

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE WENATCHEE AREA,
WASHINGTON.

BY

A. E. KOCHER.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1918.]



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., June 8, 1921.

SIR: I have the honor to transmit herewith the manuscript report and map covering the soil survey of the Wenatchee Area, Washington, and to recommend that they be published as advance sheets of Field Operations of the Bureau of Soils, 1918, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. H. C. WALLACE,
Secretary of Agriculture.

CONTENTS.

	Page.
SOIL SURVEY OF THE WENATCHEE AREA, WASHINGTON. By A. E. KOCHER.....	5
Description of the area.....	5
Climate.....	10
Agriculture.....	12
Soils.....	25
Underwood loam.....	42
Waha loam.....	43
Waha clay.....	44
Methow coarse sandy loam.....	45
Huckleberry fine sandy loam.....	48
Quincy fine sand.....	49
Quincy fine sandy loam.....	50
Walla Walla very fine sandy loam.....	52
Ritzville very fine sandy loam.....	53
Lick stony fine sandy loam.....	55
Lick coarse sandy loam.....	56
Lick sandy loam.....	58
Lick fine sandy loam.....	59
Peshastin stony fine sandy loam.....	60
Springdale fine sandy loam.....	61
Springdale loam.....	62
Wenatchee sandy loam, residual phase.....	63
Wenatchee fine sandy loam.....	63
Wenatchee loam.....	64
Ephrata fine sandy loam.....	67
Malaga stony fine sandy loam.....	69
Cashmere stony loam.....	70
Cashmere gravelly coarse sandy loam.....	71
Cashmere loamy sand.....	72
Cashmere sandy loam.....	73
Cashmere fine sandy loam.....	75
Narcisse coarse sandy loam.....	76
Leavenworth sandy loam.....	78
Leavenworth fine sandy loam.....	79
Beverly sand.....	81
Pasco very fine sandy loam.....	83
Riverwash.....	85
Rough broken and stony land.....	85
Rough mountainous land.....	86
Scabland.....	86
Irrigation.....	87
Summary.....	90

ILLUSTRATIONS.

PLATES.

	Page.
PLATE I. Fig. 1.—View looking up Wenatchee Valley, showing general conditions of topography. Fig. 2.—Alfalfa hay on Narcisse coarse sandy loam in Lake Chelan Valley-----	16
II. Fig. 1.—A type of fruit packing house. Fig. 2.—Apple orchard on the Lick fine sandy loam, showing system of clean summer cultivation-----	16
III. Fig. 1.—View near Manson in Lake Chelan Valley. Fig. 2.—Apple orchard on Waha loam, Wheeler Hill district-----	64
IV. Fig. 1.—Apple orchard on the Ritzville very fine sandy loam near Wenatchee. Fig. 2.—View looking up canyon of Icicle Creek, near Leavenworth, showing native growth of yellow pine-----	64

FIGURES.

FIG. 1. Sketch map showing location of the Wenatchee area, Washington-	5
2. Sketch map showing location of irrigated areas in Chelan County-	89

MAP.

Soil map, Wenatchee area sheet, Washington.

SOIL SURVEY OF THE WENATCHEE AREA, WASHINGTON.

By **A. E. KOCHER**.—Area Inspected by **MACY H. LAPHAM**.

DESCRIPTION OF THE AREA.

Chelan County, in which the Wenatchee area lies, is located in the north-central part of Washington. Its northern part is less than 40 miles from the Canadian boundary, while Wenatchee, in the southern part of the county, is near the geographic center of the State. The eastern boundary of the area is formed by the Columbia River; the other boundaries are formed almost entirely by the summits of mountain ranges, including a part of the Cascade Range on the west, the Methow Mountains on the northeast, and the Wenatchee Mountains on the southwest. The Wenatchee area, as surveyed, includes only the eastern part of the county, or that part which lies outside of the National Forests. It includes a number of elongated valleys with extensive intervening areas of low mountains, plateaus, and hills, containing small tracts of agricultural land. The boundaries are extremely irregular, since they conform to the outlines of the National Forests and the meanderings of the Columbia River. The area

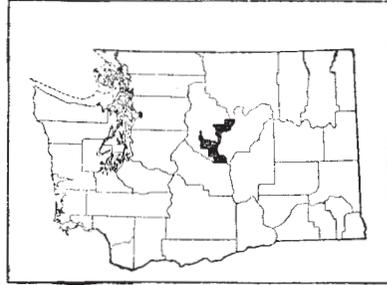


FIG. 1.—Sketch map showing location of the Wenatchee area, Washington.

is about 50 miles long north and south and about 25 miles across at its greatest width. It comprises 579 square miles, or 370,560 acres, and includes practically all of the agricultural land in the county.

Topographic sheets of the U. S. Geological Survey were used as base maps for the greater part of the area, with corrections made necessary by recent changes in roads and other cultural features. In the region around Lake Chelan some of the section lines as shown on the topographic maps are apparently not in agreement with the topography and roads. In this region the location of roads was obtained from the county engineer, and adjustments were made to coincide as nearly as possible with topography. East of Chelan the roads were located by plane-table traverse.

The Wenatchee area is a region of marked physiographic contrasts, consisting of a number of rugged mountain ranges separated by deeply eroded, sharply outlined valleys. The principal upland features are the Wenatchee Mountains, the Entiat Mountains, the Chelan Mountains, the Methow Mountains, and Chelan Butte. Although these mountain masses are separate and distinct in the area surveyed, they are in reality only outlying spurs of the Cascade Range with easterly slopes to the Columbia River.

The Wenatchee Mountains constitute a secondary range transverse to the general trend of the Cascades, though they are characterized by the same rugged topography. From an altitude of 6,000 feet at the southwest corner of T. 21 N., R. 20 E., the slope is rapidly north-eastward to the broad, flat, or gently sloping and dissected table-land of Wenatchee Heights. This table-land lies 1,500 to 2,000 feet above the Columbia, from which it is separated by very steep slopes. The topography of the Wenatchee Mountains is extremely rugged, the crest being deeply eroded, with spires and crags from which precipitous slopes lead down to narrow, V-shaped gorges 1,000 to 1,500 feet below. Mount Stuart, 9,470 feet high, 12 miles west of the area and 15 miles east of the crest of the Cascades, is the highest peak in the Wenatchee Mountains, and in its rugged outlines and its remnants of glaciers is characteristic of the topography of the main Cascade Range. In the southern part of the county smooth, flat-topped, or gently sloping ridges extend to within a mile of the Columbia River. Between the ridges are steep, rocky-sided gorges 1,000 feet or more in depth. Especially rugged topography is found bordering the canyons back of Wenatchee and in the vicinities of Monitor, Cashmere, and Leavenworth. Several smooth areas occur in the hills north of Wenatchee and Monitor. These areas, lying on the un-forested slopes 1,000 to 1,500 feet above the Columbia Valley, are conspicuous within the larger areas of rough mountain lands.

The Entiat Mountains lie between the Wenatchee and the Entiat River. They are characterized by narrow, flat-topped ridges or plateaus flanked by precipitous slopes descending to deep canyons. In elevation they range from 2,500 to 4,500 feet above sea level, and 1,500 to 3,500 feet above the valley floors, and in many places extend unbroken for several miles.

The Chelan Mountains lie between Lake Chelan and the Entiat River and the Columbia River. In their general profile they resemble the Entiat Range, with smooth-topped ridges, rising by gentle slopes, like remnants of an ancient plain. In elevation they range from 1,500 to 3,500 feet above sea level. Their descent to the Columbia, always steep, is in places precipitous and not infrequently is marked by nearly perpendicular granite bluffs. The eastern part is cut by two distinct valleys, Navarra and Knapp Coulées, which are

unique in position and geologic history. Ranging from one-fourth to one-half mile in width and 400 to 600 feet above the Columbia, these hanging valleys with smooth, gravel-covered floors contain practically no running water at the present time. They are the marks of an older geologic age, when large rivers fed by melting glaciers entered the Columbia at these points. Knapp Coulée, the eastern one, marks the beginning of Chelan Butte, a prominent spur of the Chelan Mountains, 3,892 feet high, lying between the lower or southeastern part of Lake Chelan and the Columbia River. While parts of the butte are very steep, a large proportion of it is moderately smooth and under cultivation.

The part of the Methow Mountains included in the area surveyed consists of rather steep slopes extending south and west toward Lake Chelan and east in the direction of the Columbia, together with a number of smooth plateaus, gentle slopes, and high level benches of considerable extent.

The principal lowland features are the valleys of the Columbia, Wenatchee, and Entiat Rivers, and the basin of Lake Chelan. They include nearly all of the irrigated lands in the county and constitute the source of fully 95 per cent of the agricultural products.

The Columbia Valley is unusually narrow, considering the size of the river. South of Wenatchee it ranges from one-half to three-fourths mile in width. Here it is made up of a number of narrow terraces separated by steep slopes. North of Wenatchee it varies from one-eighth to one-half mile in width, though in places it gives way to a narrow river gorge where precipitous cliffs of granite or gneiss rise 1,000 to 1,800 feet above the river bank. At Wenatchee, where the valley is joined by a number of canyons as well as by the valley of the Wenatchee River, the lowlands widen out and include a number of terraces and recent alluvial fans. This section of the valley is $1\frac{1}{2}$ to 2 miles wide and about 6 miles long.

The Wenatchee Valley extends from the Columbia River to Leavenworth, a distance of about 22 miles. The valley itself is extremely narrow, consisting of small intermittent lowlands a few rods to one-fourth mile in width. However, the term "Wenatchee Valley," as usually accepted, includes all of the sloping foothills and rolling upland surface which are under irrigation. Thus considered, the valley ranges from 1 to 2 miles in width. (Pl. I, fig. 1.)

The Entiat Valley ranges from one-eighth to one-half mile in width and is about 20 miles long. Unlike the Wenatchee Valley, it consists mostly of first bottoms and relatively low, flat terraces, smooth foothills being the exception rather than the rule. Throughout its entire length the valley is walled in by steep mountains which are broken only by a few minor streams with narrow V-shaped gorges.

The Chelan Basin extends about 12 miles along the lower part of Lake Chelan. On the south side of the lake it includes little more than smoothly sloping foothills. On the north side it includes a number of smooth terraces separated by steep, rocky slopes, and, in the vicinity of Manson, a number of prominent and rather extensive recent alluvial fans. The latter have very gentle slopes favorable to irrigation.

The drainage of the entire county is eastward into the Columbia River. Although this stream borders the county for 70 miles, it is so deeply entrenched that there are few areas of stream bottom subject to overflow, and its waters can be used for irrigation only by pumping to the terraces and adjacent slopes. The Wenatchee and Entiat Rivers cross the area in a southeasterly direction. They have their sources in the snowcapped heights of the Cascade Range and carry large volumes of water during the spring and early summer, and their flow is continuous and of considerable size throughout the entire year. They drain only small sections along their courses, as the near-by hills are short and steep and terminate at no great distance in high divides. Chelan River, the outlet of Lake Chelan, is a stream less than 4 miles in length. It has a strong, constant flow throughout the year, with an exceptionally large volume during the spring and early summer. For the most part it flows through a deep gorge cut in granite and gneiss and has a fall within this short distance of nearly 400 feet. A small amount of waterpower has been developed from this source, while the construction of a power project of considerable magnitude is under consideration. Lake Chelan, one of the most picturesque bodies of water in America, one-half to $1\frac{3}{4}$ miles wide and 55 miles long, crosses the area in a northwest-southeast direction and extends into the heart of the Cascade Range. The Columbia River also receives the waters of four streams of smaller permanent flow. Antwine Creek, in the northeastern part of the county, flows southeast through a deep canyonlike valley disproportionately large for the size of the stream. Swakane Creek enters the Columbia between the Entiat and Wenatchee Rivers, draining only a small region of Rough broken and stony land. Squillchuck and Stemilt Creeks rise in the mountains south of Wenatchee and are important because of the water they supply for irrigation and domestic purposes. In addition, there are a number of streams entering the Wenatchee and Entiat Rivers. All of the streams in the area have steep gradients and are still cutting their beds, in most cases into solid rock. There are also numerous drainage ways which carry water only after heavy rains and sudden thaws. In general the area is well drained. There is very little run-off in the cultivated portions, as most of the water is absorbed by the soil.

A large proportion of the cultivated part of the area surveyed was originally treeless, with only a sagebrush and bunch-grass covering. In most sections this condition continues to an elevation of 3,000 to 4,000 feet, where it gives place to a merchantable stand of yellow pine. At the time of settlement the lower slopes along the Wenatchee River were fairly well forested, as was also the valley floor of the Entiat River.

The first settlement in the Wenatchee area was made at Cashmere, then called Mission, in 1863. This settlement consisted of a mission for Indians, many of whom still occupy the valley of Mission Creek, which enters the Wenatchee River at Cashmere. For 20 years or more after this date there were various Indian encampments in the area, one of the largest being around the lower end of Lake Chelan. Prior to the completion of the Great Northern Railway in 1893 the Wenatchee area was very sparsely settled. A large part of the present population is derived from other parts of Washington, the Middle West, and various eastern States. Chelan County was organized from parts of Okanogan and Kittitas Counties in 1899, at which time, according to the census, it had a population of 3,931.¹ During the next 10 years the population increased to 15,104, of which 73.2 per cent was classed as rural with an average of 3.8 persons per square mile. The 1920 census gives the population of Chelan County as 20,906, of which 69.8 per cent is classed as rural, with an average of 5 persons per square mile. Following the completion of the Oroville Branch of the Great Northern Railway the settlements at Entiat and Chelan Falls grew to a few hundred people, but the Columbia Valley is still sparsely inhabited. The population is confined to the valleys and low foothills, the most thickly settled sections being in the Wenatchee Valley from Wenatchee to Cashmere, and near Dryden and Peshastin.

Wenatchee, the county seat, with a population of 6,324 in 1920, is one of the most important fruit-shipping points in the West. Cashmere, with a population of 1,114 in 1920, is also noted for its large fruit shipments. Leavenworth, with 1,791, is a division point on the main line of the Great Northern Railway. Chelan, with a population of 896, at the lower end of Lake Chelan, is a distributing center for Manson and is visited each summer by numbers of tourists. Other centers of 100 or more inhabitants are Malaga, Monitor, Dryden, Peshastin, Entiat, Chelan Falls, Manson, and Lakeside.

The transcontinental line of the Great Northern Railway, entering the county from the south, passes in a northwesterly direction through the Columbia and Wenatchee Valleys, giving direct communi-

¹ The census figures used in this report refer to the entire county. Since the unsurveyed portions, however, are mountainous and included within National Forests, the figures are nearly correct for the area surveyed.

cation with Seattle, Spokane, and the large eastern markets. Practically all of the fruit grown in the Wenatchee and lower Columbia Valleys is produced within 2 miles of this line. The Oroville Branch of the Great Northern Railway extends up the Columbia River from Wenatchee. The intensively developed orchards along Lake Chelan are from 3 to 12 miles from a shipping point. Most of the fruit grown in the area is delivered to the stations by auto truck, and the highways in the fruit-growing sections are good. Between Wenatchee and Monitor a part of the highway is paved. Owing to the dry climate and the sandy character of the soils, very little trouble is experienced with mud. The worst roads are in the hills, where the grades are necessarily steep.

Owing to the fact that fruit is almost the only commercial product grown in the area and that this commodity is produced in large quantities, considerable effort has been expended in developing suitable markets. Its profitable disposition demands long shipments to widely separated points. At the present time the principal markets for Chelan County fruits are Chicago, St. Louis, and New York, although large shipments are made to Philadelphia, Boston, and a number of other leading cities in the East. Seattle and Tacoma constitute important near-by markets. In normal times a considerable proportion of the fruit is disposed of abroad, South America, Australia, England, and Alaska being the largest buyers. In the past little attention has been given to the disposition of cull fruit, and the loss to the area from this one item has aggregated many thousands of dollars. At the present time a plant is being erected at Wenatchee for the manufacture of by-products from this class of fruit.

Most of the sheep grazed in the near-by mountains are shipped to Chicago from points within the area, while many of the cattle are disposed of at Seattle. The small quantities of hay, poultry, and dairy products produced find a ready market locally.

CLIMATE.

The Wenatchee area, although less than 100 miles distant from Seattle, has a climate as different from the Puget Sound country as though it lay in an entirely different part of the continent. The reason for this is the high barrier of the Cascade Range, which bounds it on the west and shuts off the moisture-laden winds from the Pacific. Thus the area is arid in the extreme eastern part, along the Columbia, humid in the northwestern and western parts and elsewhere at elevations above 3,000 feet, and semiarid or subhumid at intermediate altitudes. The summer temperatures in the arid, semiarid, and humid parts are high, with a high percentage of sunshine during every

month of the year. In general the climate is pleasant and healthful. Owing to the great difference in elevation between the valleys and mountainous parts of the area, there is considerable difference in the temperature and precipitation in these parts. Although complete weather records are available only for Wenatchee, it is known that the higher areas receive much more rain and snow than the valleys. Also, the temperature in the mountains in both winter and summer is considerably lower.

The following table, compiled from the records of the Weather Bureau, giving the normal monthly, seasonal, and annual temperature and precipitation at Wenatchee, may be taken as representative of conditions in the valley parts of Chelan County:

Normal monthly, seasonal, and annual temperature and precipitation at Wenatchee, Chelan County.

[Elevation 1,169 feet.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1908).	Total amount for the wettest year (1902).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	27.7	58	- 7	2.04	0.85	4.84	15.8
January.....	24.6	54	-16	1.95	1.00	1.45	16.8
February.....	29.9	64	- 5	1.75	1.00	3.55	12.8
Winter.....	27.4	64	-16	5.74	2.85	9.84	45.4
March.....	39.9	72	7	1.11	1.54	1.30	5.9
April.....	48.4	84	24	.56	.29	2.09	.4
May.....	55.4	89	28	.91	2.00	.83	0
Spring.....	47.9	89	7	2.58	3.83	4.22	6.3
June.....	61.9	97	33	.93	.03	.05	0
July.....	69.3	101	39	.50	1.33	1.16	0
August.....	68.3	99	38	.33	.16	.08	0
Summer.....	66.5	101	33	1.76	1.52	1.29	0
September.....	59.5	93	33	.83	T.	.18	0
October.....	49.5	84	20	.84	.78	.09	.4
November.....	36.5	65	- 3	2.18	.40	2.08	7.5
Fall.....	48.5	93	- 3	3.85	1.18	2.35	7.9
Year.....	47.6	101	-16	13.93	9.38	17.70	59.6

The mean annual temperature at Wenatchee is 47.6° F. The mean temperature for the winter is 27.4°, for the spring 47.9°, for the summer 66.5°, and for the fall 48.5°. The highest recorded, 101°, occurred in July, and the lowest, -16°, in January. The average

date of the last killing frost in the spring is April 22, and of the first in the fall, October 24, giving an average growing season of 199 days. The date of the latest killing frost in the spring is May 19, and of the earliest in the fall, October 1. On Wenatchee Heights, which is about 1,000 feet higher than Wenatchee, the season is said to be a week to 10 days shorter. Except in rare instances where the position with respect to canyons is such as to prevent the free circulation of air very little fruit is damaged by frost. Cherries and peaches are sometimes injured, but as a rule the late spring frosts result only in a desirable thinning of all kinds of fruit. Smudging as a means of protection from frosts is in general unnecessary and is not practiced in Chelan County.

The mean precipitation at Wenatchee is 13.93 inches. As about 65 per cent of this falls from November to March, inclusive, there is only 4.9 inches of precipitation during the remaining seven months of the year. Such a distribution is favorable to growing crops under irrigation, but is unsuited to dry farming. Fortunately, most of that part of the area that lies too high for irrigation receives a somewhat heavier rainfall, which makes it possible to grow small grains, corn, potatoes, and similar crops with a fair degree of success. The precipitation varies considerably from year to year, being 9.38 inches for the driest year and 17.70 inches for the wettest. The average snowfall at Wenatchee is 59.6 inches. As a rule snow covers the ground for only a few weeks during the winter, and plowing can usually be done during the last half of March. The snowfall in the mountains is very heavy. It usually appears about the middle of October and covers the ground until well into May.

Strong winds are common during the spring and early summer. In unprotected sections, as along the Columbia River in the southern part of the county, they sometimes cause injury to young orchards. During the rest of the year there is only a moderate wind movement. The relative humidity from March to November is very low, a condition which makes the hot summer much less oppressive than the same degree of heat would be in more humid locality.

In general, the climate is very favorable to the production of fruit, and in particular to the production of apples of an unusually high grade.

AGRICULTURE.

Although the first settlement in the area was made in 1863, permanent agriculture was not established until 20 years later, when the first irrigation ditch was built at the present site of Cashmere. For a number of years cultivation was confined to this small section, the only crops grown being those which were used at home. Cattle and horses were grazed on the hills, and their sale constituted the

only source of income. The completion of the main line of the Great Northern Railway in 1893 provided the first stimulus for agricultural development, and three years later two additional ditches were built near Cashmere. Prior to this time practically all of the valleys were barren wastes, supporting only an indifferent growth of sagebrush. It was not until the fall of 1903 that the completion of the High Line Ditch provided the water that began transformation of the large semicircular flat at Wenatchee from the sagebrush desert to the present productive orchards.

According to the United States census, at the time the county was organized in 1899 the total number of farms was only 457. The average size of farms was 206 acres, of which 15 per cent, or 30.9 acres, was improved. Of these farms 89.1 per cent were operated by their owners, 9.2 per cent by tenants, and 1.7 per cent by managers. The average value of all property per farm was \$2,829.42, of which the land constituted 68.3 per cent, buildings 10 per cent, implements and machinery 4.2 per cent, and domestic animals 17.5 per cent. The average value of farms was \$9.37 an acre. Labor for the year 1899 cost a total of \$26,030.

Since 1900 remarkable changes have taken place. The number of farms increased to 1,661 in 1910, and to 2,095 in 1920. The average size dropped to 91.9 acres in 1910, of which 27.7 per cent, or 25.4 acres, was improved. In 1920 the average size was 112.5 acres, with little change in the percentage of improved land. About the same proportions were operated by owners, tenants, and managers in 1910 as in 1900. In 1920, 82.1 per cent of the farms were operated by owners, 12.5 per cent by tenants, and 5.4 per cent by managers. The average value of all property per farm increased to \$15,018 in 1910, of which the land constituted 89.7 per cent, buildings 6.6 per cent, and implements 1.4 per cent, while domestic animals fell off to only 2.3 per cent. In 1920 the average value of property per farm was \$17,923, of which 79.4 per cent was in land, 13.3 per cent in buildings, 5 per cent in implements, and 2.3 per cent in domestic animals. The average assessed value per acre increased to \$146.64 in 1910 and decreased to \$126.53 in 1920. The increase in the average size of farms and the decrease in the assessed value per acre from 1910 to 1920 are probably due in part to the extension of agriculture into the dry-farming regions.

On the 882 farms reporting for 1909, there was a labor expense of \$399,724, or \$453.20 per farm. For 1919, 1,633 farms reported a labor expense of \$1,906,705, or \$1,167 per farm. For 1909, 1,021 farms reported the purchase of feed costing a total of \$146,469, or \$143.46 per farm, and for 1919, 1,561 farms reported a total expenditure for feed of \$375,019, or \$240.24 per farm. The use of fertilizers was reported for 1909 from only 23 farms, or only 1.4 per

cent of the total number, while in 1919 fertilizers were used on 331 farms, at a cost of \$127 per farm.

From the beginning of agriculture in the area until transportation was provided in 1893, the agricultural interests were about equally divided between stock raising and the production of fruit. According to the 1900 census, the value of animals sold and slaughtered was \$46,022; dairy products, excluding home use, \$12,989; and poultry, \$9,060. The total value of orchard products amounted to \$50,640, or a little more than the animals sold and slaughtered.

Apples have always occupied the largest acreage among the fruits, there being in 1899, according to the census, 47,483 trees, producing 27,353 bushels. There were 7,227 pear trees with a production of 3,655 bushels, 12,405 plum and prune trees yielding 11,687 bushels, 2,533 apricot trees producing 819 bushels, 15,680 peach and nectarine trees with a yield of 14,952 bushels, and 17,055 grape vines from which 147,300 pounds were harvested. The acreage and production of berries were as follows: Strawberries, 20 acres, producing 36,820 quarts; blackberries and dewberries, 8 acres, 15,220 quarts; and raspberries and loganberries, 12 acres, 19,880 quarts.

Of the hay and forage crops grown in 1899, alfalfa occupied 1,896 acres, with a production of 6,326 tons. Clover occupied 79 acres, producing 200 tons; wild grasses, 108 acres, yielding 160 tons; other tame grasses, 1,648 acres, 2,315 tons; and grains cut green for hay, 953 acres, 1,440 tons. Corn was grown on 1,772 acres, producing 31,637 bushels. Excepting the corn, the grasses, and the grains cut green, all of the crops enumerated were grown under irrigation. The small amount of dry farming done at this time is shown by the fact that the entire area in wheat, oats, and barley was only 263 acres.

The 1910 census shows a decided increase in the production of practically every crop grown, and especially in the acreage of fruit. During this decade large plantings of apples were made at Wenatchee and along the Wenatchee Valley, while the acreage of peaches was also greatly extended. The total value of all farm products, as given by the census, was \$1,746,975. Of this amount, fruits and nuts constituted \$933,249. Hay and forage amounted to \$291,475; vegetables, \$106,354; cereals, \$65,143; all other crops, \$108,880. Animals sold and slaughtered brought \$85,449; dairy products, excluding home use, \$63,524; poultry and eggs, \$91,239; and wool, mohair, and goat hair, \$226.

In 1909 the number of fruit trees in the county with their production was as follows: Apples, 421,809 trees, producing 543,757 bushels; peaches and nectarines, 113,294 trees, 5,866 bushels; grapes, 16,872 vines, 49,540 pounds; pears, 25,957 trees, 27,037 bushels; plums and prunes, 8,029 trees, 17,820 bushels; cherries, 16,447 trees, 5,807 bushels; apricots, 14,207 trees, 2,433 bushels; and nuts, mainly Per-

sian or English walnuts, 729 trees, 4,475 pounds. Strawberries occupied 55 acres with a production of 92,606 quarts; blackberries and dewberries, 11 acres, producing 19,120 quarts; and raspberries and loganberries, 15 acres, yielding 14,771 quarts.

The 1910 census reports 403 calves and 995 other cattle sold or slaughtered, about 450 horses and mules sold, and 1,893 swine and 110 sheep and goats sold or slaughtered.

By 1909 the land in alfalfa had increased to 2,733 acres, with a production of 9,231 tons. This crop was grown entirely under irrigation and solely for hay, its use in the orchards either for hay or as a cover crop not being common until some time later. The area in tame or cultivated grasses had reached 3,772 acres, producing 11,070 tons. Timothy alone occupied 681 acres, with a yield of 1,229 tons; clover alone, 56 acres, with 150 tons; timothy and clover mixed, 299 acres, yielding 457 tons. Grains were cut green from 3,989 acres, producing 4,102 tons, and 664 acres were devoted to coarse forage, with a production of 1,182 tons. The land in corn had increased to 3,491 acres, with a yield of 64,802 bushels. Wheat was grown on 820 acres, returning 16,595 bushels. Oats occupied only 32 acres, and rye only 2 acres. Potatoes were grown on 936 acres, producing 93,178 bushels, and all other vegetables occupied 598 acres.

Thus it will be seen that the area in upland crops was very small compared with the irrigated acreage in fruit. The following table, compiled by the State horticultural inspector at Wenatchee, shows the relative importance of the fruit industry at various points in the area in 1910:

Acreages and shipments of fruit from various points in Chelan County in 1910.

Shipping point.	Acres.	Cars.	Shipping point.	Acres.	Cars.
Wenatchee.....	4,630	2,622	Olds.....	1,551	480
Cashmere.....	3,490	1,181	Dryden.....	1,389	228
Chelan Falls.....	2,111	94	Leavenworth.....	721	36
Malaga.....	1,902	188	Winesap.....	170	33
Monitor.....	1,774	443			
Entiat and Wagnersburg.....	1,710	479	Total.....	21,086	6,033
Peshastin.....	1,638	249			

From an inspection of the table it will be seen that one-third of the total acreage and considerably more than one-half of the output of fruit were grown near Wenatchee and Cashmere. At that time the Chelan Falls section, which includes the newly developed section at Manson, contained a large acreage which had not yet come into bearing, although this condition was common for a number of years in all parts of the valleys. Apples constituted three-fourths of all of the fruit trees in the county.

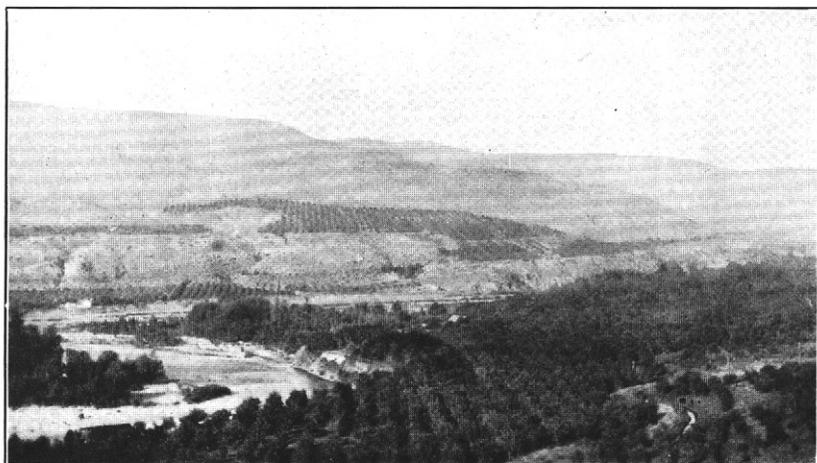
The following table, compiled by the State horticultural office at Wenatchee, shows the relative importance of the various fruits in the county in 1910:

Number and age of the various kinds of fruit trees in Chelan County in 1910.

Varieties.	Bearing age.	3 years.	2 years.	1 year.	Total.
Apples.....	442,895	135,493	141,051	343,070	1,062,509
Peaches.....	152,007	11,958	22,472	15,069	201,506
Pears.....	38,699	4,045	7,206	11,272	61,222
Plums.....	10,498	172	174	470	11,314
Apricots.....	18,605	1,567	3,862	3,160	27,194
Cherries.....	27,970	2,164	2,859	1,733	34,726
Total.....	690,674	155,399	177,624	374,774	1,398,471

Since this date plantings have continued at a slower rate. The Federal census of 1920 gives the number of bearing fruit trees of all kinds in Chelan County in 1919 as 1,697,434, yielding 6,818,068 bushels of fruit, divided as follows: Apples, 1,502,182 trees, yielding 6,300,380 bushels; peaches, 64,108 trees, 179,599 bushels; pears, 75,807 trees, 251,594 bushels; plums and prunes, 11,642 trees, 26,933 bushels; cherries, 23,693 trees, 23,623 bushels; and apricots, 19,989 trees, 35,926 bushels. There were 16,060 grapevines, yielding 141,345 pounds of grapes; and 1,341 nut trees, yielding 19,658 pounds of nuts.

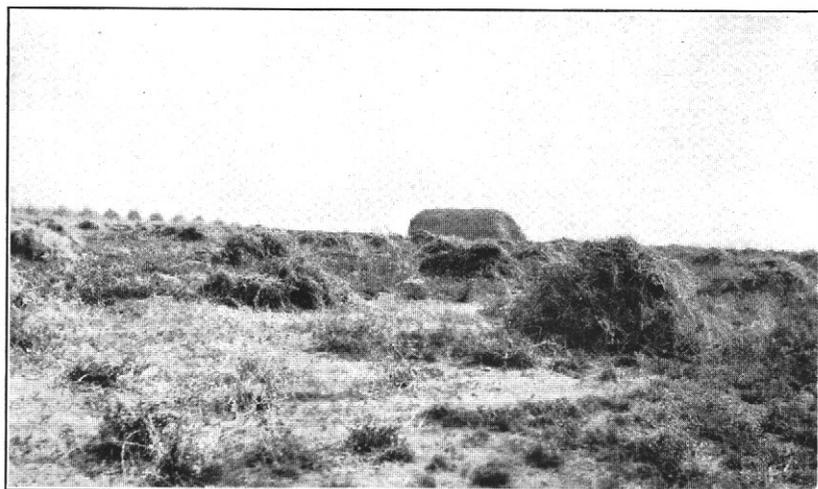
For a number of years the agricultural interests in the valleys were centered almost entirely in the production of fruit. No vegetation was permitted to grow in the orchards, the land was intensively cultivated, and nothing was returned to replace the rapidly diminishing humus. As clean cultivation continued the heavy soils became compact, while those of loose structure became more porous. Fruit trees turned yellow and showed a general condition of unthriftiness. Yields fell off, color and quality were lowered, and the size of fruit became perceptibly smaller. So strong was the faith in fruit that almost the entire acreage was planted to trees and most of the necessities of life were imported. This was the condition in 1911, when Wenatchee alone imported 150,000 pounds of butter, costing the consumer \$52,500; 200 gallons of milk daily, or 73,900 gallons a year at an annual cost of over \$29,000; 42,000 dozens of eggs, valued at \$14,700; 1,800 tons of hay and feed, costing \$28,000; and in addition 12 cars of corn, 20 cars of canned milk, and 20 cars of packing-house products. About this time it became apparent that clean cultivation had not been entirely satisfactory and that some additional crop would have to be grown in the orchards to replace the exhausted humus. Alfalfa was sown and at an early date proved decidedly beneficial. So marked was the improvement in the condition of the



S. 9912

FIG. 1.—VIEW LOOKING UP WENATCHEE VALLEY, SHOWING GENERAL CONDITIONS OF TOPOGRAPHY.

Soils of the Wenatchee series in foreground. Orchards in distance on hill slopes are on the Ritzville very fine sandy loam.



S. 10033

FIG. 2.—ALFALFA HAY ON NARCISSE COARSE SANDY LOAM IN LAKE CHELAN VALLEY.

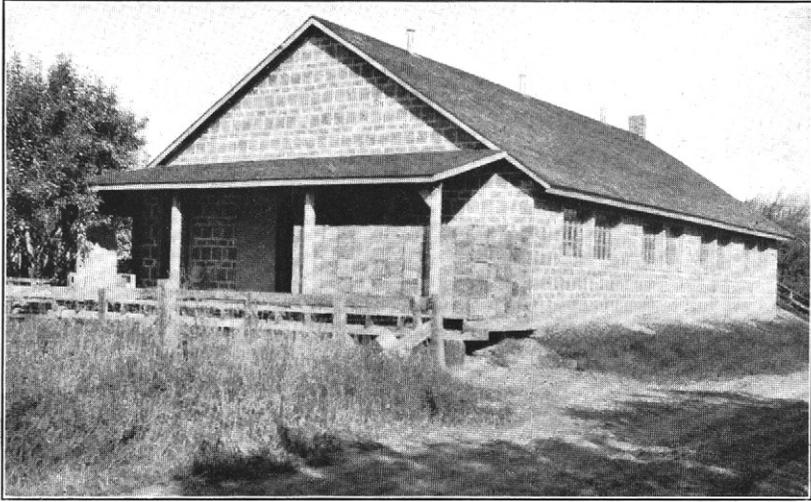


FIG. 1.—A TYPE OF FRUIT PACKING HOUSE.

This type is becoming common in the Wenatchee Valley. The building is of hollow tile construction and designed for winter storage of fruit.



S. 10036

FIG. 2.—APPLE ORCHARD ON THE LICK FINE SANDY LOAM, SHOWING SYSTEM OF CLEAN SUMMER CULTIVATION.

trees, the yield and size and quality of the fruit, that the practice rapidly extended throughout all of the valleys, until now nearly all of the orchards are seeded to alfalfa. With the extension in the acreage of alfalfa, more cows and hogs were kept, though it has been only within the last three or four years that interest has awakened to these industries.

The 1920 census reports 4,425 acres in wheat, with a yield of 40,267 bushels; 1,723 acres in corn, yielding 26,246 bushels; with small acreages in oats, barley, and rye. Hay and forage crops occupied 18,720 acres, with a yield of 24,924 tons, of which alfalfa occupied 10,418 acres, yielding 16,907 tons; the balance consisting principally of timothy, timothy and clover mixed, and small grains cut for hay.

Live stock in Chelan County is reported by the 1920 census as follows: Horses, 4,103; mules, 362; beef cattle, 1,109; dairy cattle, 4,485; sheep, 4,666; swine, 3,380; chickens, 52,074; other poultry, 1,068. The value of dairy products, excluding home use of milk and cream, was \$199,528; and value of chickens and eggs produced, \$198,332.

At the present time the agriculture in the valleys consists of growing fruit for sale and the production of dairy products and vegetables for home use. In the unirrigated portions of the area the agriculture is confined to small areas of wheat, corn, potatoes, and beans. The wheat is grown as a cash crop; the others are used at home or sold locally. The principal fruit crop is apples, followed by peaches, pears, apricots, cherries, and plums. Apparently most of the trees are now in full bearing, since the yields during the past few years have remained fairly constant. There is a tendency, however, to alternate bearing, as is shown by the following table, supplied by the State horticultural inspector at Wenatchee. This table shows in detail the shipments of fruit from Chelan County from 1907 to 1913, inclusive, and after that period the total shipments of fruit from the county:

Fruit shipments from Chelan County from 1907 to 1917, inclusive.

[Carloads.]

Year.	Apples.	Peaches.	Pears.	Plums.	Apricots.	Cherries.	Berries, vegetables, etc.
1907.....	616	301	45	65	29	10	236
1908.....	820	395	60	70	45	10	438
1909.....	697	2	63	45	4	5	80
1910.....	2,332	341	90	35	60	18	46
1911.....	1,925	413	135	35	75	30	50
1912.....	2,779	450	175	40	100	40	.....
1913.....	3,924	318	160	35	125	68	.....

Approximate total fruit shipments.

	Carloads.		Carloads.
1914.....	7,013	1916.....	7,130
1915.....	5,400	1917.....	6,999

According to the above figures, there are about ten times as many apples grown as peaches, the next largest fruit crop. Apples are not confined to any particular soils, except that they are grown only in the valleys and lower foot slopes where irrigation can be supplied. The leading varieties are Winesap, Delicious, Jonathan, Rome Beauty, and Stayman Winesap, in the order named. Most of the orchards at the present time are seeded to alfalfa, which is grown primarily as a cover crop. Many orchardists, however, follow the practice of removing one or two cuttings of hay each season, although the more successful growers do not cut the alfalfa, but consider it only as a cover crop. In growing apples with a cover crop the orchards are usually disked as early as possible in the spring, following which the land is thoroughly pulverized with a spring-tooth or spike-tooth harrow. The fields are then furrowed for irrigation, the first water usually being applied about the middle of April. Thereafter irrigations are given at intervals of 10 days to 3 weeks, depending on the season and the character of the soil.

In order to control insects and fungus diseases and insure a high grade of commercial fruit, it is necessary to spray thoroughly during the early spring and summer. The first application is usually made with a solution of lime-sulphur during the latter part of March or early April, while the trees are still dormant or as the buds are beginning to open. A second spray, composed of a solution of arsenate of lead, is applied, after most of the petals have fallen, for the control of the codling moth. Following this the trees are again sprayed during the latter part of May with arsenate of lead solution to protect the fruit against the codling-moth. In some cases an additional spraying is given for the same purpose during the latter part of summer. During the last few years spraying has been necessary for the control of woolly aphis. This insect not only attacks the leaves and twigs, but also the roots. It is combated by spraying with concentrated solution of nicotine sulphate. This material is also sometimes used in conjunction with lime-sulphur, Bordeaux mixture, or lead arsenate at the time of the other spraying, being in effect a number of sprays applied at one time. Among the fungus diseases probably the most serious is the apple powdery mildew, which is second only to the codling moth in the trouble it causes.

Practically all of the pruning is done in the winter, when the trees are dormant. As a rule the apple trees in Chelan County set large crops of fruit, which require heavy thinning by hand during the latter part of June or early July. Harvesting begins on the com-

mercial varieties about the middle of September and continues till November. A small part of the fruit is hauled to central packing sheds at shipping points for packing, but the greater part of it is hauled directly to sheds on the ranches, where it is sorted, sized, packed, and immediately delivered to the warehouses for shipment. Only a very small proportion of the fruit is stored either at shipping points or on the ranches for future shipment. All fruit shipped out of the county, except that intended for canning purposes, is rigidly inspected, which insures a very high standard of quality.

The yields of apples in the Wenatchee-Cashmere district and the cost of production, together with a number of other facts pertaining to the industry, were studied by the Office of Farm Management, U. S. Department of Agriculture, during the summer and fall of 1914. The following is a summary of some of the results obtained.² The average yield in the orchards studied was found to be 593 boxes per acre, or 7.3 boxes per tree. The total cost of production was \$469.73 per acre, or \$0.792 per box, f. o. b. Of this, labor cost constituted \$179.09 per acre, or \$0.302 per box, and cash cost, including interest on investment, \$290.64 per acre, or \$0.49 per box. This is the average cost under clean cultivation; under alfalfa management it is about 2 cents less. The orchards in the district studied averaged 6½ acres in size, with 81 trees per acre. The average investment per farm was found to be \$20,974; the average investment per acre of bearing apple trees alone, \$1,925. The equipment investment was found to be \$444 per ranch, or \$47 per acre, exclusive of live stock. There was an average of two horses per farm, or 5.3 acres per horse. These figures are believed to be fairly representative for the irrigated parts of Chelan County. Since this information was compiled, however, the item of labor-cost has increased considerably.

Peaches are an important crop among the fruits, though during the last few years a number of the older trees have been removed. This crop is confined principally to the gravelly or sandy alluvial-fan soils near the footslopes of hills or where the dry canyons emerge into the larger valleys. Peach orchards are grown entirely under irrigation and for the most part are given clean cultivation. The fruit comes on the market about the 1st of August and continues to ripen until about the middle of September. The principal varieties grown are Elberta and the Early and Late Crawford.

Pears are becoming important in the area, but are less widely distributed than most of the other fruits. They are confined chiefly to the heavier soils and are usually grown with a cover crop. The fruit begins ripening in July, and marketing continues until well into September, depending on the variety and the method of pruning the

²The Cost of Producing Apples in the Wenatchee Valley, Washington, p. 2. By G. H. Miller, Assistant Agriculturist, and S. M. Thompson, Scientific Assistant.

trees. The leading varieties are Bartlett, Anjou, and Comice, with smaller acreages of Clapp Favorite and Flemish (Flemish Beauty).

Apricots occupy a prominent place among the early fruits, 125 cars having been shipped from the county in 1913. There are no large orchards, most of the plantings being confined to small tracts on the lower slopes and within the larger canyon valleys. Many of the trees are grown without irrigation, clean cultivation being the rule for this crop. The fruit begins ripening about July 10, and is practically all marketed within a period of two weeks. The Moorpark is the leading variety.

Cherries are grown in all parts of the valleys, frequently as border trees around orchards of apples or pears. This fruit is very prolific, yielding an average of 300 to 500 pounds per tree. Marketing begins during the latter part of June, continuing until about the middle of July. The leading varieties are the Bing and Napoleon (Royal Ann), followed by the Lambert and Republican.

Plums and prunes are grown in a limited way, and they occupy an unimportant place among the fruits of the area. The total shipment in 1913 amounted to 35 cars.

Strawberries, blackberries, including the Logan, dewberries, and raspberries thrive in the area under irrigation. The 1910 census gives the total area in berries as 81 acres, with a production of 126,497 quarts. In 1920 the census returns show a decline in acreage to 55 acres. Potatoes and other vegetables are grown principally for home use.

The acreage of corn is increasing, being one of the most important dry-land crops in the county. The largest acreage is on Chelan Butte, south of Chelan. Small patches are also grown under irrigation. The crop is fed principally to work stock and hogs on the farms, although it is beginning to be used for silage in the dairy industry. The 1920 census reports 6,355 acres in corn with a production of 68,180 bushels.

Wheat and other small grains are grown only in a limited way, the largest acreage being on Chelan Butte and in the hills west of Wenatchee. The total acreage according to the 1920 census was 4,425 acres, yielding 40,267 bushels.

Alfalfa occupies a prominent place among the forage crops in the valleys, nearly all of the apple orchards being seeded to this crop. There are also a number of rather large fields devoted exclusively to the production of alfalfa hay. Practically all of the crop is used on the farms for feeding work stock and dairy cattle. Many of the more successful orchardists do not harvest alfalfa in the orchards, but grow it entirely as a cover crop; others make one to three cuttings. When grown alone for hay three cuttings are made. The crop is

grown only under irrigation, or in locations where the underground moisture supply is favorable. (Pl. I, fig. 2.)

With the extension of the alfalfa acreage the interest in dairying began to increase. At the present time there are several dairies of 10 to 20 cows, while near Manson there is a herd of 50 or more cows. Very little of the dairy products, however, is shipped out of the county, the greater part being consumed in Wenatchee and other local towns. Holstein and Jersey are the leading breeds, and recently there have been importations of some excellent breeding stock.

The soils of the Wenatchee area are, in general, fertile. This is especially true of the soils of the Walla Walla series, and applies equally well to those of the Ritzville series, in so far as it concerns their content of the mineral constituents usually regarded as necessary requirements of fertile soils. Under the intensive cultivation to which the soils of this group are being subjected, it is not at all certain that an application of readily soluble phosphorus or potash would not show a response in the crop, but, as soils are usually looked upon, these have a high to good content of lime, potash, and phosphoric acid. Analyses of samples from this area have not yet been completed, but samples from elsewhere in the State, where essentially the same climatic and geological conditions prevail, have shown a lime content of 2 per cent or higher, a potash content of 2 per cent and higher, and a phosphoric acid content of somewhat more than 0.15 per cent. These percentages must be regarded as high. The nitrogen content, however, is low. It will average about 0.07 per cent in the virgin soil, while that in the black soils of the spring-wheat belt will average around 0.25 per cent or higher.

After a few years of cultivation, unless steps are taken to maintain and increase the supply of nitrogen either directly or through the growing of leguminous crops, the best results can not be secured.

Under an intensive system of agriculture, where crops making heavy demands on the soil are grown, the low percentage of nitrogen will manifest itself in one way or another and in time crops will respond to the use of phosphatic manure also, but, under the prevailing system, where no crop is removed from the land but fruit, and where alfalfa is grown among the trees, cut, and left on the land, there seems no reason to suppose that fertilizers will be needed for many years at least.

Unlike many regions with low rainfall, mineral matter in the soils of the Ritzville series is not present in sufficiently large amounts to constitute what is known as alkali. There has been no serious injury brought about by the accumulation of alkali salts in areas of important size. The area is regarded as practically free from it. Certain difficulties have been encountered, however, which seem to be due, at least in part, to the presence in the soil of a very slight excess of

sodium salts, too small to injure the crops directly, but sufficient in amount to cause certain physical changes in the soil which are unfavorable to the accomplishment of the best results. According to Mr. Meikle, county agent of Chelan County, the soil in old orchards, where irrigation has been carried on for several years, where clean culture has been practiced, and where the cultivation has been very shallow, becomes compacted, "run together," or heavier at a few inches beneath the surface to such an extent that irrigating water does not pass through it, or if at all, at a very slow rate. The trees in such cases suffer from lack of moisture, although the amount of water is sufficient.

A study of the soils of the western part of the United States, as well as of all parts of the world where the rainfall is low, shows that a very low percentage of salts, especially of sodium salts, will cause a deflocculation of the surface soil and a transfer, under irrigation, or where subjected to percolating water from any source, of the finer particles of the soil to the subsurface or subsoil, where it accumulates to such an extent, if the action is continued, as to make the downward percolation of water slow or prevent it entirely. In most cases the dense layer forms at shallow depths.

It is not known whether this process has been in operation in the region or not, but the conditions are undoubtedly present in the low rainfall of this zone to favor its operation. It has been suggested that in this region the shallow, frequent, and clean cultivation has caused the formation of a plowpan. It is not at all improbable that there may have been a slight effect produced in this way, but that the result would have been as great as it is in so short a time from this process alone seems improbable. Plowpans are known to have been formed in the older agricultural regions of the United States, but they do not seem to have been developed anywhere to a sufficient thickness and density to prevent or seriously to retard the penetration of moisture. It seems highly probable that the compact layer in the Wenatchee area is due, at least mainly, to the presence of a very small amount of sodium salts. With the low rainfall prevailing, there was not enough moisture under virgin conditions to cause a pronounced development, though the very slight compaction and faint columnar structure of the subsurface horizon of the virgin soil is thought to be due to the action of the process.

There is no known means of preventing the action of this process. The remedy seems to lie in the adoption of methods of farming which will break up the compacted layer. The method that is being recommended by Mr. Meikle, consisting of the growth among the trees of alfalfa, or some other deep and strong rooted crops, is apparently as effective a means of accomplishing the end as any other. This seems to be an effective remedy when combined with deeper plowing

at the times when the alfalfa sod is broken up. This method has the added advantage of providing the soil with the nitrogen that is needed.

Only relatively small areas of the soils in the Walla Walla zone are irrigated or intensively cultivated. They have a higher percentage of nitrogen and a little, if any, lower percentage of the mineral constituents. Even under irrigation they will not require fertilization for some time. It is not known whether the formation of an impenetrable horizon in the subsurface is affecting them or not. If it is, the process should operate somewhat slower than in the soils of the Ritzville zone. Under dry-farming methods in this zone the farmer is confronted with a moisture problem and not a fertility problem. His soil is capable of giving full value, physically and chemically, to his scanty water supply.

In the Methow zone the percentage of readily available elements is somewhat lower than in either of the other zones. These soils approach more nearly than do those of the other zones the character of the humid timberland soils of the eastern part of the United States, where farm manures, careful cultivation, and the use of moderate amounts of chemical fertilizers give good results. It is not probable that the soils of the Wenatchee area have become depleted of their virgin fertility to any considerable extent, but in time the farmers of the Methow zone will find that good methods and moderate fertilization will pay.

The farmers of Chelan County recognize that the Wenatchee loam and the sandy loams of the Wenatchee and Cashmere series are well suited to the production of apples, and that the lighter types are adapted to this fruit only when there is an abundance of irrigation water. The Narcisse coarse sandy loam and the soils of the Quincy series are recognized as being adapted to peaches, but not so well adapted to pears as some of the heavier types, such as the Wenatchee loam. It is recognized that the Ritzville and the Walla Walla very fine sandy loams and the Underwood loam are the best soils for wheat and corn, and that alfalfa thrives on any of the stone-free soils where sufficient water can be supplied for irrigation.

The production and marketing of fruit in Chelan County has become an intensely developed and highly specialized industry. In fact, it may be said to have become two specialized industries, since the business of marketing is in the hands of trained specialists. These may represent individual buyers, or associations of growers formed for the purpose of marketing the fruit. The fruit may be sold for cash within 30 days of delivery at the warehouse, or with the understanding that payment is to be made when the fruit is finally disposed of. In the case of the fruit growers' associations the latter system is the rule. In general it may be said that the growing

of fruit, as practiced in the Wenatchee area, represents a highly scientific form of agriculture.

The dwellings in the irrigated portions of the area are of good size and substantial. Excellent packing and storage houses are being built on the farms, many of them of hollow-tile construction. (Pl. II, fig. 1.) The barns are usually small. The work stock consists of horses of medium weight. There are a few tractors of light weight and a large number of motor trucks which do most of the hauling. The spraying outfit, consisting of a small gasoline engine and a tank mounted on a wagon, is moved through the orchard either by horses or a small tractor. There is a considerable variety and an abundant supply of plows, disks, harrows, and cultivators designed to meet the various needs of the orchardist. The haying machinery is the ordinary two-horse machinery in common use throughout the West. Binders are used for cutting the grain, there being no large fields suitable for the use of combined harvesters.

Since most of the orchards are grown either under clean cultivation (Pl. II, fig. 2) or with an alfalfa cover crop, there is no definite rotation practiced in the irrigated sections. The alfalfa, once seeded, has been left to the present time. In growing wheat, the land is usually summer fallowed and sown again to wheat the following year. In some cases a crop of corn takes the place of summer fallow.

Owing to the nature of the fruit industry, there is a large demand for labor only during the harvest season, which covers less than two months in the fall. While the labor supply has always been scarce, the quality is high. To meet the demand for pickers and packers considerable numbers enter the area from Seattle and other coast cities. Each year an increasing proportion of the work of picking, sorting, and packing is done by women from cities and local towns, while women also assist in the work of thinning. Pruning is usually done in the winter by the farmer himself, but it is generally necessary to hire an additional man for a few days in the spring to help with the spraying. Most of the labor is paid either by the day or by the piece. During the present season (1918) the prices paid were very high. In normal seasons the rates paid for the various operations were as follows³: Pruning, \$3 to \$3.50 per day; packing, \$0.06 per box; packing and sorting, \$0.07 per box; thinning, \$2.50 per day; spraying with man and team, \$1.50 per hour; picking, \$2.50 per day. According to the Federal Census, the total expense for labor in 1909 was \$399,724, or \$453.20 per farm. During the present season the labor expense was nearer double this

³ The Cost of Producing Apples in the Wenatchee Valley, Washington. Office of Farm Management, U. S. Department of Agriculture.

amount, and in 1919, according to the census, it was \$661,784, including an estimated value of \$150,429 for rent and board furnished.

The farms in Chelan County vary widely in size. Throughout the valleys 20 acres of fruit is considered a large farm. Most farms range from 5 to 10 acres, the average being only 11.4 acres. In the uplands the farms range from 160 acres to 500 acres or more in size. The census of 1920 reports 82.1 per cent of the farms operated by owners, a reduction of 8 per cent in the decade. In case of tenanted farms leases usually run one year only. In apple growing the tenant receives one-half the crop and furnishes one-half of the boxes, while the owner usually supplies the team and implements.

The value of farms in Chelan County is unusually high, the census giving the average value of all property on the farm in 1909 as \$15,018 per farm. This represents an average of \$146.64 per acre. Throughout the Wenatchee-Cashmere district the average investment per farm in 1914 was \$20,974, while the average investment per acre of apples alone was \$1,925.⁴ According to the census of 1920 the value is \$17,923. A number of orchards in the vicinity of Wenatchee have changed hands at \$3,000 an acre, although at the present time they can be bought for somewhat less. Unirrigable lands in the upland sections of the county bring \$20 to \$30 an acre.

SOILS.

The Wenatchee area includes an unusually wide range of conditions that influence the character and effectiveness of the processes which convert geological formations into soils. In no other single area previously covered by the soil survey has such a wide range been included. There are very few spots in any country of the world where as wide a range of conditions can be found within so small an area, and it will probably not be possible to find an area within the United States or elsewhere in which the variations will be greater. In traveling from the Columbia River at Malaga or Wenatchee to the highest elevation within the area south of Wenatchee, as wide a range of soil conditions can be met with as may be passed over in traveling from Pueblo, Colo., to St. Louis, and it is possible that the range is as wide as would be experienced in traveling from Pueblo to Duluth, although the soils on the highest elevations were not carefully examined on account of the roughness of the mountain slopes. These mountainous areas were mapped as Rough mountainous land without reference to the character of the soils.

The range of geological conditions within the area is rather wide, but it is no wider than may be found in hundreds of areas of the same size in this country. The variation of geological conditions also

⁴ The Cost of Producing Apples in the Wenatchee Valley, Washington. Office of Farm Management, U. S. Department of Agriculture.

does not run parallel with the variations in fundamental soil conditions. The geologic structure is not systematic, has no uniform relationship to other features, and varies as widely within the area of a group of very closely related soils as within the area covered by the widest range of soil conditions and characteristics. It is a region, in other words, where the geological processes have had very little influence on the course of soil development, and their influence in determining the character of the soil is practically negligible or at least of subordinate importance. Such rocks as basalt have had some perceptible influence in determining the character of the soil because of their high lime content, but the characteristics determined by them are subordinate to the broad general soil features determined by other and stronger soil-making forces; and even the influence of basalt rocks would be less evident were it not for the fact that the soils derived from these rocks are all young and in that stage of their development where inherited characters are still recognizable. Within those soil groups whose differentiation into individuals is based on geological features only, the actual recognizable soil differences are very slight, and had it not been for differences of geological conditions which were supposed to exist no differentiation would have been made. In some of these cases, such as that of the Wenatchee and Cashmere soils, the difference is relatively small, the distinction resting to a large extent upon the difference between a supposed accumulation of the soil material in the former case by deposition in a glacial lake and in the latter by deposition from running water in the form of alluvial fans. In the types of the same texture the difference is very slight. In a similar way the difference between the various members of the Wenatchee series and those of the Peshastin series is not great.

The difference between various soils derived from the same geological formation are much greater than those between the soils mentioned above, which were separated because of differences in the geology of the parent material. The Ritzville very fine sandy loam and the Walla Walla very fine sandy loam are both derived from silty material that is identical in all respects. The soils, however, differ widely. The Ritzville is a brown soil, light in color and low in organic matter. The Walla Walla very fine sandy loam is dark brown in color, becoming almost black locally, with a moderate to rather high content of organic matter, and capable of use with a fair degree of success for dry-farmed grain production. There is always a well-defined and important difference between those soils derived from the same geological material, and in many cases no essential difference between soils derived from different geological material. It is evident, therefore, that the soil-making forces other than geological that have operated in this region have had a more important influence

in determining soil characteristics than have the geological forces and conditions.

All the soils lying east of the west line of R. 19 E. and south of Troy on the Columbia River, except those in the vicinity of Wenatchee lying above the 1,700-foot level, are predominantly light brown in color. This applies to all the well-drained soils within this area. The organic-matter content is low, ranging, as a rule, in the virgin soil, around 1.5 per cent. The texture of soil and subsoil in the virgin soil is nearly uniform throughout the soil profile, except in cases where the differences in this respect at different depths in the parent rock were marked. There has, therefore, been very slight modification of texture through translocation of fine material from the surface to the deeper horizons during soil development.

The structure is not pronounced. The immediate surface of the virgin soil is deflocculated and therefore shows no tendency to a granular structure. The subsurface to a depth of about 8 inches is slightly compact and shows a faint development of a columnar structure. The deeper horizons are usually loose.

The surface horizons of the relatively mature soils do not as a rule have sufficient carbonates to cause effervescence in acids, though they are not deficient in lime, considered agriculturally. The upper subsoil does not usually effervesce. There is no highly developed zone of carbonate accumulation in the subsoil, though enough has accumulated to be visible to the eye and to cause vigorous effervescence. This horizon lies at varying depths, but seemingly never more than 4 feet and usually less. In most areas this zone or horizon is much better developed in soils of this general character than here. The reason for its faint development here is probably due partly to the short time that has elapsed since the material was accumulated and soil development began, and partly to the very low percentage of organic matter in the surface soil.

The soils having the characteristics just described are confined to the lower levels and to the southeastern part of the area covered, and include the types of the Wenatchee, Cashmere, Peshastin, Ephrata, and Quincy series, excepting the brown phases of the Quincy.

Within a few hundred feet above the Columbia River the soils begin to change, at first slightly and not enough to warrant differentiating them from those at lower levels. At a level of about 1,100 feet above Wenatchee, or in the vicinity of Cashmere on the Wenatchee River and above Troy on the Columbia, the difference has become so pronounced that the soils, even where the parent material is the same, must be differentiated from those at lower levels. These changes are most marked in places where relatively smooth areas of land occur, such as that around Wenatchee Heights or on top of Wheeler Hill, or rather the successive stages in these changes

are most noticeable on such areas. Where the land is very hilly the evidence is not so clear on account of the rapid erosion which removes the soil material so fast that maturity of soil development is not attained. The soil is kept in a perpetually young condition and shows the characteristics of the parent formation much more markedly than on smoother areas where erosion is less active.

The soils on Wenatchee Heights present fairly well the characteristics of the mature soils of this zone. They have a strong brown color, often ranging to a darkish brown, and the content of organic matter ranges between 2 and 3 per cent, though usually nearer 2 than 3.

The texture varies from place to place, but vertically in any single locality the changes are not marked. There is a tendency for the fine material to be carried from the soil to the subsoil, making the latter heavier than the former, but it has not produced marked differences between the two horizons.

The structure of the surface and subsurface is markedly more granular here than in the soils at lower elevations. In other respects the structure is a good deal like that of the lower lying soils. There is a slight compaction and a rather well defined columnar structure in the subsurface of the virgin soil.

The surface and subsurface horizons do not effervesce in acid, but a rather well-marked zone of carbonate accumulation lies from 15 to 40 inches beneath the surface, being best developed where the soil is most mature.

These soils are being used for grain growing without irrigation, and fair results are being obtained. The successful production of apples on them requires irrigation. The most important members of this group of soils are the Walla Walla very fine sandy loam and the various types of the Waha series. The Lick, Narcisse, and Leavenworth soils and the Quincy fine sandy loam, brown phase, belong in this group, but are very close to the boundary between these soils and those of the next group to be described and do not conform to the Walla Walla group in all respects, the zone of carbonate accumulation lying deeper or being absent entirely.

In small areas around the upper limit of the zone of Walla Walla and related soils, in spots where there has been slight accumulation of soil material in recent times and where the moisture supply is somewhat higher than in the main part of the belt, the soil is darker, becoming almost black in places, and shows very faint or even no development of a carbonate horizon. The carbonate horizon may be said to occur sporadically. In most places these areas have been invaded by an open stand of western yellow pine. They were not separated from the Walla Walla soils on account of the relatively small difference from the latter as well as the small areas of occurrence.

A third zone occupies the higher slopes and mountain tops of the whole area as well as all elevations west of the western line of R. 19 E., and north of Chelan. This is the zone in which the soils were developed under the influence of a moderately heavy rainfall. They are all light in color, notwithstanding the fact that a considerable amount of organic material was dropped on them when in the virgin condition. The zone of compaction and columnar structure, more or less well developed in the subsurface of the soils of the two zones previously described, as well as the zone of carbonate accumulation, are absent. A profile includes, in the virgin soil, a thin horizon, usually not more than 3 inches and often less, of dark-colored material containing 4 or 5 per cent or often more of organic matter, underlain by a horizon of brown to yellowish-brown material with a low percentage of organic matter, extending to a depth ranging from 6 to 10 inches. A third horizon of brown slightly heavier material extends down to a depth ranging from 2 to 3 feet. Beneath this lies the unchanged or slightly oxidized parent material, consolidated or unconsolidated, as the case may be. The surface and subsurface horizons may have a coarse granular structure before they have been cultivated, but this disappears soon after cultivation begins unless it be maintained by the use of manure. A large part of this zone is made up of steep mountain slopes or stony areas in which no soil or only a very thin film is present, and is shown on the soil map accompanying this report as Rough mountainous land and Scabland. It is only on the relatively smooth areas that soils whose characteristics fit those just described have been developed.

The more important soils of this zone are the Waha loam and Waha clay, and the various members of the Springdale, Methow, Cashmere, and Huckleberry series. The Lick, Narcisse, and Leavenworth soils are similar to these soils in some respects and mark the transition from the Walla Walla zone to the Methow zone, as this may be designated.

In a few areas within the region soils developed under somewhat imperfect drainage conditions occur. They are dark in color and have imperfectly oxidized and aerated subsoils.

The soils of the Wenatchee area, as described and identified above, are arranged therefore, in three vertical zones, the boundary lines between them being highest in the southeastern part of the area and from thence slope northwestward. The line between the Wenatchee and Walla Walla zones lies at about 1,700 feet on the slopes of Wheeler Hill, about 1,000 feet in the vicinity of Cashmere, and about 700 feet on the Columbia River north of Wenatchee. That between the Walla Walla and Methow zones lies at about 3,000 feet on top of Wheeler Hill, at 1,100 feet where it crosses the valley

of the Wenatchee River, and about 900 feet where it crosses the Columbia.

Since the geological formations do not have this vertical zonation, it is evident that it can not be ascribed to geological causes. There are no accurate data available to show the distribution in detail of the climatic conditions, but it is well known that the rainfall increases with elevation. The imperfect and incomplete records available show this with sufficient clearness. The rainfall at Wenatchee is 6.93 inches; at an elevation of 2,200 feet, 1,460 feet higher than Wenatchee and a short distance south, it is 11.10 inches; at Blewett⁵ at an elevation of 2,200 feet but in the western part of the area it is about 15 inches, while at Lakeside on Lake Chelan at 1,100 feet elevation it is not far from 14 inches. At Waterville, about 20 miles south of Lakeside, the precipitation is about 12 inches notwithstanding the fact that the former village lies more than 1,000 feet higher than Lakeside. It is evident, therefore, that the rainfall increases with elevation at any one point and westward along the same parallel of latitude. This distribution corresponds to the position and "lie" of the zones of general soil characteristics, and this correspondence constitutes presumptive evidence in favor of the theory that the development of soil characteristics is controlled largely by the amount of the precipitation. The differences in temperature at the different elevations and in the various soil zones are factors of some importance, but on the basis of comparison with other regions they seem to be important mainly in so far as they influence the soil moisture through evaporation.

The Bureau of Soils does not base its soil classification entirely on the soil characteristics described above—characteristics that may be described as those of the soil profile. These are used for the broader differentiation into belts containing soils with similar characteristics. Such a differentiation is not based on the geology of the soil material, since in most, if not all, parts of the world the distribution of geological features is not so systematic as the soil features are known to be. The features of the soil profile are uniform in the mature soil within each soil belt, regardless of the distribution and character, the simplicity, or complexity of the geological features. Within each soil belt, however, the soils are classified on the basis of texture, degree of maturity attained, and the geology of the soil material. Such a classification recognizes the value of the geology of the soil material in the determination of soil features, but its importance is now recognized universally as subordinate to climatic influences. In many cases within a given soil zone no differences can be found to exist between those developed from different

⁵ This place is outside the area, southwest of Camas Land.

geological formations when differences such as texture and degree of maturity are eliminated from the comparison. Even in such cases, however, the differentiation on this basis is still carried out in the work of the bureau. In the following pages the soils are discussed with reference to the geology of the material from which they were derived.

The Wenatchee area includes a part of the Columbia Valley and a number of high mountain spurs, with intervening glacial and stream valleys on the east side of the Cascade Range. Parts of the valley and lower plateau surfaces are associated with the geologic and topographic province known as the Great Plains of the Columbia, which covers a part of the extensive soil province known as the Northwest Intermountain Region. In relation to soil classification, the mountains and most of the intermountain valleys are most closely identified with the Rocky Mountain Soil Region. Ranging between elevations of 600 and 6,500 feet above sea level, the area presents a wide variation in the character of its rocks. Because of this diversity in soil-forming materials and in such materials transported from outside sources, together with the various climatic and other agencies operative in soil formation, the area contains a number of soil groups which differ from each other in one or more of several important respects.

On the basis of their mode of formation, the soils of the area may be included in two general groups—(1) residual soils, or those formed in place through the weathering and disintegration of the underlying consolidated rocks, and (2) transported soils—the materials of which have been moved from their place of formation and redeposited through the agency of winds, ice, or water.

The residual soils are derived from two distinct classes of rocks, igneous rocks and sedimentary rocks.

The igneous rocks are also separated into two groups, which, however, sometimes merge. These consist of basic igneous rocks or those of low quartz content, and acid igneous rocks or those of high quartz content. The basic igneous rocks are represented in this area by basalt, a dark-colored, fine-grained, and geologically recent volcanic, occupying the foothills, plateau surfaces, and high mountain slopes in the southern part of the survey. In weathering it gives rise to soils of the Underwood and the Waha series. The acid igneous rocks consist of granite, gneiss, and schist. They are usually light colored, though the gneiss and schist are frequently brownish. They occupy a large proportion of the hills in the area. Granite is the most common, being especially well developed in the vicinity of Leavenworth. Gneisses and schists are widely scattered, but are especially prominent near Wenatchee and are mixed with

granite along the upper Columbia Valley. The weathering in place of this class of rocks gives rise to the Methow series of soils.

The sedimentary rocks consist of sandstone and local unimportant areas of shale. The sandstone areas are confined to rugged hills southwest and west of Wenatchee and to few points along the upper Wenatchee Valley. This rock usually occupies a lower horizon than either the basalt or granite. It weathers into the soils of the Huckleberry series.

The soils derived from transported materials fall into three natural groups, (1) wind-laid, (2) ice-laid, and (3) water-laid.

For clearness and convenience in soil classification the wind-laid or eolian soils may be considered as (*a*) wind-blown in formation, and (*b*) wind-borne or loessial in origin. The wind-blown soils are derived from near-by sources and are still being reworked and deposited to some extent by wind action. The material is transported mainly by being rolled or blown along, over, or near the surface. Soils of this kind occur mostly on the terraces along the Columbia River, and it is probable that the material is derived mainly from exposed sandy deposits first laid down by this stream. They are characteristically unweathered, and have a uniform profile and a hummocky or dunelike topography. They are classed in the Quincy series. The wind-borne or loessial soils appear to have been derived from deposition of fine materials borne by winds and transported to their present position from sources more remote. The soils are much more uniform or homogeneous in physical character than those of wind-blown origin, and have, in localities of the higher rainfall, been somewhat weathered in place and leached of lime. They occupy smooth hill slopes in the southern part of the survey and on the south side of Chelan Butte. These deposits give rise to the Walla Walla and the Ritzville series of soils.

The ice-laid soils occupy terraces and lower slopes along the Wenatchee and Antwine Valleys and the basin of Lake Chelan. These soils are derived from unassorted materials, including ice-worn boulders and great massive blocks of granite, schist, and gneiss, which were deposited by glaciers that moved down these valleys from the heights of the Cascade Range. Emerging from the Wenatchee Valley, the glacier occupying this valley moved on a few miles down the Columbia, leaving thick deposits of excessively stony material which is especially notable on the lower terraces at Wenatchee. The Chelan Basin, occupied by glacial débris to a height of 1,000 feet above the present level of the lake, was completely dammed by these deposits, causing the river draining the basin to leave its former course and cut a deep gorge through granite and gneiss. In places small glacial lakes were formed, and deposits of undoubted lacustrine origin are occasionally exposed by deep cuts, though they can rarely

be traced to the surface. The soils derived from ice-laid material are represented in the area by the Lick and the Peshastin series.

On the basis of age, topographic position, and mode of formation, the water-laid soils may be divided into three general groups—(a) soils derived from valley-filling deposits consisting of materials that have undergone marked changes through weathering in place since their deposition; (b) soils derived from recent alluvial fans; and (c) soils derived from recent alluvial deposits along the rivers.

The soils of the first group are confined principally to terraces along the Columbia and Wenatchee Rivers, although small bodies occur along Icicle Creek and the Entiat River. Evidence of age is apparent in all of the deposits, while in one series of the group the fine material of the surface soil has been carried down into the sub-soil forming a compact layer which is usually a characteristic of old valley-filling soils. In this area the materials giving rise to soils of this group are derived almost entirely from granite, schist, and gneiss. The group is represented by four series, the Springdale, Wenatchee, Ephrata, and Malaga.

The soils of the second group, occupying recent alluvial fans, are widely distributed in the area, although confined to rather small bodies. In addition to fan-shaped areas at the mouths of canyons, they occupy the narrow floors of intermittent stream valleys and gentle slopes at the foot of hills. The soil materials are derived from a variety of rocks, including granite, schist, and gneiss, and locally basalt. The recent alluvial fan soils fall into three series, the Cashmere, Narcisse, and Leavenworth.

The soils of the third group occupying the recent alluvial stream bottoms are not extensive in this area, being confined to narrow strips along the larger streams. The materials giving these soils come from a variety of rocks, among which granite is important. Small areas are sometimes flooded, but in general these soils lie above overflow. The soils are grouped in the Beverly and the Pasco series.

On the basis of color, origin, topography, and structural characteristics, the soils of the Wenatchee area are classified into soil series. The series are divided into types on the basis of texture. There are in all 18 series comprising 30 types and 11 phases, and in addition 4 miscellaneous types, mainly nonagricultural, shown on the map as Riverwash, Rough broken and stony land, Rough mountainous land, and Scabland.

The Underwood series includes types with brown to somewhat reddish, or rusty-brown surface soils and a brown to yellowish-brown, compact, heavier textured subsoil. The series is derived from basalt, boulders or fragments of which occur in the surface soil and sub-

soil. Basaltic bedrock underlies the types at variable depths. In the Wenatchee area the surface soil is rather dark brown in places, and the loam undoubtedly includes an admixture of material of wind-borne origin. The series is confined to the mountains and higher hills in the southern part of the area, where the surface consists of broad, smooth plateaus, narrow divides, and gently sloping hillsides. The greater part of the series has good surface drainage. The native vegetation consists mainly of yellow pine in the more elevated areas, with some sagebrush and bunch grass on the lower slopes. The series is differentiated from the Waha series of similar origin by its lighter and more reddish brown color and from the other residual soils of the region by its darker color and its derivation from basalt.

The surface soils of the types in the Waha series are very dark brown or dark brownish gray to black in color, though containing small to moderate quantities of organic matter. The subsoil is brown or dark brown to nearly black in color, and usually slightly heavier and more compact than the surface soil. Locally the subsoil may be mildly calcareous, but this is not characteristic, the material typically being well leached of lime. The series is residual from basalt or similar volcanic or basic igneous rocks, and is underlain by bedrock at relatively shallow depths, ledges outcropping in places. The soils occupy undulating upland plains and hill and mountain slopes, and are usually treeless or support a sparse growth of yellow pine and shrubs. Drainage is generally well developed, but some shallow, undrained depressions occur. In the present survey much of the material included with this series is of somewhat lighter brown color than typical and some parts doubtless have been modified by an admixture of loessial material. In color and other characteristics, also, the material in places resembles in some degree that giving the higher lying forested soils of the Underwood series with which it merges. The native vegetation is mainly bunch grass and sagebrush, but may locally consist of a scattered growth of yellow pine and brush.

The Methow series comprises types with gray to light-gray surface soils, deficient in humus, and a gray to slightly yellowish gray subsoil. Bedrock, granite, schist or gneiss, commonly lies at depths between 4 and 6 feet. The soils are residual in origin and in this area are derived mainly from granite and similar crystalline rocks. The series occupies upland positions and has a nearly level to rough hilly surface. Drainage is well established. The series is extensive in the northern part of the area. The greater part of it is forested with yellow pine and young fir. It was developed under moderate rainfall and is well leached and noncalcareous. As mapped in this survey the series includes some areas resembling soils of the Moscow series,

which is similar in origin but somewhat darker and more pronounced brown in color.

The surface soils of the types in the Huckleberry series are light grayish brown to rather dark grayish brown when dry, becoming brown when wet. They are low in organic matter and inclined to be loose and porous. The subsoil is light yellowish brown, yellow, or dull yellow, and normally slightly heavier and more compact than the surface soils. The depth varies considerably, but usually at 3 to 5 feet partly disintegrated rock is encountered. On the steeper areas rock outcrop is not uncommon, but loose gravel and boulders are rare. The soils are residual from sandstone, shale, or other sedimentary rocks. They are generally well leached and noncalcareous. They occupy hilly sections ranging from fairly smooth to steep. Drainage is well established and in places excessive. Lower lying areas support a growth of grasses; higher areas are covered with yellow pine.

The Quincy series includes types with brown to yellowish-brown or light grayish brown friable surface soils, low in organic matter, and a light-brown to light grayish brown friable subsoil of similar texture and structure. Typically the total depth of the soil is 6 feet or more, but in the present survey shallow areas occur, bedrock lying within 1 or 2 feet of the surface. Rock outcrops are locally encountered, but gravel or rock fragments are usually not found in any part of the soil profile. The soils are wind-blown in origin, the materials coming mainly from adjacent stream-laid deposits. These rest upon bedrock or in some places upon unconsolidated old river-laid deposits. The topography is somewhat choppy or billowy to very gently undulating and smooth. The subsoil is generally distinctly calcareous and the surface soil is calcareous in places. The series is fairly extensive on the smooth terraces along the Columbia River. Drainage is well established. The native vegetation is sagebrush.

The Walla Walla series comprises types with grayish-brown to dark grayish brown or dull-brown surface soils, underlain by a somewhat lighter brown to yellowish-brown subsoil slightly more compact than the soil. The soils generally have a moderate content of organic matter, and are free from lime. The deeper subsoil, however, may contain lime, which in many places is present in sufficient quantities to give rise to grayish mottlings and concentrations. In the areas of deep accumulations the substratum is a brown to light yellowish brown or dull-yellow, homogeneous, fine-textured, unstratified material extending to bedrock, but in this survey the soil material is rather thin. In the southern part basalt occurs at depths ranging from 18 inches to 6 feet. In other parts of the survey the series is underlain at variable depths by granite, schist, and gneiss

and here the lower subsoil may be modified in places by admixture of residual material. Such areas are less typical than those underlain by basalt. The soils of this series are derived from loessial or wind-borne materials. They are distinguished from the wind-blown soils of the Quincy series by having a more elevated position, more rugged topography, a firmer surface, and darker colored, noncalcareous surface soils. They are differentiated from the Ritzville series of similar origin by the darker color of the surface soils and their position at higher levels under less arid conditions. In this area the Walla Walla lies from 2,000 to 3,500 feet above sea level. The topography varies from smooth, level, and gently sloping to steep and broken. Drainage is good to excessive, although the soils absorb moisture readily and little damage is caused by erosion.

The surface soils of the types included in the Ritzville series are light brown to light grayish brown, sometimes slightly yellowish brown, and low in organic matter. The subsoil is somewhat lighter brown or grayish or pale yellowish. The substratum consists of light grayish brown to yellowish homogeneous and unstratified material. The surface soils are usually fairly well leached of lime; the subsoil, however, at a depth of 12 to 36 inches generally contains marked accumulations of lime. The series is derived from slightly leached and weathered wind-borne or loessial deposits similar to those giving rise to the Walla Walla series. In this survey the material is thin in places and in some of these the subsoil has been modified by admixture of residual materials derived from the underlying rocks. The soils occupy hill slopes, terracelike areas, local upland flats, and dissected plateau surfaces. Drainage is good to excessive.

The surface soils of the types included in the Lick series, as mapped in previous surveys, are light grayish brown or light brown to brown. The subsoil is light brown or yellowish brown to pale yellowish, or in places slightly reddish brown where the color has been modified by admixture of residual materials from granite and gneiss. The subsoil tends to be slightly more compact and in many places somewhat heavier than the surface soil. The series is derived from old glacial deposits, mainly from granite, gneiss, and other acidic crystalline rocks. The areas have an undulating to rolling or hilly topography. Drainage is usually well developed, though undrained depressions may occur locally.

In the present survey much of the material mapped as Lick is somewhat grayer in color than typical. The lighter textured gravelly sand type also departs from the typical series description in having a porous gravelly subsoil grading into deep deposits of porous and somewhat irregularly stratified beds of boulders, gravel, and sand, the coarser materials being waterworn. This gravelly type

represents glacial outwash and old stream-terrace deposits that differ from the Ephrata series mainly in the noncalcareous character of the subsoil.

The soils of the Lick series are closely associated with the related Peshastin soils, which occur at somewhat lower elevations and in localities of lower rainfall. The surface and subsoil materials are usually well leached and free from accumulation of lime. The types occupy smooth benches, undulating to rolling areas, and gently to steeply sloping foothills. The native vegetation is mainly sagebrush, with scattering yellow pine, in the upper Wenatchee Valley. This series is quite extensive in the area surveyed, occurring on the slopes along Lake Chelan (Pl. III, fig. 1), in the northeastern part of the area, and along both sides of the Wenatchee River from Peshastin to Leavenworth.

The Peshastin series includes types with grayish-brown to brown soils and light-brown or yellowish-brown to pale-yellow subsoils, tending to be compact and gritty. Large glacial boulders are common throughout the soil and subsoil and in places the surface is almost completely covered with ice-laid boulders from a few feet to 20 feet or more in diameter. The soils apparently are mainly ice-laid, the materials coming principally from granite, with admixtures from gneiss and schist important locally. As mapped in this area some terrace material is included. This is irregularly stratified and has probably been deposited as glacial outwash or other stream-laid sediments. In places the underlying boulders have been weathered to such an extent that the subsoil might be considered largely residual from these materials. The soils occupy smooth terraces and gently sloping or rolling foothills. They are well drained and where not too stony are retentive of moisture. The areas typically support a growth of sagebrush, but a scattering growth of yellow pine may occur locally on higher lying areas adjacent to the more elevated forested soils of the Lick series into which the Peshastin soils grade. The soils of this series are differentiated from those of the Lick series by their occurrence under semiarid to desert conditions, with consequent loss through leaching of lime and other soluble materials. The surface soils frequently effervesce slightly with dilute acid, and the subsoil is usually mildly to distinctly calcareous.

The surface soils of the types included in the Springdale series are light brown to light grayish brown to brown and have a low to moderate content of organic matter. The subsoil is light brown to slightly reddish brown, and in most places somewhat heavier or more compact than the soils. The substratum is weathered and moderately heavy to heavy in texture. Ordinarily it is compact, though in places it is less compact than the subsoil. Both the soil and subsoil

are leached and free from lime. The subsoil and substratum are in places mottled with gray and brown stains, the result of retarded subdrainage. The series is derived from old valley-filling deposits consisting mainly of glacial lake and river terrace materials, probably laid down mainly in temporary glacial lakes or in ponded stream waters, though some undifferentiated stream-laid or ice-laid materials may be included. The soils occupy undulating areas on old and more or less elevated terraces. The surface is generally smooth, but some areas are more or less eroded. Surface drainage is well developed, but subdrainage in places is restricted. The soils are retentive of moisture. They are developed typically under humid to subhumid conditions and are usually forested with yellow pine, fir, and other forest growths. As mapped in this survey, the series includes inextensive and relatively unimportant areas of soils which, unlike the typical Springdale materials, are underlain by porous stream-laid sands and gravels, and which probably represent glacial outwash deposits resembling in physical character of subsoils and substrata the materials of the Ephrata series.

The Wenatchee series comprises types with brown, or in dry field surfaces grayish-brown soils. The subsoil is characterized by light-brown or brownish-yellow to yellowish-brown, compact, heavy-textured material overlying yellowish-brown, mellow and more friable deposits extending to a depth of 6 feet or more. In the heavier types the upper subsoil is somewhat impervious to water and roots, although it is never cemented or consolidated into hardpan. The soils are deficient in humus. Usually they carry no gravel or stones, but thin lenses or strata may occur locally. The series is derived from thoroughly weathered old valley-filling deposits having their origin mainly in granite, schist, and gneiss. It is probable that the materials giving rise to these soils include deposits that have been laid down by various agencies, such as ice, glacial lakes, streams, and winds, though it would appear that they have been deposited mainly in glacial lakes. The types occupy smooth terraces with fairly good surface drainage, but with underdrainage somewhat restricted by the compact subsoil. This is one of the most important series in the area surveyed. It is distinguished from the related Springdale series of similar origin and mode of formation by the slightly darker color of the soil, its occurrence under conditions of low rainfall, the moderately calcareous character of the soil, and uniformly calcareous subsoil. The native vegetation consists of sagebrush.

Included with this series in the present survey are small areas of soil mapped as a residual phase of the Wenatchee sandy loam. This material is not properly correlated with this series and represents areas of low-lying and generally treeless semiarid or desert soil

similar in color and occurrence to the Wenatchee soils, but derived through the weathering in place of sandstones and shales. If of greater extent and importance these areas would have been mapped as a distinct series.

The types included in the Ephrata series are characterized by brown to light grayish brown soils, and a light-brown or grayish-brown subsoil. Waterworn gravel may or may not occur in the surface material, but is nearly always present in the deeper subsoil, while the substratum consists of a mass of waterworn boulders and gravel embedded in porous sand. Typically the coarse material of the substratum is mainly basalt, but in the Wenatchee area it is composed principally of crystalline rocks, while the coarse sandy material is derived from both basalt and light-colored acidic rocks. The subsoil is usually calcareous. Lime-coated boulders are found here and there in the underlying deposits, but they are much less common in this area than in the desert region to the east. The series is derived from glacial outwash and other old materials deposited by swiftly flowing streams. It occupies terraces of smooth topography and well developed drainage. The series is treeless, supporting only a scanty growth of sagebrush and other desert plants.

The types in the Malaga series have reddish-brown to dull-red surface soils and a brown to reddish-brown subsoil. Both soil and subsoil in many places contain waterworn gravel and cobblestones, the quantity increasing in the substratum. The gravel consists principally of crystalline rock. The soils are derived from old materials deposited by swiftly flowing streams. The reddish color indicates that the soils have undergone considerable weathering and oxidation; but there is little or no concentration of fine material in the subsoil. Owing to advanced age and stage of weathering, however, the surface and subsoil materials are well leached and usually free from accumulations of lime. The soils are closely associated with both the Ephrata and Peshastin series. They are differentiated from the former by their reddish color and from the latter by differences in color, origin, and character of substratum. The series occupies smooth, well-drained terraces 50 to 200 feet above the Columbia River. It occurs under semiarid or desert conditions. The native vegetation consists of sagebrush. As mapped in this survey the series includes areas of rather neutral brown color, and not as well oxidized as the typical soils of the series. Such areas represent a gradation toward the material of the Ephrata series, though usually more fully weathered and leached and lacking the lime accumulations normally occurring in the Ephrata.

The Cashmere series comprises types with brown to dull-brown or grayish-brown soils underlain by a lighter brown or grayish gritty

subsoil. The lighter textured soils generally have lighter brown or a more grayish brown color than the heavier soils. The subsoil is in many places slightly more compact than the soil, but it may include stratified alluvial deposits of variable texture. Typically, the soils occupy alluvial fans, but they also lie on alluvial slopes along the base of hills and in narrow, filled-in valleys. The higher fans are steep and the material is poorly assorted. Much of the material has been modified by weathering since its deposition. The materials come mainly from granite, schist, and gneiss, but a few local areas from sandstone. The surface is smooth, with slopes sufficient to insure good drainage. The series is developed mainly in regions of low rainfall. The material has been transported from areas of heavier rainfall, but having been deposited in comparatively recent time, has not yet been modified by desert conditions. This is an instance of noncalcareous material occurring in semiarid or desert areas but retaining the characteristics of freshly deposited alluvium in humid areas. The native vegetation consists of sagebrush. As mapped in this survey this series includes small areas of poorly assorted stony material derived mainly from basaltic rocks. The finer soil material is calcareous. These areas are of little agricultural importance. If they were more extensive the materials of this character, which were mapped as the stony loam type of the Cashmere series, would have been mapped as representing a distinct series of recent alluvial fan soils of basaltic origin and developed under desert conditions.

The Narcisse series includes types with gray to dark-gray soils and a similar colored or slightly lighter gray subsoil. The series is derived mainly from granitic materials accumulated as recent alluvial fan deposits. It is normally free from boulders and generally extends to the depth of 6 or more feet without marked change. The soils of this series have a gently sloping topography and a smooth uniform surface with good natural drainage except where occurring locally in narrow valleys or other low-lying areas. Some of the areas marginal to Lake Chelan are flooded during a part of the year, and here poor subdrainage has brought about an accumulation of alkali salts. The soils of this series, as mapped in previous surveys, occur under humid conditions and are forested. In this survey, however, they occur under conditions of limited rainfall and in their native condition they are usually treeless, the vegetation consisting of sagebrush. In some cases the soil and subsoil are mildly calcareous, but typically the carbonates have been leached out.

The surface soils of the types in the Leavenworth series are dark grayish brown to black in color, the latter when moist. The subsoil is ordinarily similar to the surface soil in color and texture, but in some places may consist of stratified or poorly assorted alluvial

deposits of variable texture. The soil is high in organic matter. The series is formed of materials accumulated as recent alluvial deposits on fans and in small areas of bottom land along intermittent streams. The material is derived mainly from granite or other quartz-bearing crystalline rocks. Drainage is well established over the more elevated and steeper areas, but is deficient where the surface is flatter and the soils heavy. The soils occur in regions of moderate rainfall and are noncalcareous. They hold moisture well. The vegetation consists of brushy and open forest growths. The series is related to the Narcisse series, from which it is distinguished by its darker color.

The types in the Beverly series have light-brown to light grayish brown surface soils and a light-brown or light grayish brown subsoil, porous in structure and typically containing a large quantity of crystalline gravel. The substratum, to many feet in depth, is a porous bed of waterworn gravel and boulders embedded in sand. The soils, which are of recent alluvial origin, occupy low terraces and first bottoms along the larger streams, the bottoms sometimes being overflowed. The surface is usually smooth, but in places hummocky. Owing to the porous substratum drainage is excessive. The native vegetation is mainly sagebrush, with willow and cottonwood on the lower lying areas.

The Pasco series includes types of recent alluvial origin. The soils are dark grayish brown to dark brownish gray and overlie similar material extending to a depth of 6 feet or more. Gravel is not usually present in either the surface soil or subsoil, but coarse gravel, derived from crystalline rocks, may occur in the substratum. The types occupy first bottoms and low stream terraces. The surface varies from nearly level to gently undulating with low rounded swells and intervening hollows. The bottoms are flooded annually for short periods. The drainage is sufficient except during high water. Alkali is sometimes present in small quantities. The soils originally supported a dense growth of sagebrush and grasses. They are distinguished from the Beverly soils by their darker and grayer color and the absence of a porous gravel stratum within the 6-foot section.

The following table gives the names and the actual and relative extent of the various soil types of the Wenatchee area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Rough broken and stony land	218, 112	58. 8	Lick sandy loam	2, 688	0. 7
Methow coarse sandy loam	15, 296	} 7. 1	Peshastin stony fine sandy loam	2, 560	. 7
Heavy phase	11, 200		Wenatchee fine sandy loam	2, 560	. 7
Rough mountainous land	19, 968	5. 4	Scabland	2, 560	. 7
Lick coarse sandy loam	11, 584	} 3. 4	Cashmere fine sandy loam	2, 176	. 6
Stony phase	1, 280		Malaga stony fine sandy loam	1, 728	. 5
Walla Walla very fine sandy loam	7, 680	2. 1	Wenatchee loam	1, 344	} . 5
Waha loam	7, 424	2. 0	Heavy phase	256	
Cashmere sandy loam	7, 424	2. 0	Quincy fine sandy loam	256	} . 4
Lick stony fine sandy loam	6, 464	1. 7	Brown phase	1, 152	
Ritzville very fine sandy loam	6, 272	1. 7	Leavenworth fine sandy loam	1, 344	. 4
Underwood loam	5, 568	1. 5	Wenatchee sandy loam, residual phase	1, 344	. 4
Cashmere gravelly coarse sandy loam	4, 416	1. 2	Springdale fine sandy loam	1, 280	. 3
Quincy fine sand	2, 624	} 1. 2	Riverwash	1, 024	. 3
Brown phase	1, 728		Springdale loam	1, 024	. 3
Huckleberry fine sandy loam	3, 648	1. 0	Cashmere stony loam	896	. 2
Narcisse coarse sandy loam	3, 008	} . 9	Leavenworth sandy loam	896	. 2
Heavy phase	448		Waha clay	704	. 2
Lick fine sandy loam	3, 392	. 9	Cashmere loamy sand	640	. 2
Beverly sand	1, 664	} . 8	Pasco very fine sandy loam	256	} . 2
Gravelly phase	832		Heavy phase	256	
Heavy phase	768				
Ephrata fine sandy loam	2, 624	} . 8			
Steep coarse-textured phase	192				
			Total	370, 560	-----

UNDERWOOD LOAM.

The Underwood loam, to a depth of about 12 inches, is a brown to somewhat reddish brown, moderately compact loam, fairly well supplied with organic matter. The subsoil consists of a brownish-yellow or yellowish-brown or light-brown fairly compact fine sandy loam to silty clay loam and rests on basaltic bedrock at depths varying from 2 to 6 feet. In some places boulders of this rock, ranging in size from 1 foot to several feet in diameter, are scattered over the surface and through the soil mass, and rock outcrop is common in the higher areas. In places the surface soil material contains a relatively large proportion of fine and very fine sand and approaches a fine sandy loam in texture.

Areas of this soil occur in the higher basalt plateau and the hilly region formed by the northeastern slopes of the Wenatchee Mountains south of Wenatchee. Other small bodies lie southwest of Wenatchee in the vicinity of Martins Ranch. The more stony areas, which are indicated upon the map by symbol, occur mainly along steep escarpments and in the vicinity of Lily Lake and Clear Lake.

Typically, this soil type is residual from basalt, but it is probable that in parts of the areas there has been an admixture of some loessial

or wind-borne material. The type in the Wenatchee area occurs mainly at elevations between 3,200 and 4,000 feet above sea level.

The topography ranges from mountainous or hilly, with steep slopes, to long smooth ridges and slopes. Topographically, the greater part of the type is suitable for cultivation, although some of the higher areas are rather steep. The soil has good natural drainage and is retentive of moisture. Owing to its greater elevation, it receives more rainfall than the valley soils. In places the steeper areas are somewhat eroded, but in general there is but little run-off, the soil absorbing most of the rainfall.

The higher areas are forested with yellow pine and mostly un-cleared. Some of the less elevated areas are treeless or support only a scattering growth of timber and brush. The untilled areas afford good grazing. Small areas are utilized for dry-farmed wheat. The type is remote from shipping points, can be reached only by steep and rough roads, and is of comparatively little importance.

WAHA LOAM.

The surface soil of the Waha loam is a dark-brown, dark grayish brown, or dull-brown loam, containing a relatively high proportion of fine and very fine sand and silt. It has a moderately compact but friable structure and a low to moderate supply of organic matter and is easily maintained in good physical condition. In places it contains subangular boulders or fragments of basaltic rock. The subsoil is medium brown to yellowish brown in color, contains some rock fragments, and tends to be somewhat more compact in structure than the surface soil. The subsoil is mildly calcareous in spots, but usually both soil and subsoil are well leached. The bedrock of basalt lies in most places at depths of 2 to 6 feet, but may locally occur at greater depths or may outcrop, especially where the type is associated with other shallow and more stony soils.

The Waha loam in this survey occupies areas on the lower slopes, ridges, and flats in the region south of Wenatchee and Monitor. Typically it is of residual origin from basalt, but it is probable that in parts of the areas on Wheeler Hill and southeast of Monitor the surface material has been modified somewhat by an admixture of loessial material. The type generally occurs at elevations below 3,200 feet. The topography ranges from smooth and undulating or nearly flat to steep and rolling. Some of the slopes are rather steep for cultivation, but the surface of most of the areas is favorable for cultivation. Drainage is well developed, and the soil is retentive of moisture. It receives somewhat less rainfall than the Underwood loam, which occupies the higher elevations and into which it merges. It is generally treeless, the native vegetation consisting mainly of sagebrush and grasses.

A considerable acreage of the Waha loam is devoted to dry-farmed wheat, and lesser areas are in corn, potatoes, and other sustenance crops. Wheat is primarily a cash crop, but fields that promise a poor yield of grain are usually cut for hay. Wheat yields 10 to 20 bushels, corn 15 to 25 bushels, and potatoes 100 to 150 bushels per acre. About 400 acres of this type on Wheeler Hill is under irrigation and used for the production of fruit. (Pl. III, fig. 2.) The principal fruit crop is apples, followed by cherries and pears. Alfalfa is grown and harvested in practically all of the orchards. Owing to the higher elevation, the seasons are somewhat shorter than in the Columbia Valley, and the yields of fruit are said to be a little lower than those obtained from the better valley soils. The treatment of orchards on this type is similar to that given orchards on the Wenatchee loam.

The Waha loam in bearing orchards has a high valuation. The rest of the type can be bought for \$20 to \$40 an acre.

This type of soil has proved productive both with and without irrigation. There are still undeveloped areas extending back into the highlands that are suitable for wheat growing. Owing to the elevation, however, the type is unfavorably situated with respect to roads and shipping points.

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

Mechanical analyses of Waha 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.	<i>Per cent.</i>
551407.....	Soil.....	0.0	0.8	2.3	19.6	29.1	38.1	10.0
551408.....	Subsoil.....	.0	.8	1.0	13.2	31.0	44.2	9.8

WAHA CLAY.

The Waha clay as mapped in this survey varies considerably in color and depth and includes considerable material not typical of the series. Typically the surface soil is a light-brown clay about 10 inches deep, but there occur areas of yellow and reddish-yellow to bluish-gray and red clay, varying from a few inches to 1 foot in depth. The subsoil is typically a brownish-yellow, red, or reddish-yellow compact clay extending to an average depth of about 4 feet, where it rests upon partly weathered basalt. Angular or subangular fragments of this rock are abundant in some areas, the more stony of these being shown on the soil map by symbol. In places the surface soil is very shallow or has been entirely removed by erosion, leaving the brightly colored subsoil exposed. Such areas are usually

bare of vegetation. When wet the soil is sticky and plastic, and on drying it bakes and cracks into small hard cubes.

The Waha clay is developed in a few small bodies in the hills south of Wenatchee. It is residual in origin, being formed through the weathering of basalt. It occupies smooth ridges and gentle slopes and has good to excessive drainage. Most of the type supports a growth of sagebrush and bunch grass, but a few areas are forested. Practically none of the type is cultivated, its principal use being for pasture. It has a low value.

With thorough tillage the Waha clay should be adapted to small grains and grain hay, but it is difficult to maintain a favorable tilth and crops are likely to suffer from drought. Increasing the humus supply should prove beneficial.

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

Mechanical analyses of Waha 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.	<i>Per cent.</i>
551409.....	Soil.....	0.9	3.6	1.7	17.2	8.0	21.5	46.7
551410.....	Subsoil.....	.4	3.8	3.2	25.9	16.5	26.1	24.2

METHOW COARSE SANDY LOAM.

The surface soil of the Methow coarse sandy loam is a gray to light-gray coarse sandy loam 12 to 15 inches deep. The subsoil is a gray to slightly yellowish gray coarse sandy loam of compact structure, grading at depths varying from 4 to 6 feet into a mass of coarse angular particles of disintegrated granite. In places the surface soil contains sufficient fine material to give it a loamy feel, but it is usually coarse in texture and deficient in humus. Both surface soil and subsoil are noncalcareous.

This type occupies several square miles a few miles north of Chelan. Other bodies of from 1 to 2 square miles in extent lie south of Lake Chelan, in Ts. 26 and 27 N., Rs. 20 and 21 E. Small areas also are mapped on the north side of Chelan Butte and in the vicinity of Dryden.

The greater part of this type is found in hilly or mountainous country, 2,500 to 3,500 feet above sea level. It consists of smooth, nearly level, or gently sloping flats occupying the crests of ridges and plateaus and rugged hillsides too steep for cultivation. Areas of steep topography of considerable extent have been included with Rough broken and stony land. Surface drainage is well developed, and in the steeper areas is excessive. The subsoil is sufficiently com-

pact to be retentive of moisture, and with good cultivation crops rarely suffer from drought.

The native vegetation consists of a valuable stand of mature yellow pine, interspersed with dense thickets of young yellow pine and fir. "Pine" grass is common, and in the more open areas bunch grass grows scatteringly.

The Methow coarse sandy loam is one of the most important dry-farmed soils in the area, although probably less than 20 per cent of it is under cultivation. Wheat, the principal cash crop, occupies about 60 per cent of the cultivated acreage, while the remainder is about equally divided between corn, beans, and potatoes. The forested areas are used to some extent as summer range for sheep. In favorable years wheat yields 12 to 20 bushels, with an average of about 15 bushels per acre. Corn yields 18 to 25 bushels, with an average of 20 bushels per acre, and potatoes yield 100 to 150 bushels per acre.

At present none of this type is under irrigation. The greater part of the cultivated land is fallowed in alternate years. Most of the wheat is sown in the fall, except in unusually dry seasons when seeding is done in the spring.

Improved land of this type is held at \$25 to \$35 an acre, depending on improvements, topography, and distance from shipping points. Some of the wooded areas are held at higher figures because of their valuable timber growth.

Although a coarse sandy loam, this soil is retentive of moisture. It is easily cultivated, is not readily shifted by winds, and is considerably more productive than the majority of soils of this class. It is deficient in humus and would be greatly improved by the plowing under of rye or other green-manure crops. Owing to its high elevation it has little prospect for irrigation. Under dry-farm conditions it seems best adapted to corn, potatoes, and beans, such crops as can be given frequent and thorough cultivation. About one-fourth of the type is unsuited to cultivation because of steep topography.

Methow coarse sandy loam, heavy phase.—The heavy phase of the Methow coarse sandy loam is somewhat darker and browner in color and slightly heavier in texture than the typical Methow, and represents a gradation toward the Moscow series which is predominantly brown rather than gray.

The surface soil is a brown to light-brown sandy loam 12 to 18 inches deep. The subsoil is brownish yellow to light yellowish brown and somewhat gritty, containing angular fragments of quartz and of the parent rock of the size of coarse sand and fine gravel. The subsoil varies widely in texture, ranging from a sandy loam to a clay loam, and is usually moderately compact. It is underlain by partly disin-

tegrated coarse-grained granite at depths varying from 2 feet to more than 6 feet.

The Methow coarse sandy loam, heavy phase, occurs in a number of comparatively small areas in the northern and central parts of the survey. It usually occupies narrow or elongated areas capping the higher ridges and somewhat larger areas on the slopes. Many of the higher flats within the Chelan and Entiat Mountains are of this soil. Other bodies lie on Chelan Butte and a few miles north of Chelan. The largest and most important area is about 5 miles north of Wenatchee. Smaller areas occur near Cashmere, Dryden, and Peshastin.

As mapped this phase of Methow coarse sandy loam includes a number of variations. Among these is a brown fine sandy loam overlying brownish-yellow heavy sandy loam at a depth of 10 to 12 inches. This variation is found within the body north of Wenatchee. Also in this vicinity are small patches in which the surface soil apparently contains considerable wind-borne material, the first few inches having much the same appearance as the Walla Walla and the Ritzville soils. Small included areas of coarse sandy loam containing angular fragments of granite occur on some of the higher hills north of Chelan. While these variations are distinct, they are of such small extent that it is not practicable to show them separately on the soil map.

The characteristic topography of the higher areas is that of narrow, flat-topped ridges or plateaus flanked on each side by steep slopes descending to deep canyons. Having elevation of 2,500 to 4,500 feet above sea and 1,500 to 3,500 feet above the valley floors and extending several miles without a break, these narrow strips suggest the remnants of an ancient plain whose present elevated position has doubtless been determined by the gradual uplift of this section of the State.⁶ In the lower areas the surface is sloping or gently rolling, practically none of the phase being too steep or rough for cultivation. The surface is well drained, while the texture and structure of the subsoil are such as to favor the retention of moisture if the soil is properly worked.

The higher areas support a vigorous growth of scattered yellow pine, with here and there small groups of various kinds of shrubs. There is also a sparse growth of "pine" grass. The lower areas are treeless, the native vegetation consisting of bunch grass and sagebrush.

The heavy phase of the Methow coarse sandy loam is at present of little agricultural importance in the area, as less than 10 per cent is

⁶For a full and interesting discussion of this point the reader is referred to Professional Paper No. 19 of the United States Geological Survey, "Physiography and Deformation of the Wenatchee-Chelan District, Cascade Range," by Bailey Willis.

under cultivation. A few apple orchards have been planted on the lower slopes near Wenatchee. Where water is available for irrigation and the trees have been given proper care satisfactory results have been obtained. Some of the tracts, however, have been poorly cared for or abandoned.

A small acreage of wheat is grown, with yields ranging from 10 to 20 bushels per acre. Corn and potatoes are grown in a small way for home use, with average yields per acre of 20 and 125 bushels, respectively.

Irrigated land of this type is held at \$100 or more an acre, while unimproved tracts at some distance from markets can be bought for \$10 to \$15 an acre.

The Methow coarse sandy loam, heavy phase, is well adapted to the common dry-farmed crops of the region. When irrigated the lower areas are well suited to fruit. Owing to the high elevation above the streams, water is available for only a small proportion of the phase. In common with most of the soils of the region, this soil is deficient in humus and needs building up by the plowing under of green-manure crops.

The following table gives the results of mechanical analyses of samples of the Methow coarse sandy loam and of the heavy phase:

Mechanical analyses of Methow coarse sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical soil:		<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
551405.....	Soil.....	10.4	28.5	6.9	12.7	13.8	24.1	3.4
Heavy phase:								
551411.....	Soil.....	8.2	18.0	7.4	24.9	16.5	19.3	5.4
551412.....	Subsoil.....	8.9	25.6	9.8	23.2	14.9	14.3	3.2

HUCKLEBERRY FINE SANDY LOAM.

The Huckleberry fine sandy loam consists of light-brown to rather dark grayish brown fine sandy loam, about 12 inches deep, resting on a light yellowish brown or yellow gritty subsoil of heavier texture and compact structure which grades at varying depths into partly weathered sandstone. Usually bedrock lies 5 feet or more below the surface, but it may occur locally within 1 foot of the surface. The soil has a low to moderate organic matter content, is friable, and easily tilled. In some areas the surface soil approaches a sandy loam in texture.

Typically the Huckleberry fine sandy loam is residual from the underlying sandstone, but as mapped it includes areas in which the soil resembles the very fine sandy loam members of the Ritzville and Walla Walla series and has probably been modified by admixture of wind-borne material.

This type is of small extent and confined mainly to the hilly section immediately southwest of Wenatchee. Three small areas occur near Leavenworth and one a little north of Blewett. The topography ranges from rolling to hilly, and some of the high hills include small areas of steep, broken slopes incapable of cultivation. Rather large areas of this soil type southwest of Wenatchee are included with Rough broken and stony land. Surface drainage is well developed and in places the run-off has caused considerable erosion. The lower areas are treeless, the vegetation consisting of sagebrush and bunchgrass, while the higher areas are forested with yellow pine.

This soil is unimportant agriculturally. About 10 per cent of it is cleared and the treeless part of the remainder is used as pasture. The principal crops are apples, apricots, cherries, and wheat. These are grown as cash crops without irrigation, except in the case of a few small orchards. The yields are fair to good.

The unirrigated land is held at \$10 to \$35 an acre, depending on location and improvements. Irrigated orchards are held at a considerably higher figure.

The Huckleberry fine sandy loam is productive, and, where the topography is favorable, is well adapted to such crops as wheat, corn, and potatoes. The greater part of it is too rough or lies too high to be irrigated economically, but under irrigation the yields compare favorably with those on other irrigated soils of the valleys.

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

Mechanical analyses of Huckleberry 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.	<i>Per cent.</i>
551403.....	Soil.....	4.4	9.5	4.1	19.5	19.8	32.8	9.3
551404.....	Subsoil.....	3.4	9.2	4.3	14.1	21.9	32.6	14.3

QUINCY FINE SAND.

The surface soil of the Quincy fine sand consists of a brown, grayish-brown or yellowish-brown fine sand of slightly loamy texture, with an average depth of about 12 inches. It is loose and incoherent and is low in organic matter. The subsoil, to a depth of 6 feet or more, is a light-brown or grayish-brown loamy fine sand or fine sandy loam, somewhat more compact than the surface material. In places the subsoil material is distinctly micaceous. In this area the texture is not uniform, varying from place to place from fine sand to sand.

This type of soil is of small extent. The most prominent areas lie within the cities of Wenatchee and Cashmere and near the mouth of the Wenatchee River. Other bodies occur along the Columbia River near Malaga and Entiat.

The type has a smoothly rolling to hummocky or billowy topography, due to the action of winds, but the land is easily prepared for irrigation. Drainage in all cases is sufficient, and in some cases internal drainage is excessive because of the open structure. There is very little run-off, as percolation into the subsoil is rapid.

A large part of this type is irrigated, and the rest supports a growth of sagebrush. Apples, peaches, and apricots are the leading cash crops, with acreages in the order named. Alfalfa is grown in most of the orchards for soil improvement, while some of the orchardists make one cutting of hay. Some fruit and garden truck are grown on the areas within the cities of Wenatchee and Cashmere. Excellent yields of peaches and apricots are obtained, and where abundant water is available fair yields of apples are harvested. Improved tracts of this type within 2 or 3 miles of shipping points command \$350 to \$500 or more an acre.

The Quincy fine sand requires considerable water for irrigation. It is well adapted to peaches, apricots, berries, and early truck. The addition of organic matter is essential to its improvement.

Quincy fine sand, brown phase.—The brown phase of Quincy fine sand represents the development or occurrence of the Quincy fine sand material under conditions of slightly higher rainfall than typical.

The surface soil is brown or light brown in color, low in organic matter, and loose and porous in structure. It is underlain by a subsoil slightly lighter brown or more yellowish brown than the soil, but generally similar in structure and texture. The surface soil and subsoil are generally less calcareous than the typical soil.

This phase of the Quincy fine sand is represented by only a few small areas occupying parts of the Columbia and Chelan River terraces in the vicinity of Hugo, Wells, and Chelan. Near Wells and Chelan are a few areas of somewhat coarser texture. In topography and drainage the phase is similar to the typical soil. A smaller proportion of the phase is irrigated, and at present it is of less importance than the normal type. It is adapted to about the same uses.

QUINCY FINE SANDY LOAM.

The Quincy fine sandy loam consists of about 12 inches of light-brown to brown fine sandy loam overlying slightly lighter colored friable material of similar or slightly lighter texture, extending to a depth of 6 feet or more. Both the soil and subsoil are moderately

compact. This type is distinguished from the Ephrata fine sandy loam by having a wind-blown origin and by the absence of gravel throughout the 6-foot profile. Only a few small areas of the Quincy fine sandy loam are developed in the survey. The most prominent of these occurs near Malaga. The type has a nearly level to gently rolling surface and is well drained.

The greater part of it is covered with sagebrush and bunch grass and is utilized to some extent for pasture. A part is used for the production of fruit. A little dry-farmed wheat is grown, with rather indifferent yields.

This is an easily tilled soil, and under irrigation and proper culture it is adapted to a wide range of fruit, truck, and general farm crops, but owing to its small extent and lack of irrigation development it is of minor importance.

Quincy fine sandy loam, brown phase.—The brown phase of the Quincy fine sandy loam represents areas of the Quincy fine sandy loam occurring under conditions of slightly greater rainfall. Consequently the materials have less of the characteristics of desert soils, and are less uniformly or less decidedly calcareous. The color is in general slightly darker and the brown tint somewhat more pronounced. In texture, structure, topography, and drainage the phase resembles the typical Quincy fine sandy loam.

Areas of the phase occur in only a few places, principally near Chelan and Chelan Falls. The native vegetation consists mainly of sagebrush and bunch grass. Undeveloped areas are utilized for pasture, and small areas are irrigated and used in the production of apples, peaches and apricots, with yields ranging from fair to good. This phase of the Quincy fine sandy loam is more extensive and more important in this survey than is the typical soil. Irrigated and developed tracts are valued at from one hundred to several hundred dollars an acre. The most highly valued land is at Chelan.

The Quincy fine sandy loam, brown phase, is well located with reference to roads and towns. It is easily tilled and is adapted to a wide range of crops. The essentials to its successful use are irrigation, the addition of organic matter, and thorough cultivation.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Quincy fine sandy loam:

Mechanical analyses of Quincy 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.	<i>Per cent.</i>
551418.....	Soil.....	1.6	8.6	5.9	33.8	28.6	16.9	4.4
551419.....	Subsoil.....	1.3	9.1	6.3	32.0	27.2	18.8	5.0

WALLA WALLA VERY FINE SANDY LOAM.

The Walla Walla very fine sandy loam, to a depth of 8 to 12 inches, is a brown to dark grayish brown or dull-brown very fine sandy loam of uniform and smooth texture, usually without gravel, rock fragments, or gritty material, and with a moderately high content of organic matter. It is somewhat sticky when wet, but is friable under cultivation, retentive of moisture, and easily maintained in a favorable condition of tilth. The subsoil is similar in texture to the soil, but of lighter brown color, and has a more compact structure, usually somewhat columnar. It is free from coarse material, except where underlain at shallow depths by disintegrated bedrock. In the areas of deeper accumulation it is underlain by a yellowish-brown or tawny-yellow stratum of homogeneous fine-textured material. The surface soil is usually leached of lime, but the deeper subsoil and substratum normally contain lime accumulations appearing as grayish mottlings.

In the present survey this type is usually underlain by basalt at variable depths, and in places bedrock lies within 18 inches to 6 feet of the surface. In the more shallow of these areas boulders or stone fragments occasionally appear, and the subsoil is locally modified by residual material from basalt.

The type is derived from slightly modified and weathered wind-borne or loessial deposits. In origin and mode of formation it is related to the soils of the Ritzville series and it merges gradually into the fine sandy loam of that series. It is distinguished from the Ritzville by a higher humus content and darker color the result of a greater rainfall induced by higher elevation.

The Walla Walla very fine sandy loam is not an extensive type but is of considerable agricultural importance. The larger areas occur upon the higher elevations of the basaltic plateau in the southern part of the survey. Other important areas occupy the crests of several ridges to the west of Chelan Butte. The surface is usually smooth, though the slope varies from gentle to steep. The areas usually occur at elevations of 2,000 to 3,000 feet.

Surface drainage is good to excessive, but the soil absorbs moisture readily and there is but little erosion. In its native condition the type supports a growth of sagebrush and bunch grass.

Wheat, corn, and potatoes, grown without irrigation, are the principal crops, the acreage in wheat greatly predominating. In favorable seasons, wheat yields 12 to 25 bushels, with an average of about 18 bushels per acre. Corn yields 18 to 25 bushels, with an average of about 20 bushels per acre. Potatoes return 100 to 150 bushels per acre.

In growing wheat in the dry-farmed section the land is generally summer fallowed. Plowing begins as soon as possible after harvest, and the following summer the land is disked or harrowed at intervals of 4 to 6 weeks in order to destroy weeds and conserve the moisture. Seeding is done in the fall after the first good rain, or when the rains are too late spring wheat is sometimes sown the following spring. In some cases the fields are planted to corn instead of fallowed. Many follow the practice of pasturing stock on the stubble in the fall and beginning the preparation for the next year's crop as early as possible in the spring. Harvesting is done with a binder, as the fields are so small or so hilly as to make the use of the combined harvester impracticable. The wheat is usually thrashed from the stack.

In value and adaptation to crops this type ranks with or slightly higher than the dry-farmed Ritzville very fine sandy loam. Owing to a slightly greater rainfall, it is in general somewhat more productive, but it is less favorably situated with regard to roads and shipping points, and to water for irrigation.

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

Mechanical analyses of Walla Walla very 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.	<i>Per cent.</i>
551413.....	Soil.....	1.5	3.0	2.3	14.6	32.2	40.6	5.8
551414.....	Subsoil.....	1.4	2.7	2.4	13.5	32.4	43.6	4.0

RITZVILLE VERY FINE SANDY LOAM.

The surface soil of the Ritzville very fine sandy loam consists of a light-brown or light grayish brown to dull grayish brown very fine sandy loam about 12 inches deep. The surface is firm and moderately compact, although the soil when broken is mellow and easily cultivated. The subsoil, to a depth of 6 feet or more, is a slightly lighter brown compact very fine sandy loam containing relatively large proportions of fine and very fine sand. In the larger and typical areas gravel and boulders do not occur in either the soil or subsoil material, nor are they exposed by cuts in the underlying material. In many of the smaller areas the wind-borne material composing this type is shallow, and the subsoil varies from the typical, consisting of a mixture of loessial and residual materials, producing a brown to slightly yellowish brown coarse-textured loam. In the southern part of the survey the type rests on basalt at depths ranging from 18 inches to 6 feet or more. In other localities the

underlying rock includes sandstone, granite, schist, and gneiss. In the sandstone area the type has a somewhat coarser texture than where underlain by basalt.

The Ritzville very fine sandy loam, though of comparatively small extent, is widely distributed throughout the area surveyed. The largest bodies lie south and southeast of Wenatchee and southwest of Malaga. Small areas are found on the lower slopes along the Wenatchee River from Sunnyslope to Monitor, and others occur in the vicinity of Chelan Butte.

The type occupies the smooth surfaces of flattish ridges, long gentle slopes, rolling hills, and steep slopes. Where these steep areas are of considerable extent they have been included with Rough broken and stony land. In general the surface of this type averages somewhat rougher than in Benton County or Franklin County, where the Ritzville soils are more extensively developed.

Drainage is good to excessive, but the run-off on the steeper slopes causes little erosion on account of the normally low rainfall and the readiness with which the moisture is absorbed by the soil.

This soil in its native state supports a good stand of bunch grass and sagebrush.

Although the Ritzville very fine sandy loam is of small extent, it is an important upland soil. Most of the small areas along the Wenatchee River and near the city of Wenatchee are irrigated and used in fruit growing. In the more hilly region in the southern part of the area a part of the type is cultivated and the rest is highly prized as grazing land.

Wheat and corn are the principal crops on the dry-farmed areas, wheat occupying somewhat the larger acreage. Potatoes are grown in a small way. Apples are the principal crop in the irrigated sections, although some cherries, peaches, and pears also are produced. (Pl. IV, fig. 1.) Apples, under irrigation, are reported to yield an average of about 700 boxes per acre.

Improved land of this type in the dry-farmed sections sells for \$20 to \$25 an acre, and unimproved land from \$10 to \$15 an acre. Near Wenatchee the bearing orchards under irrigation are held at \$1,000 or more an acre.

The Ritzville very fine sandy loam is retentive of moisture, is easily worked, and responds readily to good treatment. It is especially adapted to wheat where rainfall is sufficient, while corn and potatoes also are grown with success. The soil is somewhat deficient in humus but is generally well supplied with lime. Clean cultivated fields have a tendency to blow, and the plowing under of organic matter is decidedly beneficial. Under irrigation this soil is well adapted to apples and other tree fruits.

LICK STONY FINE SANDY LOAM.

The surface soil of the Lick stony fine sandy loam is a light-brown or light grayish brown, friable fine sandy loam, usually low in organic matter, 10 or 12 inches deep, with more or less numerous glacial boulders, mostly granite scattered over the surface and embedded in the soil material. In the typical areas the boulders ordinarily range from 1 to 6 feet in diameter, but in some areas they are very large, sometimes 10 feet or more in diameter, and very abundant on the surface and in the soil. The soil material, though analyzing a fine sandy loam, normally carries an appreciable amount of coarse, gritty particles.

The subsoil may have the same color as the surface soil, or may be a slightly lighter brown, a more yellowish brown, or in places slightly reddish brown. It is ordinarily somewhat more compact than the surface soil.

Both surface and subsoil materials are well leached and non-calcareous.

The type is derived from weathered glacial deposits having their source mainly in granite, gneiss, and similar rocks.

The Lick stony fine sandy loam occurs in small to moderately extensive areas, usually narrow strips, widely distributed over the western and northern parts of the survey. The largest bodies are in the vicinity of Leavenworth, at intervals in the valleys of the Wenatchee River and Peshastin Creek, between Leavenworth and Cashmere, and on the hill slopes north of Lake Chelan. The excessively stony area is comprised in a strip about one-half mile wide and 3 miles long, which occupies the lower slope of a hill south of Leavenworth, and in an area in the bend of the Wenatchee River near by.

The Lick stony fine sandy loam has a diversified topography, ranging from level to gently sloping, as on the terraces in the vicinity of Leavenworth, to steeply sloping, as on the hillsides near Chelan. Here the surface is considerably eroded and much of the type could well be correlated with Rough broken and stony land. These areas are excessively drained, both because of their slope and the porous character of the material. The surface of the lower lying terraces is usually smooth, and cultivation is prevented only by the presence of stones. Drainage in these areas is good but not excessive.

Some of the areas support an open or scattering growth of yellow or scrub pine (Pl. IV, fig. 2); others mainly sagebrush. The type is of little agricultural importance and is utilized mainly for grazing. On some of the smooth terraces, where the boulders are small and not too numerous, small patches can be cleared and cultivated. The type is, however, not very well adapted to dry farming.

LICK COARSE SANDY LOAM.

The surface soil of the Lick coarse sandy loam is a light grayish brown friable sandy loam of coarse texture, with a depth of 12 to 15 inches. In places it contains considerable fine material, causing the soil when wet to have the appearance of a rather coarse loam. The organic matter content is low. The subsoil is typically a light grayish brown or brownish-gray coarse sandy loam of compact structure, extending to a depth of 6 feet or more. In places the material in the substratum is light brownish yellow when moist, but in most cases it assumes a grayish color on exposure to the air. The type is normally free from gravel, except in areas adjacent to Rough broken and stony land or local rock outcrops, where angular fragments of granite or schist are more or less common throughout the surface material. Glacial boulders are sometimes found on the surface and are quite common in the soil mass.

The type includes a variation in which the surface soil is somewhat browner than typical. The difference in color is readily detected when the soils are moist, but in dry fields the difference is almost imperceptible.

The Lick coarse sandy loam is quite extensively developed in the region of Lake Chelan. It occupies many broken and irregular strips on the lower slopes along the north side of the lake. A few bodies lie along the south side of Lake Chelan and others near the northeast corner of the area.

The topography is rolling to hilly, although practically all of it is sufficiently smooth for cultivation. It ranges in elevation from 1,100 to 2,500 feet above sea level, or from the level of Lake Chelan to 1,500 feet above. The lower, smoother areas require but little leveling for irrigation, but the high rolling bodies are too rough or too high above the source of water to be economically irrigated. The type is well drained, retentive of moisture, and easily tilled.

The Lick coarse sandy loam is one of the important soils of the area. The native vegetation, sagebrush, has been removed from about 75 per cent of its area and the land placed under cultivation. About 20 per cent of the cultivated acreage is irrigated and used in the production of fruit, while of the rest part is used in fruit growing, but by far the greater part in growing small grains, mainly wheat. Apples constitute the chief cash crop, although there are small acreages of cherries, pears, and peaches grown commercially. The yields of fruit compare favorably with those obtained on the other irrigated soils of the valley. Alfalfa is grown in many of the irrigated orchards. The crop is usually cut three times during the season, with an average total yield of 3 to 5 tons per acre. Dry-farmed wheat returns 5 to 20 bushels per acre, depending

on the rainfall. The type is handled in the same manner as the adjoining soils of the area.

Undeveloped tracts of the Lick coarse sandy loam can be bought for \$15 to \$25 an acre, while irrigated orchards in full bearing command \$500 or more an acre.

The Lick coarse sandy loam is greatly improved by the addition of humus. As a means of accomplishing this it is recommended that a crop of alfalfa be turned under every two or three years and that not more than one hay crop be removed from the orchards during any one season. A still better way is to refrain entirely from cutting hay in the orchards, using the alfalfa only as a cover crop and a means of building up the organic matter in the soil. With good treatment the land is productive and adapted to all of the common crops of the region. On some of the steeper areas care is needed in irrigation to prevent removal of the surface soil.

Lick coarse sandy loam, stony phase.—The stony phase of the Lick coarse sandy loam differs from the Peshastin stony fine sandy loam mainly in the slightly grayer color, coarser texture, and noncalcareous character of the material. The phase consists of about 12 inches of light brownish gray or light grayish brown stony sandy loam of medium to coarse texture overlying a grayish coarse sandy loam subsoil containing stones and bowlders ranging up to several feet in diameter. In places excessively stony material extends to a depth of many feet, while in others the soil is shallow and overlies granitic bedrock. The stone and bowlders which have been deposited in their present position through the action of glaciers are mainly granite.

This phase of the Lick coarse sandy loam occurs in small areas on the shores of Lake Chelan, the most prominent being at Lakeside, First Creek, and near Alkali Lake. Another body lies about 4 miles northeast of Chelan.

The surface of this phase ranges from gently sloping to very steep. A number of small areas are much dissected. Drainage is usually excessive. Practically all supports its native cover of sagebrush and grasses and is utilized for pasture. The greater part of it is nonagricultural.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Lick coarse sandy loam:

Mechanical analyses of Lick 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.	<i>Per cent.</i>
551420.....	Soil.....	11.1	24.4	5.8	20.5	14.8	19.7	3.4
551421.....	Subsoil.....	10.8	24.2	6.4	19.7	14.9	21.3	2.4

LICK SANDY LOAM.

The surface soil of the Lick sandy loam consists of a layer, about 12 inches thick, of a gray to brownish-gray or grayish-brown, friable sandy loam of medium to relatively coarse texture. The subsoil consists of gray gritty material, varying in texture from a fine sandy loam, rather high in silt, to a coarse sandy loam. Usually the subsoil extends to depths of many feet without important change, but in places glacial boulders 1 to 3 feet in diameter are embedded in the underlying material. The subsoil is fairly compact and retentive of moisture.

As mapped the type includes small areas of fine sandy loam and small bodies in which the deeper subsoil and substratum, when moist, are brownish yellow. As a rule the surface material is free from gravel and stones, except where the type approaches Rough broken and stony land or areas of stony glacial soils.

The Lick sandy loam is moderately extensive, but is confined mainly to the region of Lake Chelan. The most prominent areas lie on the high terraces back of Wells and Hugo. Small but important bodies occur on the lower part of the north slope of Chelan Butte and near Lakeside, and one small area about 1 mile north of Leavenworth.

The type occupies terracelike positions 500 to 1,500 feet above the rivers and the lake. The topography is generally smooth, and the slope is sufficient to provide good surface drainage. Except in a small area along Antwine Creek, water is not available for irrigation.

This soil type has at present only a local importance agriculturally. About 75 per cent of it has been cleared of its native growth of sagebrush and bunch grass and is being used in the production of wheat and corn, the former occupying much the larger acreage. Wheat returns from 5 to 18 bushels per acre. Corn yields an average of about 20 bushels per acre. Most of this land is summer fallowed, and both spring wheat and fall wheat are sown, depending on whether or not fall rains come sufficiently early to insure a satisfactory growth before severe weather sets in.

Land of this type ranges in value from \$25 to \$50 or more an acre. The Lick sandy loam under present conditions is adapted only to the dry-farmed crops of the region. Yields can be materially increased by the addition of organic matter, as this has a tendency to make the soil more coherent and more retentive of moisture. Alfalfa is not successful without irrigation, and at the present time water for this purpose is not available.

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

Mechanical analyses of Lick 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.	<i>Per cent.</i>
551422.....	Soil.....	14.8	14.3	5.6	14.3	20.5	27.4	3.1
551423.....	Subsoil.....	5.5	10.2	3.8	17.2	20.5	36.9	5.6

LICK FINE SANDY LOAM.

The surface soil of the Lick fine sandy loam consists of grayish-brown or light brownish gray friable fine sandy loam, low in humus and 12 to 18 inches deep. The upper subsoil is a gray or brownish-gray gritty material of compact structure, varying in texture from heavy sandy loam to sandy clay. This passes at depths of 3 to 5 feet into gray or pale brownish yellow heavy loam or sandy clay. Typically neither gravel nor stones are found in either the surface soil or subsoil, but partly weathered bowlders of glacial origin are sometimes exposed by cuts in the deeper underlying material. In places the surface material is somewhat browner than is typical, the brown color being especially noticeable after rains.

The type is fairly extensive. It occupies strips one-fourth to three-fourths miles in width along both sides of the Wenatchee River from Leavenworth to Peshastin. A small but important body occurs near Dryden, and an area nearly 2 square miles in extent lies on the high benches west of Wells.

The area near Wells is situated several hundred feet above the valley of Antwine Creek; has a level or very gently sloping surface. The other areas have a smoothly rolling topography that allows of irrigation without much leveling. The type is well drained, and the structure of the subsoil is such as to favor the retention of moisture.

The Lick fine sandy loam consists mainly of glacial material, coming entirely from crystalline rocks and mainly from granite.

Although the Lick fine sandy loam is of comparatively small extent, it is important in the agriculture. Originally it supported a fair growth of yellow pine, but this has been removed from about 75 per cent of the area along the upper Wenatchee Valley, and the land placed under irrigation and planted in orchards. Apples are the leading cash crop, occupying fully 80 per cent of the cultivated acreage of the type in this valley. There are a few fields of alfalfa to supply feed on the farms, and small acreages of peaches, cherries, and pears, grown commercially. The yields of all crops compare favorably with those obtained on any of the better soils of the county.

In the northeastern part of the area the type is dry farmed, mainly to wheat and corn. Wheat is grown as a cash crop, with yields ranging from 5 to 10 bushels in dry years to as much as 25 bushels per acre when rainfall is favorable. Corn is grown only for home use. It yields 15 to 25 bushels per acre.

Under dry farming the land is handled in about the same manner as the Ritzville very fine sandy loam. Most of the irrigated orchards are given clean cultivation.

The price of the greater part of the Lick fine sandy loam is rather high, owing to its favorable location with respect to towns and shipping facilities. Irrigated orchards range from \$500 an acre upward.

The Lick fine sandy loam is a desirable soil for the production of fruit, alfalfa, potatoes, and vegetables. Owing to the naturally low humus content, the orchards would undoubtedly be benefited by growing alfalfa as a cover crop among the trees instead of giving them clean cultivation. Water for irrigation does not appear to be available for the high body in the northeastern part of the area, but the farms appear thrifty under dry farming.

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

Mechanical analyses of Lick 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.	<i>Per cent.</i>
551424.....	Soil.....	1.0	3.7	2.4	18.2	38.8	28.4	7.3
551425.....	Subsoil.....	1.1	3.9	3.1	15.0	40.5	28.0	8.0

PESHASTIN STONY FINE SANDY LOAM.

The Peshastin stony fine sandy loam consists of about 12 inches of light-brown to brown fine sandy loam, becoming grayish in dry bleached field surfaces, overlying a yellowish-brown, compact, gritty subsoil of somewhat heavier texture, extending to a depth of many feet. Glacial boulders 1 to 6 feet or more in diameter are common on the surface and are thickly embedded in the underlying material. In places the boulders in the subsoil and substratum are partially disintegrated. As a rule the boulders are granitic and subangular in shape. In places they are distributed over the area at intervals of several rods apart, with small intervening patches of deep, friable soil suitable for gardening.

Areas are included in which the boulders are of unusual size and abundance. Such areas represent unsorted débris laid down by melting ice. The surface is virtually paved with massive boulders, 10 to 20 feet or more in diameter, while the underlying material is

a mass of large angular bowlders embedded in a yellowish-brown heavier sandy loam to clay loam extending to a depth of many feet. The rocks, which are of granite, gneiss, and schist, show considerable weathering.

Parts of the type depart somewhat from the typical in that the material contains much waterworn gravel and cobblestones while lacking large bowlders. The parent material in such areas is probably largely waterlaid, and except for its brown color appears to be identical with the more highly oxidized reddish-colored soils of the Malaga series. The typical Peshastin soils are considered to be derived from material mainly of ice-laid origin.

The Peshastin stony fine sandy loam is widely distributed in the area surveyed. The bodies usually occur as comparatively small, narrow strips, some of which extend unbroken for several miles. The type is found at Wenatchee and at frequent intervals along the Columbia River from Malaga to Chelan.

The most prominent of the excessively stony areas lie in the southern part of the city of Wenatchee and at Malaga.

Practically all of this type is still in sagebrush, about the only exception being where it occurs in towns. The type is used principally for grazing. On some of the smooth terraces where bowlders are small and not too numerous it is feasible to prepare small patches for cultivation by removing the surface stones. Irrigation, however, is essential in the use of this soil. The type is mainly nonagricultural.

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

Mechanical analyses of Peshastin stony 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.	<i>Per cent.</i>
551468.....	Soil.....	0.0	3.8	3.3	35.9	20.5	28.9	7.7
551469.....	Subsoil.....	.0	3.3	2.9	29.5	22.4	30.0	12.0

SPRINGDALE FINE SANDY LOAM.

In the typical development of the Springdale fine sandy loam the surface soil consists of about 10 to 18 inches of a light-brown or light grayish brown fine sandy loam, of medium to low organic-matter content, underlain by a lighter brown or somewhat more reddish brown subsoil, slightly heavier and more compact than the surface soil. The surface and subsoil normally have been leached of their lime. The subsoil is underlain by a weathered substratum, moderately friable to somewhat compact in structure, slightly mottled in places with gray and brown iron stains. It also is noncalcareous.

As mapped in this survey the type includes small areas in which the subsoil and substratum consist predominantly of porous stratified sand and gravel, lacking in the subsoil the compactness existing in the typical areas. Such included materials are stream-laid or glacial outwash deposits not properly belonging in this series, and are more truly a humid equivalent of the calcareous desert materials giving the Ephrata series.

The areas of the Springdale fine sandy loam are inextensive and widely scattered. The more typical lie in the valley of the Wenatchee River near Dryden. An area in the Columbia Valley near Wells and a small area southeast of Leavenworth represent the included variation with porous subsoil and substratum. Two small areas south of Dryden and between this point and Bender Canyon are also included in which the surface soil is of slightly coarser texture than typical and which, if more extensive, would have been mapped as the Springdale sandy loam.

The topography is smooth and nearly level to gently sloping. Surface drainage is well developed. In the included areas with porous subsoil the subdrainage is excessive. The typical areas, however, are retentive of moisture under cultivation and irrigation.

The greater part of the area near Wells and parts of the type in the Wenatchee Valley are irrigated and devoted to the production of fruit.

Land of this type in bearing orchards is valued at \$500 or more an acre.

SPRINGDALE LOAM.

The surface soil of the Springdale loam is a brown to light-brown moderately compact loam, with a low to moderate organic-matter content. Under thorough cultivation it has a mellow, friable structure, but it is quite sticky when wet, and tends somewhat to puddle and bake under unfavorable conditions of drainage or cultivation. The upper subsoil is typically compact, light brown to yellowish brown in color, and of loam to clay loam texture. At a depth of 2 or 3 feet the subsoil usually becomes more friable. Both surface and subsoil materials are generally well leached and noncalcareous.

The type is developed in a number of small areas lying in the valley of the Wenatchee River near Peshastin and Dryden. It occupies nearly level to very gently sloping terraces well above the present stream bottoms. Surface drainage is in general well developed; only in some of the more nearly level areas is it somewhat restricted. The subdrainage is more or less retarded by the compact subsoil throughout the type.

The Springdale loam was originally treeless or at most supported only an open or scattering growth of forest trees.

While of small extent, this is an important type of soil. It is devoted mainly to fruit culture under irrigation. Apples are the principal product. Areas in bearing orchards have a high value. In general physical character, products, cultural practices, relation to agriculture, and value the type is similar to the Wenatchee loam.

WENATCHEE SANDY LOAM, RESIDUAL PHASE.

The residual phase of the Wenatchee sandy loam is similar in essential features of surface and subsoil to the typical Wenatchee sandy loam, but is underlain, usually at a depth of 3 to 5 feet, by beds of shale and sandstone, and it is probable that the soil materials are derived mainly by weathering in place of these underlying rocks.

In origin, mode of formation, topography, and agricultural use this phase is related to the Huckleberry fine sandy loam, but occurs at a somewhat lower elevation, it having the climatic environment of the other Wenatchee soils. It generally has a cover of sagebrush and bunch grass. It is mildly calcareous, and if of greater extent it probably would be placed in a series of desert soils corresponding, except for a higher content of lime, to the Huckleberry series.

The surface soil is a light-brown or light grayish brown sandy loam, generally of rather fine texture, low humus content, and friable structure. At an average depth of about 12 inches this is underlain by a dull-yellow or yellowish-brown, compact sandy loam or loam subsoil. In places outcrops of the bedrock occur, and here and there scattered fragments appear on the surface and embedded in the soil material.

This phase of the Wenatchee sandy loam is limited to a few small areas occupying smooth and gently sloping to rough and steep hill-sides west and southwest of Wenatchee. Much of the surface is too steep to be conveniently cultivated, and the phase is of minor agricultural importance.

WENATCHEE FINE SANDY LOAM.

The surface soil of the Wenatchee fine sandy loam consists of 12 to 18 inches of a brown fine sandy loam, containing generally a relatively large proportion of very fine sand. The subsoil typically is a yellowish-brown, compact, heavy sandy loam or silty loam to clay loam, but includes local areas of material of grayish-brown color. The compact layer varies from 10 to 24 inches in thickness, and is underlain at a depth of 2 to 3 feet by a stratum of yellow or yellowish-brown friable silt loam, silty clay loam, or very fine sandy loam, normally extending to a depth of many feet. The entire soil section is typically free from gravel or stones. The surface soil has a friable structure and is easily tilled. The texture varies from typical fine

sandy loam to sandy loam in extreme cases, as in the southwestern outskirts of Wenatchee and in the eastern part of the area lying immediately north of that town. The area lying along Yaxon Canyon is browner than typical, approaching the Springdale in character.

This type of soil, although inextensive, is important. It occupies a number of areas on the outskirts of Wenatchee and at various points along the Wenatchee River. Its topography is that of level to very gently sloping terraces. The surface is entirely unmarked by drainage courses, but the soil absorbs the rainfall readily and the type seems adequately drained.

Probably 95 per cent of this soil type is irrigated, the greater proportion of it being in orchards. The same crops are grown, the same methods employed, and about the same yields obtained as on the loam and sandy loam types of the series.

Land values range high, from \$500 to \$1,000 or more an acre, depending on improvements and the nearness to towns.

The Wenatchee fine sandy loam ranks high among the soils of the area for the production of fruit and alfalfa. The soil requires the same treatment for its improvement as do the other types of the series.

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

Mechanical analyses of Wenatchee 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.	<i>Per cent.</i>
551437.....	Soil.....	0.6	3.3	2.7	16.2	41.2	32.1	4.1
551438.....	Subsoil.....	.0	2.5	2.1	14.5	30.2	40.4	10.4

WENATCHEE LOAM.

The surface soil of the Wenatchee loam consists of 12 to 18 inches of brown to grayish-brown, moderately compact micaceous loam. When thoroughly cultivated, it has a friable, mellow structure, but it is sticky when wet, and if allowed to become too dry the surface bakes hard and cultivation is difficult.

The subsoil is in two horizons, an upper one of compact, more or less impervious, yellow-brown or brownish-yellow loam or clay loam, and a lower, consisting of a more friable brownish-yellow silt loam or very fine sandy loam. The compact layer appears to have resulted from a concentration of the finer particles of silt and clay washed downward from the surface soil. It has a uniform thickness of 12 to 18 inches and rarely extends below a depth of 3 feet. In places



S. 10014

FIG. 1.—VIEW NEAR MANSON IN LAKE CHELAN VALLEY.

Showing characteristic topography and orchard planting on the glacial granitic soils of the Lick series.



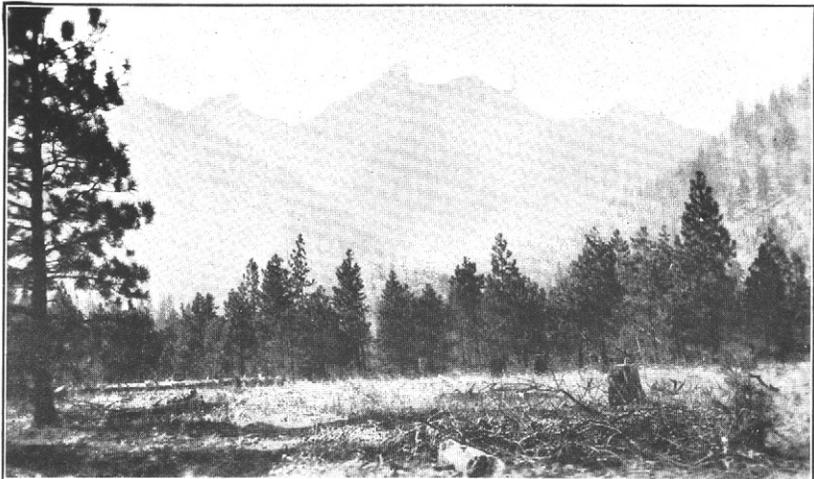
S. 9911

FIG. 2.—APPLE ORCHARD ON WAHA LOAM, WHEELER HILL DISTRICT.



S. 10046

FIG. 1.—APPLE ORCHARD ON THE RITZVILLE VERY FINE SANDY LOAM NEAR WENATCHEE.



S. 10034

FIG. 2.—VIEW LOOKING UP CANYON OF ICICLE CREEK, NEAR LEAVENWORTH, SHOWING NATIVE GROWTH OF YELLOW PINE.

the friable layer is reached within 2 feet; its texture, structure, and color remain fairly uniform to a depth of 6 feet or more. No gravel and but little gritty material is found typically in either the surface soil or subsoil and no stones are exposed by cuts in the underlying deposits.

In some of the areas patches occur in which the texture approaches a very fine sandy loam, and in others small bodies of typical silt loam are included. Both these variations have a more friable surface soil and are more easily handled than the typical loam.

The Wenatchee loam occurs in a number of small bodies within or near the city of Wenatchee, and there are small but important areas near Cashmere and Monitor.

The Wenatchee loam occupies nearly level to very gently sloping terraces 20 to 100 feet above the streams. Except in some of the more nearly level areas, the surface drainage is adequate. The under-drainage is somewhat restricted by the compact structure of the subsoil, and where the impervious layer occurs near the surface the water-holding capacity of the soil is reduced, and frequent irrigations are necessary to produce the best results.

The Wenatchee loam originally supported a vigorous growth of sagebrush and bunch grass. It is now one of the most important agricultural soils in the county, practically the entire type being used in the production of fruit. Apples are the principal cash crop, occupying perhaps 90 per cent of the entire acreage. Cherries and pears are also produced on a commercial scale. Alfalfa is grown in nearly all of the orchards and harvested for home use. Although it is generally recognized that it is better for the orchards if hay is not removed from the fields, nearly all of the orchardists cut their alfalfa once, while some remove two crops, and a few make three cuttings during the season. The yields of hay range from 1 to 1½ tons an acre for each cutting. The yield of apples varies greatly, ranging from 500 to 1,000 packed boxes per acre. The average for well-cared-for orchards of full bearing age is probably not less than 800 boxes per acre. The leading varieties are Winesap, Jonathan, Delicious, and Rome Beauty, with Stayman Winesap, Esopus, and Black Ben following in the order named. Intensively farmed orchards of from 5 to 10 acres are the rule on the Wenatchee loam, and all buildings and improvements are of an unusually high type.

In handling this soil, most of the orchards are disked as early as possible in the spring. Owing to the level surface and rather heavy texture, the soil does not dry as early as some of the lighter types, and disking is usually delayed until about the second week in April. On well-drained gravelly types cultivation sometimes begins the latter part of March. After disking, the land is harrowed

and smoothed with various implements and later furrowed for irrigation. Irrigation usually begins soon after the middle of April and continues at intervals of 10 to 15 days until well into September. After the fruit is harvested the alfalfa is sometimes disked. In the case of clean-cultivated orchards the land is usually cultivated or harrowed after each irrigation and after rains sufficiently heavy to pack the surface.

The Wenatchee loam has a high valuation. The greater part of it is held at more than \$1,000 an acre.

This is one of the most desirable soils in the valley. It is very productive, and if properly handled is easily tilled. Care is necessary, however, in working parts of the type, as some of the fields which are deficient in humus have a tendency to bake between irrigations. Also in places where the compact stratum lies relatively near the surface water has difficulty in penetrating into the subsoil, and the result is an oversaturation of the surface soil, while the subsoil remains dry and hard, resisting the penetration of roots. To remedy this it is recommended that alfalfa be plowed under as deeply as possible in order to increase the supply of humus and to loosen the compact layer. The better orchardists on this type do not cut alfalfa in the orchards but allow it to go back into the soil for fertilization. This is a commendable practice and should be more generally followed throughout the Wenatchee Valley.

Wenatchee loam, heavy phase.—The surface soil of the Wenatchee loam, heavy phase, consists of a brown or dark-brown compact heavy loam or clay loam. The color is grayish brown when dry. The soil is low in organic matter, and has a tendency to puddle when wet and to become hard and intractable when dry. The depth ranges from 8 to 15 inches. The soil is underlain by a compact, impervious layer of yellowish-brown clay loam or clay containing medium and coarse sand and ranging in thickness from a few inches to 2 feet. When dry this layer is hard and brittle, with an adobelike structure, and is locally known as hardpan. It differs, however, from a true hardpan in that it is not cemented, and during the early spring months, when it is thoroughly saturated, fairly pervious, resembling the subsoil of the other members of the series. At depths ranging from 18 to 30 inches the impervious layer gives place to brownish-yellow friable material of somewhat lighter texture.

This phase is very inextensive, occurring in only a few small bodies near Wenatchee, southwest of Cashmere, and about $1\frac{1}{2}$ miles east of Monitor. Near Wenatchee the surface is nearly level. The other bodies are gently sloping. Surface drainage is only fairly well developed, while the compact subsoil retards the downward movement of water. In places this condition seriously interferes with irrigation, as only that part of the soil section above the impervious

layer is effective in storing moisture. In poorly drained areas the soil is somewhat mottled.

This phase of the Wenatchee loam is unimportant. About 75 per cent of it is used for growing apples, pears, and cherries, of which apples occupy the largest acreage. A little wheat is grown, and the rest of the land is in timothy and clover hay or is used for pasture. Yields of fruit are low, and the trees look stunted and unthrifty. When thoroughly irrigated, hay yields fairly well. Plowing is usually shallow, and sometimes the only preparation for wheat is disking.

Prices range from \$50 to \$350 an acre.

The Wenatchee loam, heavy phase, is poorly adapted to fruit raising. It ranks as an inferior soil, not only because of its low average yields but also because it is a difficult soil to handle. In some cases repeated shallow plowings have intensified the compact layer by forming an impervious plowpan at the bottom of the furrow. It has been demonstrated that this soil can be improved considerably by deep plowing, the turning under of alfalfa, and heavy applications of barnyard manure.

EPHRATA FINE SANDY LOAM.

The Ephrata fine sandy loam consists of 10 to 12 inches of light-brown fine sandy loam of rather light texture, overlying a light-brown or grayish-brown to yellowish-brown fine sandy loam subsoil containing varying quantities of waterworn gravel and cobbles. The subsoil, at depths ranging from 3 to 6 feet, passes into a porous mass of rounded gravel and boulders, in most places embedded in coarse sands. In the southern part of the area, where the development is typical, a black sandy substratum composed partly of basalt occurs, but in other parts the coarse material appears to be composed entirely of crystalline rocks. In places gravel is fairly abundant on the surface, and the surface soil, although rather firm in its native state, becomes loose and porous under cultivation. In places the surface is quite sandy, having been modified to some extent by accessions of wind-blown material.

The Ephrata fine sandy loam occurs in a number of small, narrow, areas in the Columbia and Wenatchee Valleys. The most prominent bodies, from the standpoint of agricultural use, occur near Wenatchee and Cashmere. Somewhat larger bodies lie near the mouth of the Chelan River and at various points between Malaga and the southern boundary of the county.

This type of soil occupies old river terraces, 50 to 300 feet or more above the present flow of the streams. The surface is nearly level or gently sloping and is easily prepared for irrigation. Owing to

the porous subsoil, drainage is excessive, and the soil is incapable of storing sufficient moisture to grow crops without irrigation.

Practically all the area of the type near Wenatchee and along the Wenatchee River has been cleared of its cover of sagebrush and the land placed under irrigation and used for the production of fruit. About 50 per cent of the area in other parts of the survey likewise is used for commercial fruit growing. Apple orchards occupy fully 80 per cent of the irrigated acreage. The other fruits grown commercially are peaches, pears, cherries, and apricots. Alfalfa is grown in most of the orchards for soil improvement and as feed for dairy cattle and work stock. Where sufficient water is available, the yields on this type compare favorably with those obtained on the more productive soils of the valley.

Lands of this type in bearing orchards range in value from \$500 an acre upward. Unimproved areas are held at \$25 to \$100 an acre.

The Ephrata fine sandy loam is popular because it is easily cultivated and irrigated. Plowing under alfalfa has improved its physical condition and has resulted in greatly increased yields. The soil requires thorough cultivation, where this can be given, and copious irrigation for best results.

Ephrata fine sandy loam, steep coarse-textured phase.—The surface soil of the Ephrata fine sandy loam, steep coarse-textured phase, is a light-brown loose gravelly sand. This is underlain by a mass of gravel, cobblestones, and sand extending to a depth of 6 feet or more. The coarse material is derived mainly from crystalline quartz-bearing rocks and is maturely waterworn. Stratification is usually pronounced. In places a bed of coarse black basaltic sand underlies the type at a depth of 6 to 20 feet. The soil is almost devoid of organic matter, and, because of the porous, gravelly structure of the subsoil and substratum, can not retain moisture, consequently, vegetation suffers quickly from drought during dry periods.

The phase is confined to narrow strips in the Columbia and Wenatchee Valleys.

The type occurs mainly on steep slopes separating level terraces. Both surface drainage and underdrainage are excessive. The greater part of the phase is still covered with a growth of sagebrush. This soil has little agricultural value, since it is too porous and droughty for dry farming, and too steep and gravelly for irrigation.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Ephrata fine sandy loam:

Mechanical analyses of Ephrata 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.	<i>Per cent.</i>
551430.....	Soil.....	1.7	5.7	4.0	25.9	36.4	21.8	4.6
551431.....	Subsoil.....	5.6	9.0	5.0	25.6	30.8	20.6	3.8

MALAGA STONY FINE SANDY LOAM.

The surface soil of the Malaga stony fine sandy loam consists of pale-red to reddish-brown or dull-red fine sandy loam containing a quantity of well-rounded gravel and boulders. The red tint, which is most pronounced when moist, frequently gives way to a dull-brown color when dry. The subsoil, beginning at a depth of about 12 inches, is a brown fine sandy loam with a decided reddish cast, containing a large proportion of waterworn gravel and cobblestones, the quantity of which increases with depth until at about 6 feet the material is a porous bed of sand, gravel, and boulders. In places boulders are lacking on the surface and the soil is a gravelly fine sandy loam. The type has a firm surface. The content of organic matter is moderate.

The Malaga stony fine sandy loam occupies a number of areas along the Columbia River. The largest ones lie at Malaga and between this place and the south boundary of the county. Another narrow area about 3 miles in length extends down the river from Zena.

This type occurs on nearly level to gently sloping terraces 50 to 300 feet above the Columbia. The surface is usually smooth, although in the southern part of the county it is marked by depressions characteristic of a glacial topography. In this vicinity the surface is also strewn with boulders 10 to 20 feet in diameter, which are undoubtedly of glacial origin. The greater part of the material giving rise to this type, however, is probably water laid, having been deposited by swiftly flowing streams. The gravel and larger cobblestones are composed principally of crystalline rocks, but the soils may overlie either granitic or basaltic bedrock. Owing to the porous structure, the underdrainage is usually excessive.

A small percentage of this type on the higher terraces near Malaga is under cultivation, and the rest is in sagebrush and bunch grass and used for pasture. The few irrigated orchards on the type look well, but the soil requires a great deal of water. Some tracts which at one time were farmed are now abandoned to sagebrush.

The land ranges in price from \$25 to more than \$100 an acre, depending on location and improvements.

The Malaga stony fine sandy loam is well located with respect to roads and towns and is favorably situated for irrigation. Little leveling is necessary to prepare it for the application of water, but the soil is so gravelly that large quantities are required to produce the best results. In some areas the expense of removing surface bowlders would be considerable.

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

Mechanical analyses of Malaga stony 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.	<i>Per cent.</i>
551428.....	Soil.....	2.8	5.1	2.1	18.2	34.9	36.0	0.9
551429.....	Subsoil.....	.3	1.7	1.2	15.7	53.4	24.2	3.4

CASHMERE STONY LOAM.

The Cashmere stony loam, as mapped in this area, varies widely in texture. Typically the surface soil consists of brown to dark-brown loam containing varying quantities of subangular fragments of basalt. The subsoil, to many feet in depth, is a mass of unassorted basaltic bowlders, ranging from a few inches to several feet in diameter, with but little fine interstitial material, a dark-brown loam. At the mouths of some of the canyons the type is a mass of large basaltic bowlders with very little interstitial material of any kind.

An important variation is found in the canyons of Stemilt and Squillchuck Creeks. Here there are a number of areas naturally free from stones and others that have had the stones removed. The soil here is deep and consists of a dark-brown heavy loam containing a small quantity of angular fragments of basalt. The organic-matter content is high. The structure is moderately compact and the moisture-holding capacity unusually favorable.

The type is confined to the narrow canyons in the southern part of the county, and occurs only in small bodies. As most typically developed it occupies recent alluvial fans at the mouths of canyons, but it is also found on fan-shaped areas along the base of hills and in narrow recent alluvial stream bottoms. The material composing the type is derived mainly from basalt, although there are a few included areas in which it has come from sandstone. The surface is usually smooth, with a gentle slope in the direction of the streams, and drainage is fairly adequate.

Probably less than 20 per cent of this soil type is under cultivation. The rest supports a growth of bunch grass, sagebrush, and shrubs. Apples are the principal crop. The orchards give large yields of

fruit of excellent color and quality. Alfalfa is grown to some extent, with yields of 3 to 5 tons per acre. Several fields are in native grasses and either cut for hay or used for pasture.

This type is not sold except in connection with larger areas of adjoining rougher soils.

Where the Cashmere stony loam is not too stony it is well suited to all the common crops of the region. It requires irrigation for best results, although when carefully worked the soil is retentive of moisture and can be used for dry farming. At least 50 per cent of the type is too stony for cultivation and is best adapted to grazing.

CASHMERE GRAVELLY COARSE SANDY LOAM.

The surface soil of the Cashmere gravelly coarse sandy loam consists of about 12 inches of brown to grayish-brown or dull-brown coarse sandy loam containing a large percentage of angular or sub-angular rock fragments from 2 to 6 inches in diameter. The subsoil is a light-brown to grayish-brown gravelly sandy loam of medium to coarse texture, underlain at depths varying from 3 to 5 feet by a mass of partly rounded gravel, cobbles, and coarse sand. On the upper part of some of the steeper alluvial fans composed in part of this soil and for short distances where the intermittent streams debouch onto the larger valley floors the surface is strewn with large granitic boulders, and the soil is in many places a grayish-brown coarse sand. Most of the material of this soil comes originally from granite. There are, however, a few included valleys south of Wenatchee, in which a small amount of sandstone material is found. Basalt fragments are also encountered in the type in this vicinity, although the soil in such areas is not considered typical. The soil is low in organic matter and is porous and leachy.

The Cashmere gravelly coarse sandy loam, though widely distributed in the survey, is confined to small bodies. Among the more prominent areas are those on the recent alluvial fans and in the narrow canyons near Wenatchee. The largest body, about one-fourth mile in average width and 5 miles in length, lies in Navarre Coulée. A number of bodies occur along the Columbia River, at Lakeside and at various other points along Lake Chelan, in Knapp Coulée, and in several places in the northeastern part of the area.

The type occupies recent alluvial fans of uniform slope and the floors of narrow canyons. The surface is smooth and sloping, the upper parts of the slopes being rather steep and the lower more gentle and in places almost level. The few intermittent streams that cross the type flow in poorly defined channels and overflow after heavy rains, depositing fresh material of rather coarse texture. Owing to the porous, leachy structure the soil dries out quickly, and underdrainage

is excessive. The surface requires very little leveling to prepare it for irrigation.

This type of soil is of minor importance. Probably one-half of it is under irrigation and the rest is still in sagebrush. The principal crops are apples, peaches, cherries, and alfalfa, all of which are grown for sale. Small patches of grapes, berries, potatoes, and corn are grown for home use. Where an abundance of water is available for irrigation, good crops are obtained, but the soil requires frequent and copious irrigation, and the supply of water for some of the fields is insufficient to give the best results. For this reason alfalfa is rarely cut from orchards, although 3 good cuttings are obtained where the crop is grown alone.

Except near towns, where the type is held at a high figure for home sites, the value is rather low.

The soil is deficient in organic matter, and the yield of all crops is greatly increased by plowing under alfalfa or applying barnyard manure. The type seems especially well adapted to peaches, grapes, small fruits, and vegetables. With an abundance of water it gives good results with apples and alfalfa.

CASHMERE LOAMY SAND.

The Cashmere loamy sand consists of about 12 inches of micaceous brown or dull-brown loamy sand, overlying a brown or dull-brown sandy loam or loamy sand subsoil of medium to coarse texture. The soil is low in organic matter, and both the surface and subsoil materials have a loose structure. At a depth of 3 to 5 feet the subsoil grades into light-brown medium to coarse sandy loam containing subangular rock fragments. In places gravel occurs on the surface, but never in sufficient quantities to interfere with cultivation. The material from which the type is derived comes almost entirely from granite.

This type is of small extent, the soil true to type being confined to four small areas near Olds, Sunnyslope, Zena, and about 1 mile north of Monitor.

A few small areas of gravelly loamy sand occurring along Icicle Creek near Leavenworth and a few in the upper part of Entiat River Valley are shown on the soil map as of this type. They do not belong to the Cashmere series, however, and have been included in this survey because of their very small extent. They are essentially like the Springdale soils, but since no Springdale loamy sand was mapped they could not be combined with the Springdale.

The topography of the Cashmere loamy sand is gently sloping and smooth, the surface being favorable for irrigation. The body near Sunnyslope occupies a stream bottom. The type is cut only by shallow channels of intermittent streams that overflow their banks after

heavy rains. Owing to its porous structure the soil quickly absorbs water and the overflows are decidedly beneficial. Although the underdrainage appears to be excessive, the soil retains moisture well and seems to require no more water than the sandy loam member of the series.

The native sagebrush growth has been removed from practically all the type, and the land is now under irrigation and utilized in the production of apples. Alfalfa is grown in most of the orchards and cut once or twice for hay. The trees on this type are thrifty and yield about the same as those on the Cashmere sandy loam.

The Cashmere loamy sand has a high value because of orchard development and the favorable location with respect to roads and towns. It is adapted to the same range of crops as the Cashmere sandy loam and requires the same treatment for its improvement.

The following table shows the results of mechanical analysis of a sample of the soil of the type:

Mechanical analysis of Cashmere loamy sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551446.....	Soil.....	8.7	19.7	9.9	32.2	14.5	11.7	3.5

CASHMERE SANDY LOAM.

The surface soil of the Cashmere sandy loam is a brown sandy loam from 12 to 24 inches deep, the average depth being about 18 inches. The upper subsoil consists of a brown and somewhat compact sandy loam, grading into brown sandy loam containing coarse sand and small angular fragments of gravel. In many places the substratum consists of a mixture of angular gravel or broken rock with a small proportion of fine material. Typically gravel is not present on the surface, though it may occur locally. The soil is well supplied with organic matter.

Although most of the areas of Cashmere sandy loam are small, they are widely distributed and sufficiently numerous to form in the aggregate a rather large acreage. The most important areas occur on the recent alluvial fans within or near the city of Wenatchee. Important bodies lie at various points along the Wenatchee River, the principal ones being near Monitor, Cashmere, and Dryden. Other areas occur on the south side of Chelan Butte, in Knapp Coulée, and at various points within the Entiat Valley.

The Cashmere sandy loam consists of poorly assorted material which has been swept down the narrow canyons in times of flood and

deposited in sloping fan-shaped areas on the floors of the larger valleys. In many places the type occupies strips along the foot of hills, and in such locations the surface has considerable slope. As mapped the type includes colluvial and recent alluvial deposits in the narrow canyons. The only streams passing through the type are intermittent in character and have poorly defined channels which are easily overflowed. Many of the drainage courses follow slight ridges that have been formed by successive depositions of material, and the gentle slope of the land away from these insures excellent surface drainage. In some instances drainage is excessive, owing to the porous structure of the deeper subsoil.

The Cashmere sandy loam is one of the most important and highly developed soils in the area surveyed. Originally it was covered with sagebrush, but the greater part of it has been cleared and brought under irrigation. Apples are grown commercially on probably 90 per cent of the cultivated acreage. Cherries, pears, peaches, and apricots also are grown for market. Alfalfa is sown in most of the orchards, and there are a few fields devoted exclusively to this crop. Yields of apples vary greatly with the treatment given the orchards. Where the soil has received sufficient water and has been given the benefit of a cover crop and not more than one cutting of hay has been removed the yields average about 800 boxes per acre. For the entire type the yields range from 400 to as much as 1,000 boxes per acre. Other fruits yield equally as well. Alfalfa gives 1 to 1½ tons at each cutting. The land is handled in about the same way as the Wenatchee sandy loam, except that in the more gravelly subsoil areas a little more water is used in irrigation.

The price of orchards on this type is high, many of them being held above \$1,000 an acre.

In common with the other soils of the valley, the Cashmere sandy loam responds readily to good treatment. With careless management, under which the soil loses its humus, the yield decreases and the general condition of the trees is impaired. In general, there is no greater difference in yields obtained from orchards on different soils than in yields obtained from orchards on the same soil type under different methods of treatment. The record of yields for 6 years from two Ben Davis apple orchards, one grown under clean cultivation on Wenatchee loam and the other with alfalfa as a cover crop on Cashmere sandy loam, shows the great advantage of a cover crop over clean cultivation. The orchards on Wenatchee loam under clean cultivation averaged 10.2 boxes per tree annually, while the orchard in cover crop on the Cashmere sandy loam averaged 19 boxes per tree annually.⁷ The alfalfa in this instance was not cut for hay.

⁷ Information furnished by P. S. Darlington, District Horticultural Inspector.

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

Mechanical analyses of Cashmere 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.	<i>Per cent.</i>
551444.....	Soil.....	4.1	16.2	9.7	27.0	14.9	20.7	7.6
551445.....	Subsoil.....	1.7	12.7	10.6	30.9	18.7	17.9	7.6

CASHMERE FINE SANDY LOAM.

The surface soil of the Cashmere fine sandy loam consists of a brown fine sandy loam containing a moderate to good supply of organic matter, with an average depth of 18 inches. The subsoil consists of a brown sandy loam, sometimes slightly compact, carrying a small quantity of coarse sand and angular gravel. The substratum, to a depth of 6 feet or more, is composed of strata of gravelly sandy loam, sandy loam, and gravelly sand. In some places the surface soil resembles the Ritzville soils and may possibly include a small proportion of wind-borne material. The type also resembles the Wenatchee fine sandy loam, but is distinguished from it by the presence of gravel and the absence of the compact layer in the subsoil.

The Cashmere fine sandy loam is very inextensive. Small areas occur a little northwest of Wenatchee, west of Olds, near Monitor, Cashmere, and Malaga, and in the valley of Icicle Creek south of Leavenworth.

Most of the areas occupy gently sloping recent alluvial fans. The larger area occurring south of Leavenworth lies on the alluvial bottoms of Icicle Creek but is not overflowed. The surface is smooth, requiring little preparation for irrigation. Owing to the favorable structure of the subsoil, most of the type has good natural drainage. Because of its small extent it has only a local importance. Most of the areas are under irrigation and used in the production of fruit. The same crops are grown and the same cultural methods used and practically the same results obtained as on the Cashmere sandy loam. The area in the Icicle Creek bottoms, owing to its favorable position is being successfully farmed without irrigation. Wheat, corn, and hay are grown, the yields comparing favorably with those obtained on many of the irrigated soils. Owing to its peculiar topographic position, at the opening of Icicle Creek canyon, the temperature is usually too low in this area for best results with fruit.

The land of this type has a high value, especially near towns.

The Cashmere fine sandy loam has many desirable features. It is well located with respect to towns and roads and is adapted to the

production of fruit, alfalfa, and the general farm crops of the region. It is easily worked. Being well drained, it dries out early in the spring and is especially well suited to potatoes, berries, and early truck crops.

The following table gives the results of mechanical analysis of a sample of the soil of this type:

Mechanical analysis of Cashmere fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551466.....	Soil.....	3.7	9.1	5.4	29.6	32.6	16.3	3.5

NARCISSE COARSE SANDY LOAM.

The surface soil of the Narcisse coarse sandy loam consists of about 12 inches of medium to dark brownish gray coarse sandy loam containing sufficient fine material to give it a loamy texture and a moderately compact structure. The subsoil is similar to the surface soil in color, texture, and structure to a depth of 5 or 6 feet. Below this depth there occurs in places a coarse, loose-structured material. In the larger areas both the soil and subsoil are free from gravel or stones, but where the type occupies coulées and narrow canyons small granitic fragments are commonly present on the surface, while the upper margins of many of the fans and canyon slopes are strewn with boulders. The soil is low in organic matter. In general it is friable, and, considering its coarse texture, it is surprisingly retentive of moisture.

The largest body of Narcisse coarse sandy loam occurs at Manson, where it occupies a fan-shaped area extending south from Alkali Lake down to Lake Chelan. Several small fan-shaped areas occur in this vicinity. Small elongated bodies are also found along Antwine and Chumstick Creeks and in the Entiat River Valley.

Typically the Narcisse coarse sandy loam occupies recent alluvial fans, but some recent alluvial flood plains in the narrow valleys are included. In this area the soil material is derived entirely from granite. Portions of the type near Manson have the appearance of being beds of old glacial lakes, and it seems probable that at one time several small lakes occupied the depression leading from Alkali Lake to Lake Chelan. In the lower part of these depressions drainage is imperfectly developed, and small areas show traces of alkali, but the type is for the most part well drained. The surface is smooth, with gentle, uniform slopes requiring no leveling for irrigation.

Originally the type supported a vigorous growth of sagebrush and various grasses. The greater part along Lake Chelan is now cleared

and under irrigation. It is used in the production of apples and alfalfa. Apples are the leading crop. Most of the orchards are in alfalfa, which is usually cut once or twice for hay. There are also a few rather large fields devoted exclusively to alfalfa. Three cuttings are usually made, yielding 1 ton to 1½ tons or more per acre. The alfalfa is used for feeding work stock and dairy cows. Many of the orchards on this type are just coming into bearing. The trees are vigorous and give promise of becoming heavy producers. Only a small proportion of the type in other sections of the area is farmed, its only use being for grazing.

Orchard tracts on the Narcisse coarse sandy loam are held at a high figure. Undeveloped areas can be bought for \$15 to \$25 an acre.

The Narcisse coarse sandy loam requires irrigation for profitable development, and where this can be supplied it is well adapted to fruits, alfalfa, and the general crops of the region. The few small areas showing traces of alkali are in need of better drainage and would be benefited by heavy applications of barnyard manure. The entire type would be improved by the plowing under of alfalfa.

Narcisse coarse sandy loam, heavy phase.—As mapped in this survey, the heavy phase of the Narcisse coarse sandy loam varies considerably in color and texture. Typically it consists of an upper layer, about 10 inches thick, of dark brownish gray fine sandy loam or loam of high organic matter content and a subsoil layer of dark brownish gray compact fine sandy loam, loam, or clay loam extending to a depth of 6 feet or more. The material throughout the profile is gritty owing to the presence of some coarse sharp sand. Coarse material constitutes the greater proportion of the material in the substratum. In places where the content of organic matter is high the moist surface is black.

Soil of this phase is confined to two small areas near Lake Wapato. The larger of these occupies an elongated depression, apparently the bed of a former lake. A part of the other area is still flooded by Lake Wapato during the winter and spring. The sides of the depressions slope gently toward the center, and the lower parts are poorly drained. Near the shore of the lake alkali salts have accumulated in injurious quantities.

The Narcisse coarse sandy loam, heavy phase, has little agricultural importance at present, only a small proportion of it being under cultivation. Alfalfa is grown in a small way with good results, but the greater part of the land, which is still covered with a thick growth of native grasses, is used as pasture for dairy cows. With irrigation the soil should be well suited to alfalfa.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Narcisse coarse sandy loam :

Mechanical analyses of Narcisse 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.	<i>Per cent.</i>
551455.....	Soil.....	8.6	28.6	4.9	14.5	12.1	25.4	6.1
551456.....	Subsoil.....	9.0	28.3	9.6	15.1	13.6	19.1	5.3

LEAVENWORTH SANDY LOAM.

The material of the Leavenworth sandy loam, to an average depth of about 2 feet, consists of dark-brown to black sandy loam containing a large quantity of organic matter. Below this, to a depth of several feet, is a dark-brown to black sandy loam of somewhat more gritty texture than the surface soil and containing varying quantities of fine, partially rounded gravel. In places the surface soil extends to depths of 40 inches or more, and here the lower part of the profile is somewhat more compact.

The Leavenworth sandy loam is confined to small areas, but is widely distributed through the survey. It occurs for the most part in long narrow strips on alluvial fans, at the foot of hills, or on the floors and lower slopes of narrow canyons. The most important areas are in Bender Canyon west of Cashmere, in Williams Canyon near Dryden, and along Chumstick Creek north of Leavenworth. A small area is mapped south of Monitor.

Typically the Leavenworth sandy loam consists of recent alluvial fan material derived principally from granite. As mapped in this area it includes recent alluvium in stream bottoms and colluvial material along the sides of narrow canyons. In a few instances narrow strips of residual material on the upper part of the slopes, which were too small to be differentiated, have also been included. As a rule, the stream-bottom areas are somewhat lighter colored and coarser textured than typical. Except in a few low areas along the streams, the type is not overflowed, and in general the sloping surface gives good drainage. The greater part of the type is easily prepared for irrigation, although on some of the steeper slopes care is necessary to prevent erosion.

The native vegetation consists of small trees and shrubs. A large proportion of the type in Bender Canyon is cleared and used in the production of apples. Most of the rest of the land is uncleared and used as pasture. Water for irrigation is available on a part of the type, but many of the orchards are unwatered. The yield of fruit from

irrigated orchards compares favorably with those obtained on any of the better soils of the valley. Somewhat smaller returns are obtained from the dry-farmed areas.

The land has a wide range in value, depending on the improvements and nearness to towns.

The Leavenworth sandy loam seems well adapted to fruit and the other common crops of the region. Irrigation is desirable, though not necessary for profitable crop production. With an abundance of water, the type is especially well adapted to the production of alfalfa.

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

Mechanical analyses of Leavenworth 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.	<i>Per cent.</i>
551451.....	Soil.....	8.4	14.4	6.6	22.5	11.8	24.4	12.1
551452.....	Subsoil.....	7.2	14.6	8.0	23.0	12.3	24.2	10.8

LEAVEN WORTH FINE SANDY LOAM.

The surface soil of the Leavenworth fine sandy loam consists of a very dark brown or black, friable, micaceous and rather heavy fine sandy loam extending to a depth of 12 to 18 inches. The subsoil is a very dark brown or black, micaceous fine sandy loam or loam, grading at 24 to 30 inches into a grayish-brown, sometimes mottled, micaceous clay loam, containing some medium sand, coarse sand, and angular granitic gravel. Both the soil and upper subsoil contain a large quantity of organic matter.

The extent of this type is small. The largest and most important areas lie near Leavenworth and in the extreme southwestern corner of the survey. Smaller areas are developed around Dryden and Peshastin.

The type occupies smooth, gently sloping alluvial fans and comparatively low basinlike areas at the foot of hills. The surface requires practically no leveling to prepare it for irrigation. The sloping fans have good drainage, but drainage in the lower areas is slow.

Owing to its small extent this type is of little agricultural importance, although most of it is cleared and under irrigation. A variety of crops, including orchard and small fruits, vegetables, small grains, and alfalfa, are being grown both for sale and for home use. Wheat yields 15 to 20 bushels per acre, potatoes 100 to 150 bushels per acre, and other crops in proportion.

A gravelly variation of this type is mapped just north of Leavenworth. Here the surface and subsoil material contains a large proportion of granitic fragments from one-half inch to 2 inches in diameter, the quantity in places being sufficient to interfere with cultivation. The area, which is shown on the soil map by gravel symbols, occupies a gently sloping fan at the base of a steep mountain composed of Rough broken and stony land, and the surface of the upper part of the fan is strewn with large granite boulders.

Another variation occurs in a small valley basin known as Camas Land, on the western boundary of the survey. The soil here is somewhat heavier in texture than typical, approximately a heavy loam or clay loam. It becomes sticky and plastic when wet, but breaks into a friable seedbed under favorable conditions of drainage and cultivation. This area occupies a smooth depression with gently sloping sides, surrounded by lighter textured soils containing many glacial boulders. It appears to be the bed of an old glacial lake, although the gently sloping sides are covered with typical colluvial or recent alluvial-fan material. An intermittent drainage channel runs the length of the area. It consists of a succession of deep holes which contain water the greater part of the year. The outer parts of the area are well drained, but in the lower central part the water table is less than 3 feet below the surface and even the upper subsoil is usually saturated.

The native vegetation in this area consists of coarse grasses, dock, and other weeds. About one-half of this body has been brought under the plow and is used in the production of small grains. On a small part of the remainder the wild grasses are cut for hay, and the rest of the land is used for pasture. Fair to good yields are obtained, depending on the season.

The areas of typical soil lying near the town of Leavenworth are held at a high figure.

The typical Leavenworth fine sandy loam in general is considered an excellent soil for vegetables and general farm crops. Parts of it are suitable for fruit growing. It has a high content of organic matter and a high degree of friability under irrigation, and the better drained areas warm up early in the spring.

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

Mechanical analyses of Leavenworth 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.	<i>Per cent.</i>
551453.....	Soil.....	1.9	4.6	4.2	26.2	19.7	32.7	10.9
551454.....	Subsoil.....	.6	3.7	3.4	22.4	20.5	31.8	17.6

BEVERLY SAND.

The surface soil of the Beverly sand consists of a light-brown to light grayish brown sand of fine to medium texture extending to an average depth of 12 to 15 inches. It is usually micaceous, low in organic matter, and loose and incoherent. The subsoil is similar to the soil, except that it contains a large percentage of waterworn gravel, the proportion increasing to a depth of 3 or 4 feet, where stratified beds of gravel and bowlders are encountered. Fine gravel sometimes occurs on the surface in small patches, and waterworn bowlders are embedded here and there in the surface soil, but rarely in sufficient quantities to interfere with cultivation.

Typically this soil is composed of water-laid material, but in this area some small bodies of wind-blown sands are included. The texture varies considerably within short distances, sand of fine, medium, and coarse textures sometimes occurring within the same field.

The Beverly sand is confined to comparatively narrow strips along the larger streams. The most important bodies extend more or less continuously along both sides of the Wenatchee River from Cashmere to within a short distance of the Columbia River. Small but important areas lie along Mission Creek, and along the Wenatchee River and Icicle Creek near Leavenworth. Small strips are also mapped on the Columbia at Wells.

This type is confined to first bottoms and low terraces along streams of perennial flow. The lower areas are sometimes flooded. The surface is smooth except for irregularities due to drifting and to old river channels. Surface and internal drainage are good to excessive.

Although the Beverly sand is of small extent, it has considerable agricultural value. Probably 50 per cent of it has been cleared of sagebrush, sumac, and other small shrubs, and placed under irrigation. Apples are the principal crop, and some peaches and a small quantity of pears are produced commercially. Alfalfa is grown among the trees as a cover crop, and alone in a number of fields for hay. While some alfalfa is sold, the greater part of it is fed to work stock on the farms. A small acreage of corn is grown for home use. On account of the low humus content fruit trees do not make a rapid growth on this type of soil, although orchards which have reached full bearing age are giving satisfactory yields. Alfalfa returns 2 to 3½ tons, and corn 15 to 20 bushels, per acre.

The Beverly sand is handled in much the same manner as the other soils in the valleys, except that on parts of it greater quantities of water are used for irrigation. Vetch is grown in a few of the orchards as a cover crop, but the practice is not common. None of the land is farmed without irrigation.

Undeveloped tracts of Beverly sand can be bought for \$25 to \$40 an acre. Lands in bearing orchards are held at \$250 to \$500 or more an acre, depending on the quality of the orchard, the location, and water right.

The Beverly sand responds readily to good treatment. In handling this soil an effort should be made to keep it under a cover crop, preferably alfalfa or vetch, as much of the time as practicable. These crops should be plowed under at regular intervals. This practice will in time render the soil more coherent and retentive of moisture and reduce drifting. Except where water for irrigation is abundant, alfalfa should not be cut for hay in orchards on this type, as the soil is rarely sufficiently productive to warrant the removal of both hay and fruit crops.

Beverly sand, gravelly phase.—The surface soil of the Beverly sand, gravelly phase, is a light-brown to light grayish brown incoherent sand of medium to coarse texture, containing varying quantities of waterworn gravel. The subsoil, beginning at a depth of about 12 inches, is similar to the surface soil, but the content of gravel increases with depth and at about 3 feet the material is a stratified mass of gravel, cobblestones, and sand. In this area the type appears to be composed entirely of quartz-bearing crystalline rock material. The area of the phase is small. Areas lie along the Wenatchee River near Monitor, along Icicle Creek south of Leavenworth, and on the Columbia 1 mile south of Wells. The type occupies first bottom or low terrace areas, and a part of it is subject to overflow. Owing to the porous structure of the underlying material the drainage is good except during periods of high water.

This soil has little agricultural importance. A few small patches have been cleared of sagebrush and are used in the production of alfalfa, strawberries, and vegetables for home use. It is poorly adapted to alfalfa. With copious irrigation it is fairly well suited to berries and vegetables, but the soil at best is only moderately productive.

Beverly sand, heavy phase.—The surface soil of the Beverly sand, heavy phase, as typically developed, consists of brown to light grayish brown friable fine sandy loam. As mapped it varies considerably in texture; near the streams it approaches a sandy loam, and in some of the old washes a gravelly sandy loam. The soil is micaceous and composed mainly of materials derived from crystalline rocks. The subsoil, encountered at a depth of about 12 inches, is a light-brown sandy loam of fine to medium texture containing varying quantities of waterworn gravel. This in most cases continues without material change to a depth of 6 feet or more, where it passes into a mass of water-rounded gravel and boulders, characteristic of the series.

The Beverly sand, heavy phase, is inextensive. Small bodies lie on the Columbia River near Chelan Station and southwest of Hugo. Other areas occur at various points along the Wenatchee River and along Mission and Icicle Creeks. The phase is confined to low terraces in the valleys, and some parts are subject to overflow. The surface is smooth and drainage is adequate.

This phase of the Beverly sand is of little importance. Probably not more than 25 per cent of it is under cultivation, the remainder being in sagebrush, sumac, and other small shrubs. There are a few commercial apple orchards, and alfalfa is grown for home use. None of the land is farmed without irrigation.

This land is held at \$25 to \$300 an acre, depending on improvements and location.

The Beverly sand, heavy phase, is easily prepared for irrigation, and when irrigated is well adapted to the common crops of the area. Adding organic matter to the soil improves its physical condition and increases crop yields. The land should be kept under cover crop as much as possible.

PASCO VERY FINE SANDY LOAM.

The surface soil of the Pasco very fine sandy loam is rather dark brownish gray or dark-brown very fine sandy loam, 12 to 18 inches deep, containing a relatively large proportion of silt and having the smooth feel of a silt loam. The subsoil consists of a gray or dark-brownish, friable, very fine sandy loam or loam also high in silt, extending without marked change to a depth of 6 feet or more. The type is low in content of organic matter, and when dry the surface of cultivated fields has a characteristic ashy appearance.

This soil type is of small extent. The largest area occurs near the mouth of the Wenatchee River. Others lie along the Columbia and near the town of Cashmere. They occupy terraces ranging in height from a few feet to 20 feet above the river. The surface varies from nearly level to undulating, with low, rounded swells and intervening hollows. The hollows are flooded every summer, as are all of the lower benches. In most of the lower areas the soil is marked by brownish-yellow iron stains, the effect of poor drainage. Some accumulation of alkali has occurred here. Except in the overflowed areas the drainage is sufficient.

The native vegetation is principally sagebrush and a rather coarse grass.

The type is unimportant agriculturally; only about 30 per cent of it is under cultivation. The rest, however, has considerable value as pasture. The crops grown are wheat, apples, and pears. Wheat is not always successful, as the soil receives insufficient moisture to enable the plants to make sufficient fall growth, and parts of the type

apparently contain too much alkali for this crop. Apples and pears give good results where drainage conditions are favorable.

The Pasco very fine sandy loam could be much improved by the addition of humus. The lower areas are in need of artificial drainage to hasten the removal of overflow water and to prevent the further accumulation of alkali. For best results this soil requires irrigation. With irrigation and drainage it should be adapted to the production of alfalfa, potatoes, berries, and tree fruits.

Pasco very fine sandy loam, heavy phase.—The surface soil of the heavy phase of the Pasco very fine sandy loam consists of a dark brownish gray, smooth, friable silt loam of rather heavy texture extending to a depth of 12 to 15 inches. The soil is high in humus and when wet is nearly black. The subsoil is a dark brownish gray friable silt loam extending to a depth of 6 feet or more, where it rests on beds of waterworn gravel.

Only three small areas of this phase are mapped in the area. All these occur along the Columbia, two near the mouth of the Wenatchee River, and the other about 2 miles west of Malaga.

The soil is composed of the finer river sediments deposited by back water from the Columbia in times of flood. It has a rather uneven surface, consisting of low, rounded swells with intervening depressions. The lower parts are flooded annually during the latter part of June or early in July, and the entire phase is more or less sub-irrigated during the period of high water in the river. Except when the river is at flood stage, drainage is fairly adequate.

This soil was originally covered with sagebrush and native grasses, but is now practically all under cultivation. The crops grown are alfalfa, corn, oats, and fruit. Alfalfa occupies about one-half the acreage. It is cut three times a year and yields $3\frac{1}{2}$ to 5 tons per acre per season. Corn yields 60 to 75 bushels per acre, but the greater part of this crop is used for silage, of which it yields 15 to 20 tons per acre. Oats cut green for hay yields about 2 tons per acre. The hay is used as a soiling crop and fed during the summer to dairy cattle. During the present season (1918) millet and peas were sown together, following the July flood, but the result was disappointing.

In handling this soil an effort is made to grow such crops as can be harvested before the midsummer flood. Oats are sown about March 15 and cut green for hay in June. Following the recession of the water the land is again plowed and seeded to oats or some crop that will mature sufficiently to be ready for harvest by October.

Owing to its small extent, the heavy phase of the Pasco very fine sandy loam is unimportant. It is exceptionally well suited to the production of corn, either for grain or silage, and is a satisfactory soil for alfalfa or oats. Because of the uneven distribution of moisture throughout the season, the greater part of the phase is not well adapted to fruit.

The following table gives the results of mechanical analysis of a sample of the soil of the typical Pasco very fine sandy loam:

Mechanical analysis of Pasco very fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
551462.....	Soil.....	<i>Per cent.</i> 0.4	<i>Per cent.</i> 0.4	<i>Per cent.</i> 0.4	<i>Per cent.</i> 13.4	<i>Per cent.</i> 41.7	<i>Per cent.</i> 39.4	<i>Per cent.</i> 4.6

RIVERWASH.

Riverwash consists of a mixture of coarse sandy material, water-worn gravel, and cobblestones, extending to a depth of several feet. In places the gravel and cobblestones constitute 90 per cent or more of the mass, while elsewhere a foot or more of wind-blown sand may lie over the gravel beds. The type is confined to narrow strips on the flood-swept banks, bars, and islands of the larger streams. It is mapped in various places along the Columbia, Wenatchee, and Chelan Rivers. During high water the areas are flooded to a depth of several feet. Riverwash has no vegetation, and during low water it is a barren waste, with practically no value for agriculture.

ROUGH BROKEN AND STONY LAND.

Rough broken and stony land, the most extensive type mapped in the present survey, covers 58 per cent of its total area. The type includes rough mountainous areas with deeply-dissected and in places precipitous slopes thinly veneered with stony soils whose continuity is broken in many places by extensive masses of rock outcrop. It includes also those areas so thoroughly dissected as to be too rough for agricultural use regardless of the presence or absence of stones. In the southern part of the county the rock is principally basalt, where for several miles the type forms a precipitous cliff between the lower lying Columbia River terraces and the tillable soils of the upland plateau. This cliff ranges from one-half to three-fourths miles in width, with a rise in elevation within this distance of 1,000 to 1,700 feet. West of Wenatchee the extensive area of Rough broken and stony land is predominantly of sandstone formation. On account of the rapidity with which this rock weathers, much of this region is maturely dissected by deep canyons, while the ridges and upper slopes show steep escarpments and castlelike exposures of sandstone. In places the weathering of the soft sandstone has proceeded so rapidly that it has gained sufficiently on the process of erosion to cover the rocks with a thin mantle of soil. Elsewhere the rock giving rise to this type is mainly granite, with local exposures of gneiss and schist. The soil material has a wide range in color and texture, and represents a number of the residual, glacial, and other soil series of the survey.

ROUGH MOUNTAINOUS LAND.

Rough mountainous land, as mapped in the Wenatchee area, includes a number of distinct conditions in soil and topography, which it was not practicable to separate upon the map because of their inaccessibility, rough topography, and the remote and doubtful possibility of their becoming useful agriculturally. This miscellaneous material consists of extensive rough mountain areas of shallow or stony soils, including small, isolated, widely scattered areas having comparatively smooth surfaces and deeper friable soils suitable for cultivation. Were it not for the presence of these small included areas of favorable soil and topography this material would be classified with Rough broken and stony land. The underlying rock consists of a massive basalt, and this rock outcrops or lies at very shallow depths over extensive areas. The fine surface soil material is mostly of wind-borne origin, and is identical with the Walla Walla very fine sandy loam. In places, however, the soil material is residual and not unlike that of the Underwood series. The soils are well supplied with organic matter, and where of sufficient depth are retentive of moisture.

Rough mountainous land is mapped only in the southern part of this survey where an extensive area extends east from the crest of the Wenatchee Mountains for a distance of about 12 miles to within one-half mile of the Columbia River. It varies in elevation from 1,000 to nearly 6,000 feet above sea level and is confined principally to mountain slopes and steep sides of canyons, the crests of the ridges being covered with the soil materials of the Walla Walla very fine sandy loam or of the Underwood loam. Drainage is invariably excessive.

The lower areas support a good growth of bunch grass, which is utilized for grazing cattle and horses; the elevated areas are covered with a valuable stand of timber, principally yellow pine. None of the type is cultivated. A few small patches are capable of being farmed, but they are widely scattered and remote from roads. The type as a whole has a low value and is mainly nonagricultural.

SCABLAND.

Scabland is confined to areas of geologically recent basaltic lava flow and associated basaltic rock terraces in eroded stream valleys and canyons. Usually the lava is but slightly weathered, or the soil material is removed by winds or by erosion as fast as it accumulates. The surface is less rugged than in the areas of the Rough broken and stony land or Rough mountainous land, but the surface in detail is frequently extremely rough and characterized by small flats or pockets of shallow soil material interspersed with areas of exposed bedrock and masses of angular basaltic fragments. The successive

steps or terraces are usually separated by steep or vertical walls of basalt. The soil material consists of brown fine to very fine sandy loam extending without material change to the underlying rock. The soil is usually shallow, but in small local patches it may exceed 6 feet in depth. On some of the lower terraces along the Columbia River the surface material contains varying quantities of waterworn gravel. The soil on the higher areas is mainly of wind-borne origin and finer textured than along the river. If the stone-free areas were of sufficient size they would be mapped with the Ritzville series.

Scabland occurs only in small bodies in the southern part of the area. It is confined principally to ridged or uneven-surfaced terraces along the Columbia River, but small areas occur in the hilly section southwest of Malaga. In the latter locality the type includes areas that would have been classified as Rough broken and stony land but for their small extent. The terraces lie 100 to 300 feet above the river and are separated from the stream by steep basaltic cliffs. The ridges on the terraces are formed mostly by outcrops of basalt. Owing to the sloping surface and the shallow depth of the soil, the drainage is excessive and the land droughty.

The areas of Scabland have practically no value for cultivated crops, although in some places it would be possible to develop small patches of soil between the masses of rock outcrop if water for irrigation were available. At present water for this purpose is not available, and it is doubtful whether the small areas would justify the expense of such development. The greater part of the Scabland is covered by a good growth of bunch grass which gives it a certain value for grazing.

IRRIGATION.

Irrigation has been practiced in parts of the Wenatchee Valley for 35 years, though it has been only within the last 22 years that any acreage of consequence has been watered. In fact it has been only 15 years since irrigation water reached the present intensively developed orchards at Wenatchee. During the last 10 years irrigation water has also been supplied to extensive orchard tracts at Manson, Wenatchee Heights, and at various points in the Columbia Valley.

The Miller Ditch, the first built in the area, was established at Cashmere in 1883 and is still operated under this name. The year 1896, however, marked the real beginning of irrigation construction in the Wenatchee Valley. During this year the Gunn Ditch was established and the ditch built which originally covered the Warner Flat near Cashmere. Following this, construction was rapid, the High Line Ditch, covering 9,000 acres, reaching Wenatchee in 1903. The reason for the rapid construction at this time was the fact that

transportation facilities had just been provided by the completion of the Great Northern Railway (1899), and that the marked adaptability of the valley soils to the production of fruit under irrigation had but recently been demonstrated. Rapid extension was also favored by the facts that the land was easily prepared for irrigation and that the Wenatchee River afforded an abundant water supply which could be cheaply applied by gravity.

The High Line Ditch is the largest and most important ditch in the county. The diversion is made from the north bank of the Wenatchee River about three-fourths mile above Dryden. From this point it skirts the foothills along the north side of the valley to the eastern part of Sunnyslope, where it is piped southward underground, crosses the Wenatchee River about 1 mile above the Columbia, continues southward near the hills, and waters the large semi-circular flat at Wenatchee. For the most part it flows in an unlined ditch, with wooden flumes where it crosses draws, and with one rather long tunnel opposite Monitor. At times serious damage is caused by the banks giving way, and some of the weaker places are now being lined with concrete.

The Gunn Ditch takes its water from the north bank of the Wenatchee River at Monitor and flows down the valley at a lower level than the High Line. Both ditches cross the Wenatchee River on the same bridge, the Gunn Ditch paralleling the railroad and watering the lower part of the flat as far south as Wenatchee. The Monitor section and parts of the Cashmere district are watered by the Olive Ditch, which flows well up on the slopes along the south side of the valley, and the Jones-Shotwell Ditch, which follows down the river at a lower level. The greater part of the upper valley is watered by the Icicle Ditch, which is diverted from the south bank of Icicle Creek several miles up the granite gorge. The water is piped across the Wenatchee River to supply the orchards on the north side of the valley between Leavenworth and Peshastin. Mission Creek Valley is irrigated from a ditch which obtains its water from an intake in Mission Creek about 4 miles south of Cashmere. About 400 acres are irrigated on Wenatchee Heights with water secured from a reservoir in the mountains.

These ditches irrigate a total of over 15,000 acres of fruit of which over 11,000 acres are located between Wenatchee and Cashmere.

Nearly 2,000 acres are irrigated at Malaga with water pumped from the Columbia or obtained from other sources. About the same acreage is under irrigation along the Entiat Valley and at Wagnersburg and Winesap. The water for the Entiat Valley is obtained by gravity from the Entiat River, while the other localities obtain their water by pumping from the Columbia. Pumping is also done from the Columbia to water small acreages at Chelan Falls, Hugo, and Wells.

Nearly 2,000 acres are under irrigation at Manson and along the shores of Lake Chelan. Considerable water is obtained from Wapato Lake, the level of which has been raised several feet by the construction of a dam across the natural outlet at the north end.

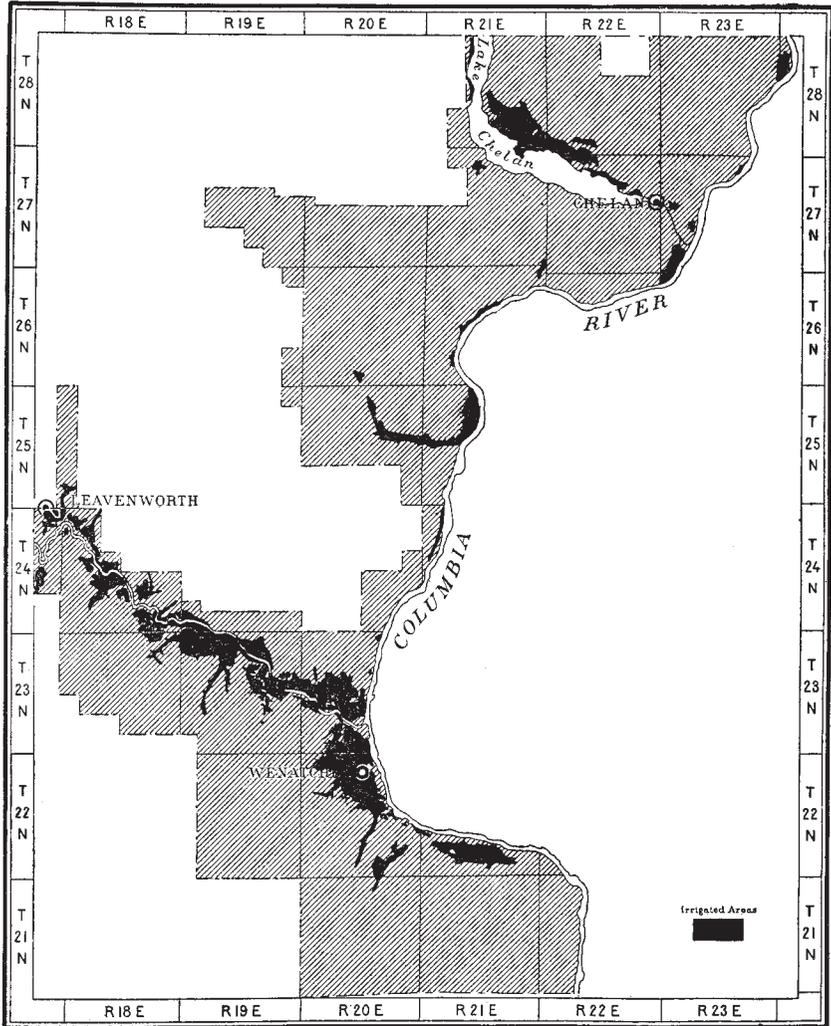


FIG. 2.—Sketch map showing location of the irrigated areas.

Excepting Wapato Lake, whose waters are slightly brackish, the irrigation water used in Chelan County is of excellent quality. Most of it is derived from melting snow, and, if properly utilized, is ample for a much larger acreage than is now being watered. Owing to topography, however, practically all of the land suitable for irrigation in the county has now been reclaimed. The sketch map (fig. 2) shows the areas under irrigation.

The quantity of water used varies with the supply available, the character of the soil and subsoil, and whether or not alfalfa is harvested from the orchards. In some cases where the supply is short, only one-half miner's inch is applied. On most soils this has been found insufficient to permit cutting alfalfa from among the trees. Throughout the greater part of the valleys where water is supplied by gravity ditches, somewhat larger quantities are used. The length of the irrigation season is about five months, or from the middle of April to the early part of September.

Excepting small gardens, practically the only crops irrigated in Chelan County are fruit and alfalfa. In orchard irrigation the furrow system is used entirely, four to six furrows, from 4 to 6 inches deep and about 3 feet apart, being made between tree rows. Owing to the favorable natural slopes little leveling is required before the original application of water, and most of the fields are irrigated now with a minimum of labor.

SUMMARY.

Chelan County is located in the north-central part of Washington. The Wenatchee area includes the eastern part of the county, or all that part not included within national forests. It comprises practically all the territory within that county that is suitable for agriculture. It covers 579 square miles, or 370,560 acres.

The area surveyed is a region of marked physiographic contrasts consisting of rugged mountain ranges, plateaus, and sharply outlined valleys. Although these mountain masses are distinct in the area surveyed, they are in reality outlying spurs of the Cascade Range. For the most part they lie between elevations of 1,500 and 4,500 feet above sea level. The principal valleys are those of the Columbia, Wenatchee, and Entiat Rivers, and the basin of Lake Chelan. They are rather narrow, and lie between elevations of 600 and 1,100 feet.

The area is drained by the Wenatchee, Entiat, and Chelan Rivers, which flowed southeastward into the Columbia River. The Columbia River extends for 70 miles along the eastern boundary of the area.

The principal towns are Wenatchee, Leavenworth, Cashmere, and Chelan.

Transportation is provided by the main line of the Great Northern Railway, which crosses the area through the Columbia and Wenatchee Valleys, and by a branch of the same line that runs up the Columbia River from Wenatchee.

The principal markets for fruit are Chicago, St. Louis, and New York. In normal times large shipments are made to England, Australia, and South America.

The climate is pleasant and healthful. The mean annual precipitation at Wenatchee, in the valley, is 13.93 inches; it is somewhat

greater in the hills. Its distribution is favorable for growing crops under irrigation but is unsuited to dry farming. In general the climate is favorable to the production of fruit, especially apples.

The agriculture is confined principally to the irrigated valleys and consists chiefly of the production of fruit. Apples are the principal crop. They are grown almost entirely under irrigation, and their culture in this area represents a highly scientific form of agriculture.

The values of the irrigated orchards are high, but appear to be warranted by the large investments and by the returns.

The soils of the area are of two general groups, residual and transported. The residual soils are derived from two kinds of rocks, igneous and sedimentary. The igneous rocks comprise basalt, granite, gneiss, and schist. The basalt rocks give rise to the Underwood and the Waha series of soils, and the last three named to the Methow series. The sedimentary rocks consist principally of sandstone, which gives rise to the Huckleberry series.

The transported soils are of three kinds, wind-laid, ice-laid, and water-laid. The wind-laid soils consist of wind-blown material giving rise to the soils of the Quincy series, and wind-borne material giving rise to the soils of the Ritzville and Walla Walla series.

The soils composed of ice-laid materials are correlated in the Lick and the Peshastin series.

The water-laid soils include (a) old valley-filling soils, (b) recent alluvial fan soils, and (c) recent stream-bottom soils. The first group includes the Wenatchee, Springdale, Ephrata, and the Malaga series. The Wenatchee series is one of the most important in the area. The soils of the recent alluvial fans comprise the Cashmere, Narcisse, and the Leavenworth series. Of these the Cashmere and Narcisse are very important series. The soils of the recent stream bottoms include the Beverly and the Pasco series, which are of small extent.

In all there have been recognized and differentiated upon the soil map a total of 30 individual soil types with 11 subordinate phases, representing 18 distinct soil series; in addition to which there are 4 types of miscellaneous materials, mainly of nonagricultural character.



[PUBLIC RESOLUTION—No. 9.]

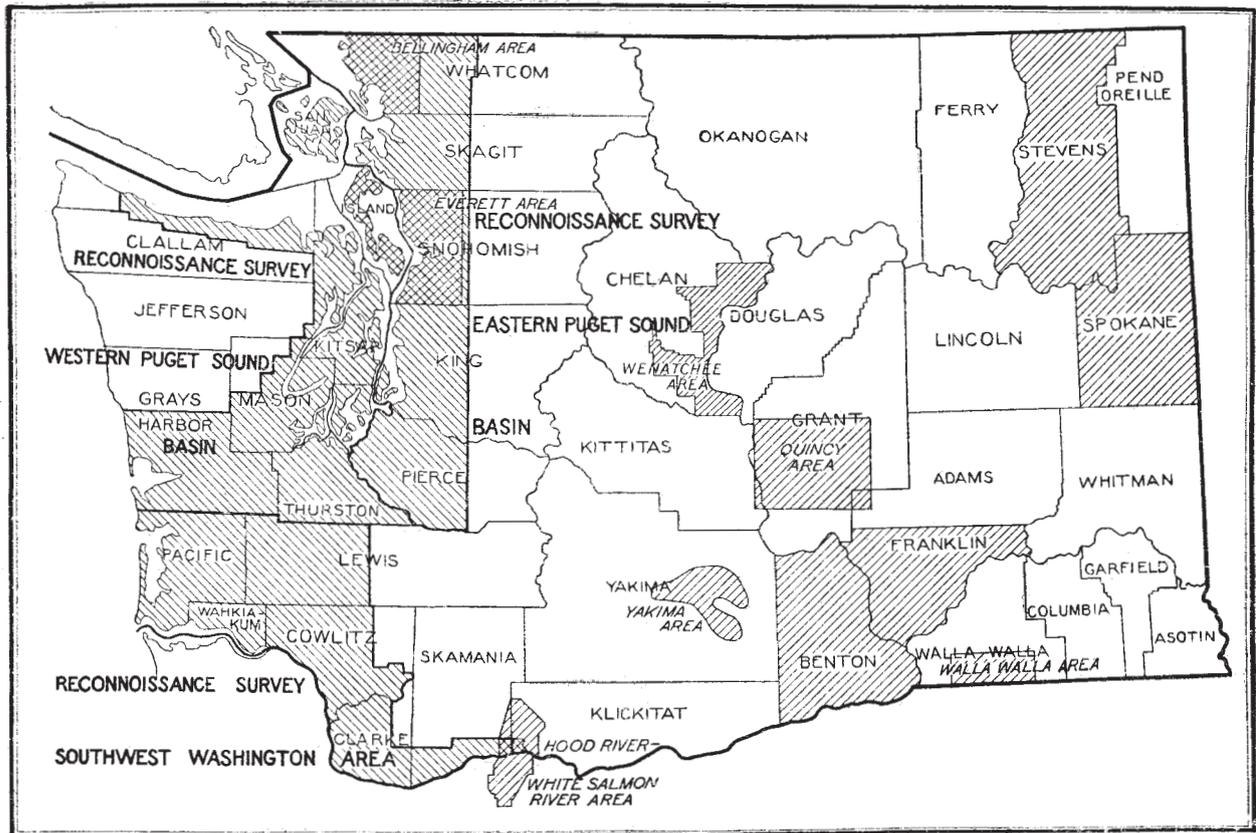
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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 Washington, shown by shading.

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