U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE BEAR RIVER AREA, UTAH.

BY

CHARLES A. JENSEN AND A. T. STRAHORN.

[Advance Sheets—Field Operations of the Bureau of Soils, 1904.]

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

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[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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SOIL SURVEY OF THE BEAR RIVER AREA, UTAH.

By CHARLES A. JENSEN and A. T. STRAHORN.

LOCATION AND BOUNDARIES OF THE AREA.

The Bear River area lies in Bear River Valley, in the north-central part of the State of Utah, and the city of Brigham, about 8 miles north of the southern boundary of the area surveyed, lies in north

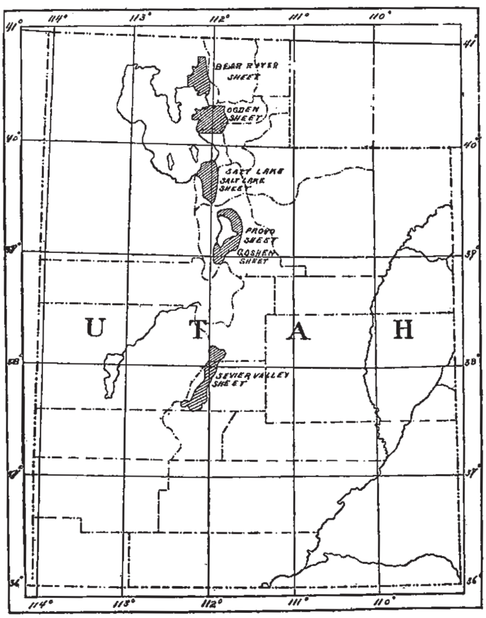

FIG. 1.—Sketch map showing location of the Bear River area, Utah.

latitude 41° 30′ and west longitude 112°. The parallel of 42° north latitude forms the northern boundary of the State. The area surveyed extends north and south from T. 8 N. to T. 12 N., inclusive, a distance of 30 miles, varies in width from 6 to 15 miles, and comprises 213,632 acres, or about 334 square miles. This includes practically all the irrigable land in the valley within the State and also part of the former bed of Great Salt Lake.

About 20 square miles in the extreme northern part of the State, part of it irrigable, was not included in the survey.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The area surveyed was settled about 1850, the first settlement in the State having been made at Salt Lake City in 1847 by Brigham Young and his followers. For a number of years settlements were confined to the eastern side of the valley, comprising in order from south to north the towns of Willard, Brigham, Honeyville, Deweyville, and Collinston. The last-named town was settled later than the others.

During the completion of the Central Pacific Railroad, now the Southern Pacific, in 1868–69, other settlements were established, the principal one being Corinne. This town was for some time an important freighting terminus for points in Idaho and Montana, until the Utah and Northern Railroad, now the Oregon Short Line, was built north into those States.

The only source of population for a number of years was the immigration of members of the Mormon Church from eastern States, and, at a later date, from foreign countries. With the advent of the railroads the Gentiles began to populate the State, especially the mining regions. In a short time outside capital began to be invested in many enterprises.

Agricultural development in a country with a small amount of precipitation necessarily depends on the development of irrigation systems. Before these are established stock raising and mining constitute the principal industries, and both of these are at present of great importance in the State of Utah.

Irrigation in the area surveyed was first practiced in and around Brigham, Boxelder Creek and other smaller mountain streams being diverted for this purpose. No elaborate canal system was built, and each person helped himself to what water he wanted or needed, building private ditches for this purpose. A well-regulated system is now in force, dividing these streams among the irrigators.

The first elaborate and most important irrigation system in the area was the Bear River canal, which was built during the late eighties and early nineties, but not entirely completed until some years later. This system was at first confined to the area west of Bear River, but during 1903–4 a branch, known as the East Side Canal, was built on the east side of that river, and was first used in 1904.

Before the Bear River Canal was built considerable dry farming was carried on, but this has since been practically abandoned in favor of the safer method of irrigation.

For a more complete history of irrigation in Utah, the reader is referred to other publications of the Bureau of Soils.[a]

CLIMATE.

The climate of the valley is semiarid. The normal annual rainfall at Corinne, in the central part of the area, is 11.62 inches, and the relative humidity is low. From June to October, inclusive, the season when crops require the greater part of the moisture necessary to their growth, the rainfall is but 2.99 inches. There is an abundance of sunshine, especially during summer, and the wind movement is seldom high enough to cause damage.

The normal annual temperature is 51.3° F. at Corinne; the highest monthly normal is 80°, in July, and the lowest is 24°, in January. The summer days often become quite warm, but owing to the low humidity the heat is not oppressive, and usually the nights are cool.

Severe electric storms often visit the valley, but the damage done by these is unimportant.

Spring frosts are seldom of much consequence, but the fall frosts sometimes nip the fruit, though without much resultant injury. The average date of the last killing frost in spring is about May 15, and of the first in fall about October 7.

Normal monthly and annual temperature and precipitation.

Month.	Corinne.		Ogden.		Logan.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*	*° F.*	*Inches.*
January	24.7	1.27	28.5	1.49	24.2	1.09
February	30.1	1.25	33.0	1.56	25.7	1.16
March	39.9	1.26	41.1	1.59	33.8	1.83
April	50.5	1.10	52.6	1.42	46.7	1.80
May	61.2	1.18	61.8	1.61	55.2	2.21
June	71.4	.50	72.0	.57	63.4	.64
July	79.6	.47	79.4	.25	71.0	.40
August	74.4	.43	76.7	.47	70.5	.51
September	65.6	.64	65.7	.68	61.1	1.09
October	51.5	.95	51.8	1.33	50.2	1.15
November	37.3	1.03	39.3	1.21	37.9	1.14
December	29.0	1.54	31.7	1.65	25.8	1.08
Year	51.3	11.62	52.8	13.83	47.1	14.10

[a] A Soil Survey in Salt Lake Valley, Utah, by Gardner and Stewart, in Field Operations of the Division of Soils, 1899; Soil Survey in Weber County, Utah, by Gardner and Jensen, in Field Operations of the Division of Soils, 1900; Soil Survey in Sevier Valley, Utah, by Gardner and Jensen, in Field Operations of the Division of Soils, 1900.

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PHYSIOGRAPHY AND GEOLOGY.

Physiographically, the valley may be divided into three sections: The cultivated mountain slopes on the east and west sides of the valley; the low-lying, flat bottom lands, which formerly were covered by Great Salt Lake in its concentrated condition, and the higher lying and level prairie lands, north of the lake bottom lands, and included between the mountains.

The cultivated mountain slopes are not steep, and vary from a quarter of a mile to 1 mile in width on the east side, while their width is less on the west side of the valley. There are no rolling foothills between the mountains and the valley, but the mountains rise abruptly from the slopes, those on the east side to a height of 5,000 or 6,000 feet above the valley, or about 10,000 feet above sea level; those on the west side to not more than 8,000 feet above the sea.

The lake bottom lands form an uninterrupted level area. The level valley floor north of the lake lands is broken by Little Mountain, which covers a surface area of about 7 square miles, and reaches an altitude about 1,200 or 1,500 feet higher than the surrounding valley. One or two smaller hills, in the northwestern part of the valley, are the only other breaks in the general level, except the gorges cut by Bear and Malade rivers.

The mountains on the west side of the valley, as far as included in the survey, take a course a little east of north to the north side of T. 11 N., at which point the range doubles back on itself, forming a cove of about 10 square miles; from there it again turns and takes a course due north to the State line. This loop narrows the valley to a width of about 6 miles at the northern limit of the area.

Malade River enters the valley at the north end and flows into Bear River at Bear River City. Bear River enters the valley at the northeastern limit of the survey, and flows due south as far as Corinne, at which point it turns and flows almost due west into Great Salt Lake.

The area surveyed lies near the northern limit of what was formerly Lake Bonneville, this lake covering in earlier geologic times about two-thirds of the western part of Utah, with a narrow strip of eastern Nevada, and extending a short distance into Idaho on the north. Originally the upper shore of Lake Bonneville was about 1,000 feet above the present level of Great Salt Lake, and with the exception of a drop of 375 feet, due to an early outlet northward into Snake River, this whole body of water has gradually evaporated, leaving the present Great Salt Lake, Utah Lake, and Sevier Lake. Lake Bonneville lay wholly within the Great Basin, which includes practically all of the State of Nevada, three-fourths of the western part of Utah, a small corner of southeastern Idaho and southwestern Wyoming, and much of southern Oregon and southern California.

The Wasatch Range, in the area surveyed, is composed almost entirely of limestone and primary and secondary quartzite, with some shale, the former two overlying each other in alternate layers. This range has been greatly flexed and broken, forming in several places practically perpendicular walls of limestone and quartzite hundreds of feet high, facing the valley and showing dips of 50° to 60° northward. In a few places the dip is southward. Little Mountain and the mountains on the west side of the valley are also composed chiefly of limestone and quartzite. The Wasatch Range is broken just east of Brigham by Boxelder Canyon, and the creek issuing from this canyon has formed quite an extensive delta, on which Brigham is located. Other smaller and less important deltas have been formed all along the slopes of these mountains by wash from intermittent streams.

After Lake Bonneville had been confined to Salt Lake Valley the waters from Bear River, including the Cache Valley streams, flowed into Bear River Valley at the present entrance of Bear River, making deep deposits of soil in the northern end of the valley, consisting of fine sandy loam, fine sand, and sand. These deposits were later capped by clay loam and clay when the flowing waters were less in volume and the lake was shallower. As the lake receded Bear River gradually cut its way into its own deposits until at present the channel varies in depth from a few feet at Corinne to perhaps 150 feet near the mouth of the canyon. Malade River likewise cut a channel in these same deposits varying in depth from 10 to 50 feet within the area surveyed. This latter river, however, has not been an important agent in soil formation in the Bear River Valley. Numerous beds of shells exist in the northern part of the valley, and are sometimes cut into in canal excavations.

SOILS.

Thirteen soil types were recognized in the area surveyed. The following table shows the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Salt Lake clay loam	70,656	33.2	Malade sandy loam	3,264	1.6
Jordan loam	61,632	28.8	Jordan clay	2,688	1.3
Fresno fine sandy loam	21,504	10.1	Bingham stony loam	1,984	1.0
Malade loam	16,640	7.8	Salt Lake sandy loam	1,408	.7
Bingham gravelly loam	10,304	4.8	Meadow	448	.0
Malade fine sandy loam	10,112	4.7	Total	213,632	
Salt Lake loam	6,912	3.2			
Malade fine sand	6,080	2.8			

JORDAN LOAM.

The Jordan loam is a type of soil established in an earlier survey in this State, and is of considerable extent in Bear River Valley. As mapped in this area it consists of about 12 inches of gray, heavy fine sandy loam, underlain to a depth of from 2 to 3½ feet with loam, which becomes heavier with increased depth. From this point the subsoil consists of a clay loam, which usually grades into clay at from 4 to 6 feet. In small areas of local depression the third foot becomes clay, which continues to 6 feet.

There are two general areas of this type; one, and by far the largest, lies in the northern part of the valley, extending from the north end of Little Mountain northward to the limit of the survey. In this area the soil, especially the subsoil, is reddish in color, and contains considerable lime. The other group of areas is located on the east side of the valley, along the foot of the mountain slopes, partly extending into the low-lying lake bottom lands. In these areas both soil and subsoil are gray or black in color and, like the first-mentioned area, usually contain considerable lime. A light phase of this type is found in Boxelder Lake, which dries up every year, and in the cove north of Honeyville. In these areas the clay subsoil is found at a lower depth, and is sometimes entirely wanting in the 6-foot profile.

The areas occupied by the Jordan loam are usually level, and those on the east side of the valley are low and wet as well. The drainage is good where the type lies adjacent to Malade or Bear River, and in the extreme northern part of the area, next to the foothills and north of Honeyville. The remaining portions are poorly drained, especially Boxelder Lake and the areas at the foot of the mountain slopes on the east side of the valley, some of which are themselves drainage catchments for the surrounding land.

This soil type owes its origin to two modes of formation. In the northern part of the area it has been formed from sediment carried down by Bear River and deposited in Lake Bonneville when that lake was shallow. Probably much of the soil was deposited after the lake had receded from the northern part of the valley, by overflows and floods of Bear River before that stream had cut its present deep channel. The type in this part of the valley is distinctly stratified, and often contains beds of shells showing lake deposition. The southern and eastern areas have been formed partly by lake deposition and partly by wash from the mountain slopes.

Considerable quantities of alkali, or soluble salts, are found in this type in its southern and eastern locations and in that part lying west and north of Little Mountain. The extreme northern area of the type and that part lying north of Honeyville are free from harmful accumulations of alkali.

The Jordan loam, where free from alkali, is well adapted to grain and sugar beets, and where naturally well drained, to alfalfa and orchard fruits.

The following table gives mechanical analyses of the soil and subsoil of the Jordan loam:

Mechanical analyses of Jordan loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11211	Cen. sec. 7, T. 10 N., R. 4 W.	Loam, 0 to 12 inches	0.1	0.4	0.4	1.6	19.7	51.8	25.5
11476	W. cen. sec. 10, T. 11 N., R. 3 W.	Loam, 0 to 18 inches	.1	.4	.2	1.4	6.4	53.9	37.4
11477	Subsoil of 11476	Clay, 24 to 48 inches	.1	.1	.1	.9	3.6	51.1	43.8
11212	Subsoil of 11211	Clay, 24 to 36 inches	.3	.3	.1	.4	5.3	45.1	48.4

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11211, 24.5 per cent; No. 11212, 32.2 per cent.

SALT LAKE CLAY LOAM.

The soil of the Salt Lake clay loam, to a depth of about 12 inches, consists of heavy fine sandy loam, underlain to 6 feet with loam or heavy loam and, rarely, with clay loam. Occasionally a stratum of fine sandy loam or fine sand is found in the third, fourth, or fifth foot section, but this is not a necessary characteristic of the type.

The Salt Lake clay loam occurs in large areas in the southern and southwestern parts of the survey, representing the recent lake bottom; an area adjoining the east side of Little Mountain; smaller areas in and around Corinne, and other areas in the southern township of the survey, along the foot of the mountain slopes. All the areas are level, and those in the recent lake bottom are low and often wet. A few sloughs traverse the areas of this soil east of Little Mountain.

Where the Salt Lake clay loam adjoins Bear River or Malade River, it is well drained, but the remainder has poor natural drainage, and the water table is close to the surface. The recent lake-bottom area has, of course, no drainage at all, and is itself a drainage catchment basin for the whole valley. This area is often entirely covered with water in the spring, owing to the high water in Bear River. With the exception of those areas adjacent to Bear and Malade rivers and the bluff line indicated on the map, where drainage is good, the whole type is badly alkaline. There is an area west of Corinne, however, which is pretty well reclaimed.

The Salt Lake clay loam is of lacustrine origin. Only small areas of it are cultivated, chiefly in and around Corinne, to some extent east of Little Mountain, and in a few places on the east side of the valley, southwest of Brigham. Where not alkaline the type is cultivated to alfalfa and fruit, and to a small extent to grain. Many of the low-lying areas are devoted to hay production and grazing, to which the type is well adapted in its natural condition, especially south of Corinne and west of Brigham.

Some parts of this type in the recent lake bottoms sustain a heavy growth of coarse sedge, which is gathered for winter feed for cattle. These lake-bottom areas are also quite largely used for grazing purposes, as on many parts of them salt grasses grow fairly well, especially where copiously overflowed during the high water of Bear River.

The following table gives mechanical analyses of the Salt Lake clay loam:

Mechanical analyses of Salt Lake clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11203	N. cen. sec. 2, T. 9 N., R. 3 W.	Loam, 0 to 12 inches	0.1	0.5	0.6	6.5	30.5	43.4	18.3
11468	S. cen. sec. 36, T. 10 N., R. 3 W.	Heavy loam, 0 to 24 inches	.3	.2	.3	3.7	20.4	51.8	22.9
11466	Cen. sec. 10, T. 10 N., R. 3 W.	Heavy loam, 0 to 18 inches	.1	.5	.5	4.2	15.6	52.2	26.8
11202	Cen. of SW. ¼ sec. 21, T. 10 N., R. 4 W.	Heavy loam, 0 to 24 inches	.0	.0	.1	.3	14.8	56.0	28.4
11469	Subsoil of 11468	Heavy loam, 24 to 48 inches.	.0	.2	.2	9.9	25.2	46.3	18.2
11467	Subsoil of 11466	Heavy loam, 24 to 48 inches.	1.1	1.5	.7	3.0	17.6	52.3	23.4
11204	Subsoil of 11203	Clay, 24 to 36 inches	.0	.1	.1	1.1	12.6	47.1	39.0

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11202, 1.5 per cent; No. 11203, 5.2 per cent; No. 11204, 12.8 per cent.

MALADE LOAM.

The Malade loam consists of about 12 inches of fine sandy loam, underlain to 3 or 4 feet with loam, or sometimes clay loam, which is in turn underlain with fine sandy loam, sometimes extending to 6 feet, but more often grading into fine sand or sand in the lower part of the profile.

The type is located on the east side of Bear River, extending several miles south and west and 6 or 7 miles north of Corinne. A few small areas of bottom land along Bear River are composed of this type. The surface of the type is generally quite level.

The areas of Malade loam lying east of Bear River are generally well drained, owing to their proximity to the river channel. Those lying west and south of Corinne, however, are not naturally well drained, except where they adjoin the natural sloughs which intersect some portions of this type. The underground water map shows much of this type to have water within 3 to 6 feet of the surface, a considerable part of the area so affected being virgin land that has never been irrigated.

This soil type has been formed by deposits from the flood waters of Bear River, and these periods were succeeded by deposition in more quiet waters, probably during one of the temporary higher stages of the lake, before it reached anything like its present low stage. The areas lying east of Bear River are not badly affected with alkali, but those west and south of Corinne contain considerable alkali, especially in the subsoil. Where free from alkali the type is well adapted to sugar beets and grain, and, also, when the water is not too near the surface, to fruit and alfalfa.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Malade loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11199	½ S. of NW. cor. sec. 33, T. 10 N., R. 3 W.	Fine sandy loam, 0 to 12 inches.	0.0	0.4	0.9	25.2	25.8	32.7	15.0
11462	S. cen. sec. 26, T. 10 N., R. 3 W.	Loam, 0 to 12 inches	.3	1.0	.7	5.1	27.5	47.5	17.4
11459	N. cen. sec. 9, T. 9 N., R. 2 W.	Loam, 0 to 12 inches	.2	.4	.4	9.9	19.5	49.0	20.4
11200	Subsoil of 11199	Loam, 24 to 36 inches	.0	.2	.8	28.1	23.8	25.5	21.6
11463	Subsoil of 11462	Clay loam, 12 to 36 inches.	.0	.2	.1	3.3	29.4	36.7	30.2
11460	Subsoil of 11459	Heavy clay loam, 12 to 24 inches.	.7	1.7	.7	4.7	18.9	33.3	36.9
11201	Subsoil of 11200	Fine sandy loam, 48 to 60 inches.	.0	.2	.3	31.4	43.1	14.1	10.8

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$) : No. 11199, 0.6 per cent; No. 11200, 8.1 per cent.

FRESNO FINE SANDY LOAM.

The Fresno fine sandy loam, as mapped in the Bear River Valley, consists usually of 6 feet of fine sandy loam, but in some parts of the area surveyed the subsoil from the fourth to the sixth foot, inclusive, is a sandy loam, the third-foot section, in local areas, being a light loam.

The type is found in nearly all parts of the survey, its principal occurrences being a few miles west of Corinne; west of Little Mountain; along the lower course of Malade River; scattered areas along Bear River from Corinne north to the limit of the survey; the cove northwest of Roweville, and smaller areas at the foot of the mountain slopes on both sides of the valley. Where the type occurs west of Little Mountain it is underlain with clay loam and clay, while in the other areas it is underlain usually with a lighter soil than the type itself.

The mountain slope areas of the type have, of course, the general slope of these places, while the remaining areas are level. West of Little Mountain, in the recent lake-bottom country, the type occupies local elevations left as little knolls and mounds, varying in height from a few feet to 15 or 20 feet above the lake-bottom land. These were formerly isolated islands. The surface of these areas is generally level. The type as a whole is well drained.

The areas west of Little Mountain have been formed by transporting the fine sandy loam from the surrounding hills and mountains, this having been deposited colluvially on top of the loam and clay formed from very much older lacustrine deposits. The areas along the mountain slopes owe their origin to the same agency, while those along the rivers have been formed from sediment carried by the water during overflows or when these channels were shallower than at present.

The type west of Little Mountain, and also that part west of Corinne, contains considerable alkali, but the remainder is practically free from harmful accumulations of salts.

Much of this type along the rivers is dry-farmed, owing to the difficulty of supplying it with water.

The Fresno fine sandy loam is well adapted to grain, sugar beets, alfalfa, and fruit. The area west of Little Mountain is not cultivated, owing to lack of water and to the presence of alkali.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Fresno fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11206	⅛ E. of cen. sec. 16, T. 10 N., R. 4 W.	Very fine sandy loam, 0 to 18 inches.	0.1	0.2	0.2	1.5	28.4	59.8	9.9
11470	NW. cor. sec. 24, T. 10 N., R. 3 W.	Fine sandy loam, 0 to 18 inches.	.3	.9	.9	24.8	31.7	28.1	12.9
11472	SE. cor. sec. 3, T. 9 N., R. 3 W.	Fine sandy loam, 0 to 12 inches.	.2	.7	1.3	32.9	30.4	18.5	16.0
11208	NE. cor. sec. 23, T. 10 N., R. 3 W.	Fine sandy loam, 0 to 12 inches.	.4	1.0	.8	18.4	20.8	40.2	18.3
11473	Subsoil of 11472	Fine sandy loam, 24 to 48 inches.	.0	.4	.8	19.3	35.7	28.1	15.1
11471	Subsoil of 11470	Fine sandy loam, 24 to 48 inches.	.0	.3	.5	29.4	30.9	19.5	18.9
11209	Subsoil of 11208	Fine sandy loam, 24 to 36 inches.	.0	.1	.1	27.3	36.1	16.4	19.7
11207	Subsoil of 11206	Loam, 36 to 60 inches	.3	.2	.1	1.6	30.5	46.5	20.5

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11206, 13.2 per cent; No. 11207, 16.8 per cent; No. 11208, 23.5 per cent; No. 11209, 21.7 per cent.

MALADE FINE SANDY LOAM.

The soil of the Malade fine sandy loam, to a depth of from 2 to 2½ feet, consists of a gray fine sandy loam of the same texture as the Fresno fine sandy loam, underlain to 6 feet with loam or clay loam—usually clay loam in the fifth and sixth foot sections—and intensely red in color. This subsoil is about the same as the subsoil of the Jordan loam, but is usually lighter in texture.

This type occurs in narrow strips of land along the east side of the valley, usually occupying the lower portion of the mountain slopes; also in a small area at the foot of the mountain slope on the west side of the valley, north of the Southern Pacific Railroad; another south of Corinne; and a long strip on the west side of Bear River, just back of the higher forelands adjacent to the river.

The type is generally well drained; that on the east side of the valley because of the mountain slope, the lower part of which the type occupies; and that along Bear River because of its proximity to the banks of that stream. The area south of Corinne is located next to the bluff, which also insures good natural drainage.

The heavy subsoil of this type has been deposited in quiet water from the silts and clays carried down by Bear River, while the top covering of fine sandy loam has been formed colluvially from the surrounding higher lying forelands along the river or from the mountain slopes during later periods.

There is very little alkali in the Malade fine sandy loam, the heavy subsoil being comparatively free from it, owing to the good drainage conditions of the type.

The soil is cultivated principally to alfalfa, and some orchard fruits are grown. It is well adapted to sugar beets.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Malade fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11196	½ N. of SE. cor. sec. 10, T. 9 N., R. 3 W.	Fine sandy loam, 0 to 12 inches.	0.1	0.7	0.5	19.1	39.9	24.9	14.8
11455	S. cen. sec. 8, T. 11 N., R. 2 W.	Loam, 0 to 24 inches	.1	.5	.9	10.6	24.2	48.6	15.0
11457	½ N. of SE. cor. sec. 10, T. 9 N., R. 3 W.	Fine sandy loam, 0 to 24 inches.	.1	.2	.3	18.0	28.0	36.6	16.5
11197	Subsoil of 11196	Fine sandy loam, 24 to 36 inches.	.1	.2	.1	15.3	38.6	26.5	19.0
11456	Subsoil of 11455	Clay loam, 24 to 48 inches.	.2	.5	1.3	13.5	18.5	39.4	26.7
11458	Subsoil of 11457	Clay loam, 24 to 48 inches.	.1	.1	.1	4.4	11.6	55.0	28.7

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11196, 5.2 per cent; No. 11197, 23.9 per cent.

MALADE FINE SAND.

The Malade fine sand consists of fine sand without much change in texture to a depth of 6 feet. It is located along the banks of Bear River, and extends from a point 2 miles south of Bear River City north to Collinston. The surface of the individual areas is usually level, but the more typical are usually raised above the surrounding land. A few local areas occur below the Bear River embankments, next to the stream itself.

The Malade fine sand has been formed from materials deposited by Bear River during overflows mainly before the channel reached its present depth. Some of these fine sand areas occupy high forelands along the river. The soil as a whole is well drained, and free from alkali.

The Malade fine sand is well adapted to any crop suited to the climate of the valley, and especially to sugar beets under irrigation.

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Malade fine sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
11454	N. cen. sec. 12, T. 11 N., R. 3 W.	Fine sand, 0 to 36 inches	0.1	2.4	17.1	48.2	22.4	5.9	4.0
11453	N. cen. sec. 7, T. 11 N., R. 2 W.	Fine sand, 0 to 48 inches	.0	.2	1.2	57.7	25.7	7.2	8.0
11226	S. cen. sec. 1, T. 11 N., R. 3 W.	Fine sand, 0 to 18 inches	.0	.3	2.1	44.4	34.9	9.3	9.1
11227	Subsoil of 11226	Fine sand, 36 to 48 inches	.0	.0	Tr.	35.2	38.6	16.2	10.1

The following sample contains more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11226, 1 per cent.

MALADE SANDY LOAM.

The Malade sandy loam consists of about 12 inches of fine sandy loam, underlain to 5 feet with a coarse sandy loam, often containing a high percentage of clay; and this, in turn, is underlain to 6 feet with a fine sandy loam or fine sand. The surface foot is usually quite loose in texture, but below that the soil is generally very compact.

The type is located on the east side of Bear River, adjacent to that stream, and extends from Corinne north to Bear River City. The surface is level, but higher than the surrounding land, the sandy loam occupying the forelands along the river.

The type owes its origin to deposits from Bear River during overflows. It is well drained and free from alkali.

This soil is well adapted to any crop grown in the area, and is one of the best soils for sugar beets when irrigation is practiced. It was dry-farmed to some extent before the East Side Canal was built.

The following table gives a mechanical analysis of a typical sample of this soil:

Mechanical analysis of Malade sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
11465	NE. cor. sec. 9, T. 10 N., R. 2 W.	Sandy loam, 0 to 24 inches	0.0	0.2	0.7	45.8	23.3	10.2	19.8

BINGHAM GRAVELLY LOAM.

The Bingham gravelly loam consists of a fine sandy loam or loamy sand containing considerable gravel, especially in the subsoil. The gravel varies in size from fine gravel to fragments 3 or 4 inches in diameter. As mapped in this area the gravel usually reaches the surface, but may be from 1 to 2 feet below. In some places there is very little interstitial soil, this being the case where the slopes are steepest and the water action greatest.

The type is located on the east side of the valley, along the slopes of the mountains. A few isolated areas occur in other parts of the valley. The soil is well drained and free from alkali.

The Bingham gravelly loam has been formed entirely from wash from the hills and mountains, and numerous small deltas have been formed by the intermittent streams. The largest delta area, on which the city of Brigham is located, occurs at the mouth of Boxelder Creek.

The type is important, owing to its adaptation to fruit and truck farming, and is devoted largely to orchard fruits, consisting of apples, pears, peaches, apricots, plums, and cherries. Small fruits, particularly strawberries and raspberries, and considerable quantities of vegetables are grown, these often being cultivated as intermediary crops in the orchards.

This type of soil occurs in several other areas already surveyed in Utah, and the following analyses of samples taken in the Salt Lake survey will serve to show the texture of the interstitial material:

Mechanical analyses of Bingham gravelly loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4362	SW. ¼ sec. 15, T. 3 S., R. 2 W.	Fine sandy loam, 0 to 15 inches.	1.50	2.71	5.81	8.87	27.93	33.21	13.53
4363	S. cen. sec. 24, T. 2 S., R. 2 W.	Fine sandy loam, 0 to 15 inches.	.66	1.77	7.71	8.50	28.71	26.57	15.98
4312	SW. ¼ sec. 2, T. 2 S., R. 2 W.	Fine sandy loam, 0 to 12 inches.	7.57	2.64	2.88	7.29	13.06	41.46	18.15
4313	SE. ¼ sec. 34, T. 3 S., R. 2 W.	Fine sandy loam, 0 to 15 inches.	.33	.77	2.48	4.09	15.73	43.99	22.66

JORDAN CLAY.

The Jordan clay consists of about 12 inches of clay loam or clay, underlain to 6 feet with stiff, tenacious gray or yellow clay. Occasionally a thin stratum of fine sand or sand is found, which may occur at any depth between the second and sixth foot sections.

This type occurs at the lower limit of the mountain slopes on the east side of the valley, in the southern township, and extending into the recent lake bottom of Great Salt Lake. It is low lying, often wet or poorly drained, and contains considerable soluble salts. It is lacustrine and colluvial in origin, and is of no value except for pasturage during the summer.

The following table gives mechanical analyses of typical samples of the soil and subsoil of the Jordan clay:

Mechanical analyses of Jordan clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11480	SW. cor. sec. 15, T. 9 N., R. 2 W.	Clay loam, 0 to 24 inches.	0.1	0.5	0.5	13.0	22.0	31.7	32.3
11478	¼ W. of E. cen. sec. 10, T. 9 N., R. 2 W.	Clay, 0 to 24 inches	.3	.6	.5	5.8	13.2	32.5	47.3
11479	Subsoil of 11478	Clay, 24 to 48 inches	.2	.4	.4	5.5	19.3	39.7	34.0
11481	Subsoil of 11480	Clay, 24 to 48 inches	.0	.4	.4	9.9	15.4	38.4	35.4

SALT LAKE LOAM.

The Salt Lake loam consists of from 2 to 3½ feet of loam, very fine in texture and grading into clay loam, and underlain to 6 feet with fine sandy loam, fine sand, or sandy loam.

The type is found only in the lake bottom, having been formerly, as late as the early seventies, in fact, part of the bed of Great Salt Lake. It is very level and very poorly drained. It was deposited in the lake from sediment carried down by the streams, and contains an excessive amount of alkali, both in the soil and subsoil.

On some parts of the type, where there is a considerable overflow of Bear River during the spring, a rank growth of sedge flourishes. The only value of the type consists in this sedge, which is cut for winter feed, and in the grazing it affords.

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Salt Lake loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11482	Cen. sec. 5, T. 8 N., R. 2 W.	Loam, 0 to 24 inches	0.2	0.2	0.4	9.0	23.3	43.4	23.5
11483	Subsoil of 11482	Sandy loam, 24 to 48 inches.	.1	.5	2.4	34.3	31.1	20.6	10.9

SALT LAKE SANDY LOAM.

The Salt Lake sandy loam consists of 6 feet of sandy loam, usually coarse in texture, and generally interstratified with either fine sandy loam, sand, fine sand, or light loam. The type as mapped in this area shows considerable variation in texture.

This soil is found in what was formerly the bottom of Great Salt Lake, and was deposited in the lake by sediment and wash from the mountains and river. It is excessively salty, and is of no value except in a limited way for grazing in spring and summer.

MEADOW.

Meadow is a type of but small extent in the area surveyed, and consists of from 2 to 3 feet of loam, containing in the surface foot considerable muck, underlain with gravelly loam or gravel.

The type is located in small areas north and southwest of Brigham; is low lying, poorly drained, free from alkali, and is used both for pasturage and the production of hay.

BINGHAM STONY LOAM.

The Bingham stony loam is an unimportant type, of little or no agricultural value, found at the base of the mountains along the east side of the valley. It is used along with the mountains for grazing purposes.

HARDPAN.

A few small areas of hardpan were found northwest of Willard and northwest of Corinne, but there is no general distribution of it in the valley. It was noticed, in fact, in only two borings at 2 or 3 feet below the surface, and consisted of 1 or 2 inches of soil cemented together with lime carbonate. Quite often small particles of hardpan, the size of fine gravel or coarse sand, were found, but these seemed to occur loose in the soil and not in compact layers.

WATER SUPPLY FOR IRRIGATION.

The Bear River canal system is the most extensive and important factor in the irrigation of Bear River Valley lands. It covers practically all the irrigable land between Bear River and the mountains on the west side of the valley and extends from the northern end of the valley south to and beyond Corinne. This canal was built in the late eighties and early nineties by foreign capital, but owing to financial and other difficulties it was not at first a success. It is said to have cost approximately $2,000,000 to complete it. It is now successfully operated by the present owning company.

The capacity of the canal at the intake is 600 second-feet, and it irrigates at present about 34,000 acres, with a total capacity of 50,000 acres. A permanent water right costs $25 an acre, but does not carry with it any ownership or stock in the canal. The annual water rental is $1 an acre, which amount is paid whether the water is actually used or not. For this sum the irrigator is allowed water at the rate of 1 second-foot per 80 acres, which is equivalent to about 34 acre-inches per season. Some of the higher lying and better drained land can use this amount safely, but much of the level and lower lying land ought not to have so much water applied to it, as it is more economical to use less water than is actually paid for than to raise the underground water table too near the surface.

In 1903 and 1904 another canal was built on the east side of Bear River, called the "East Side Canal," and from this a branch canal was built along the mountain slope on the east side of the valley. The East Side Canal gets its water from the Bear River Canal at Bear River Canyon, paying the older company a certain rental for the water thus obtained. The Bear River Canal, however, has the priority of right, and in years of scant water supply the East Side Canal must surrender its water to the other company. During a season like 1904, however, there is sufficient water for all concerned.

The following is the laboratory analysis of water taken from the Bear River Canal near Trenton on July 27, 1904. The Water, as will be noticed, is of excellent quality. For purposes of comparison, the analysis of water from Salt Creek, taken on the same day at the source of that stream, is added.

Chemical analyses of irrigation water.

[Parts per 100,000.]

Constituent.	No. 312, canal water, Bear River, SW. cor. sec. 1, T. 11 N., R. 3 W.	No. 313, Salt Creek water, S. cen. sec. 6, T. 11 N., R. 3 W.	Constituent.	No. 312, canal water, Bear River, SW. cor. sec. 1, T. 11 N., R. 3 W.	No. 313, Salt Creek water, S. cen. sec. 6, T. 11 N., R. 3 W.
Ions:			Conventional combinations:		
Calcium (Ca)	5.4	7.1	Calcium sulphate ($CaSO_4$)	5.7	11.2
Magnesium (Mg)	2.7	3.4	Calcium bicarbonate ($Ca(HCO_3)_2$)	6.4	
Sodium (Na)	3.5	63.2	Calcium chloride ($CaCl_2$)	5.7	10.5
Potassium (K)	2.2	4.0	Magnesium bicarbonate ($Mg(HCO_3)_2$)	16.2	
Sulphuric acid (SO_4)	4.0	7.9	Potassium chloride (KCl)	4.2	7.6
Chlorine (Cl)	5.6	100.9	Sodium bicarbonate ($NaHCO_3$)	9.8	36.6
Bicarbonic acid (HCO_3)	25.4	26.6	Sodium carbonate (Na_2CO_3)	1.9	1.9
Carbonic acid (CO_3)	1.1	1.1	Magnesium chloride ($MgCl_2$)		13.3
			Sodium chloride (NaCl)		133.1
			Total solids	49.9	214.2

The following table gives measurements of the discharge of Bear River at Collinston, as furnished by Prof. George L. Swendsen, of the United States Geological Survey:

Discharge measurements of Bear River.

Date of measurement.	Discharge in second-feet.	Date of measurement.	Discharge in second-feet.	Date of measurement.	Discharge in second-feet.	Date of measurement.	Discharge in second-feet.
1900.		1900.		1902.		1903.	
Feb. 17	1,567	Dec. 26	862	July 16	324	Aug. 28	30.6
Mar. 31	2,228	1901.		July 20	205	Oct. 24	902.6
Apr. 30	3,671	Feb. 18	1,415	Aug. 13	68	Nov. 19	722
May 20	3,775	May 27	4,274	Aug. 26	60	1904.	
June 29	1,158	July 31	264	1903.		Jan. 29	641.8
July 26	627	Aug. 30	377	Jan. 5	349	Mar. 5	2,199
Aug. 28	542	Sept. 14	392	Apr. 6	2,332	May 10	6,334
Sept. 24	831	Oct. 21	973	May 30	2,863	June 8	5,172.6
Oct. 29	819			July 1	1,366	July 7	1,803.3
Nov. 12	1,336						

These measurements, being taken near Collinston, represent the flow after the Bear River Canal and East Side Canal have taken their water. The discharge shows great irregularity from year to year, being extremely high in 1904 and low in 1902 and 1903. The canals are in use from May to October.

Boxelder Creek, the next important stream for irrigation purposes in the area surveyed, irrigates the delta on which the city of Brigham is located, as well as some of the surrounding lower lying meadow and hay land. The entire creek is used, and much more water could be profitably utilized were it obtainable. The discharge of the creek varies greatly from spring to fall, but, as a rule, does not fall below a certain minimum in any year. The source of the creek is a few miles up Boxelder Canyon. The average minimum discharge is said to be about 24 second-feet, and with this about 2,500 acres are irrigated, which is an allowance of 1 second-foot per 104 acres. The creek is divided among the irrigators in such a manner that all share the surplus or deficiency, a certain fraction of the flow being directed to its proportional amount of land. The present irrigators hold the water by priority, and a share—which means the privilege of using a certain fraction of the stream for a certain number of hours per week—sometimes sells for as much as $150. Shares on a sixteenth part of the creek have been sold for that price, and a share on an eighth or larger fraction of the stream would, of course, cost more.

There are a number of other smaller streams that are used, all along the slope of the Wasatch Mountain Range and all originating but a short distance back in the mountains. Some of these are piped down the mountain slopes, and all are distributed among the landowners in the manner in which Boxelder Creek is apportioned. The water of these streams is of excellent quality, not only for irrigation, but for domestic use as well.

Some small areas in the northern part of the valley are dry-farmed, usually to wheat, and in seasons as favorable as 1904 good crops are obtained. Dry-farmed wheat yields from 10 to 30 bushels per acre.

UNDERGROUND AND SEEPAGE WATERS.

A map was constructed showing the depth to standing water in the area at the time of the survey. While this depth will vary during the season, being greater during a wet spring and less during the summer, and influenced locally, or even generally, by irrigation, the map, nevertheless, shows very closely the position of the underground water table. The importance of keeping the water under control can not well be exaggerated, as the underground water primarily governs the alkali conditions, especially in the large level areas where this water is normally near the surface and the natural underground drainage is not good.

The extent of the various areas of underground water, as classified on the map according to depth, is shown in the table following.

Areas of underground water.

Depth.	Acres.	Per cent.
Less than 3 feet	64,640	30.3
From 3 to 6 feet	57,216	26.7
From 6 to 10 feet	39,808	18.6
Over 10 feet	51,968	24.3
Total	213,632	

The underground water was tested frequently in various parts of the area, as were also some of the natural springs. As would be expected, considering the general distribution of alkali in the subsoil, the underground water is often very salty. This is especially true of the level area north and west of Corinne, up to and including Tremont. The surface well waters examined contained from 150 to 500 parts of salts per 100,000 parts of water. These salts consisted principally of chlorides, with some bicarbonates, and from 3 to 20 parts of alkaline carbonates, or black alkali. Sulphates were not often present.

The deeper seated waters are more salty, generally, than the surface well waters, especially west of Bear River. This has often been learned from experience in attempting to obtain better water by passing the first stratum of surface well water.

The underground water along the east side of the valley is very good, containing very little alkali. Many successful artesian wells have been drilled in T. 8 N., R. 2 W., but efforts in this line in the northern part of the valley have not yet been successful. The water from the flowing wells mentioned is of very good quality.

There are many salty springs in the area, especially at the south end and west side of Little Mountain. These contain from 2,000 to 3,000 parts of salts per 100,000 parts of water, and vary in temperature from 70° to 105° F.

Quite often gas is found in drilling artesian wells in the southern part of the area. These gas reservoirs are found at 90 feet and deeper, but they are generally of but temporary endurance, though one was used for more than a year for burning brick.

One of the best indicators of future alkali conditions is the position of the underground water table. As will be seen from the map, the water is already dangerously near the surface in the western part of the valley. A great many factors must be considered in determining how near the surface the water table may approach with safety—such as the character of the soil and subsoil, fall of the land, whether the alkali is in the subsoil or naturally near the surface, whether shallow or deep rooted crops are to be grown, and, most important of all, whether the irrigator can control his tendency to use water too freely.

Drainage of the area north and west of Corinne, up to within 3 or 4 miles of Tremont, will be necessary in order to render this as yet virgin land suitable and safe for cultivation, for the water table is already too near the surface. This condition is attributable partly to the canals traversing the area, partly to the drainage from the irrigated lands farther north, and largely to the almost perfect levelness of the land. The drainage scheme for this kind of land must necessarily be quite comprehensive in scope, and it would generally be impracticable for individual farmers to drain isolated farms. This could be done, however, by those whose lands are adjacent to the natural sloughs that traverse some parts of the area. Beginning 2 or 3 miles north of Little Mountain and running south along the east side of the mountain is a series of natural sloughs well able to receive drainage water from the surrounding country. Another system of sloughs is found in the southern half of T. 10 N., R. 3 W., entering and traversing part of T. 9 N., and finally emptying into Bear River Bay. These sloughs would be of great value as common main drains. T. 11 N., R. 3 and 4 W., could be drained into the swamp located in the southeastern corner of T. 11 N., R. 4 W. This swamp has an outlet south into the lake bottom country.

Another area where drainage is practicable is Boxelder Lake. This intermittent lake, which dries up during the summer months, occupies about 7 or 8 square miles in T. 10 N., R. 2 W., adjoining the Oregon Short Line Railroad track, and partly traversed by the latter, and extends about 1 mile into T. 9 N., R. 2 W. This lake receives the drainage from mountain slopes and from sloughs west of Honeyville, and already has a natural outlet slough, which drains southwestwardly into the lake bottom land, but no attempt is made to deepen it or to keep it clean, and in its present condition it is inadequate to carry off the surplus water. This basin receives an enormous quantity of water during winter, which would greatly assist in the reclamation of the land.

People farming in the western part of the valley complain that two or three years' irrigation ruins the land by bringing up the alkali, and that there was no alkali when they began farming. The fact is that the alkali is in the subsoil, and under certain conditions soon comes to the surface. Land in which the alkali amounts to 0.6 per cent or more in the first 6 feet will certainly give trouble when excessively irrigated, if suitable drainage is not provided.

ALKALI IN SOILS.

The usual method of determining the soluble salt content, viz, by the electrical resistance offered to a water-saturated portion of the soil, was used in this survey. The alkali map represents the average salt content thus determined to a depth of 6 feet, each foot section being determined separately.

The actual and relative extent of the various grades of alkali soils, as shown on the map, are given in the following table:

Areas of alkali land.

Grade.	Acres.	Per cent.
Less than 0.2 per cent	75,584	35.4
From 0.2 to 0.4 per cent	11,648	5.5
From 0.4 to 0.6 per cent	8,000	3.7
From 0.6 to 1 per cent	14,528	6.8
From 1 to 3 per cent	25,280	11.8
Over 3 per cent	78,592	36.8
Total	213,632	

The alkali areas are located in the southern, western, and southwestern parts of the survey, extending from 4 to 6 miles in all directions from Little Mountain; and there is also an area in Boxelder Lake, beginning about 2 miles north of Brigham. The only areas entirely free from alkali are in the northern end of the valley from Tremont north to the limit of the survey, in the extreme northwestern part of the survey and along the mountain slope on the east side of the valley. The areas of greatest salt content are located chiefly in what was formerly part of Great Salt Lake—that is, since it became practically concentrated with salt—and in the beds of Boxelder Lake. In these areas the average salt content for the first 6 feet is anywhere from 3.50 per cent to 10 per cent.

As has been mentioned in another part of this report, Salt Lake Valley, the northern end of which is called Bear River Valley, lies in what was in earlier geologic times Lake Bonneville. This immense body of water was mostly evaporated, and was finally confined to the Salt Lake Valley. As evaporation proceeded and the lake lowered, the water became more saline, due to concentration of the solution, and as it receded from the northern end of the valley it left the soil impregnated with its contained salts. As the lake dwindled in size it became more and more salty, leaving the bottom land next to its shores heavily impregnated with alkali. All the alkali in the area owes its origin to this process of lake recession and concentration.

The alkali is composed principally of chlorides, by far the largest constituent being sodium chloride or common salt. There are also limited quantities of alkaline carbonates and hydrogen carbonates, but sulphates are very seldom found. The alkaline carbonates (black alkali) were found practically everywhere in very small quantities, both in the soil and the subsoil, but with one or two exceptions tests showed less than 0.05 per cent. The underground water almost always contained black alkali. There are many local black-looking alkali spots throughout the area that are commonly supposed to be chiefly alkaline carbonates, but tests never showed more than traces, the principal constituents being chloride and some bicarbonates.

In order to make the alkali conditions more readily apparent and to increase the value of the alkali map, a legend was adopted and used on the alkali map to show the salt content of the surface foot of soil. By this it will be seen that almost invariably, with the exception of the lake bottom land, the surface foot contains less alkali than the average for the first 6 feet. This is often true also of the second foot section, and in some places even of the third foot of soil. Generally the maximum salt content was found in the third or fourth foot section, but sometimes as deep as the sixth foot. Borings made to a depth of 10 feet showed very little change in salt content from the fifth to the tenth foot.

Because of the fact that the surface soil to a depth of 1 or 2 feet is very often comparatively free from alkali, a native growth of sagebrush, rabbit bush, flowers, and grasses often prevails where the average salt content for the first 6 feet of soil is from 1 per cent to 3 per cent. By these conditions the people are often led to believe that the soil is free from alkali. When, however, such vegetation as young greasewood, samphire, salt grasses, etc., predominates, the alkali is not far below the surface.

In arid regions where irrigation is practiced the question of the reclamation of alkali lands always arises sooner or later, even if the soils are at first free from alkali, and especially if irrigation is too lavishly practiced. In a large part of Bear River Valley the question comes up immediately upon attempting to cultivate the land, as much of it is already heavily impregnated with salts.

The most permanent method of reclaiming alkali land is by artificial underground drainage and flooding combined. It should be strongly urged, however, that only enough water be used in the present cultivation of crops to satisfy immediate plant needs, thus taking precautionary measures against the surface accumulation of alkali. If this precaution were taken when the land is first brought under cultivation, the necessity for underdrainage would be greatly postponed. When the subsoil is alkaline and the water table is within 5 or 6 feet of the surface, it is worse than folly to saturate the soil and subsoil simply because there happens to be water enough to do so. The crops can use but a certain amount of this moisture, and can obtain it as well, and live under more favorable circumstances, if only enough water is used to satisfy them.

That two or three years' irrigation will materially raise the water table was interestingly shown in a few places where isolated farms surrounded by virgin unirrigated land had been farmed and irrigated for that length of time. The water table in the cultivated fields was 3 or 4 feet higher than in the surrounding virgin soil. A cheap, convenient, and valuable instrument for a farmer to possess is an inch or inch and a quarter auger, with a 6-foot handle welded on, by the use of which the irrigator can keep himself informed of the position of the underground water table, and also judge better of the amount of moisture in the soil, thus making the application of water an intelligent operation rather than a mere guess.

Some questions were asked and a few complaints made about the effect of the water in the mill race on the land which it traverses on its way to Corinne Mills. This water is taken out of Salt Creek about 1½ miles below the source of that stream, and traverses considerable land on its way down. It no doubt influences the underground water table along its course, just as any canal would, but that it brings much alkali to the land does not seem probable. This stream was examined at its source and was found to contain 214 parts of salts in 100,000 parts of water. A glance at the alkali map will show that it traverses land carrying 0.60 per cent or more of alkali in the first 6 feet. Now, 214 parts of salts in 100,000 parts of water is equivalent to about 0.07 per cent of salt in soil of a loam texture. There could thus hardly be any addition of alkali to the soil from such water. Furthermore, this creek was also tested on the south side of section 27, T. 10 N., R. 3 W., after crossing practically two townships, and was found to contain 295 parts of salts per 100,000 parts water, an increase in salt content of 81 parts.

RESISTANCE OF PLANTS TO ALKALI.

Some data were obtained concerning the amount of alkali that crops in the valley would withstand. As the alkali conditions change more or less during the growing season, due to surface evaporation, irrigation, etc., the data can not be regarded as absolute, but the information may be of value.

Young wheat was found doing well with from 0.50 to 0.56 per cent of salt in the surface foot, and oats were growing not quite so favorably; both crops, however, would apparently mature satisfactorily.

During the spring, when sugar beets were young, tests were made at the root crowns of beets that seemed to be growing in their limit of alkali, and the amount of soluble salt found in the first foot was 1.52 per cent. No examination was made of the second foot. Late in the summer, however, the same field was visited and borings were made in the same alkali spot, and it was found that beets were growing well and would mature in soil carrying from 2.50 per cent to 4.70 per cent in the surface foot, with 0.42 per cent to 0.84 per cent in the second foot. These were isolated beets growing in alkali spots that had killed out most of those planted. As the surface foot of soil carried more salt in late summer than in spring, when the field was first examined, and as the beets mentioned were well able to mature, it would seem that 1.50 per cent of alkali in the surface foot was not more than beets could endure. Examinations made at the same time in the best part of the field, where a crop of 20 tons per acre might be expected, showed 0.47 per cent in the first foot and 0.33 per cent in the second foot.

The fact that the sugar beets were found to grow in such a high percentage of alkali seems at first sight somewhat strange, but the amount of alkali in which a crop is found growing at any one time tells very little of the life history of that crop. Because sugar beets were found growing in from 3 to 4.70 per cent of alkali in the surface foot of soil late in summer does not argue that the same sugar beets would have been able to resist such quantities in their younger stage, and in fact they did not do so.

In the early part of the season, when the beets were 4 or 5 inches high, it was found that 1.50 per cent of soluble salts in the first foot was about the maximum content that the beets could stand. Other plants were examined that were dying, but in no case was it found that any of these were growing in less than 1.50 per cent. As this was early in the season and the ground was yet quite moist, owing to the late spring rains, the alkali was not yet so much concentrated at the surface as it was later in the season. Even in the earlier tests, however, there was a slight concentration of alkali at the surface, below which the beet roots were growing, so that the roots themselves were probably growing in a little less than 1.50 per cent alkali. As they grew they naturally increased in resistance, and so were able to withstand the gradually increasing amount of surface alkali. In the latter part of the season there was a heavy incrustation of alkali on the surface of the soil, which probably did exert a proportionally increased deleterious effect on the growth of the beets, but the active absorbing portions of the roots were below it. The concentration of the second foot, however, shows that even the young plants were growing in the presence of considerable alkali.

An interesting case of alfalfa growing in alkali soil was found in section 31, T. 10 N., R. 3 W. A heavy, well-matured crop was growing in soil containing the following percentages of salt from the first to the sixth foot, respectively: 0.14, 0.27, 0.43, 2.00, 3.12, and 3.75—an average of 1.62 per cent; and there was standing water at 4 feet. It may be that the roots of the alfalfa had accommodated themselves to the existing conditions and were confined to the first 3 or 4 feet of soil, though in view of the deep-rooted character of the crop it is hardly supposable that such was the case. The water table was probably temporarily high owing to recent irrigation. This case demonstrates what can be done with alkali land if properly irrigated and the subsoil water not allowed to carry salt to the surface. A crop will germinate in but a small proportion of the amount of alkali which it will endure when once well started; hence more care must be exercised in getting a good stand than is necessary to carry a crop to maturity.

An apple and peach orchard was found dying in section 1, T. 9 N., R. 3 W., where the salt content, in percentages from the first to the sixth foot, respectively, was as follows: 0.09, 0.16, 0.39, 0.48, 0.69, and 0.86, an average of 0.44 per cent. Standing water was here at 4 feet below the surface, and this is not a good test as to the effect of alkali alone, as with the water table so near the surface it, also, would be likely to interfere with the proper development of the trees. It is quite probable that if the water table had been 2 or 3 feet lower the trees would have been able to stand the amount of alkali found.

Owing to the recession of Great Salt Lake, large areas of lake-bottom land have been formed in the southern and southwestern parts of the survey. The water is usually within 2 or 3 feet of the surface, and the soil is excessively salty, containing more than 3 per cent in the first foot, with increasing amounts at greater depths. However, large tracts of this land support a heavy crop of sedge wherever Bear River overflows it copiously during the late winter and spring. Tests in heavy growths of this sedge showed from 3 to 5 per cent of alkali in the first foot, with increasing salt content in the subsoil. Large quantities of this plant are harvested for winter feed, and while not a choice hay, it is fed to cattle until the spring. Grasses are grown in small quantities on the same land, which makes it valuable for summer grazing. The following varieties, which were determined by Professor Spillman, promise to be of considerable value for such land: *Distichlis spicata*, *Polypogon monspeliensis* (beard grass), *Scirpus maritimus* (sedge), and *Puccinellia airoides* (slender meadow grass). The last-named grass should be cultivated in preference to the coarse sedge, as it is much more succulent for feeding, though the yields are not so large.

AGRICULTURAL CONDITIONS.

The farming class in the Bear River Valley are evidently prosperous, and there is every indication that this prosperity will continue in the future. The homes and farms on the eastern side of the valley, which was settled first, are generally free from debt, but the farms on the western side of the valley, especially in the northern part of this section, are yet quite heavily mortgaged, many of them being entirely new or of only a few years' cultivation. The farm dwellings are neat in appearance and well built, but are often without good outbuildings.

The Twelfth Census reports the value of farm lands and improvements (except buildings) for Boxelder County, in which the present soil survey was made, as $2,636,160; farm buildings, $510,990, and farm implements and machinery, $204,990. The census of 1900 also shows that 80 per cent of the farms of the county are operated by their owners.

The average size of farms along the eastern side of the valley, east of Bear River, is less than that of those on the west side. The eastern side, being the first settled, was subject to the restrictions in size imposed at that time, and so generally practiced during the early Mormon occupation of the State. The average size of farms in the county, according to the Twelfth Census, is 561.1 acres and the number of farms is 1,020. This, however, includes much land not yet cultivated, as the acreage of improved farms is only 20 per cent of the entire acreage owned as farms. The data mentioned above, however, refer to conditions existing in 1900, and at the present time the percentage of improved land is undoubtedly greater, owing to better facilities for irrigation and for marketing crops, especially in the northern part of the valley.

The farming population is composed chiefly of whites, including many nationalities. There are very few negroes or Chinese in the valley. During the last two years prominence has been given to the sugar-beet industry, and the labor in the beet fields is largely performed by Japanese. The expenditure for labor in 1900 for the county was $128,890, an average of $130 per farm. On many farms, however, little or no labor is employed, the work being done by the family. Labor is hired principally for the harvesting of the hay and grain crops.

Of the general farm products the largest acreage is in wheat, followed by alfalfa, there being only a small difference in the acreage and value of each of these crops. There is a large acreage in wild and cultivated grasses, and also in barley. It is now claimed that 3,000 acres in the area are planted to sugar beets. Wheat yields from 25 to 40 bushels, barley from 40 to 60 bushels, and oats from 50 to 120 bushels per acre, all under irrigation. Alfalfa, by far the most important hay crop, yields three or four cuttings each year, amounting to from 5 to 8 tons per acre, depending on the seasons, and there is usually good pasturage after the last crop is removed. It sells at from $3 to $4 in the stack in the fall, from $4 to $5 during winter, and when baled and shipped to Salt Lake City at from $7 to $9 a ton.

Considerable early truck is grown along the slopes of the Wasatch Mountain Range, especially in and around Brigham. Orchard and small fruits are also important crops on the gravelly delta on which

Brigham is located. The small fruits ripen early, thus being assured of a good market. Until a few years ago the orchard fruits were confined to the eastern mountain slopes, but recently the people in the western part of the valley have become interested, with the result that many orchards are being set out, while others started a few years ago are just beginning to bear. Apples constitute the principal fruit, and peaches and apricots are next in importance. Pears were extensively set out when interest was first aroused in this industry; but, unfortunately, the pear blight has killed nearly every tree in the western part of the valley. This disease does not attack so readily the fruit trees on the east side of the valley, on the gravelly mountain slopes. It is estimated that the annual sales of orchard fruits, small fruits, melons, and cantaloupes produced in and around Brigham amount to about $100,000, and in the whole county to about $150,000. Tomatoes are an important crop, and many of these, together with orchard fruits, are canned, there being two canneries in the area, one at Brigham and one at Willard.

Sugar beets have become one of the important crops during the last two years (1903, 1904). A factory was built at Garland in 1903, and in 1904 3,000 acres were cultivated to sugar beets, principally in the northern end of the valley. The price paid for them is a flat rate of $4.50 a ton delivered at the factory, or from $4 to $4.25 on cars. Some of the soils are excellently adapted to sugar beets, and in some parts of the area as high a yield as 40 tons per acre has been secured. It is estimated that the average yield is from 12 to 15 tons per acre.

Other important industries are cattle and sheep raising. The stock range in the Wasatch Mountains during the summer season, and are brought back to the mountain range on the west side—Promontory Range—for the winter, except those fed in the valley for special purposes. According to the Twelfth Census, the value of live stock in Boxelder County was over $1,000,000, and of dairy products about $55,000.

The recognition of the adaptation of soils to crops is considered only for vegetable and truck crops, and to a certain extent for sugar beets. In the general farming in the valley, however, by far the most important consideration is whether the desired crop can be grown without being killed out by the alkali already present in the surface or by that which will probably come to the surface after irrigation. This is perhaps of more significance than the texture of soils as adapted to crops, for any crop seems to do well on any type of soil if the alkali and underground water are kept under control.

The gravelly soils along the east side of the valley are devoted to orchard fruits, small fruits, melons, cantaloupes, tomatoes, etc. The new land in the western and central parts of the valley, when cleared of its native growth of sagebrush and greasewood, is generally planted to cereals—usually wheat—which may be spring or fall sown. After two or three years' cultivation to this crop the usual practice is to plant the land to alfalfa. The previous cultivation puts the land into good mechanical condition and enables it to be properly leveled and checked for permanent irrigation. It is often doubtful, however, if this practice is of universal value, as the two or three years' cereal cultivation often brings the subsoil alkali to the surface, thus making it difficult to obtain a good stand of alfalfa. When it is desired to grow alfalfa on land where there is danger of a rise of alkali, it would be a better practice to put the soil into good mechanical condition, sow the alfalfa seed at once, and at the same time put in a nurse crop. The alfalfa will resist considerably more alkali after a stand is obtained than it will in germinating and beginning its growth. The alkali map will be of considerable assistance in determining which method should be employed.

The transportation facilities in the area are good, the valley being traversed north and south along the east side by the Oregon Short Line Railroad, and east and west by the Southern Pacific Railroad, via Corinne, and by a branch of the Oregon Short Line from Brigham to Garland via Corinne, on the west side of Bear River. This branch railroad is to be extended to Malad City, Idaho.

Many of the farm products, especially alfalfa, are sold in the local market. Much alfalfa, and also most of the fruit, is sold to commission houses or shipped direct to Salt Lake City, part of it being sold there, though a great deal is shipped to Montana, Idaho, Nevada, and Wyoming. There are good markets for all crops raised.

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