Issued June 26, 1915.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE CACHE VALLEY AREA, UTAH.

BY

J. W. NELSON AND E. C. ECKMANN.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1913.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1915

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., December 26, 1914.

SIR: Under the cooperative agreement with the State of Alabama a soil survey of Bullock County was carried to completion during the field season of 1913.

I have the honor to transmit herewith the manuscript and map covering this work, and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1913, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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Soil map, Cache Valley sheet, Utah.

SOIL SURVEY OF THE CACHE VALLEY AREA, UTAH.

By J. W. NELSON and E. C. ECKMANN.

DESCRIPTION OF THE AREA.

Cache Valley lies in the northern part of Utah and extends into Idaho. In shape it is an irregular oval, with its long axis north and south. The maximum width, about 19½ miles, is attained at the Utah-Idaho boundary. From this point the valley narrows both north and south. About two-thirds of the valley, a segment 44 miles in length, lies in Utah, and it is this part which is covered by this survey. It contains 450 square miles, or 288,000 acres.

No base map was available for the plotting of the soil and the base map used was made by plane-table traverse.

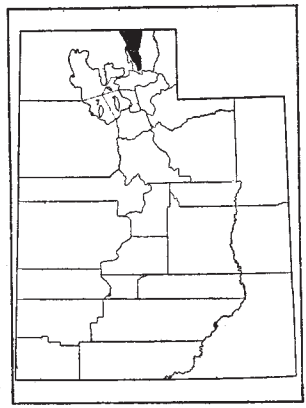


FIG. 1.—Sketch map showing location of the Cache Valley area, Utah.

Cache Valley is one of about sixty of the subsidiary valleys included within the physiographic province known as the Great Basin. Formerly it was occupied by Lake Bonneville, a Quaternary lake which covered an extensive area in the Great Basin region. During the time of Lake Bonneville water covered the valley to a depth of about 800 feet and hundreds of feet of sediment were deposited over its bottom. The disappearance of the lake exposed a nearly level surface now known as the valley floor.

On all sides the valley is surrounded by high, deeply furrowed mountains which are spurs of the Wasatch Range. The mountains on the east side are higher and cover a greater area than those on the west. The former comprise a large catchment basin for an excellent supply of pure water, which enters the valley from that side.

The smaller range of mountains on the west side separates Cache Valley from the Salt Lake Valley.

The average elevation of the valley is about 4,400 feet above sea level and the highest or Bonneville terrace is about 800 feet higher.

The foothills and lower mountain slopes are marked by numerous old lake terraces and deltas varying in width from a few rods to more than a mile. These are conspicuous from all parts of the

valley and mark the different levels of old Lake Bonneville. The survey was extended up the sides of the mountains only as far as the soils can be used for farming.

The floor of the valley is a broad, slightly undulating plain, which merges with the gentle slopes of the foothills of the near-by mountains.

The generally uniform topography is broken by Newton Butte, Smithfield Butte, Mount Smart, and Battle Creek Butte, the latter two lying outside the area and all forming conspicuous features of the landscape. In the southern end and near the middle of the east side the gentle mountain slopes are marked by large, irregular, fan-shaped terraces which extend from the mouths of the large canyons for some distance into the valley.

Those portions of the mountains immediately bordering the valley are treeless, except for small groves of pine, maple, and quaking aspen in the deep recesses and on the well-protected northern slopes. Facing the valley the mountain slopes are more rugged. They are covered with a thin mantle of soil and support a moderate growth of cedar, a scant growth of brush, and a heavy carpet of grass. Cedar seldom grows below an elevation of 5,500 feet on the mountain slopes adjacent to the valley. Oak and maple are stunted and bush-like. Along the streams, before they emerge from the mountains, box elder, ash, locust, and hackberry occur. (Pl. I, fig. 2.)

In the valley the vegetation along the streams consists of cottonwood, birch, willow, wild rose, hawberry, wild hops, and other vines; otherwise the valley in its natural state was treeless. Carolina poplar, Lombardy poplar, box elder, locust, balm-of-gilead, ash, some elm, catalpa, walnut, and butternut now flourish around the towns and villages, and rows of Lombardy poplar in many places mark farm boundaries. Low-lying areas on the valley floor, where moist and free from alakali, are covered with a heavy growth of grass; those that are not so well drained support at most a moderate to scant growth of greasewood and salt grass and in some places are barren. The mountain foot slopes and better parts of the valley in their native state support a moderate to heavy growth of gray sage.

The main streams enter the valley from the east and south. Bear River and its tributaries receive the entire drainage of the valley. The valley is very well supplied with water for household and irrigation purposes. That portion of it included within a line drawn from Smithfield west to Bear River, then to Mendon, Wellsville, Hyrum, Logan, and back to Smithfield, lies within an artesian belt the center of which is west of Logan. Many wells of constant flow are located in this zone. One of these is shown in Plate I, figure 1.

The valley was first visited by white settlers in 1847, but it was about 10 years later that active development began. The first settlers were Mormon pioneers who were attracted to the valley by the fertility of the soil and the abundant supply of good water. Development was slow, however, until after the coming of the railroad in 1873. Prior to this it was necessary to haul most of the farm products 90 miles or more to market.

Soon after 1860 the inception of mining in Montana gave a great impetus to the development and settlement of the valley, and in 1870 the population of the area had increased to 8,229. The population has grown steadily since that time and in 1910 was 23,062, or 19.8 per square mile.[1] From general appearances, the valley seems to be sparsely settled, owing mainly to the communal custom of the people. Ninety to 95 per cent of the inhabitants live in towns or villages, and about the same proportion follow agricultural pursuits.

The population is mixed. It consists principally of Scandinavians, Germans, and English. Many of the older people are foreign born.

The main line of the Oregon Short Line Railroad enters the valley through Bear River narrows and passes north along the west side of the valley. A branch line from Cache Junction passes around the south and east sides of the valley and another branch line of the same road goes directly from Cache Junction to Logan. These lines afford good passenger and freight facilities, although some communities, including Clarkston, Lewiston, and Paradise, are several miles distant from stations.

Logan is the county seat of Cache County and the principal city of the area. An interurban car line connects it with Smithfield on the north and Providence on the south. The State agricultural college, Brigham Young College, and New Jersey Academy are located at Logan. Besides these the area is well supplied with good schools. (Pl. II, fig. 1.)

The towns located along the east and south sides of the valley are mainly dairy and sugar-beet centers and considerable fruit is grown locally. The west side is noted for its grain and alfalfa production. Lewiston, Trenton, and Benson lie in excellent sugar-beet and potato districts.

There are two beet-sugar factories located within the area—one at Logan and one at Lewiston. The area also supports four milk condenseries, several dairies, nearly a dozen flour mills, the same number of banks, several knitting factories, limekilns, and brick factories.

[1] These figures are taken from the United States census for the whole of Cache County. They are believed to represent approximately the population of the Cache Valley area, as practically all of the inhabited region of the county is included within this area.

Several power plants for the generation of electricity are located near points where Logan River and Blacksmith Fork emerge from the mountains. These with smaller local plants supply cheap power and lighting for the valley and outside points.

The area has more than 700 miles of roads, which, with the exception of a few of the principal highways, are only in fair condition. They are, however, receiving considerable attention at present.

The valley is generally very prosperous and its greatest need is more people and a more intensive system of agriculture.

CLIMATE.

Cache Valley has the invigorating climate characteristic of the mountain plateau region of the United States. The spring and fall months, with mean temperatures of 45.7° F. and 49.9° F., respectively, are very pleasant. Comparatively high temperatures prevail during the afternoons of the summer months, but the difference between the actual and sensible temperatures is so great that the days are not oppressive and the nights are always cool. The winters are generally cold and dry, the mean temperature for these months being 25.3° F. The annual mean temperature for the valley is 47.6° F.; the highest recorded is 100° F. and the lowest —19° F., giving a range of 119° F.

Cache Valley is included within the semiarid belt, the average annual precipitation being only 15.69 inches. The rainfall is greatest during the spring months, with a total of 6.12 inches, and least in the summer, when only 2.11 inches falls, and this is practically all in the form of thunderstorms. The fall and winter seasons have about the same amount, 3.62 and 3.84 inches, respectively. The rainfall is quite uniform over the valley, but is somewhat greater along the east and south sides. The distribution is such that it is never necessary to irrigate in the spring to cause germination of seed or to bring seeded crops up. Snowfall varies considerably, ranging from a few inches to 2 feet or more. On the surrounding mountains, however, snow falls every month with the exception of July and August. It disappears from the mountain peaks usually by the middle of July, although occasionally remaining the entire year. In periods widely separated, hailstorms of varying intensity and destructiveness have passed over parts of the valley, but they are of infrequent occurrence and of local extent. Very little fog is seen at any time, but a moderate to heavy dew occurs throughout much of the growing season, which is an advantageous feature in a region of such scant rainfall.

The amount of rainfall and its distribution are favorable for the production of dry-farm crops, such as grain, alfalfa, alfalfa seed, and a few other crops of less importance. To extend the range of crops or to get the maximum yields of most of the crops mentioned irrigation must be resorted to.

The great number of warm, uniform, clear summer days hastens the growth and maturity of crops. The nights are too cool for the profitable production of corn on a large scale, but fair yields of flint corn, sweet corn, and popcorn are frequently obtained, especially along the east and south sides of the valley. The average date of the first killing frost in the fall is October 8 and the last in spring May 10. The earliest date of killing frost recorded in the fall is September 14 and the latest in spring June 17. There is an average growing season of 150 days which is too short over the greater part of the valley to make the growing of tomatoes, cantaloupes, watermelons, peaches, and grapes on a commercial scale practicable, although fair quantities of all these products, except peaches, are produced in favorable places along the east and south sides of the valley and in sandy areas elsewhere.

The cold winds come from the northwest and north. The prevailing winds are from the southwest and are strongest during the late spring and early summer months, when they are warm, and if prolonged for several days usually bring rain. Around the mouths of large canyons, such as Logan Canyon, Blacksmith Fork Canyon, East Fork Canyon, and some others, over an area of approximately 2 square miles, frosts are less likely to occur than farther out on the valley floor. This makes such places especially favorable for the culture of the more tender fruits and truck crops. The dry summer winds cause a high rate of evaporation, the loss from a free water surface being reported as 50 to 60 inches annually. This emphasizes the necessity of thorough cultivation of the soil to conserve moisture and prevent the rise and accumulation of alkali.

The climate of the valley is favorable for the growing of the more hardy varieties of apples, pears, plums, and cherries. Only in a few small areas, already mentioned as lying within the range of the canyon breezes, can peaches, apricots, and Japanese and American plums be produced, and even in such places the crops are uncertain and the trees subject to more or less damage by low winter temperatures. For the successful growing of fruit on a large scale over most of the valley smudging may be found necessary.

The following table gives the normal monthly, seasonal, and annual temperature and precipitation at Logan:

Normal monthly, seasonal, and annual temperature and precipitation at Logan.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	°F.	°F.	°F.	Inches.	Inches.	Inches.
December	25.3	57	−15	0.96	0.30	1.99
January	24.4	54	−15	1.53	0.40	2.28
February	26.3	58	−19	1.35	1.22	2.02
Winter	25.3			3.84	1.92	6.29
March	35.3	73	− 3	2.01	2.22	2.61
April	47.4	90	13	1.67	1.60	2.47
May	54.3	90	24	2.44	2.13	5.05
Spring	45.7			6.12	5.95	10.13
June	66.5	95	31	0.83	0.63	1.43
July	71.5	100	37	0.47	0.20	0.71
August	70.7	99	35	0.81	0.73	4.55
Summer	69.6			2.11	1.56	6.69
September	61.4	93	26	1.09	2.07	1.62
October	50.1	85	19	1.28	0.37	0.60
November	37.8	73	−11	1.25	0.64	1.07
Fall	49.8			3.62	3.08	3.29
Year	47.6	100	−19	15.69	12.51	26.40

AGRICULTURE.

Both dry and irrigation farming are carried on extensively in the Cache Valley area. The lands above the existing canal systems, usually too uneven for irrigation, and much of the heavy valley soils, mainly of the Trenton series, which puddle badly and which are in places affected with alkali, are used for dry farming. Wheat, rye, barley, some oats, and alfalfa are the main crops on these areas, though in favorable years on soils retentive of moisture sugar beets, potatoes, corn fodder, sorghum, and a few other minor crops can be grown successfully. Under irrigation alfalfa, small grains, grasses, sugar beets, potatoes, sweet corn, and popcorn, and in favorable localities bush and vine fruits, truck crops, and tree fruits yield excellent returns.

Dairying, the raising of hogs, and poultry and bee keeping are all industries adding greatly to the incomes of farmers. Fish culture is also locally of some importance.

In addition to these more or less intensive industries of the valley, thousands of sheep and cattle are pastured in the near-by mountains. This stock belongs mainly to farmers living in the valley. Large shipments are made from local points.

The average size of farms in Cache Valley has increased from 85 acres in 1880 to 154.3 acres in 1910. The increase in size is probably due mainly to the increase in dry farming or the need of larger acreages under dry-farming conditions to enable farmers to gain a livelihood. With this increase in farm acreage there has been a slight increase in the number of farms and in the proportion of improved land in farms. The demand for farm land in the part of Cache County surveyed has been so great in recent years that almost every available acre has been utilized and the farms have encroached upon the mountain slopes until the rough stony areas have been reached. This change has been accompanied by a marked increase in the value of farm lands.

The several systems of farming practiced and the special industries of sufficient importance will be considered separately in the following pages.

DRY FARMING.

Dry-farming practices are systematic and up to date, and the only unfavorable feature of the system noted is the failure to maintain the humus content of the soil. This important soil constituent is partially restored, however, by the use of headers and combined harvesters in most instances, which leave a very high stubble to plow under. The practice in dry-farm grain growing is to allow the land to lie fallow each alternate year. The most successful farmers plow their lands as soon as possible after the grain is cut and let the land lie undisturbed through the winter. Then the soil is dragged, disked, or harrowed the following spring as soon as dry enough. Fallow fields are harrowed after each rainstorm during summer to keep the surface mulched, thus conserving the moisture. Fall wheat is sown, if moisture conditions are favorable, late in August or in September, in order that the plants may cover the ground well before winter sets in. If the surface moisture is deficient, fall seeding is deferred until late in October or November to avoid the germinating of the seed and its subsequent destruction for want of sufficient moisture. If moisture conditions are at all favorable in the fall and the above practice is followed carefully, the best farmers say that they are able to maintain an average yield of 30 bushels of wheat per acre every other year, or an average of 15 bushels per acre per year.

For dry-farmed wheat, oats, barley, or rye the cost of production per acre should not exceed $2.50 where the work is done by the farmer and $4.50 if done by contract.[1]

On a basis of $4.35 for the production of wheat on 1 acre every other year, with wheat selling for 70 cents a bushel and a yield of 30 bushels per acre, a net income of $16.65 every two years, or $8.33 an acre per year is obtained. Considering the usual rate of 8 per cent interest on the investment, this makes dry-farm land unprofitable for wheat production in the Cache Valley area when its market price is about $104 an acre. These yields can not be obtained on all dry-farm lands in the area, for they are not all equally adapted to grain culture. For the poorer lands the net returns are one-third or one-half less than the above figures.

Most of the dry-farmed grain is cut and thrashed in one operation, and the sacked grain is either hauled to market immediately or piled in the field and covered with straw until sold.

Very little spring wheat is grown, because of greater difficulty in maturing it without irrigation. Oats are generally grown as a spring crop, but require one irrigation for the best returns. Rye is always planted in the fall and produces heavy yields. Barley is generally sown in spring, and in favorable years very satisfactory yields are obtained. It is undoubtedly the best grain for spring sowing.

Among the leading varieties of winter wheat for dry farming in Cache Valley are Gold Coin, Turkey Red, Martins Amber, Odessa, New Zealand, Silver Chaff, Fife, and Kharkof. For spring planting the New Zealand, Club, and Sonora are favorite varieties. Among the oats Sixty-day, Kherson, Burt, and Swedish Select are leading varieties. Both the two-rowed and six-rowed varieties of barley are grown.

Land for grain is usually plowed from 8 to 12 inches deep. Where the soil is heavy deep plowing gives the best returns.

ALFALFA AND GRASSES.

Although a considerable area of the low moist lands of the valley is devoted to the production of the cultivated grasses, alfalfa is by far the most important hay crop. It was introduced into the valley by the early settlers and has steadily increased in importance to the present time.

A number of soil types occurring in the valley are well suited for alfalfa production. The types of lighter texture, however, where moisture conditions can be controlled, give the best results when seed

[1] See report of tests made at the substation of the Utah State Agricultural Experiment Station at Nephi, Utah.

production is the aim. Seed is produced almost entirely on dry-farmed land. If the season is wet, the second crop may become too rank even on dry-farmed land for good seed production, and it is cut for hay; but if the weather remains dry, the second crop will reach a height of only 8 to 15 inches, and it is this condition which produces the best quality and heaviest yield of seed. Generally where fruit production is unprofitable the gravelly soils can be made to produce the largest profits when utilized for alfalfa seed production. From 1 to 2 tons of good hay from the first cutting and from 5 to 8 bushels of seed per acre are not uncommon yields on such lands. Alfalfa seed sells for 10 to 15 cents a pound when well cleaned and in good condition.

The average yield per acre of alfalfa hay in the valley is about 3 tons, but where proper irrigation is practiced and each crop cut as soon as ready, yields of 5 and 6 tons per acre in three cuttings are easily obtained on the best soils. The average price per ton is $7 to $8, and in some years it reaches $15 or more per ton. It costs from $6 to $8 an acre to plant alfalfa and from $2 to $2.50 a ton thereafter to grow and place the hay in the stack.

With alfalfa spring sowing is practiced, and no catch crop is used in dry-land seeding. Where water is available for irrigation a catch crop of wheat or oats is frequently used with excellent results. This enables the farmer to get some returns from the land the first year. Generally there is no return from the alfalfa field the first year, but where water is available and soil conditions are favorable yields of 2 tons of hay per acre have been obtained. In some cases a small yield of seed is obtained the first year on dry-farmed land.

The third cutting of alfalfa is generally reduced considerably by frost. The second and third crops may be advanced nearly a week each by irrigating the preceding crop a few days before cutting. This stimulates a new growth at the crowns of the plants and as soon as the standing crop is removed active growth begins. This practice has proved desirable in the valley, where the irrigation waters are nearly clear. If the water is muddy, however, dirt accumulates on the stems of the plants and dusty hay results. One good irrigation—about 4 to 6 inches of water—is sufficient for each crop of hay.

Besides alfalfa certain grasses are found valuable. For dry farming, brome grass, tall oat grass, orchard grass, giant rye grass, and bunch grass do well on nearly all the soils not too wet or too strongly impregnated with alkali. The giant rye grass and bunch grass seem to thrive better than the other species at elevations above 6,000 feet. Timothy and redtop are grown on the low wet soils free from alkali and give heavy yields of hay.

SUGAR BEETS.

The growing of sugar beets is one of the most profitable industries in the valley. A wide range of soil types, varying in texture from fine sandy loams to silty clays, are utilized. Beets thrive even on the very heavy soils of the area, because of their silty nature, the high lime and humus content, and the existence of the granular structure favorable to development of root crops. Soils for this crop should be well drained and free, or nearly free, from alkali for best results. Sugar beets are, however, quite resistant to white alkali where the soil is kept in good tilth.

Although most of the soils of the valley are high in humus, applications of manure are beneficial in beet growing. Excellent yields are obtained on alfalfa stubble. Yields on the light-textured soils decline sooner than on the heavy types.

For the best results the land is plowed in the fall to a depth of 10 to 12 inches, and on the heavy types again in spring to a depth of 6 to 8 inches. For the lighter types, fall plowing, followed by a heavy spring disking, may suffice. This is followed by harrowing until the seed bed is in a loose, friable condition and free from clods. The seed is planted by drills in rows from 15 to 18 inches apart and from one-half to 1¼ inches deep. Fifteen to twenty pounds of seed are sown per acre. Thinning is done when the plants have four leaves, the beets being left from 6 to 8 inches apart in the row. The closeness of beets in the row and of the rows themselves depends upon the fertility and texture of the soil. Shallow cultivation follows thinning, and care is exercised not to throw dirt against the plants, for they need all the air and sunshine possible. Hoeing is frequent enough to keep the weeds down. Shallow furrows are used for irrigation, and the best results are obtained where the furrows run between different rows at successive irrigations.

The Trenton fine sandy loam subirrigates quite freely, and on this type furrows 1 foot to 1½ feet deep are plowed through the field at intervals of 50 to 100 feet and water is run along them. The distance between the furrows depends upon the texture of the soil and the nature of the subsoil. Irrigation should not be given until the crop shows need of moisture, and even then the soil should be examined 1 foot to 2 feet deep to note the moisture content. This encourages the development of a long tap root. Too early irrigation, alkali land, and too much fresh manure produce a short, stubby, branched, and undesirable beet.

The usual tendency is toward the overirrigation of this crop, and considerable injury to the soil results. Cross ditches every 20 or 30 rods apart, the distance depending upon the nature of the soil, are desirable. Otherwise the upper part of the field is overirrigated

before the lower part receives enough water. Flooding and overflowing should be avoided, as it puddles and packs the soil around the beets and greatly interferes with their development.

From two to four irrigations are ample, the last being given about 20 to 30 days before digging. Cultivation follows irrigation as soon as possible, and at best is from 4 to 6 inches deep. This forms an effective mulch and prevents evaporation. Hilling the beets and breaking off the leaves is avoided at all times.

Factories at Logan and Lewiston take the beets grown in the valley.[1] The acreage supplying the Logan factory has averaged 4,000 acres for the last 5 years and that supplying the Lewiston factory 5,375 acres. The average yield per acre in tons covering the same period has been 11.95 tons for the lands supplying the Logan factory and 11.99 tons on the area tributary to the Lewiston factory. The average sugar yield per ton of beets for the last 5 years has been 225 pounds at Logan and 218 pounds at Lewiston. Four dollars and fifty cents a ton is paid to the farmer for beets delivered at the factories or on the cars.

A considerable part of the labor in beet culture is performed by Japanese and boys. Five dollars an acre is the price paid for thinning. Japanese also rent land for beet growing at a rental of $12 to $15 an acre per year.

The total cost per acre of the production of beets, including the cost of seed and all operations from plowing the land to delivery on the cars or at the factory, is reported to be about $35. The cost varies greatly with the character of the soil and the efficiency of the labor.

With present practices and allowing 8 per cent on the investment, the maximum price of land for commercial sugar-beet growing is about $250 an acre. When land commands a higher price in the market than this, either greater yields of beets must be obtained, expenses reduced, or the land used for the production of more profitable crops.

A number of attempts have been made in the valley to produce sugar-beet seed, and the results have shown that it can be done successfully. As yet little attention has been given to seed production, and the crop has offered no special inducement over other crops as profitable and requiring less labor. Nevertheless with proper system there seems to be no reason why the growing of sugar-beet seed in the area should not be among the leading agricultural pursuits. In experiments conducted by the State experiment station a yield of 4,196 pounds of seed per acre was obtained. The price usually paid for seed in the valley would insure a satisfactory profit.

[1] Statistics given in this and succeeding paragraphs were supplied by the Amalgamated Sugar Co.

FRUIT CULTURE.

Only slight attention has been given to fruit culture in Cache Valley heretofore and only in very recent years has it been demonstrated that this business is one of the most profitable which yet awaits development.

Apples.—Among the fruits which can be successfully grown in the area the apple is probably the most important. Small quantities of apples have been grown in the valley for many years. That the industry has been unprofitable is believed to be due to lack of knowledge as regards varieties suited to the region, failure to recognize the important factor of soil adaptation, lack of care in selecting orchard sites, and failure to combat insect and other pests.

Much of the valley soil is too heavy for the best results with apples. The mountain foot slopes and old lake terraces along the east and south sides of the valley best meet the requirements for the development of apple orcharding. There is here in nearly all places along the slopes at the foot of the massive-limestone mountains a belt of country 1 mile or 2 miles wide where the soil-forming processes and materials have been such as to give rise to soils especially adapted to orcharding. In places, however, the subsoil is a compact, heavy clay extremely high in lime, and such areas should be avoided.

Some good results have been obtained in growing apples on the Trenton fine sandy loam and on the heavy phase of this type in the valley floor, but the element of risk is much greater in such places on account of the possibility of injury from winter and spring freezes, alkali, and overirrigation.

The soils and subsoils on the foot slopes of the low mountain range from Mendon to Clarkston are generally heavier than the soils lying along the higher mountains formed of massive limestone. The former soils have been derived from softer marly limestones, which break down readily and weather into finely divided material in a relatively short time. Apple trees grown on such soils with very heavy, compact subsoils high in lime thrive until their roots reach the dense underlying material, and then the leaves frequently turn yellow and in most instances the trees become scrubby, lack vigor, and fail to bear well. There are some local areas, however, along the western mountain foot slopes where the subsoils are lighter, more silty, and easily penetrated by roots.

In growing apples where the subsoils are dense and heavy it has been the custom to irrigate the trees frequently and heavily. Irrigation is given the small orchards in such places every 10 days to 2 weeks. This keeps the roots of the trees in a water-logged soil much of the time and does more or less damage to the trees. It is very essential in choosing soil suitable for an orchard to select areas

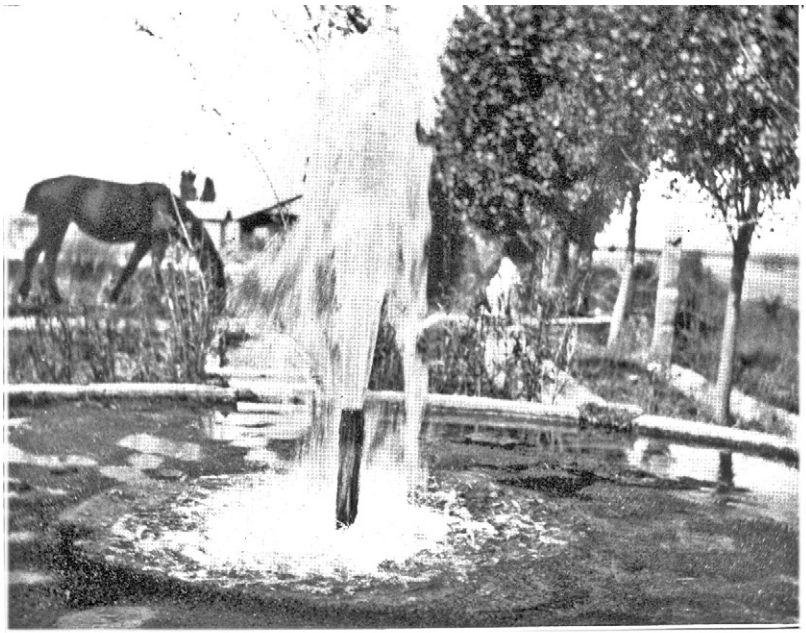


FIG. 1.—ARTESIAN WELL ON SOILS OF THE TRENTON SERIES WEST OF LOGAN.

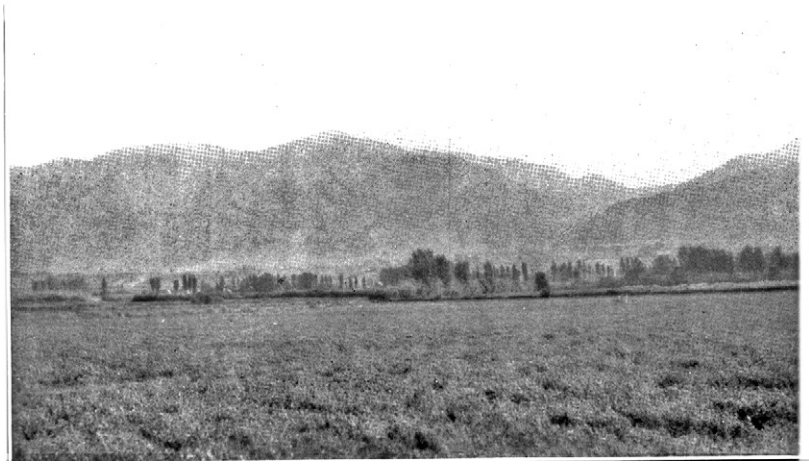


FIG. 2.—VIEW IN CACHE VALLEY FROM POINT SOUTHWEST OF LOGAN.

Wasatch Mountains in distance, showing faintly higher lake terraces at their foot. Alfalfa on soils of the lake bottom in foreground.

FIG. 1.—VIEW IN VICINITY OF LOGAN.

Soils of Logan series in foreground. Terrace on right in distance occupied by soils of the Hyrum series, and constituting portion of the old delta of Logan River.

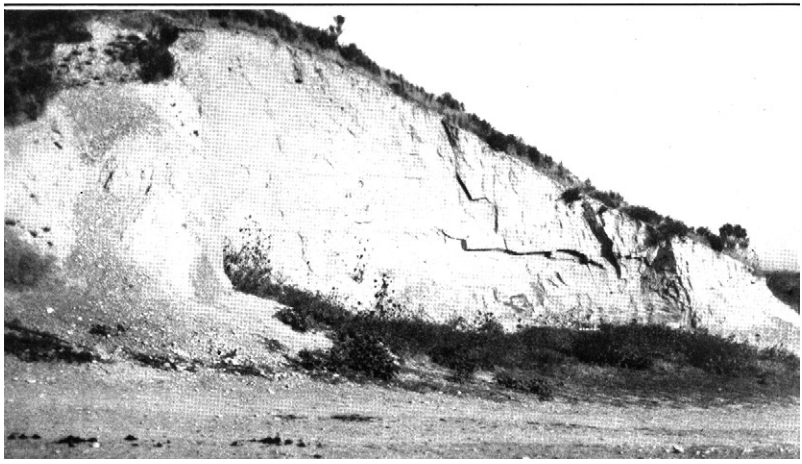


FIG. 2.—FINER STRATIFIED BONNEVILLE LAKE SEDIMENTS NEAR HYRUM.

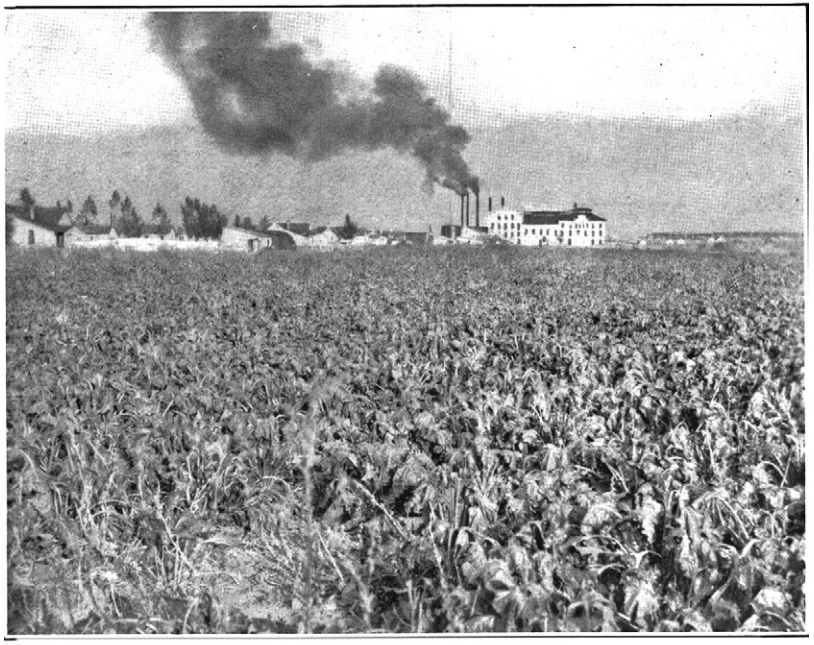


FIG. 1.—SUGAR BEETS ON SOILS OF THE TRENTON SERIES.
Sugar factory in distance, Lewiston, Utah.

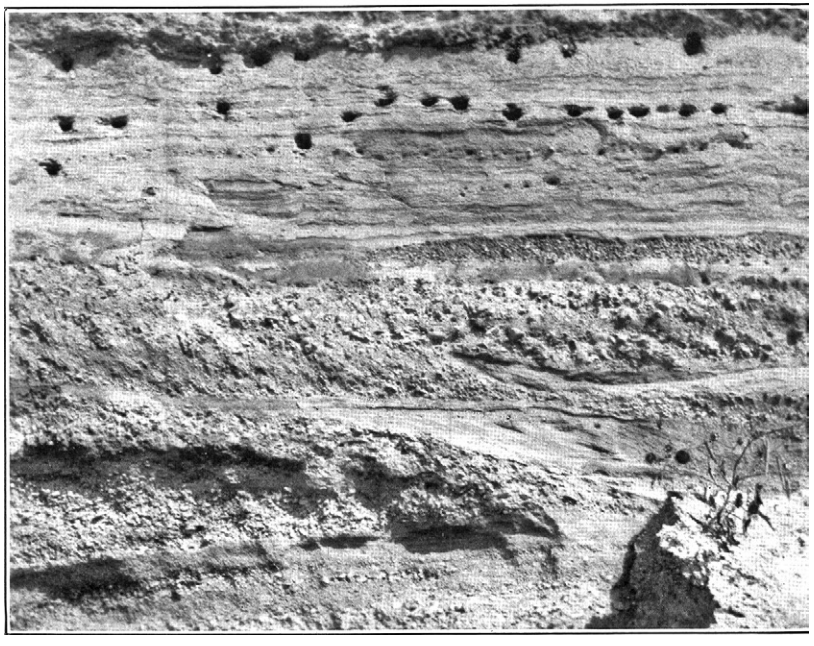


FIG. 2.—POROUS SUBSTRATUM UNDERLYING SOILS OF THE HYRUM SERIES.
Gravels with interstratified sands, showing cross bedding and lens structure.

OATS ON LOGAN LOAM NEAR PARADISE.

where the subsoil structure is open enough to give good drainage. It is this condition found in the belt of the eastern mountain foot slopes that helps to make it the most desirable section for apple growing. The high terrace soils with gravelly subsoils and a gravel substratum are also among the choicest apple soils of the area and excellent results are obtained wherever orchards have been set in such places. The types of the Millville, Sterling, Hyrum, and Mendon series where well drained and located above the valley floor are the best soils for apple culture in the area.

Of the valley floor soils the fine sandy loams, loams, and silt loams of the Trenton and Salt Lake series are to be preferred for apple culture.

Of the apples tried, the Jonathan, Gano, Missouri Pippin, Mammoth Black Twig, Rome Beauty, and Ben Davis, in the order named, seem to be best suited to conditions in the area.

Apple trees are ordinarily long lived in this section, and the fruit is of good color, flavor, and keeping quality. The trees usually come into bearing the fourth or fifth year.

The entire cost, above that of the land and water, of bringing an orchard into bearing in Cache Valley can be more than met by returns from intertilled crops. In many places in the valley nearly $100 an acre net has been realized from hoed crops planted between the young trees.

Some of the fruit now produced is sold by growers individually and part through the local fruit growers' association. The disposal and proper marketing of the fruit at the best possible price has not received the consideration due it, but growers are now beginning to realize that this question is as important as growing the fruit.

Peaches.—The climate of the area as a whole is too cold for commercial peach culture; but there are a few favorably located places along the east side of the valley, on the high gravelly terraces and foot slopes, where good yields of fruit of fine quality have been obtained. Localities near the mouths of large canyons are especially favorable for the growing of this fruit because of the strong canyon breezes which blow nearly every night, thus protecting such places from the danger of severe unseasonable frosts. Peach growing can only be developed on a small scale to supply the local demand and as an incidental. Early and late Crawfords and Elbertas are the favorite varieties. The Hyrum gravelly fine sandy loam and Sterling gravelly sandy loam and the loams of these and the Millville series where well drained and favorably located are the types upon which peaches do best.

Pears.—Pear culture in Cache Valley has been practically abandoned on account of blight, and the existing orchards are badly

neglected. The climate and soils of the valley are favorable for the production of this fruit.

Pears have a wide range of adaptation to soil conditions, and naturally thrive in the absence of blight on the various well-drained types of the Millville, Sterling, Hyrum, Mendon, and Trenton series. This fruit will succeed on lighter and heavier soils than will the apple.

Of the varieties tested in the valley and adapted to conditions here the most promising are Bartlett, Aniou, Comice, Bosc, Winter Nelis and Kieffer.

Cherries.—The fine sandy loams, silt loam, loams, and gravelly loams of the Trenton, Millville, Sterling, Hyrum, Salt Lake, and Mendon series give the best results in cherry culture. This fruit will grow and in many instances produce heavy yields on the well-drained soils. The trees are shorter lived and more irregular in growth and bearing on the heavier types of soil.

Conditions of climate are generally unfavorable for the sweet varieties. Of the 23 varieties tested at Logan by the State experiment station, Early Richmond and Montmorency for early and Double Natte and Ostheim for late are the most desirable for the soils and climate of the valley.

Cherries command a ready market at 5 cents a pound. Trees yield from 50 to 250 pounds each, depending upon the variety, age of tree, size, and vigor. The trees bear regularly, producing crops each year when given moderate attention. Sour cherries begin to bear two or three years after planting.

Plums.—Plums thrive and yield regularly, and bear well-colored and good-flavored fruit. Of the desirable varieties tested at the experiment station the Lombard, Free Damson, Pond Seedling, and Green Gage are among the best varieties. Plums may be grown on about the same range of soils as pears.

Berries.—Currants, gooseberries, and raspberries thrive in all parts of the valley and on nearly all soils where well drained and free from alkali. Dewberries have proved successful along the eastern mountain foot slopes. Heavy yields are obtained each year with moderate care and a ready market for the fruit prevails at all times.

Strawberry growing is developing rapidly along the east side of the valley on the mountain foot slopes and high terraces. The industry is proving to be one of the most profitable yet undertaken by the farmers. The valley floor and west side are not well suited to this fruit on account of the generally heavier soils and greater danger from frosts. Senator Dunlap, Marshall, Glen Mary, and Sample are favorite varieties in the valley. The plants are set out in early spring and no crop is obtained the first year. Heavy yields are obtained the second and third years and net returns of $100 to $250

an acre per year for the three years' life of the patch are not uncommon. Well-drained fine sands, fine sandy loams, loams, silt loams, and gravelly loams of the Millville, Sterling, Hyrum, Logan, Mendon, and Salt Lake series have proved the most desirable types for this crop.

MELONS AND VEGETABLES.

Watermelons and cantaloupes are produced on the Trenton fine sandy loam and also on the lighter members of the Millville, Sterling, and Hyrum series. The heavy types are too cold and hold the maturity of the fruit back until destroyed by fall frosts. Profitable yields are obtained where good care is given these crops and a home demand much greater than the supply always exists.

The growing of tomatoes is limited by the climate, and only on the fine sands, fine sandy loams, silt loams, and gravelly loams, and in well-protected coves and slopes are they able to mature before being killed by autumn freezes.

The demand for navy beans far exceeds the supply and those grown find a ready market at good prices. Good yields are obtained. This is one of the crops planted in young orchards.

Potatoes are a much neglected crop in Cache Valley. This is mainly due to the irregularity of the markets, as there are very few, if any, pests or diseases, and all that is necessary is to have the soil in good condition and to cultivate and irrigate the crop properly.

Cache Valley took first prize in the State fair in 1912 for the largest yield of potatoes, which was nearly 700 bushels per acre. Potatoes find an almost ideal soil in the Trenton fine sandy loam and the loam and silt loam of the Salt Lake, Millville, Mendon, Hyrum, Sterling, and Logan series. When grown on the clay loams and clays the tubers became knotty and misshapen. With moderate care yields of 250 to 350 bushels per acre are not uncommon on the best potato soils. Ohio, Mammoth, Pearl, Rural New Yorker, and Burbank are desirable varieties for production on the soils and under the climatic conditions of the area.

Potatoes placed in pits or in well-ventilated cellars keep well until late the following spring, and the only difficulty now existing in the commercial production of this crop is the finding of suitable markets.

Cabbage and cauliflower thrive on the silty clay loams, clay loams, silt loams, and loams of the Millville, Salt Lake, Trenton, Logan, and Mendon series of soils. Large quantities of these products could easily be grown, but the home demand is slight and no outside market now exists.

There is a strong demand for onions in Utah and surrounding States, and the crop is grown to some extent in Cache Valley. The fine sandy loam, silt loam, loam, and silty clay loam types of the area give good yields of this crop, 500 to 800 bushels per acre being fre-

quently obtained. The average price received by the growers is nearly 1 cent a pound. Besides onions, asparagus, celery, peas, cucumbers, and certain other truck crops may be grown successfully in the valley.

HOGS.

The raising and fattening of hogs has been receiving much attention in recent years. The large western cities and the mining camps offer excellent markets. By pasturing the hogs on alfalfa through summer and fattening them in the fall on concentrates, pork can be produced at little cost. Tamworth, Berkshire, and Duroc-Jerseys are the more popular breeds.

POULTRY.

The production of poultry products is becoming an important industry in the area. Conditions of soil and climate seem favorable to this business, and those engaged in it are apparently successful.

White Leghorn is probably the most popular breed where egg production is the chief aim and the Buff Cochin, Plymouth Rock, and Rhode Island Red the favorite breeds for meat production. The demand for all poultry products is good.

BEEKEEPING.

Beekeeping has been an important industry in the valley for many years. The sources of honey are alfalfa, sweet clover, mustard, sunflower, and numerous other plants. That the pasturage and other conditions are favorable is shown by the high honey yields, which according to the statements of some of the leading apiarists average about 100 pounds per hive. Honey brings 6 cents a pound extracted and 10 to 15 cents a pound in the comb. The honey is of excellent quality, ranking with the best produced in the West.

The largest producer in the valley owns about 4,500 stands. There is still ample room for the expansion of beekeeping. This has proved an excellent side line for the small farmer.

DAIRYING.

Dairying has grown very rapidly in the last decade and has developed to such proportions that it now supports four large milk condenseries and several factories making butter. Besides this, much milk is sold for local consumption. Much butter is made on the farm.

Most of the dairy herds consist of grade animals, but in recent years the importation of pure-bred Jersey and Holstein cattle has been pronounced. This improvement of the herds has done much to place the dairy industry on a paying basis.

The dairy industry is most highly developed along the east side of the valley, but is rapidly spreading to other sections. At present milk produced on the west side of the valley is handled by the factories at Wellsville, Logan, Smithfield, and Richmond. There is much room for expansion in this specialty in Cache Valley.

HORSE RAISING.

Cache Valley has long been noted for its excellent horses. Many carloads are shipped to California and surrounding States each year, and good prices are obtained. Draft breeds, such as Percheron, English Shire, Clydesdale, and Belgian, predominate.

SOILS.

Cache Valley is part of the Great Basin. It is separated from the main area of the latter by a low range of mountains, across which Bear River has cut a narrow gorge serving as a drainage outlet from the valley and an easy entrance to it from the main body of the basin. It lies on the extreme eastern border of the basin, its eastern boundary being the westward slope of the Wasatch Mountains. In its origin it is like the rest of the basin, being due in the beginning to earth movements, the most important of which consisted of faulting and the subsidence of the area of the basin or the rise of the country surrounding it. Since its original formation, however, it has been greatly modified, through the accumulation of sediment washed into it from surrounding mountains. The existing topography of the valley has already been described.

From the point of view of agriculture and of soils or of soil material, the original shape of and the original material within the Cache Valley is of little importance. The whole valley floor and practically all of the adjacent slopes as far up the boundary mountain sides as the soil survey was extended or as far as agricultural operations now extend are shaped by a coating of unconsolidated material deposited since the original formation of the valley. This material consists of unconsolidated marl or limy clay, clay, sand, gravel, and bowlders. The thickness of the layer varies greatly, reaching a maximum in the central part of the valley and gradually thinning out on the adjacent mountain slopes.

Owing to various changes in conditions which have obtained since the original formation of Cache Valley, the processes by which the filling and reshaping of the valley have been effected have doubtless changed many times. The various materials deposited in the valley since its formation may be conveniently grouped under (1) lake-laid deposits and (2) alluvial deposits.

There are two kinds of lake-laid deposits, laid down at widely different times and under geographic conditions that must have differed widely. The older deposit is exposed at the surface only on the slopes of the adjacent mountains and in the higher parts of the valley. It consists of soft marly clays and soft limestones, nearly white in color, with doubtless more or less associated deposits of sand and gravel, although such deposits were not definitely identified during the progress of the work. These deposits occur mainly along the west side of the valley, from near Mendon northward to the vicinity of Clarkston. They are found also along the eastern slope, and in places extend up to the top of the low range separating Cache Valley from the Malade Valley west of it. Similar deposits occur in the branch of the Cache Valley lying north of Newton, as well as on the low ridge separating this arm from the main valley. They extend above the level of the younger lake deposits referred to and in such cases show clearly by their erosion and weathered character that they are older. On the eastern side of the valley these deposits are found only in a few places, mainly in the vicinity of Richmond and in the southern part south and southwest of Hyrum. They have been an important factor in the formation of the Mendon soils. (Pl. II, fig. 2; Pl. III, fig. 2.)

The younger lake deposits are the most important of all the deposits in the valley. They occupy about 90 per cent of the area covered by the soil map and have been deposited so recently that they retain essentially the topography or surface shape that they had when deposited. They have been modified in the surface layer by the accumulation of organic matter and by weathering processes to the extent of oxidation and the disintegration of some of the less resistant material, but the topography, except in a few places where narrow valleys have been cut into them and a few others where later deposits have been laid over them, is that of the original deposits. It is constructional.

The central or axial belt of the valley consists of a smooth plain floored with these young lake deposits and with more or less material laid on top of them, as will appear later. These younger lake deposits are of great thickness, at least 800 feet thick in places. The lake deposits mantle the surrounding mountain slopes up to a level of about 800 feet above the existing valley floor. They decrease in thickness, however, and finally thin out entirely at the level just mentioned. The thickness along the slopes is not the same at all points, nor does it decrease at a uniform rate with the increase in elevation. In general the deposits are thin and decrease uniformly with the rise in elevation along the west side of the valley north of Wellsville. Along the east side and the south and north ends of the valley there is considerable variation. This variation is due to

the drainage of the adjacent mountains. Wherever streams of considerable size entered the former lake, there was an accumulation of thick deposits in the lake around their point of entrance. These accumulations took the form of deltas, which were built out into the lake, the top being built up to the level of the lake at the shore line or possibly slightly above it and sloping thence gently lakeward to the delta front, where there was a steep drop to the floor of the lake. At points where large streams, such as Logan River, entered the lake the delta deposits are several hundred feet thick. Between the deltas the deposits are much thinner and thin gradually toward the shore line. When the lake was drained the deltas were left as terraces. They are confined to the eastern side of the valley. No stream of any size entered the lake from the western side, so no opportunity for the building of deltas existed there. The important deltas on the east side are at Logan and Hyrum, while smaller ones were built where Smithfield, Millville, and Providence now stand. The Bear River built its delta north of the northern boundary of this area, and the Little Bear River built no well-defined one.

By far the greater number of the soils of the area are derived from these lake deposits. They are differentiated into series on the basis of the color, the character of the subsoil, and the source of the material. The important series are the Millville, Preston, Hyrum, Salt Lake, and Mendon.

The alluvial deposits consist of two kinds: (1) Alluvial fan, and (2) river or creek alluvium. The alluvial-fan deposits belong to two series—an old series and a recent one. Before the later series of lake deposits were laid down there was a period when at least the upper part of the valley was not occupied by a lake. During that time alluvial-fan deposits were spread out in the valley. The most extensive of these old fans lies in the vicinity of Avon and thence northward to the neighborhood of the Hyrum Delta. The relation of these old fan deposits to the older lake deposits is not known, but it is thought they are younger.

In recent times most of the streams have deposited fans on the floor of the lake. Small intermittent streams entering from the mountains have built steep fans on the mountain slopes and on top of the thinned lake deposits; in most cases, however, streams have cut valleys into the lake deposits and far below the level of the former shore line, and their fans have been built below the eroded gullies. The larger streams have built larger fans out on the flat lake-bottom plain. It is not at all improbable that practically the whole of the low lake floor has been covered with a thin fan of recent river deposits that lie on the boundary between true lake deposits, true alluvial deposits, true alluvial fans, and true delta deposits. Bear River bluffs, through the low lake plain, are higher immediately

along the edge of its more recently formed narrow valley. This is to be considered merely as the now trenched remnant of a former progressively advancing delta made in the receding lake by Bear River.

The modern alluvial deposits are found along the stream valleys. Logan River has cut deep into the Logan Delta and formed a valley with a narrow but well-defined flood plain across it some 300 feet or more below the upper surface of the delta. Other streams have cut into the other deltas. All the larger streams have eroded shallow valleys into the lake floor. The depth, however, is rarely more than 20 feet, and often less. Well-defined alluvial belts have been formed in these valleys. The predominant alluvial soil series is the Logan.

The rocks in the mountains surrounding the valley are mainly limestones with strong quartzite ledges. Some sandstones occur, but they are very limited in extent. Quartzites and limestones have not formed distinct bodies of soil peculiar to each and capable of separation in the survey, but have disintegrated together and have given rise to soils with preponderating limestone material.

The limestones which prominently affect the soil material include the massive crystalline limestones of the higher mountains, fossiliferous limestone, soft marly limestones of Tertiary age, travertine and oolitic limestone. The only notable deposit of travertine occurs slightly southeast of Millville, at the base of the mountains. Massive limestone, mainly calcium carbonate with some magnesian limestone, occurs all along the east and south sides of the valley and on the west forms a mountain just west of Wellsville and Mendon. A small outcrop occurs at Blackrock, south of Cache Junction and another along the east side of Newton Butte, while a high mountain composed of the material occurs just west of Clarkston. The soft, marly Tertiary limestones occupy hills and footslopes which are quite easily eroded. The material is frequently exposed as white or light-gray patches along slopes and ridges. It is most prominently developed along the western part of the valley in the vicinity of Mendon. Important areas of oolitic limestone occur west of Newton, south of Cache Junction, and in a few other places in the valley.

The oolitic limestone is the purest in the area, analyzing as high as 98 per cent carbonate of lime. The massive limestone averages about 90 per cent, and the soft fragmentary Tertiary impure material forming the low hills and mountains west of Newtan 50 per cent or less. The travertine contains about 95 per cent of lime.

The soils derived from the oolitic and fossiliferous material are unimportant in extent and were included with the other residual soils, whether above or below the lake terraces. These limestone soils have been mapped as the Richmond and the Blackrock series,

in addition to which an extensive nonagricultural type designated as Rough stony land is recognized. The soils of these series have been influenced somewhat by lake sediments on the lower slopes and by some alluvial wash and alluvial-fan and colluvial deposits on the higher and steeper slopes.

The Rough stony land is confined to that part of the area lying above the agricultural lands along the outer margins of the area and is too rough and broken for agricultural use. It is suited only to grazing and to forestry.

In the Cache Valley area a total of 12 soil series, represented by 38 soil types, in addition to one nonagricultural separation, were mapped.

The following table gives the name and the actual and relative extent of each of the soil types mapped in the area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Trenton fine sandy loam	20,992	10.5	Mendon fine sandy loam	3,328	1.2
Heavy phase	9,280		Sterling loam	3,264	1.1
Trenton clay	29,120	10.1	Hyrum loam	2,880	1.0
Avon silty clay loam	26,688	9.3	Logan gravelly fine sandy loam	2,496	.9
Mendon clay loam	26,368	9.2	Richmond gravelly loam	2,432	.8
Mendon loam	23,872	8.3	Avon gravelly silty clay loam	2,240	.8
Rough stony land	18,752	6.5	Salt Lake loam	2,112	.7
Millville loam	13,440	5.0	Cache clay	1,856	.6
Light phase	768		Millville silty clay loam	1,728	.6
Millville gravelly loam	11,584	4.0	Avon gravelly silt loam	768	.3
Blackrock gravelly loam	8,448	2.9	Logan silt loam	512	.2
Salt Lake silt loam	8,320	2.9	Trenton clay loam	448	.2
Sterling gravelly sandy loam	8,064	2.8	Sterling gravelly coarse sandy loam	384	.1
Salt Lake silty clay loam	7,808	2.7	Mendon gravelly loam	384	.1
Trenton loam	7,104	2.5	Hyrum silt loam	320	.1
Logan clay	6,528	2.3	Sterling fine sandy loam	320	.1
Logan loam	6,464	2.2	Logan fine sand	320	.1
Hyrum gravelly loam	6,208	2.2	Preston fine sand	320	.1
Trenton silty clay loam	5,824	2.0			
Richmond silty clay loam	4,544	1.6	Total	288,000	
Avon silt loam	4,288	1.4			
Mendon silty clay loam	4,096	1.4			
Hyrum gravelly fine sandy loam	3,328	1.2			

AVON SERIES.

The Avon series is derived mainly from pre-Bonneville sedimentary deposits washed into the valley prior to its occupancy by that lake. The soils occupy a position above the highest lake terraces and are badly dissected and eroded in most places. For convenience, and because of limited extent, the few scattering alluvial fans of recent formation occurring on the mountain foot slopes have been

included within this series. The soils are characteristically heavy and are a medium to dark brown in color, often with a distinct reddish tint. The subsoil is usually reddish brown to grayish brown or sometimes light gray in color, and is calcareous.

The material giving rise to the soils of this series seems to have come mainly from limestone and quartzite rocks. A greater variety of rocks is, however, probably represented to a minor extent. Varying quantities of rounded quartzite bowlders occur over the surface in many places. Small quantities of reddish sandstone fragments are found in places on the surface, but these have influenced the soil in a slight degree only. The drainage is good and no alkali is present.

AVON GRAVELLY SILT LOAM.

The Avon gravelly silt loam consists of a friable, loose-structured, medium-brown silt loam, from 10 to 18 inches deep, containing a moderate to large amount of quartzite and limestone gravel. The subsoil is a reddish to reddish-brown clay loam to clay, containing some gravel. It is more or less compact, has a moderate to low lime content, and is uniform to considerable depths. In places bowlders of quartzite and limestone are found upon the surface, and the content of coarse rock material makes cultivation difficult.

The type has a small extent. It occupies a position on high mountain foot slopes along the east and south sides of the valley. It has a moderately to steeply sloping topography, and is considerably dissected by ravines and deep, narrow valleys. It is thoroughly drained and no trouble from alkali occurs.

The type occurs about the broken boundaries of the heavier types of this series and the steep slopes of old ravines. It lies above sources of water supply for irrigation and is topographically poorly adapted to irrigation, even were water available. It is generally treeless, but supports a growth of sage, rabbit bush, and other desert shrubs and grasses. It is best suited for use as grazing land and sells for $10 to $25 an acre.

Results of mechanical analyses of samples of soil and subsoil are given in the following table:

Mechanical analyses of Avon gravelly silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520643	Soil	1.0	1.0	0.8	3.2	17.3	58.5	18.5
520644	Subsoil	2.5	4.4	4.5	9.4	17.7	36.3	24.6

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520643, 1.52 per cent; No. 520644, 7.86 per cent.

AVON SILT LOAM.

The Avon silt loam, to a depth of 10 to 22 inches, consists of a medium-brown to grayish-brown or dark reddish brown heavy silt loam which in places contains considerable quantities of quartzite fragments of varying sizes. The subsoil is a yellowish-brown or light-brown silty clay loam or silty clay extending to a depth of 6 feet or more. It has a compact structure and a moderate to high lime content. Occasionally it contains a few pebbles, mainly of quartzite and limestone. This type has the typical derivation given in the series description, but as mapped includes considerable recent material derived from the higher slopes and distributed as local alluvial-fan or alluvial surface wash deposits, which in this case it did not seem advisable to attempt to differentiate.

The type occupies a position above the highest Bonneville terrace. It is not extensive, being confined to a few small bodies in the east and south parts of the valley. It occupies a position high on the slopes and in places adjoins the Rough stony land. The type has a moderately rolling to rough topography, and is more or less dissected by ravines, giving it a surface which is too uneven for tillage or for irrigation in most places. The drainage is well established and the soil is free from alkali.

The type is treeless, but supports a growth of grass. It occurs above all existing canals and is utilized for pasture or for dry-farmed crops. Only a small part of the type is farmed, but where tilled it produces very good yields of wheat, rye, barley, and alfalfa. Land of this type sells for $15 to $35 an acre.

Average results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Avon silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520605, 520627, 520635, 520639.	Soil.....	0.3	0.9	0.8	2.3	16.6	60.7	18.5
520606, 520628, 520636, 520640.	Subsoil.....	.5	.9	1.0	3.4	18.6	47.0	28.7

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520640, 9.31 per cent.

AVON GRAVELLY SILTY CLAY LOAM.

The Avon gravelly silty clay loam consists of 10 to 18 inches of brown to dark-brown silty clay loam containing varying amounts of quartzite and gravel cobbles and bowlders. The subsoil to a depth of 6 feet or more is a reddish-brown to light-brown clay loam to clay

containing varying quantities of subangular gravel and a moderate to small quantity of lime.

Soil of this type is confined to a few irregular bodies on high mountain foot slopes along the east and south sides of the valley. The surface is usually very much dissected and the soil unsuited to tillage or irrigation even were water available. Some grasses and desert shrubs give grazing during parts of the year. The soil contains some humus and is friable and granular under cultivation, though difficult to till on account of the high content of gravel. Wherever tillage is possible dry-farmed crops, such as wheat and alfalfa, especially for seed, are the products best suited to the land.

This type of land sells for $10 to $30 an acre, depending upon the possibility of tillage.

Results of mechanical analyses of samples of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Avon gravelly silty clay loam.

[Fine earth.]

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520637	Soil	1.3	1.4	1.1	4.3	16.6	52.4	23.1
520638	Subsoil	2.1	1.9	1.1	4.5	15.0	40.4	35.2

AVON SILTY CLAY LOAM.

The Avon silty clay loam consists of 12 to 20 inches of medium-brown to dark-brown friable heavy silty clay loam. The subsoil is similar in texture to the surface material, but it is pink to light yellowish brown in color. The subsoil is more calcareous than the soil, in places being slightly mottled with lime and containing small calcareous nodules.

The surface soil is normally of compact structure, but contains a moderate to large amount of humus, which, with the lime present, causes it to crumble into a well-pulverized mass when exposed to the weather for a short time. In prolonged dry periods, also, the type cracks quite badly, but it lacks that adobe structure common in many similar soils of the West.

The surface of the Avon silty clay loam often carries varying quantities of quartzite cobbles and bowlders. On sharp ridges and steep slopes these are so numerous that tillage is impossible. In other places the type is practically free from coarse rock fragments and the surface is favorable for farming.

A large area of the Avon silty clay loam is mapped. It occurs on the mountain foot slopes along the east and south parts of the valley from 5,500 to nearly 6,000 feet above sea level. South to southeast of Avon there is a moderately uniform body of this soil which is smooth and well suited for farming. The soil in this body is most typical. Usually the land is badly dissected and too rough for tillage.

In its native state this type supports a good growth of grass, with moderate growths of willow, wild cherry, service berry, and maple along the creeks and on well-protected slopes.

Wherever the type has been farmed it has given good yields of grain. It lies above existing irrigation canals, except in one locality, and must continue to be used for dry farming. The areas too rough for cultivation furnish good grazing. Many perennial streams and springs having their origin on this type supply water to ranches lower down in the valley and to cattle grazing upon the land. Land of this type sells for $5 to $75 an acre, depending upon whether it can be irrigated or farmed or is so rough as to be fit only for grazing.

The average results of mechanical analyses of samples of soil and subsoil are shown in the following table:

Mechanical analyses of Avon silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520629, 520689	Soil	0.2	0.5	0.7	2.8	15.9	52.4	27.5
520630, 520690	Subsoil	.6	2.6	2.8	5.4	12.6	36.8	39.5

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520630, 6.79 per cent; No. 520689, 2.77 per cent; No. 520690, 32.75 per cent.

Sterling Series.

The soils of the Sterling series are light yellowish brown to medium-brown and sometimes rather dark brown, and are underlain by light-gray to yellowish-brown subsoils of calcareous character. These subsoils rest upon a bed of stratified gravel in places, including pockets or lenses of sand. The underlying gravel is often coated with lime carbonate. This series of soils is derived from lake-laid deposits occurring as terraces, delta deposits, bars, beaches, embankments, etc., about basins formerly occupied by Quaternary lakes, such as the Bonneville Basin in Utah. Sometimes the deposits have been subjected to much subsequent modification, and the material as recognized includes undifferentiated reworked material of similar mineralogical derivation, distributed as local alluvial-fan

deposits or as accumulations of sheet surface wash. In the Cache Valley drainage is well established and the soils are free from injurious accumulations of alkali.

In mapping, the Sterling soils are sometimes with difficulty separated from adjacent bodies of Hyrum and Millville soils and may as mapped include some areas of these soils.

The Sterling soils seem to have been formed mainly of material derived from massive limestone rocks, but probably include some material from other rocks.

STERLING GRAVELLY COARSE SANDY LOAM.

The Sterling gravelly coarse sandy loam consists of open-structured medium-brown coarse sandy loam. The subsoil is quite similar to the surface soil in texture, structure, and color to the depth of 6 feet, but increases in lime content. It is underlain by a bed of gravel.

The type occupies an ancient beach on the Provo terrace near Sterling, and has a ridgelike topography. It covers only 0.6 square mile.

The soil is thoroughly drained and free from alkali, and in its natural state supports a sparse growth of scrubby sage and some grasses. Most of it is farmed. Fair yields of alfalfa seed are obtained. With water for irrigation, the type gives good results with apples, plums, and sour cherries. It sells for $25 to $75 an acre.

A mechanical analysis of a sample of soil gave the following results:

Mechanical analysis of Sterling gravelly coarse sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520680	Soil	8.0	41.4	17.0	6.4	6.2	14.4	6.8

STERLING GRAVELLY SANDY LOAM.

The Sterling gravelly sandy loam consists of 10 to 20 inches of porous medium-brown to grayish-brown sandy loam containing varying amounts of waterworn gravel. The subsoil is a light yellowish gray or grayish-brown gravelly loam to a depth of 6 feet. The soil contains a small to moderate amount of organic matter. The subsoil is open, porous, and incoherent and loses its moisture rapidly. The lime content of the subsoil is high.

The type occurs in a number of bodies from Smithfield southward to the vicinity of Hyrum. It occupies areas of almost level to gently sloping topography on the Provo terrace of Lake Bonneville and its immediate slopes. It is well to excessively drained and has a smooth surface well suited for irrigation. No alkali occurs, but the lower slopes below the terrace are sometimes wet from seepage water, as is the case near Hyrum.

In its native state this type supports a small growth of sage and other desert shrubs and grasses. It is all capable of being irrigated and with water can be used for the production of apples, pears, cherries, and bush and vine fruits. It is now used for grain and alfalfa production mainly, of which good yields are obtained. Without irrigation, however, the type will not hold enough moisture to mature crops properly.

This type should rank among the choicest fruit soils of the valley. Its elevated position makes the danger from frost damage less, and there is no likelihood of injury from a water-logged condition of the soil or from accumulations of alkali.

Land of this type sells for $50 to $250 an acre, depending upon its development and location.

Average results of mechanical analyses of samples of soil and subsoil are given in the following table:

Mechanical analyses of Sterling gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520647, 520661.....	Soil.....	6.6	11.8	7.8	13.2	20.9	25.9	13.5
520648, 520662....	Subsoil.....	9.2	20.5	17.6	15.6	10.7	16.9	9.4

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520647, 8.61 per cent; No. 520648, 33.34 per cent; No. 520661, 32.45 per cent; No. 520662, 38.54 per cent.

STERLING FINE SANDY LOAM.

The Sterling fine sandy loam consists of a medium-brown to grayish-brown fine sandy loam, 12 to 20 inches deep, containing in places a small amount of gravel. The subsoil is a light yellowish gray to light yellowish brown fine sand to clay loam to 6 feet or more, and is underlain by gravel beds. The surface soil contains a moderate amount of organic matter, and the subsoil is high in lime.

The Sterling fine sandy loam occurs on the Provo terrace southwest of Hyrum and northeast of Logan. It has a smooth, uniform surface, well suited to irrigation, and is well drained and free from alkali or

the danger of its accumulation. The Sterling fine sandy loam is now used mainly for grain and alfalfa growing, but the farmers are beginning to realize its value for other crops, including fruits and vegetables.

Practically all the type is served by irrigation canals. Land with the water rights sells for $150 to $300 an acre, depending upon location and development. Under dry-farming conditions this type sells for $75 to $100 an acre. The water supply is restricted over parts of the type, and at present the cost of water is relatively high.

The results of mechanical analyses of samples of the soil and subsoil follow:

Mechanical analyses of Sterling fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520681	Soil	0.4	5.0	12.5	27.2	16.0	25.6	13.1
520682	Subsoil	.5	4.2	8.2	38.3	20.0	14.4	14.3

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520682, 42.59 per cent.

STERLING LOAM.

Typically the Sterling loam to a depth of 12 to 22 inches consists of a friable, well-granulated light-brown to rather dark-brown loam. The subsoil is a reddish-brown to yellowish-brown or gray loam to clay loam, extending to a depth of 6 feet or more. This rests upon a substratum of gravel many feet in thickness. The subsoil is very calcareous. Rounded waterworn gravel sometimes occurs in small quantities in the soil and subsoil.

The type is located on the Provo terraces, where it is confined to a few small areas along the east and south parts of the valley.

The surface, which slopes very gently valleyward, is uniform and smooth. The type is very well drained and no danger from alkali occurs.

For the most part the origin of this soil is typically that brought out in the series description, but as mapped it includes small undifferential areas of later alluvial-fan deposits.

In its natural state the type supports a sparse growth of grass and sagebrush. Most of it has been placed under cultivation, being used mainly for the growing of small grains, alfalfa, sugar beets, and potatoes. All this soil is irrigable. It ranks among the best soils of the area for the production of orchard fruits and the area devoted to fruit production is gradually extending.

Very few farmsteads are located on this type, though it is well suited for such use. Land with water rights sells for $150 to $300 an acre, according to location and state of development.

The average results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Sterling loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520651, 520657.....	Soil.....	0.4	1.1	1.6	7.4	29.6	45.6	14.3
520652, 520658.....	Subsoil.....	.4	1.4	1.9	8.9	32.9	40.8	13.7

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520651, 0.59 per cent; No. 520652, 25.93 per cent; No. 520657, 19.77 per cent: No. 520658, 57.40 per cent.

TRENTON SERIES.

The Trenton series includes types with medium-brown, light grayish brown or pinkish-brown surface soils, and pinkish-gray to light pinkish brown or yellowish-gray subsoils, frequently mottled with white, yellow, red, or greenish colors. The upper subsoil is highly calcareous. Materials giving these soils are composed of lake-laid sediments derived from a variety of igneous, metamorphic, and sedimentary rocks, limestones probably predominating.

The Trenton series of soils is the most extensive in the area surveyed. It occupies portions of the valley floor and consists of sediments deposited in Lake Bonneville at a time when that lake occupied the valley.

TRENTON FINE SANDY LOAM.

The Trenton fine sandy loam, to a depth of 12 to 20 inches, consists of a medium grayish brown to light grayish brown light fine sandy loam. The subsoil is a light pinkish gray to brownish-gray fine sandy loam to sandy clay. The lower subsoil is high in lime and is underlain by a deep substratum of pinkish lake-laid silts and clays.

The type occurs in a belt from one-fourth to one mile wide along both sides of Bear River in the central and northern central parts of the survey. It is extensively developed at Lewiston, in the northern part of the valley and is also found northeast of Wellsville in the southeastern part of the valley. It does not occur west of the junction of Clay Slough with Bear River.

The Trenton fine sandy loam lies higher than the heavier types of this series and usually slopes gently from the river bluffs outward. It has a smooth surface and sufficient slope for irrigation. It is generally free from overflow, the drainage is good, and only in depressed areas has alkali given any trouble. Overirrigation in the vicinity of Lewiston and some other places is raising the water table, and considerable damage may result in the future unless precautions are taken to keep the ground water at a proper depth below the surface.

Sage and certain grasses constitute the native vegetation of this type where well drained, with salt grass, alkali weeds, and some greasewood in the poorly drained depressions and low-lying areas.

This type ranks high among the soils of the valley. It warms early in the spring and has a wide range of profitable crops. Sugar beets, grain, alfalfa, potatoes, corn, and garden truck are the main crops grown. The yields on this soil decrease more quickly than on the heavier soils and care must be exercised to keep up the organic-matter supply. Alfalfa and manure are the main sources depended on for nitrogen and humus supply, no commercial fertilizer being used.

The average yield of crops is kept down by the lax methods employed by some of the farmers. Where the practices are good high yields are possible. In 1912 potatoes yielded nearly 700 bushels per acre on a small tract of this type in Lewiston, and yields of 250 to 350 bushels per acre are obtained with ordinary care. Sugar beets yield from 20 to 25 tons per acre on land in good condition. (See Pl. III, fig. 1.) Yields of 400 to 600 bushels of onions per acre are easily possible. Alfalfa produces from 3 to 7 tons per acre, depending upon the care and attention given the crop; wheat from 30 to 60 bushels; and oats 60 to 100 bushels per acre. Other crops suited to this soil yield equally as well. These yields are on the irrigated areas; without irrigation the soil produces only moderate yields of the small grains, alfalfa, and alfalfa seed.

Several prosperous towns and settlements are located upon this type, chief among which are Lewiston, Trenton, Stevenson, and Benson. Where irrigation is possible on this type farmers generally live upon it. The land sells for $100 to $350 an acre, depending upon the location and degree of improvement. The roads are generally sandy and heavy in dry weather, but moderately good at other times of the year. The great ease with which this soil can be handled and the slight wear upon machinery make farming very attractive and profitable upon it.

Apples do very well, but the type is not as suitable for the production of this fruit as are the mountain foot slope soils, on account of the less satisfactory drainage conditions and the greater likelihood of damage by freezing and frost.

Dairying, hog raising, and poultry raising are thriving industries.

All in all, this type is the best general-purpose soil in the valley. Twenty to thirty acres under irrigation are ample for the support and comfort of a fair-sized family, and the greatest drawback to further development is the individual control of large tracts.

Trenton fine sandy loam, heavy phase.—In addition to the soil as already described, a heavy phase of the type was mapped.

The soil of this phase to a depth of 12 to 22 inches is a light grayish brown to medium grayish brown fine sandy loam. It sometimes assumes a rather dark gray color. The subsoil to about 4 feet is a brownish-gray or yellowish-gray calcareous silt loam or fine sandy loam, often becoming heavier in texture with depth to 5 feet, where it changes to a pinkish-gray silty clay loam to silty clay. The surface soil is high in humus, friable, and easily tilled. This phase of the type is light in texture near the typical fine sandy loam, but becomes heavier as the loam or clay types of the series are approached.

Part of the phase lying a short distance northwest of Benson is marked by small sink holes from 1 foot to several feet in diameter and in places 10 feet or more deep. These are attributed to deposits of gypsum in the underlying formations, which have been dissolved away, allowing the surface material to subside. These sink holes are not general over the type, which has for the most part a uniform surface and enough gradient for irrigation.

The heavy phase occurs in a few places over the valley proper and frequently as a narrow strip between the bodies of typical Trenton fine sandy loam and the heavier types of the series. It occurs mainly in the central part of the valley, along the course of Bear River.

The soil is usually well drained, but occasionally on its lower margin seepage water has collected to some extent and some alkali has accumulated. Excessive irrigation on the higher soils is responsible for this condition.

Sagebrush and a scant growth of grasses form the vegetation before cultivation. Nearly all of this phase is now under cultivation. The crops and industries are about the same as on the typical soil. The yields compare favorably with those on the latter. Fewer farm buildings are situated on the phase, however, and it is used more extensively for dry farming.

Land values vary considerably, but in general they are lower than for the typical Trenton fine sandy loam.

Below are given the average results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the typical Trenton fine sandy loam and the soil and subsoil of its heavy phase:

Mechanical analyses of Trenton fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520607, 5206101..	Soil.....	0.1	0.2	2.1	40.7	28.2	18.4	10.3
520608, 5206102..	Subsoil.....	.0	.1	2.0	44.4	32.4	10.6	10.0
520609.....	Lower subsoil.	.0	.1	5.0	57.9	27.3	5.5	3.9
Heavy phase:								
520612, 5206103..	Soil.....	0.0	0.1	1.1	19.9	37.6	30.1	11.2
520613, 5206104..	Subsoil.....	.0	.3	1.1	20.4	33.9	28.7	15.2

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520608, 4.25 per cent; No. 520609, 12.06 per cent; No. 520613, 20.88 per cent; No. 5206101, 0.54 per cent; No. 5206102, 17.29 per cent.

TRENTON LOAM.

The Trenton loam consists of 10 to 12 inches of grayish-brown to dark grayish brown heavy loam. The subsoil, which is usually, though not always, heavier than the surface material, is a pinkish to light reddish gray loam or silty clay loam to clay, 24 to 32 inches deep, grading into a light-gray to light yellowish gray or pinkish-gray silty clay to clay of high lime content. The substratum is a pinkish to mottled red, yellow, or greenish clay, with occasional seams of fine sand or silt.

This type occurs only in a few small areas scattered over the valley floor, generally next to areas of the clay of the series.

Its surface is generally smooth and level to very gently undulating, and favorable to irrigation. It occupies a position below the Trenton fine sandy loam and receives the drainage from the higher lying soils. This has given it a high water table in most places and poor to partial drainage.

The low-lying position of this type and its high water table make the conditions favorable for the accumulation of alkali. Many areas are already seriously affected, and are increasing in extent and concentration each year. Chloride, sulphate, and carbonate of sodium or black alkali are the predominating salts.

This soil, where affected with alkali, supports a moderate growth of salt grass and some greasewood; elsewhere the vegetation consists of sagebrush and grasses.

Dry-farmed wheat, oats, flax, and alfalfa yield heavily on the better-drained areas. Sugar beets, onions, Canada field peas, and truck crops thrive on the areas free from alkali.

Very few farm buildings appear upon this type, as its low-lying position makes it unsuitable for such use. It is generally owned and farmed with more desirable land. Some of it is used for pasture.

Dry-farming land of this type sells for $25 to $60 an acre, depending upon the degree of improvement, location, and proportion of the tract well drained.

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

Mechanical analyses of Trenton loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520610, 520699, 5206107.	Soil.....	0.0	0.4	0.8	12.0	25.2	40.9	20.4
520611, 5206100, 5206108.	Subsoil.....	.0	.2	.5	2.4	24.6	40.2	32.1

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520610, 1 per cent; No. 520699, 2.40 per cent; No. 5206100, 21.56 per cent; No. 5206107, 28.45 per cent; No. 5206108, 4.50 per cent.

TRENTON CLAY LOAM.

The surface soil of the Trenton clay loam is a light grayish brown to dark grayish brown, sometimes pinkish, clay loam.

The upper subsoil is generally similar to the surface soil, though usually slightly lighter gray. The deeper subsoil is a compact silty clay loam or silty clay of pinkish-gray color and high lime content.

The soil and subsoil material is derived from lacustrine sediments derived from a variety of rocks, in which, however, limestone material probably predominates, and transported by streams to ancient Lake Bonneville in the waters of which they were deposited. The type occupies the comparatively recent slightly sloping lake bottom. A single body of this soil is mapped about 2 miles northwest of Richmond. The surface is smooth or but slightly uneven and well adapted to irrigation. Alkali is present only locally and in small quantities, the natural drainage being much better in this type than in the other lower lying soils of the series. The type is utilized mainly for general farming, but is of minor importance among the soils of the area on account of its small extent.

TRENTON SILTY CLAY LOAM.

The Trenton silty clay loam to a depth of 10 to 18 inches is a medium grayish brown to light pinkish brown or pinkish-gray clay loam of silty clay loam texture. The subsoil is a light yellowish or light pinkish brown clay with a high lime content at lower depths. The soil and subsoil resemble the Trenton clay in color, but there is little or no mottling present in the subsoil.

Areas of this type occur on gentle slopes along the margin of the valley floor, and southeast of Newton and in the vicinity of Trenton. They are moderately to well drained, though along their lower margins irrigation has been excessive and below canals seepage has caused water-logged areas and alkali accumulation.

Dry-farmed crops yield well on this type and the yields under irrigation are heavier than on the clay of the series. It is utilized mainly for the production of grains, alfalfa, and sugar beets. Its fair to good slope makes it better suited to irrigation than the Trenton clay.

Land on this type sells for $50 to $100 an acre without water rights.

The average results of mechanical analyses of samples of the soil and subsoil follow:

Mechanical analyses of Trenton silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520685, 5206109....	Soil.....	0.3	0.6	0.8	4.2	12.3	53.1	28.6
520686, 5206110....	Subsoil.....	.1	.1	.1	.6	4.5	45.7	48.7

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520685, 1.79 per cent; No. 520686, 34.81 per cent; No. 5206110, 29.45 per cent.

TRENTON CLAY.

Typically, the Trenton clay consists of a pinkish-gray or light yellowish gray or grayish-brown compact clay of medium to heavy texture. The soil varies in depth from 8 to 12 inches and rests upon a heavy, tenacious, pinkish to light yellowish gray clay of close structure and high lime content. The substratum is a pinkish to yellowish-gray heavy clay containing small seams of silt or fine sand.

Where drainage is not well established the subsoil is somewhat mottled with red, yellow, and white. The flatter parts of the type also are lighter in color than the more uneven parts, owing to the effects of poorer drainage and the presence of standing water during the periods of wet weather. Such places are more or less puddled also, and are usually low in organic matter. The higher and more hummocky parts are pinker in color, but appear light gray on the surface when dry.

The Trenton clay is the second most extensive soil in the area surveyed, covering a large part of the valley floor. It is most extensively developed west and southwest of Richmond, Smithfield, and Logan, and east of Newton. The type occurs upon the comparatively recent bed of Lake Bonneville and presents a generally level appearance. Closer inspection, however, shows the surface to

be quite hummocky and irregular in most places. The most typical body lies about 2½ miles south of Lewiston. Here the surface features are more uniform, the only irregularities being small hollows, gullies, and beds of intermittent stream ways.

The surface of this soil is gently sloping. Drainage is poor to fair. Irrigation on the higher-lying lands near-by is causing considerable seepage to collect in places and areas which were well drained at one time are now becoming water-logged and unfit for tillage. Some alkali, mainly chlorides and sulphates of sodium, has accumulated in the poorly drained areas. In its natural condition this soil supports a heavy growth of sage and a sparse growth of grasses. In depressions, where alkali occurs, greasewood and salt grass predominate.

Dry-farmed grain and alfalfa are the only crops grown on the Trenton clay. Its crop range is restricted, and much of it is used as pasture. The soil is difficult to plow, but when well tilled it breaks down into a granular seed bed, and the better-drained areas give good yields.

Land of this type sells for $25 to $60 an acre, depending upon the location and development.

Average results of mechanical analyses of samples of soil and subsoil are given in the following table:

Mechanical analyses of Trenton clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520603, 520687.....	Soil.....	0.0	0.1	0.2	1.4	4.9	37.2	56.3
520604, 520688.....	Subsoil.....	.0	.1	.1	.3	2.7	44.9	52.0

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520687, 3.36 per cent; No. 520688, 30.36 per cent.

Millville Series.

The Millville series is characterized by medium to light-brown or grayish-brown soils and light yellowish gray or pinkish-gray to light-yellowish calcareous subsoils. The subsoils often appear quite silty and are underlain by a substratum of fine and usually quite compact lake-laid sediments. The series consist of old, narrow, eroded lake terraces, alluvial fans and foot slopes, the material thus being partly alluvial and partly lacustrine. The series differs from the Mendon series in color, humus content, origin, the generally lighter texture of subsoil, and adaptability to crops. The Millville series originated from the massive crystalline limestones of the Wasatch Mountains and is quite extensively developed along the base of the mountains.

The topography is of sloping or rolling to dissected character, but is in general not unfavorable to cultivation and the use of farm machinery. The drainage over most of the series is very good, but a high-water table and some alkali occur in places near the lower margin, where springs are frequent.

MILLVILLE GRAVELLY LOAM.

The Millville gravelly loam, to a depth of 10 to 18 inches, consists of a grayish-brown to light-brown, friable, granular loam, carrying varying quantities of gravel. The subsoil, which extends to a depth of 6 feet or more, is light grayish brown to light yellowish gray calcareous gravelly loam to gravelly sand. The gravel content of the subsoil is much greater than that of the surface soil.

Small to fairly large bodies of this soil are located on the mountain foot slopes along the eastern and western sides of the valley. They have a smooth, uniform surface in most places and need little leveling to prepare them for irrigation. In general the type is well drained and free from alkali. Its position on the mountain slopes is high enough to give it freedom from severe freezes in spring.

All the Millville gravelly loam is farmed under irrigation, being used for the production of grain and alfalfa.

Results of mechanical analyses of samples of soil and subsoil are given in the following table:

Mechanical analyses of Millville gravelly loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520672	Soil	4.4	3.7	2.5	5.3	20.2	48.9	15.2
520673	Subsoil	5.9	8.4	6.6	14.0	21.4	31.4	12.7

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520673, 33.47 per cent.

MILLVILLE LOAM.

The Millville loam consists of 15 to 22 inches of a medium-brown to grayish-brown or dark-brown loam, high in silt, smooth-textured, and granular. Generally the subsoil is a loam or a silty clay loam of a light yellowish gray or pinkish-gray or light-yellowish color, though the texture varies and may be of any class from fine sandy loam to clay. Between Smithfield and Logan thin seams of fine sand also frequently occur in the subsoil of this type. The subsoil contains much lime and is open and permeable.

Bodies of this soil lie along the east side of the valley and west of Mendon and Clarkston. It has a gently sloping topography and the

drainage is generally good. Alkali occurs only in areas near the foot of the slopes, in places where the water table is within 2 or 3 feet of the surface. At present the quantity is small, but it will increase unless the ground water is lowered by drainage.

This is a relatively extensive and important agricultural soil. It is practically all under tillage and most of it is under irrigation. On the west and south sides of the valley it is used mainly for dry-farmed crops, owing to the inadequate water supply there. It is most highly developed along the east side of the valley, where it ranks among the choicest lands of the valley for the production of general farm crops and late truck. The better drained parts lying well up the mountain slopes are suitable for orchard sites. Sugar beets find almost ideal conditions on this type. The soil responds well to applications of manure and the plowing under of leguminous crops. The yields of all crops grown are heavy. Land of this type sells for $50 to $300 an acre, depending on its location and suitableness for the production of special crops.

Millville loam, light phase.—The Millville loam, light phase, to a depth of 15 to 24 inches, consists of a medium-brown to grayish-brown, fine-textured, friable, granular silty loam of slightly lighter texture than the typical Millville loam.

The subsoil is a yellowish-brown to light yellowish gray or pinkish-gray silt loam to silty clay loam with small seams of fine sand or silt in places. At lower depths the subsoil is usually heavier than near the surface. It is moderately well supplied with lime.

This phase of the type has a relatively small extent, but is nevertheless an important agricultural soil. It is confined to the eastern and southern portions of the valley, where it occupies the mountain foot slopes below the highest terrace of Lake Bonneville. The surface is moderately sloping and quite uniform, giving it good drainage and consequent freedom from alkali accumulations.

All the light phase areas are farmed under irrigation. Small grains, corn, alfalfa, and truck are the important crops. There are also some small orchards on the type. The open, friable nature of the soil makes it suitable to a wider range of crops than now grown.

Some of the most promising young orchards in the valley are located on this soil. Jonathan, Gano, Rome Beauty, and Ben Davis are the apples now grown. The fruit colors well and has a good flavor.

Many prosperous farmsteads are located near and on this phase of the Millville loam. The land sells for $200 to $300 an acre, with water rights.

Average results of mechanical analyses of samples of the soil and subsoil of the typical Millville loam and its light phase are given in the following table:

Mechanical analyses of Millville loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520659, 520667...	Soil.....	0.3	0.9	1.1	7.6	27.8	48.6	13.7
520660, 520668...	Subsoil.....	.4	1.1	1.3	9.3	33.4	38.6	15.7
Light phase:								
520625, 520645...	Soil.....	0.1	0.3	0.5	6.3	39.8	41.6	11.4
520626, 520646...	Subsoil.....	.1	.1	.2	3.4	39.9	40.8	15.0

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520625, 40.63 per cent; No. 520646, 7.04 per cent; No. 520659, 3.61 per cent; No. 520660, 51.38 per cent; No. 520667, 13.88 per cent; No. 520668, 42.54 per cent.

MILLVILLE SILTY CLAY LOAM.

The Millville silty clay loam, to a depth of 12 to 22 inches, consists of a smooth-textured, friable medium-brown to rather dark brown silty clay loam. The subsoil is a reddish to pinkish-gray or brown clay, grading into a light yellowish gray clay as depth increases, the lighter color being due to the higher lime content. In some places the subsoil at about 5 feet is underlain by a gravelly loam, but in most places it extends to and beyond the profile limit of 6 feet.

Usually the Millville silty clay loam is the lowest of the foot-slope soils, though it may occur midway up the slopes. Only a few small bodies are found. These lie along the east side of the valley. Where located on a good slope the land is moderately drained to well drained and free from alkali. The surface of the type is generally uniform. Frequently areas occupy slight depressions, and in some of these, where the water table is near the surface, a little alkali is found. Uncultivated areas of this type support a fair growth of grasses, with some sagebrush.

Where farmed it is used for the production of small grains, alfalfa, and sugar beets, to which it is well suited.

Land of this type sells for $75 to $150 an acre, depending upon its drainage and location.

Results of mechanical analyses are given below:

Mechanical analyses of Millville silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520663.....	Soil.....	0.1	0.6	0.5	1.4	8.6	63.5	25.2
520664.....	Subsoil.....	.1	.5	.8	2.2	9.7	55.7	31.1

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520663, 1.68 per cent; No. 520664, 27.20 per cent.

PRESTON SERIES.

The types included in the Preston series have light-brown surface soils and yellowish-brown subsoils. The soils consist of wind-laid deposits occupying valley plains, the materials forming the deposits having been originally laid down in lakes or by streams. The topography is undulating as the result of drifting. In the areas so far encountered the soil material is open and porous, drainage is excessive, and the soils droughty.

PRESTON FINE SAND.

The Preston fine sand consists of about 20 inches of medium-brown to light-brown fine sand, grading into a yellowish-brown fine sand extending to many feet in depth. The soil and subsoil material is low in humus and porous in structure. In most places it drifts.

Only one small body of this soil occurs in the valley. It is situated near Cornish, in the northern part of the survey. It supports a scant growth of sage and rabbit bush. The surface is undulating to low rolling and drifted. When irrigated the soil assumes a better physical condition and is productive. Early truck crops, potatoes, corn, alfalfa, and alfalfa seed, and cherries of the sour varieties are some of the successful crops.

The results of mechanical analyses of samples of the soil and subsoil follow:

Mechanical analyses of Preston fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520697	Soil	0.0	0.4	4.0	67.7	18.3	6.1	3.2
520698	Subsoil	.0	.5	5.9	72.2	12.8	4.5	3.7

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520698, 2.06 per cent.

RICHMOND SERIES.

The soils of the Richmond series are gray to dark gray and the subsoils gray to yellowish gray. The substratum consists of bedrock, which occurs at depths varying from a few inches to 6 feet or more. In shallow areas the material is generally quite uniform in color and texture down to the parent rock, but in places where it is deep the material from 2 feet down is lighter in color and more limy than the surface soil.

The Richmond soils are derived from various limestone formations through the processes of weathering.

In the Cache Valley most of the residual soils have been classed with the Richmond series, and a few minor areas of soils derived from rocks other than limestone have been included with the series.

RICHMOND GRAVELLY LOAM.

The Richmond gravelly loam consists of a medium-gray or rather dark gray or yellowish-gray light-textured loam 4 to 36 inches deep, containing varying amounts of gravel. The subsoil is a light-gray to light yellowish gray, compact gravelly loam or clay loam. In gulches and small hollows the soil and subsoil are frequently deeper than 6 feet, but in such places the material is partly colluvial or alluvial. Generally the soil and subsoil become somewhat lighter in color with increase in depth. Bedrock in most places is reached at 48 inches or less. Gravel is present in large quantities. It usually consists of angular to subangular fragments of limestone.

The Richmond gravelly loam occurs in a number of strips along the eastern margin of the valley, but is of small extent. It generally occupies steep slopes and is marked by outcrops of the parent rocks.

Drainage is excessive and the soil is free from alkali.

Sagebrush and grass are the only forms of vegetation existing on this type in its natural state. The areas lie above the present irrigation canals and are used only for pastures.

Average results of mechanical analyses of samples of the soil and a single analysis of the subsoil are given in the following table:

Mechanical analyses of Richmond gravelly loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
5206118, 5206121...	Soil.....	6.8	8.7	5.7	15.3	17.6	33.7	12.5
5206119.....	Subsoil.....	4.3	6.4	5.0	13.5	19.6	32.2	19.6

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 5206118, 13.47 per cent; No. 5206119, 20.50 per cent; No. 5206121, 41.72 per cent.

RICHMOND SILTY CLAY LOAM.

The Richmond silty clay loam, to a depth of 6 to 18 inches, is a well-granulated, friable, brownish-gray to medium gray silty clay loam. The underlying rock is found at varying though relatively shallow depths. Where the subsoil occurs it is light yellowish gray or pinkish in color, highly calcareous, and slightly heavier than the soil, the difference increasing with depth, but in places it has about the same texture as the surface material. Generally the soil material overlying the limestone bedrock is not more than 60 inches deep, but in slight valleys and ravines it may extend to more than 6 feet deep. Both soil and subsoil contain varying quantities of subangular gravel and stones.

This type occupies the moderate to steep and rolling mountain foot slopes marginal to the valley floor. This position makes it well drained and free from alkali.

In its native state the type supports a moderate growth of bunch grass and some sagebrush. In many places the type is too rough and irregular for tillage and is generally utilized for pasture. Elsewhere it is tilled with moderate difficulty, side-hill plows being generally used. Dry-farmed grain is the main cultivated crop. The type holds moisture well and where the soil body is 5 feet deep good yields are produced.

Land of the Richmond silty clay loam sells for $10 to $35 an acre, depending upon the location and its suitability for crop production.

The texture of the soil and subsoil as indicated by mechanical analyses is shown in the table which follows:

Mechanical analyses of Richmond silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
5206129	Soil	1.4	2.4	1.7	5.1	14.2	55.1	20.3
5206130	Subsoil	1.0	1.2	1.0	4.0	14.2	52.8	25.9

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 5206129, 3.04 per cent; No. 5206130, 24.02 per cent.

Blackrock Series.

The soil of the Blackrock series is medium gray to light gray or yellowish gray. The subsoil is light gray or yellowish gray and calcareous. The series is underlain usually within the 6-foot section by limestone rock, from which the soil materials are derived. The subsoil is sometimes wanting, the surface soil resting on bedrock. Rock outcrop occurs in places and fragmental rock frequently in both soil and subsoil. Soft and usually impure Tertiary limestones and marls supply the materials to form the series of soils. The topography is rolling to steep, drainage excessive, and the soils free from alkali.

As mapped the soils of the series include small undifferentiated areas of alluvial and colluvial material. Little quartzite or sandstone is present in the limestone giving these soils, and it erodes readily, forming rounded hills and ridges.

The soils covering one small hill of oolitic limestone, a mile west of Newton, and another similar outcrop 1½ miles slightly southeast of Cache Junction, have been included in this series because of the close approach of the soil to the typical Blackrock material.

BLACKROCK GRAVELLY LOAM.

The Blackrock gravelly loam to a depth of 6 to 18 inches consists typically of a medium to light-gray calcareous loam, usually low in humus and containing varying amounts of shaly limestone fragments. Where the underlying bedrock is deeper than 1 foot the tendency is to form a subsoil heavier in texture than the surface material. In most places the bedrock occurs at a less depth than 60 inches, but in ravines, where material has been washed in, the soil and subsoil may extend below the depth of 6 feet. The type includes, as mapped, some undifferentiated bodies of heavier clay loam texture, of somewhat lighter gray or yellowish-gray color, and higher lime content.

This type occurs mainly in the northwestern part of the area, where it occupies moderate to steep slopes. It is excessively drained, free from alkali, and supports a moderate to good growth of grass and bushes.

The soil is friable and absorbs water readily, but its prevailing steep topography and shallow depth cause excessive drainage, and the land becomes very dry during the summer months. As nearly all of it lies above existing irrigation systems, its main value is for pasturage. Attempts have been made to till the deeper parts, but the steep slopes and high content of gravel make cultivation difficult. Land of this type brings from $10 to $25 an acre.

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

Mechanical analyses of Blackrock gravelly loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520695	Soil	2.3	3.6	2.5	11.9	22.4	41.7	15.5
520696	Subsoil	5.9	4.8	3.3	19.0	19.1	34.1	13.6

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520695, 47.93 per cent; No. 520696, 60.65 per cent.

HYRUM SERIES.

The soils of the Hyrum series are medium gray to dark gray or dark brownish gray. The subsoils are light gray to yellowish gray or yellowish brown, usually calcareous and underlain by a substratum of stratified gravel, often with pockets or lenses of interstratified sands and commonly incrusted with lime. The members of this series are derived from lake-laid deposits, occurring mainly as terraces around extinct lakes. Subsequent to deposition the

material has been subject locally to some modification by erosion and by the addition of alluvial material in small fans or by colluvial wash. The material is derived largely from crystalline limestone, but is more or less mixed with material from other kinds of rocks. Except for local eroded areas the topography is gently sloping and smooth.

A prevailingly dark-gray color distinguishes the Hyrum soils from the related Sterling soils.

HYRUM GRAVELLY FINE SANDY LOAM.

The Hyrum gravelly fine sandy loam consists of 10 to 20 inches of friable brownish-gray or medium-gray fine sandy loam containing a moderate to large quantity of gravel. The subsoil is a light yellowish gray or gray gravelly sand to gravelly fine sandy loam, extending to 6 feet or more, and resting upon a stratum of porous gravel many feet in thickness. The subsoil is calcareous.

Areas of this soil lie on the Provo and associated terraces. They are usually small and surrounded by heavier types. The soil in some cases forms the brow of the terrace, where it breaks to the valley below. It is not an extensive type, and, with the exception of one important body near Newton, is confined to the east and south parts of the valley.

Most of the areas have a nearly level to gently sloping surface. The large body occurring near Newton is more rolling. The soil is favorably situated for irrigation, and needs little or no preparation before water can be applied. Like the Sterling soils, it is well drained and free from alkali.

In its native state the type supports a scant growth of sage and grass. It now is practically all under cultivation and is used mainly for the production of grain and alfalfa. A little fruit is produced also, and this industry is increasing in importance. Land of this type sells for $50 to $150 an acre.

Average results of mechanical analyses of samples of soil and subsoil are given below:

Mechanical analyses of Hyrum gravelly fine sandy loam.

[Fine earth.]

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520616, 520674.....	Soil.....	5.1	10.2	7.7	18.0	17.1	29.1	12.7
520617, 520675.....	Subsoil.....	10.7	19.8	24.7	24.1	9.0	8.0	3.9

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520616, 8.72 per cent; No. 520617, 42.97 per cent; No. 520674, 5.40 per cent; No. 520675, 3.75 per cent.

HYRUM GRAVELLY LOAM.

The Hyrum gravelly loam to a depth of 8 to 20 inches is a medium-gray to dark-gray loam containing gravel. The subsoil to 6 feet consists of a gravelly loam to gravelly sandy loam. Beneath the subsoil is found the typical substratum of gravel common to the Hyrum and Sterling series. The subsoil is light gray to light yellowish gray in color and extremely calcareous. It is moderately open in structure and permits of the ready downward movement of water. The gravel in this type is well rounded and ranges from small to medium.

The type occurs along the eastern side of the valley and in the southern part. It lies upon the Provo terrace and its immediate slopes. The topography is smooth and uniformly sloping. It is thoroughly to excessively drained and is free from alkali.

A sparse vegetation, mainly sagebrush and rabbit bush and grasses, is found on the uncultivated areas of the type. Much of the type is under cultivation, producing moderate to good yields of wheat, oats, and alfalfa. A large proportion of the area covered is irrigated. It is a suitable soil for orchard crops if care be exercised in the selection of sites. The rougher, more elevated, and nonirrigable portions are suitable only for pasture.

Land of the Hyrum gravelly loam type sells for $10 to $100 an acre, depending upon the location, uniformity of the surface, and the presence or absence of facilities for irrigation.

The average results of mechanical analyses of samples of soil and subsoil are given in the following table:

Mechanical analyses of Hyrum gravelly loam.

[Fine earth.]

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520649, 520678, 520693	Soil	3.3	3.2	3.5	10.3	16.9	46.4	16.1
520650, 520679, 520694	Subsoil	15.7	16.9	7.4	17.3	14.2	14.2	7.4

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520649, 9.61 per cent; No. 520650, 43.13 per cent; No. 520679, 27.34 per cent; No. 520693, 13.65 per cent; No. 520694, 49.25 per cent.

HYRUM LOAM.

Typically the Hyrum loam is a medium-textured, friable, medium-gray to dark-gray loam resting on a subsoil of gray to light yellowish gray gravelly loam to clay loam or silty clay loam. The subsoil is high in lime and has a structure permitting the ready passage of water. It rests upon the usual substratum of gravel.

This type is of moderate extent. It lies on the Provo or similar terraces occurring at an elevation of 100 to 300 feet above the valley floor. It is most typically and extensively developed near Paradise.

The type has a smooth, uniform, level, or gently sloping surface, and requires little or no preparation for irrigation. It is well drained and free from alkali and all under cultivation. It produces heavy yields of alfalfa, grain, and sugar beets. Land of this type sells for $150 to $250 an acre.

The average results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Hyrum loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520633, 520653.....	Soil.....	0.9	2.9	2.8	7.9	24.1	44.6	16.6
520634, 520654.....	Subsoil.....	.7	1.6	2.0	10.3	26.7	38.0	20.5

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520634, 25.86 per cent; No. 520654, 4.68 per cent.

HYRUM SILT LOAM.

The Hyrum silt loam to a depth of 12 to 22 inches consists of an open-structured, friable, granular silt loam of medium-gray or brownish-gray color. The subsoil is a calcareous clay loam of permeable structure, containing some gravel in places and light gray to light yellowish gray in color. The typical substratum of porous gravel is present.

The type occurs in a very few small bodies on the Provo terrace along the east and southeastern sides of the valley. It has a smooth, uniform surface and requires no preparation for irrigation. The type is well drained and is not affected with alkali.

In its native state the type supports a small growth of sagebrush and other desert shrubs and grass. It is all farmed under irrigation, being used for the production of small grains, alfalfa, and sugar beets. It is a suitable soil for growing tree and vine fruits, beans, and onions and other vegetables. With proper care it produces heavy yields.

Land composed of the Hyrum silt loam sells for $100 to $250 an acre, with water rights.

The results of mechanical analyses of samples of the soil and subsoil follow:

Mechanical analyses of Hyrum silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520641	Soil	0.4	0.5	0.5	2.1	17.1	62.1	17.3
520642	Subsoil	1.6	3.2	1.7	4.4	19.9	45.2	24.2

Salt Lake Series.

The soil of the Salt Lake series is dark gray to black. The subsoil is gray to pinkish gray, heavy, compact, and calcareous. The substratum consists of deep deposits of lake sediments of light-gray or pinkish-gray color, similar to those occurring as a substratum of the Trenton and Cache series.

The Salt Lake series is derived from lake-laid sediments occupying the lower, often recently exposed, beds of lakes of the Bonneville or similar basins. The materials are of mixed derivation. The members of the series, which are generally without gravel, occupy low-lying flat or very gently sloping plains of uniform surface, except where marked by sloughs or lagoons. Drainage is usually imperfectly developed and areas of barren character with a high water table and excessive accumulations of alkali salts are frequent.

In Cache Valley the soils of this series are usually associated with the soils of the Trenton and the Cache series, from which they are distinguished by the dark color of the surface soil.

Salt Lake loam.

The Salt Lake loam to a depth of 12 to 20 inches consists of a medium to dark gray loam, containing a relatively large proportion of very fine sand and approaching a silt loam in texture. This is underlain by a clay loam to loam subsoil, extending to 6 feet or more. In color the subsoil ranges from a medium gray to light yellowish gray or pinkish gray. It is high in lime. A substratum of pinkish lake-laid clays and silts occurs below the subsoil.

A few bodies of this soil of moderate to small extent are mapped in the eastern and south-central parts of the area surveyed. They have a uniform, gently sloping surface, broken only by an occasional small creek or depression. Drainage is more or less imperfect and the water table lies near the surface. There is usually sufficient fall to make artificial drainage effective.

Small, depressed areas, in which the movement of water is slow, have become strongly impregnated with alkali. Sodium carbonate or black alkali is a prominent salt in such accumulations.

This type has been mainly used as pasture and in the production of wild and cultivated hay. In places where sufficiently drained and properly farmed it produces heavy yields of the general farm and truck crops.

Land of this type sells for $100 to $250 an acre, depending upon the drainage and location. It is too poorly drained in most places for residence. Many springs of good water occur and artesian water is available over much of the area.

The results of mechanical analyses of samples of soil and subsoil are given in the following table:

Mechanical analyses of Salt Lake loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520618	Soil	0.0	0.2	0.9	8.2	39.4	39.3	12.3
520619	Subsoil	.0	.9	2.5	8.6	30.8	36.5	20.7

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520618, 3.93 per cent.

SALT LAKE SILT LOAM.

The Salt Lake silt loam consists of a dark-gray to nearly black fine-textured loam from 20 to 36 inches deep, underlain by a light brownish gray or light yellowish gray to medium-gray silty clay loam or silty clay. The surface soil contains much organic matter and the subsoil much lime. A substratum of fine lake-laid sediments, mostly of silt and clay of pinkish color, lies beneath the subsoil.

The type is confined mainly to the south-central part of the valley. Toward the middle of the valley it has somewhat the characteristics of the Trenton soils, into which it gradually passes. It is most typical along its eastern margin and in the body west of Providence.

This type has a uniformly smooth surface well adapted to irrigation. Artesian water of good quality may be obtained throughout its area. A number of springs and perennial streams occur on it, and the water table lies near the surface over much of it, though little damage occurs from water-logging, except in the flatter and more level areas. In many places it would be materially benefited by artificial drainage. The shallow water table tends to keep the soil cold and holds crops back in the spring.

Small patches of alkali land occur in some of the low-lying areas of this type. Alkali is slowly increasing in concentration in the low-lying parts of the type, and unless these areas are drained in the near future considerable damage may result. Small to mod-

erate amounts of black alkali are among the soluble salts found in these areas.

A heavy growth of water-loving grasses, with some greasewood and salt grass where alkali is present, forms the vegetation on this soil. Willow and various small bushes occur where small streams cross the type, but they are confined to the banks of the streams.

Practically all of the type is utilized for farming or as pasture land. On the better drained portions of the type excellent yields of sugar beets, potatoes, small grains, and alfalfa are obtained. Certain truck crops, among them onions, can be grown successfully. Corn for ensilage makes a heavy growth.

The low-lying position makes the type unsuitable for residence. Land of this type brings from $50 to $200 an acre. It is a comparatively easy type to handle and is well worth the expenditure necessary to drain and reclaim it.

The average results of mechanical analyses of soil and subsoil and a single analysis of the lower subsoil are shown in the following table:

Mechanical analyses of Salt Lake silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520620, 520665...	Soil.....	0.3	0.6	0.7	3.6	19.7	57.9	17.0
520621, 520666...	Subsoil.....	.1	.5	.7	3.4	17.7	53.3	24.4
520622.....	Lower subsoil.	.0	.1	.2	.8	14.1	61.5	23.3

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520665, 37.22 per cent; No. 520666, 36.27 per cent.

SALT LAKE SILTY CLAY LOAM.

To a depth of 15 to 24 inches the Salt Lake silty clay loam consists of a fine-textured, well-granulated, open-structured black silty clay loam. The subsoil is a medium to light-yellowish or pinkish-gray calcareous clay. A high organic-matter and lime content make the type friable and granular.

The type is confined to a few well-defined bodies of considerable extent, lying in the south-central and eastern parts of Cache Valley. It usually occurs in low flat places and is moderately well to poorly drained. Its surface is smooth and uniform in most places, but occasional small hummocks and depressions occur. It is, in places, traversed by creeks and sloughs and in certain localities portions of the soil areas are subject to overflow, temporary ponds forming during wet periods.

Alkali occurs in various places over the type. Some black alkali is present in these accumulations, but as yet it is not a serious menace.

The type supports a heavy growth of grasses, and in wetter spots rushes and cat-tails. Where well drained it may be used for the production of wheat, oats, sugar beets, and corn. Because of its wet condition very little of the type is at present under cultivation, but it furnishes excellent pasturage for dairy cows, and produces heavy yields of hay when seeded to the cultivated grasses.

Artesian water is available over much of the type. This water is of excellent quality and is present in large quantities.

No buildings appear on this type, because of its low-lying position. The land sells for $25 to $100 an acre, the higher price being paid for the better-drained areas under cultivation.

Average results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Salt Lake silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520623, 520655.....	Soil.....	0.0	0.2	0.7	2.0	8.6	62.3	26.1
520624, 520656.....	Subsoil.....	.0	.1	.1	.5	4.2	56.8	38.3

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520655, 7 per cent; No. 520656, 53.56 per cent.

CACHE SERIES.

The types placed in the Cache series have light-gray to pinkish soils and light-pinkish subsoils. The deeper subsoil is often mottled. Both soil and subsoil material are calcareous and similar in color and general character to the material forming the subsoils of the Salt Lake and Trenton series, from which the Cache soils are distinguished mainly by the color of the soil. A light-pinkish calcareous substratum of lake sediments of fine, compact character underlies the subsoil. The Cache soils are of lake-laid origin, the material being of mixed derivation. Drainage is poorly established and the soil and subsoil are heavily impregnated with alkali salts. Organic matter is deficient in both the soil and subsoil and they are usually compact and intractable.

CACHE CLAY.

Typically the Cache clay consists of a heavy, compact, tenacious clay, light gray to light yellowish gray at the surface and grading rapidly into a pinkish heavy clay below. From a depth of about 2 feet downward the subsoil changes to a white, light-gray or light yellowish gray, very calcareous clay. At 5 to 6 feet the usual pink lake-bed material occurring as a substratum under the soils of the

series is found. The lower subsoil is generally mottled with red, yellow, green, and white stains.

One moderate-sized and one small area of the Cache clay are shown on the map, about 3½ miles east of Newton. The type is confined to the lower valley floor, and receives much drainage from the higher surrounding soils. It is thus wet much of the time, and the subsoil is saturated at all times.

The Cache clay is almost devoid of vegetation. It can be of no value until reclaimed, and reclamation would be difficult. It sells for $5 to $8 an acre.

A mechanical analysis of a sample of soil gave the following results:

Mechanical analysis of Cache clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520611a.....	Soil.....	0.1	0.2	0.2	0.7	3.7	48.8	46.7

MENDON SERIES.

The types included in the Mendon series are medium gray or dark gray to black in color. The subsoil under moist field conditions is yellowish gray or pinkish gray, but in the air-dry samples a neutral light-gray or ashen-gray color prevails. The material is highly calcareous and sometimes mottled in the lower part of the soil section. The series rests on a substratum of light-gray to dark-gray calcareous lake deposits. The light-colored subsoil and substratum frequently closely approach the surface or outcrop, producing characteristic light-gray patches upon ridges and slopes.

The materials giving this series are predominantly recent alluvial-fan and alluvial foot slope deposits, derived mainly by erosion from more elevated lake-laid deposits. They include, however, some material coming directly from the higher mountain slopes and may as mapped include some undifferentiated terrace areas. While more or less mixed, the material is believed to be derived mainly from limestone. The topography is comparatively flat to gently sloping, though some eroded or rolling areas occur. The surface drainage is thorough. The subdrainage is, however, restricted, and local seepage areas, where the water table lies near the surface, occur. A few low-lying bodies contain alkali.

MENDON FINE SANDY LOAM.

The Mendon fine sandy loam is a medium-gray, friable, light fine sandy loam, underlain to a depth of about 6 feet by a medium yellowish-gray to pinkish-gray or light-gray fine sandy loam, grad-

ing into a drab mottled calcareous clay loam to clay. The surface material sometimes has a brownish tint. At times of high winds the soil drifts slightly. Varying quantities of fragments of light-colored limestone about the size of a grain of wheat are numerous in some areas. In places where the surface soil has been eroded away the gray calcareous subsoil is exposed.

The Mendon fine sandy loam has a small extent, the larger bodies occurring north of Newton and in the vicinity of Richmond, and is thoroughly to excessively drained. It occupies moderate to very gentle foot slopes, the surface is smooth, and practically no leveling is required to prepare the land for irrigation.

In its native state the type supports a good growth of grass, some rabbit bush, and a little sage brush. Where farmed it is used mainly for dry-farmed crops on account of the scarcity of irrigation water. Small grains and alfalfa seed are the important crops. Moderate to good yields are obtained. With irrigation the type has a much wider range of crops to which it is suited.

Land of this type without water sells for $35 to $85 an acre; with water these prices are more than doubled.

Average mechanical analyses of samples of the soil and subsoil and a single analysis of the lower subsoil gave the following results:

Mechanical analyses of Mendon fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
5206111, 5206113.	Soil.....	0.3	0.8	3.0	35.4	25.4	22.7	12.0
5206112, 5206114.	Subsoil.....	.2	.6	2.4	39.8	25.1	18.9	12.9
5206115.....	Lower subsoil.	.1	.3	.9	13.0	13.2	43.1	29.1

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 5206111, 5.43 per cent; No. 5206112, 23.52 per cent; No. 5206113, 15.09 per cent No. 5206114, 33.45 per cent No. 5206115, 32.43 per cent.

MENDON GRAVELLY LOAM.

The Mendon gravelly loam, to a depth of 10 to 18 inches, consists of a medium-gray to dark-gray, sometimes dark brownish gray loam containing gravel. The subsoil is a light yellowish gray gravelly sandy loam to gravelly clay loam. The gravel content is large enough to make tillage difficult.

Small bodies of this soil occur on each side of the recent lake floor. The type occupies moderate to steep slopes, is usually excessively drained, and is free from alkali.

On uncultivated areas a moderate growth of grasses, sage brush, and rabbit bush exists. Where tilled, small to medium yields of small grains and alfalfa seed are obtained. The land is mainly dry-

farmed. Experience shows it to be especially well adapted to the production of alfalfa seed, which yields from 5 to 10 bushels per acre under favorable conditions, and grain from 10 to 25 bushels per acre. In general, owing to its limited extent, gravel content, and unfavorable location with regard to irrigation, it is of comparatively little importance. Land of this type sells for $15 to $50 an acre.

MENDON LOAM.

The surface soil of the Mendon loam consists of 12 to 22 inches of medium to dark-gray or black, smooth-textured friable loam. The subsoil is a fine-grained silty clay loam to clay of a pinkish to light yellowish gray color, extending to 6 feet or more and underlain by a stratum of fine-textured lake deposits. In places where the type is flat or slightly depressed and not very well drained, the subsoil is mottled with yellow iron stains. The lime content of the subsoil is high and the type as a whole is very retentive of moisture. The surface often contains small angular particles of disintegrated limestone fragments.

The Mendon loam, which is relatively extensive, occurs mainly near the base of the mountain foot slopes along the west and south sides of the valley. One or two bodies lie near Smithfield, on the east side of the valley.

This soil has a gently sloping topography, its lower margin adjoining the valley-floor soils. In places the type is nearly flat and receives the drainage from the higher surrounding soils. Here a high water table and some alkali may exist.

In general the origin of this soil is as stated in the series description, but locally there are differences seen in the soil which may be traced with reasonable certainty to the influence of particular rock formations. The type is mainly derived from material washed from impure Tertiary limestone. As soon as the higher and massive Paleozoic limestones of certain mountain areas are approached the type changes in color, in humus content, in texture, and in productivity, slowly grading into the Millville loam, which, though occupying similar positions, differs in its origin, color, texture, and crop value.

In its native state the type supports a good growth of grasses, some sagebrush, and rabbit bush on the better drained parts, and greasewood on the poorly drained areas. Some black alkali occurs where the drainage is poor, but such accumulations are not extensive.

The type is used mainly for dry-farmed grain and alfalfa on the west side of the valley, and for alfalfa, sugar beets, and small grains along the east side, where irrigation is practiced. It is all irrigable and needs little or no leveling to prepare it for irrigation. Under dry-farming conditions it yields 20 to 35 bushels of grain and 5 to 8

bushels of alfalfa seed per acre. With irrigation the yields of grain are nearly doubled.

Land of this type of soil sells for $25 to $150 an acre.

Average results of mechanical analyses of samples of soil and subsoil are given below:

Mechanical analyses of Mendon loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520676, 520683.....	Soil.....	0.2	0.6	1.1	8.4	25.8	49.1	14.4
520677, 520684.....	Subsoil.....	.1	.3	1.0	5.4	15.9	50.9	26.2

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520676, 40.61 per cent; No. 520677, 47.38 per cent; No. 520683, 1.56 per cent; No. 520684, 41.50 per cent.

MENDON CLAY LOAM.

The Mendon clay loam consists of a medium dark gray or nearly black friable rather silty clay loam. The subsoil consists of a dense, pinkish to light yellowish gray calcareous clay, in places mottled with white and yellow. The subsoil is underlain by pinkish fine-textured lake sediments. On ridges and knolls in many places the subsoil is exposed at the surface, owing to the removal of the surface material by erosion. Such spots are plainly visible in plowed fields. They range in size from a few square rods to an acre or more.

Typically the Mendon clay loam has a high content of organic matter, as might be inferred from its dark color. In many places small soft limestone particles about the size of a wheat kernel occur in the soil in moderate quantities. This material does not occur in the related Millville series. The subsoil of the Mendon clay loam is so compact that roots and water usually enter it with difficulty.

The type is an extensive one and is developed mainly in the northwestern part of the area surveyed, with a few smaller bodies along the eastern margin of the valley in the vicinity of Cove, Richmond, and Smithfield.

Most of the type occurs on the lower foot slopes and has a fairly uniform topography. This position requires little or no preparation for irrigation. Occasional small ravines and intermittent stream ways intersect the type on the lower areas, and the higher lying portions of the type are quite badly dissected and eroded.

This type is well drained in most places and is free from alkali, except in a very few local patches near its lower margin. Excessive irrigation on the higher lying lands has raised the water table and wet areas are slowly increasing in extent.

Several prosperous towns are situated on this type, and it ranks high as a general farming and dairy soil. The higher slopes and much of the lower lying areas are used for dry-farmed crops. Wheat yields an average of about 30 bushels per acre under a system of summer fallowing each alternate year. Alfalfa yields from 2 to 4 tons of hay per acre, and in dry years a fair quantity of seed. The yields of wheat are not increased under irrigation, but alfalfa yields nearly double the quantity of hay. No alfalfa seed is produced under irrigation. With irrigation the range of crops is greatly increased, and sugar beets, corn, cabbage, cauliflower, plums, and pears all do well. Potatoes do moderately well, but unless very carefully handled and irrigated the tubers are knotty and irregular. Enough truck is grown on this type for local consumption, but it is late in maturing. Beans and peas do especially well.

The roads over the type are moderately good in summer but cut deeply when very dry. In wet weather they are almost impassable at times. Land of this type sells for $25 to $175 an acre.

The results of mechanical analyses of samples of the soil and subsoil follow:

Mechanical analyses of Mendon clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
5206116	Soil	0.2	0.5	1.7	6.9	14.0	51.7	25.2
5206117	Subsoil	.0	.1	.3	1.6	5.7	58.5	33.8

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 5206116, 2.45 per cent; No. 5206117, 35.4 per cent.

MENDON SILTY CLAY LOAM.

The surface soil of the Mendon silty clay loam consists of a heavy though friable silty clay loam, dark gray to black in color. The subsoil is a light yellowish gray, heavy, compact clay loam or clay. Small angular particles of light-colored fragmentary limestone occur in the soil as the result of washing from the higher slopes.

The type is not very extensive, occurring as a few bodies in the southern part of the valley and in the vicinity of Cove, Smithfield, and Richmond in the northeastern part. It occupies moderate to gentle slopes traversed by occasional small ravines and stream channels. The topography is in general favorable to irrigation. The higher lying areas are well drained and free from alkali in most places. Dry-farmed crops, principally small grains and alfalfa, are grown with satisfactory yields. This is an excellent type for dry-farmed wheat. With even a little irrigation it produces heavy yields

of alfalfa. The first cutting of alfalfa is too heavy for good seed production. The soil is a general farming type and makes good land for dairying. The roads are very heavy and almost impassable in wet weather, but moderately good when dry. Land of this type sells for $60 to $100 an acre.

The results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Mendon silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
520691	Soil	0.4	1.1	1.4	5.2	17.5	50.9	23.2
520692	Subsoil	.8	.9	1.2	8.5	15.3	44.1	29.3

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 520691, 5.15 per cent; No. 520692, 53.9 per cent.

LOGAN SERIES.

The soils of the Logan series are dark gray to medium gray or black, often with a brownish tint, and the subsoils medium gray to light gray or pinkish gray and calcareous. They consist of recent alluvial deposits occupying present river flood plains or lower minor terraces. The materials are of mixed derivation, but that they are largely influenced by limestone and older unconsolidated calcareous deposits is recognized. Except for minor irregularities and the presence of sloughs and stream channels, the surface is smooth, and well adapted to irrigation. Drainage is poorly established and lower lying bodies are subject to overflow. A high water table usually exists, and accumulations of alkali may occur locally.

In origin, mode of formation, and topography the soils of this series as developed in the Cache Valley are related to those of the Jordan series. The Logan soils differ from the latter in having a lighter colored calcareous subsoil, and less well-developed drainage.

LOGAN FINE SAND.

The Logan fine sand, to a depth of 12 to 20 inches, consists of a light to medium-gray or sometimes light yellowish brown fine sand. The subsoil is a light-gray to light yellowish gray fine sand to silty loam, containing seams of fine sand or silt. The texture varies considerably from place to place and with the depth, depending upon the velocity and volume of the current of water which deposited the material in each particular instance.

The type is not extensive and is developed mainly along Bear River, where it is confined to the low, narrow river bottom.

It has very little slope, but its surface is broken by old channels of the river which have been partly abandoned and filled.

Though moderately to poorly drained, but little alkali occurs in this soil. This freedom is probably due mainly to periodical overflow and the ready passage of water downward through the soil and subsoil.

In its native state the type supports a moderate to heavy growth of brush, willow, and hawberry. Part of this land is used for pastures and part is farmed to grain, alfalfa, sugar beets, and potatoes. With good care excellent yields are obtained. Early maturing truck crops thrive. With a moderate amount of leveling the type is well adapted to irrigation.

Land of this type brings from $25 to $125 an acre, depending upon the location, freedom from brush, and uniformity of the surface.

The results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Logan fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
5206127	Soil	0.1	0.3	1.4	47.3	28.0	13.4	9.1
5206128	Subsoil	.0	.2	.6	46.0	38.1	8.4	6.7

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 5206127, 14.65 per cent; No. 5206123, 18.75 per cent.

LOGAN GRAVELLY FINE SANDY LOAM.

The Logan gravelly fine sandy loam consists of 12 to 24 inches of dark-gray, fine-textured, friable sandy loam containing varying quantities of gravel. The subsoil is a medium to light-gray gravel or gravelly fine sandy loam to gravelly loam to a depth of 6 feet or more.

But little of this soil occurs in Cache Valley. It is confined to a few small bodies near Logan and southward from Millville to a point east of Hyrum.

The type has a uniformly smooth surface favorable to irrigation. It drains readily, but on account of its low-lying position and nearness to streams and because of the excessive irrigation practiced on near-by soils, it has a high water table. No alkali occurs.

The type is a very good general purpose soil. It gives large yields of small fruits and vegetables. Land of this type sells for $50 to $100 an acre.

A mechanical analysis of a sample of soil gave the following results:

Mechanical analysis of Logan gravelly fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
5206122.....	Soil.....	4.2	6.1	6.5	23.8	22.2	26.4	10.5

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 5206122, 38.9 per cent.

LOGAN LOAM.

The Logan loam consists of a smooth, moderately well granulated medium to dark-gray loam, 12 to 22 inches deep, underlain by a medium-gray compact to pervious silty clay to silt loam. The soil and subsoil vary considerably and may contain small bodies of clay or silt or fine sand too small to separate on a map of the scale used in this survey.

This is the second most extensive of the Logan soils. It has a smooth, uniform surface and in many places is wet and swampy; but very little alkali is present.

In its natural condition the type supports a heavy growth of grass, brush, and willow.

Most of the land is used for hay production and as pasture. Where well drained it gives good crops of small grains, alfalfa, sugar beets, potatoes, asparagus, onions, cabbage, and cauliflower. (See Pl. IV.) When sown to timothy and redtop it produces heavy yields of excellent hay. The type is suitable for dairying, and sells for $35 to $100 an acre.

The results of mechanical analyses of samples of soil and subsoil are given in the following table:

Mechanical analyses of Logan loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
5206123.....	Soil.....	0.0	0.4	0.8	12.5	25.5	42.8	18.2
5206124.....	Subsoil.....	.0	.2	.2	4.9	17.0	48.9	29.0

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 5206123, 25.5 per cent; No. 5206124, 21.79 per cent.

LOGAN SILT LOAM.

The Logan silt loam consists of a friable silt loam from 12 to 22 inches in depth. Typically the surface soil ranges from medium

gray to dark gray, but as mapped in Cache Valley much of the soil is lighter gray or yellowish gray or has a light-brownish tint. The subsoil is a very fine sandy loam to silty clay loam extending to a depth of 6 feet or more. The subsoil has an open structure and is easily penetrated by roots and water.

A few small bodies of the Logan silt loam are mapped in the Cache Valley. They lie along Bear River and the other larger streams of the valley. These areas are low lying and have a nearly level, uniform surface well suited to irrigation. Some of the areas are inadequately drained, and in these a small amount of alkali occurs.

Brush of different kinds, willow, and vines form the natural vegetation. Better-drained areas are seeded to alfalfa. Areas under cultivation are used mainly for the production of grain. Potatoes, onions, sugar beets, and other truck crops are even more profitable than the general farm crops. Little or no irrigation is necessary on this type, because of its low-lying position.

Land of this type of soil sells for $35 to $100 an acre.

The results of mechanical analyses of samples of soil and subsoil are given in the following table:

Mechanical analyses of Logan silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
5206125	Soil	0.0	0.2	0.3	1.3	15.2	70.6	12.6
5206126	Subsoil	.0	.1	.2	19.0	46.5	25.8	8.1

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 5206125, 22.34 per cent; No. 5206126, 18.63 per cent.

LOGAN CLAY.

The Logan clay consists of 12 to 18 inches of a dark-gray to brownish-gray or nearly black clay, resting on a subsoil of light yellowish gray to ashy-gray silty clay to fine sandy loam.

This is the most extensive of the Logan soils. It lies in the low river bottoms of the larger streams of the valley.

It has a uniform and nearly level surface. In many places poorly drained and swampy areas exist. Accumulations of alkali are found in some of these wet areas.

In its native state the Logan clay supports a moderate to heavy growth of grass, with some willow, sagebrush, and other shrubs and vines. Well-drained areas free from alkali are used for alfalfa and grain culture. It gives good yields of alfalfa where the water table

is 4 feet or more below the surface. Uncultivated areas afford excellent pasturage during the summer months. Land of this type sells for $20 to $75 an acre.

The results of mechanical analyses of samples of soil and subsoil are given in the following table:

Mechanical analyses of Logan clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
5206105.....	Soil.....	0.1	0.8	2.7	9.7	6.3	44.5	36.3
5206106.....	Subsoil.....	.2	.4	.8	21.1	36.4	29.8	11.0

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 5206105, 25.93 per cent; No. 5206106, 22.29 per cent.

MISCELLANEOUS MATERIAL.

Rough Stony Land.

Lying above the tillable mountain foot slope soils and surrounding most of the valley are extensive areas of land, badly dissected by gulches and ravines and too steep, shallow, and rocky for farming. This has been mapped as Rough stony land. A few bodies of this type also occur within the agricultural soils of the valley. The soil types of the Rough stony land were not differentiated, as this land is suited only to grazing and forestry. This material is residual. The land supports a moderate growth of grass and brush. It is of little value, bringing about $5 to $15 an acre.

IRRIGATION.

Cache Valley has a supply of water equal to its needs if properly used. The amount available depends upon the depth of snowfall in the mountains, but even when that is light the supply of water is usually ample. Bear, Logan, and Cub Rivers and Blacksmith Fork are the main sources of supply, but water from numerous perennial and intermittent creeks, springs, and artesian wells is also used. Practically no attempts have been made to use water pumped from wells for irrigation, but the water supply could undoubtedly be augmented in this way.

The duty of water in Cache Valley varies greatly. Where plentiful it is used extravagantly, and where scarce it is used economically. The Utah State station at Logan found that during July, 1896, the duty of water varied at different places under different conditions

from 39 to 125 acres for 1 second-foot; that is, 1 second-foot covered only 39 acres in one place and in another 125 acres during the month of July. In 1896 the duty of water in Cache Valley for June was 52 acres per second-foot and in July 67 acres. In August it was 113 acres and in September 166 acres. The duty of water, however, to be of the greatest value, should be ascertained for each of the important soil types of the valley.

There are numerous canal systems in Cache Valley, most of which are community ditches constructed many years ago. As early as 1897 there were 118 separate small canal systems. Since that time a few additional canals have been constructed, chief among which is the West Cache Canal. The two Bothwell canals take out of Bear River west of Cache Junction, but carry water to the Bear River Valley only.

In the community ditch system the landowners of a given district cooperate for the irrigation of their lands. The water is diverted directly from the rivers without any dam in the channel in most instances, and a main canal carries the water to the district to be irrigated. The expenses of maintaining each system are borne proportionally, each landowner contributing in money and labor his share of keeping the canals in order. Very little trouble has occurred yet in the adjustment of water rights and the maintenance of the canals, and although there has been considerable loss of time and expense in useless duplication of canals, the water has been obtained very cheaply and satisfaction has resulted in most instances.

There is one small storage reservoir in the area. It is situated about 4 miles north of Newton and supplies that town and the surrounding country with water for irrigation purposes. This reservoir was built by citizens of Newton by community labor and has been in operation for 40 years or more. Poor flume construction has resulted in many breaks and the loss of the entire volume of stored water. Otherwise, the system has proven satisfactory.

The methods of irrigation most generally followed in the valley are the furrow and flooding methods. The soils are prevailingly heavy and for best results the shallow furrow method is used for alfalfa and other general farm crops. For fruit, several deep furrows are made between each two rows of trees and a stream turned into each furrow.

On the firm loams, silty clay loams, clay loams, and clays with a generally uniform surface and slope, with an abundance of water, and particularly if alfalfa is the main crop, the system of flooding between field ditches over long, narrow lands is the cheapest method of irrigation used in the area. It is not so economical in the use of water, however, as is the furrow method. The lands and ditches may be

straight, or on contour lines if the slope is uneven. In this system the land should be sufficiently level for the water to spread from ditch to ditch, and if the lands are long the water may be turned in at proper intervals from side ditches.

A very common practice in the area is to plow furrows at intervals of a few rods through the fields to be irrigated. Small dams are made in the furrows at varying distances, depending upon the uniformity and slope of the land between the furrows. The water is then diverted from the head lateral into the several furrows and flooded across to the next furrow at each dam. As soon as the water reaches across to the lower furrow the dam is removed and the water run to the next one, the operation being repeated until the end of the field is reached. With this system one can cover from 5 to 10 acres or more per day, depending upon the uniformity of the land and the amount of water available. This system makes it possible, on the soils of Cache Valley, to irrigate evenly without giving the upper part of the field an excess in order to reach the lower end. This system has given very good satisfaction in most parts of the valley, but, like other forms of flooding, is extravagant in the use of water and may seriously affect the physical condition of the soil, although in this region, with the abundance of lime and humus in the soils and subsoils and the already excellent granulation, flooding involves less risk than where the lime and humus content are low and the soils heavy.

The light types of the Trenton series, such as the fine sandy loam, subirrigate readily, making the application of water an easy matter. In such types deep furrows are plowed through the fields, 50 to 200 feet apart, depending upon the physical properties of the soil, and water is simply run along the furrows. After the lapse of some time the irrigator, by digging into the soil a foot or two, can determine if the soil moisture has met between the furrows and when this happens the water is turned off. This system is very economical in the use of water, but unless care is taken much damage to land and crops may result. The tendency has been to apply too much water.

DRAINAGE.

Areas of considerable extent along the east side of the valley, which were among the choicest lands, have, in recent years, been almost ruined for crop production by excessive irrigation on higher lands and by waste and seepage from leaky canals. The evils of overirrigation are very perceptible now in various localities about Lewiston, in the Trenton country and along the east side of the valley from Hyrum north to the State line. The water table has been sufficiently raised in many places to increase evaporation and

this has often caused the deposition of alkali salts at the surface. A number of fields ruined by a high water table and alkali, which but a few years previously had been among the most productive in their vicinities, were encountered during the survey. Most of the damage has occurred in low areas of level or nearly level surface and on areas lying near the foothills, where drainage from the higher lands collects. There is sufficient fall, however, in nearly all parts of the valley to remove the surplus waters if drainage ways are provided. The most poorly drained soils in the area are those of the Salt Lake, Trenton, and Logan series, and of the Millville and Mendon series along their lower margin. In fact, the greater part of the valley-floor soils will in time become affected by the rise in the water table, unless precautions are taken to prevent it. Much of the land is now bordering on this condition.

Several small fields along the east side of the valley have already been drained and excellent results obtained. These examples show what may be done in the case of extensive areas of excellent land, now almost useless on account of their excess of moisture. Areas which would be greatly benefited by drainage have been inclosed with blue dash lines on the map. These areas outlined are not now all uncultivable, but they have at least a shallow water table, and if irrigation is increased will soon need attention.

ALKALI.

Cache Valley is an old lake basin, the receding waters of which were drained away mainly through the Bear River narrows west of Cache Junction. The last remnants of the lake were evaporated from depressions too low for drainage, leaving their accumulated salts behind. The waters in these depressions were undoubtedly saline and, judging from the composition of the water of Great Salt Lake to-day, were mainly charged with sodium chloride. Chemical examination should therefore show an excess of sodium salts, especially the chloride in the old lake depressions.

The following table gives the results of analyses of two composite samples of alkali crust taken in different parts of the valley. No. 12 represents a composite sample taken from the big flat mapped as Cache clay about 3 miles east of Newton. This flat is still the bed of a shallow temporary lake during very wet periods. This area is typical of many of the low flats occurring around the margin of Great Salt Lake at the present time, and it seems to be a modified remnant of one of the slight depressions of the ancient lake. Sample No. 25 is a composite of alkali crusts collected east and south of Benson, where the alkali accumulations appear to be of later date and are still forming.

Analyses of alkali crusts.

[Parts per 100,000.]

Constituent.	Sample No. 12, Cache clay.	Sample No. 25, Salt Lake silty clay loam.
Ca	1,524	676
Mg	312	416
Na	13,055	4,933
K	Trace.	Trace.
SO_4	3,496	9,052
Cl	21,056	2,804
HCO_3	80	396
CO_3	None.	240

From the above analyses it will be seen that there is a preponderance of sodium chloride from the flat east of Newton and a preponderance of sulphates and sodium carbonate east and south of Benson.

In places where the ground water is high and its movement sluggish, excessive evaporation has caused the accumulation of excessive amounts of salts in such areas. Along the east side of the valley overirrigation on the uplands has been largely responsible for the waterlogged and alkaline condition of many of the choicest lands there. Wherever the water table has risen sufficiently excessive evaporation has deposited large quantities of alkali salts and wherever the humus content is moderate to high there is a marked accumulation of sodium carbonate or black alkali.

The bodies of alkali in the Cache Valley area are scattered and are usually small and variable. In many of the large bodies outlined about half the area is affected by alkali, the remainder being nearly free. Here the affected areas were too small and numerous to separate on a map of the scale used in this survey, so the entire areas were outlined.

Alkali lands are not extensive enough in Cache Valley to warrant the construction of a separate alkali map, but the affected areas are outlined on the soil map and indicated under two grades. The areas marked with an S are land which contains numerous barren or unproductive alkali spots, and those marked A carry rather uniformly an excess of alkali salts.

The area of high water table and alkali concentration is in many places increasing as a result of overirrigation on the higher lying lands. The damage from this cause in the course of a few years will amount to a large sum, unless drainage systems are installed in the affected areas. Lands which now rank among the choicest of the valley are threatened by this danger. Many acres of valuable

land have been almost ruined in this way in the last 20 years. Some of the more progressive farmers have already installed drainage systems, and in practically all instances the almost complete reclamation of the affected land has resulted.

A narrow belt of alkali land from one-fourth to one-half mile wide occurs just below the West Cache Canal, extending south from a point just west of Merrills. Near the center of the valley the entire area covered by the Cache clay is very high in alkali and entirely unfit for farming until reclaimed. This is the most highly charged alkali area in the valley, and it is devoid of vegetation, except for an occasional alkali weed. The alkali is largely sodium chloride, or common salt. Another moderately large area occurs northwest of Logan, but the salt content in this body is very irregular and spotted. Most of the other affected areas are small and occur as local bodies in slight depressions scattered over the valley floor. The affected areas are always associated with a high water table.

Drainage is practicable in nearly all affected areas and the cost of reclamation should be moderate in most instances. It is questionable, however, whether the present price of land would warrant the reclamation of the Cache clay type on which the fall is slight and where the cost would be high both on this account and on account of the heavy texture of the soil and subsoil.

In all drainage systems of any consequence, the assistance of a competent drainage engineer should be sought, because errors in construction may easily cause the waste of much time and money.

SUMMARY.

The Cache Valley area lies in northern Utah and in the physiographic province of the Great Basin, at an average elevation of 4,400 feet above sea level. It is about 40 miles long, with a greatest width of about 19 miles, and contains an area of about 450 square miles.

The valley is oblong in shape, with its greatest axis extending north and south and its greatest width at the State boundary. It is an old lake basin, with an extensive level plain constituting the valley floor. This is surrounded by mountain foot slopes and high, steep mountains. The drainage is through the Bear River.

The valley was first settled about 1850. A community system of organization exists. Though 90 to 95 per cent of the population are engaged in farming, fully 90 per cent of the inhabitants live in cities, towns, and villages.

Most of the work done on farms is by the owner and his family. A small area of farming lands is operated by tenants.

The area is well supplied with transportation facilities, and no part of the valley is more than 8 miles from a railroad. Logan is the county seat and principal city. There are 14 other thriving towns and smaller villages in the area.

The mean annual temperature is 47° F. The maximum summer temperature is seldom more than 95° F. The minimum for winter occasionally nears 20° F. below zero. The mean annual rainfall is about 16 inches. The average date of the last killing frost in spring is May 10, and of the earliest in autumn, October 8. The prevailing winds are from the southwest.

Alfalfa hay, alfalfa seed, small grains, sugar beets, potatoes, truck crops, and fruit are among the leading crops. Dairy products, hogs, poultry products, and honey are also important. Many cattle and sheep are kept in the surrounding mountains. The raising of horses has been an important industry in the valley for years. Most of the products of the valley are shipped to distant markets.

Dry-farmed grain and alfalfa are successfully grown in the area, but irrigation is necessary for the best returns of all crops except grain.

The valley is well watered and adapted to a varied agriculture. The east side of the valley is excellently adapted to apple, pear, plum, cherry, and bush and vine fruit culture.

The area supports two large sugar factories and four large milk condenseries, besides a number of dairies.

Some alkali occurs in low, poorly-drained places over the valley floor, and a considerable area is in need of drainage.

Twelve soil series were encountered in the area in addition to the nonagricultural type of Rough stony land. The Richmond and Blackrock series are residual in origin and embrace three types. The soils of these series occupy an elevated position, are sometimes badly dissected and rough in topography, and are mainly suited to grazing.

The Avon series occurs only along the east and south parts of the valley. It comprises badly eroded heavy soils suited to grazing only, except in a few small areas. Four types of soil occur in the Avon series.

Soils of the Sterling series lie on the Provo terrace, 100 to 400 feet above the valley floor. They are well drained and suitable for fruit and truck growing and general farming.

The Hyrum series has a location similar to the Sterling series and is a good soil for the production of the crops mentioned.

The Mendon series of soils occurs mainly along the west side of the valley. The soils of this series are for the most part well drained

and productive, ranking high as grain and alfalfa soils. The series includes eroded old narrow lake terraces and alluvial foot slopes.

The Millville series occupies a similar position to that of the Mendon series, principally along the west side of the valley. It is a good fruit soil.

The Trenton series of soils occurs on the valley floor and is the most extensive series of soils in the area. Members of this series at Lewiston and along Bear River rank among the best in the area for sugar beets, alfalfa, potatoes, bush and vine fruits, and truck crops. The heavier types are better suited to the production of grain and alfalfa. Considerable alkali exists in places and caution is necessary in irrigation.

The Salt Lake series occurs along the east and south-central parts of the valley. In most places the soils of this series need drainage and alkali is found in low, flat areas. When drained, the soils rank high for the production of sugar beets, onions, potatoes, corn, alfalfa, small grains, and late truck. Bush and vine fruits also thrive.

The Logan soils are moderately well to poorly drained. Potatoes, sugar beets, small grain, alfalfa, and truck crops give good yields on properly drained areas.

The Cache series is represented by one type only, the Cache clay. It is located in the low, flat parts of the valley floor, runs high in alkali, and except for an occasional alkali weed is devoid of vegetation. Drainage is necessary before it can be used for agriculture.

The Preston fine sand is a very inextensive but productive soil.

The Rough stony land for the most part occurs on the mountain slopes above the agricultural soils. The land was not differentiated into soil types because of its lack of importance to agriculture. It is used for pastures.

[PUBLIC RESOLUTION—No. 9.]

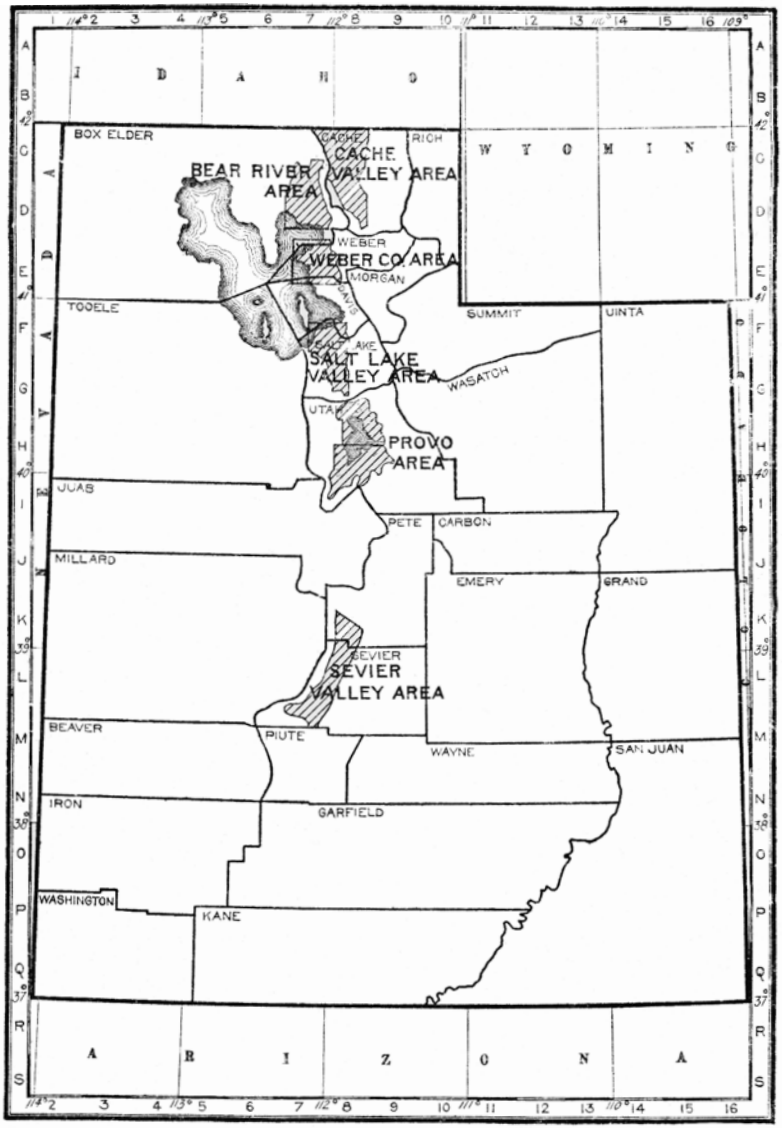
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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.]



Areas surveyed in Utah.

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