.18	2.08	2.51	2.68
Clover & Timothy						
Acres	1595	1510	1908	1802	1146	1567
Tons Ac.	1.92		1.85	1.53	1.91	1.76
Wild Hay						
Acres	314	558	1213	864	1420	1484
Tons Ac.	0.98		1.19	1.39	1.14	1.72
Peaches						
Trees	46420		24918	28538	29130	40016
Bu.per tree	1.6		1.3	0.9	1.1	1.0
Cherries						
Trees	13115		33830	37268	48436	51870
Lb. per tree	37		60	30	63	38
Plums						
Trees	65974	90593	69444	85617	89436	90434
Bu. per tree	0.4		1.3	1.7	2.7	1.9
Apricots						
Trees				15076	7094	3351
Bu. per tree				0.61	0.91	0.74

1/ Table summarized from the Bureau of the Census Reports.

With drainage and better reclamation practices the yields of wild hay have nearly doubled. During the same period the yield per acre of alfalfa, clover and timothy dropped to about 93 percent. It has been estimated that 60 percent of the wild hay acreage in Gem County is in the Emmett Valley. The other 40 percent is upstream along the Payette River.

History of the Emmett Valley. (6) (7)

In the early 1870's James Wardwell built a sawmill on the Payette River at the head of the lower valley, where the Umatilla stage line crossed the river. A postoffice called Emmettsville was built a few miles below the sawmill. A village grew up around the sawmill and in a few years the postoffice and name were transferred to the new settlement. Eventually, the settlement became a trading point for the lumbermen and stock raisers of the Payette Valley. The surrounding hills of unoccupied public lands made stock raising one of the natural industries of the early settlers. The fertile lands, the abundance of water, and the easy methods of irrigation soon made farming an industrial companion to stock raising. The soils, climate and other factors were very favorable for the growing of prunes and other fruit. More fruit was shipped from Emmett during 1919 and 1920 than from any other point in Idaho. Nearly 15,000 acres of land in the vicinity of Emmett was planted to orchards. When Gem County was created on March 19, 1915, Emmett was made the County Seat.

The first record indicating a drainage and alkali problem was obtained from "The Emmett Index," published on December 31, 1903.

"The Block House Swamps" 1/: "Almost anyone in the Payette Valley can tell you where the Block House swamps are located, but very few can tell you where the name, which is a peculiar one, originated."

"The swamps, which lie about three miles southwest of Emmett have been in existence ever since the first settlers came to this valley. The reason of their being so well known, is that the swampy nature of the ground afforded great pasture for horses and cattle. It is said that the Indians would come down from the mountains in the winter and camp along the river. They would then turn their horses loose in the swamps and have no fear of not finding them in the spring, as they would not stray away, the country surrounding the swamps being extremely barren, devoid of all vegetation except sagebrush.

1/ The Emmett Index - December 31, 1903.

"In the early 60's four bachelors, George Andrews, Mose Rice, Tom Anderson and Jack Howard, took up a thousand acres of the swamp land and fenced it in for grazing purposes. They lived in a large house, which resembled an old time block house. It was located near the present road to Falk's store, about a half mile below the McNish saw-mill. These old bachelors lived there a number of years. Because of the odd appearance of the house and their owning most of the swamp, someone started calling the swamps the Block House and it has been kept up ever since.

There is only one drawback to the swamps as an ideal pasture land. It is full of pot holes, which are alkali gathering, reminding one of a boil being of the same shape. The center is full of very soft alkali mud in which a person or animal would sink from sight in a very short space of time if not rescued. Cattle have got into them and sunk. Some of the holes are as much as forty or fifty feet in circumference.

Attempts have been made to drain the swamps to convert them into farming land, but it is probable that they will be there for years, a great place for mallards, but no good for agricultural purposes."

The problem.

The problem areas of the Emmett Valley are generally characterized by high water table conditions and the soils have low salinity, high pH, high soluble and exchangeable sodium percentages and low rates of infiltration and permeability. (5)

Water-logging and alkali conditions have reduced the value and production of the soils of a large portion of the Emmett Valley. Water-logging has damaged approximately 35 square miles of land in the valley. This ranges from barely visible damage to bogs, swamps and complete abandonment. Water-logging in the valley is probably due to an aggregation of the following water sources.

1. Artesian water raising from below the surface soil.
2. Over-irrigation.
3. Seepage from canals and ditches.
4. Seepage from adjacent hills.

A fairly large water-logged acreage is also attributed to soil changes. Soil changes occur where a horizontal soil stratum changes from a more to a less permeable one. These soil changes may be very slight from a sandy loam to a silt loam, or they may be very great and change from a coarse sand or gravel to a very slowly permeable clay. Ground water moving down from higher elevations is retarded by these soil changes. The ground water table is built up and water-logging occurs.

Alkali elements have damaged approximately 25 square miles in the valley. The part damaged is very extensive and is characterized by areas of poor germination or stunted plant growth, or by areas entirely barren. These unproductive areas are principally on the following soils:

1. Letha clay loams to sandy loams.
2. Reed silty clays to loams.
3. Cannon clays to gravelly clay loams

Alkali and saline soils are usually formed as a result of a high water table or water-logged conditions. The ground water which contains dissolved salts rise to the surface by capillary action and evaporates, leaving soluble salts in the surface soil. The low rates of infiltration and permeability are possibly due to the alkali condition. The soil colloids tend to become saturated with sodium which generally results in poor soil structure and impaired permeability.

Native vegetation of the problem area.

The problem area is characterized by barren spots and native alkali or salt tolerant plants. Native plants found in the water-logged alkali area include saltgrass, salt brush, alkali weed, greasewood, poverty weed and foxtail. Stunted growth and off color plants can be observed in the most of the affected area.

Previous Investigations.

At various times since 1915 Federal, County and private agencies have made investigations in the Emmett Valley. Much progress has been made towards solving the drainage and reclamation problems. Some of these studies and investigations are listed below.

1. An investigation was started in 1915 on the Canyon County Drainage District No. 1 by Mr. E. O. Larson. Test wells were installed and readings made.

2. During 1918 crop survey maps were prepared for the Canyon County District No. 1.

3. An investigation was made in the Canyon County Drainage District No. 2 with 75 test wells and 6 measuring stations for drainage flow.

4. An investigation was made in the Canyon County Drainage District No. 1 with 23 wells.

5. In 1936 the Bureau of Reclamation began an extensive study of the water tables around the southern edge of the valley adjacent to and below its Black Canyon Canal.

6. In 1940 an alkali and soil survey was initiated by the Idaho Agricultural Experiment Station and the Division of Soil Survey B.P.I.S. and A.E.

7. In 1947 the Idaho Agricultural Experiment Station, the Division of Soil Surveys and the U. S. Regional Salinity Laboratory B.P.I.S. and A.E. initiated an investigation to study characteristics of the saline and alkali soils and other soil problems of the area.

Glossary of terms

Aggregates: Fragments or clods the soil forms during the drying and cracking process.

Alkali soil: Soils which have an excessive degree of saturation of exchangeable sodium in the base exchange complex. The exchangeable sodium percentage is greater than 15 and the conductivity of the saturation extract is less than 4 millimhos per cm - pH values 8.5 to 10.

Artesian aquifer: A confined water-bearing strata in the soil. The water is generally confined by a layer of slowly permeable clay or shale over the aquifer.

Color indicators: A complex dye which changes color with slight changes of pH values. Used in classifying soils with respect to acidity or alkalinity.

Electrical conductivity: The reciprocal of the electrical resistance in ohms of a conductor which is 1 cm. long and has a cross-sectional area of 1 sq. cm. A quantitative method of determining the degree of salinity in soil or water samples.

Evaporation ring: A twelve inch length of well casing with a bottom welded on. Used in measuring the water lost to evaporation.

Exchangeable sodium percentage: The degree of saturation of the soil base exchange complex with sodium.

$$\text{e.s.p.} = \frac{\text{Exchangeable sodium}}{\text{Cation exchange capacity}} \times 100$$

Geochemical chart: A graphical method of analyzing ionic analysis data.

Ground water table: The upper boundary for ground water. It is the point at which the pressure in the water is equal to the atmospheric pressure.

Glossary of terms(continued)

Hydraulic gradient: The decrease in hydraulic head per unit distance in the direction of flow in the soil.

Infiltration rate: The rate of movement of water into the soil per unit of time.

Infiltration ring: A twelve inch length of pipe or well casing to be used in measuring the infiltration rate of the soil.

Ionic analysis: The quantitative determination of the major cations and anions in the soil or water. Usually includes the following cations Ca, Na, K, Mg; anions Cl, SO_4, HCO_3 and CO_3.

Irrigation efficiency: The percentage of irrigation water delivered to the farm or field that is available in the soil for consumptive use by the crops.

Length of run: The distance water must travel in furrows or over the surface of the field from the head ditch to the end of the field.

Observation well: Hole in the ground used to determine the depth to water or hydrostatic pressure of the entire underground soil profile to the depth of the well. The well indicates the level of the surrounding ground water table.

pH: An expression of acidity or alkalinity. pH of 7 is neutral. Values grading below 7 become more acid and values ranging above, indicate stronger alkalinity.

Permeability: The volume of water crossing unit area in unit time with unit hydraulic gradient and at a standard temperature of 68°F. Expressed in inches per hour or centimeters per hour.

Piezometer: A pipe driven into the soil so that there is no leakage down the outside of the pipe and all entrance of water into the pipe is from the bottom. The piezometer indicates pressure at the point of entrance rather than the level of the ground water table.

Proctor needle: Equipment for measuring the bearing load, in pounds per square inch, on a soil surface before the needle penetrates the soil.

Saline soil: Conductivity of the saturation extract is greater than 4 millimhos per cm. (at 25°c) and the exchangeable-sodium percent is greater than 15. The pH is generally above 8.5.

Soil change: A point where a soil stratigraphy changes from a more to a less permeable profile. This change may interfere with the movement of water through the soil.

Soluble sodium-percentage: This term is used in connection with irrigation waters and soil extracts to indicate the proportion of sodium ions in solution in relation to the total cation concentration.

Soil amendments: The most general soil amendments are gypsum, sulphur, limestone and sulfuric acid. They are applied to an alkali soil to reduce the exchangeable-sodium-percentage to a good crop-growing level.

PROCEDURE FOLLOWED

The procedure followed during the investigation has been to initiate various studies and then follow through with sufficient routine observations so that reliable conclusions can be drawn. Observations on the major portion of these studies will be continued over the next year or two to check the initial conclusions and to observe any beneficial or detrimental effects from the reclamation work.

The following is a calendar of events since this investigation was initiated.

1. A topographic survey was obtained for the southeastern portion of the valley.

2. A soil survey was obtained for the Emmett Valley.

3. An alkali survey was obtained for the Emmett Valley.

4. The soil sample locations from Research Bulletin No. 17 (5) were relocated in the field and the field conditions were studied.

5. The U. S. Bureau of Reclamation well locations and well readings were obtained.

6. The soil and alkali surveys were checked.

7. Piezometers (3) were installed in Ranch A to observe the influence of open drains in the Letha Soil Series.

8. The soil and alkali surveys were checked on Ranch B.

9. Piezometers were installed in Ranch B to observe the influence of open drains in the Muck soils.

10. The soil and alkali surveys were checked on Ranch C.

11. Piezometers were installed in Ranch C to obtain the influence of open drains above a soil change.

12. The soil and alkali surveys were checked on Ranch D.

13. Piezometers were installed in Ranch D to obtain the influence of open interception drains above soil changes and in Snow soils.

14. The soil and alkali surveys were checked on Ranch E.

15. Piezometers were installed in Ranch E to obtain the influence of tile drains in Letha soils.

16. The soil and alkali surveys were checked on Ranch F.

17. Piezometers were installed in Ranch F to obtain the influence of open drains in the Moulton soil series.

18. Observations were initiated on Ranch G to determine the influence of open drains on the Reed soil series.

19. Water samples of the Payette River, drain water and artesian water were obtained and an ionic analysis made by the U. S. Bureau of Reclamation.

20. The soil and alkali surveys were checked on the Ranch I reclamation plots.

21. Twenty-seven infiltration rings were driven on the Ranch I reclamation plots. (Silty clay - highly alkaline soils) Three ring replicates were set up - river, drain and artesian water was applied as leaching water - zero, five and ten tons of gypsum were applied to the soil in the various rings.

22. The soil and alkali surveys were checked on the Ranch H Greasewood reclamation plot. The soils are moderately alkaline, rapidly permeable and have a drainable gravel strata at $3\frac{1}{2}$ feet.

23. Twenty-seven infiltration rings were driven on the Ranch H Greasewood alkali reclamation plot. Three replicates identical to the Ranch I plot were set up.

24. The soil and alkali surveys were checked on the Ranch H Saltgrass alkali reclamation plot. The soils are moderately alkali, moderately to rapidly permeable and have a drainable gravel strata at 6 1/4 feet.

25. Twenty-seven infiltration rings and one evaporation ring were driven on the Ranch H Saltgrass alkali reclamation plot. Three replicates identical to the Ranch I plot were set up.
    One evaporation ring was also installed on the Ranch I plot.

26. The installation, operational and maintenance costs on vertical drainage wells were obtained from the Pioneer Irrigation District at Caldwell, Idaho.

27. An artesian well location survey was initiated in the Emmett Valley.

METHODS OF OBTAINING DATA

The methods of securing the basic data on the various studies were generally adapted from research in other areas. Additional needed techniques were developed as the investigation progressed. These techniques and methods have been modified and simplified to aid in deriving maximum production with limited personnel and equipment.

The following methods and techniques were used in obtaining the various sections of the report.

1. All available records were checked for information and data pertaining to the problem area. The more valuable data was assembled and included in this report.

2. An artesian well location survey was made on the portion of the valley south of the river. Questionaires were sent out to all the farm owners in that area.

3. Piezometers and wells were used to obtain the hydraulic gradient of the ground water table and to detect artesian pressures on the various farms studied.

4. Water applied to the various farms was obtained from the water companies. Drain water effluent was measured at drain outlets. Surface waste was measured or estimated.

5. Crop increases were obtained from individual farmers for the various farms studied.

6. Chemical analysis on various soil and water samples were made by the Bureau of Reclamation.

7. Water samples were analyzed with a conductance bridge during the alkali reclamation studies.

8. Infiltrometer rings were used to measure the effect of gypsum and various reclamation waters on the alkali soils.

9. Aggregates were recorded during the alkali reclamation studies on the Ranch I plot.

10. The inches of water applied to each ring was measured.

11. The structure, workability and amount of visible gypsum was recorded after each leaching period.

12. Proctor needle readings were made in each ring after each leaching period to determine surface hardness.

13. The intake rate was measured in the rings with a standard evaporation hook gage.

14. The soil and water temperature was recorded for each infiltration period. These temperature readings were used to convert the intake rate to a standard temperature.

15. Barometric readings were made at the beginning and end of each infiltration period to determine the effect if any on the infiltration.

16. pH readings were made at each infiltration run to aid in analyzing the results in each ring.

DATA GATHERED

This section includes a summary of the data gathered since the drainage investigation was initiated in August 1951 on the following subjects:

1. Topographic survey
2. Soil Survey
3. Alkali survey
4. Artesian well survey
5. Ground water survey
6. Drainage Investigations
7. Alkali reclamation
8. Vertical drainage

Topographic Survey

Emmett Valley comprises the principal body of valley lands of the Payette River within the county. The valley begins at the mouth of the basalt bordered Black Canyon near the Black Canyon Dam about 5 miles northeast of Emmett. This alluvial valley widens out to a width of 4 to 6 miles and extends down the river about 14 miles. The altitude varies from 2200 to 2500 feet. A strip of bottom land 1/4 to 3/4 miles wide borders the river. A nearly level alluvial terrace, 2 to 5 feet or so above the bottom lands extend southward for 1 to 2½ miles. This alluvial terrace contains many old partially filled channels, sloughs and playa-like flats. Northeast of Emmett this terrace is slightly higher above the bottom lands. South and west of Letha, in the southwestern part of the valley, a second nearly level terrace lies about 2 to 5 feet above the first terrace. These low terraces grade into a continuous 1/4 to 1/2 mile wide belt of sloping coalescing alluvial fans. These fans were built up by streams emerging from the nearby hills. Above these fans a strongly dissected terrace or upland plain rises steeply some 300 to 700 feet to a crest and slopes gently towards the Boise river. The Payette river flows along or near a 30 to 50 foot escarpment on its north side. This escarpment leads up to a gently sloping terrace or bench. This terrace is 1 to 3 miles wide and comprises the greater part of the valley on the north side of the river.

During 1920 a topographic survey was completed on the southeastern portion of the Emmett Valley. The survey was made by Hays, Sloan, and Lewis. A copy of the survey, 8 inches to the mile, with a two foot contour interval, is in the Smoke Insurance Office in the bank building in Emmett. A copy of the survey with a ten foot contour interval is shown in figure 2. The valley east-west slope is roughly ten feet per mile. The north south slope is relatively flat. In some locations the slope is towards the south rather than north towards the river. This flat north-south slope and the high river level with respect to the farm land makes drainage towards the river unfeasible in a large part of the problem area.

Soil Survey

A soil survey of the Emmett Valley area was initiated August 26, 1939 under a survey work plan for Gem County, Idaho in which the entire county outside of the National Forest was to be included. This area amounted to about 422 square miles. The Bureau of Plant Industry, Idaho Agricultural Experiment Station and Soil Conservation Service were listed as cooperating agencies.

In 1940 the survey was continued under a cooperative agreement between the Idaho Agricultural Experiment Station and the Division of Soil Survey, Bureau of Plant Industry Soils and Agricultural Engineering.

The terraces above the river probably were formed of river transported material mixed with material from the adjoining uplands of the Payette and Idaho formations, whereas, the river bottom lands and the soils south of the river are derived from more recent, mixed transported soil materials. The alluvial material deposited by the Payette River had its origin principally from acid to somewhat subbasic igneous rocks, such as quartz, monzonite, granodiorite, quartz diorite, and granite, which predominate in the drainage basin of the river above Emmett. A minor proportion probably was derived from basalt, which underlies a small part of the drainage basin, particularly Squaw Butte and the adjoining area north of Black Canyon. It is likely that a considerable admixture of quartz and other acid igneous material has been derived from the Payette and Idaho formations. A description of each soil series follows:

Power series

The Power series includes most of the soils on the Bench lying north of the Payette River. An area of about one square mile lies south of Letha in an old high alluvial fan or remnant of this terrace. The soils have light gray silt loam surface horizons with brown compact subsoils and are underlain with mixed and stratified deposits of sand, gravel and cobbles. In the virgin state the soil had a characteristic

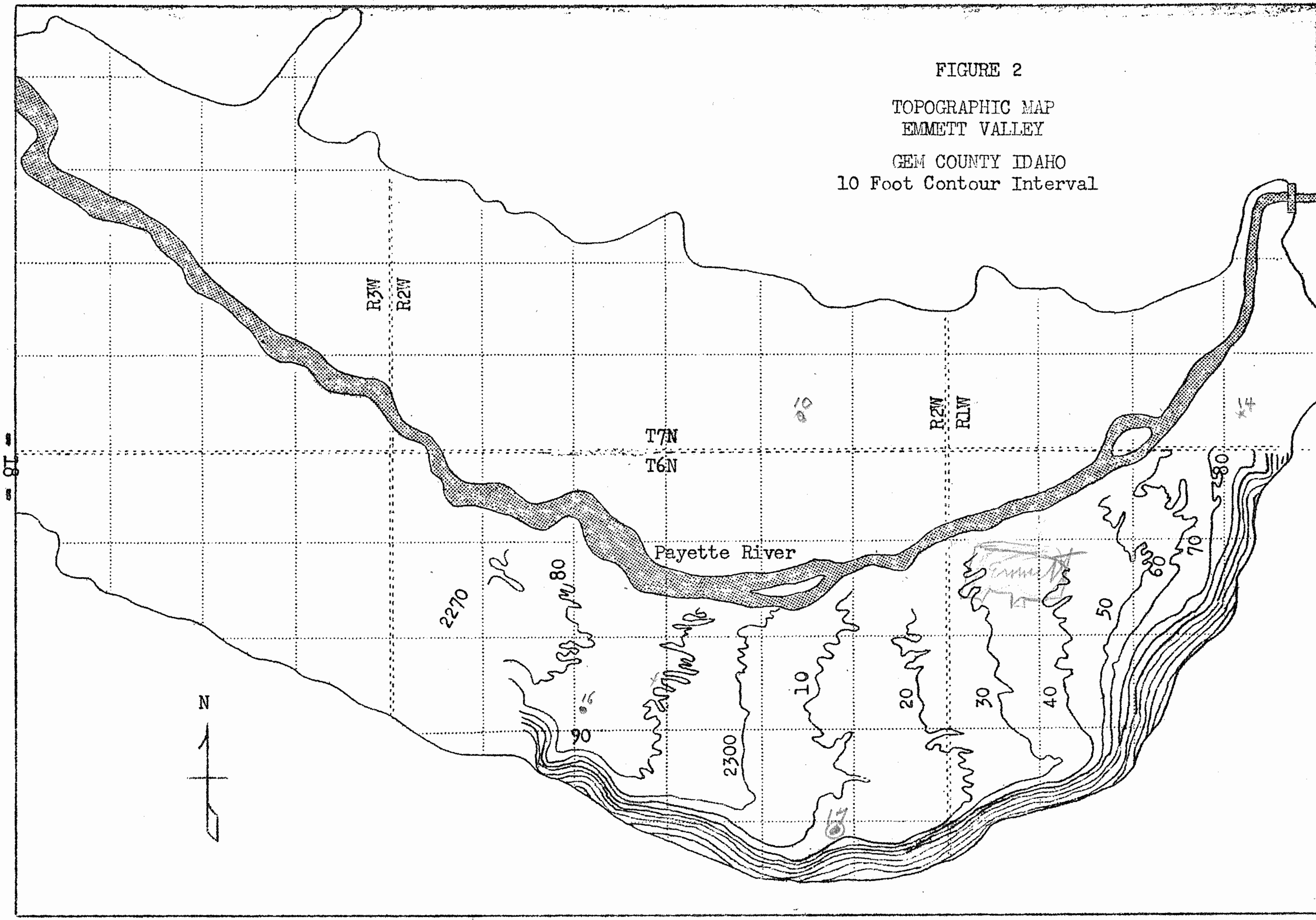


FIGURE 2

TOPOGRAPHIC MAP
EMMETT VALLEY

GEM COUNTY IDAHO
10 Foot Contour Interval

microrelief of slight mounds and depressions and a cover of sagebrush and sparse grass. In many places leveling operations have exposed the less permeable and presumably high-sodium "B" horizon, which has resulted in a spotted growth pattern in many cultivated fields. The parent material consists of old alluvium, mainly of medium and somewhat light textures, deposited by the Payette River.

The internal drainage of the soil is variable but probably dominantly somewhat slow, ranging to very slow in the spots of poor vegetation. The water table is low enough so as not to interfere with drainage at the present time.

Soils of the Power series have the following textural range: Clay, silty clay, sandy clay, silty clay loam, clay loam, silt loam; sandy loam, coarse sandy loam and gravelly clay loam.

Bramwell series.

Most of the Bramwell soils lie on a continuous belt of sloping coalescing alluvial fans between the main valley and the steep hills facing the valley from the south. The soils are principally quartzic and micaceous alluvium washed more or less locally from the Payette formation and other soils in the hilly uplands underlain by the Payette geologic formation.

The remaining Bramwell soils are alluvial soils having a grayish-brown surface soils of a wide range in texture and stratified subsoils. The soils generally have loose loamy coarse sand or coarse sand below a depth of 12 to 45 inches. They are well drained. The coarser - textured soils generally lie higher on the fans and are lighter colored. The finer textured soils lie on the flatter lower edges of the fans and have stratified subsoils in which the strata range from heavy textures to loamy coarse sand to at least moderate depths.

Soils of the Bramwell series have the following textural range: Coarse sandy clay, clay loam, loam, sandy loam, coarse sandy loam, loamy coarse sand, gravelly loamy coarse sand, sand, gravelly coarse sand.

Letha series.

The soils of the Letha series occur extensively on the level lands in the valley west of Emmett, fairly close to the Payette River, and extend to the Payette, Gem County line. The soils are poorly drained and have a fluctuating water table at depths of 20 to 45 inches. The soils lie on a nearly level low terrace only a few feet above the present flood plain of the river. The surface is very gently undulating and has a relief of 6 to 24 inches between the broad swells of ridges and the narrow meandering channels of an old flood plain.

The alluvium is medium to very light textured and was deposited by the Payette River with mixtures of outwash from the nearby Payette hills. The soils are moderately alkali and non-saline. The subsoil strata are generally heavier textured.

Soils of the Letha series have the following textural range: Clay loam, silt loam, fine sandy loam, loam, sandy loam, gravelly loam, gravelly clay loam, gravelly coarse sandy loam, sand.

Emerson series

Soils of the Emerson series occur south of the Payette River in an arc extending from the Black Canyon Dam to an area generally south of Emmett. These soils are not generally effected by a high water table. The water table averaged about 4 to 5 feet below land surface in the area south of Emmett. The soils occur on nearly level low terraces and are from medium to coarse-textured older alluvium of the Payette River.

Soils of the Emerson series have the following textural range: Loam, gravelly loam, fine sandy loam, loamy fine sand, sand, gravelly sand loam, gravelly sand, gravelly loam, sand.

Cannon series.

The soils of the Cannon series are light colored and are found in the flat backwater settling basins of the low terraces or old flood plains of the river. The soils are medium to heavy textured and are underlain by loose porous strata of gravel or sand at depths of 20 to 60 inches.

Flood waters of the intermittent streams from the Payette hills deposited their coarser load on the fans while the finer material was carried farther down into the flat basins below the fans. The soils were evidentally formed under poor or somewhat poor drainage and more or less saline and alkali conditions.

Soil types of the Cannon series include the folowing textural range: Clay, gravelly clay, silty clay, sandy clay, silty clay loam, clay loam, gravelly clay loam.

Nolan series.

The Nolan soils were formed in very poorly drained marshy areas with abundant growth of water-loving plants. The soils are fairly dark colored but contain less organic matter than the muck soils. They are generally non-alkali. The surface soils are generally dark-gray fine granular silt loam or heavy silt loam. The surface soil extends to 15 or 30 inches and grades into a medium textured light brownish gray soil. Loose gravel or micaceous sand generally underlies the medium textured strata at 35 to 45 inches.

Soils of the Nolan series have the following textural range: Silty clay loam, gravelly silty clay loam, loam, clay, silty clay.

91 series.

The surface soils are dark colored and very heavy. The subsoils are medium to slightly heavy textured. The soils have moderate internal drainage. They occur in level backwater settling basins in association with the Cannon, Nolan and Muck soils. The soils are lighter colored and somewhat more calcareous than the Nolan soils but resemble them in their friable nature. The soils are slightly to moderately affected by salts or alkali.

Soils of the 91 series have the following textural range: Clay, silty clay, clay loam, silty clay loam, loam.

Reed series.

The Reed soils are light colored saline-alkali or alkali soils formed from laminated fine silty sediments relatively free of gravel. They occur in a nearly level to very gently undulating terrace in the southwest corner of the valley. These deposits probably represent the remnants of a lake terrace formed in the valley of the Payette River.

These heavy soils extend downward 15 feet or more to gravel. Internal drainage is slow to very slow.

Soils of the Reed series have the following textural range: Silty clay, silty clay loam, silt loam, loam.

Moulton series.

The Moulton soils include imperfectly to poorly drained soils occurring in medium positions on flood plains. Textures range from very light to medium. The subsoils are stratified but chiefly light or very light textured. Strata of loose gravel and sand lie below a depth of 20 to 35 inches. The soils may be slightly saline and highly alkalin.

Soils of the Moulton series have the following textural range: Clay loam, loam, sandy loam, very fine sandy loam, loamy fine sand, gravelly loam, gravelly fine sandy loam, loamy coarse sand, gravelly sand, gravelly coarse sand.

Wardwell series.

The Wardwell soils lie on a terrace about 20 feet above the flood plain in an area northeast of Emmett. The soils are not effected by a high water table. The soils have moderate to strong textural and structural profile development. The deep subsoils generally have a high pH and may contain some soluble salts.

The following soil types are included in the Moulton series: Clay loam, loam, fine sandy loam, sandy loam, gravelly loam, sand.

Muck series.

Several areas of muck and peaty muck soils occur in the lower parts of the low terrace or old flood plain in the south portion of the valley. Before drainage was initiated the vegetation consisted of tules, sedges and reeds. The muck varies in depth from a few inches to more than 72. The Muck soils are generally underlain by sandy strata. The soils are neutral to slightly alkalin in some areas.

The Muck soils were delineated as follows: Shallow muck 6" to 12" muck 12" to 36", Peaty muck, deep peaty muck 72" plus.

Snow series.

The Snow soils occur in the nearly level floors or flood plains of the small valleys crossing the Bench north of the river. A few areas occur as small alluvial fans of these streams where they emerge from the Bench on to the Payette River flood plain. The surface soils are generally dark-grayish brown. The surface textures are primarily medium to heavy. The subsoils are similar in color and stratified with sandy loam and light clay loam layers to a depth of 35 to 60 inches. Below 60 inches loose loamy sand, sand, and gravel occur.

The Snow soils have the following textural range: Clay, silty clay loam, clay loam, coarse sandy loam, silt loam, loam, sandy loam, coarse sandy loam.

The general location and extent of the various soils series are shown in figure 3. The severely water-logged and problem area occurs primarily in areas of Letha, Reed, Canon and Muck soils. The Reed and some Muck soils do not lend themselves favorably to open or tile drains because of their thickness and low permeabilities.

Alkali Survey.

An alkali survey, including alkali and saline conditons of the Emmett Valley area, was initiated in 1941 by the same personnel that made the soil survey. The alkali survey was conducted in conjunction with the soil survey. The various classes or degree of salinity and alkali were based mainly on obvious conditions of alkali and salinity as evidenced by salt accumulation, natural vegetation, crop growth and the morphology of the soils. These field observations were checked by conductivity and pH tests.

In the alkali survey the soils were delineated into the following classes:

Alkali free.

Natural cover of sagebrush and cheatgrass or of cheatgrass and annual weeds, as well as cropland and irrigated pasture on soils not considered to be inherently alkali or saline.

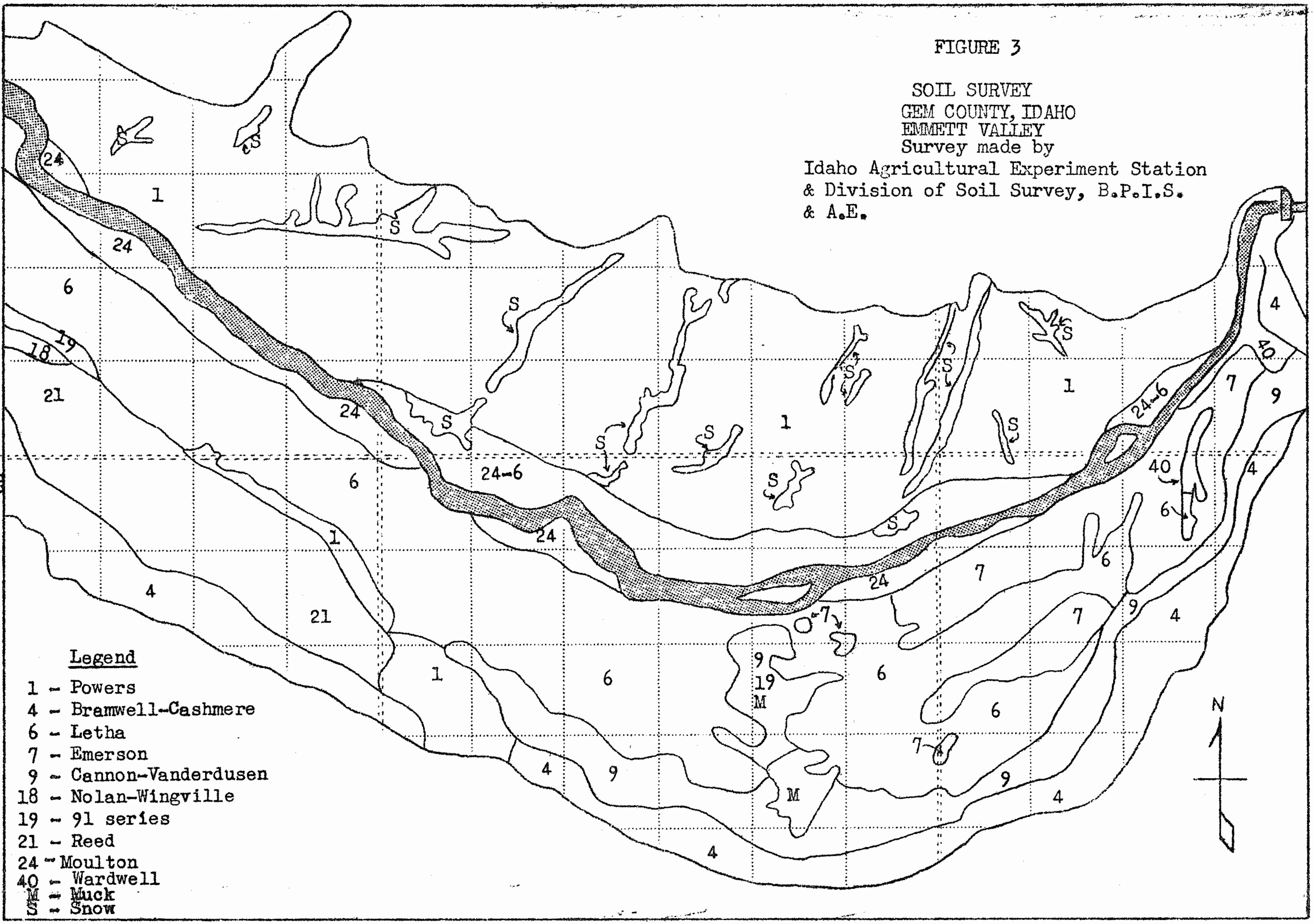


FIGURE 3

SOIL SURVEY
GEM COUNTY, IDAHO
EMMETT VALLEY
Survey made by
Idaho Agricultural Experiment Station
& Division of Soil Survey, B.P.I.S.
& A.E.

Surface free of alkali, alkali in the sub-strata.

Cropland or irrigated pasture supporting a uniform fair to good vegative cover, apparently free of salt and alkali, but because of the inherent characteristics of the soil, usually have salt and alkali in the deeper subsoil.

Slightly alkali.

Cropland supporting a fair but uneven or spotty vegetative cover with fair to good crop growth on 75% or more of the area, or irrigated pasture supporting 60 to 65% or more cover of palatable grasses and legumes. In cropland of this class the visibly affected alkali or saline spots are barren. In irrigated pasture the visibly affected alkali and saline spots support a dominant cover of saltgrass and Greasewood.

Moderately alkali.

A natural greasewood cover, with or without saltgrass, or a uniform revegetated cover of which saltgrass comprises 35 to 40% or more of the vegetation.

Strongly alkali.

Alkali and saline affected areas in which alkali spots occupy 25% or more of the area with the intervening areas supporting saltgrass, and greasewood or a poor to good growth of crops. If allowed to lie idle, these lands will in a few years time have a uniform saltgrass cover.

The general location and extent of the various classes are shown in figure 4. The alkali area generally occurs on the Letha, Reed and Cannon soil series. The Letha soils are generally moderately permeable and should reclaim fairly rapidly following drainage. The Cannon soils will be slightly more difficult to reclaim due to a slower permeability in the surface soil. However, open or tile drainage is very feasible on the Cannon soils due to the permeable substrata. The Reed soils will be the most difficult to reclaim due to the slow permeability and thickness of the strata. The 15 feet or more of slowly permeable soil makes the efficiency of open or tile drains very low. This requires a very close spacing of drains and coupled with the gypsum required for reclamation on heavy alkaline soils makes reclamation very costly.

Chemical Analysis of Selected Soil Samples in the Emmett Valley. (5)

During 1950 the U. S. Regional Salinity and Rubidoux Laboratories, Division of Soil Surveys and the Idaho Agricultural Experiment Station published a bulletin entitled "Characteristics of Saline and Alkali Soils in the Emmett Valley area, Idaho."

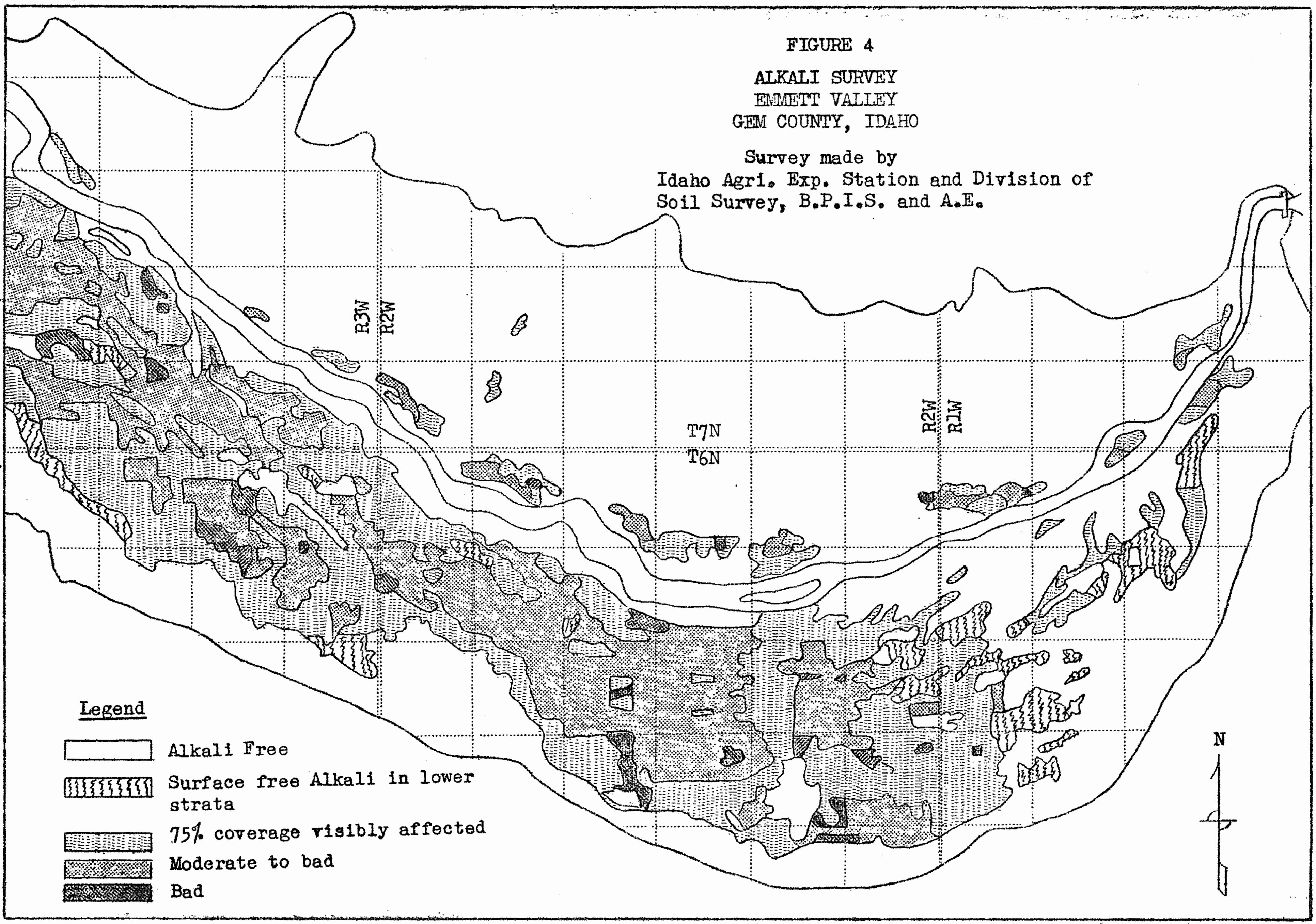


FIGURE 4
ALKALI SURVEY
EMMETT VALLEY
GEM COUNTY, IDAHO
Survey made by
Idaho Agri. Exp. Station and Division of
Soil Survey, B.P.I.S. and A.E.
R3W
R2W
T7N
T6N
R2W
R1W
Legend
Alkali Free
Surface free Alkali in lower strata
75% coverage visibly affected
Moderate to bad
Bad
N

The chemical and physical characteristics of 35 selected soil samples were given in the Appendix of the above mentioned publication. The location of the soil samples are shown in figure 5. A major part of the soil samples are located in the acute problem area. (See figure 4) The chemical and physical characteristics of the soils sampled are given in Appendix tables 1, 2, 3, and 4.

The chemical analysis can be used to obtain a fairly reliable estimate of the tonage of gypsum required to remove the sodium from a given soil sample and establish a permanent reclamation. The following calculation is an example of the methods generally used to determinethe amount of gypsum required for reclamation.

Sample calculation of gypsum required to reclaim the soil profile analysis presented in Appendix Table 2, sample No. 23.

Depth of Sample	Exch. sodium		Safe sodium		Base exchange capacity		Gypsum required to replace one m.e./100 grams of soil		Portion of foot analyzed		Gypsum required for reclamation
Inches	%		%		m.e./100 grm		Tons		Ft.		Tons
0-8	(53.8	-	15)	x	39.6	x	1.75	x	0.666	=	20.6
8-16	(73.7	-	15)	x	50.6	x	1.75	x	0.666	=	34.6
16-28	(81.9	-	15)	x	51.7	x	1.75	x	1	=	40.6
28-35	(83.5	-	15)	x	55.3	x	1.75	x	0.583	=	26.0
39-52	(100	-	15)	x	12.8	x	1.75	x	1.083	=	20.6
	Total tons of gypsum required to reclaim soil to 52 inches										142.4

Artesian Well Survey

An artesian well survey of the Emmett Valley was initiated during 1952. On April 7th a card questionnaire was mailed out to farm owners in the problem area south of the Payette River. A 65 percent return was obtained on the questionnaire.

The results of the questionnaire are given in figure 6. The artesian aquifer underlies the water-logged alkali area very accurately (See figure 4). However, the area is water-logged and alkali for a distance of about 1½ miles above the farm furthermost east, having a flowing artesian well. This 1½ miles can possibly be accounted for in two ways:

1. The artesian aquifer probably extends east of the last farm indicating an artesian well. However, a number of artesian

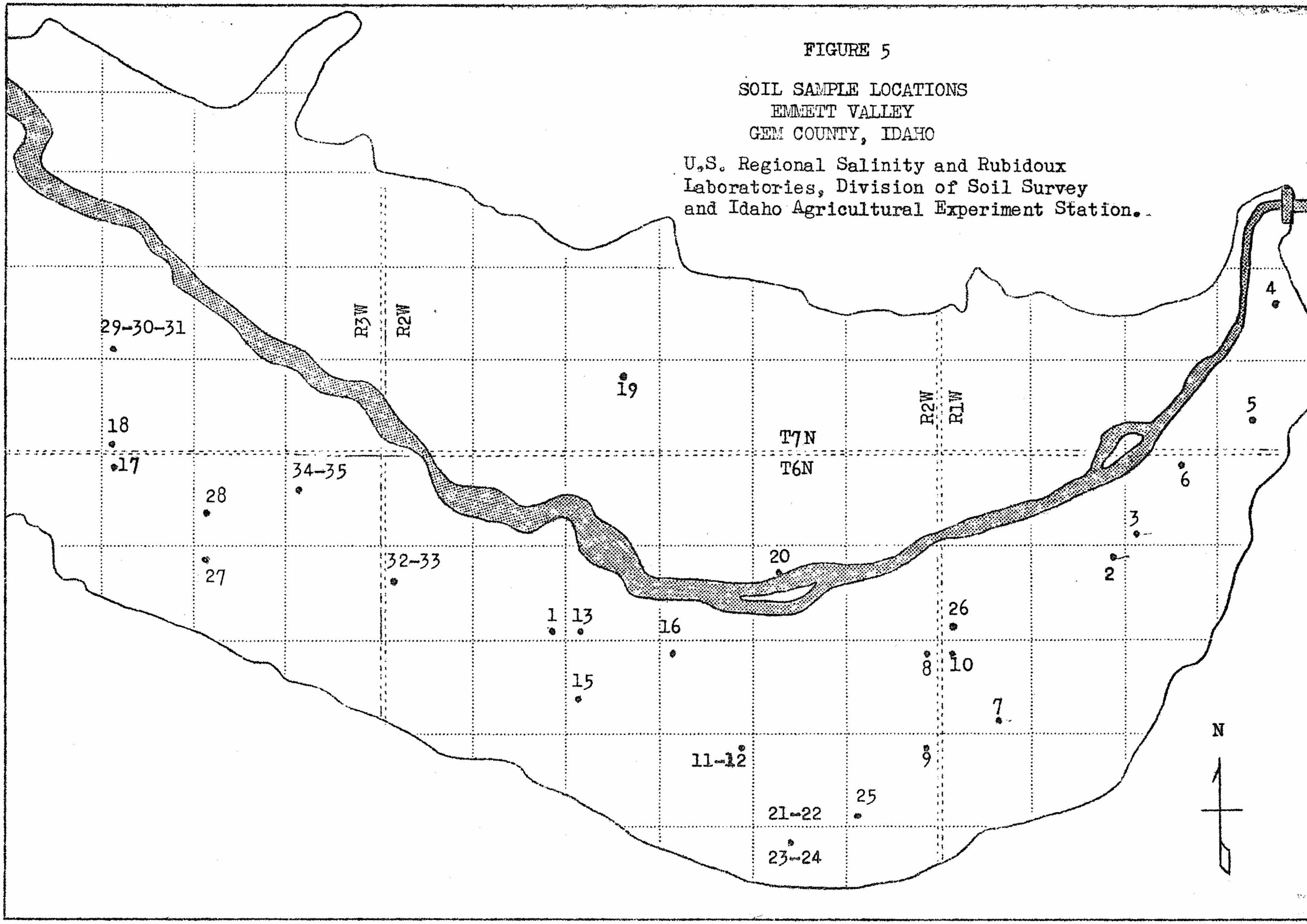


FIGURE 5

SOIL SAMPLE LOCATIONS
EMMETT VALLEY
GEM COUNTY, IDAHO

U.S. Regional Salinity and Rubidoux Laboratories, Division of Soil Survey and Idaho Agricultural Experiment Station.

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, RESEARCH

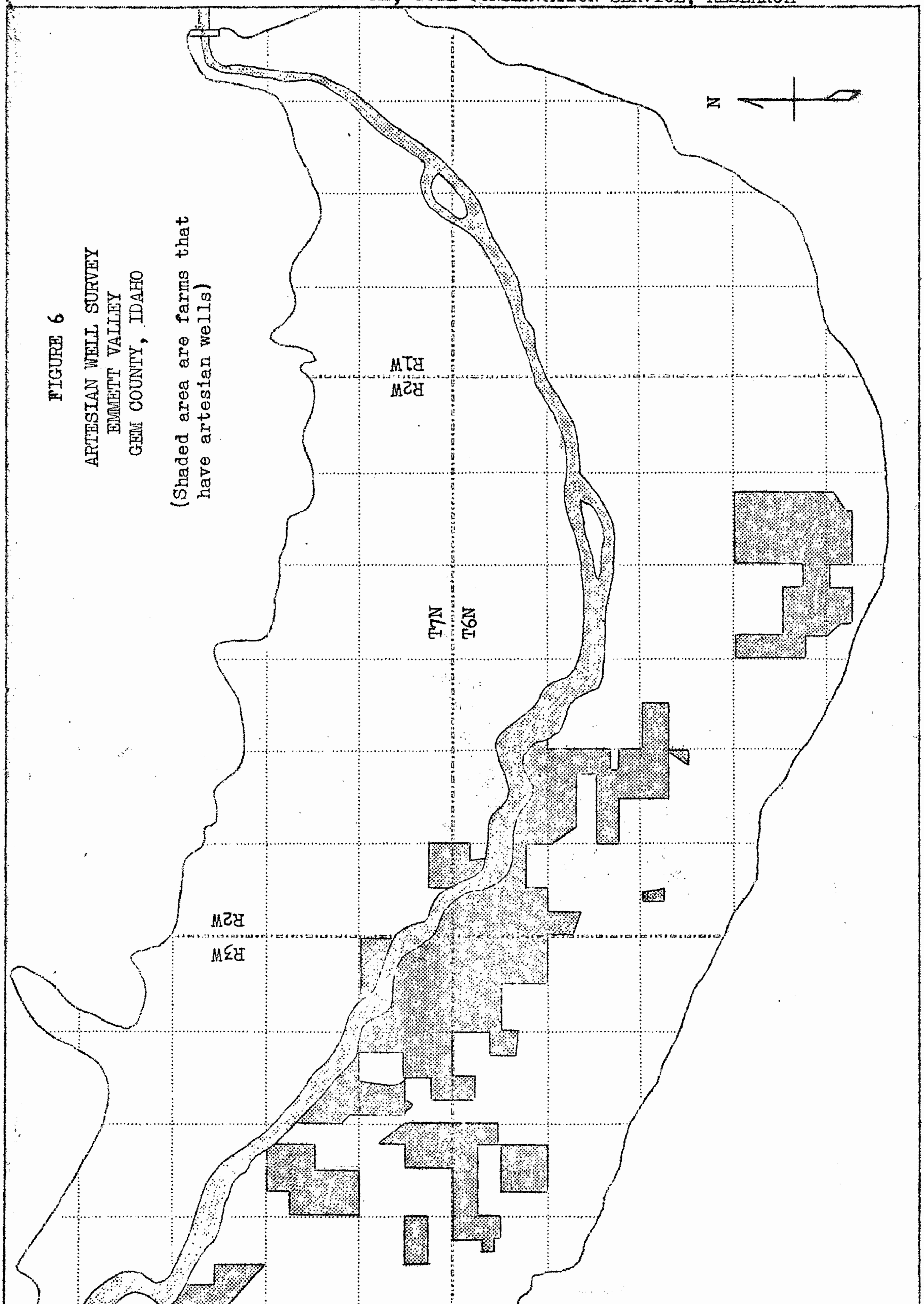


FIGURE 6

ARTESIAN WELL SURVEY
EMMETT VALLEY
GEM COUNTY, IDAHO

(Shaded area are farms that have artesian wells)

wells were attempted a half to three-quarters of a mile east of the last known well and no free flowing artesian aquifers were encountered.

2. Artesian water moving toward the surface forms a water mound and retards unconfined ground water moving down from upslope. The water table is slowly raised until the areas become water-logged and alkali.

Ground Water Survey.

During 1936 the U. S. Bureau of Reclamation initiated a ground water investigation in the area bordering the Black Canyon Canal on the southern edge of the Emmett Valley. A total of 91 observation wells were installed and monthly readings were made from 1936 to 1945. The observations were discontined from 1946 to 1950. The observations were resumed in 1950 and have been continued to date.

The well locations are shown on figure 7. The observation wells are located an eight of a mile up to two miles below the Black Canyon Canal.

A table of the high and low water table elevations, by years, are given in appendix table 5. The ground water fluctuation varies with the well location. In some areas the fluctuation is very small and in other areas the fluctuation may be 10 to 14 feet between the low and high ground water cycle.

Drainage Investigations.

An investigation to determine the range of influence and the performance of open drains in five of the major soil series in the Emmett Valley was initiated during the past year. Piezometers were installed at right angles to the proposed drain locations to determine the ground water level prior to drainage. Observations on the soil profile and the drain's effect upon the ground water table were observed during the drain construction periods. Piezometer observations were continued during the fall and winter to obtain the minimum and maximum ground water level following drainage. The effective range of influence varied from about 100 feet or less in the silty clays to 400 feet or more in the sandy loams underlain with gravel.

Drainage investigations were set up on seven farms in the valley. They covered the following soil series and textures:

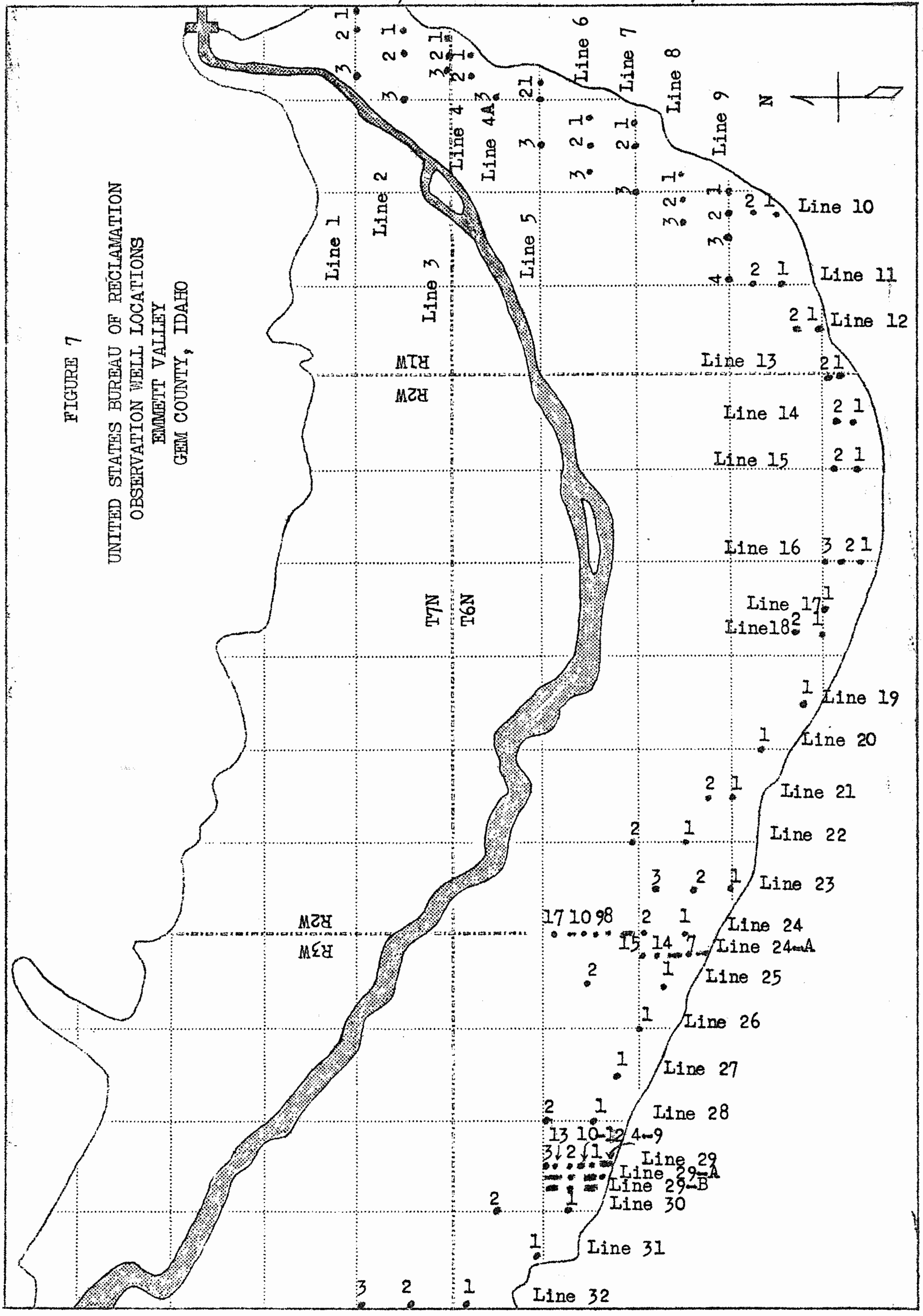


FIGURE 7
UNITED STATES BUREAU OF RECLAMATION
OBSERVATION WELL LOCATIONS
EMMETT VALLEY
GEM COUNTY, IDAHO

Ranch	Soil Series	Texture
A	Letha	Sandy loam
B	Muck	Silty clays
C	Snow	Clay loam
D	Snow	Clay loam
E	Letha	Clay loams and gravelly fine sandy loams
F	Moulton	Loam to loamy fine sand
G	Reed & Nolan	Silty clay loams

The ranch locations are shown on figure 8. Five of the ranches are located in the general problem area south of the Payette River and the remaining two, Ranches C and D, are located on problem areas north of the river. Ranch D is located at the toe of the bench escarpment, and Ranch C is located at the toe of the escarpment on Bissell Creek.

The observations, field work, and conclusions are given individually and alphabetically for the various ranches.

Ranch "A".

Ranch "A" is located east of the artesian aquifer water mound or dam. It is in the area where the ground water from the upper valley backs up against this water dam and slowly water-logs the area.

The ranch has several small cultivated areas, but has been used primarily for pasture. Figure 9 was taken looking north from a central point on the ranch and shows the native vegetation and slight undulating topography. The ranch had several low wet areas prior to drainage and leveling.

Figure 10 shows the open drain from the northeast corner of the farm looking west. The drain is approximately six feet deep. This drain extends around three sides of the ranch (See figure 11). It goes up the west side, along the north side and nearly across the east end of the farm. Figure 10 shows approximately 18 to 20 inches of soil mantle over a coarse sand and gravel strata. The spoil bank was segregated at the time of construction. The coarse gravel was piled adjacent to the drain and the soil mantle was deposited in the field. The soil mantle was utilized in leveling the ranch and the coarse gravel was smoothed out and used as a berm along the drain.

A soil and alkali map for the ranch is shown in figure 11. The soils are primarily Letha with eight bars or islands of Emerson. (See figure 11) The soil mantle is primarily a sandy loam with mantles of loam on some of the Emerson soil areas. It is roughly 4 to 5 feet from the surface to gravel and cobble in the Letha soils and 20 to 40 inches in the Emerson soils. At several places the Emerson gravel bars

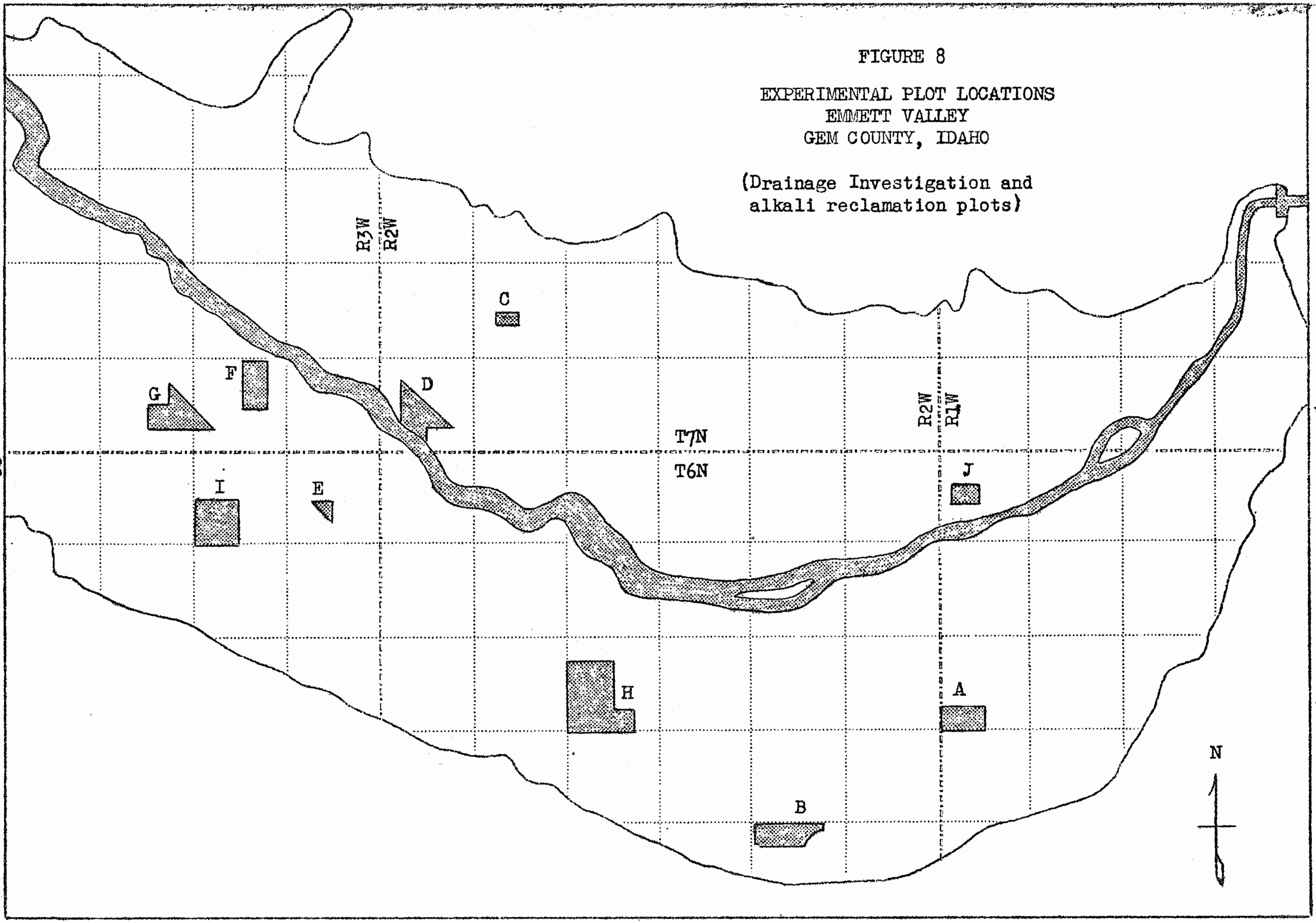


FIGURE 8

EXPERIMENTAL PLOT LOCATIONS
EMMETT VALLEY
GEM COUNTY, IDAHO

(Drainage Investigation and
alkali reclamation plots)

DRAINAGE INVESTIGATIONS
RANCH "A"

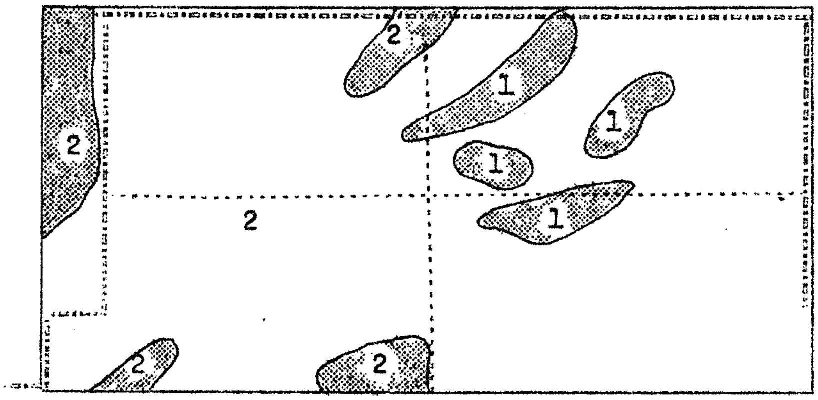
Emmett Valley
Gem County, Idaho

Figure 9. Looking north from center of farm. Soils belong to the Letha and Emerson series and are primarily fine sandy loams.

Figure 10. Looking west along open drain, from the north east corner of the farm. Drainable strata of sand and gravel is visible below a two foot soil cap.

FIGURE 11
RANCH "A"
EMMETT VALLEY
GEM COUNTY, IDAHO
(8 inches to the mile)

SOILS MAP



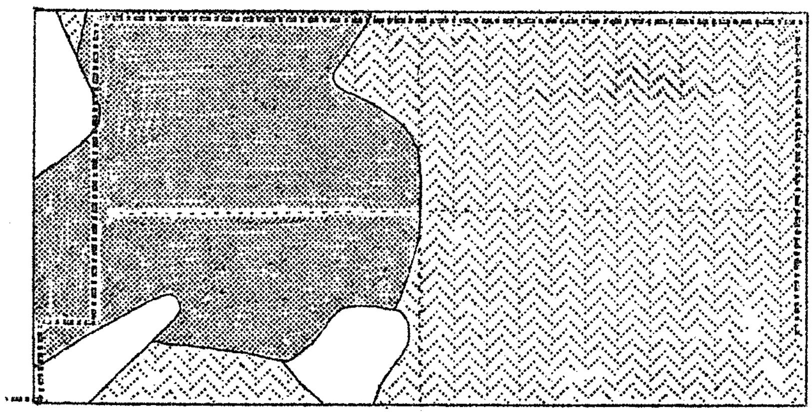
<u>SOIL SERIES</u>

Letha - - - - - - - - - - -
Emerson - - - - - - - - - -

<u>TEXTURE</u>

1 - Loam
2 - Sandy Loam

ALKALI MAP



Alkali Free - - - - - - -
Slightly Alkali - - - -
Moderately Alkali - - -
Open Drains
Ground Water Profiles

extended to within several inches of the surface. The soils lend themselves very favorably to open or tile drainage as the coarse gravel and cobble makes an excellent aquifer.

The soils range from alkali free to moderately alkali. There are three alkali free areas on the ranch. These areas are farmed and produce fairly good crops. About 60 percent of the ranch is slightly alkali and the remainder is moderately alkali. A few spots in the moderately alkali area indicated a very high pH (9.6+) with Thymol Blue. This high pH suggests that some spots in the moderately alkali area may be strongly alkali.

The ranch is being leveled from virgin soil and will be cropped during 1953. No irrigation information is available on the ranch this year. Irrigation observations will be made during the 1953 irrigation season.

Some spots on the ranch indicated a very high ground water table prior to drainage. There were several springs or seeps on the ranch that dried up following drainage; however, some small areas remained wet during the 1952 irrigation season. These low wet areas may be improved considerably following leveling.

Twelve piezometers were installed on the ranch in an east-west and a north-south line. (See figure 11) The ground surface and ground water profiles are shown in figure 12.

The east-west piezometer line indicates that ground water is moving into the farm from areas to the east. Water is probably also seeping from the canal on the east side of the ranch as the water table came up three feet at a distance of 100 feet from the drain during the high ground water period. The interception drain along the east side of the ranch is a foot shallower than the adjacent irrigation canal and probably allows a large quantity of ground water to enter the farm.

The north-south piezometer line indicates that the ground water comes to within two feet of the surface on the south side during the irrigation season. The ground water moves slowly towards the south during the low ground water period and towards the center of the ranch from both the north and south sides during the high ground water period. The elevated head ditch along the south side of the ranch is evidently contributing considerable water to the ground water problem during the irrigation season.

The areas cropped during the 1952 season indicates a slight to fair crop increase due to the drainage.

Conclusions on Ranch "A".

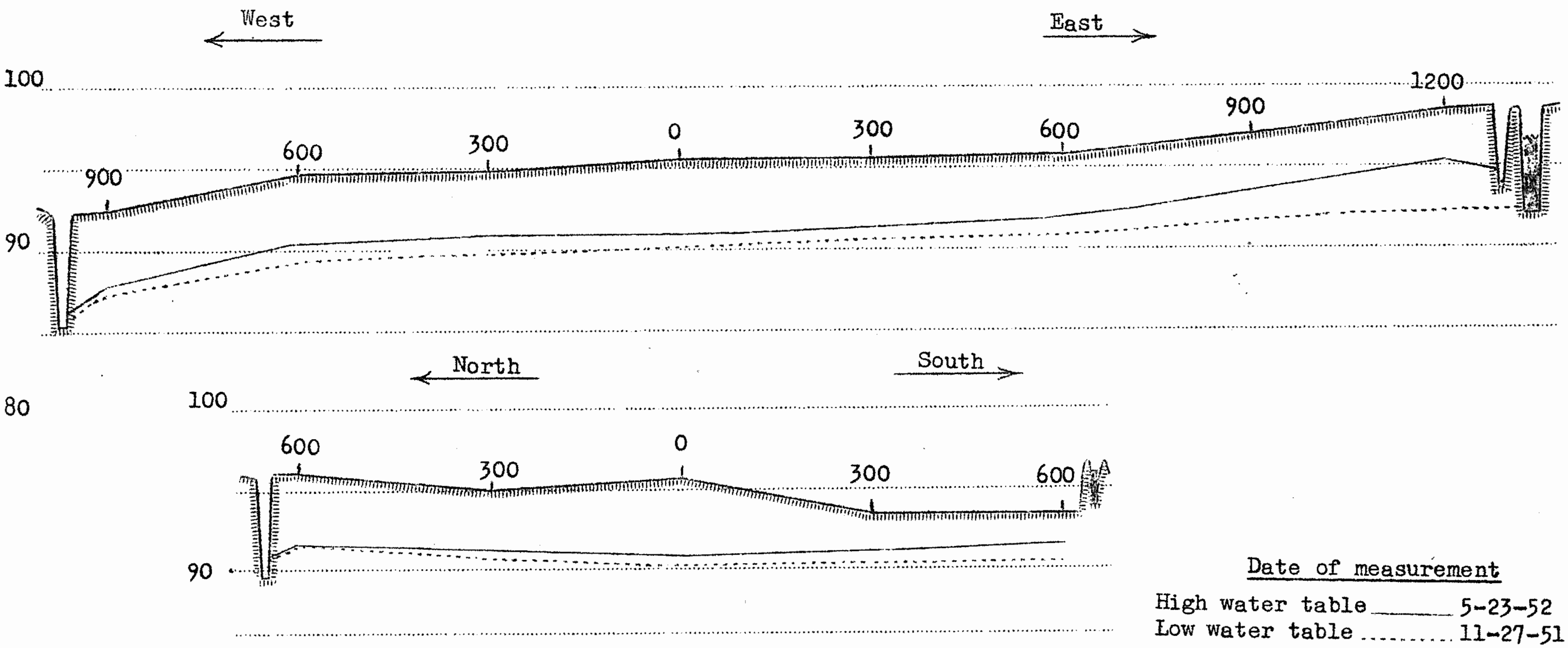
1. The present drainage system will not completely reclaim the entire ranch.

2. A tile drain or an open drain will be required in the southern portion of the ranch. A shallow east-west drain exists at about the 300 foot south piezometer (see the north-south piezometer line, figure 12) This existing shallow drain could be deepened and extended to drain the southern portion of the ranch.

FIGURE 12

RANCH "A"

Ground Water Profile
Emmett Valley
Gem County, Idaho



3. The east interception drain is too shallow and should be deepened. It is a foot shallower than the irrigation canal just east of the drain.

4. Better drainage system would have been obtained with a drain along the east-west piezometer line with a foot and a half deeper "T" interceptor drain paralleling the canal on the east.

5. The ranch should be border irrigated to keep as much of the land as possible under water during irrigations. This helps prevent alkali moving to the surface along furrow ridges.

6. All drains should be kept clean and open to pick up a maximum quantity of ground water.

Ranch "B".

Ranch "B" is located at the southern edge of the valley, (see figure 8 for location) The problem area was severely water-logged prior to drainage Three bog holes existed in the area and were so soft and fluid that a post or timber could be pushed down seven or eight feet with ease. The water-logged area has been used as pasture.

Figure 13 was taken looking northwest from a point midway along the new drain. Small rose bushes are shown in the picture. The black spoil band at the right is the muck spoil bank from the new drain.

Figure 14 is looking north along the partially constructed drain. The view shows the sloughing and caving characteristics of the muck soils. The shallow portion of the drain was constructed in 1951. A year was allowed for the drain to stabilize prior to completion. During 1952 the drain was deepened and cleaned out. Another stabilization period will be required before the drain can be completed.

The new open drain cuts through Cannon and Nolan clays prior to the entering the water-logged Muck soils. The soils and alkali maps are shown in Figure 15. The Nolan and Cannon soils are underlain with sand and gravel within the drain depth and are readily drainable. The Muck soils vary in depth. In some locations along the drain the Muck was underlain with sand within the drain depth and in other sections the muck was very deep and boiled into the drain faster than it could be bailed out. The muck soils are slowly permeable and have a very low intake rate.

The alkali concentration on the ranch varies from alkali free to moderately alkali. The acutely water-logged Muck soils are surprisingly alkali free. (see figure 15) This phenomenon is attributed to the decaying peat giving off an acid that tends to counteract the alkali condition. The entire Muck soil series is alkali free and shows up as an alkali free island on the Alkali Survey Map of the valley. (See figure 4 - T 6 N R 2 W Sec. 23)

DRAINAGE INVESTIGATIONS
RANCH "B"

Emmett Valley
Gem County, Idaho

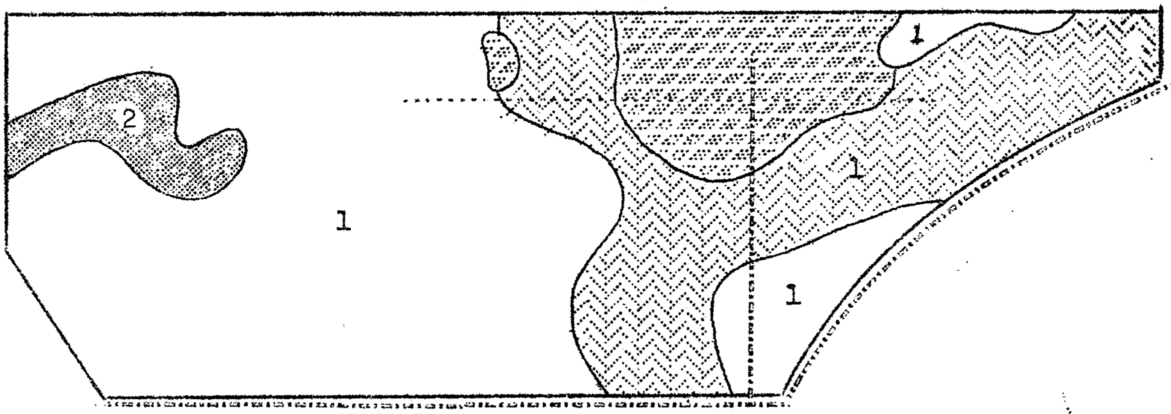
Figure 13. Looking north west from center of new drain. The soils belong to to the Muck series. Wild rose bushes in foreground.

Figure 14. Looking north along partially constructed drain. Caving and sloughing tendency of drain bank is shown.

FIGURE 15

RANCH "B"
EMMETT VALLEY
GEM COUNTY, IDAHO
(8 inches to the mile)

SOILS MAP



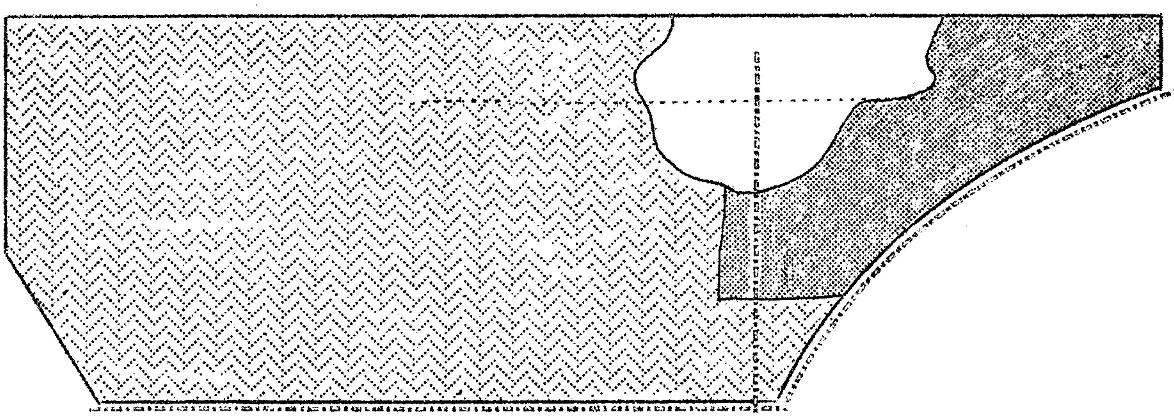
SOIL SERIES

Muck - - - - - -
Nolan - - - - -
Canon - - - -
91 Series - -

TEXTURE

1 - Clay
2 - Silty Clay Loam

ALKALI MAP



Alkali Free - - - - - - -

Slightly Alkali - - - - -

Moderately Alkali - - - -

Open Drains

Ground Water Profiles ....

The water-logged area on the ranch is currently being leveled and has not been irrigated since the study was initiated; consequently no irrigation information is available.

The general ground water table, prior to drainage, was very high. Springs occurred in several areas and the water table averaged a few inches from the surface under most of the Muck soils. Two flowing artesian wells exist in the general area. One four-inch artesian well is located in the center of the newly constructed drain. The well casing was cut off at drain bottom level and works very effectively as a vertical drain in the artesian aquifer.

Fourteen piezometers were installed in the ranch to obtain the open drain's effect upon the high water table in the Muck soils. Twelve piezometers were installed in an east-west line, two piezometers in a north-south line off the stub end of the drain. The piezometer line locations are shown on figure 15. The ground surface and ground water profiles are shown in figure 16. The east-west piezometer line indicates that the open drain is only partially effective in the Muck soils. The east line indicates a greater effective distance than the west section. The water table stood within a foot of the surface at a point 200 feet west of the drain during the high ground water table. The ground water table was within two feet from the ground surface at a point 300 feet west of the drain during the low ground water period. The north piezometer line at the stub end of the drain, (see figure 16), indicates very slight effect beyond one or two hundred feet from the drain.

Conclusions on Ranch "B"

1. The present drainage system will not completely reclaim the water-logged area on the ranch.

2. Tile drains would be unfeasible in the Muck soils due to caving, sloughing and heaving tendencies of the soil. It would be practically impossible to install tile drains, also, there is very little chance of keeping them intact following installation.

3. The installation of open drains in the Muck soils at the present time is too costly for the benefits derived. It cost $1624.00 to dig 1186 feet of drain on Ranch "B". More than half of the 1186 feet of drain was in the Nolan and Cannon soils and would run about 50 cents a foot to dig; consequently, the cost of digging the six to seven and one-half foot drain in the Muck soils cost approximately $2.50 a foot. This is too high a cost for the effective area drained.

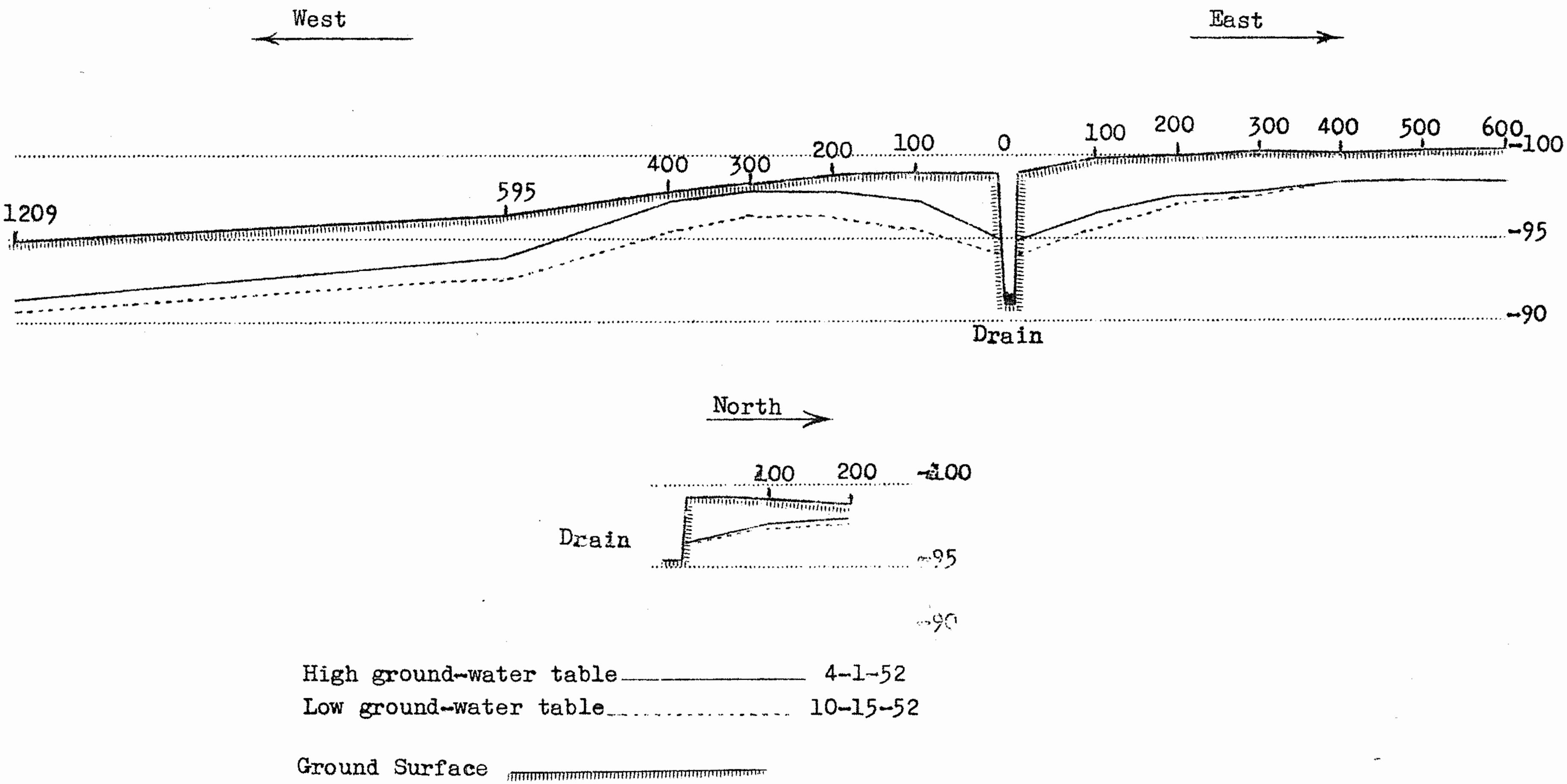
4. Pumping from wells in the artesian aquifer would be the most economical method of draining the Muck soils.

5. The Muck soils will be very difficult to maintain level enough to surface irrigate. The soils heave out of level and may require a level touch-up nearly every year.

6. Sprinkler irrigation may be feasible on the Muck soils for some high priced crops. Sprinkler costs coupled with drainage costs will be very high.

FIGURE 16

RANCH "B"
GROUND-WATER PROFILE



7. The maintenance cost on the drain will be very high in comparison with the more stable soils. Cleaning to remove the sloughing and heaving muck soil may be required yearly for several years.

8. If additional open drainage work is done on the Muck soils, it should be done with a light dragline and jarring kept at a minimum.

RANCH "C"

Ranch "C" is located in one of the perennial stream channels cutting across the Bench north of the Payette River. This drainage problem is due to a soil change coupled with a break in grade. The water-logged area is located between the bench escarpment and the creek.

The water-logged area is used as pasture during the low ground water period.

Figure 17 shows a view north along the proposed route of the tile or open drain. The proposed drain would be located at the break in grade and follow the contour of the escarpment toe. The seepage line can be seen eight or ten feet above the basin floor on the toe of the escarpment.

Figure 18 shows a view looking north over the bog area. The bog supports a luxuriant growth of water-loving plants. During the summer months, the seepage water accumulates and stands two or three inches deep on the surface. Muskrats live in the bog and apparently thrive very well.

The soils and alkali maps and a cross section of the bog area are shown in figure 19. The soils in the bog area belong to the Snow series and are primarily clay loam. This slowly permeable clay loam strata overlies a sandy loam strata. (See figure 19 cross section at "A") The sandy loam soils extend upstream from the problem area a distance of a mile or more. The soil change from a sandy loam to a clay loam gives a good key to the cause of water-logging.

An alkali map of the problem area is given in figure 19. The soils are alkali free and will respond very rapidly following drainage. No soil amendments will be required as with the alkali soils.

The bog area is waste land consequently no irrigation or cropping information is available.

The general ground water table is very high during the summer months. Water stands several inches deep on the surface and the soil gets fairly soft and fluid. This condition is generally due to the quicksand condition caused by water moving to the surface from deeper strata.

DRAINAGE INVESTIGATIONS
RANCH "C"

Emmett Valley
Gem County, Idaho

Figure 17. Looking north along proposed route of interceptor drain. The soils belong to the Snow series and are primarily clay loam.

Figure 18. Looking north west over the bog section. During the summer months seepage water accumulates and stands 2 or 3 inches deep on the surface.

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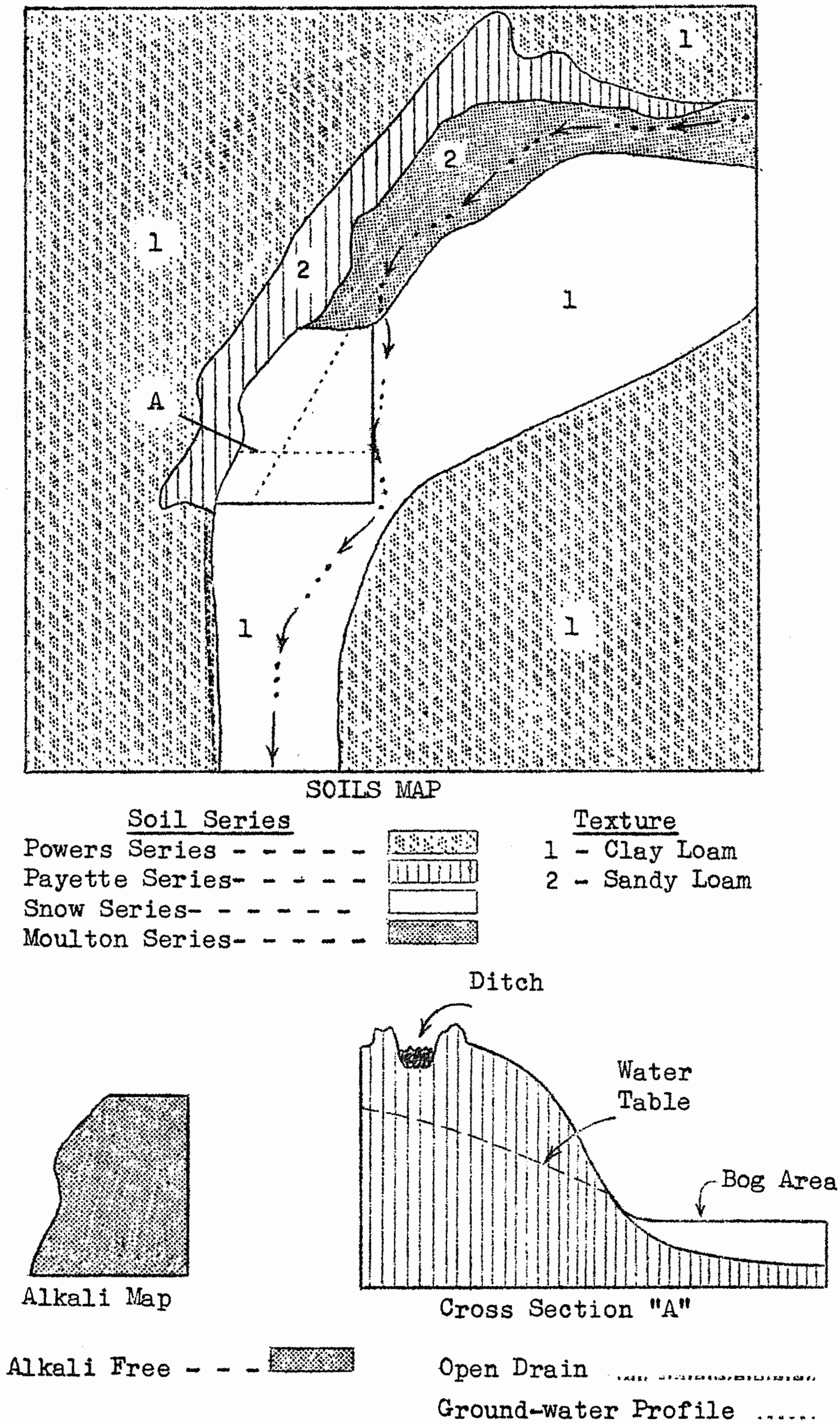
FIGURE 19

RANCH "C"
EMMETT VALLEY
GEM COUNTY, IDAHO
(8 inches to the mile)



Ten piezometers were installed in the bog area in ... east-west and north east-southwest lines. (See figure 19) The ground surface and ground water profiles are given in figure 20. The east-west piezometer line indicates a hydrostatic pressure in the sandy loam soil below the clay loam cap. This pressure stands one foot above the ground surface at the escarpment toe and drops down to ground level at a point 300 feet east of the escarpment. The east-west piezometer line indicates the ground water moves towards the west during the low ground water period and towards the east during the high part of the cycle. The north-east south-west piezometer line indicates that considerable ground water is moving down from upstream as well as at right angles off the bench. The hydrostatic pressure drops nearly four feet during the low ground water cycle.

Conclusions on Ranch "C".

1. The water-logging is due to a soil change in conjunction with a break in slope.

2. Seepage water is moving into the area from the bench lands and down the creek bottom. The Bench seepage water is probably due to over-irrigation, canal and ditch losses. The water moving down the creek bottom is possibly due to creek seepage losses in the sandy loam soils.

3. A tile or open drainage system will reclaim the bog area. The drain should follow the escarpment toe and then east-west along the north edge of the bog. An interception drain in this location would cut off seepage water from the bench and that moving down stream in the sandy loam soil.

4. The bog area will respond very rapidly following drainage. No gypsum or soil amendments will be required for reclamation.

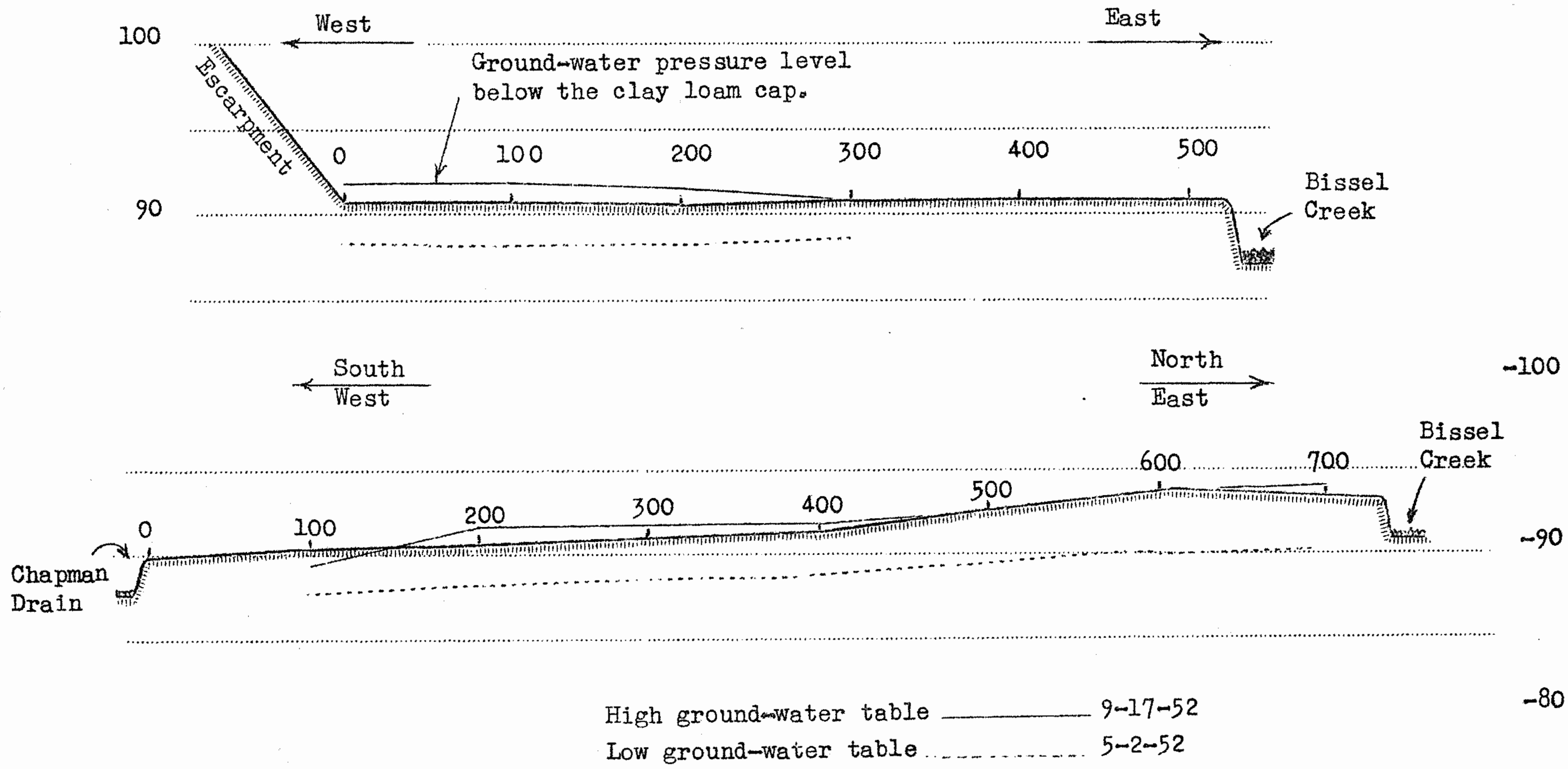
Ranch "D"

Ranch "D" is located on a narrow stretch of land between the toe of the bench escarpment and the Payette River. (See figure 8 for location.) Water-logging on Ranch "D" is possibly coming from two sources: The primary source is probably from the bench area and the secondary source from the Payette River adjacent lands and the artesian aquifer. An open interceptor drain was installed during 1952 along the toe of the bench escarpment. This drain has worked very well.

Figure 21 shows the flat level terrace and the Bench escarpment in the background. The ranch has several slightly low areas that form bogs or mud holes following rains or irrigations. This condition is primarily due to the very low intake rate of the soils and the topography.

Figure 22 shows the open interception drain along the toe of the Bench escarpment. The drain is in a clay loam soil and cuts into a more permeable substrata in sections along the drain. Watercress and moss raise the water level in the drain $1\frac{1}{2}$ to $2\frac{1}{2}$ feet during the late

FIGURE 20
RANCH "C"
GROUND-WATER PROFILE



DRAINAGE INVESTIGATIONS
RANCH "D"

Emmett Valley
Gem County, Idaho

Figure 21. Looking north towards the Emmett Bench escarpment. The soils belong to the Snow series and are primarily loam and clay loam.

Figure 22. Looking west along the interception drain. The drain is located at the break in grade and soil change to intercept seepage water from the bench.

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summer and fall when the water table problem is most acute. This watercress condition reduces the effective depth of the drain at the time it is needed the most.

A soil and alkali map for the ranch are shown in figure 23. The soils are primarily of the Snow and Moulton series. The textures range from clays to sandy loams in the surface soils and are underlain by a sand and gravel strata at a depth of 35 to 60 inches. The drainage problem is very similar to the Ranch "C" problem in that it is a soil change condition coupled with a break in grade. This heavy soil cap was transported down the small gullies or valleys by perennial streams and flash floods and deposited at the mouth of the gulley. This condition is shown on figure 3 at Township 7 North, Range 2 West Section 31.

The soils range from alkali free to strongly alkali. The area being studied to determine the effect of drainage upstream from a soil change is alkali free. The area shown as slightly alkali shows up in the crop growth and the area shown as strongly alkali is generally devoid of crop plants.

The irrigation efficiency was relatively low during 1952. However, this low irrigation efficiency was probably due to the poor level condition of the field. The field is to be leveled during 1953 and should alleviate this condition.

The general ground water condition prior to drainage was comparable to Ranch "C". The area was very wet and swampy according to farmers living in the area. The area responded very rapidly after the drain was dug.

Six piezometers were installed at 100 foot intervals in a line at right angles to the drain to determine the drain's range of influence. (See figure 23 for piezometer location line) The ground surface and ground water profiles are shown in figure 24.

The north-east, south-west piezometer line indicates that seepage water from the bench has been effectively cut off. The drain affects the water table in the field for a distance of about 100 feet. This is a rather short distance, however, the soils are very slowly permeable and a 100 foot influence is about all that can be expected. The ground water table is approximately two feet lower during the low part of the cycle. Very little ground water is moving under the farm either toward or away from the drain. The chief function of the drain appears to be intercepting seepage water from the bench.

The crop responses have been very good following drainage. The field was used as pasture prior to drainage and has since dried up enough to be cropped. During the 1951 season 4 ton of corn per acre were harvested and during the 1952 season 2820 pounds of oats and grain per acre were harvested.

FIGURE 23
RANCH "D"
EMMETT VALLEY
GEM COUNTY, IDAHO
(8 inches to the mile)

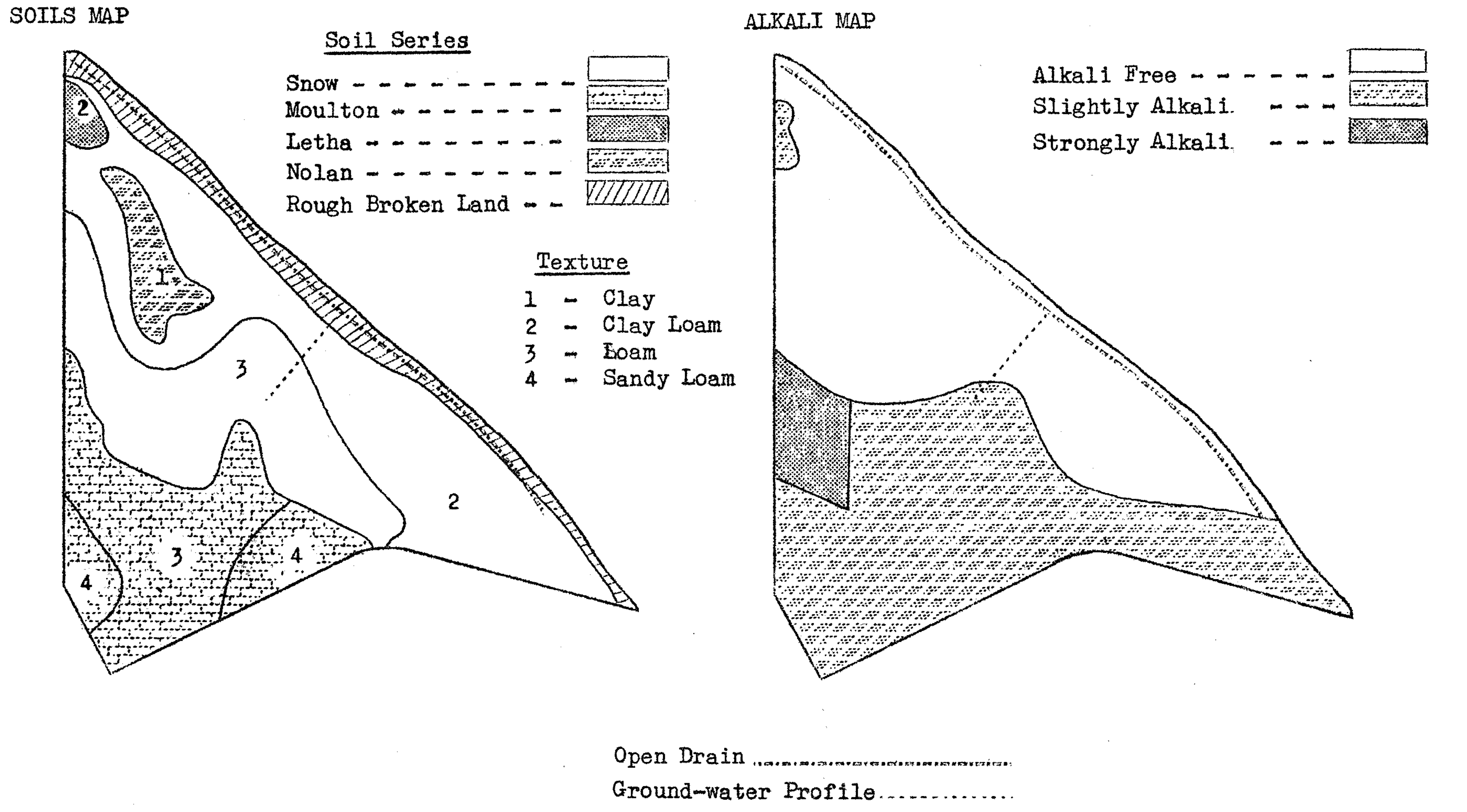
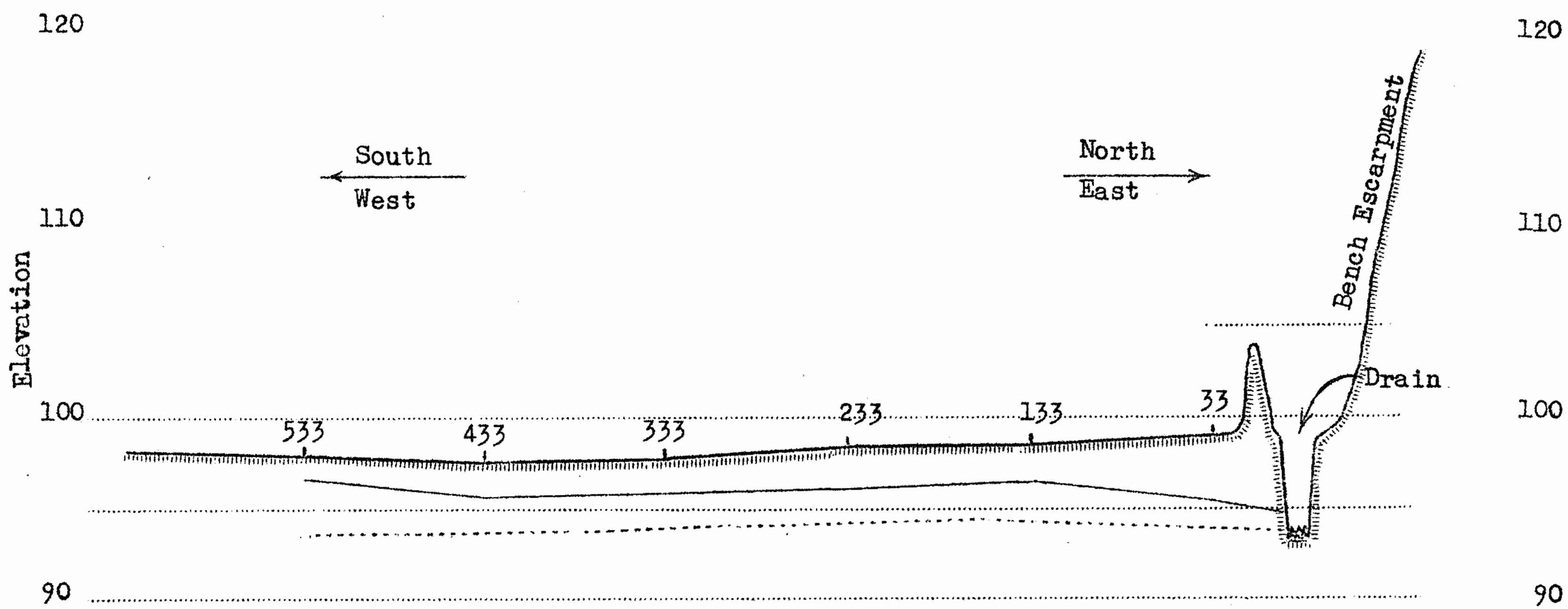


FIGURE 24

RANCH "D"
GROUND-WATER PROFILE



Date of Measurement

High Water-table ________ 9-17-52
Low Water-table 5-2-52

Conclusions on Ranch "D"

1. The drain should be cleaned and graded to its outlet. This will give a maximum depth drain at the farm.

2. Controlled wasteways should be constructed at the points where waste water from the Bench is being dumped into the drain. This will help prevent plugging of the drain by silt, sand, and gravel from the Bench escarpment.

3. Weed and moss eradicators should be used in the drain to control the watercress and moss. This will contribute $1\frac{1}{2}$ to 2 feet to the effective depth of the drain.

4. Increased irrigation efficiency should be attained. A high irrigation efficiency would help the overall drainage problem.

5. The feasibility of another open or tile drain in the more permeable Moulton soils should be investigated.

Ranch "E"

Ranch "E" is located in the Letha soil series. This series makes up the bulk of the water-logged and alkali soils in the Emmett Valley. (See figure 8 for location). The field investigated has an acutely high water table and the soils are slightly to strongly alkali.

Figure 25 depicts the gently undulating surface characteristics typical of the Letha soils. The soils on the left of figure 25 are slightly alkali and those on the right are moderately alkali. The area supports a good growth of water loving plants and grasses.

Figure 26 shows the wide shallow canal located on the north edge of the field. The canal has a coarse gravel bottom and evidentally loses considerable water to the surrounding ground water table.

A soils and alkali map and a cross section soil profile are shown in figure 27. The soils belong to the Letha series and range from clay loam to gravelly fine sandy loam. The loamy sand and gravelly fine sandy loam are adjacent to and under the canal. This condition contributes to the water-logging problem. A cross section along the piezometer line at section A, is shown at the bottom of figure 27. The field has a soil change condition where the more permeable strata is pinched off. This is effected by the clay loam strata getting deeper or thicker.

The soils range from slightly to strongly alkali. There is one strongly alkali spot in the field; however, some of the area indicated as moderately alkali is very close to being strongly alkali. The field averages about 50 percent slightly alkali and 50 percent moderately to strongly alkali.

The very low irrigation efficiency on the field is primarily due to the poor topographic condition of the field which needs leveling.

DRAINAGE INVESTIGATIONS
RANCH "E"

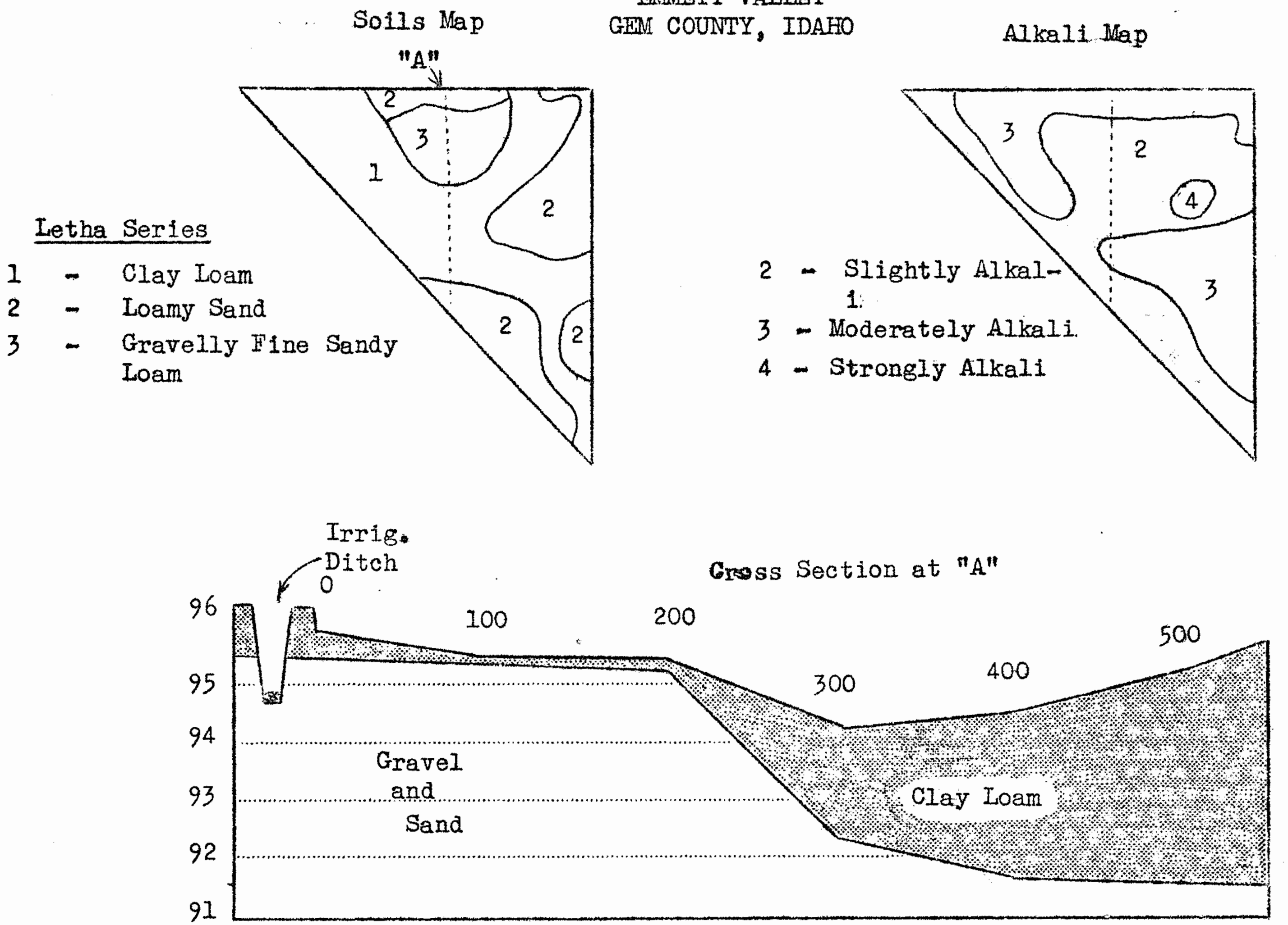
Emmett Valley
Gem County, Idaho

Figure 25. Looking north east along proposed route of tile drain. The area is slightly to strongly alkalin.

Figure 26. Looking east along shallow ditch at the north side of the farm. The ditch is 1 1/2 feet deep and approximately 12 feet wide.

FIGURE 27

RANCH "E"
EMMETT VALLEY
GEM COUNTY, IDAHO



Cross Section and Ground-water Profile ....

The general ground water table is very high during the irrigation season. It is high enough to cause seepage water to stand in the low swales in the field following heavy irrigations. Water will flow from an open auger hole in the low swales following these heavy irrigations.

Seven piezometers and four wells were installed on the field in a north-south line. (See figure 27) The ground surface and four ground water profiles are shown in figure 28. The north-south piezometer and well line gives the following indications for the four dates shown in figure 28. The observations on April 14, 1952 were made when the canal was dry and the ground water table had a chance to level off or to partially drain out through natural and installed drainage. The profile indicates that there is a slight natural drainage towards the south and away from the river. The uneven profile line is probably due to an east-west ground water movement through soils at varying rates.

The observations on September 3, 1952 were made when the canal was half full and the field had just been heavily irrigated. The profile indicates that considerable water is going into the ground water table when the gravelly fine sandy loam and sandy loam soils are irrigated. (See the soils map on figure 27 for the gravelly soil locations) Free artesian pressures were indicated at two of the observation stations. The water table also drops off very rapidly towards the south which indicates ground water is entering the farm from the north side.

The observations on September 10, 1952 were made when the canal was full and irrigation had just started. The profile indicates that considerable water is being lost from the wide shallow canal to the ground water table. Natural drainage at this time is also towards the south.

The observations on December 17, 1952 were made when the canal was practically dry and had only a few pools of standing water. The field was not being irrigated at the time of observations. The profile indicates that considerable ground water is moving into the field from the adjacent fields to the south. The natural drainage at this observation was towards the sloughs and river on the north.

The pasture response on the field is fairly poor. Some of the strongly alkali area production is very poor and another section on the extreme west corner is swampy and produces very little feed.

Conclusions on Ranch "E"

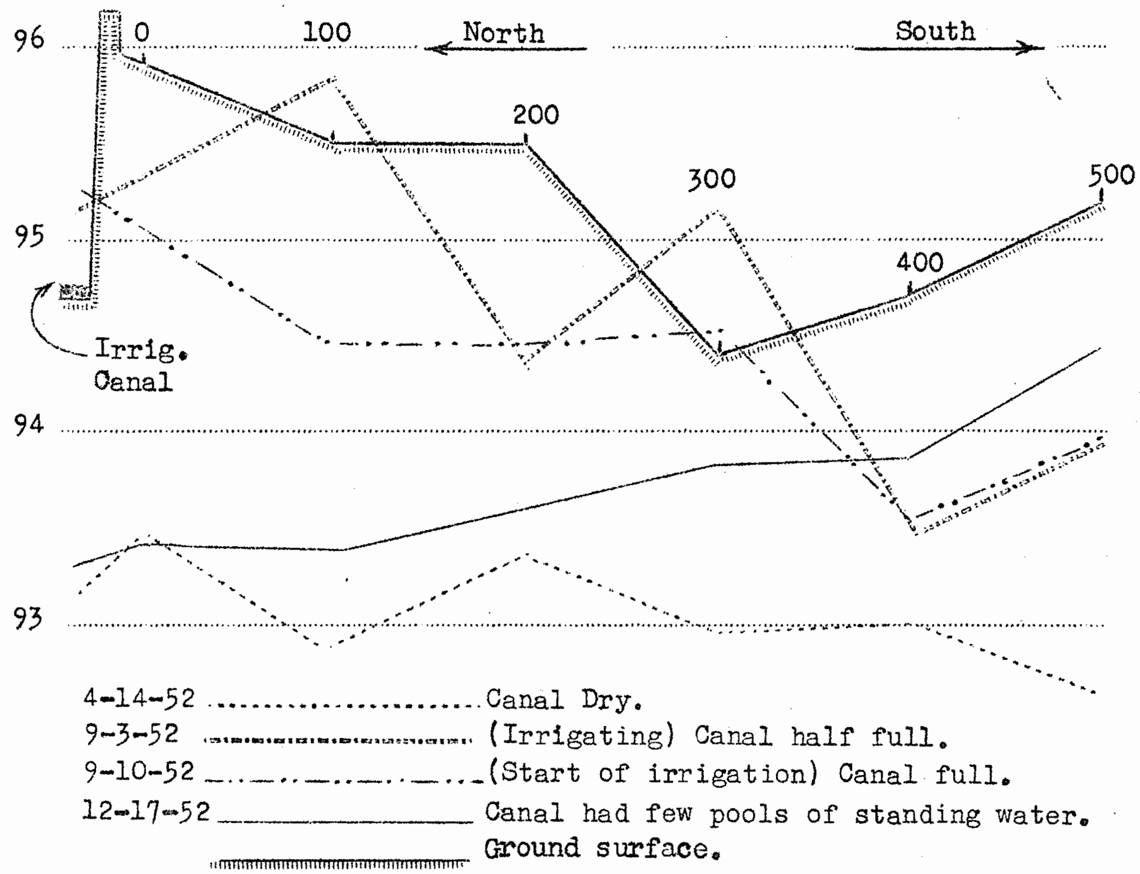
1. Over-irrigation is contributing very heavily to the waterlogged condition of the field. The irrigation efficiency should be increased on the field - especially on the gravelly fine sandy loam and sandy loam.

2. The wide shallow irrigation canal is contributing considerable water to the ground water table through seepage losses. The canal should be narrowed and lined through the gravel sections to prevent seepage losses.

3. A tile drain should be installed in the low "Y" shaped swale on the farm. This "Y" shaped drain would effectively drain the field.

FIGURE 28

RANCH "E"
GROUND-WATER PROFILE
AT CROSS SECTION A



The drain should be about $5\frac{1}{2}$ feet deep for best results.

4. Any leveling on the field should be done only after a good soil survey has been made. The soil mantle is very shallow in some areas and a six inch cut may expose a gravel bar.

Ranch "F"

Ranch "F" is located in the artesian aquifer area with its north boundary bordering on the Payette River. (See figure 8 for location) The north one-third of the ranch produces fairly good crops. The other two-thirds of the ranch is used as pasture.

Figure 29 shows the ranch from a central location - looking northwest. The ranch is cut by numerous east-west sloughs that will eventually be cleaned and deepened and used for drains or they will be drained and filled in. The section shown in figure 29 is slightly to moderately alkali.

Figure 30 shows a dragline at work in one of the east-west sloughs which contain stagnant water. The slough is being cleaned and deepened and will be used as an interceptor drainage channel. The slough is in readily drainable soils. The drain spoil bank was segregated as in Ranch "A" and the soil mantle will be used in leveling the fields and filling the sloughs that will not be used as drains.

Soils and alkali maps for the ranch are shown in figure 31. The soils are primarily of the Moulton and Letha series with isolated bars of Emerson, 71 series and Letha. The soil mantle texture ranges from loam to gravelly loamy sand with the largest percentage of the ranch being fine sandy loam and loamy fine sand. The ranch is underlain with a strata of loose gravel and sand below a depth of 20 to 40 inches. The highly permeable substrata reacts very favorably to drainage and a good range of influence is obtained with 5 to 8 foot open drains.

The soils range from alkali free on the north one-third of the ranch, adjacent to the Payette River, to moderately alkali in the south-one-half of the ranch. A few spots in the moderately alkali area border on being strongly alkali.

The ranch has been generally over-irrigated on the bad areas. This over-irrigation was primarily due to low areas and poor leveling. As the ranch is leveled, the irrigation efficiencies should increase.

The ground water table prior to drainage was very high over the greater portion of the ranch. Dead sloughs and small bogs stood at the free ground water level. A number of these sloughs have dried up since the open interceptor drain was installed. (See figure 31 for drain location)

Fourteen piezometers were installed on the ranch in north-south and east-west lines. (See figure 31 for location of these piezometer lines) The ground surface and the ground water profiles are shown in figure 32.

DRAINAGE INVESTIGATIONS
RANCH "F"

Emmett Valley
Gem County, Idaho

Figure 29. Looking north west from center of farm. Sloughs are to be cleaned, deepened and used for drainage channels.

Figure 30. Looking west from south center of farm. Slough is being cleaned and deepened and will be used as an interceptor drain.

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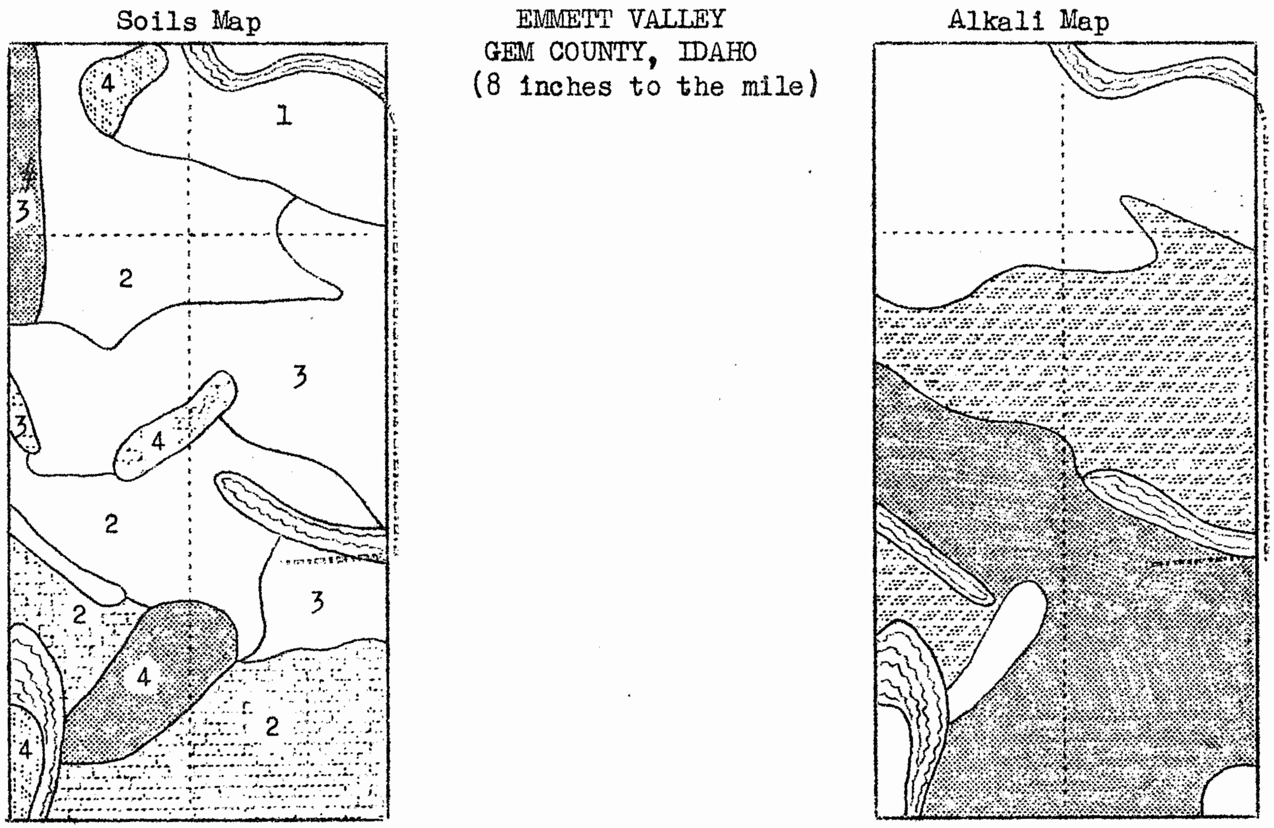
FIGURE 31

RANCH "F"
EMMETT VALLEY
GEM COUNTY, IDAHO
(8 inches to the mile)



Soil Series

Moulton - - - - -
Letha - - - - - -
Emerson - - - - -
71 Series - - - -

Texture

1 - Loam
2 - Fine Sandy Loam
3 - Loamy Fine Sand
4 - Gravelly Loamy Sand

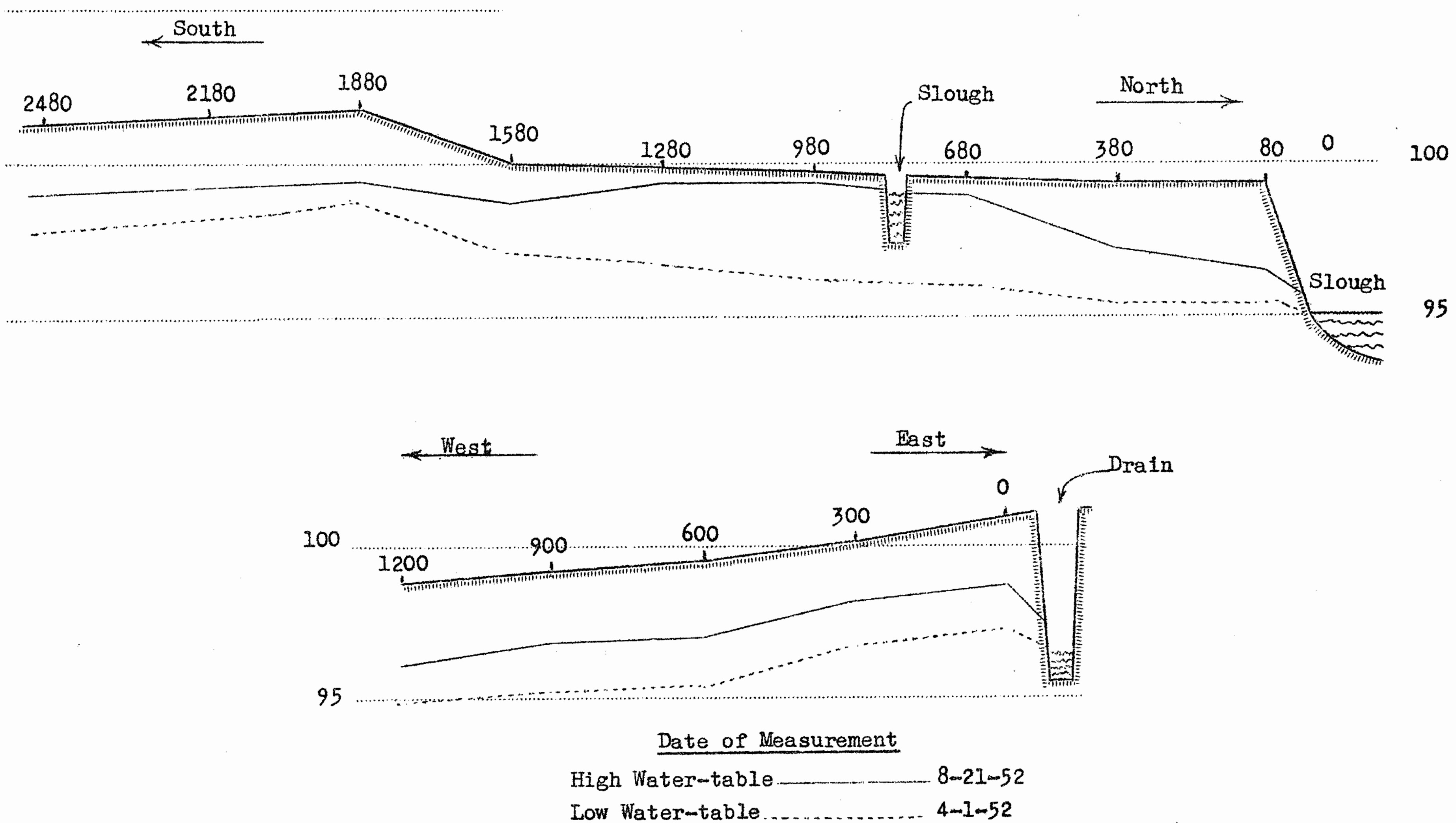
Open Drain

Ground-water Profile ....

Alkali Free - - - - - -
Slightly Alkali - - - -
Moderately Alkali - - -

FIGURE 32

RANCH "F"
GROUND-WATER PROFILE



The north-south piezometer line indicates that the ground water table during the high ground water period is due to seepage from sloughs and over-irrigation. The slough shown on the north-south line between stations 680 and 980 is recharged by irrigation waste water. If this slough was cleaned out and deepened, it would lower the ground water table in the center of the farm. During August 1952, the water table stood within a six inches of the surface at station 980 on the north-south line. During the low ground water period, the water table at this point dropped 3 feet.

The east-west piezometer line indicated better overall drainage on the north portion of the ranch. This area prior to drainage had a high water table under most of it. The major ground water source was cut off by the interceptor drain. The ground water table dropped about 1½ feet during the low ground water period.

Approximately one-third of the ranch was cropped during 1952. The crop production figures indicated a fairly good increase on the north third of the ranch. The first wild hay c rop was cut from the slightly alkali area. (See the alkali map on figure 31 for location) However, the general use of the southern two-thirds of the ranch during 1952 was for pasture.

Conclusions on Ranch "F"

1. The standing stagnant sloughs should be drained.
2. Waste ditches should be constructed to get the surface waste water off the farm as soon as possible.
3. The east-west slough between stations 680 and 980 on the north-south piezometer line should be cleaned, deepened and used as a drain. A tile drain would be very desirable as it would not take up farm land and hinder farming operations.
4. The drain on the east side of the ranch should be extended to the south boundary and the shallow open drain running along the south boundary should be connected to it.
5. A very high irrigation efficiency should be attained on the ranch. This would reduce the amount of water percolating to the ground water table.
6. Gypsum or other soil amendments will be required to reclaim the southern portion of the farm.

Ranch "G"

Ranch G is located in the artesian aquifer area at the western end of the Payette Valley. (See figure 8 for location) The soils are slowly to moderately permeable. The surface is slightly undulating and about half of the ranch is covered with a native vegetation.

Figure 33 shows a section of the ranch looking west from the north-south county road which divides the ranch. The area on the left of the picture is being used as hay and pasture land. During the 1952 season it produced 2760 pounds of alfalfa per acre. The area shown on the right of the picture is slightly to moderately alkali.

DRAINAGE INVESTIGATIONS
RANCH "G"

Emmett Valley
Gem County, Idaho

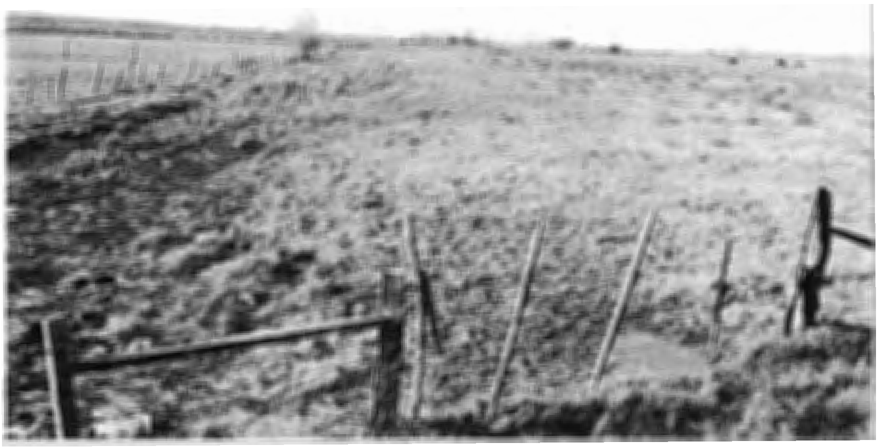


Figure 33. Looking west along proposed drain route from the north south road disecting the farm. Land on right side of the fence is strongly alkalin.

Figure 34. Looking north along section of drain that was installed during 1952. This section of drain is in slowly permeable soil.

AGR-SCS-PORTLAND, ORE. FEB. 1953

The slough in figure 33 will be eventually cleaned out, deepened and used as a drain to help reclaim the land shown, and to drain a standing swamp at the extreme east end of the ranch.

Figure 34 shows a section of the drain that was constructed during 1951. The section shown is in Reed silty clay loam soil.

Soils and alkali maps for the ranch are shown in figure 35. The soils are primarily Reed, Nolan, Letha and 91 series. The textures range from silty clays to loamy sands. The Reed soils are generally heavy to a depth of 15 feet or more before the gravel strata is encountered. Internal drainage is slow or very slow and makes drainage rather costly. The Nolan soils are slowly permeable; however, they are underlain with loose gravel or micaceous sand at a depth of four to six feet. The Letha soils are lighter surface texture and have a drainable gravel strata at depths of 2 to 5 feet. The drain location with respect to the soils and alkali is shown in figure 35.

The soils range from slightly to strongly alkali. The Reed soils that are moderately to strongly alkali are going to be very difficult and costly to reclaim.

Ground water observations were not made during 1952 due to a personnel shortage. However, it is anticipated that a ground water study will be made on the Reed soils during 1953.

The alfalfa adjacent to the drain showed a slight increase the first year following drainage. The area cropped produced 1660 lbs. of alfalfa per acre prior to drainage and 2160 pounds the first year following drainage.

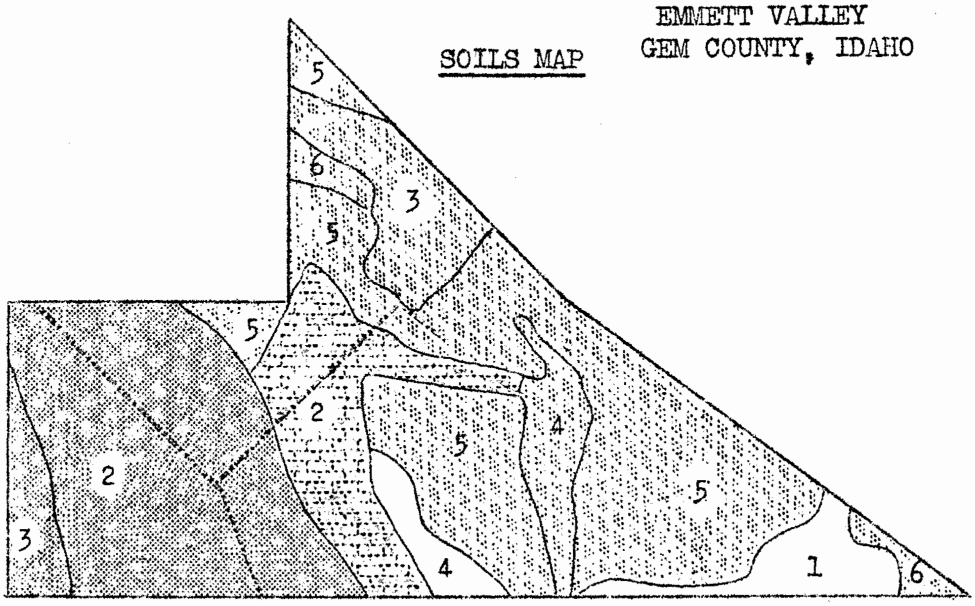
Conclusions on Ranch "G"

1. Reclamation of the moderately to strongly alkali Reed soils will be very difficult and costly.
2. Gypsum or other soil amendments will be necessary to reclaim the moderately to strongly alkali Letha soils.
3. The drain completed during 1951 should not be extended to the bog area at the east end of the ranch before arrangements are made to apply gypsum or some other soil amendment to the moderately and strongly alkali soils.

Summary of the Drainage Investigations to date

A summary of the water table information collected on the seven ranches investigated is given in table 4. The work done to date is not conclusive due to a lack of irrigation information on one-half of the soils studies and one-third of the farms studied still to be drained. Observations on the various ranches will be continued during the drainage investigation. The ground water elevations will be observed with piezometers and wells as the various ranches are drained, leveled and put into production.

FIGURE 35
RANCH "G"
EMMETT VALLEY
GEM COUNTY, IDAHO

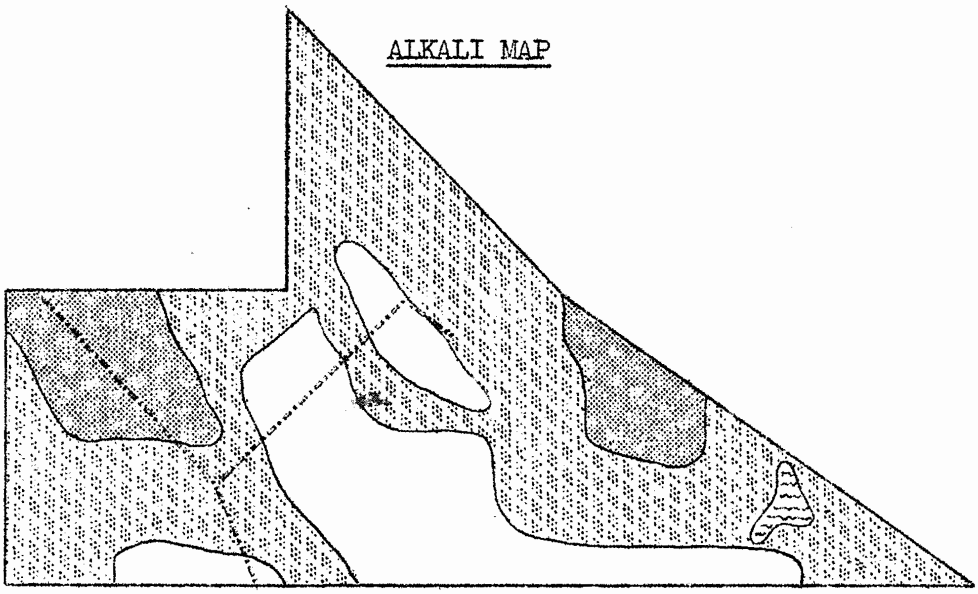


Soil Series

Letha - - - - - - - -
Reed- - - - - - - - -
Nolan - - - - - - - -
91 Series - - - - - -

Texture

1 - Silty Clay
2 - Silty Clay Loam
3 - Silt Loam
4 - Loam
5 - Fine Sandy Loam
6 - Loamy Sand



Slightly Alkali - - - - - - -
Moderately Alkali - - - - -
Strongly Alkali - - - - - -
Open Drain

Table 4. Water Table Elevations
For the Six Ranches Investigated

Ranch No.	Area	Soils: Series	Soils: Texture	Depth of drain	Dur. irrig	Maximum Water Table: Distance to max water table	Maximum Water Table: Distance from drain or slough to a drawdown of 4 ft	3 ft	2 ft	1 ft	Minimum Water Table: Distance to max water table	Minimum Water Table: Distance from drain or slough to a drawdown of 4 ft	3 ft	2 ft	1 ft
	Ac			ft.		ft.	ft.	ft.	ft.	ft;	ft.	ft.	ft.	ft.	ft.
A	80	6	SL	6.2	No	2	750	850	950	–	3	825	950	–	–
B	105	M	C–M	7.5	No	0.5	–	40	80	200	2	60	120	260	–
C	6	S	CL	–	No	1 Art.					2.5				
D	80	S	CL–L	6.0	Yes	1	20	60	133	533	4	150	–	–	–
E	20	6	CL–LS–GSL	–	Yes	0.7 Art.					1.4				
F	71	24	L–FSL–LFS	6.0	Yes	0.5	–	80	410	580	3	80	280	–	–

Soils

Series

6 – Letha
24 – Moulton
M – Muck
S – Snow

Texture

M – Slowly permeable Muck
C – Clay
CL – Clay loam
L – Loam
FSL – Fine sandy loam
SL – Sandy loam
LFS – Loamy fine sand
LS – Loamy sand
GSL – Gravelly sandy loam

The following tentative conclusions have been formed from the investigations to date.

1. The present drainage system is not adequate to completely reclaim any of the ranches investigated. Additional tile, open drains or wells will be required to complete the drainage job.

2. A rather close spacing of tile or open drains will be required to lower and maintain the ground water level at a safe depth of $4\frac{1}{2}$ feet. Drains $6\frac{1}{2}$ feet deep, spaced at 200 foot intervals will be required to adequately drain the slowly permeable soils and artesian areas similar to the muck soils investigated. This spacing of drains will expand to 7 or 8 hundred feet depending upon the depth to and the presence of the permeable gravel substrata.

3. A valley wide study of irrigation efficiencies and length of run for furrows and borders should be initiated. A high irrigation efficiency will keep the amount of water lost to the ground water table at a minimum and aid in the overall drainage problem.

Drainage Installation in the Emmett Valley, Idaho from 1927 to 1953

A summary of the open and tile drains installed in the Emmett Valley since 1927 is shown in table 5. During that period 100 miles or more of open drains were installed. Since 1944 drainage systems have been installed on at least 215 farms. There is one tile drain in the valley and no vertical drainage wells.

Crop Increases Due to Drainage and Reclamation

A summary of the crop production figures on the various ranches investigated is presented in table 6. Crop production on land used prior to drainage is also shown. It will be noted that the good crop increases were generally obtained on the alkali free or slightly alkali lands. Some of these lands were very wet and supported bogs or tule patches. All that was needed on the farms that responded rapidly was drainage. Very slight crop increases if any were obtained on the moderately to strongly alkali soils following drainage. Soil amendments will be required on these strongly alkali soils before significant increases in crop production will occur.

Table 5. Drainage Installations in the Emmett Valley, Idaho from 1927 to 1953.

Year	Individual Farm Drains	Drainage Installation					
		Tile Drains		Open Drains		Vertical Drains	
		Per Yr.	Total	Per Year	Total	Per Year	Total
	Number	Miles	Miles	Miles	Miles	Number	Number
1927-28				19.96	19.96		
- -				10.66	30.62		
35 -36				3.45	34.07		
38 -40				2.46	36.54		
44	8			4.06	40.60		
45	6			2.01	42.61		
46	24			8.24	50.85		
47	54			17.02	67.87		
48	39	0.15	0.15	9.17	77.04		
49	27			10.65	87.69		
50	40			6.72	94.41		
51	12			4.60	99.01		
52	4			0.99	100.00		

Table 6. Crop increases due to drainage and reclamation.

No.	Area	Open Drains	Drainage Cost	Soils			Farm		1949		1950		1951		1952	
				Series	Texture	Alkali	Leveled	Leached	Crop	Fert	Crop	Fert	Crop	Fert	Crop	Fert
	Ac.	Ft.	Dollars				–	–	Lb. ac.	Lb.ac	Lb.ac	Lb. ac.		Lb. Ac.	Lb .Ac	Lb.Ac
A	80	7340	3906	6	SL	F-S-M	–	No	P	–	P	–	P ▒	–	P	–
B	105	1186	1624	M-18-9	C-M	F-S-M	–	No	P	–	P	–	P ▒	–	P	–
C	6			S	CL	F	No	No	S	–	S	–	S	–	S	–
D	80	2804		S	CL-L	F	No	No		▒		–	C-8000	–	o-G 2820	M-light
E	20			6	CL-LS-GSL	S-M-H	No	No	P	–	P	–	P	–	P –	–
F	12.3	2030	843	24	LFS		slight	No	P		P	–	U-0.67 ▒		A-3740	–
F	12.9			24	L		Yes	No			C-1000	N-200	G-3030 ▒	N-150	A-3720	–
F	6.8			24	FSL		Yes	No	A-8000	–	A-8000	–	A-8000 ▒	–	G-18000	N-150
F	6.9			24-7	L-FSL-LFS		Yes	No			0-1600	–	G-3030 ▒	–	0-1600	N-150
F	32.2			24-6	FSL-LFS		No	No					U-0.67 ▒	–	U-0.67	–
G	24	1200	444	21-18	SCL	S-M-H	Yes	No	P	–	C-1240	–	A-1660 ▒	–	A-2160	–
H	280			6	L-SL	M	No	No	P	–	P	–	P	–	P	–
I	160			21	SC-SCL	H	No	No	P	–	P	–	P	–	P	–
J	2	800	144	24-39	SL	F	Yes	No	S	▒ –	0-2560	–	A-1000	–	A-10,000	M-ligh
J	5			M-39	SL	F	Yes	No	S	▒ –	0-1600	–	A-1600	–	C-4000	M-ligh
J	7			M-39	SL	F	Yes	No	S	▒	C-10,000	–	A-7428	–	A-12,000	M-ligh
J	16			M-39	SL	F	Yes	No	S	▒ –	0-1600	–	0-1600	–	0-960	M-ligh

Legend

Soils

Series
6 - Letha
7 - Emerson
9 - Cannon
18- Nolan
21- Reed
24-Moulton
39-39 Series
M - Muck
S - Snow

Texture
M - Slowly permeable
C - Clay
SC - Silty Clay
SCL- Silty Clay Loam
CL - Clay Loam
L - Loam
FSL - Fine Sandy Loam
LS - Loamy Sand
GSL - Gravelly Sandy Loam

Alkali
F - Alkali free
S - Slightly alkali
M - Moderately alkali
H - Strongly alkali

Crop
A - Alfalfa
B - Barley
C - Sweet corn
G - Grain
O - Oats
P - Pasture
S - Swamp
U - Animal Units per acre

Ferterlizer
M - Manure
N - Ammonium Nitrate

▒ _ Drainage Installed

Alkali Reclamation Investigations

An investigation to determine the effect of various leaching waters and various amounts of soil amendments on the alkali soils in the Emmett Valley was initiated during the past year. Three types of leaching water was used during the investigation. These types available for large scale use were river water, drainage water and artesian water. Various applications at the rate of 5 and 10 tons of gypsum per acre were used for the soil amendments. Checks were made on soils having no soil amendments added.

Twelve inch long sections of steel well casing were used to form the check plots. These sections of well casings were driven seven inches into the soil. This left five inches of ring above ground to act as a leaching pond well. The various types of leaching water and amounts of soil amendments were applied to the soil inside these rings.

Eighty-one rings were installed on three of the most typical alkali problem areas. Twenty-seven rings were installed in a slowly permeable strongly alkali soil. Two other sets of 27 rings each were installed in moderately permeable and alkali soils. Rings with a welded, leak proof, bottom were installed at each set of ring locations. These rings were used as evaporation pans and rain gages.

The following observations and records were obtained on the ring studies:

1. Inches of water applied
2. Water and soil temperature at a depth of approximately one inch below the soil surface in the rings.
3. Barometric pressure at the time of measurements
4. Evaporation during the measurements and an aggregate or total evaporation during the period of leaching
5. Intake rates
6. pH readings of the soil surface and leaching water during each run (2)
7. Aggregation of the soil in the rings following leaching periods.
8. Soil structure during the investigation
9. Soil workability during the investigation
10. Visible gypsum between leaching periods.
11. Pentrometer or Proctor needle readings between leaching periods

Chemical analysis of the river, drain and artesian waters used in the investigation

A chemical analysis of the various reclamation waters used in the rings is presented in table 7. The analysis was made by Dr. V. C. Bushnell of the U. S. Bureau of Reclamation. A summary and several computations made from the analysis in table 7 is shown in table 8. The last column in table 8 indicates that 0.6 of a pound of usable gypsum is applied to the soil in one acre foot of river water. 397 pounds of

Table 7. Chemical analysis of the river, drain and artesian waters used in the Alkali Reclamation Investigations. 1/

April 24, 1952

Sample No.	pH	$ECx10^5$ at 25°C	Boron p.p.m.	Anions, m.e./l CO_3	HCO_3	CL	SO_4	Cations, m.e./l Ca	Mg	Na	K	Residual Na_2CO_3 m.e./l	Percent Sodium Found	Possible	Salinity Laboratory Rating
1 2/	7.50	12	0.23	0.00	0.91	0.03	0.78	0.48	0.16	0.45	0.06	0.27	39.1	100	Good
2 3/	7.70	65	0.07	0.00	4.36	0.46	2.00	1.69	0.63	3.84	0.14	2.04	61.9	100	Doubtful
3 4/	7.97	44	0.25	0.00	2.97	0.44	1.17	2.73	0.17	1.47	0.04	0.07	33.3	100	Good

1/ Analysis by the U. S. Bureau of Reclamation
2/ Payette River water - Sec. 31, T. 7N. R 2W., 4/22/52
3/ Forgy drain water - Sec. 31 T 7N R 2W., 4/22/52
4/ Soulen artesian water - Sec. 36, T. 7N., R 3W., 4/22/52

Table 8. Percentages of various anions, cations and available gypsum in the river, drain and artesian waters used in the Alkali Reclamation Investigations, Emmett Valley, Idaho

Sample No.	HCO	CL	SO_4	Ca	Na	Total Ca SO_4	Total Ca SO_4	Ca excess over Na	Effective gypsum in one ac. foot of water
	o/o	o/o	o/o	o/o	o/o	P.P.M.	Lb/Ac.ft.	P.P.M.	Lb/Ac. Ft.
1	53	2	45	42	39	33	88	0.06	0.6
2	64	7	29	27	61	101	274	- 43	-397
3	65	10	26	62	33	186	500	25	233

gypsum will be required to counteract the effect of an acre foot of drain water. However, with the application of one acre foot of artesian water, 233 pounds of usable gypsum is applied to the soil. This is a very significant difference and shows up in the field work presented later in the report.

The chemical analysis data from table 7 is shown in figure 36 on a Geochemical chart. The plotted percentages of anions and cations are merged together and give the sample locations on the chart. The shaded portion of the diagram designates good irrigation water and the area outside the smaller shaded diamond is generally classified as irrigation sewage and unfit for use as irrigation water. The artesian water rates the highest on the chart, the river water is second and the drain water rates as unsatisfactory. The Payette River water plots fairly close to the borderline between good and poor irrigation water.

Electrical conductance fluctuations of the various leaching waters during the investigation.

Water samples were run on a conductance bridge for the various river, drain and artesian waters. This was done to determine the fluctuation or trends in the saline concentration during the investigation. The electrical conductance at various times during the investigation is presented in table 9.

The electrical conductance for the artesian water remained fairly constant; however, the river and drain water had considerable fluctuation. The river was high during May and June and tapered to a low during September. The drain water was high during April and low during September. This low period during September was due to surface waste water diluting the drain water.

Table 9. Electrical conductance ($k \times 10^5$ at $25^\circ c$) of the various leaching waters applied during the 1952 alkali reclamation investigations.

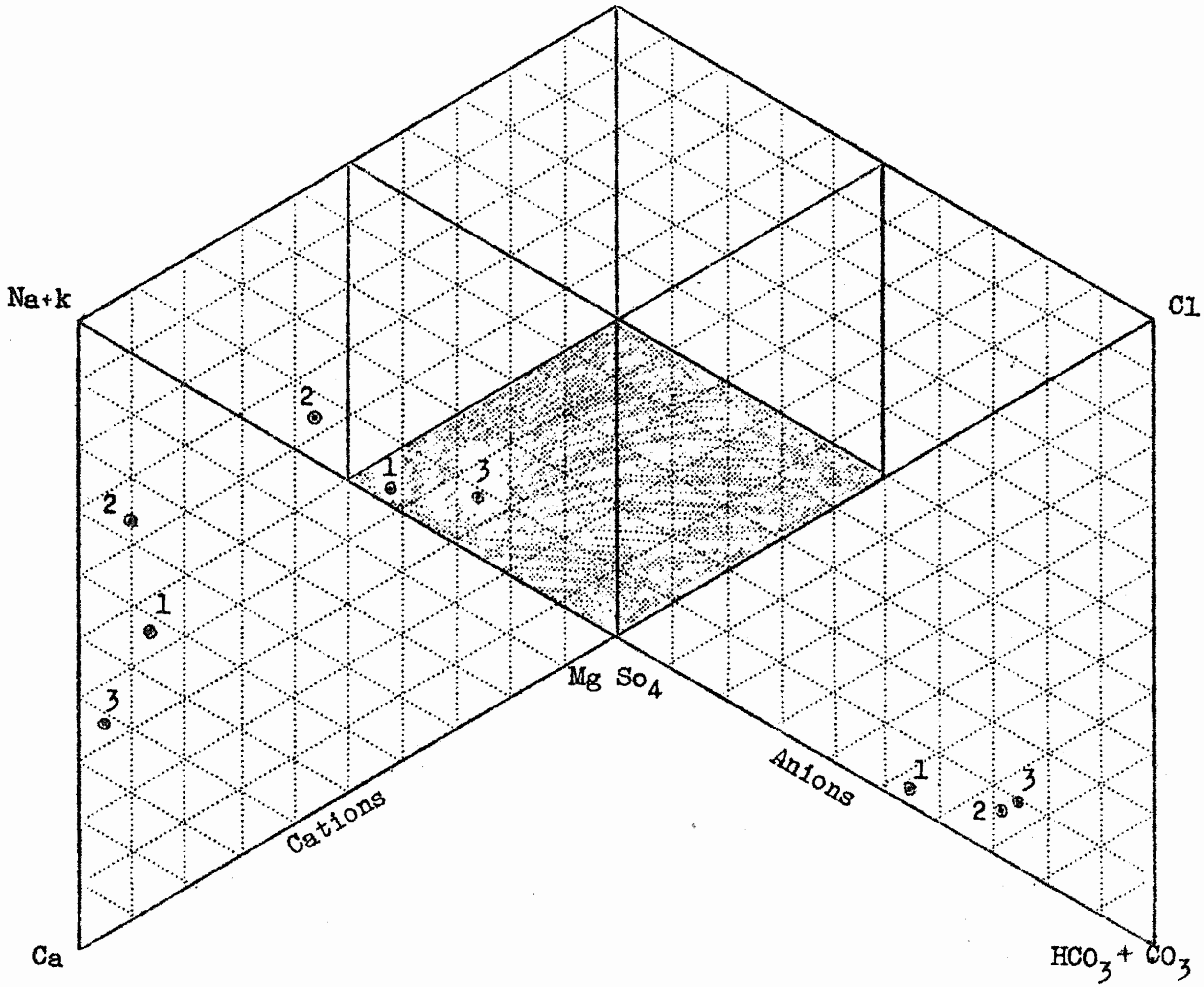
	4/18	4/23	4/24	5/5	6/11	6/17	6/19	9/8	9/9
River	12	11	12	19	26	10	13	5	7
Drain	61	67	64	36	54	34	31	22	23
Art.	37	43	44	43	49	56	53	46	41

The artesian water was lower during the winter months and higher during the summer. The drain water fluctuation should have a noticeable effect upon the results of the rings the drain water is used in.

- 72 -

FIGURE 36

GEOCHEMICAL CHART
WATER SAMPLES FROM
EMMETT VALLEY
GEM COUNTY, IDAHO



LEGEND

Payette River Water	1
Porgy Drain Water	2
Soulen Art. Water	3

Ranch "I" Alkali Reclamation Investigation

Ranch "I" is located in the eastern end of the Emmett Valley on one of the old undulating terraces adjacent to the Payette river. (See figure 8 for ranch location) The soils are strongly alkali and silty clay to a depth of 10 to 20 feet. The soils respond very slowly to tile or open drains and require considerable gypsum or other soil amendments to effect a complete reclamation. Reclamation on this ranch has been very costly and has proven very unsatisfactory to date.

Infiltrometer ring layout: The infiltrometer ring layout and a general view of the farm are shown in figure 37. The rings were installed about 50 feet from a six foot open drain. This drain maintains a sufficiently low water table under the rings to permit reclamation with soil amendments. The rings were also located in an area that was completely devoid of any pasture or native weeds. When water is applied to this barren spot a black crayon color or scum forms on the surface or evaporation edges of the wet area. The ranch is used as a part time pasture during the year. The pasture is very spotty and varies from absolutely barren areas to some small areas that have very poor pasture growth.

The infiltrometer ring layout, the rings using river, drain, and artesian water, and the amount of gypsum applied to each ring is shown in figure 38. River water was applied in the upper left nine rings, drain water in the upper right nine rings, and artesian water was applied in the lower center nine rings. The tons of gypsum per acre that were applied to each ring are shown by the number immediately above each ring. This layout of 27 rings gave three replicates of each treatment. The rings were not all the same size and were installed so that there was an equal number of large, intermediate, and small rings for each treatment and set of replicates. The evaporation ring shown on figure 38 consisted of a 12 inch long section of 12 inch diameter well casing with a plate welded in the bottom. The ring was used as a combination evaporation pan and rain gage.

Ranch "I" soils at the plot location: The general valley soil survey shows the Reed soils are very slowly permeable to a depth of fifteen feet or more. A ten foot soil survey at the plot location is presented on a Soil Profile Chart, figure 39. The soils were found to be silty clay loam and clay to a depth of 10 feet. Two thin hard crumbly fractured clay strata were found at 3.6 and 8.2 feet. A fairly large quantity of ground water was being carried in the fractured clay strata. The water table was measured at 3.6 feet which indicated the strata was not under pressure at this location in the field.

A pH reading with a color indicator (Thymol Blue) was made at each six inch interval and soil change for the 10 foot soil log. The pH was found to be very high at the surface, but was below 8.5 at a depth of three feet. The pH was very low for the remainder of the 10 feet. The pH also indicates that the alkali is concentrated in the upper one to two feet of soil.

ALKALI RECLAMATION INVESTIGATIONS
RANCH "I"

Emmett Valley
Gem County, Idaho

Figure 37. Looking north over the Ranch "I" alkali reclamation plot. The soils are silty clay to 10 feet and strongly alkalin in the top two feet.

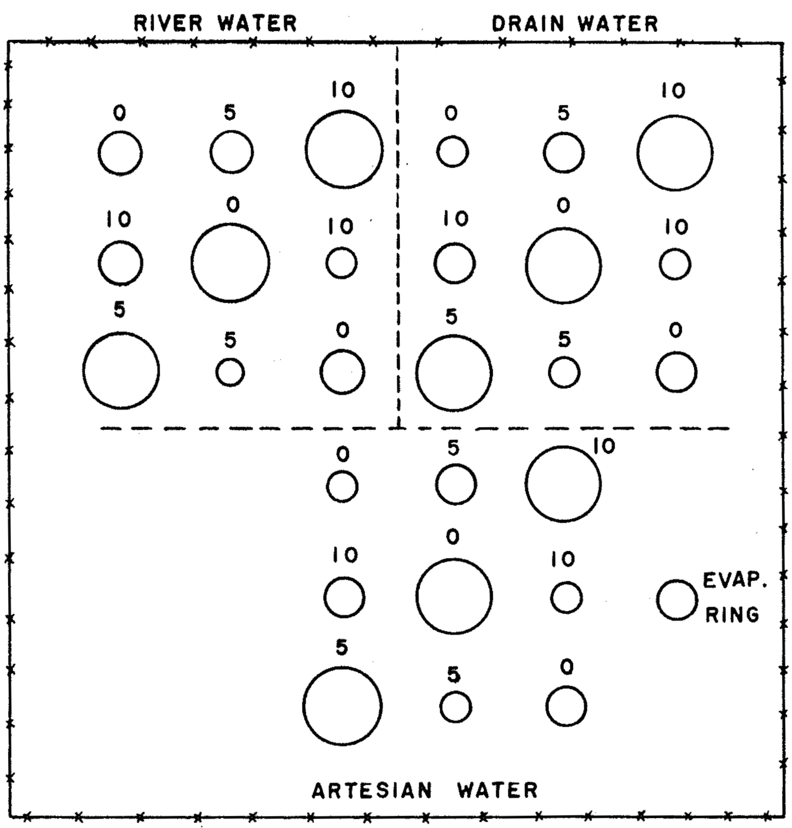


Figure 38. Infiltration Ring layout on the Ranch "I" plot. Numbers refer to the tons of gypsum applied per acre.

U. S. DEPARTMENT OF AGRICULTURE
Soil Conservation Service

SOIL PROFILE CHART

For Drainage Investigations

1 - Clay
2 - Silty clay loam
3 - Clay loam
4 - Silt loam
5 - Loam
6 - Sandy loam
7 - Loamy fine sand
8 - Sand
9 - Coarse sand and fine gravel
10 - Coarse gravel
11 - Cobble

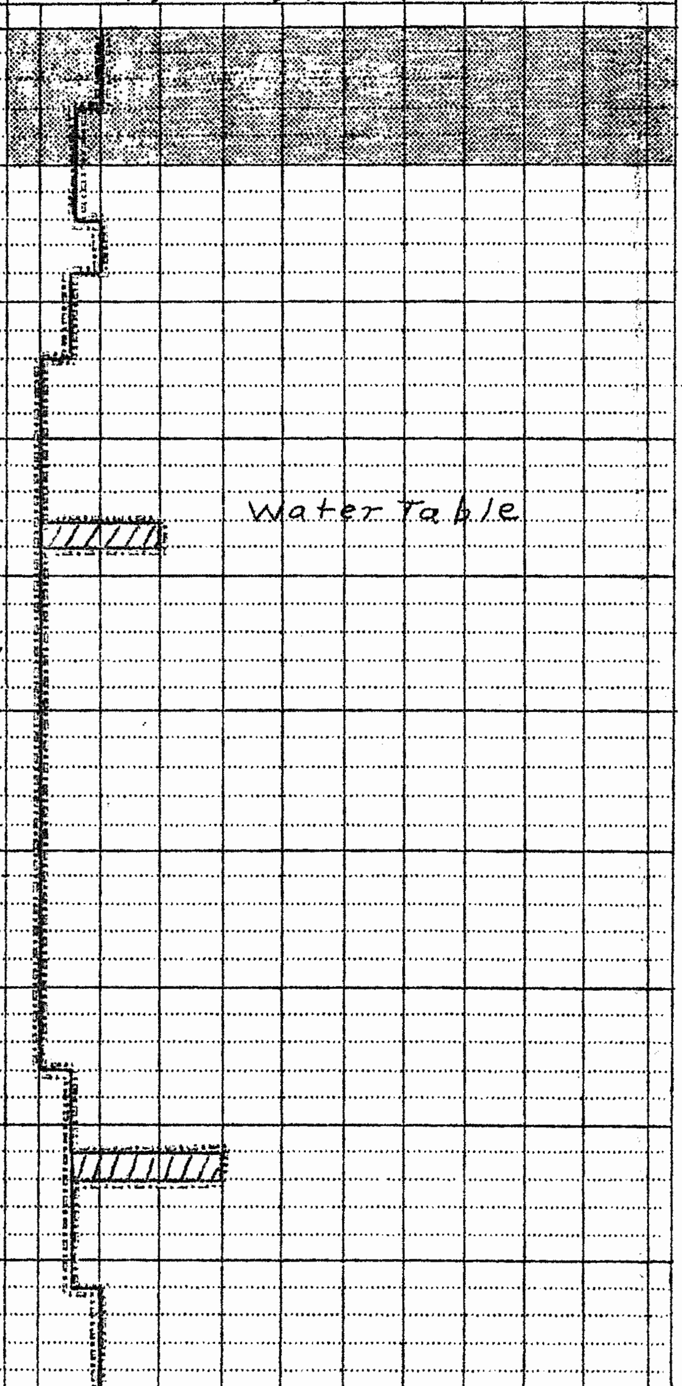
Property *Ranch "I" Alkali Reclamation Plot*

Boring No. */* Land Use *Grazing* Crop Condition *None*

Technician *G.B.B.* Date Survey *1-22-53* Symbol *Reed*

Depth in Feet	Texture	Special Features
0.0		
		pH 9.6
		pH 9.2
		pH 9.2
1.0	SiC	pH 9.4 Roots
		pH 8.7 Moist
	SiCL	
2.0		pH 8.6 Crumbly
	SiC	
		pH 8.4
	clay	pH 8.5
		pH 8.6
3.0		pH 8.3 Small Root
		pH 8.2 {Hard Crumbly
	Clay	pH 8.2 {fractured
4.0		pH 8.2 {Clay
		Water
		Slushy
		pH 8.3 Darker Brown
5.0		pH 8.3
		pH 8.3
		Very plastic
6.0	Clay	pH 8.3
		pH 8.3 Brown stain
7.0		pH 8.2
		pH 8.2 Slightly
	SiC	Motled
8.0		pH 8.2 Fairly Dry
	Clay	pH 8.2 Fract. Clay
9.0		pH 8.2
		pH 8.2
	SiCL	pH 8.2

Permeability: Slow (1, 2) | Moderate (3, 4, 5) | Rapid (6, 7, 8) | Very Rapid (9, 10, 11)



A sample "Ring Infiltration Test" sheet for ring number 14 is shown in figure 40. The pH was run on the soil prior to leaching, on the water in the ring during the leaching, and on the soils during the drying period. The gallons of water applied, the inches of rain, and other pertinent data is recorded under the remarks column.

Soil aggregates formed in the infiltration rings during drying: During the drying between leaching periods, it was observed that the soils in the various rings cracked into aggregates or clods. It was also observed that the number of aggregates correlated very closely to the type of water used in the rings and the amount of soil amendment added to each ring. The aggregates formed following the first leaching period are presented in figure 41. The top set of pictures were obtained from the rings having no soil amendments added and the bottom set were obtained from the rings having a gypsum application of 10 tons per acre. The upper set of rings show an interesting indication. The ring using river water had no aggregates, the one using drain water had one large crack through the center, and the ring using artesian water had four large distinct cracks in it. The rings having a 10 ton application of gypsum showed comparable results.

A summary of the aggregates following the first, second, and third leaching periods are given in table 10. The aggregate numbers shown are an average of the three replicates for each treatment.

Table 10. Summary of the aggregates in the Ranch "I" infiltration rings, following the first, second, and third leaching periods.

Type water used	Gypsum applied per acre	Following the first leaching period 6-22-52	Following the second leaching period 7-29-52	Following the third leaching period 10-20-52
	Tons	Aggregates	Aggregates	Aggregates
River	0	1	1	1
	5	4	3	1
	10	8	7	4
	Total	13	11	6
Drain	0	1	3	2
	5	4	4	2
	10	9	7	4
	Total	14	14	8
Artesian	0	1	4	3
	5	10	3	4
	10	6	7	4
	Total	17	14	11

FIGURE 40

RING INFILTRATION TEST

No. 14

Farm Ranch "I" Installed 4/14/52 By G.B. Bradshaw

Location Emmett Valley Idaho Size 18 Inch

Soil type Silty Clay Water used Drain

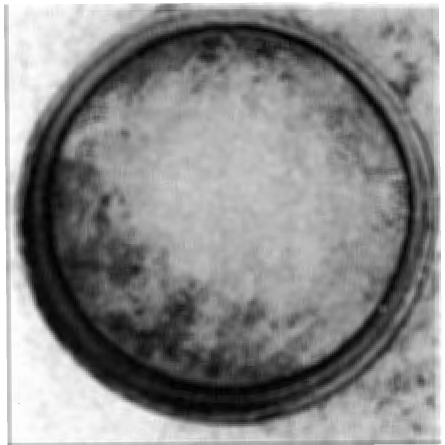
Crop Condition None Amendment None

1952

Mo.	Day	Time	Elapsed time Minutes	Depth to water Inches After filling	Depth to water Inches Before filling	Intake during period Inches	Rate per hour Inches	Water temp. F.	Baro. pressure Ft.	Ph soil	Remarks
9	8									9.6	
		1420		7.05				73	2215	8.4	9 gal.
		1620	120		6.77	0.28	0.12	78	2270		Applied
	9	1300			6.00	0.77		65	2241	8.7	
		1612	200		5.88	0.12	0.02	66	2200		
	10	1040			5.52	0.36		59	2332		
		1635	355		5.28	0.24	0.02	75	2450	8.7	
	11	1135			4.98	0.30		64	2370		
		1420	165		4.99	0.01	0.01	69	2307	8.6	0.02 Rain
		1510		6.70							2 gal.
	23	1000			2.91	3.71				9.3	
	25				Water					9.2	
	29				Water					9.2	
10	1				Dry					9.2	
	3									9.4	
	14									9.6	
	20									9.6	
											11 Gal Applied

Figure 41. Infiltration Ring aggregates on the Ranch "I" alkali reclamation plot following the first leaching period. (June 11, 1952)

No gypsum applied to rings

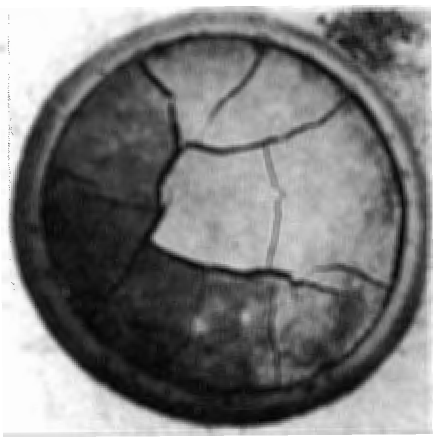


River Water

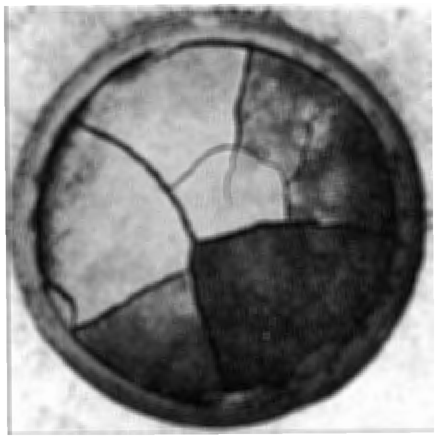
Drain Water

Artesian Water

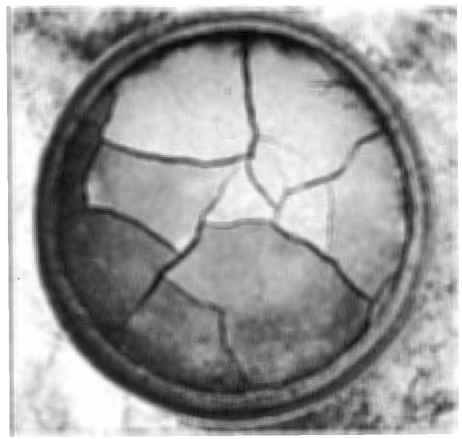
10 Tons of gypsum per acre applied to rings



River Water



Drain Water



Artesian Water

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The aggregate totals shown in table 10 indicates that the drain and artesian water have a more pronounced effect upon the structure of the soil than the river water has. Comparison of the soils having no soil amendments added indicates that the river water has very little effect upon the aggregation of the soils, the drain water is second and the artesian water has the greatest effect upon aggregation. It also appears that the gypsum is being used up and the structure temporarily created in the soils by the application of gypsum is being lost. One interesting point obtained from the table is that some structure is being built up by the drain and artesian water without the application of gypsum.

Structure, workability and visible gypsum: A summary of structure, workability and visible gypsum following the three leaching periods is presented in table 11. The observations were made in the field, visually and with respect to working the soil in the various rings with a 3/4 inch wood chisel.

Table 11. Summary of structure, workability and visible gypsum following the three leaching periods on the Ranch "I" Investigation.

Water used 1952	No gypsum applied to soil			5 Tons of gypsum per acre			10 Tons of gypsum per acre		
	1st 6/11	2nd 7/31	3rd 10/20	1st 6/11	2nd 7/31	3rd 10/20	1st 6/11	2nd 7/31	3rd 10/20/52
				Structure					
River	poor	poor	poor	fair	fair	poor	fair	fair	poor
Drain	poor	poor	poor	fair	poor	poor	fair	good	fair
Artesian	poor	poor	poor	fair	good	fair	fair	good	fair
				Workability					
River	hard	hard	hard	mod.	mod.	mod.	easy	easy	mod.
Drain	Mod.	hard	hard	mod.	mod.	mod.	mod.	easy	easy
Artesian	Mod.	Mod.	hard	easy	mod.	mod.	mod.	easy	easy
				Visible Gypsum					
River	-	-	-	mod.	trace	none	consid.	trace	trace
Drain	-	-	-	mod.	trace	none	consid.	mod.	trace
Artesian	-	-	-	mod.	trace	trace	consid.	mod.	trace

Analysis of table 11 indicates that some structure is being developed in the slowly permeable soils with an application of 10 tons of gypsum per acre. It would appear, however, that the structure degenerated during the third leaching period. The application of gypsum had a marked effect upon the workability of the soil. The check plots, with no gypsum applied remained hard to work after the three leaching periods. The rings having an application of five tons of gypsum per acre worked up moderately. The rings having an application of 10 tons of gypsum per acre worked up easily. It would appear that the soil structure decreased and the workability increased as the gypsum applied to the soil was used up.

Proctor needle tests: A series of 10 tests were made in each ring with a Proctor needle, Pentrometer , following the 2nd and 3rd leaching periods to determine the bearing in pounds per square inch for the soils under the various treatments. This makes 30 replicates for each treatment shown. A summary of the pentrometer data is presented in table 12.

Table 12. Summary of the Proctor Needle data following the second and third leaching periods on the Ranch "I" investigations.

Water applied	Gypsum applied	Proctor Needle value following the 2nd leaching period 7/31/52	Proctor Needle value following the 3rd leaching period 10/20/52
	Tons/ac.	Lb. sq. in.	Lb. sq. inc.
River	0	3047	2185
	5	1911	2164
	10	2222	1853
Drain	0	3409	2317
	5	1911	2056
	10	1704	1881
Artesian	0	3099	2150
	5	1911	2014
	10	1859	1888
Ground surface outside the rings		2051	2604

The three different waters used give very similar results. The drain water without gypsum gave slightly higher values than the river or artesian waters. A considerable reduction in bearing load was recorded between the 0,5 and 10 ton applications of gypsum. The rings without gypsum showed approximately a 33% reduction in bearing load between the second and third leaching period.

Intake rates: A summary of the intake rates for the three leaching periods are presented in table 13. The intake rates have been corrected for evaporation and a viscosity correction has been applied to convert the intake rates to a standard temperature of 60 degrees Fahrenheit.

The final intake rates indicate a slightly higher intake for both the river and artesian waters on the rings having no gypsum applied. The final intake rate for the rings using artesian water and having 10 tons of gypsum applied to the soil was double the rates for the river or drain water with 10 tons of gypsum.

The intake rates are still very low and will make reclamation very long and costly.

Table 13. Summary of the intake rate data for the 1st, 2nd, and 3rd leaching periods on the Ranch "I" investigation. 1/

Water applied	Gyp. appl.	First Leaching Period							Second Leaching Period					Third Leaching Period		
		4/22	4/24	4/25	4/28	5/2	5/5	5/9	6/11	6/12	6/13	6/17	9/8	9/9	9/10	9/11
	T/ac.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.
River	0	0.04	0.02	0.01	0.00	0.00	0.01	0.01	0.04	0.02	0.01	0.02	0.08	0.02	0.02	0.02
	5	0.07	0.03	0.01	0.02	0.01	0.02	0.01	0.06	0.02	0.01	0.03	0.11	0.03	0.03	0.02
	10	0.06	0.03	0.02	0.01	0.01	0.02	0.01	0.05	0.02	0.02	0.03	0.11	0.04	0.04	0.03
Drain	0	0.06	0.03	0.00	0.00	0.00	0.01	0.00	0.03	0.01	0.02	0.09	0.02	0.02	0.02	0.01
	5	0.10	0.03	0.03	0.02	0.01	0.02	0.01	0.06	0.02	0.02	0.02	0.10	0.02	0.02	0.01
	10	0.10	0.03	0.03	0.03	0.01	0.02	0.01	0.09	0.03	0.03	0.06	0.13	0.06	0.05	0.03
Artesian	0	0.03	0.02	0.01	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.02	0.08	0.02	0.02	0.02
	5	0.10	0.03	0.03	0.02	0.01	0.02	0.01	0.06	0.02	0.01	0.02	0.13	0.03	0.03	0.02
	10	0.07	0.03	0.02	0.02	0.01	0.02	0.01	0.13	0.03	0.02	0.04	0.15	0.07	0.06	0.06

1/ The intake rates have been corrected for evaporation and to a standard temperature of 60 degrees Fahrenheit.

Table 14. Summary of the pH values on the Ranch "I" investigation from April 22 to October 20, 1952.

Water applied	Gyp. appl.	First Leaching Period (Dates)								Dry	Second Leaching Period			
		4/22	4/25	4/30	5/2	5/5	5/9	5/14	5/19	6/11	6/12	6/13	6/16	6/17
River	0	9.6+	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
	5	9.6+	8.6	8.6	8.7	8.6	8.7	8.4	8.3	8.5	8.2	8.2	8.5	8.4
	10	9.6+	8.4	8.9	8.7	8.7	8.7	8.3	8.3	8.5	8.1	8.1	8.5	8.3
Drain	0	9.6+	9.2	9.5	9.4	9.5	9.5	9.6	9.5	9.6	9.2	9.1	9.1	9.1
	5	9.6+	8.6	9.0	8.9	8.6	9.1	9.0	8.9	8.6	8.5	8.5	8.8	8.8
	10	9.6+	8.5	8.7	8.5	8.2	8.7	8.7	8.7	8.4	8.3	8.3	8.3	8.4
Artesian	0	9.6+	9.5	9.3	9.6	9.5	9.6	9.6	9.6	9.6	9.6	9.3	9.4	9.3
	5	9.6+	8.4	8.5	8.4	8.5	8.3	8.5	8.5	8.6	8.4	8.2	8.3	8.3
	10	9.6+	8.1	8.1	8.1	8.1	8.1	8.1	8.4	8.3	8.3	8.1	8.2	8.2

1/ The pH values shown are an average of three replicates.

Table 14 (continued). Summary of the pH values on the Ranch "I" investigation from April 22 to October 20, 1952.

Water applied	Gyp. appl.	6/19	6/20	6/23	6/24	6/25	6/26	6/27	6/30	7/7	7/31	9/8	9/9	9/10
		Second Leaching Period										Third Leaching Period		
River	0	9.5	9.6	9.6	9.6	9.6	9.6	9.6	9.5	9.5	9.4	8.7	9.1	9.2
	5	8.6	8.5	8.8	8.6	8.4	8.4	8.6	8.3	8.4	8.4	8.2	8.3	8.3
	10	8.6	8.5	8.4	8.4	8.3	8.3	8.2	8.2	8.3	8.1	8.1	8.1	8.2
Drain	0	9.2	9.1	9.1	9.1	9.0	9.0	9.1	9.1	9.4	9.3	8.5	8.7	8.7
	5	9.0	9.2	8.9	9.0	8.9	8.8	8.9	8.8	8.6	8.4	8.4	8.4	8.5
	10	8.8	8.5	8.3	8.3	8.3	8.2	8.2	8.3	8.3	8.2	8.3	8.3	8.5
Artesian	0	9.3	9.5	9.6	9.6	9.5	9.6	9.6	9.6	9.5	9.3	8.6	8.7	8.9
	5	8.5	8.3	8.5	8.4	8.5	8.4	8.5	8.3	8.4	8.2	8.3	8.3	8.3
	10	8.3	8.3	8.3	8.3	8.4	8.4	8.5	8.3	8.2	8.2	8.2	8.3	8.4

		Third Leaching		Drying Period					
		9/11	9/23	9/25	9/29	10/1	10/3	10/14	10/20
River	0	9.4	9.0	9.2	9.4	9.5	9.4	9.5	9.5
	5	8.3	8.4	8.5	8.4	8.5	8.5	8.5	8.5
	10	8.3	8.3	8.4	8.2	8.2	8.3	8.3	8.3
Drain	0	8.7	8.8	8.9	9.2	9.3	9.4	9.4	9.5
	5	8.7	8.7	8.7	8.6	8.7	8.7	8.5	8.6
	10	8.7	8.2	8.4	8.2	8.3	8.2	8.4	8.2
Artesian	0	9.1	9.2	9.3	9.3	9.4	9.4	9.6	9.3
	5	8.2	8.4	8.5	8.5	8.5	8.5	8.5	8.6
	10	8.0	8.2	8.3	8.2	8.2	8.3	8.4	8.1

pH values: A summary of the pH values from April 22 to October 20, 1952 on the Ranch I alkali reclamation plot is presented in table 14. The pH values shown in table 14 are an average of three replicates. The pH values were obtained on the soil surface in the rings during the drying periods and the pH of the leaching water was obtained during leaching periods. The pH values were obtained with Thymol Blue (Color Indicator)

The pH values compare very favorably with the amount of gypsum applied to the soil in the rings. The final pH values compare very closely between the rings using river, drain and artesian water. The average pH of the soil in the rings having no gypsum applied runs about 9.5, in the rings having 5 tons of gypsum added to the soil, it is about 8.6 and the rings having 10 tons added, the pH is about 8.2. An interesting trend occurred in the series of tests over the period from April 22 to October 20. The pH in the rings using river and drain water and having a 10 ton application of gypsum dropped very slowly during the study. They had a final pH of 8.2 to 8.4. The average pH on the rings using artesian waters and having a 10 ton gypsum application dropped from 9.6+ to 8.1 immediately. The pH average increased to about 8.4 during the second leaching period and then dropped again at the end of the season.

A plotting of the pH values during the study are presented on figure 42. The pH values were fairly well jumbled up during the three leaching periods, but ended in three definite groups following the third leaching period.

The pH values of the rings having no gypsum applied to the soil ended with 9.3 to 9.5, the soils having a 5 ton gypsum application, ended at 8.5 to 8.6, and the soils having a 10 ton application ended at 8.1 to 8.3.

Depth of water applied: A summary of the depth of water applied during the three leaching periods is presented in table 15. The inches of water shown in table 15 are the differences between the depths applied and the evaporation during the leaching period. An intake rate figure cannot be computed directly from the inches of water applied and the length of leaching period because of different drying times at the end of the leaching periods and some of the rings went dry during the leaching periods.

FIGURE 42

SUMMARY OF THE pH VALUES ON THE RANCH "I" INVESTIGATION FROM APRIL 22 TO OCTOBER 20, 1952.

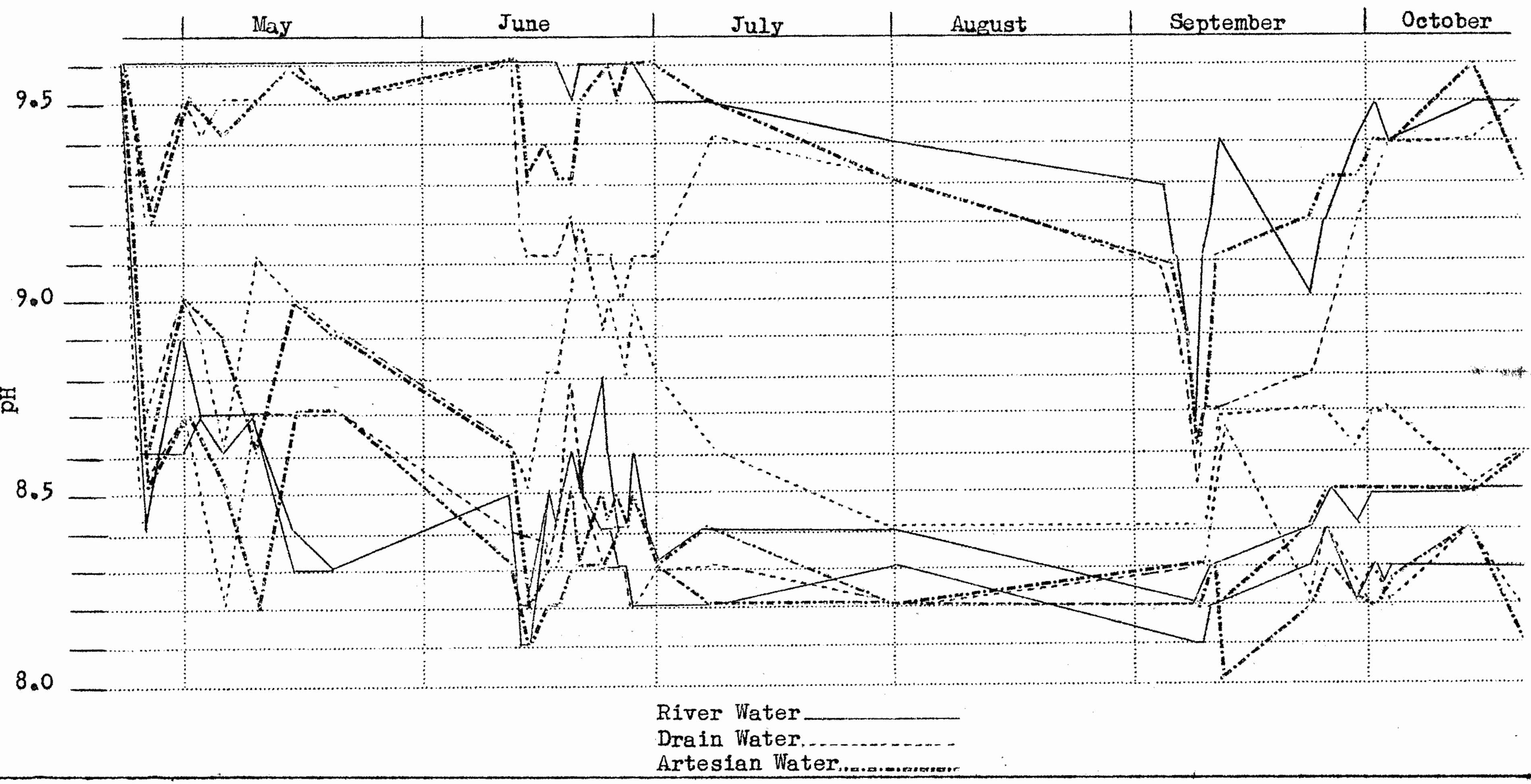

Table 15. Summary of water applied to the various treatments in the Ranch "I" alkali reclamation rings.

Water applied	Leaching period No.	No gypsum applied In. water	5 tons of gypsum per acre In. Water	10 tons of gypsum per acre In. water
River	1st	3.6	7.8	8.6
	2nd	2.7	7.0	5.9
	3rd	4.4	6.7	6.3
	Total	10.7	21.5	20.8
Drain	1st	4.3	10.4	12.0
	2nd	2.2	5.2	9.7
	3rd	5.6	5.6	8.5
	Total	12.1	21.2	30.2
Artesian	1st	2.8	9.1	8.4
	2nd	1.4	5.2	8.6
	3rd	4.7	5.4	7.9
	Total	8.9	19.7	24.9

1st leaching period had an average 30 day duration
2nd leaching period had an average 22 day duration
3rd leaching period had an average 21 day duration

Summary of the Ranch "I" alkali reclamation study:

1. The Reed soils are slowly permeable to a depth of 15 feet or more.

2. The soil profile is strongly alkali in the top foot, moderately alkaline in the second and third foot and alkali free below three feet.

3. Ground water is moving laterally in a fractured clay strata at a depth of $3\frac{1}{2}$ feet.

4. The drain and artesian water tend to aggregate the soil without the application of gypsum.

5. The aggregation in the soils having gypsum applied decreased with each leaching period. This was evidently due to the gypsum being used up in the soil.

6. The structure and workability of the soil was initially improved, but was decreasing at the end of the third leaching period.

7. The application of 5 and 10 tons of gypsum decreased the bearing load of the soil about 6 and 15 percent. The pentrometer test is a very good indication of workability and structure in the soil.

8. The artesian water with ten tons of gypsum applied to the soil gave the highest intake rate. It was about twice the intake rate of the river and drain water. The intake rate increased with each leaching period.

9. The pH observations indicate very beneficial results from the application of gypsum. Five tons of gypsum gives comparable results with 10-ton applications. This may be very valuable to the farmer in that the application of gypsum can be put on a pay as you go basis. This will not alter the total amount of gypsum required, but may allow the gypsum to be applied in smaller quantities. The rings using artesian water generally had lower pH readings.

10. Nine to thirty inches of water percolated the soil in the three leaching periods that totaled 63 days of continuous ponding or leaching.

11. Reclamation of the slowly permeable Reed soil will be very slow and expensive and may not be feasible at the present time. The cost of open or tile drains would be very high and the gypsum application required to reclaim the soil may run as high as 30 tons per acre in some areas to completely reclaim the soil.

12. Observations will be continued on the ring tests to observe any future trend and to determine when the gypsum is used up.

Ranch "H" Greasewood Alkali Reclamation Investigation

Ranch "H" is located in central part of the Emmett Valley, south of the Payette River on a nearly level low terrace a few feet above the river flood plain. The area has a water table that fluctuates between 20 and 45 inches. The surface is very gently undulating and has a relief of 6 to 24 inches between the broad swells of ridges and the narrow meandering channels of an old flood plain. (See figure 8 for ranch location) The soils are moderately to strongly alkali and rapidly permeable to a depth of 3.5 feet. A coarse sand and gravel bar lies below 3.5 feet. The soils will respond very rapidly to drainage and reclamation.

Infiltrometer ring layout: The infoltrometer ring layout and a general view of the farm are shown in figure 43. The rings were installed on one of the gently undulating ridges.

It was determined that the water table under the rings would be low enough to permit experimental reclamation with soil amendments. The ranch is in a virgin condition and has a native vegetation cover of greasewood and saltgrass. The ranch is used as pasture during the year. The area produces some pasture during the spring, however, the over-all pasture production is very poor.

The infiltrometer ring layout, the rings using river, drain and artesian water, and the amount of gypsum applied to each ring is shown in figure 44. River water was applied to the right 9 rings, drain water to the middle nine rings and artesian water was applied to the left nine rings. The tons of gypsum per acre applied to each ring is shown by the number above the rings. This layout of 27 rings gave 3 replicates of each treatment. The rings were all 12 inches in diameter. The evaporation ring shown on figure 44 consisted of a 12 inch long section of 12 inch diameter well casing with a welded-in bottom. The ring was used as a combination evaporation pan and rain gauge.

Ranch "H", greasewood, soils at the plot location: The general valley soil survey shows the Letha soils is medium to very light surface textured with some heavier subsoils. Gravel strata may underlie these soils at depths of 3 to 8 ft. A four foot depth soil survey at the plot location is presented on a soil profile chart figure 45. The soils were primarily a loamy fine sand to a depth of $3\frac{1}{2}$ feet and gravel below that. Two thin cememted sand strata were found at depths of $1\frac{1}{2}$ and 3 feet. The water table during January was below the four foot survey.

ALKALI RECLAMATION INVESTIGATIONS
RANCH "H"

Emmett Valley
Gem County, Idaho

GREASEWOOD

Figure 43. Looking west over the Ranch "H", Greasewood, alkali reclamation plot. The soils are rapidly permeable to the gravel strata and moderately alkalin to a depth of four feet.

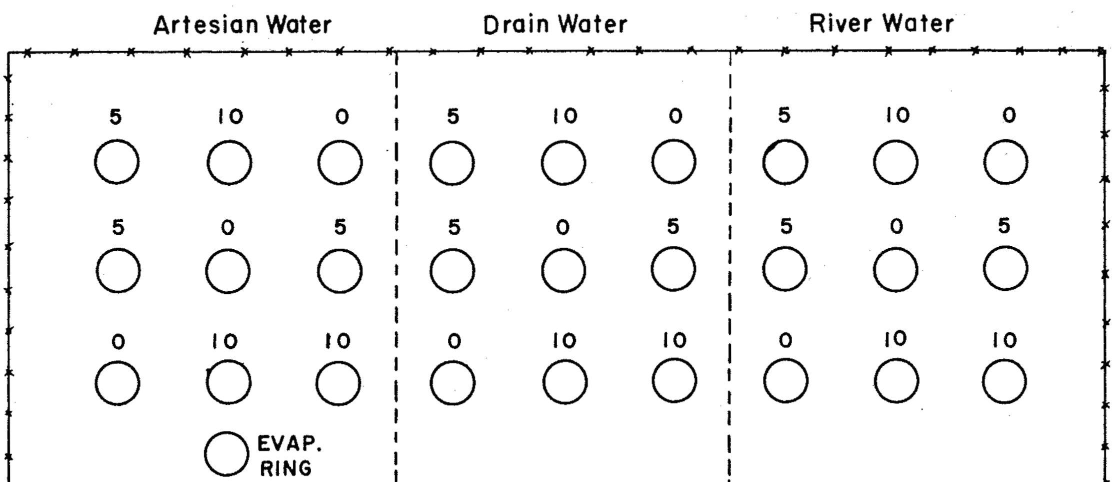

Figure 44. Infiltration Ring layout on the Ranch "H", Greasewood, plot. Numbers refer to the tons of gypsum applied per acre.

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FIGURE 45

U. S. DEPARTMENT OF AGRICULTURE
Soil Conservation Service

SOIL PROFILE CHART

For Drainage Investigations

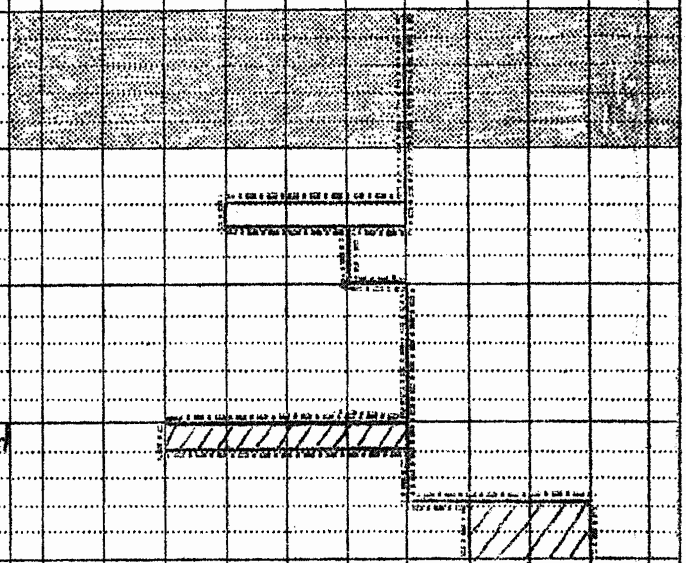
1 - Clay
2 - Silty clay loam
3 - Clay loam
4 - Silt Loam
5 - Loam
6 - Sandy loam
7 - Loamy fine sand
8 - Sand
9 - Coarse sand and fine gravel
10 - Coarse gravel
11 - Cobble

Property *Ranch "H" Grease Wood Alkali Rec. Plot*

Boring No. *1* Land Use *Grazing* Crop Condition *None*

Technician *G. B. B.* Date Survey *1/22/53* Symbol *Letha*

Depth in Feet	Texture	Special Features	Permeability: Slow (1, 2), Moderate (3, 4, 5), Rapid (6, 7, 8), Very Rapid (9, 10, 11)
0.0			
		pH 8.2	
		pH 9.2	
1.0		*pH 9.6*	
		pH 9.6	
	Sand	*pH 9.4 Cemented Sand Few rocks*	
2.0		*pH 8.8*	
		pH 8.4 Few roots	
3.0		*pH 8.6 Gravel*	
	Sand	*pH 9.6 Cemented Sand Calcareous*	
		pH 9.0 Coarse Gravel	
4.0			
5.0			
6.0			
7.0			
8.0			
9.0			



A pH reading with a color indicator (Thymol Blue) was made in the profile at each six inch depth or soil change. The pH was found to be fairly low right at the surface, high at a depth of six inches (9.2) and generally remained above 8.6 to a depth of 3½ feet. The pH indicates a fairly uniform distribution of alkali in the soil profile.

Structure, workability and visible gypsum: A summary of structure, workability and visible gypsum prior to and following the two leaching periods is presented in table 16. The observations were made in the field, visually and with respect to the difficulty of working up the soil in the various rings with a 3/4 inch wood chisel.

Table 16. Summary of structure, workability and visible gypsum prior to and following the two leaching periods on the Ranch "H" greasewood investigation.

Water used	Prior to Leaching	No gypsum applied to soil		5 tons of gypsum per acre		10 tons of gypsum per acre	
		1st 8/5/52	2nd 10/20/52	1st 8/5/52	2nd 10/20/52	1st 8/5/52	2nd 10/20/52
			Structure				
River	poor	poor	poor	fair	poor	fair	fair
Drain	poor	poor	poor	mod.	mod.	fair	fair
Artesian	poor	mod.	mod.	mod.	fair	fair	fair
			Workability				
River	mod.	mod.	mod.	mod.	mod.	easy	easy
Drain	mod.	mod.	mod.	mod.	mod.	easy	mod.
Artesian	mod.	mod.	easy	mod.	easy	easy	easy
			Visible Gypsum				
River	-	-	-	mod.	trace	mod.	mod.
Drain	-	-	-	trace	trace	mod.	mod.
Artesian	-	-	-	mod.	trace	mod.	mod.

Analysis of table 16 indicates that a fair structure is being developed in the soils with a 10-ton application of gypsum. The table also indicates that the artesian water without any gypsum applied is developing some structure in the soil. The application of gypsum has a good effect upon the workability of the soil. The artesian water alone, without any gypsum, had a good effect upon the workability of the soil. There was still considerable gypsum visible following the two short leaching periods.

Proctor needle tests: A series of 10 tests were made in each ring with a Proctor Needle (Pentrometer) following the two leaching periods to determine the bearing in pounds per square inch for the soils under the various treatments. This makes 30 replicates for each treatment shown. A summary of the pentrometer data is presented in table 17.

Table 17. Summary of the Proctor Needle data following the first and second leaching periods on the Ranch "H" Greasewood investigations.

	Gypsum applied	Proctor Needle values following the 1st leaching period 7/31/52	Proctor Needle values following the 2nd leaching per. 10/20/52
	Tons/ac.	lb. sq. in.	lb. sq. in.
River	0	1833	1583
	5	1630	1406
	10	1446	1406
Drain	0	1772	1489
	5	1609	1575
	10	1487	1550
Artesian	0	1589	1387
	5	1222	1279
	10	1426	1536
Ground Surface outside the rings		1365	1799

The Proctor Needle results for the three different waters following the 1st and 2nd leaching period were fairly erratic and indicated no definite trend. The artesian water showed a lower value on all averages except for the 10 ton application. Without the application of gypsum. The artesian water indicated the best effect, the drain water second, and the river water last. The final Proctor Needle average indicated the soils using artesian water to be 100 pounds per square inch less than the drain and 200 pounds less than the river water. The results are very favorable towards the artesian water.

Intake rates: A summary of the intake rates for the two leaching periods are presented in table 18. The intake rates have been corrected for evaporation and a viscosity correction has been applied to convert the intake rates to a standard temperature of 60 degrees Fahrenheit. The final intake rates indicate a higher intake for both the river and the artesian waters. The three waters in respect to intake are artesian first, river second, and drain the slowest. The rate of increase for all waters, with the respect to the application of gypsum, was: 100% increase with 5 tons and 200% increase with the 10 ton application. The intake rate increased very favorably with the gypsum applications.

pH values: A summary of the pH values from June 17 to October 20, 1952 on the Ranch "H" greasewood alkali reclamation plot is presented in table 19. The pH values shown in table 19 are an average of three replicates. The pH values were obtained from the surface soil in the rings during the drying periods and the pH of the leaching water was obtained during the leaching periods.

Table 18. Summary of the intake rate data for the first and second leaching periods on the Ranch "H" greasewood investigation. 1/

Water applied	Gyp. appl.	First Leaching Period 6/17	6/18	6/19	6/20	6/23	6/24	Second Leaching Period 9/8	9/9	9/10	9/11
	T/ac.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.
River	0	0.37	0.08	0.06	0.05	0.01	0.00	0.23	0.09	0.05	0.06
	5	0.53	0.14	0.18	0.07			0.26	0.20	0.12	0.14
	10	0.49	0.21	0.24	—			0.42	0.31	0.16	0.20
Drain	0	0.36	0.06	0.05	0.04	0.01	0.01	0.17	0.07	0.04	0.04
	5	0.49	0.08	0.11	0.08			0.28	0.12	0.08	0.08
	10	0.70	0.15	0.11				0.32	0.20	0.13	0.14
Artesian	0	0.48	0.11	0.08	0.06			0.19	0.08	0.06	0.09
	5	0.57	0.22	0.19				0.30	0.26	0.18	0.20
	10	0.53	0.21	0.19				0.43	0.40	0.33	0.27

1/ The intake rates have been corrected for evaporation and to a standard temperature of 60° degrees F.

Table 19. Summary of the pH values on the Ranch "H" greasewood investigation from June 17 to October 20, 1952.[1]

Water applied	Gyp. appl.	Dry	First Leaching Period						Drying Period			Second Leaching Period		
		6/17	6/17	6/18	6/18	6/19	6/20	6/23	6/30	7/7	9/8	9/8	9/9	9/10
	T/ac.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In.hr.	In. hr.	In. hr.	In. hr.	In.hr.	In.hr.	In.hr.
River	0	9.6	9.6	8.8	8.8	8.6	8.2	8.4	8.5	9.0	9.1	8.2	8.1	8.2
	5	9.4	8.8	8.1	8.3	8.2	8.1	8.2	8.3	8.6	8.5	8.2	8.0	8.2
	10	9.3	8.8	8.1	8.1	8.2	8.2	8.1	8.2	8.3	8.3	8.1	8.0	8.2
Drain	0	9.2	9.0	8.6	8.6	8.2	8.4	8.4	8.5	9.1	9.3	8.2	8.0	8.3
	5	9.6	9.1	8.2	8.4	8.2	8.3	8.4	8.6	8.7	8.6	8.1	8.0	8.2
	10	9.5	8.7	8.2	8.4	8.2	8.2	8.3	8.3	8.3	8.2	8.2	8.0	8.2
Artesian	0	9.6	8.8	8.1	8.4	8.3	8.3	8.3	8.7	8.8	9.2	8.2	8.0	8.2
	5	9.6	8.8	8.1	8.3	8.2	8.2	8.2	8.3	8.4	8.5	8.3	8.0	8.3
	10	9.6	8.4	8.1	8.4	8.2	8.2	8.3	8.3	8.3	8.3	8.2	8.0	8.1

1/ The pH values shown are an average of three replicates.

Water applied	Gyp. appl.	Drying Period						
		9/23	9/25	9/29	10/1	10/3	10/14	10/20
	T/ac.	In.hr.	In. hr.	In. hr.	In. hr.	In.hr.	In.hr.	In.hr.
River	0	8.4	8.7	8.8	9.0	9.0	8.7	8.9
	5	8.4	8.3	8.2	8.3	8.5	8.2	8.8
	10	8.2	8.2	8.1	8.3	8.2	8.2	8.2
Drain	0	8.6	9.0	9.0	9.1	9.0	8.9	8.9
	5	8.4	8.4	8.3	8.3	8.4	8.3	8.4
	10	8.3	8.3	8.2	8.3	8.0	8.2	8.3
Artesian	0	8.5	8.4	8.4	8.7	8.6	8.6	8.5
	5	8.3	8.3	8.3	8.2	8.2	8.2	8.3
	10	8.3	8.2	8.2	8.2	8.1	8.1	8.2

The pH values compare very favorably with the amounts of gypsum applied to the soil. For gypsum applications of 0,5, and 10 tons per acre, the final pH of the soil in the various test rings was: river - 8.9,8.8 and 8.2; drain - 8.9, 8.4, 8.3; artesian - 8.5,8.3 and 8.2. The over-all pH values for soil in the rings using artesian water are slightly lower than those using the river and drain water. The pH readings on the soil in the rings without gypsum were 0.4 of a pH in favor of the artesian water. The pH values rose considerably on the untreated plots during the drying period. The pH values have not formed in a definite pattern as they did in the Ranch "I" investigation (See figure 42)

Depth of water applied: A summary of the depth of water applied during the two leaching periods are presented in table 20. The inches of water shown in the table are the differences between the depths applied and the evaporation during the leaching periods.

Table 20. Amount of water applied to the various treatments in the Ranch "H" greasewood alkali reclamation rings.

Water applied	Leaching period No.	No gypsum applied In. water	5 tons of gypsum per acre In. water	10 tons of gypsm per acre In. water
River	1st 1/	9.3	13.0	14.3
	2nd 2/	11.4	14.3	16.4
	Total	20.7	27.3	30.7
Drain	1st	10.0	13.4	13.4
	2nd	9.9	12.8	16.4
	Total	19.9	26.2	29.8
Artesian	1st	12.0	14.1	13.9
	2nd	12.1	13.5	16.4
	Total	24.1	27.6	30.3

1/ 1st leaching period had an average of 4 to 8 days duration
2/ 2nd leaching period had an average of 4 days duration

Summary of the Ranch "H" greasewood alkali reclamation study:

1. The soils are rapidly permeable and should reclaim very rapidly following drainage.

2. The soils are moderately alkali to a depth of 3½ feet. A very permeable gravel bar lies below 3½ feet.

3. A fair structure is being developed in the soils with the application of gypsum. The artesian water alone is developing some structure in the soil.

4. The Proctor Needle indicated the following effects on the soil due to the river, drain, and artesian waters: artesian water indicated the best effect, the drain water second, and the river water poorest.

5. The ring tests using artesian water showed highest intake rate, river second, and drain water lowest.

6. The over-all pH values for the rings using artesian water are slightly lower than those for the river and drain water.

Ranch "H" saltgrass alkali reclamation investigation

The saltgrass plot is located about 150 feet southeast from the greasewood plot. The general description of the area and soils are identical to the greasewood plot. The soils are moderately alkali to a depth of 6 feet. A coarse sand and gravel bar lies below 6 feet. The soils will respond rapidly to drainage and reclamation.

Infiltrometer ring layout: The infiltrometer ring layout and a general view of the farm are shown in figure 46. The rings were installed in one of the gently undulating valleys on the terrace. The water table is sufficiently low to permit reclamation during the study. The soil is in its native condition and has a cover of saltgrass. The area is used as pasture.

The infiltrometer ring layout, the rings using river, drain and artesian water, and the amount of gypsum applied to each ring is shown in figure 47. River water was applied to the right 9 rings, drain water to the middle 9 rings, and artesian water was applied to the left 9 rings. The amount of gypsum in tons per acre that was applied to each ring is shown by the number above the rings. This layout of 27 rings gave 3 replicates for each treatment. The rings were all 12 inches in diameter. The evaporation ring results from the greasewood plots was applied to the saltgrass plot data.

Ranch "H" saltgrass soils at the plot location: Soil survey to a depth of seven feet at the plot location is presented on a Soil Profile Chart, figure 48. The soils were primarily sandy loam to a depth of six feet with strata of silt loam and sand in the profile. A coarse sand and gravel bar lies at a depth of six feet. A pH reading was obtained at each six inch interval or soil change. The pH was found to be fairly low at the surface, high at a depth of 0.3 feet (9.0) and generally remained above 8.6 to a depth of six feet. The pH indicates a fairly uniform distribution of alkali in the soil profile.

Structure, workability and visible gypsum: A summary of structure, workability and visible gypsum prior to and following the first leaching period is presented in table 21. The observations were made identical to those on the Ranch "I" and Ranch "H" greasewood investigations.

ALKALI RECLAMATION INVESTIGATIONS
RANCH "H"

Emmett Valley
Gem County, Idaho

SALT GRASS

Figure 46 Looking north over the Ranch "H", Salt Grass, alkali reclamation plot. The soils are moderately to rapidly permeable and alkalin to a depth of six feet.

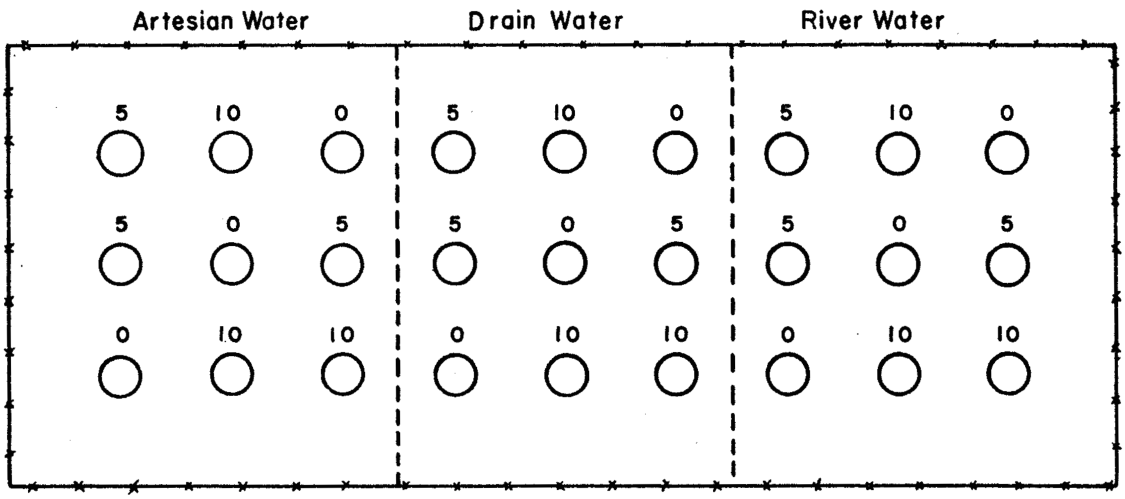


Figure 47 Infiltration Ring layout on the Ranch "H", Salt Grass, plot. Numbers refer to tons of gypsum applied per acre.

ADS-SCS-PORTLAND, ORE. FEB. 1953

FIGURE 46

U. S. DEPARTMENT OF AGRICULTURE
Soil Conservation Service

SOIL PROFILE CHART

For Drainage Investigations

1 - Clay
2 - Silty clay loam
3 - Clay loam
4 - Silt loam
5 - Loam
6 - Sandy loam
7 - Loamy fine sand
8 - Sand
9 - Coarse sand and fine gravel
10 - Coarse gravel
11 - Cobble

Property *Ranch "H" – Salt Grass Alkali Rec. Plot*

Boring No. *1* Land Use *Grazing* Crop Condition *None*

Technician *G. B. B.* Date Survey *1/22/53* Symbol *Letha*

Depth in Feet	Texture	Special Features
0.0		
		pH 8.1
		pH 9.0
		pH 8.9
1.0		*pH 9.0*
		pH 9.4
	SSiL	
2.0		*pH 9.2*
		pH 9.0
3.0		*pH 8.9*
		pH 8.6 Motled
		pH 8.7 Roots
4.0		*pH 9.1 Green Color*
		pH 8.3 Free Water
5.0		*pH 8.7 Mica*
		pH 8.7 Motled Green with Black
6.0		*pH 8.7 Motled Grey*
		pH 8.7 Black like ashes
	Gravel	
7.0		
8.0		
9.0		

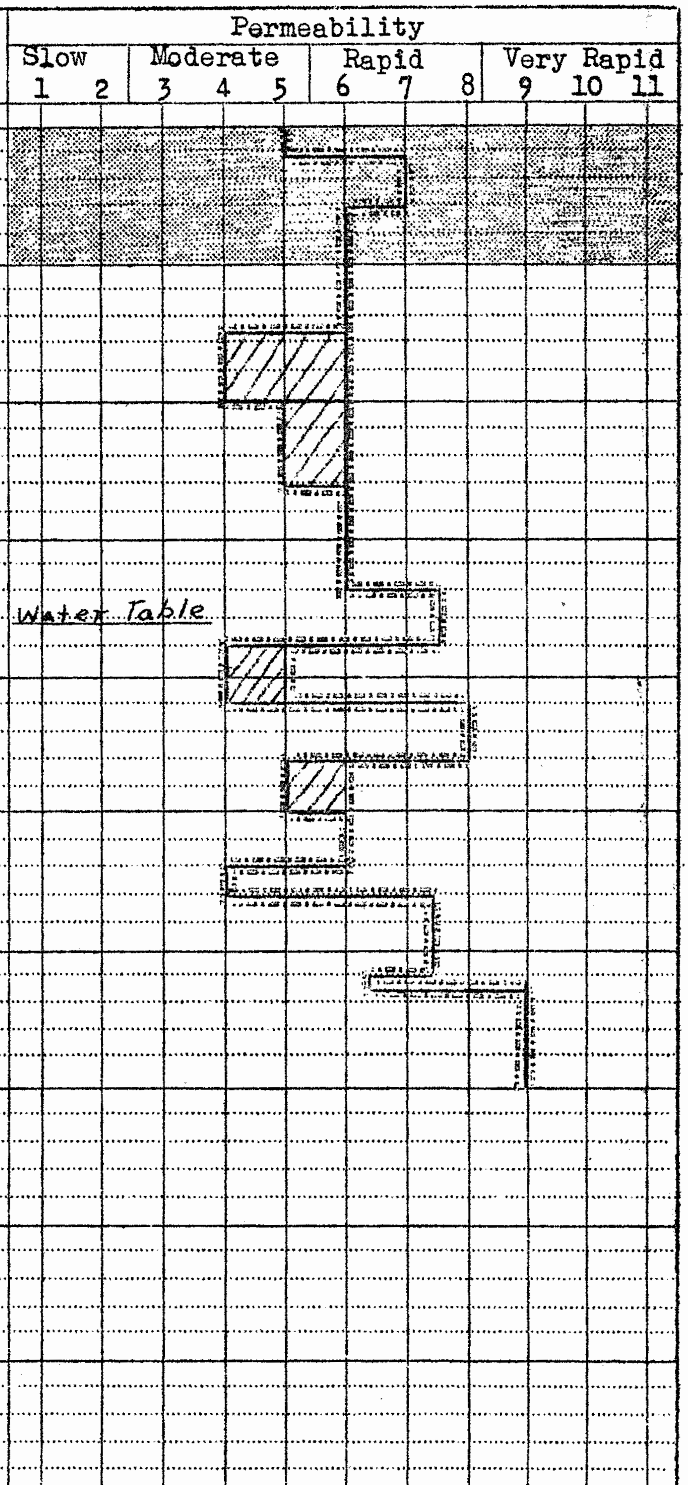


Table 21. Summary of structure, workability and visible gypsum prior to and following the first leaching period on the Ranch "H" saltgrass investigations.

Type water used	Prior to leaching 8/5/52	No gypsum applied to the soil 10/20/52	5 tons of gypsum per acre 10/20/52	10 tons of gypsum per acre. 10/20/52
		Structure		
River	poor	fair	fair	fair
Drain	poor	fair	fair	fair
Artesian	poor	poor	fair	fair
		Workability		
River	hard	easy	easy	easy
Drain	hard	easy	easy	easy
Artesian	mod.	mod.	easy	easy
		Visible gypsum		
River	-	-	mod.	considerable
Drain	-	-	mod.	"
Artesian	-	-	mod.	"

Analysis of table 21 indicates that a fair structure is being developed in the soils. The artesian water does not show up as favorably as the river and drain water in table 21. The workability was increased by all three treatments.

Proctor Needle tests: A series of 10 penetration tests were made in each ring with a Proctor Needle (pentrometer) prior to and following the first leaching period. A summary of the data is presented in table 22. The Proctor Needle results for the first leaching period indicates an improvement from all the treatments. The rings using artesian water had slightly lower readings than either the river or drain water.

Intake rates: A summary of the intake rates for the first leaching period is presented in table 23. The intake rates have been corrected for evaporation and a viscosity correction has been applied to convert the intake rates to a standard temperature of 60 degrees Fahrenheit.

Table 22. Summary of the Proctor Needle data prior to and following the first leaching period on the Ranch "H" saltgrass investigation.

Water applied	Gypsum applied	Proctor Needle values prior to the 1st leaching period	Proctor Needle values following the 1st leaching period
	Tons acre	7/5/52	10/20/52
		Lb. sq. in.	Lb. sq. in.
River	0	1817	1471
	5	2249	1361
	10	2139	1300
Drain	0	2051	1493
	5	2178	1577
	10	2330	1554
Artesian	0	1921	1204
	5	1518	1049
	10	2063	1265
Ground surface outside the rings			2100

Table 23. Summary of the intake rate for the 1st leaching period on the Ranch "H" saltgrass investigation. 1/

Water applied	Gypsum applied	First Leaching Period 9/8/52	9/9	9/10	9/11
	Tons	In. Hr.	In. Hr.	In. Hr.	In. Hr.
River	0	0.08	0.03	0.03	0.01
	5	0.12	0.04	0.04	0.03
	10	0.09	0.03	0.03	0.02
Drain	0	0.10	0.05	0.03	0.02
	5	0.13	0.04	0.03	0.02
	10	0.13	0.04	0.04	0.02
Artesian	0	0.14	0.08	0.05	0.03
	5	0.14	0.16	0.11	0.08
	10	0.22	0.11	0.07	0.04

1/ The intake rates have been corrected for evaporation and to a standard temperature of 60 degrees Fahrenheit.

The final intake rates indicate that the river and drain water give about equal rates. The artesian water has about double the rate obtained using the river or drain water. The rates were relatively erratic, but should stabilize in subsequent leaching periods.

pH values: A summary of the pH values from September 8 to October 20, 1952 on the Ranch "H" saltgrass alkali reclamation plot is presented in table 24. The pH values shown in table 24, are an average of three replicates. The pH values were obtained in the same manner as those on the Ranch "I" and Ranch "H" greasewood investigations. The pH values shown on September 8, prior to leaching were from surface samples and were low due to a recent rain. The pH at a depth of 0.3 feet was 9.0 or higher. This same condition was obtained in January when the soil log was made. (See figure 48) The pH values dropped to 8.1 or 8.2 in all rings as soon as the leaching water was applied. As the rings dried out following leaching, the pH values increased in the soils not having an application of gypsum. The rings using artesian water without the application of gypsum remained low for the duration of the observations. The pH values have not formed a definite pattern to date.

Depth of water applied: A summary of the depth of water applied during the first leaching period is presented in table 25. The inches of water shown in table 25 are the differences between the depths applied and the evaporation during the leaching period.

Table 25. Summary of water applied to the various treatments in the Ranch "H" saltgrass alkali reclamation rings. 1/

Water applied	Leaching 1/ period	No gypsum applied	5 tons of gypsum per acre	10 T. of gypsum per acre
	No.	In. water	In. water	In. water
River	1st	6.5	7.4	6.7
Drain	1st	7.0	10.1	7.0
Artesian	1st	8.9	12.3	11.6

1/ 1st leaching period had an average of 8 days duration.

Summary of the Ranch "H" saltgrass alkali reclamation study:

1. The soils are moderate to rapidly permeable and should reclaim rapidly following drainage and the application of soil amendments.

2. The soils are moderately alkali to a depth of six feet.

3. A fair structure is being developed in the soil and the workability is being improved with all treatments.

4. The Proctor Needle indicates that all treatments are improving the soil. The rings using artesian water had slightly lower readings than either the river or drain water.

5. The rings in which artesian water was used showed about double the intake rate of the rings where river or drain water was used.

6. The pH values dropped to 8.1 or 8.2 in all rings as soon as the water was applied. As the rings dried out following leaching, the pH values increased in the soils where gypsum wasn't applied. In soils having gypsum applied, the pH remained low during the leaching and drying period.

Table 24. Summary of the pH values on the Ranch "H" Saltgrass investigation from Sept. 8 to Oct. 20, 1952. 1/

Water applied	Gyp. appl.	Dry	1st Leaching Period			Drying Period						
		9/8	9/8	9/9	9/10	9/23	9/25	9/29	10/1	10/3	10/14	10/20
	T/ac.	In. hr.	In. hr.	In. hr.	In. hr.	In. hr.	In. hr.	In. hr.	In. hr.	In. hr.	In. hr.	In. hr.
River	0	8.8	8.1	8.2	8.2	8.5	9.1	8.9	8.7	8.6	8.6	8.7
	5	8.5	8.1	8.2	8.2	8.1	8.5	8.2	8.3	8.1	8.2	8.2
	10	8.5	8.1	8.2	8.1	8.0	8.2	8.2	8.3	8.4	8.4	8.2
Drain	0	8.5	8.2	8.2	8.2	8.5	8.7	8.7	8.8	8.7	8.7	8.5
	5	8.1	8.2	8.1	8.1	8.1	8.3	8.3	8.3	8.0	8.3	8.1
	10	8.2	8.1	8.2	8.2	8.1	8.1	8.1	8.2	8.0	8.2	8.2
Artesian	0	8.3	8.1	8.2	8.0	8.2	8.4	8.3	8.3	8.2	8.2	8.2
	5	8.6	8.2	8.2	8.1	8.1	8.1	8.1	8.0	8.1	8.1	8.1
	10	8.0	8.1	8.2	8.1	8.1	8.1	8.1	8.0	8.1	8.1	8.1

1/ The pH values shown are an average of three replicates.

Summary of data on the three alkali reclamation plots

A summary of the observations and data on the three alkali reclamation plots is presented in table 26. A total of 7400 observations and field measurements were summarized and condensed to form the table. It contains a summary of the aggregates, Proctor Needle readings, intake rates, and pH readings for the total of six leaching periods. Three leaching periods on the Ranch "I", two on the greasewood and one on the saltgrass plot have been made to date. The averages of the results from each set of three replicates were classified as first, second, third etc., according to the number of aggregates, softness from the Proctor Needle tests, rapidity of the intake rate, and alkali improvement indicated by the pH values. The spread of the rings using artesian water is blocked in with a dotted line. The blocked-in area indicates that the artesian water is in the upper portion of the table and possibly indicates an over-all advantage in using the artesian water to reclaim the alkali land in the valley. By assigning a figure of 10 to a rating of first, 9 to second, 8 to third, etc., and adding up the totals of the river, drain and artesian waters, a figure was obtained showing the over-all desirability of water for use in reclamation of alkali areas. The totals obtained were:

Artesian water - - - - - - - - - - - 230 points
River water- - - - - - - - - - - - - 159 points
Drain water- - - - - - - - - - - - - 151 points

This tabulation indicates that the artesian water gives considerably better results and that the over-all difference between river and drain water is rather slight. Observations were made on December 9th - two days following a five day rain which totaled 1.72 inches, to determine the number of rings that had rain water standing on the surface. A summary of these observations are presented in table 27. There was no water standing on any of the soils having a 10-ton application of gypsum, eight out of the 27 rings having 5 tons of gypsum added, had water standing on them, and 20 out of the 27 having no gypsum added had water standing on the surface. The test rings using artesian water had 7 rings or 26% with standing water, the rings using river water had 9 rings or 33% with water standing on the surface, and the rings using drain water had 12 rings or 44% with water standing on the surface.

Table 26. Summary rating for the aggregates, Proctor Needle, intake rates, and pH values for the Ranch "I", Ranch "H" greasewood and the Ranch "H" saltgrass alkali reclamation investigations.

Rating	Aggregates final "I"	Proctor Needle final readings "I"	Proctor Needle G.W.	Proctor Needle S.G.	Intake Rate final readings "I"	Intake Rate G.W.	Intake Rate S.G.	pH final readings "I"	pH G.W.	pH S.G.
1st	D-10	R-10	A-5	A-5	A-10	A-10	A-5	A-10	A-10	A-10
2nd	R-10	D-10	A-0	A-0	D-10	A-5	A-10	D-10	R-10	A-5
3rd	A-10	A-10	R-5	A-10	R-10	R-10	A-0	R-10	D-10	D-5
4th	A-5	A-5	R-10	R-10	A-5	D-10	R-5	R-5	A-5	D-10
5th	A-0	D-5	D-0	R-5	R-5	R-5	D-10	A-5	D-5	D-5
6th	D-5	A-0	A-10	R-0	R-0	A-0	D-0	D-5	A-0	A-0
7th	D-0	R-5	D-10	D-0	A-0	D-5	D-5	A-0	R-5	R-10
8th	R-5	R-0	D-5	D-10	D-5	R-0	R-10	D-0	R-0	D-0
9th	R-0	D-0	R-0	D-5	D-0	D-0	R-0	R-0	D-0	R-0

Legend:

"I" - Ranch "I" Alkali reclamation plot
SG - Ranch "H" Saltgrass alkali reclamation plot
GW - Ranch "H" Greasewood alkali reclamation plot
R-0 - River Water - No gypsum applied to soil
R-5 - River water 5 tons of gypsum applied to soil
R-10- River water 10 tons of gypsum applied to soil
D-0 - Drain water - No gypsum applied to soil
D-5 - Drain water 5 tons of gypsum applied to soil
D-10 -Drain water 10 tons of gypsum applied to soil
A-0 - Artesian water - No gypsum applied to soil
A-5 - Artesian water 5 tons of gypsum applied to soil
A-10- Artesian water 10 tons of gypsum applied to soil

Table 27. Summary of the rings that retained rain water on the surface the second day following a 1.72 inch period of heavy precipitation.

Comparison Item		Rings with rain water standing on the surface: Number	Percentage
Gypsum	10 tons gypsum	0	0
	5 tons gypsum	8	30
	None	20	74
Water	Artesian	7	26
	River	9	33
	Drain	12	44
Artesian + 10 tons gypsum		0	0
River + 10 tons gypsum		0	0
Drain + 10 tons gypsum		0	0
Artesian + 5 tons gypsum		2	22
River + 5 tons gypsum		2	22
Drain + 5 tons gypsum		4	44
Artesian		5	56
River		7	78
Drain		8	89

Table 27 indicates the application of gypsum has a greater effect upon the intake rate than the type of leaching water. This was expected from the water analysis prior to the investigations. The bottom section of the tabulation compares the water and gypsum and indicates the artesian water as being the most beneficial; the river water, second, and the drain water was the poorest.

Vertical Drainage Investigations

During the course of the investigation, it was concluded that the use of pumped wells could have an important place in the over-all drainage plan for the Emmett Valley. As a forerunner to making a vertical drainage investigation in the valley, it was decided that some initial costs, maintenance and operation figures and radius of influence data be obtained on existing wells in the Emmett Valley. It was found that there were no drainage wells in operation in the valley and that these cost estimates would have to be obtained from other areas which were similar in nature and had a similar drainage problem.

The Pioneer Irrigation District with offices at Caldwell, Idaho was selected as a comparison area. The Pioneer Irrigation District has thirty wells ranging in depth from 60 to 165 feet. These wells are used jointly as drainage and irrigation wells. Mr. John Turner former president of the Pioneer Irrigation District Board stated, "That during the low ground water table years when drainage was not a problem, the wells had been pumped to supplement the short supply of irrigation water. During years of adequate irrigation water supply, the wells had been primarily used for drainage; and that the wells had paid for themselves either as irrigation or drainage wells."

A summary of the installation costs and operational costs were obtained from the Pioneer Irrigation District office in Caldwell. The initial costs for the 30 wells, installed from 1936 to 1950 is presented in Appendix Table 6. Well numbers 29 and 30 gave the best cost estimates as they were installed during 1949 and 50. Well No. 29 is 143 feet deep and cost a total of $5464; well No. 30 is 98 feet deep and cost $4395.75. The wells both have 20 inch casings.

A summary of the available operating costs during 1950, 51 and 52 are presented in Appendix Table 7. Wells 29, 30 and 12 were selected because of their date of installation and their drainage range of influence.

A summary of the number of acre feet pumped from 10 wells during the period from 1926 to 1934 is presented in Appendix Table 8. During this period 83 acre feet of water was removed per day, 2490 acre feet per month, and 12,450 acre feet during a five month period. The extent of the area drained was satisfactory to both the Pioneer Irrigation District and the local farmers.

Detailed information concerning the Franklin Road Well, No. 12, for the year 1934 and on estimate cost for 1953 is presented in Appendix Table 9. The over-all well efficiency would probably be higher in 1953 than it was in 1934.

The cost information and drainage estimates presented in Appendix Tables 6 to 9 inclusive may not apply completely to the Emmett Valley and they will be adjusted following further investigation into drainage and the possible installation of a test vertical drainage well in the valley.

FUTURE SCOPE OF THE INVESTIGATIONS

Continued investigations

The following investigations will be continued:

1. Open drainage investigations
   a. Continue ground water observations on the ranches investigated during the last year.
   b. Observations will be initiated on several additional ranches to give an observation on each of the major soil series.
   c. Increase the number of ranches observed for crop production figures.
2. Alkali reclamation
   a. Continue the alkali investigations using the ring method on the three plots.
3. Continue and refine the artesian well location survey.

New investigations

1. Artesian well survey.

A representative number of artesian wells, approximately 20 scattered over the area, will be selected in the valley and surveyed for the following items:

a. Depth
b. Size
c. Pressure
d. Temperature
e. Discharge
f. Chemical analysis

2. Approximately 20 artesian wells will be selected, scattered throughout the valley, and the following measurements made each week or month depending upon the fluctuation.

a. Pressure
b. Temperature
c. Conductance

3. Vertical drainage investigation.

The transmissibility of both confined and unconfined aquifers will be measured on as many artesian and pumped wells as possible. The thickness and extent of both confined and unconfined aquifers will be determined.

4. Install additional observation wells to extend the Bureau of Reclamation observation well lines from their terminal points to the Payette River on at least two or three lines.

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APPENDIX

1. Chemical and physical characteristics of selected soil samples from Emmett Valley Area, Idaho (table copied from characteristics of saline and alkali soils in the Emmett Valley area, Idaho (5)

2. Chemical and physical characteristics of selected soil samples from the Emmett Valley area, Idaho (5)

3. Chemical analysis of saturation extracts of selected soil samples from the Emmett Valley area, Idaho (5)

4. Permeability, pH, capillary rise, and settling volume of selected soil samples from the Emmett Valley area, Idaho (5)

5. Observation well readings (data collected by the U.S.B.R.)

6. Initial costs of drainage and irrigation wells in the Pioneer Irrigation District at Caldwell, Idaho.

7. Operating costs of drainage and irrigation wells in the Pioneer Irrigation District at Caldwell, Idaho.

8. Summary of the water pumped from 10 wells in the Pioneer Irrigation District during the period of 1926 to 1934.

9. Detailed information concerning the Franklin Road well, No. 12 for the year 1934.

Appendix Table 1. - Chemical and physical characteristics of selected soil samples from Emmett Valley Area, Idaho. 1/

No.	Location	Soil type	Depth	pHs 3/	Salt 4/	EC_1 5/	Soluble Na 6/	Sol. Ca 6/	Exch. Na 7/
			Inches		%	mhos x 10^3	m.e./1	m.e./1	m.e./100 gm.
1	SE of SE	Letha fi.	0-½	9.3	3.00	125.0	611.5	0.11	
	Sec. 8	sa. loam	1/2-5	10.2	0.43	4.50	62.35	0.12	6.9
	T6N R2W		5-12	10.3	0.21	3.60	41.57	0.41	8.4
			12-24	10.2	0.30	3.60	28.73	0.31	8.4
			24-36	9.9	0.20	2.00	22.59	0.41	8.1
			36-48	9.6	-	0.94	9.48	0.34	7.9
			48-60	9.2	-	0.75	7.15	0.21	8.7
2	NE of NE	Letha fi.	0-6	9.6	-	1.80	16.98	0.64	3.5
	Sec. 8	sa. loam	6-12	9.8	-	3.10	13.63	13.48	4.7
	T6N R1W		12-24	9.1	-	1.20	11.89	0.45	6.9
			24-33	8.6	-	0.70	6.70	0.53	3.6
3	SW of SW	Letha fi.	0-6	7.0	-	0.27	1.53	1.02	0.08
	Sec. 4	sa loam	6-12	6.8	-	0.28	0.78	1.17	0.02
	T6N R1W		12-24						
			24-36	8.0	-	0.38	1.59	1.31	0.02
4	SW of NE	Wardwell-	0-8	6.6	-	0.15	1.12	0.42	0.03
	Sec. 27	Letha	8-20	6.6	-	0.20	1.13	0.18	1.7
	T7N R1W	loam	20-25	7.9	-	0.60	5.78	0.44	2.1
			25-36	8.0	-	0.40	3.76	0.44	1.7
			36-48	8.0	-	0.50	3.96	0.66	1.7
			48-60	7.9	-	0.51	4.53	0.37	2.5
5	NE of SW	Vander-	0-8	6.8	-	0.60	1.23	1.25	0.6
	Sec. 34	dasson	8-16	7.5	-	0.50	2.61	0.84	1.2
	T7N R1W	si. clay	16-30	7.4	-	0.40	2.50	0.59	1.4
6	NW of NE	Wardwell-	0-7	7.0	-	0.32	2.28	0.32	0.6
	Sec. 4	Letha	7-14	7.1	-	0.17	1.72	0.17	1.6
	T6N R1W	fi. sa.	14-22	8.4	-	0.24	6.34	0.24	3.8
		loam	22-36						
			36-44	9.1	-	0.27	2.70	0.27	1.7
7	SW of SE	Letha fi.	0-7	6.8	-	1.91	0.62	1.91	0.06
	Sec. 18	sa. loam	7-14	8.0	-	0.19	3.08	0.19	1.5
	T6N R1W		14-24	8.7	-	0.24	8.94	0.24	8.0
			24-36	9.1	-	0.29	8.47	0.29	6.7
			36-48	8.6	-	0.17	6.37	0.17	3.4
8	NE of NE	Wardwell-	0-6	8.0	-	1.23	3.09	1.23	0.5
	Sec. 13	Letha	6-10	8.4	-	0.52	4.92	0.52	1.8
	T6N R2W	fi. sa.	10-18	9.1	-	1.22	8.85	1.22	8.9
		loam	18-26	9.3	-	5.60	8.41	18.46	8.6
			26-36	9.3	-	0.96	8.59	1.00	4.8
9	NE of NE	Letha	0-6	8.7	-	0.83	7.39	0.77	2.0
	Sec. 24	fi. sa.	6-12	9.2	-	1.07	10.51	0.64	3.2
	T6N R2W	loam	12-24	8.5	-	0.68	4.54	0.30	1.9
10	NW of NW	Letha	0-6	10.2	-	3.20	21.98	16.52	7.4
	Sec. 18	fi. sa.	6-12	9.7	-	1.40	13.06	1.74	7.4
	T6N R1W	loam	12-24	9.3	-	0.78	7.51	0.19	6.4

1/ Taken from University of Idaho Research Bulletin No. 17.

Appendix Table 1. - Chemical and physical characteristics of selected soil samples from Emmett Valley Area, Idaho. 1/
(continued)

No.	Location	Soil type	Depth	pHs 3/	Salt 4/	EC1 5/	Soluble Na 6/	Sol. Ca 6/	Sol. Exch. Na 7/
			Inches		%	mhos x 10^3	m.e./l	m.e./l	m.e./100gm
11	NE of NE	Letha	0- 6	8.8	-	1.13	10.23	1.12	2.7
	Sec. 22	fi. sa.	6-12	9.0	-	0.61	6.26	0.87	3.0
	T6N R2W	loam	12-24	8.8	-	0.60	7.05	0.19	5.5
			24-29	9.1	-	0.72	7.93	0.10	6.0
			29-44	9.0	-	1.80	1.80	9.72	3.3
12	NE of NE	Vander-	0- 6	10.2	-	3.40	38.57	0.27	11.0
	Sec. 22	dasson	6-12	10.1	-	6.80	23.75	21.38	12.1
	T6N R2W	si. cl.	12-28	10.1	-	2.08	23.01	0.79	10.3
		loam	28-36	10.1	-	1.40	13.80	0.10	5.1
			36-46	9.1	-	1.09	34.77	0.07	5.5
13	SW of SW	Letha	0- 6	7.2	-	0.26	0.72	0.82	0.6
	Sec. 9	fi. sa.	6-12	7.9	-	0.40	3.32	0.41	1.1
	T6N R2W	loam	12-16	8.4	-	0.52	5.00	0.22	13.8
			16-30	8.4	-	0.45	3.75	0.18	3.2
14	NE of SE	Bramwell	0- ¼	8.8	-	2.40	23.63	1.53	8.3
	Sec. 2	si. loam	¼- 4	9.2	-	2.37	25.59	1.03	13.9
	T7N R3W		4-12	9.5	-	2.85	33.98	1.16	11.4
			12-24	9.7	-	2.85	33.69	0.38	12.2
			24-32	8.9					
			32-48	9.0					

1/ Samples collected by H. E. Dregne, G. M. Schafer, and C. A. Mogen, July, 1947. Analyses made at Idaho Agricultural Experiment Station by G. C. Lewis, C. L. Tyler, and C. G. Thomas.

3/ pH of saturated paste.

4/ Per cent salt, dry basis, from paste resistance and Bureau of Soils table for mixed neutral salts.

5/ Electrical conductivity of 1:1 soil-water extract in millimhos per cm.

6/ Soluble sodium and calcium in 1:1 extract in milliequivalents per liter.

7/ Exchangeable sodium from difference between total extractable sodium and soluble sodium in 1:1 extract in millequivalents per 100 gm.

8/ Less than 0.20 per cent salt.

Appendix Table 2. - Chemical and physical characteristics of selected soil samples from the Emmett Valley area, Idaho [1]

No.	Location	Soil type	Depth	SP[2]	pHs[3]	Salt[4]	Lime[5]	Exch Na[6]	B.E.C.[7]	E.S.P.[8]	Sand[9]	Silt[9]	Clay[9]
			Inches	%		%		m.e./100 gm.		%	%	%	%
15	NW¼SW¼	Letha	0- 3	29.0	8.7	0.06	3	5.73	26.2	21.8	76.0	18.7	5.3
	Sec. 16	fi sa.	3-11	27.2	10.3	0.13	4	13.24	27.9	47.5	71.7	19.5	8.8
	T6N R2W	loam	11-24	35.3	10.4	0.23	3	16.68	26.7	62.4	72.9	17.3	9.8
			24-36	37.2	10.2	0.21	4	18.16	23.9	76.0	74.9	15.1	10.0
			36-49	34.7	9.7	0.08	4	8.64	24.5	36.1	87.3	7.5	5.2
16	NE¼NW¼	Letha	Crust		9.6	3.0							
	Sec. 15	fi. sa.	0- 7	28.5	10.0	0.14	3	10.92	26.1	41.9			
	T6N R2W	loam	7-16	29.7	9.1	0.06	3	13.84	30.2	45.9			
			16-24	32.4	8.8	0.05	2	8.34	14.9	56.0			
17	NW¼NW¼	Bramwell	0- 6	44.4	8.7	0.33	4	19.41	26.6	73.0	28.3	46.4	25.3
	Sec. 3	si. loam	6-18	49.1	9.4	0.50	4	25.05	28.6	87.7	27.2	47.6	25.2
	T6N R3W		18-30	47.8	8.6	0.18	4	15.58	26.9	57.9	29.0	44.7	26.3
18	SW¼SW¼	Bramwell	0- 6	50.2	7.8	0.05	4	0.76	21.1	3.6			
	Sec. 34	si. loam	6-13	43.0	7.9	0.05	2	1.01	24.4	4.1			
	T7N R3W		13-24	53.2	7.9	0.07	4	1.22	12.7	9.6			
			24-30	53.5	7.9	0.08	4	1.80	18.7	9.6			
19	NW¼NE¼	Power	0- 7	40.5	6.5	0.03	0	0.90	13.5	6.7	56.4	29.7	13.9
	Sec. 33	si. loam	7-14	50.6	7.2	0.10	0	4.14	24.2	17.1	43.9	27.8	28.3
	T7N R2W		14-23	43.5	7.8	0.18	2	5.08	25.6	19.8	53.2	25.8	21.0
			23-32	42.1	7.6	0.33	3	3.73	25.3	14.7	58.6	30.8	10.6
20	SE¼NW¼	Moulton	0- 6	49.5	8.2	0.20	3	4.10	12.9	31.8			
	Sec. 11	fi. sa.	6-12	36.0	8.5	0.08	1	4.12	10.4	39.6			
	T6N R2W	loam	12-24	31.1	7.7	0.03	0	0.57	8.0	7.1			
21	NE¼ NW¼	Vander-	0- 7	43.0	7.6	0.07	4	4.93	21.2	23.2			
	Sec. 26	dasson	7-16	40.2	8.1	0.12	4	13.35	24.5	54.5			
	T6N R2W	si. clay	10-23	49.1	9.0	0.17	4	15.01	18.7	80.3			
			23-28	48.5	9.2	0.17	4	12.50	14.0	89.3			
			28-41	48.8	9.4	0.16	3	12.27	11.8	100.0			
22	(10 ft. from-	Vander-	0- 7	49.0	7.8	0.06	4	3.47	17.9	19.4			
	above)	dasson	7-16	43.9	8.1	0.06	4	3.86	16.5	23.4			
		si. clay	16-23	46.8	7.9	0.05	4	1.47	17.9	8.2			
			23-28	38.0	7.6	0.04	1	1.47	15.4	9.5			
			28-41	39.2	7.6	0.05	1	3.42	14.9	23.0			

1/ Taken from University of Idaho Research Bulletin No. 17.

Appendix Table 2 (Cont.) - Chemical and physical characteristics of selected soil samples from the Emmett Valley area, Idaho[1]

No.	Location:	Soil type:	Depth :	SP[2]:	pHs[3]	: Salt :	Lime[5]:	Exch. Na[6] :	B.E.C.[7]:	E.S.P.[8]:	Sand[9]:	Silt[9] :	Clay[9]
			Inches	%		%		m.e./100gm		%	%	%	%
23	(200 Yrds.	Vander-	0- 8	87.5	8.2	0.30	4	21.29	39.6	53.8	23.5	36.8	39.7
	from above)	dasson	8-16	57.7	8.9	0.34	4	37.27	50.6	73.7	15.2	44.7	40.1
		si. clay	16-28	55.0	8.9	0.35	4	42.42	51.7	81.9	18.0	48.7	33.3
			28-35	110.0	9.0	0.40	4	46.07	55.3	83.5	26.7	39.4	33.9
			39-52	54.0	9.3	0.14	1	13.28	12.8	100.0	77.4	12.6	11.0
24	(10 ft.	Vander-	0- 8	72.6	7.5	0.09	4	1.57	43.1	3.6			
	from above)	dasson	8-16	67.6	7.8	0.09	4	2.33	41.4	5.6			
		si. clay	16-28	63.3	7.7	0.09	4	2.96	41.4	7.1			
			28-35	59.1	7.8	0.09	4	3.33	35.2	9.5			
			35-52	62.4	7.6	0.10	4	3.07	40.3	7.6			
25	SW¼SW¼	Vander-	0- 3	57.0	7.0	0.11	0	5.50	28.6	19.2	21.1	40.1	38.8
	Sec. 24	dasson	3- 8	71.0	7.7	0.15	3	12.01	45.1	26.7	14.6	51.7	33.7
	T6N R2W	si. clay	8-22	75.3	8.0	0.20	3	23.06	66.2	34.9	35.3	40.3	24.4
			22-32	72.9	8.2	0.18	4	21.02	51.2	41.2	43.9	43.6	12.5
			36-38	41.8	8.4	0.05	0	2.35	5.7	41.2	88.9	6.9	4.2
26	SW¼SW¼	Wardwell	0- 2	49.0	6.7	0.04	0	0.57	11.6	4.9	71.2	21.5	7.3
	Sec. 7	fi. sa.	2-11	33.7	7.4	<0.03	0	1.51	8.6	17.6	71.9	21.4	6.7
	T6N R1W	loam	11-15	33.4	7.8	0.08	0	5.73	15.8	36.2	63.6	18.8	17.6
			15-22	33.9	8.4	0.07	3	6.16	14.9	41.4	67.6	18.3	14.1
			22-30	30.0	8.6	0.05	3	3.71	11.1	33.4	77.0	13.6	9.4
27	NW¼NW¼	Bramwell	0- 6	50.0	8.0	0.04	2	0.75	23.8	3.1			
	Sec. 11	si. loam	6-13	37.1	8.2	0.05	0	2.93	18.2	16.1			
	T6N R3W		13-25	70.1	8.3	0.21	2	10.80	35.7	30.3			
			28-38	94.5	8.6	0.14	4	7.12	27.5	25.9			
28	NW¼SW¼	Bramwell	0- 1	51.0	9.8	0.62							
	Sec. 2	si. loam	1- 6	48.0	9.2	0.19							
	T6N R3W												
29	SW¼SW¼	Letha	0- 7	36.3	7.2	<0.03	0	0.46	10.8	4.2			
	Sec. 27	fi. sa.	7-13	34.0	7.4	<0.03	0	0.44	9.2	4.8			
	T7N R3W	loam	13-32	32.2	7.6	0.04	1	1.70	18.1	9.4			
			32-40	23.7	7.7	<0.03	0	1.26	8.0	15.8			
30	(same field	Bramwell	0- 6		8.9	0.19	4	16.03	27.1	59.2			
	as 18)	si. loam	6-12		8.6	0.17	4	16.73	28.8	58.2			
			12-30		8.4	0.15	4	10.80	27.8	38.9			

Appendix Table 2 (cont.) - Chemical and physical characteristics of selected soil samples from the Emmett, Valley area, Idaho 1/

No.	Location	Soil type	Depth	SP[2]	pHs[3]	Salt[4]	Lime[5]	Exch. Na[6]	B.E.C.[7]	E.S.P.[8]	Sand[9]	Silt[9]	Clay[9]
			Inches	%		%		m.e./100 gm		%	%	%	%
31	(5 ft.	Bramwell	0- 6		8.2	0.08	3	4.41	24.9	17.7			
	from above)	si. loam	6-12		8.3	0.13	0	6.18	18.0	34.3			
			12-30		8.6	0.17	4	12.55	27.9	45.0			
32	SW¼NW¼	Letha	Crust										
	Sec. 7	fi. sa.	0- 6	31.7	8.6	0.47	4	7.92	17.1	46.3			
	T6N R2W	loam	6-12	29.4	8.8	0.23	4	10.61	16.5	64.4			
			12-24	29.4	8.9	0.16	4	15.24	18.7	81.6			
			24-34	35.9	8.8	0.10	4	9.98	13.5	73.9			
33	(10 ft.	Letha	0- 6	31.1	8.6	0.08	3	7.33	16.7	43.9			
	from above)	fi. sa.	6-14	31.6	8.4	0.06	3	7.13	16.8	42.4			
			14-28	29.6	8.4	0.05	3	6.70	18.7	35.8			
			28-32	34.0	8.2	0.04	4	1.66	11.0	15.1			
34	SW¼NW¼	Letha	0- 6	37.7	9.0	0.15	3	13.71	19.5	70.4			
	Sec. 1	cl. loam	6-14	40.4	8.8	0.12	4	12.04	19.2	62.8			
	T6N R3W		14-28	41.6	9.0	0.13	2	11.61	14.8	78.5			
35	(15 ft	Letha	0- 6	43.1	8.1	0.06	3	1.96	20.6	9.5			
	from above)	cl. loam	6-14	52.1	8.0	0.05	4	1.79	16.2	11.0			
			14-28	41.9	8.1	0.06	4	2.30	14.4	16.0			
			28-34	40.4	8.1	0.05	4	2.56	14.4	17.8			

1/ Analyses by U. S. Regional Salinity Laboratory
2/ Saturation percentage
3/ pH of saturated paste
4/ Per cent salt from paste resistance and Bureau of Soils tables for mixed neutral salts.
5/ Relative lime content as estimated from effervescence with acid: 0 = no effervescence, 1-4 indicate increasing effervescence.
6/ Exchangeable sodium content, milliequivalent per 100 gm.
7/ Base exchange capacity
8/ Exchangeable sodium percentage, i.e., exchangeable sodium content times 100 divided by base exchange capacity.
9/ Mechanical analyses by Div. Soil Mgt. & Irrig. under direction of Dr. L. T. Alexander. Sand: 2-0.02 mm.; Silt: 0.02-0.002 mm.; Clay: less than 0.002 mm.

Appendix Table 3. - Chemical analysis of saturation extracts of selected soil samples from the Emmett Valley area, Idaho[1] *

No.	Depth	ECe[2]	Na	Ca	Mg	CO_3	HCO_3	Salt[3]
	Inches		m.e./l	m.e./l	m.e./l	m.e./l	m.e./l	%
15	0- 3	2.50	25.8	1.07	0.11	0	14.7	.06
	3-11	5.64	66.0	0.40	0.46	37.9	5.4	0.14
	11-24	6.48	77.0	0.92	1.05	51.2	4.7	0.20
	24-36	4.73	55.4	1.01	0.62	30.3	7.6	0.15
	36-49	2.32	25.1	0.31	0.10	8.5	7.1	0.07
16	Crust	101.0	5380.0	0	0	3210.0	1066.0	18.80
	0- 7	5.52	73.2	1.51	0.94	27.5	24.2	0.15
	7-16	1.47	15.6	0.64	1.57	0	25.1	0.04
	16-24	0.99	11.2	0.42	0.74	0	8.5	0.03
17	0- 6	5.85	71.9			0	50.7	0.23
	6-18	8.63	102.8	0.83	0.31	38.9	27.5	0.41
	18-30	1.52	17.2	0.41	0.15	0	12.8	0.06
18	0- 6	0.78	2.82	4.14	0.92	0	6.6	0.03
	6-16	0.50	2.55	2.15	0.61	0	4.2	0.02
	13-24	0.46	3.13	1.49	0.44	0	4.2	0.02
	24-30	0.51	3.80	1.24	0.51	0	3.3	0.02
19	0- 7	0.60	2.29	0.86	0.35	0	3.3	0.01
	7-14	0.91	9.14	0.75	0.43	0	6.1	0.04
	14-23	2.80	25.4	2.81	2.52	0	5.2	0.09
	23-32	6.57	51.7	31.18	8.00	0	3.8	0.27
20	0- 6	5.38	54.6	5.88	2.00	0	34.1	0.22
	6-12	2.34	22.2	1.95	0.68	0	15.1	0.08
	12-24	0.73	4.93	2.06	0.63	0	4.2	0.02
21	0- 7	1.58	16.7	3.07	0.52	0	17.5	0.06
	7-16	1.74	22.1	1.29	0.49	0	15.6	0.07
	16-23	1.94	22.2	0.79	0.32	0	16.5	0.08
	23-28	1.61	20.7	0.60	0.00	0	14.7	0.07
	28-41	1.60	19.1	0.51	0.09	0	15.1	0.07
22	0- 7	1.18	12.5	1.67	0.31	0	13.2	0.05
	7-16	1.05	13.5	1.16	0.25	0	10.9	0.05
	16-23	0.79	8.06	1.29	0.19			0.03
	23-28	0.73	7.12	2.37	0.27			0.03
	28-41	0.78	6.84	1.71	0.29	0	3.8	0.02
23	0- 8	2.36	30.1	2.13	0.43	T	16.1	0.20
	8-16	3.24	33.9	1.67	0.30	T	23.7	0.17
	16-28	3.12	37.9	1.03	1.01	1.9	18.0	0.15
	28-35	1.96	26.6	1.40	1.56	9.5	8.5	0.23
	39.52	1.50	17.1	0.97	0.07		12.8	0.08
24	0- 8	1.02	3.67	2.18	0.67	0	5.7	0.03
	8-16	0.49	3.21	1.80	0.40	0	3.3	0.02
	16-28	0.46	3.41	1.38	0.36	0	3.3	0.02
	35-52	0.50	3.72	1.29	0.39	0	2.8	0.02

* Taken from University of Idaho Research Bulletin No. 17.

Appendix Table 3(Cont.). - Chemical analysis of saturation extracts of selected soil samples from the Emmett Valley area, Idaho [1]

No.	Depth	EC_e [2]	Na	Ca	Mg	CO_3	HCO_3	Salt [3]
	Inches		m.e./l	m.e./l	m.e./l	m.e./l	m.e./l	%
25	0- 3	1.35	15.3	2.32	0.31	0	14.7	0.07
	3- 8	0.97	10.7	0.95	0.09	0	10.0	0.06
	8-22	0.95	11.1	2.43	0.75	0	8.0	0.07
	22-32	1.01	11.2	3.35	0.84	0	8.0	0.08
	36-38	2.30	22.4	0.71	0.07	0	5.7	0.08
26	0- 2	0.75	8.38	2.13	0.77	0	6.6	0.04
	2-11	0.61	6.42	0.61	0.27	0	5.2	0.02
	11-15	0.95	12.6	0.07	0.39	1.4	7.6	0.03
	15-22	0.99	11.1	0.63	0.27	T	8.0	0.03
	22-30	0.87	10.3	0.32	0.27	1.4	4.7	0.02
27	0- 6	0.71	3.25	2.45	1.57	0	5.6	0.02
	6-13	0.97	9.35	0.70	0.76	0	7.1	0.03
	13-25	2.08	22.8	0.59	0.71	0	9.0	0.12
	28-38	1.20	12.2	0.48	0.40	0	11.8	0.09
28	0- 1	15.02	226.0	2.39	0.00	49.2	116.0	0.92
	1- 6	4.00	48.9	2.39	0.73	2.8	35.0	0.18
29	0- 7	0.50	2.50	1.80	0.41	0	4.7	0.01
	7-13	0.38	2.31	1.79	0.40	0	3.3	0.01
	13-32	0.48	3.35	1.79	0.42	0	5.2	0.01
	32-40	0.56	5.10	0.92	0.11	0	4.2	0.01
30	0- 6	3.23	44.1	1.38	0.60			0.16
	6-12	2.18	30.1	1.10	1.42			0.11
	12-30	1.47	17.8	0.52	0.48			0.07
31	0- 6	1.44	15.2	1.56	0.45			0.06
	6-12		20.8					
	12-30	1.55	18.3	0.46	0.30			0.07
32	Crust	130.0	6240.0	8.47	2.19	94.8	137.0	21.90
	0- 6	23.8	326.0	9.11	1.42	0	10.9	0.75
	6-12	8.77	97.5	1.84	0.61	0.5	10.9	0.20
	12-24	4.81	57.1	0.77	0.16	1.4	11.3	0.12
	24-34	1.49	21.1	0.51	0.25			0.06
33	0- 6	4.13	43.2	2.30	0.73	1.4	11.8	0.10
	6-14	2.37	28.7	1.51	0.61	1.4	12.8	0.07
	14-28	1.67	20.4	1.07	0.41	1.4	8.0	0.04
	28-32	1.32	11.7	0.92	0.26		3.8	0.03
34	0- 6	2.74	39.5	1.93	0.56			0.11
	6-14	1.66	25.1	1.29	0.62			0.08
	14-28	1.42	19.1					0.06
	28-34	1.62	21.4					0.07
35	0- 6	1.24	24.3	2.45	1.12	T	8.5	0.08
	6-14	0.86	10.1	1.38	0.50	0	5.2	0.04
	14-28	0.89	9.90	0.92	0.41	T	3.3	0.03
	28-34	0.86	9.30	0.83	0.36	T	3.8	0.03

1/ Analyses by U. S. Regional Salinity Laboratory

2/ EC_e = Conductivity of saturation extract in millimhos per centimeter.

3/ Salt = Per cent salt, dry weight basis, calculated from chemical analyses data on typical extracts.

Appendix Table 4. - Permeability, pH, capillary rise, and settling volume of selected soil samples from the Emmett Valley area, Idaho 1/

No.	Depth	Permeability 2 River Water	Permeability 2 Gypsum Added	pHe 3	pH5	pH60 3	Cap. rise 4 1 hr.	Cap. rise 4 24 hrs.	Set. 5 Vol.
	Inches	in./hr.	in./hr				cm.	cm.	ml.
15	0- 3	0.122	0.175	8.8	10.0	10.0	9.3	32.1	21
	3-11	0.082	0.234	10.2	10.6	10.4	8.9	32.6	29
	11-24	0.135		10.4	10.7	10.4	10.1	32.4	25
	24-36	0.134		10.2	10.5	10.3	11.4	35.0	25
	36-49	0.010	0.354	9.8	10.5	10.2	6.1	14.8	34
16	Crust			9.6					
	0- 7	0.035	0.213	10.0	10.7	10.3	6.7	21.0	23
	7-16	0.025	0.112	9.2	10.2	10.2	3.8	15.0	22
	16-24	0.149		9.2	10.2	9.9	8.6	34.0*	19
17	0- 6	0.009	0.039	9.4	10.5	10.5	2.8	9.5	30
	6-18	0.029	0.078	10.0	10.6	10.6	4.1	13.4	32
	18-30	0.032	0.151	8.9	10.5	10.4	3.5	13.4	32
18	0- 6	0.082	0.178	8.4	8.7	9.4	6.3	25.9	28
	6-13	0.072	0.173	8.5	8.9	9.4	5.1	23.8	25
	13-24	0.230		8.4	9.2	9.6	5.6	24.9	27
	24-30	0.60		8.6	9.2	9.7	7.8	30.5	30
19	0-7	0.118	0.378	8.2	7.1	7.1	9.9	34.7	23
	7-14	0.057	0.550	9.0	8.5	8.5	4.9	13.2	30
	14-23	0.222		8.5	9.1	9.5	8.8	39.0*	25
	23-32	0.89		8.1	7.8	8.0	13.5	72.0*	23
20	0- 6	0.97		8.6	9.6	9.8	9.5	28.4	30
	6-12	0.33		8.8	9.6	9.6	15.3	36.8	28
	12-24	1.57		8.4	8.1	7.8	21.2	97.0*	20
21	0- 7	0.090	0.445	8.6	9.2	9.5	5.9	23.5	20
	7-16	0.005	0.181	9.1	9.6	9.9	3.8	9.0	29
	16-23	0.037	0.248	9.3	10.0	10.1	5.3	13.6	29
	23-28	0.002		9.3	10.2	10.2	5.9	9.6	40
	28-41	0.001		9.4	10.2	10.3	2.6	4.3	81
22	0- 7	0.55	3.6	8.5	9.3	9.5	9.5	30.7	28
	7-16	0.58	3.7	9.1	9.4	9.6	13.5	56.0*	28
	16-23	1.42		8.6	9.0	9.4	16.9	61.0*	29
	23-28	1.92		8.6	8.8	8.9	21.1	72.0*	25
	28-41	2.05		8.6	8.9	8.9	21.2	71.0*	30
23	0- 8	0.001	0.006	8.9	9.7	10.1	1.0	2.0	75
	8-16	0.004	0.016	9.3	10.0	10.3	1.5	5.1	54
	16-28	0.039	0.193	9.3	10.0	10.3	5.5	19.1	35
	28-35	0.028	0.228	9.4	10.1	10.2	4.0	8.0	40
	39-52	0.013	0.252	9.5	10.2	9.8	6.2	11.4	30
24	0- 8	0.74	3.1	8.6	8.4	8.9	9.0	24.3	28
	8-16	0.57	1.82	8.5	8.6	9.1	10.2	30.4	35
	16-28	7.7		8.5	8.7	9.2	10.0	33.0	32
	28-35	3.2		8.4	8.6	9.2	12.7	28.4	38
	35-52	3.1		8.5	8.6	9.2	13.5	40.0*	33
25	0- 3	0.016	0.197	8.8	8.6	8.6	2.8	8.5	30
	3- 8	0.026	0.413	9.0	9.2	9.7	2.0	3.8	32
	8-22	0.056	0.271	8.9	9.3	9.8	3.0	7.8	32
	22-32	0.178	0.76	8.8	9.5	9.6	5.5	19.8	35

Taken from University of Idaho Research Bulletin No. 17.

Appendix Table 4. - Permeability, pH, capillary rise, and settling volume of selected soil samples from the Emmett Valley area, Idaho 1/
(continued)

No.	Depth	Permeability 2/ River Water	Permeability 2/ Gypsum Added	pHe 3/	pH5	pH60 3/	Cap. rise 4/ 1 hr.	Cap. rise 4/ 24 hrs.	Set. 5/ Vol.
	Inches	in./hr	in./hr				cm.	cm.	ml.
26	0- 2	3.5		8.3	6.8	8.1	14.5	48.0*	26
	2-11	0.21	0.45	8.6	8.0	7.7	11.6	41.0*	29
	11-15	0.019	0.217		9.2	8.4	6.0	16.8	27
	15-22	0.135	0.42	9.0	9.6	9.7	7.4	28.9	23
	22-30	0.018		9.0	9.7	9.5	7.0	19.2	30
27	0- 6	0.33		8.6	8.7	8.5	8.0	29.0	30
	6-13	0.067		8.8	9.1	8.6	4.5	17.8	25
	13-25	0.047	0.35	9.0	9.6	9.9	6.9	16.0	29
	28-38	0.021	1.01	9.0	9.6	9.9	2.8	6.0	64
28	0- 1	0.010	0.018	9.5	10.5	10.3	3.9	12.3	39
	1- 6	0.003		9.4	10.1	10.1	3.6	10.3	38
29	0- 7	0.93		8.3	7.4	8.2	19.0	64.0*	25
	7-13	0.36		8.4	7.6	7.3	15.8	55.0*	23
	13-32	0.38		8.5	8.8	8.7	11.7	44.0*	20
	32-40	1.27		8.6	8.7	8.5	12.7	66.0*	20

* Extrapolated values from eight-hour run.

1/ Analyses by U. S. Regional Salinity Laboratory
2/ Permeability in inches per hour of disturbed soil samples for first 24-hour run. Synthetic Payette river water used in first permeability column; in the second column the equivalent of 10 tons of gypsum per acre of soil was added to the soil surface.
3/ pH of saturation extract, 1:5, and 1:60 soil-water suspensions respectively.
4/ Height of rise of wetting front by capillarity in dry sieved soil in 1 and 24 hours respectively.
5/ Volume occupied by 15 grams of soil after flocculation from 1:60 soil-water suspension with $CaCl_2$.

Table 5. - Observation well readings data collected by the U.S.B.R.
Low and high elevations by years.

Line	No.	Ground surface elev.	1936 L	1936 H	1937 L	1937 H	1938 L	1938 H	1939 L	1939 H
3	1	2457.2	D	D	D	D	D	D	D	D
	2	2419.6	16.0	18.8	16.4	18.8	16.4	18.1	13.7	13.8
	3	2413.4	04.2	08.9	04.1	09.5	02.6	05.1	99.3	06.6
4	1	2422.7	18.0	23.0	18.3	23.0	20.3	Destroyed		
	2	2414.2	09.8	12.9	11.2	12.1	11.2	Destroyed		
4A	3	2409.4	04.9	09.5	05.5	09.7	D	08.1	D	08.1
5	1	2446.7	D	D	D	D	D	D	D	D
	2	2414.3	06.4	14.0	08.8	11.6	09.3	11.2	05.5	13.9
	3	2395.0	89.5	94.1	89.5	93.4	89.8	93.2	D	89.6
6	1	2408.0	03.1	07.7	03.0	07.5	05.2	07.4	04.7	07.2
	2	2397.0	D	94.2	D	94.9	D	95.8	D	91.1
	3	2391.7	83.6	88.6	D	89.2	84.5	89.1	84.0	88.3
7	1	2450.0	D	D	D	D	D	D	D	D
	2	2439.1	34.4	34.7	D	36.2	D	35.8	D	35.5
	3	2398.9	D	90.1	D	90.3	D	89.7	D	90.9
8	1	2466.4	D	D	D	D	D	D	D	D
	2	2399.0	D	D	D	86.0	D	85.9	D	85.7
	3	2386.1	77.4	81.4	76.8	81.8	79.0	81.9	78.7	81.9
9	1	2466.7	D	D	D	D	D	D	D	D
	2	2390.1	D	82.9	D	83.7	D	83.3	D	83.9
	3	2377.5	71.3	74.3	71.4	76.3	72.0	76.5	71.7	75.8
	4	2369.1	64.1	67.8	63.9	67.6	64.1	67.8	64.1	67.4
10	1	2317.7	D	D	D	D	D	D	D	D
	2	2390.5	D	80.6	D	80.7	D	80.0	D	85.4
11	1	2365.9	58.5	60.5	D	60.5	58.2	61.4	58.1	60.6
	2	2367.9	61.3	65.8	61.0	65.1	61.5	65.9	61.2	67.1
12	1	2379.7	D	D	D	D	D	D	D	D
	2	2358.5	52.4	54.0	51.7	54.1	51.9	54.5	51.9	54.4
13	1	2378.0	D	66.8	D	67.0	D	68.6	D	D
	2	2357.0	50.7	53.4	50.5	53.9	51.2	53.6	51.1	56.5
14	1	2378.5	D	D	D	D	D	D	D	D
	2	2351.8	50.0	51.2	50.2	51.9	50.2	51.8	50.5	51.6
15	1	2455.7	D	D	D	D	D	D	D	D
	2	2389.0	D	78.4	D	85.3	D	81.1	D	D
16	1	2371.6	D	62.4	D	59.7	D	66.2	D	D
	2	2347.0	40.7	44.9	39.2	44.5	39.2	44.1	39.3	43.5
	3	2339.3	35.4	36.7	35.8	37.2	35.8	36.9	D	36.7
17	1	2351.9	D	43.4	D	43.8	D	42.9	D	43.9
18	1	2369.6	D	D	D	D	D	D	D	D
	2	2330.3	27.3	28.1	27.1	27.9	27.4	28.0		
19	1	2333.3	D	28.2	D	25.9	D	25.1	D	24.6
20	1	2326.1	16.8	19.6	17.5	19.6	18.0	19.8	D	19.4
21	1	2326.3	D	D	D	D	D	D	D	D
	2	2326.3	15.8	22.2	15.9	22.7	15.9	21.8	D	22.3
22	1	2393.0	D	D	D	D	D	D	D	D
	2	2308.6	05.5	07.2	05.4	07.1	05.7	06.5	05.6	06.6
23	1	2417.7	D	D	D	D	D	D	D	D
	2	2382.4	D	D	D	D	D	82.2	D	72.7
	3	2348.0	D	D	D	D	D	39.6	D	38.8
24	1	2357.6	D	D	D	D	D	D	D	D
	2	2323.0	16.1	18.8	16.0	20.7	16.1	18.5	15.7	18.4

Table 5 (Cont.) - Observation well reading data collected by the U.S.B.R. Low and high elevations by years.

Line:	No.:	1940 L	1940 H	1941 L	1941 H	1942 L	1942 H	1943 L	1943 H	1944 L	1944 H
3	1	D	D	D	D	D	D	D	D	D	D
	2	D	17.4	D	17.9	D	18.5	15.6	18.6	13.6	18.8
	3	99.8	07.5	99.6	07.6	99.7	10.1	00.5	09.0	00.0	08.1
4	1	Destroyed									
	2	Destroyed									
4-A	3	D	08.5	D	07.4	D	02.9	D	08.8	D	06.5
5	1	D	D	D	D	D	D	D	D	D	D
	2	04.1	14.2	04.1	10.4	05.9	13.9	06.7	13.9	07.5	08.8
	3	D	90.3	D	90.7	D	95.1	D	92.4	D	91.2
6	1	05.7	07.2	04.8	07.7	04.6	07.3	07.5	07.7	03.4	06.8
	2	D	90.6	D	91.1	D	93.5	D	92.0	D	90.2
	3	D	88.2	D	87.2	D	89.5	83.8	89.0	84.0	88.3
7	1	D	D	D	D	D	44.1	D	D	D	D
	2	D	36.2	D	36.0	D	36.4	D	34.9	D	33.4
	3	D	88.8	D	90.4	D	91.9	D	91.3	D	89.2
8	1	D	D	D	D	D	D	D	D	D	D
	2	D	85.2	D	87.4	D	88.1	D	87.2	D	86.6
	3	77.1	81.5	76.4	82.7	77.0	86.3	79.0	82.5	79.9	84.3
9	1	D	D	D	D	D	D	D	D	D	D
	2	D	83.9	D	85.4	D	85.6	D	85.3	80.4	84.2
	3	71.6	77.0	71.2	77.2	73.0	76.0	74.9	76.4	73.4	77.6
	4	64.5	67.5	64.3	67.5	64.6	67.3	65.4	67.9	64.6	67.6
10	1	D	D	D	D	D	03.9	D	D	D	D
	2	D	85.2	D	84.2	D	82.9	D	82.5	D	81.6
11	1	58.1	65.2	D	60.3	D	60.9	58.4	60.9	58.3	60.5
	2	61.4	65.0	61.0	66.0	61.5	65.7	62.7	67.9	61.9	66.0
12	1	D	D	D	D	D	D	D	D	D	D
	2	52.0	55.3	51.1	54.5	51.8	54.4	52.4	54.4	52.4	54.3
13	1	D	D	D	Destroyed						
	2	50.2	55.1	50.7	51.4	50.9	54.6	51.1	57.1	51.0	56.3
14	1	D	D	D	D	D	D	D	D	D	D
	2	50.8	51.7								
15	1	D	D	D	D	D	D	D	42.2	D	D
	2	D	D	D	D	D	D	D	78.0	D	D
16	1	D	D	D	68.6	D	64.6	D	65.0	D	63.5
	2	D	44.1	D	43.6	D	44.6	39.9	43.7	D	42.8
	3	D	35.8	D	D	D	35.2	D	35.5	D	35.3
17	1	D	43.7	D	44.4	D	46.5	D	43.6	D	43.6
18	1	Destroyed									
	2										
19	1	23.7	25.0	D	25.3	D	25.5	D	24.7	D	24.3
20	1	17.1	20.3	D	17.8	D	24.1	D	D	D	D
21	1	D	D	D	D						
	2	D	18.9	D	17.5	D	19.1	D	19.0	D	19.1
22	1	D	D	D	D	D	D	D	D	D	D
	2	05.6	07.9	05.2	06.9	05.1	06.6	06.1	06.8	06.3	07.0
23	1	D	D	D	D	D	D	D	D	D	D
	2	D	72.9	D	75.5	D	81.4	D	D	D	D
	3	D	44.0	D	44.8	D	42.8	D	46.7	D	46.4
24	1	D	D	D	D	D	D	D	D	D	D
	2	16.0	18.1	16.0	18.3	16.4	18.4	17.0	18.6	16.7	18.5

Table 5 (Cont.) - Observation well readings data collected by the U.S.B.R.
Low and high elevations by years.

Line	No.	1945 L	1945 H	1950 L	1950 H	1951 L	1951 H	1952 L	1952 H
3	1	D	D	D	D	D	D	D	D
	2	16.0	17.3	14.5	17.1	14.8	18.8	13.5	18.9
	3	00.8	06.4	Filled in					
4	1	Destroyed							
	2	Destroyed							
4-A	3	D	06.0	D	08.8	D	08.8	D	08.2
5	1	D	D	Destroyed					
	2	08.3	08.5	10.5	13.9	10.1	13.9	12.0	13.9
	3	D	91.4	D	93.8	D	93.7	D	91.7
6	1	04.7	07.1	04.4	07.6	04.9	06.8	05.2	07.0
	2	D	90.5	D	92.0	D	95.9	D	90.7
	3	83.9	88.0	Destroyed					
7	1	D	D	D	49.5	D	D	D	D
	2	D	34.4	Destroyed					
	3	86.9	88.0	87.7	91.2	88.6	98.6	88.4	90.2
8	1	Destroyed							
	2	D	D	D	88.9	D	D	D	D
	3	81.4	83.1	80.5	82.5	79.3	83.0	78.5	85.1
9	1	D	D	D	D	D	D	D	D
	2	79.6	83.8	D	83.4	D	83.5	D	81.5
	3	73.3	75.5	73.0	75.9	D	75.8	72.9	75.6
	4	65.5	67.1	65.6	Destroyed				
10	1	D	D	D	D	D	D	D	D
	2	D	82.4	D	D	D	79.0	D	80.4
11	1	58.3	60.9	Destroyed					
	2	62.6	65.0	Destroyed					
12	1	D	D	D	D	D	D	D	69.6
	2	52.7	54.2	53.6	58.9	56.1	58.6	57.6	58.6
13	1	Destroyed							
	2	52.8	56.3	51.3	55.7	51.9	56.8	52.1	57.1
14	1	D	D	D	D	D	Destroyed		
	2	Destroyed							
15	1	D	D	D	D	D	42.3	D	43.7
	2	D	D	D	D	D	D	D	D
16	1	D	D	Destroyed					
	2	39.0	41.6	Destroyed					
	3	D	35.4	Destroyed					
17	1	D	42.8	D	44.4	D	48.2	D	43.3
18	1	Destroyed							
	2	Destroyed							
19	1	D	26.1	Destroyed					
20	1	Destroyed							
21	1	Destroyed							
	2	18.2	Destroyed						
22	1	D	D	D	D	D	D.	D	D
	2	05.7	07.2	05.6	06.8	05.4	07.7	06.0	07.7
23	1	D	D	D	D	D	D	D	D
	2	D	81.9	Destroyed					
	3	D	D	D	D	D	D	D	D
24	1	D	D	Destroyed					
	2	16.8	17.6	16.3	17.8	16.3	18.4	16.5	18.4

Table 5 (Cont.) Observation well reading data collected by the U.S.B.R. Low and high elevations by years.

Line	No.	Ground surface elev.	1936 L	1936 H	1937 L	1937 H	1938 L	1938 H	1939 L	1939 H
25	1	2339.8	D	D	D	D	D	D	D	D
	2	2305.7	02.4	05.7	01.8	05.1	02.6	05.6	02.1	05.1
26	1	2336.1	D	31.9	D	34.2	D	31.0	D	33.4
27	1	2331.0	D	27.9	D	28.6	21.6	26.3	D	28.7
28	1	2342.0	D	D	D	D	D	D	D	D
	2	2296.4	90.7	93.3	91.0	92.3	90.9	93.6	90.4	92.3
29	2	2331.5	D	22.3	D	22.0	D	25.6	D	D
	3	2300.1	94.8	96.9	95.4	97.9	95.2	97.3	95.1	97.0
30	1	2358.8	D	D	D	D	D	D	D	D
	2	2288.7	81.8	83.1	81.2	83.0	81.4	83.1	81.3	83.0
31	1	2374.6	D	66.5	D	65.4	D	D	D	D
32	1	2305.8	D	04.9	D	07.7	D	04.7	D	03.5
	2	2276.7	70.0	73.3	D	73.2	D	72.8	D	73.4
	3	2267.6	58.0	61.3	D	63.1	D	61.4	D	61.5