

Issued January 13, 1917.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE STATE OF WASHINGTON, ERNEST LISTER,
GOVERNOR; HENRY LANDES, STATE GEOLOGIST.

SOIL SURVEY OF FRANKLIN COUNTY,
WASHINGTON.

BY

CORNELIUS VAN DUYN, IN CHARGE, AND J. H. AGEE, OF THE
U. S. DEPARTMENT OF AGRICULTURE, AND FRED W. ASHTON,
OF THE WASHINGTON GEOLOGICAL SURVEY.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1914.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1917.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., March 18, 1916.

SIR: During the field season of 1914 a soil survey was made of Franklin County, Wash. This work was done in cooperation with the State of Washington, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this area and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1914, as provided by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

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MAP.

Soil map, Franklin County sheet, Washington.

SOIL SURVEY OF FRANKLIN COUNTY, WASHINGTON.

By CORNELIUS VAN DUYN, In Charge, and J. H. AGEE, of the U. S. Department of Agriculture, and FRED W. ASHTON, of the Washington Geological Survey.

DESCRIPTION OF THE AREA.

LOCATION.

Franklin County, Wash., is in the southern part of central Washington, north of the junction of the Columbia and Snake Rivers. It includes all or parts of 43 townships, and has a total area of 1,229 square miles, or 786,560 acres. Its extreme length from east to west is 56 miles, and its greatest width from north to south, 37 miles. The meridian of 119° west longitude and the parallel of $46^{\circ} 30'$ north latitude intersect near the center of the county.

Except on the north, the geographical boundaries of the county are natural ones. The Columbia River, which forms the western boundary for about 50 miles, separates Franklin from Benton County; the Snake River, which flows along the southeastern boundary a distance of about 60 miles, separates this county from Walla Walla County; and the Palouse River separates it from Whitman County on the east. The county is bounded on the north by Adams and Grant Counties, the boundary following the township line between townships 14 and 15 north, from the Palouse River westward to the line between ranges 27 and 28, where it turns southward for 4 miles, and then extends westward to the Columbia River.

The base map used in platting the soils of Franklin County was compiled from United States Geological Survey sheets, United States Reclamation Service sheets, and United States Land Office plats. The marks for the majority of the original section corners are not in place, and the resurveys do not always check with the original survey, so that it is often difficult to keep an accurate location. The base map shows the roads, railroads, towns, streams, schoolhouses, and occupied houses.

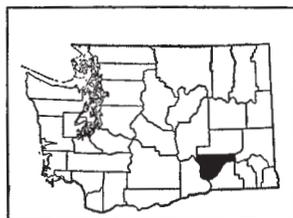


FIG. 1. Sketch map showing location of Franklin County, Wash.

PHYSIOGRAPHY.

Franklin County lies within the physiographic and geologic province known as the Great Plains of the Columbia River,¹ extending from the Cascade Mountains on the west to the Blue Mountains on the southeast, to the Bitterroot and Coeur d'Alene Ranges on the east, and to the Okanogan Highlands on the north. The term "plain," however, in a literal sense is not applicable to parts of this county, nor to local areas in other parts of the general province. Within this vast area there are several types of topography, all of which are represented in this county, and which are similar in having a native vegetation of sagebrush and bunch grass, with no timber

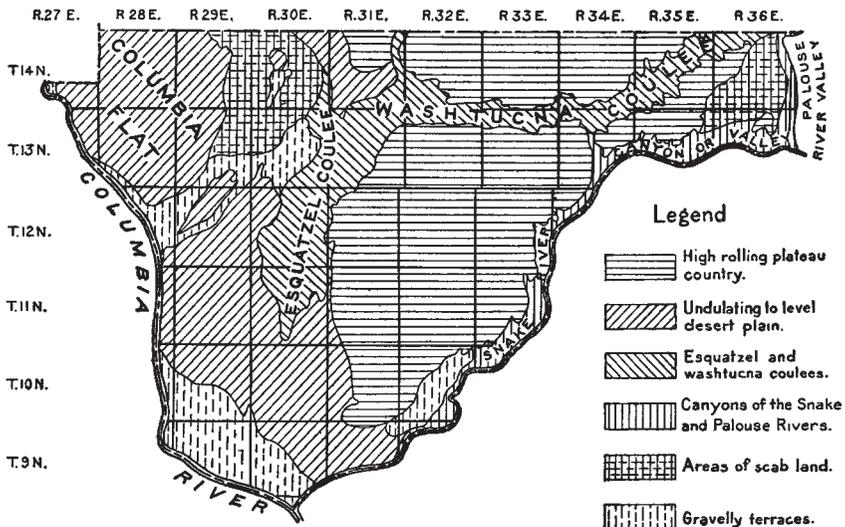


FIG. 2.—Sketch map showing physiographic divisions.

growth, a moderately high elevation, and a substratum of basaltic rock.

In general the Esquatzel Coulee² may be considered the line between what might be termed the desert plain on the west and the high rolling plateau on the east. For descriptive purposes the county may be divided into six physiographic divisions, (1) the high rolling plateau country, (2) the undulating to level desert plain, (3) the Esquatzel and Washtucna Coulees, (4) the canyons of the Snake and Palouse Rivers, (5) the areas of "Scabland," and (6) the gravelly terraces. The accompanying sketch map shows the location and approximate extent of these divisions (fig. 2).

¹ Geology and Water Resources of a Portion of East-Central Washington, by F. C. Calkins, U. S. Geological Survey. Also Geology and Water Resources of a Portion of South-Central Washington, by G. A. Waring, U. S. Geological Survey.

² The term "coulee" is here used as locally understood.

The high rolling plateau country.—The high rolling plateau is the western continuation of the well-known "Palouse country" of southeastern Washington and the adjoining parts of Idaho. In this county it occurs east of the Esquatzel Coulée and the Connell Northern branch of the Northern Pacific and north of the sand-hill section. The topography ranges from rolling to hilly and the region includes a large number of drainage ways. These are usually narrow, steep-sided, V-shaped draws, and small valleys, which unite to form coulées at lower elevations. Many of the drainage ways have been cut through the fine-earth mantle into the bedrock beneath. They carry no water, except after a sudden thaw of snow, and have resulted from erosion under more humid climatic conditions. The largest of these are Smith Canyon and Rye Grass Coulée, both of which join the main Esquatzel Coulée Valley near Eltopia. In general, the elevation of this division is greatest in the north and west. It ranges from about 800 to 1,800 feet above sea level.

The undulating to level desert plain.—Extending northwestward from the Snake River near its junction with the Columbia River and lying west of Esquatzel Coulée and the Connell Northern branch of the Northern Pacific there are several high-lying flats, separated by areas of Scabland and gravelly terraces. These constitute the division referred to herein as the undulating to level desert plain. One of these flats, known as Columbia Flat, occupies more than three townships in the northwestern corner of the county. A large part of this flat is covered with wind-blown sands, and has a choppy to undulating topography. The eastern continuation of Saddle Mountain, a long, narrow ridge extending eastward from the Columbia River, lies to the north of this flat. Its gentle southern slope merges gradually with the slope of the Columbia Flat, while to the east the ridge gradually sinks to the level of the plain.

A small flat north of Koontz Coulée, and Owens Flat, covering more than a township immediately south of this coulée, are practically all in cultivation.

These flats range from 900 to 1,200 feet in elevation and rise gradually toward the north. They are bounded by steep escarpments of semiconsolidated material, where they break away toward the lower surrounding areas of Scabland and terraces. Facing the Columbia River there is a long, steep escarpment, extending from the northern county line to a point 15 miles northwest of Pasco. The drop in elevation is 500 or 550 feet within a distance of one-fourth to one-half mile. This escarpment is known as the "White Bluffs," and is one of the most marked topographic features of south-central Washington.

The Esquatzel and Washtucna Coulées.—Washtucna Coulée enters the county near the northeastern corner, extends southwestward to

Kahlotus, and then westward to Connell, where it joins the Esquatzel Coulée. Beyond the northern boundary of the county it swings to the east and joins the valley of the Palouse River, a large gravel bar with a thin mantle of soil forming the divide between them. The total length of the Washtucna Coulée in this county is about 30 miles. Its width at the bottom is from one-fourth to one-half mile and its rocky sides rise either precipitously or by terraced slopes to a height of 200 to 350 feet above the bottom. The width of the top, or the distance between the areas of upland, ranges from 2 to 4 miles. Near Connell the coulée widens and has quite extensive areas of gravelly terraces. No tributary coulees or draws of any size enter it from the south and only a few join it from the north.

The Esquatzel Coulée enters the county from the north near the line between ranges 31 and 32, extends southward to Connell, where it is joined by the Washtucna Coulée, and then turns southwestward to Mesa. At this point it again turns southward, and in the vicinity of Sagemoor its rocky sides disappear beneath the fine-earth mantle. The course of this coulée, or valley, may be said to continue until it emerges on the gravelly plain a few miles north of Pasco. Below Connell the coulée is more properly a continuation of Washtucna Coulée and might be included with it, thus limiting the Esquatzel Coulée to the part north of Connell. Such an interpretation, however, is contrary to the accepted limits of the two coulees. In width and depth of the coulée proper it is comparable with the Washtucna Coulée, but it has larger areas of Scabland and terraces on each side.

Another old channel extends from just east of Eltopia southward to the Snake River about 4 miles northeast of Pasco. This is as prominent a topographic feature as the Esquatzel Coulée below the town of Eltopia. Smith Canyon and Rye Grass Coulée are tributary to it near its head. Only a narrow gravel bar, covered with a thin mantle of soil, separates it from the Esquatzel Coulée. About a mile above Mesa the Esquatzel Coulée receives its only prominent tributary. This is a small coulée which has a more or less well defined course southeastward from the northern county line.

At Washtucna, less than a mile north of the county line and near the eastern extremity of the county, the bottom of the Washtucna Coulée has an elevation of 1,000 feet; at Kahlotus the elevation is 910 feet and at Connell 838 feet. At Mesa the elevation is 677 feet, at Eltopia 591 feet, and at Glade 493 feet. There is a greater fall between Connell and Eltopia, a distance of 19 miles, than between Washtucna and Connell, a distance of 30 miles. In places there is a well-defined stream channel, in others none. It is believed that there is in places a subsurface flow in the gravel which fills the coulée to some depth. Above Kahlotus is Harder Spring, which has a large constant flow throughout the year. This water follows a short chan-

nel to Washtucna Lake, a body of water about 2 miles long and one-half mile wide, which has no visible outlet, being retained by a gravel bar and wash from a long draw tributary to the coulée just below the west end of the lake. The water, like that from wells in Kahlolus, is slightly alkaline. Sulphur Lake, 8 miles east of Connell in the same coulée, is another lake of the same character, although there is no visible spring feeding it. The water doubtless is supplied by seepage from a long, narrow draw to the north. A number of other flats, or playas, occur throughout the length of both coulées. These usually are covered with water after a sudden thaw of snow in the surrounding hills. This water either seeps away through the underlying gravel or is evaporated.

The canyons of the Snake and Palouse Rivers.—The Snake River Canyon is one of the most prominent topographic features of southeastern Washington. From its junction with the Palouse River southwestward to near its junction with the Columbia River, a distance of nearly 60 miles, the Snake River flows with long, graceful curves some 500 to 700 feet below the level of the highest rock outcrops and from 700 to 1,000 feet below the rolling plateau or "wheatlands." A few miles above its junction with the Columbia River the canyon gradually becomes lower and the sides less rocky and precipitous. The especially rocky and irregular nature of the north side is due to the presence of a large number of tributary draws and coulées, the largest of which are Devils and McCoy Canyons. Only a few small areas of low river terrace occur, while small areas of higher terrace are quite frequent. The terraced character of the canyon is due mainly to outcrops of successive sheets or flows of basalt which have been cut through by the river. The elevation of the river where it enters the county is nearly 500 feet, and at its junction with the Columbia River about 350 feet. The Snake River has long reaches of deep, quiet water, separated by stretches of swiftly moving water and often by rapids.

In places the Palouse River traverses a more pronounced canyon than the Snake River, though one which is developed on a smaller scale. The river has an elevation of about 950 feet at the northeastern corner of the county and of nearly 500 feet where it joins the Snake River. The drop at Palouse Falls, near the middle of its course along the county line, is said to be over 150 feet. The canyon has no tributaries in this county. A few springs occur along the bluffs.

Areas of Scabland.—Two widely separated areas of Scabland, one in the eastern part of the county, the other a few miles northwest of Mesa, may be described, as they do not readily fall into the other divisions. Land of much the same character occurs in the last two divisions mentioned, but these areas are distinct from both the large coulées and the canyons of the rivers. The topography is level to

undulating and terraced. The terraces are due entirely to the level, sheetlike character of the upper rock surfaces. Rock outcrops, cliffs, and small canyons form the details of the general surface features. Skootenay Springs, or Eagle Lake, northwest of Mesa, is a well-known watering place. There are few springs, however, or areas of shallow water. There is no run-off from land of this character.

The gravelly terraces.—The areas of gravelly terraces have been distinguished from the areas of Scabland on account of the absence of rock outcrop, cliffs, and canyons. While the general topography is similar, the details furnished by rock outcrop are absent. The largest area of level to gently undulating gravelly terrace country occur in the vicinity of Pasco, on the Snake River Flat near Page, and northwest of Mesa. Surface drainage and draws are uncommon in areas of this character.

Although there are numerous drainage ways in Franklin County, few of them carry water, except immediately after sudden thaws. Over the greater part of the county there is no surface run-off, the water being removed by seepage and evaporation.

SETTLEMENT.

Although the earliest settlement in the county doubtless was made near the junction of the Columbia and Snake Rivers, the southern and western end of the long freight haul to Fort Colville, the Hudson Bay Co.'s post on the Columbia River in Stevens County, the activities of the company apparently did not affect later settlement. Permanent settlement dates from the establishment of Ainsworth, now Ainsworth Junction, about three miles east of the present town of Pasco and near the earlier settlement. Ainsworth was established about the time of the building of the Northern Pacific Railway, now the Walla Walla branch, across the Snake River into the county from the south, in 1871. Ainsworth was the terminus of this line for several years, and became the county seat when Franklin County was separated from Whitman County and organized in 1883. In 1884 the main line of the Northern Pacific Railway from Tacoma was extended across the Columbia River, and Pasco was established as its temporary western terminus. Connection with the line ending at Ainsworth and with the main line to the east was soon made. Pasco became the county seat in 1885. The Lewiston branch of the Northern Pacific Railway and the Connell Northern branch were soon constructed, and the Connell branch of the Oregon-Washington Railroad & Navigation Co. was completed in 1904, with Connell, formerly Palouse Junction, as its western terminus. There had been an earlier temporary line over nearly the same route. In 1909 the Spokane, Portland & Seattle Railway and in 1914 the Oregon-

Washington Railroad & Navigation Co.'s line across the eastern part of the county were completed.

Franklin County lies within the Northern Pacific Railway land grant, and only every other section was subject to homestead entry. The discovery that parts of the county were suited to the production of wheat and the promotion of irrigation schemes gave an impetus to settlement in 1901, 1902, and 1903. The settlers came from this and other States, mainly the North Central States. Nearly every desirable 160-acre tract of public land was filed upon, and much of the railroad land was sold at 50 cents to \$2.50 an acre. Some of the settlers remained only a few months, others long enough to prove up and to sell their claims; only a very small percentage of the original settlers remain.

POPULATION.

The 1890 census reports the population of Franklin County as 696. In the 1900 census it is given as 486, and in the 1910 census as 5,153. The figures for 1910, however, do not represent the maximum which was attained about 1904, nor do they give a correct idea of the present population, which is somewhat less than that reported in 1910. Deducting the population of Pasco from the total for the county, the density of population is about 2.5 per square mile. The present population has a wide distribution, and is densest in the country about Connell, and sparsest in the areas of sandy soils and of Scabland, or the western and southern parts of the county.

The population of Pasco, the county seat, is reported in the 1910 census as 2,083. This is by far the largest town in the county. It is a division point on the Northern Pacific Railway and an important railroad center for three branches and two main-line railroads. The development of the surrounding country has only begun, and is dependent upon the availability of water for irrigation. Pasco has an advantageous location near the junction of the Columbia and Snake Rivers, and upon the completion of the Celilo Canal and the establishing of navigation to the coast, it should become an important distributing center for a large area.

Connell, with a population of about 600, is the next town of importance. It is the southern terminus of the Connell Northern branch of the Northern Pacific and the western terminus of the Connell branch of the Oregon-Washington Railroad & Navigation Co. Its location in the central part of the county and in the center of a large wheat-growing area makes it a commercial center and shipping point of considerable local importance.

Kahlotus, in the eastern part of the county, on the Spokane, Portland & Seattle Railway and the Connell branch of the Oregon-Washington Railroad & Navigation Co., and Mesa and Eltopia,

in the central part of the county on the main line of the Northern Pacific Railway, are locally important as wheat-shipping points. A large area in the eastern part of the county is tributary to Wash-tucna, just across the county line in Adams County. Warehouses for storing and shipping grain are located at convenient points on all the railroads. Page and Snake River are post offices on the Snake River, and Ringold is a post office in the northwestern part of the county, on the Columbia River.

TRANSPORTATION.

The main line of the Northern Pacific Railway crosses the Columbia River at Pasco and follows the Esquatzel Coulée across the county in a north and south direction. The Lewiston branch of the Northern Pacific Railway extends along the north bank of the Snake River to the eastern boundary of the county. The Walla Walla and Pendleton branches of the same line leave the county near Ainsworth Junction, about 3 miles from Pasco.

The Spokane, Portland & Seattle Railroad enters the county over the Northern Pacific Railway's Columbia River bridge at Pasco, and uses, jointly with the Lewiston branch, the tracks as far as Snake River Junction, from which point the former continues along the river on a high grade and turns up Devils Canyon into Wash-tucna Coulée, following the coulée to the northern county line.

The Connell branch of the Oregon-Washington Railroad & Navigation Co. extends eastward from Connell through the Washtucna Coulée and connects with southeastern Washington and main-line Oregon-Washington Railroad & Navigation Co. points. The Connell Northern branch of the Northern Pacific Railway connects with points on the Chicago, Milwaukee & Puget Sound Railroad and on the Great Northern Railroad to the north. In addition, the Oregon-Washington Railroad & Navigation Co. has a line which crosses the Snake River near the eastern county line and follows the Palouse River for a distance of 7 miles, crossing into Whitman County. This line follows the south side of the Snake River nearly to its junction with the Columbia. The extreme northwestern corner of the county is reached from points on the main line of the Chicago, Milwaukee & Puget Sound Railroad or its Hanford branch on the west side of the Columbia River. Neither of these lines enters the county. There is a total of approximately 175 miles of railroads in the county, which is adequate for the present population and kind of farming.

A few years ago a line of boats operated along Columbia River, but at present there is but little water transportation. The Columbia River, upon the completion of the Celilo Canal at The Dalles, will be navigable from its mouth to Priest Rapids, 80 miles

or more above Pasco, and should become an important avenue of commerce. At certain seasons the Snake River is navigable to Lewiston, Idaho, and beyond, and the project of making it navigable at all seasons is under consideration.

The county roads are, except in a few sections, sufficiently numerous to meet the needs of the present population. Many of these roads are natural ones and have had no work done upon them. Northwest, south, and southeast of Connell they follow the section lines more closely than in other parts of the county. On the heavier soils the roads are in good condition during the greater part of the year. In the hauling season they quickly become bad and almost impassable. At this time the main roads usually are covered with a layer of straw, which greatly improves them. In the sandy sections of the county there are few roads, and no improved ones. Many of them are impassable for automobiles during a large part of the year. There is less than 10 miles of State road in the county. In areas where long hauls and long drives are necessary the elimination of steep grades, even at the expense of distance, should be accomplished.

Private ferries at White Bluffs, Hanford, Timmermans, and Pasco afford connection with Benton County and western points, and the Lyons, Snake River, and Pasco-Burbank ferries, the last a county ferry, give access to places on the south side of the Snake River.

Wheat is practically the only product exported from the county. The greater part of the wheat is shipped by rail to the Pacific coast ports and either milled there or sent by boat to California, eastern or foreign markets. The production of berries and fruit has not yet been developed on a commercial scale, except on a few of the older settled ranches along the river, and the surplus is marketed at home.

A mail boat runs daily between Pasco and Hanford, touching at intermediate points. A fairly adequate telephone service is maintained through nearly all the settled sections of the county. The country and village schools are very good. No rural mail routes are maintained in the county, as the settlement is too sparse.

CLIMATE.

GENERAL CONDITIONS.

Franklin County lies east of the Cascade Mountains, on the eastern slope of the Columbia River Basin, and ranges in elevation from about 300 to 1,800 feet above sea level. The high mountains west of the county intercept the moist winds from the Pacific Ocean, and the climate therefore resembles more closely that of the continental Interior than that of a coast State. Although not far from the Pacific Ocean and Puget Sound, the annual precipitation is low, and a part

of the area lies within what has been called the arid belt of the State. The county is subject to continental extremes of temperature, but not to the same extent as eastern Montana and the Dakotas, because of the protection from the north and east winds afforded by the Rocky Mountains.

The county is more subject to late spring and early fall frosts than western Washington, and the growing season is therefore shorter. But the number of bright clear days is greater both in winter and in summer, and this is some compensation for the shorter growing season.

PRECIPITATION.

The average annual precipitation for stations in and near the county is shown in figure 3. It varies from less than 7 inches along the Columbia Valley at Pasco to 10.7 inches at Ritzville, 17.6 inches at Walla Walla, and 22.4 inches at Colfax and Dayton. The maximum recorded for any year at Pasco is 9.92 inches, at Hatton 12.69 inches, at Ritzville 12.19 inches, and at Dayton 33.5 inches. The minimum for any year at Pasco is 3.58 inches, at Hatton 6.68 inches, at Ritzville 5.86 inches, and at Dayton 4.01 inches.

The very low precipitation of the county is accounted for by the fact that the air in its movement from the west loses most of its moisture in passing over the Cascade Mountains, the forced ascent causing a rapid cooling and consequent rapid condensation of the moisture content. Then, in descending the eastern slopes it is dynamically warmed by increasing pressure at lower levels, and its capacity for moisture rapidly increases, such conditions favoring clear skies and scant precipitation. As a result of the change in humidity the annual precipitation gradually decreases toward the Columbia River. As the air moves up the slope toward Spokane and the Blue Mountains it gradually cools again and, having gathered moisture in its descent, the humidity increases, causing a rapid increase in precipitation, as shown on the chart (fig. 3).

The monthly distribution of rainfall is irregular. The winter wet season, from October to March, and the summer dry season, from April to September, prevail, as a result of the proximity to the western coast, but the contrast between the two seasons is much less marked than in western Washington, and all the stations show a secondary maximum in May and June. The winter maximum is accounted for by the greater number and intensity of cyclonic storms in the winter and the further cooling of the air, already deprived of most of its moisture, as it moves farther inland. The early summer maximum is accounted for by the heavy showers and thunderstorms, with occasional so-called cloud bursts that occur as convectional summer storms following periods of bright, warm weather.

These storms bring the summer average up higher in proportion to the winter average than it is in western Washington. Farther east in the continental Interior the summer months have a greater total

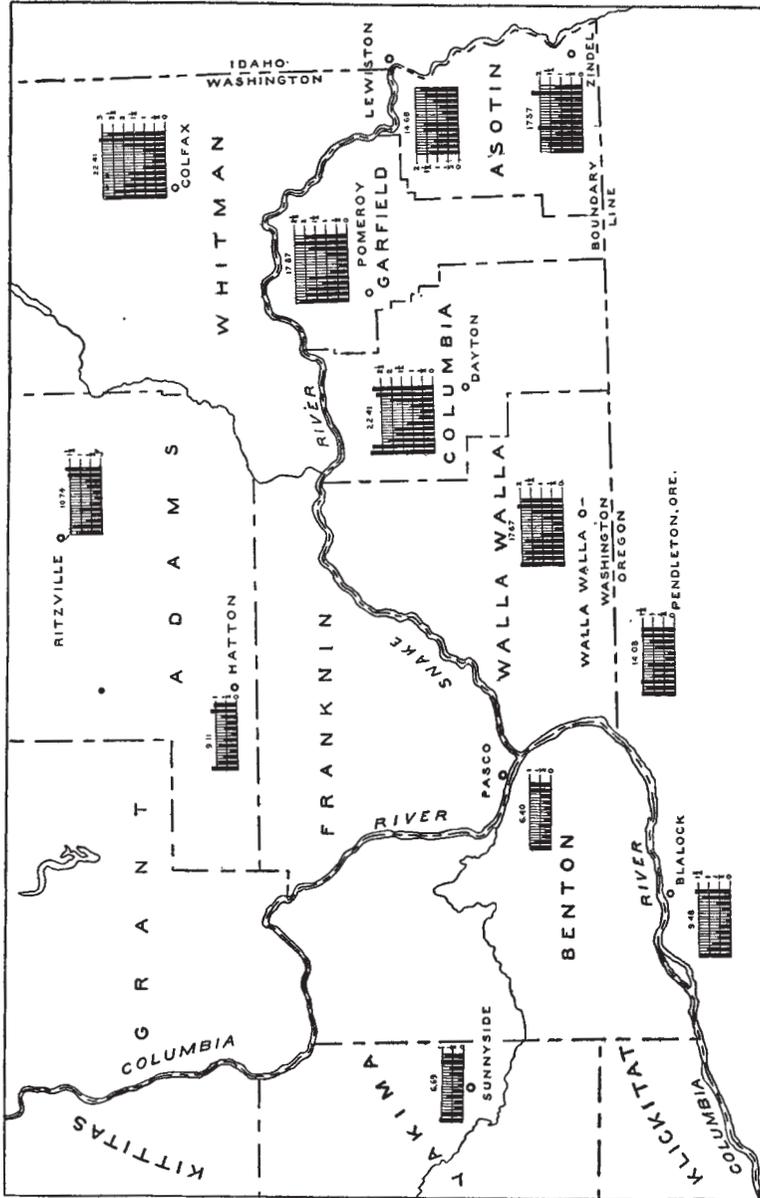


FIG. 3.—Average annual precipitation and monthly distribution.

precipitation than the winter months, owing to the effect of convectional storms. In this area, then, we find evidence of the two great controls of precipitation, the oceanic and cyclonic, with a marked

winter maximum, and the continental or convectional with a summer maximum, the former being more pronounced because of the proximity to the Pacific Ocean.

The average snowfall throughout the area varies from 10.8 inches at Kennewick and 14.4 inches at Hatton to 30 or 40 inches at the more easterly stations with higher elevations. The maximum annual snowfall varies from 19.5 inches at Pasco to 25.4 inches at Hatton and 72.3 inches at Dayton, but the snowfall may be as low as 2 or 3 inches. Generally, the snow remains on the ground for several weeks at a time during the cold period following the storm. Frequently, however, the storm center is so far north that the storm may be followed by a "chinook," or warm, dry wind from the southwest, in which case the snow rapidly melts. The snow acts as a blanket and prevents the freezing of roots of trees and plants. In melting it supplies moisture slowly enough to be readily absorbed and retained by the fine-grained, deep soil of many parts of the county. It is, however, unfavorable to grazing and the cattle-raising industry of this section of the State, and often causes considerable loss.

Another important factor in the climate of this area, especially for the ripening and coloring of fruits and the maturing of grains, is the large number of clear days. The average year of this section consists of 180 to 200 clear days, 70 to 90 partly cloudy days, and 80 to 100 cloudy days, and of these there are only 60 to 90 days on which precipitation of more than 0.01 inch occurs. There are usually about 250 to 290 days of each year with at least a few hours of sunshine.

TEMPERATURE.

The mean annual temperature varies from 54° F. at Pasco to 48° F. at Colfax. It shows only slight variation between different elevations, and does not differ greatly from the mean annual temperature of western Washington. But in the annual, monthly, and daily ranges of temperature this section differs decidedly from western Washington. At Pasco the annual range is 46°, or from 77° in July to 31° F. in January. At Hatton the range is 44°, or from 72° to 28° F. At Walla Walla there is a range of 40°, from 73° to 33° F. At Colfax the range is only 34°, from 65° to 31° F. In western Washington the annual range is only 20°, or from 60° to 40° F.

The records of the highest and lowest temperatures commonly show an absolute annual range of 110°, from 100° to -10°, and temperatures as high as 115° and as low as -21° have been recorded at Pasco. At Walla Walla the highest temperature recorded is 113° and the lowest -17°; at Hatton the highest is 109° and the lowest -26° F. But these extremes occur only in extended hot, dry spells in the summer and in cold waves in the winter, and on account of

the low relative humidity are not felt as they would be if the air were moist. During the warmest weather in the summer the evenings generally are cool and pleasant.

The occurrence of cold waves in the winter and warm waves in the summer is due to the presence of well-developed high-pressure areas central over the plateau and mountain country of Canada and northern United States and low-pressure areas to the south. This causes the air to move westward, bringing with it from the Interior the low temperatures of the winter and the high temperatures of the summer.

The daily range of temperature is high both in summer and in winter, but especially so in summer when the thermometer often varies more than 45° in the 24-hour period.

The following table shows the mean monthly, seasonal, and annual temperature and precipitation at Moxee in Yakima County:

Normal monthly, seasonal, and annual temperature and precipitation at Moxee, Yakima County, Wash.

| Month. | Temperature. | | | Precipitation. | | |
|----------------|--------------|-------------------|-------------------|----------------|-----------------------------------|------------------------------------|
| | Mean. | Absolute maximum. | Absolute minimum. | Mean. | Total amount for the driest year. | Total amount for the wettest year. |
| | ° F. | ° F. | ° F. | Inches. | Inches. | Inches. |
| December..... | 31.4 | 67 | - 8 | 1.11 | 0.52 | 0.59 |
| January..... | 29.8 | 59 | -28 | 1.48 | 0.75 | 7.39 |
| February..... | 34.4 | 71 | -22 | 0.97 | 0.51 | 0.44 |
| Winter..... | 31.9 | 71 | -28 | 3.56 | 1.78 | 8.42 |
| March..... | 42.2 | 76 | 2 | 0.58 | 0.15 | Trace. |
| April..... | 50.3 | 87 | 16 | 0.46 | 0.10 | 0.07 |
| May..... | 58.0 | 99 | 24 | 0.80 | 0.49 | 0.46 |
| Spring..... | 50.2 | 99 | 2 | 1.84 | 0.74 | 0.53 |
| June..... | 64.6 | 106 | 30 | 0.65 | 0.29 | 0.01 |
| July..... | 71.3 | 107 | 36 | 0.26 | 0.02 | 0.12 |
| August..... | 69.8 | 108 | 35 | 0.20 | 0.13 | 1.22 |
| Summer..... | 68.6 | 108 | 30 | 1.11 | 0.44 | 1.25 |
| September..... | 59.9 | 98 | 24 | 0.42 | 0.21 | 0.54 |
| October..... | 50.1 | 89 | 13 | 0.52 | 0.21 | 0.82 |
| November..... | 39.2 | 72 | -22 | 1.22 | 0.53 | 2.19 |
| Fall..... | 49.7 | 98 | -22 | 2.16 | 0.95 | 3.55 |
| Year..... | 50.1 | 108 | -28 | 8.67 | 3.91 | 13.75 |

Average date of first killing frost in fall, September 21; of last in spring, May 23. Date of earliest killing frost in fall, September 6; of latest in spring, June 14.

The explanation of the wide annual, monthly, and daily variation in temperature is found, first, in the very slight moderating influence the ocean winds exert here on account of being intercepted by the Cascade Mountains; second, in the fact that only the Rocky Mountains protect this region from the low winter and high summer temperatures of the continental Interior; third, in the fact that the air, having been deprived of most of its moisture in passing over the Cascade Mountains is usually at a low relative humidity, allowing very rapid radiation of heat by night and during the winter, and stronger heating by the sun's rays by day and during the summer, thus increasing the daily and annual range of temperature.

KILLING FROSTS.

From the dates at which the earliest and latest killing frosts in the fall and spring have occurred at different stations for the last 10 or 12 years, the average dates on which killing frosts may be expected have been worked out.

In general the extensive higher uplands are subject to frosts before the lower lying areas, but locally a smaller upland area or sloping land may be free from killing frosts, while the lower valleys are subject to heavy frost. This is especially true when the lower valley does not have good air drainage and the cold air from the higher divides and slopes settles and, collecting in the lowlands, favors frost.

The earliest frosts in the fall on the average occur in the eastern part of the area before September 15, but in the southwestern part they do not occur before October 15. The average date at Walla Walla is November 3. Frosts have occurred as early, however, as August 18 in the eastern part of the area and as early as September 25 in the western part.

The latest frost in the spring may be expected about June 1 in the eastern section and not later than April 28 in the western section of the county. Frosts have, however, occurred as late as July 1 in the eastern section and as late as May 25 in the western part.

This gives an average growing season of 140 days, from April 28 to October 15, in the southwestern part of the county, and 107 days, from June 1 to September 15, in the higher eastern part.

WINDS.

The winds of this section, owing to topographic irregularities, are somewhat irregular, but the prevailing direction is generally south, southwest or west. Only occasionally is there any wind from the east or northeast. They are the result of a well-developed high-pressure area over the mountains to the northeast of this county, and usually cause or accompany the cold waves of winter or the warm waves of summer.

The chinooks, common on the eastern slope of the Cascades west of the Columbia River, lose their typical characteristics here on account of the fact that by forced ascent the air becomes cooler and more humid. A wind from the southeast blowing over the Blue Mountains may be a dry, warm chinook, causing rapid melting of the snow and rapid evaporation in the winter.

Strong winds are quite common in the spring and early summer months, and often give rise to unpleasant and sometimes destructive sand and dust storms. In the late summer and the winter months strong winds are not common and winter blizzards are almost unheard of.

RÉSUMÉ.

The climate of this section shows characteristics of the three types—oceanic, continental, and mountain. The high temperatures of summer, the low temperatures of winter, the large number of clear days, and the secondary summer maximum of precipitation are all characteristics of the continental Interior. The winter maximum of rainfall and the fact that the extremes of temperature are not as marked nor of as long duration as farther east are evidence of the oceanic influence. The clear, dry, exhilarating air and the strong mountain winds are the result of the surrounding mountainous topography.

Although the low precipitation makes irrigation necessary for profitable crop production, the other climatic conditions are favorable for agricultural development.

AGRICULTURE.

Before the production of farm crops was undertaken this section of the State was included in a rich grazing region, where a luxuriant growth of nutritive bunch grass afforded abundant pasturage for horses and cattle. Like many other grazing sections, a scanty water supply was its greatest handicap. The Columbia River on the west, the Snake River on the southeast, Skootenay Springs and Crab Creek to the north, and Washtucna Lake and Harder Spring to the east were the only watering places for this extensive area of open country, which at one time supported large numbers of horses and cattle. In the unbroken country, the old trails leading to the watering places may be followed for long distances. Overgrazing, which was first felt in areas near the watering places, and the development of wheat farming caused a decline in the extent of stock raising, until now only land unsuited to cultivation on account of the nature of the soil, the topography or the droughty character, is devoted to open grazing.

When settlement began the land was classed as: (1) Government land, subject to homesteading in 160-acre tracts or to leasing; (2)

railroad land, comprising every other section or square mile in the county, subject to purchase or to lease; and (3) State land, comprising sections 16 and 36 in each township, subject to purchase or to lease. Within a few years after the beginning of settlement practically all the public land except the very roughest areas had passed into private ownership. In the wheat-growing sections most of the railroad land and State land had been purchased at a low price.

As every settler was required to clear and to have a certain number of acres in crops at the end of a given period in order to secure title to the homestead, practically every 160-acre tract of public land had at least a small clearing. The size of the clearings depended to some extent upon the means and good faith of the homesteaders and upon the character of the soil. They varied from a few acres to 160 acres in size and were devoted mainly to the production of garden crops and to grain. The crops from the smaller tracts were consumed at home; the grain from the larger clearings was either fed at home or thrashed and hauled to market.

In certain sections farming was successful from the very beginning. The soil was new and free from noxious weeds, and during a number of favorable seasons the acreage of wheat extended rapidly until nearly all the loamy soils of the county were in cultivation. In addition, large tracts of loose sandy soil and of rough droughty land were cleared and devoted to the production of grain. Attempts to farm such areas, however, resulted disastrously in most cases.

Gradually through failure of crops from one cause or another, the dissatisfaction of the farmers, the exhaustion of the limited resources of the average settler, and for other reasons the number of settlers and farms decreased. This was accompanied by an increase in the size of farms and in the acreage of wheat grown by the more successful farmers, through purchase or lease of adjoining land. The acreage in cultivation, however, has never equaled that of the period of greatest farming activity—about 1904—and many thousand acres, once producing crops, are now idle.

The data in the following table, giving the land in farms and improved land, and tenure of farms, are compiled from the census reports for 1890, 1900, and 1910:

Land and farm area and tenure of farms.

| Census year. | Total farms. | Area in farms. | | Improved land. | | Farms operated by— | | |
|--------------|--------------|------------------|---------------|------------------|---------------|--------------------|------------------|------------------|
| | | In all farms. | Per farm. | In farms. | Per farm. | Owners. | Tenants. | Managers. |
| | | <i>Per cent.</i> | <i>Acres.</i> | <i>Per cent.</i> | <i>Acres.</i> | <i>Per cent.</i> | <i>Per cent.</i> | <i>Per cent.</i> |
| 1890.... | 30 | 0.9 | 236 | 19.6 | 46 | 100 | ..... | ..... |
| 1900.... | 61 | 13.2 | 1,665 | 4.7 | 78 | 85.2 | 11.5 | 3.3 |
| 1910.... | 620 | 50.2 | 625.5 | 70.5 | 440.7 | 89.7 | 5.4 | 1.9 |

The table indicates that agriculture at censuses prior to 1910 was quite limited. It consisted of farming on the scattered homesteads. The acres per farm reported in 1900 (1,665) is either an error or is based on data which include in farms the extensive areas of public and railroad land leased for grazing purposes and not actually owned by the farmers. The decade between 1900 and 1910 shows a marked increase in settlement and agricultural development and really marks the beginning of the existing type of agriculture. Extensive settlement and development began in the early part of this decade, and reached a maximum about 1904. From that time until 1910 there was quite an exodus of settlers and a decrease in the acreage in cultivation and in crop production. From 1910 to the present time also there has been a gradual decline in farming activities. The census data, therefore, do not accurately represent the agricultural development of the county. In the 10 years from 1905 to 1915 the number of farms decreased and the size of farms increased; there was less change in that period in the total acreage in cultivation than the areas of abandoned land indicate.

The size of the farms is influenced by at least two main factors—the character of farming, viz, grain farming in a region where summer fallowing must be practiced, and the small size of the irrigated tracts. In the grain-growing sections of the county the size of farms ranges from 160 acres to three or four sections, with an average of more than a square mile. As a rule approximately one-half of this acreage is in wheat, the remainder in summer fallow. The size of the irrigated tracts varies from a few acres to 150 acres, with an average of about 25 acres.

The census reports a relatively high percentage of farms operated by the owners. There is, however, an extensive acreage of leased land in the wheat-growing sections of the county. This land is leased by the owners of both large and small farms from nonresidents, who own or control at least one-half of the grain land.

The farm water supply is a factor which has a great influence on agricultural development. Rivers with an abundance of water flow along the western, southern, and eastern sides of the county in channels from 500 to 1,000 feet below the surface of the dry-farming country. Aside from these there are no perennial streams, only three springs of any importance, and very few areas where shallow dug or surface wells occur.

Water for farm and household use was necessarily hauled from the rivers, springs, and surface wells by the early settlers. It was stored in large concrete cisterns in the ground. The time and labor required to provide a supply of water for home use in the case of the early homesteader was not prohibitive, but to haul for such long distances over steep and rough roads required too much time, and

became too expensive as farming operations developed. As a result deep wells now furnish water for the farms of a large part of the county. For the remainder water is hauled from surface wells in coulées, from springs, and from rivers, or is pumped directly from surface wells.

There are approximately 100 deep wells and 325 farmhouses in the higher lying sections of the county. Windmills supply the power for pumping the greater part of the year. Gasoline engines are used when the winds are too light or are infrequent.

No later agricultural data are available for Franklin County than those of the 1910 census. The following table gives an idea of the general character of the agriculture of the county, and, assuming that the year 1909 was an average one, of the production and value of the principal crops:

Acreage, production, and value of important crops and production and value of animal products of Franklin County reported in the 1910 census.

| Product. | Area. | Production. | Value. | Product. | Production. | Value. | | |
|---------------------------|---------------|-----------------|--------------|---------------------------------|----------------|-------------|---------|----------|
| Cereals: | <i>Acres.</i> | <i>Bushels.</i> | } \$809, 728 | All other crops | <i>Number.</i> | \$1, 240 | | |
| Corn | 121 | 1, 670 | | Animals sold and slaughtered .. | | | 19, 996 | 172, 008 |
| Oats | 1, 356 | 7, 234 | | Calves | | | 83 | |
| Wheat | 111, 059 | 947, 403 | | Other cattle | | | 546 | |
| Rye | 195 | 1, 775 | | Horses and mules | | | 437 | |
| Barley | 428 | 5, 384 | | Swine | | | 2, 678 | |
| Hay and forage: | | <i>Tons.</i> | } 104, 736 | Sheep and goats..... | 16, 252 | ..... |  |  |
| Alfalfa | 243 | 1, 252 | | Dairy products, excluding | | | | |
| Grains cut green... | 14, 909 | 6, 565 | | home use | | 19, 924 | | |
| Coarse forage..... | 58 | 34 | | Poultry and eggs..... | | 48, 544 | | |
| Special crops: | | <i>Bushels.</i> | } 3, 224 | Wool, mohair, and goat hair... | | 39, 061 | | |
| Potatoes | 179 | 8, 774 | | Total value | | 1, 203, 460 | | |
| All other vegetables..... | 28 | ..... |  |  |  |  |  |  |
| Fruits: | <i>Trees.</i> | | | | | | | |
| Apples..... | 2, 233 | 516 | | | | | | |
| Peaches..... | 2, 901 | 425 | | | | | | |
| Grapes..... | <i>Vines.</i> | <i>Pounds.</i> | | | | | | |
| | 6, 229 | 3, 800 | | | | | | |

Since 1909 there has been a decrease in the acreage devoted to all grains other than wheat and rye and an increase in the acreage of alfalfa, special crops, orchard fruits, grapes, and small fruits. This increase is due to the extension of irrigation. While no statistics have been officially published since the 1910 census was taken, an estimate, based on observation in the field, places the total area now producing crops under irrigation at 2,200 acres. This is confined to tracts comparatively near the Columbia and Snake Rivers.

The controlling factors in the selection of land for cultivation by dry farming are soil and topography. Other conditions, such as market and transportation facilities, have very little influence on

this kind of farming. In order to give an idea of existing conditions sketch maps or charts of selected townships (figs. 4 and 4A), typical of their respective parts of the county, have been prepared. These show the actual distribution of crops in widely separated sections, the classification being as follows: (1) All land in grain crops—wheat is the only crop grown, except rye in a few small tracts and vegetables in small patches near the farmhouses; (2) land in summer fallow, plowed in the spring, to be sown to wheat the following fall; (3) land formerly farmed to grain, but now supporting only a growth of weeds; (4) pasture land which covers unbroken areas and has a natural bunch-grass cover; (5) uncleared brush land which supports a medium to dense growth of desert shrubs; (6) irrigated land planted mainly to orchards and alfalfa.

One section charted embraces nearly the whole of T. 13 N., R. 28 E., which lies in the northwestern part of the county. It has a variety of soil types, including quite extensive areas of wind-laid sand. Comparison with the soil map will show that the uncleared areas are largely confined to the more sandy country and the abandoned land to the less sandy regions. It covers a part of the level to undulating desert plain and, topographically, is well suited to the production of crops. It is rather distant from markets and transportation facilities. The soils, as a rule, are too light for dry farming, as attempts to grow grain have proved. Rye is the only crop grown. Ten farmhouses are situated in this township and six of these are on the terraces near the river. Only one deep well occurs within the area. Over one-half the township supports a native cover of sagebrush. Nearly 40 per cent has been cleared and farmed at some time, but farming was generally unsuccessful. There is a small acreage of irrigated land on the river terraces and the foot slopes in the southwestern corner of the township.

Township 12 N., R. 32 E., is in the east-central part of the county. It lies within the wheat belt of the county and the principal soil type is the Ritzville silt loam. There apparently is very little difference between the soil of this township and that of the area in T. 14 N., R. 32 E. There is, however, a marked difference in topography. The valleys are comparatively narrow, deep, and numerous. The surface is rolling to hilly in contrast to the sloping to rolling surface of the country in the latter section. The location is not so favorable for crop production. As good crops are being produced by the best farmers in this township as in the area included in T. 14 N., R. 32 E., and the percentage of land too steep for farming is comparatively low. There are 10 farmhouses and 3 deep wells. The table shows that nearly one-half the township was formerly farmed to wheat, and only 28 per cent is now in wheat and 18 per cent in summer fallow.

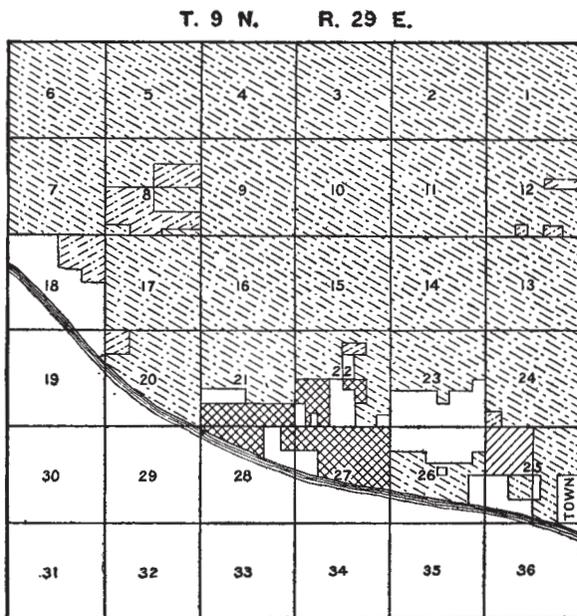
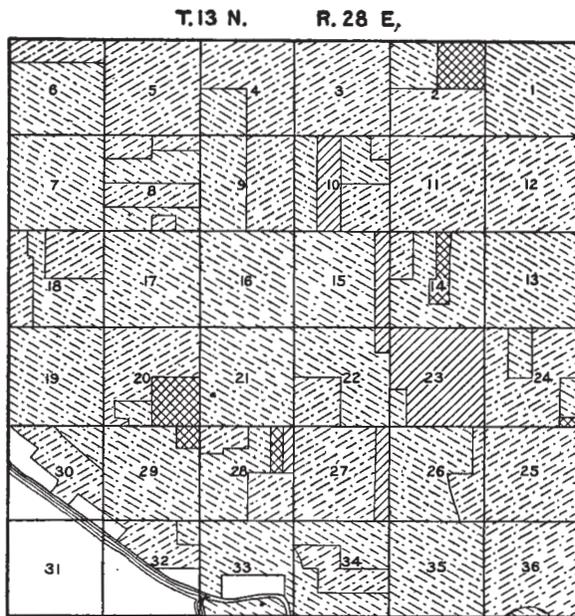
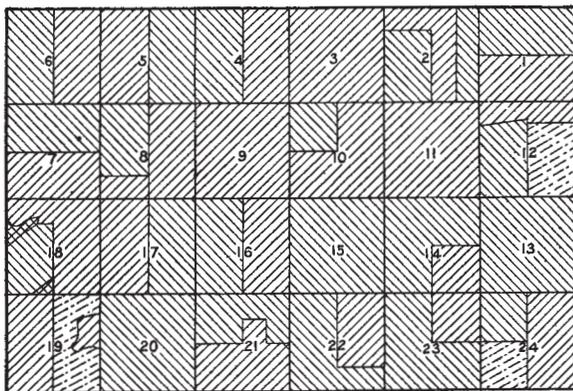


FIG. 4.—Classification of land according to present use in selected townships.

T. 12 N. R. 32 E.



T. 14 N. R. 32 E.



LEGEND

-  All sowed grains (wheat and rye)
-  Summer fallow.
-  Land formerly farmed to grain, now abandoned.
-  Pasture land, native grasses.
-  Land supporting medium heavy growth of desert-shrubs.
-  Irrigated land, mainly orchards and alfalfa.

FIG. 4A.—Classification of land according to present use in selected townships.

The part of T. 9 N., R. 29 E., within Franklin County, was also charted, to show use made of the land. The soils are for the most part wind-laid sands over the older sedimentary formations. They are too light and droughty for dry farming, and the table shows that only a very small proportion of the township has ever been dry-farmed and that that has since been abandoned. Over 83 per cent has its original covering of brush. The 7.6 per cent of irrigated land occurs within a belt of terraces along the Columbia River. There are 23 farmhouses, and these are mainly confined to this belt.

The 24 sections, northern part of T. 14 N., R. 32 E., embrace a portion of the wheat belt of the north-central part of the county. This section is well adapted to dry farming both as regards soil and topographic conditions. The Ritzville silt loam is practically the only soil type. Nine farmhouses are situated within this area, nearly all having deep wells. This is considered one of the best wheat sections in the county. Nearly equal areas are in wheat and summer fallow. The percentage of abandoned land and pasture is very low.

The following table gives the percentage area of the several divisions in the different townships or parts of townships covered in figs. 4, 4A.

Classification of land according to use in several widely separated parts of the county.

| Use. | Township. | | | |
|---------------------------|-----------------------|-----------------------|----------------------|-------------------------------|
| | T. 13 N., R. 28 E. | T. 12 N., R. 32 E. | T. 9 N., R. 29 E. | Part T. 14 N., R. 32 E. |
| | <i>Per cent.</i> | <i>Per cent.</i> | <i>Per cent.</i> | <i>Per cent.</i> |
| All sowed grains..... | 5.0 | 28.0 | 1.0 | 48.2 |
| Summer fallow..... | | 18.4 | | 47.1 |
| Land formerly farmed..... | 39.8 | 44.6 | 3.5 | 4.5 |
| Pasture land..... | 2.0 | 9.3 | 4.4 | .2 |
| Uncleared brush land..... | 52.0 | | 83.5 | |
| Irrigated land..... | 1.2 | | 7.6 | |

The acreage devoted to the production of wheat by dry-farming methods so greatly exceeds that of all other crops that a discussion of wheat growing practically describes the present agriculture of the county. From the beginning of the development of the high plateau and desert-plain sections wheat has been the leading crop. Reference to the preceding table and charts shows that this crop is grown extensively in the central and eastern parts of the county. Except in a few fields, no wheat is grown on soils coarser or lighter than a very fine sandy loam, and the silt loam is the favorite soil for the production of wheat by dry-farming methods on account of its good moisture-holding capacity.

By far the greater part of the crop is winter wheat. The varieties grown are the Turkey Red, Fife, Red Russian, Club, Bluestem, and a number of hybrids. The greater part of the crop is thrashed for grain, but a large acreage is cut green for forage.

In this section, as the precipitation of one season does not afford sufficient moisture for the production of a crop, it is necessary to conserve the moisture of an extra season. To accomplish this such methods as will control the moisture supply and at the same time reduce soil-blowing to a minimum are essential. The moisture supply is best conserved by having the soil in proper condition to absorb all the precipitation, to permit the water to sink to a moderate depth, and to prevent its loss through evaporation and through the growth of other vegetation.

The methods of farming in the wheat-growing sections conform more or less to this general plan. The successful methods used on the soils of heavier texture and higher organic-matter content in the region of greater precipitation to the east and southeast are modified to meet conditions in this section, where the moisture-holding capacity of the soil is lower and the tendency of the soil to blow greater. The land is plowed in the spring or early summer, is harrowed, and weeded sufficiently during the summer to keep the fallow clean and to provide a mulch to prevent evaporation of the moisture. The seed is sowed in the fall, usually after the first fall rains.

Modifications of this general plan are practiced by many farmers. In some cases the field is disked in the fall and in others in the early spring, before plowing. This breaks up the stubble and straw and mixes them with the soil, allowing the moisture to sink to a greater depth than where the surface is firm and fairly compact. It also makes plowing easier and hastens the germination of weed seeds. The breaking up of the stubble and straw by disking prevents the forming of a layer of low moisture-conducting capacity between the seed bed and the moist soil beneath.

The land is plowed to a depth of 6 to 10 inches with gang plows drawn by 4 to 12 horses. After plowing the practices again vary widely with the farmer and the tendency of the soil to blow. The general practice is to harrow and weed only enough to keep the fallow clear. When the surface is too fine and loose there is considerable danger of the soil blowing. The weeder is much more extensively used than the harrow, as the former has a knife or bar, which runs a few inches below and parallel with the surface, and either cuts off or pulls up the weeds. The surface is pulverized as little as possible in this manner. Scattered weeds are sometimes removed by hand. Subsurface packers are not used to any extent. It is an essential feature of dry farming in this section to destroy the weed growth. A Russian thistle growing on the fallow during

the summer will remove enough moisture for the growth of several wheat plants. These thistles grow abundantly and luxuriantly in all areas of plowed land.

In this section it usually is necessary to wait until after the first fall rains before seeding, in order that the surface soil may have sufficient moisture for the germination of the seed. When the wheat makes a good start in the fall the danger of destruction or injury by blowing is greatly reduced.

A few farmers harrow the wheat fields in the spring, in order to loosen the surface and form a mulch. This is done without damage to the wheat if the crop is well rooted.

In some cases instead of plowing for summer fallow the surface is deeply disked. This practice is common on soils of lighter texture, and leaves all the stubble and trash on the surface to aid in the prevention of blowing. This is not continued for more than two crops before the soil is plowed again. Another practice, which is often followed, is to allow the field to "volunteer." The grain remaining on the ground after the harvesting operations is either left on the surface or disked in. In favorable seasons this germinates and a good stand is often secured. In some cases additional grain is scattered on the surface before disking. The volunteer method does not, as a rule, give as high yields as fallowing, but the quality of the wheat is always good and the cost of production low. Thistles and mustard are usually much more abundant in crops grown in this way than in those grown by summer fallowing.

The wheat crop is either cut by headers and then stacked, or cut and thrashed at one operation by combined harvesters. In a few cases the wheat is headed and hauled directly to the thrasher. A very small acreage is cut with the binder. The grain is sacked and either hauled directly to the warehouse or stacked in the field.

A contract for the sale of the crop is often made before it is thrashed. Many of the farmers are forced to sell as early as possible in order to obtain money to meet obligations; others hold the crop for higher prices.

The yields of wheat have such a range that it is difficult to give the average for the wheat-growing section of the county. Farming methods and the season are mainly responsible for this range. The yields vary from a few bushels to 35 bushels per acre, the latter being exceptional. The average is probably about 10 bushels per acre, and this is the product of two years, as the land is idle, or in fallow, every other year.

The straw is either used for winter forage or left on the field to be plowed under to increase the organic-matter content of the soil. Very few farmers burn the straw. In some fields where thistles grow rapidly after the wheat is cut, they are burned over before plowing.

Wheat, both standing and in the stack, is insured against loss by fire. Large tracts have been destroyed by fires, which started in a number of ways. Great care is taken to prevent the spreading of fire before the wheat harvest.

Wheat and rye cut green furnish practically all the forage for the farm animals. A common practice is to cut a narrow strip around the wheat field, so that the combined harvester may be used without the destruction of large quantities of standing grain. The forage is stacked near the farm buildings for winter use. Wheat is also crushed and fed to farm horses during the working season. Large quantities are fed to hogs when the price of wheat is not high.

The acreage devoted to the production of rye is very small. This crop is grown mainly in small tracts near the farm buildings for pasturage. It is chiefly a volunteer crop, and is grown in the sandy sections to some extent. It is either cut for hay or pastured; only a small percentage is thrashed for the grain. Rye seems to require less moisture than wheat, and is more successful on the sandy and droughty soils in certain sections of the county. It takes the place of grass pasture, which in the wheat lands is found only on steep slopes.

Other grain crops are of minor extent. Oats and barley give fair to low yields. They are produced only for use on the farm. The land is prepared in the same way as for wheat. These crops produce lower yields and are less profitable than wheat. They are not grown under irrigation.

Only a few fields were devoted to corn in the season of 1914. Small varieties are planted, and these do not always mature seed. The crop does best where planted on summer fallow of the previous season, rather than on summer fallow land to be followed by seeding of wheat in the fall. Clean cultivation is practiced. The nights are rather cool during a part of the growing season for a good corn country, but with the acclimation of certain varieties it is believed that the crop will be profitably grown. The corn is somewhat injured by grasshoppers after wheat harvest.

Potatoes are not grown on a commercial scale. Their production is confined to small patches near the farm houses or to some situation where moisture conditions are favorable. Moderate yields of potatoes of good quality are obtained. The early varieties usually are planted. Under irrigation the production of this crop is much more certain and successful, and the industry promises to develop quite extensively with the extension of this kind of farming.

Vegetables are grown mainly for home use. In the wheat country the gardens are small and often neglected. Under irrigation the production of vegetables for local markets is profitable. It is probable that their production will become important as the country

develops. Watermelons and cantaloupes are not produced for shipping, but are grown for home use and local markets. Their production promises to increase with the extension of the irrigated area.

Attempts to grow alfalfa by dry-farming methods have been rather unsuccessful in this county. In a few places scattered plants indicate that the soil is adapted to the crop and that its production would be entirely practicable with a slightly greater moisture supply. The development of this industry in the wheat-growing sections would be of great benefit to the farmers, even though the yields were low. A few farmers are experimenting with small plots in garden tracts.

In the irrigated sections alfalfa is probably the main source of income. The soils seem to be well adapted to its production. Three cuttings and some pasturage are obtained. The yields range from 3 to 8 tons per acre per season. The crop usually is sown in drills without a cover crop, and is irrigated either by the check or gravity system. Liming is not practiced. The alfalfa hay finds a ready market in the adjoining wheat country and in near-by towns. Much of it is fed on the farm where it is produced.

With the extension of irrigation this crop will probably become one of the most important of the section. Both climate and soil are favorable to its successful production. It will find a ready market at good prices for feeding farm and range stock.

In nonirrigated sections fruit growing is confined to a few trees near the farmhouses for the production of fruit for home use. While it is not probable that fruit growing in the uplands will ever be developed on a commercial scale without irrigation, sufficient fruit for home use can be produced, with a surplus in some cases for market.

In irrigated sections the commercial production of fruit has not been extensively developed. A few orchards are in bearing and are producing good yields. Apples, cherries, and peaches are the principal fruits. A large acreage is in young orchards. The trees are making a good growth, and as a rule receive excellent care. In time certain sections of the irrigated land will doubtless develop into important fruit-growing centers. The industry along the Columbia River would be greatly aided by water transportation. At present the surrounding country and near-by towns constitute good markets for the greater part of the crop.

Crops of alfalfa, rye, berries, and vegetables are grown between the young fruit trees. Winter cover crops are not used to any extent. The interplanted crops are an important source of income in the younger orchards.

The success of the fruit industry in near-by sections, of similar character and climate, indicates that fruit in parts of the irrigated

area in this county should do well. At present the area in orchards in the county is not being extended.

A small number of English walnut and almond trees have been set out on one of the older ranches north of Ringold. These trees are making a vigorous growth and are producing good yields of nuts of excellent quality. More extensive planting, however, will be necessary to determine whether this industry can be developed on a commercial scale.

A few vineyards are in bearing and give good results. Table grapes and grapes for the production of grape juice are grown. The climate and soil seem to be well adapted to grape growing, which is being successfully developed in irrigated sections on the west side of the Columbia River.

The production of berries is not extensive. Some strawberries are grown, mainly in the young orchards. Berries of good eating and shipping qualities are produced. This industry is a source of considerable income in other irrigated sections, where further advanced, and will doubtless become important as this section develops.

At the present time the open range consists of areas of rough or sandy country, which have never been plowed. The extensive areas of land which were once farmed and are now idle afford very little grazing, as the bunch grass returns to the fields very slowly. Many such areas should never have been broken, as they were not adapted to dry farming. They support only a growth of weeds, which are a menace to surrounding farms. The native bunch grass is very nutritious. Overgrazing has reduced the value of much of the range land, which is now used for grazing large flocks of sheep, passing back and forth from the summer range in the mountains to winter quarters in this and near-by sections.

Cattle and horses, as a rule, are grazed within fenced areas; only a few are seen on the open range. Neither cattle raising nor horse raising is considered a special industry, although the latter has developed to some extent in the last few years, and a surplus of horses is now raised in the county. The animals graze on fields of native grass and on stubble land the greater part of the year and require very little care. On account of the scarcity of forage crops, it is probable that cattle raising will never become an important industry.

A branch of the live-stock industry which has been developed to some extent in the last few years is hog raising. Patches of rye, wheat, and weeds afford grazing, and wheat constitutes practically the only grain feed. When low or normal prices for wheat prevail, raising hogs by this method is profitable. In a few cases alfalfa is used as a range for hogs.

Poultry raising is not a special industry. Both the poultry and eggs are used at home, a small surplus being exchanged for household supplies at local stores.

Dairy farming has not been developed to any extent owing to the lack of forage crops and pasture land. Dairying will probably never be practiced extensively in the wheat country, but with the extension of irrigation it should become more important in the irrigated sections. Many of the farmers produce milk and butter for home use. At certain seasons of the year they have a small surplus to sell, and at other seasons they purchase dairy products.

Horses and mules are used as work stock. From 4 to 12 horses are used to haul farm implements and farm products. The grade of work animals is fair to good, as a rule, and is showing a gradual improvement. Comparatively little of the county is adapted to the present style of farm tractors and similar machinery.

There is considerable room for improvement in the character of the farm buildings. The early shacks are being replaced by better structures. The barns usually are small and inadequate for sheltering the stock and farm implements. The supply of the latter is usually adequate, and the implements are of improved style, but considerable money and time could be saved by giving them better care. The surroundings of the farmhouses could be greatly improved and made more homelike. Trees, mainly locust and fruit trees, have been planted around many of the houses, but others have no shade whatever. With proper care and attention to this matter, the farm homes could be greatly improved. The trees would not only afford protection from winds, but would also supply fruit for home use.

The task of clearing the land of brush is comparatively easy and inexpensive when compared with the clearing of forested regions. The usual method is to hitch a team to each end of a railroad rail and to haul it back and forth across the area to be cleared. The brush is then raked by a specially designed brush rake into windrows and either burned or hauled away for fuel. Brush has been cleared from many acres for fuel alone, particularly by the early settlers and homesteaders. The cost of clearing varies with the character of the brush and ranges from \$1 to \$2 an acre, depending upon the methods used and the cost of labor. Upon removal of the brush the land is ready for breaking and for the production of a crop the following year, if in the wheat growing section, or as soon as prepared for water if in the irrigated section.

The value of the farm crops destroyed annually by rabbits, squirrels, gophers, and other rodents amounts to a large sum. Strips of varying width are destroyed along wheat fields. If all of the country were settled and in cultivation the extermination of these animals could be accomplished in a comparatively short time,

but the large areas of abandoned and unbroken rough land makes this almost an impossibility. The use of poison is the prevailing method of destroying these animals.

Crop rotation is not practiced; wheat follows wheat with an intervening season in summer fallow. The adoption of a rotation is not practicable under the present system of farming in the wheat lands, and the development of irrigation farming is of such recent date and minor extent that rotations have not been adopted in irrigated regions. It would seem advisable to develop a farming system which would permit some form of rotation in the wheat-growing section in order to aid in maintaining the productiveness of the soils.

The use of commercial fertilizers has never reached any importance and probably will not for some time to come. The 1910 census reports a total expenditure of \$85 in the county for fertilizer in 1909. Little manure is saved and applied to the fields. The stock grazes on the range so much of the time that very little manure accumulates in barnyards. The application of manure would be beneficial, although there is a common belief that barnyard manure has little effect on the soils of this section. It would aid in protecting the surface from blowing and also add some organic matter to the soil, even if the fertilizing elements of the manure were not needed. Lime is not applied in the preparation of land for alfalfa, and, as a rule, is not necessary.

The demand for farm labor is not uniform. It comes at two seasons—those of plowing and of harvesting. Fairly efficient farm labor is available in all seasons except at harvest time. Ordinarily laborers are hired by the month, while harvest hands are paid by the day. The supply of harvest hands is uncertain, but, as a rule, sufficient help is available at that season from outside sources. Wages are comparatively high. A total expenditure of \$316,251 for labor in the county in 1909 is reported in the census of 1910.

In some parts of the wheat-growing section the amount of land available for renting greatly exceeds the demand, and in such places the rent is often very low. Renting for cash is an uncommon practice. In a few instances nonresident owners rent for the payment of the taxes. Share rent on a half-and-half basis is the usual custom. In case of crop failure or low yields the loss to the tenant is the greater, and this system does not seem to be the best one possible in a section of uncertain yields. The following plan has been adopted in certain cases: The first 10 or 12 bushels belong to the renter, the next 3 to the owner, with the remainder divided half and half. This helps the renter in case of low yield. The irrigated farms are operated by their owners.

Land values are for the most part low. Comparatively little land is changing hands. The sale value of land in the wheat-growing

sections varies with the location, the character of the soil, and the topography, ranging from \$8 to \$15 an acre. Land in the sandy parts of the county may be purchased very cheaply. A large part of this is railroad land, which is on the market at \$2.50 to \$5 an acre. Improved land in irrigated sections is held at \$100 to \$400 an acre. Unimproved land in these sections may be purchased at \$10 to \$50 an acre, depending upon the character of the soil and location.

The adaptation of certain soils to the production of crops is generally recognized. The principal consideration is the physical properties affecting moisture-holding power and resistance to drifting. These properties exist to a certain degree in all the soils, but are better developed in the soils of finer and heavier texture and of greater depth. While all the soils absorb practically the entire scanty precipitation, all do not retain equal quantities of moisture within reach of crops. The loose surface of the sandy soils tends to retain some moisture near the surface, but the greater part of the water sinks too deep to be available. Evaporation is fairly high from the firm surface of the heavier soils in their natural state. When the surface is covered with a loose soil mulch evaporation is reduced to a minimum and the soil moisture is held within reach of shallow-rooted crops. As wheat may be produced with a smaller supply of moisture than almost any other crop that can be grown successfully under other climatic conditions existing in this section, the soils having the properties mentioned above are best adapted to its production. The light sandy soils are subject to blowing when the native vegetation is removed.

Some varieties of wheat are better suited to the arid conditions than others, but a certain amount of moisture must be present if any plant is to grow well. This is illustrated by the greater growth of the native plants in more favorable seasons and after periods of increased moisture. In seasons of greater rainfall and more favorable distribution good yields of crops are obtained without special attention to the conservation of moisture, and in seasons of little or no rainfall the best methods do not insure a good yield. Among some farmers there is a tendency to believe that the careless and cheaper methods of preparing a larger acreage produce the greater returns in a series of years. It is the highest average in any series of years that largely determines the profit, and this can only be attained by careful preparation and cultivation to conserve the moisture.

In this connection the question of the drifting of soil deserves attention, as its prevention is closely related to the conservation of moisture. The problem resolves itself into the extent to which the soil may be worked in order to hold the moisture and yet not so pulverize the surface that the soil is easily moved by the wind. The dust mulch so highly recommended for some sections is too fine and

too easily moved for the soils of this climate. A fine, granular soil seems to resist the attacks of the wind, but this is often difficult to obtain or to maintain. The stirring of the surface when in the proper moisture condition is necessary.

It is generally recognized that the arid soils in cultivation tend to become lighter, as more fine material is removed than is deposited. In addition there is a decrease in the naturally low organic-matter content, accompanied by a greater tendency to blow. To a certain extent this may be counteracted by plowing under all stubble, straw, and weeds. The disking of certain soils, leaving the vegetable matter on the surface, and the spreading of straw or manure on portions of fields especially subject to blowing are practiced. Anything that will protect the fields from the wind will aid in solving this problem.

In certain parts of the wheat belt of western Kansas the land is listed instead of being plowed, the surface being thrown into a series of parallel ridges and troughs. This method could be followed to advantage in areas in this county subject to drifting. The ridges could be made transverse to the prevailing direction of the wind, and the amount of surface exposed directly to the attack of the wind materially decreased. In addition, when these ridges are worked down all the stubble is left on or near the surface.

It is necessary for each farmer to study conditions and modify the general methods to fit his individual needs. In this section it is advisable to cultivate as little as possible, provided the weeds are destroyed. The constant shifting of the surface by winds aids in holding the moisture and decreases the necessity of cultivation.

SOILS.

RELATION TO GEOLOGY.

Franklin County occupies a portion of the Northwest Intermountain Region.¹ This region includes that part of the Northwest known as the Great Plains of the Columbia, which cover portions of Washington, Idaho, and Oregon. The bedrock which underlies this region is a dark, almost black, heavy volcanic rock known as basalt. This occurs at varying depths or constitutes a large part of the surface material. (See Plate I, fig. 1.)

Older formations were completely covered by the extensive floods of this lava of the early Miocene² and the former have had no influence on the soils of the county. This volcanic rock is known as the Yakima basalt and is made up of successive layers or sheets, aver-

¹ For a discussion of the various soil provinces of the United States, see Bul. 96, Bureau of Soils, U. S. Dept. Agriculture.

² Water-Supply and Irrigation Paper No. 118, U. S. Geol. Survey, "Geology and Water Resources of a Portion of East-Central Washington," by F. C. Calkins.

aging about 50 feet in thickness, extending over great areas without thinning. Several of these sheets are exposed in the canyons of the Snake and Palouse Rivers. In places thin deposits of stratified material or of weathered basaltic rock occur between the layers. The lower limits of this rock have never been determined in this and adjoining counties. In places within the Northwestern Intermountain Region it is known to have a thickness of at least 2,500 feet, while its thickness in other places is estimated at 5,000 feet.

Over a part of the surface of this lava flow there was deposited, also in Miocene times, the sedimentary beds of the Ellensburg formation.¹ These consist of semiconsolidated strata of sand, silt, and clay which were laid down in horizontal layers in lakes. Their character and depth are shown by exposures in the White Bluffs, where they form a steep slope or bluff 300 to 500 feet or more in height. Well borings in the desert plain back of this bluff show at least 700 feet of fine material above the basalt. To the east the beds are much thinner, approximately 150 feet deep.

The original distribution of these beds can not be determined, but exposures and cuts indicate that as far as their direct influence on the formation and derivation of the soils of the county is concerned, the Esquatzel Coulée may be considered as defining in a general way their eastern boundary. The only exposure of these beds east of the coulée is about a mile north of Connell, and here they are covered deeply by unstratified material. It is probable that material of this character extended farther east and has either been removed by erosion or covered by later formations to such a depth that no exposures occur.

East of the Esquatzel Coulée and south of a line extending in a general southeasterly direction from near the northwestern corner of T. 10 N., R. 31 E., nearly to the Snake River, there is an extensive area of stratified unconsolidated deposits differing from the Ellensburg. These extend up the canyon or valley of the Snake River for a long distance. Here, however, the areas are rather small and more or less isolated. (See Pl. I, fig. 2.) Exposures indicate that these consist of successive strata of silt and fine sand, which have been fractured, faulted, and folded to such an extent that they are no longer horizontal. They are not as thinly laminated as those described above. The sand strata frequently are of lens shape. Transverse vertical veins of silty material are numerous. These vary from a fraction of an inch to a foot or more in thickness, and extend to the surface in many places, although evidences of stratification are not present in the surface material. Boulders and gravel occur on the surface and in the stratified deposit.

¹ Ibid.

Following the deposition of the lake-laid material there was a period of deformation in which the layers of lava and the overlying stratified beds were folded and otherwise raised or lowered. Better illustrations of this are afforded in other parts of south-central Washington than in Franklin County. These folds extend in a general east-to-west direction and the only prominent one in this county is the low eastern continuation of the Saddle Mountain anticline, which enters the county in range 29 east and gradually merges with the desert plain a few miles farther east. Portions of this ridge are covered by the stratified deposits already mentioned.

Granitic glacial boulders are found in places on the surface of the lake-laid material. While not numerous, their presence indicates the existence of either a lobe of the continental ice sheet or of a glacial lake in which drift ice deposited material from the regions of crystalline rocks to the north and northwest. The boulders are more numerous in the case of the more southerly body. As they appear to lie on or near the surface of the old deposits, it seems probable that the existence of the glacial lake was of short duration and that very little material was laid down during that period.

In the uplands of the eastern half of the county, excluding areas of current-laid material and Scabland, the surface of the Yakima Basalt is covered to a depth of 25 to 100 feet or more by a light-brown material of high silt content. This material is of remarkably uniform texture and structure to the underlying basalt. No gradation through partially decomposed rock occurs. The texture of the surface also is very uniform over large areas. Material of this character is regarded as of loessial or wind-borne origin.

These earlier deposits are in places covered or traversed by two later series of deposits of widely different character and origin, viz, wind-blown deposits of sand and alluvial deposits. The former are very extensive and the latter quite widely distributed.

Brief mention should be made of the location and origin of the coulée and old-stream channels, as the conditions existing during the period of their development have had a marked influence on the formation of large areas of soil. Washtucna Coulée and Esquatzel Coulée, south of Connell, to the point where it merges with the desert plain north of Pasco, is the course followed by the Palouse River before it was turned abruptly southward near the northeastern corner of the county by stream capture. A fairly well defined channel enters the county in R. 29 E. and, following a rather irregular southeasterly course, joins the Esquatzel Coulée less than a mile north-east of Mesa. In the area of Scabland south of this short coulées are numerous. These seem to give way to two large coulées, which extend southward or southwestward, joining the Columbia River Valley. Two others cross the Columbia Flat from the same vicinity, one

merging into the desert plain in T. 14, R. 27 E., and the other bearing southwestward and joining the Columbia River Valley about 3 miles above Ringold. All these except the old Palouse River channel are rather closely associated in their location and origin. Present conditions of elevation indicate that the streams forming them came from the north, where a flat gravel plain of similar character to that mapped as of glacial-outwash origin in the Quincy area¹ separates them from the areas of Scabland and outwash soils of the Crab Creek country in the southeastern part of the Quincy area.

At present the general slope of the lava plain appears to be to the southwest. Its elevation near the northeastern corner of the county is approximately 1,500 feet, and that of the most southwesterly exposures of the rock is approximately 700 feet above sea level. Farther south and west its surface evidently sinks more rapidly, as no outcrops occur along the Columbia River at elevations of 350 to 400 feet. Well borings at Pasco, where the elevation is 370 feet, show nearly 400 feet of stratified material above the surface of the basalt.

SOIL GROUPS.

Transportation, erosion, deposition, and weathering are the agencies which have resulted in the formation of the soils of the county during the periods and under the conditions described. The eastern part of the county is characterized by extensive areas of soil of uniform color, texture, and structure, the western part by a wide variety of soil types and of soil series. Other noticeable features are the prevailing light-brown color of nearly all the soil types, the small extent of the recent alluvial soils, and the slight influence of weathering of the underlying basaltic rock on the soil material.

On the basis of origin and the processes by which the soil materials were accumulated the soils of Franklin County may be separated into four general groups: (1) Soils derived from loessial material, (2) soils derived from eolian material, (3) soils derived from old sedimentary valley-filling material, and (4) soils derived from current-laid material. The last group may be further subdivided into (*a*) glacial-outwash material, (*b*) alluvial-fan and recent valley-filling material, and (*c*) river flood-plain material.

The extent and location of these groups are shown on the accompanying sketch map of the county (fig. 5). On the sketch map is shown also a fifth group, which includes small areas of soils of groups 2 and 4 occurring in such intimate association that they can not be indicated separately.

These five groups of soils are further separated into series and the series into soil types, which are shown on the soil map accompanying

¹ Soil Survey of the Quincy Area, Washington, Field Operations of the Bureau of Soils, 1911.

this report. The relative proportion of the different-sized particles composing the soil material determines the texture, and it is on the basis of texture that the soil types are separated. Soils of similar color, character of subsoil or substratum, origin, and mode of formation in the same soil region or province form a soil series. A soil series thus consists of a number of related soil types, which differ essentially in texture and may range from coarse stony, sandy or gravelly types through the finer loams to clay. Variations in the type, where of sufficient importance to have an influence on the agricultural value of the soil, are recognized as phases. If of sufficient importance and extent the phases are shown on the map; if not, their character, extent, location, and agricultural value are merely noted in the description of the type.

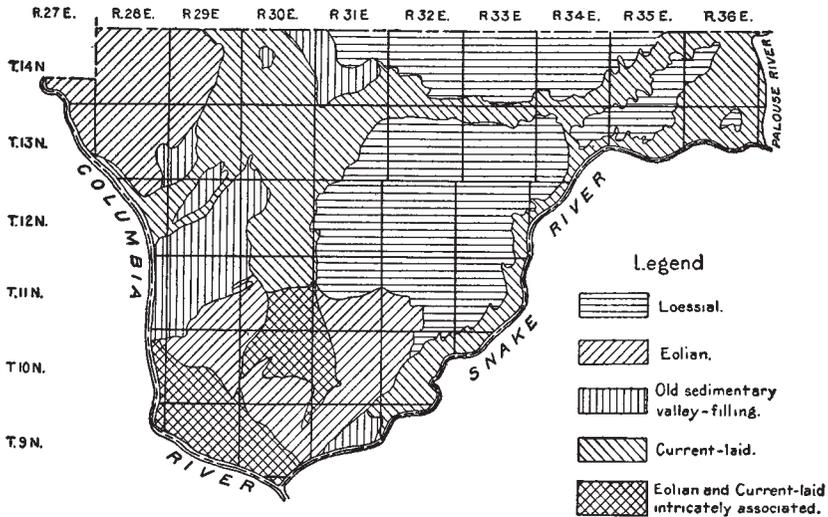


FIG. 5.—Sketch map showing soil groups.

SOILS DERIVED FROM LOESSIAL MATERIAL.

The soils of the loessial group occupy the high rolling plateau of the eastern part of the county. The areas are extensive and are interrupted only by belts of current-laid material and Scabland occurring along Washtucna and Esquatzel Coulees and a few smaller coulees and also along the canyons of the Snake and Palouse Rivers. Old and present streams have removed the portions of this material formerly connecting these areas and have cut down into the basalt, thus forming the present coulees and canyons. The former well-developed and well-defined drainage system extending throughout the soil types of this group has determined its rolling and hilly topography, the present topography being due to agencies of drainage and erosion rather than to wind action.

In this group the soil types are derived from the mantle of fine material, from 25 to 100 feet or more in depth, which overlies the basalt. This is a light-brown to grayish-brown, homogeneous material, with a high silt content and uniform structure and texture to the bedrock. Laminations do not exist, and there is no gradation through partially decomposed rock to the unaltered bedrock, as would be the case if this mantle had been weathered in place. That it is not of residual origin is also borne out by its color, which is not that of basaltic soils in this region. As it does not have the characteristics of material transported by being rolled or blown along the surface by winds, such as is being deposited in other parts of the county, it is classed as loess. The modification of this material by weathering subsequently to its deposition probably has been very slight. Much of this material within this and adjoining regions is believed to be of preglacial origin, but it is probable that considerable accessions of fine dustlike material are still made by the summer dust storms which frequently sweep over the country.

The types derived from this loessial deposit belong to the Ritzville series, by far the most extensive and the most important series from the standpoint of crop production in the county.

SOILS DERIVED FROM EOLIAN MATERIAL.

In occurrence the group of eolian soils is mainly confined to two rather extensive sections, one in the northwestern corner and the other in the southern part of the county, though small, isolated bodies are found in other parts of the western half of the county. Some soils derived from old sedimentary valley-filling material and from current-laid glacial outwash material are associated with those of this group.

All the eolian soils have the ridged to choppy and undulating topography characteristic of wind-blown sand. (See Pl. II, figs. 1 and 2.) They are formed from a surface deposit of sandy material transported by the wind mainly from the sandy channel of the Columbia River. Some material of the underlying formation reworked by the wind is included.

The soils of this group consist of different grades of sand and are classed with the Quincy series, including light-brown to brown material without calcareous hardpan, with the Koehler series, including light-brown material with calcareous hardpan, with the Winchester series, including darker brown to dark-gray material, some of which in this area is underlain by a gravel substratum, and as Dunesand.

Unlike the material of the preceding group, the material of this group has been transported mainly by being rolled along the surface or carried by winds blowing across the surface of exposed sandy

deposits. It is of much less homogeneous character than the loessial material of the preceding group, is much more readily traced to its source, and sometimes shows evidence of wind stratification.

SOILS DERIVED FROM OLD SEDIMENTARY VALLEY-FILLING MATERIAL.

The soils of the old valley-filling group are found in several areas in the western and southern parts of the county. That these several areas originally were connected is indicated by their similarity in character, elevation, and topography. The intervening material has been removed by erosion. In addition a large part of the eolian soils classed with the second group is a surface deposit superimposed over the material of this group, so that its present extent is only a small part of its former area.

The formation giving rise to at least a large part of the material of this group and underlying all the group is of lake-laid origin, and consists of practically unconsolidated strata of fine material, mainly silt and clay, extending to depths having a known range of 150 to 700 feet and probably more. The soils are derived partly from the weathering of the underlying formation and partly from accessions of loessial or wind-borne material, such as is described under the first group. Wind-laid material, as described in the second group, reworked with that of the original surface, has also contributed to the soil-forming material.

The soils of this group have a firm surface, compact structure, and a level to undulating or sloping to rolling topography. They are well drained and do not contain alkali in injurious quantities.

The soil types comprising this group are classed with two soil series—the Burke, including light-brown soils with a calcareous hardpan, and the Sagemoor, including light-brown soils without the hardpan.

SOILS DERIVED FROM CURRENT-LAID MATERIAL.

Glacial-outwash deposits.—The Glacial-outwash soils of the fourth group occupy high terraces in the western half of the county and occur along the courses of present or former streams. The larger area in the western part of the county is closely associated with coulées or old stream channels connecting parts of this county with the lower Crab Creek country several miles to the north. The soils are composed of basaltic and crystalline rock material deposited probably by glacial streams. The coarse materials are well rounded and have been transported for long distances.

The soil types are similar to those mapped in the extensive glacial-outwash deposits in the eastern part of the Quincy area. Later surveys will doubtless show these two bodies of similar material to be

connected. The soils usually are excessively drained and are free from overflow.

This group of soils is of moderate extent in the county and is represented only by the Ephrata series, which has light-brown soils and coarse, porous subsoils and substrata.

Alluvial-fan and recent valley-filling deposits.—These soils occur where the sediment-laden streams of the uplands emerge onto the river terraces or the coulée floors. The material consists of reworked old sedimentary deposits and soils of loessial and current-laid origin, mainly of the Ritzville, Burke, and Ephrata series of soils. The characteristic topography is that of low, broad, sloping areas or local alluvial fans, adjoining escarpments or bluffs inclosing stream or coulée valleys. The soil areas usually are small and the total extent of the group is not great. The material is deposited mainly by minor intermittent streams or by surface wash, principally during periods of rapidly melting snows.

The group includes the soil types of the Ringold series, with gray soils, and of the Washtucna series, whose soils are of light-brown color. The alluvial-fan phase of the Ephrata very fine sandy loam also is included.

River flood-plain deposits.—The soils of the flood-plain group occupy first bottoms and lower stream terraces. The deeper subsoils and substrata are gravelly and pervious. The material is derived from a variety of rocks and soils, and in some cases has been transported long distances. The soils of this class have a wide distribution throughout the valley of the county. They are included in part with the Beverly series, with subsoils and substrata of coarse, rounded fragments of crystalline and other rocks. This series occupies lower terraces than the Ephrata series, but is not subject to overflow. Scabland also is included with this group.

Areas of other soils of the group occurring on lower terraces or in first bottoms along present rivers and intermittent streams are comparatively narrow and are not of great extent. They are composed of fine sediments derived from a variety of sources and deposited during periods of overflow. Under present climatic conditions accessions of material are small and very infrequent. The depth to underlying gravelly material is always greater than in the case of the soils of the Beverly series. These areas include soils of the Esquatzel series with light-brown soils, and the Pasco series, with medium grayish brown to dark-brown soils.

In all, these groups include 12 soil series, embracing 26 true soil types, and 4 types of miscellaneous character. Only 4 of these series were established prior to this survey. The extent and distribution of the various soils are indicated by means of colors on the accompanying soil map.

The following table gives the name and the actual and relative extent of each soil type mapped in Franklin County:

Areas of different soils.

| Soil. | Acres. | Per cent. | Soil. | Acres. | Per cent. |
|-----------------------------------|---------|-----------|------------------------------------|---------|-----------|
| Ritzville silt loam..... | 246,336 | 31.3 | Ephrata sandy loam..... | 9,152 | 1.2 |
| Ephrata very fine sandy loam..... | 109,440 | 14.2 | Washtucna silt loam..... | 8,704 | 1.1 |
| Alluvial-fan phase..... | 1,984 | | Rough broken land..... | 7,936 | 1.0 |
| Scabland..... | 73,536 | 9.3 | Esquatzel very fine sandy loam... | 7,232 | .9 |
| Burke very fine sandy loam..... | 35,392 | 5.9 | Koehler very fine sand..... | 4,672 | .6 |
| Deep phase..... | 11,200 | | Dunesand..... | 4,352 | .6 |
| Winchester sand..... | 33,344 | 5.5 | Ritzville very fine sandy loam.... | 3,904 | .5 |
| Loamy phase..... | 9,984 | | Beverly very fine sandy loam..... | 3,456 | .4 |
| Quincy fine sand..... | 34,688 | 4.4 | Quincy very fine sand..... | 3,392 | .4 |
| Quincy sand..... | 30,336 | 3.9 | Pasco very fine sandy loam..... | 1,728 | .2 |
| Koehler sand..... | 26,624 | 3.4 | Ringold clay loam..... | 1,664 | .2 |
| Ephrata fine sandy loam..... | 23,744 | 3.0 | Beverly gravelly fine sand..... | 1,472 | .2 |
| Sagemoor fine sandy loam..... | 21,568 | 2.7 | Ritzville fine sandy loam..... | 1,472 | .2 |
| Winchester fine sand..... | 16,768 | 2.1 | Riverwash..... | 768 | .1 |
| Sagemoor very fine sandy loam... | 16,384 | 2.1 | Pasco fine sand..... | 448 | .1 |
| Sagemoor silt loam..... | 14,592 | 1.9 | | | |
| Koehler fine sand..... | 10,816 | 1.4 | Total..... | 786,560 | ..... |
| Burke fine sandy loam..... | 9,472 | 1.2 | | | |

MINERALOGICAL CHARACTER.

A mineralogical examination was made of samples from four soil types, representative of large soil areas—the Ritzville silt loam, Burke very fine sandy loam, Sagemoor very fine sandy loam, and Beverly very fine sandy loam. The results show a remarkable similarity in the chief mineral constituents and a very low percentage of glassy material or volcanic ash.

One purpose of the examination, which was made in the laboratories of the Bureau of Soils, was to determine the relative amount of volcanic-ash material present, as the common belief in central Washington is that all soils of this character are mainly composed of volcanic ash. The results of the examination follow:

Mineralogical constituents of four extensive soils.

| Ritzville silt loam. | Burke very fine sandy loam. | Sagemoor very fine sandy loam. | Beverly very fine sandy loam. |
|--|--|---|--|
| Sample No. 551113. Orthoclase, quartz, biotite, hornblende, plagioclases, etc., and traces of isotropic material of low refractive index. | Sample No. 551170. Very similar, mineralogically, to the foregoing; the grains, however, appear larger. The isotropic material is present only in traces. | Sample No. 551195. Similar to the foregoing samples; isotropic material in traces. | Sample No. 551134. Similar to the foregoing samples; isotropic material slightly more abundant; few spicules present. |

RELATION OF FLORA TO SOILS.

Franklin County lies within the treeless sagebrush plain of central Washington. The variations in climate and water supply are not sufficient to cause any marked difference in the native vegetation in different parts of the county. Trees along the banks of the Columbia and Snake Rivers are uncommon. Originally juniper was common in the sandy region of Tps. 10 and 11 N., Rs. 31 and 32 E., but only a few small, scattered trees remain. In general the sagebrush decreases in size and abundance eastward across the county, the opposite being true with respect to the bunch grass. The texture and moisture-holding capacity of the soils in their natural state have a marked influence on the flora. Soils that have a firm surface support mainly a growth of sagebrush and a certain species of bunch grass, with only a few of the other desert plants. Soils having a loose sandy surface support a growth of rabbit brush, black sage, thorny sage, and a number of other desert shrubs, with species of bunch grass. In addition to the bunch grasses, there are a great many other sand-loving plants, including sunflower, sand dock, etc.

RELATION OF SOILS TO TYPE OF AGRICULTURE.

Under existing climatic conditions, the agricultural value of the soil types depends more upon their moisture-holding power than upon their natural fertility. Soils having such texture, structure, and depth as not to be subject to drifting, ordinarily hold sufficient moisture for successful crop production, and although they may contain less available plant food are more desirable and have a comparatively high agricultural value. In humid regions or in irrigated sections, however, conditions are different. Under the present conditions of rainfall, high evaporation, and strong winds, soils of a texture coarser or lighter than a very fine sandy loam are not as a rule well adapted to dry farming, and not even those of that texture unless there is at least 3 feet of fine material overlying the hardpan or gravel substratum. A greater depth is, of course, preferable. Soils of sandy loam and fine sandy loam texture should have a greater depth of fine material than the very fine sandy loam. In general, even under careful methods of farming, any soil that drifts badly holds too little moisture for the profitable production of farm crops for a series of years. This does not mean that any soil that has drifted under existing methods of farming is not adapted to dry farming, for in some cases the drifting could have been prevented by improved methods. Some exceptions to the general rule occur in the case of the lighter soils.

No comparison of the different types on the basis of adaptability to particular crops and of agricultural value in a country of this character can be made further than that already given. The develop-

ment of land under irrigation is too recent and too limited to form a basis for deduction regarding the relative agricultural value, adaptability, and productiveness of the soil types under that method of farming. Soils of any texture and depth may be farmed in this way, some requiring more time and expense for preparation than others, and greater effort to insure good crops.

RITZVILLE SERIES.

The Ritzville series consists of light-brown soils and somewhat lighter grayish brown to light-brown subsoils. The subsoil material extends to basaltic bedrock. The deeper subsoils and substratum are usually more or less calcareous. The types are remarkably uniform in color, texture, and structure over extensive areas. When moist the brown tint is accentuated but under dry field conditions a light grayish brown color is developed. Their topography is rolling to hilly, the drainage good, and no alkali is present.

The series is composed of fine material believed to be loess. While the series as a whole shows little or no modification by the later or recent reworking of the surface material by the wind, the types having a texture coarser than silt loam, which seem to be really departures from the typical material of the series, do show some modification in this way.

The series comprises the extensive wheatlands of a large part of central and south-central Washington and may extend into adjoining States. Its light-brown color differentiates it from the related and associated dark-colored soils of the Walla Walla series.

RITZVILLE FINE SANDY LOAM.

The Ritzville fine sandy loam consists of 12 inches of a light-brown fine sandy loam, underlain by a light grayish brown to light-gray fine sandy loam subsoil which extends to a depth of 3 to 5 feet, where it rests upon the typical deep, fine, compact silty material which constitutes both the lower subsoil and the substratum of the type and gives rise to the silt loam type of the series. In texture the material grades toward a loamy fine sand of fairly compact structure. In places a thin mantle of loose fine sand covers the surface.

In occurrence this type is associated with the Quincy sand and fine sand. It is not extensive and is confined to Tps. 10 and 11 N., R. 31 E., where it occurs as small areas between sand ridges. Other bodies too small to show on the map occur in other parts of these townships. The soil areas are covered with bunch grass, in contrast with the sagebrush cover of the surrounding sandy soils. These small areas may be distinguished from a distance, and are merely portions of the original surface not covered by the wind-blown sands of the Quincy and related series.

The surface of the type is undulating to rolling. Its elevation is between 700 and 800 feet. The drainage is good.

The coarser material of the type has probably been blown from near-by areas of sandy soils and incorporated into the type by the shifting and reworking of the original material. The deep subsoil consists of the original loessial material and is similar to that mapped as the Ritzville silt loam. Accessions of wind-blown dust and fine particles have contributed to its formation to a small degree.

The greater part of this type is covered with an original growth of bunch grass and scattering sagebrush. Attempts to cultivate have not been successful on account of its low moisture content and the tendency of the soil to drift when the surface is broken and exposed.

Careful handling of this soil and some protection from the wind would decrease the chances of loss of crops to some extent, but irrigation is necessary for its development. No water is available for this purpose at present, and the type probably will continue to be used for the grazing of sheep and cattle.

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

Mechanical analyses of Ritzville 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> |
| 551188..... | Soil..... | 0.9 | 5.1 | 4.0 | 44.4 | 30.4 | 12.4 | 2.3 |
| 551189..... | Subsoil..... | 2.0 | 9.8 | 5.9 | 26.9 | 33.0 | 16.4 | 6.1 |

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO₃): No. 551189, 4.36 per cent.

RITZVILLE VERY FINE SANDY LOAM.

The soil of the Ritzville very fine sandy loam is a light-brown very fine sandy loam, with a depth of 12 inches. The subsoil is a grayish to light yellowish brown or light-brown very fine sandy loam, which grades into a silt loam below a depth of 3 to 4 feet. The latter, at a depth of 6 feet or more, is underlain by a substratum of similar unstratified, homogeneous material which extends to bedrock, 50 to 100 feet below the surface. Unbroken areas have a firm surface, and the structure of the entire soil section is compact.

The only difference between the soil and upper subsoil of this type is a slight, gradual change in color. In places the texture of the soil approaches a very fine sand, and on the other hand it sometimes grades toward a silt loam. The boundaries separating this soil from the silt loam type, with which it is closely associated, are arbitrary. Doubtless some areas of this type occur within the extensive areas of the Ritzville silt loam.

Four areas of the Ritzville very fine sandy loam are mapped in Franklin County, one in T. 11 N., R. 31 E., another in T. 11 N., R. 32 E., a third in T. 12 N., R. 31 E., and the fourth in T. 13 N., Rs. 31 and 32 E.

The surface of this type is sloping to gently rolling. The latter topography is due to the presence of a few draws, which traverse parts of the type. All the rainfall is quickly absorbed by the soil. Occasionally a slight run-off follows a sudden thawing of snow.

The occurrence of this type on exposed west or southwest slopes apparently is due to the removal by the wind of a part of the fine material of the Ritzville silt loam, which it so closely resembles. The areas in T. 11 N., Rs. 31 and 32 E., appear to be portions of the Ritzville silt loam that have been modified by accessions of very fine sand from the extensive sandy areas to the south and west. In these cases the material of very fine sandy loam texture is shallow, approximately 12 inches in depth.

The areas in T. 12 N., R. 31 E., and T. 13 N., Rs. 31 and 32 E., are in cultivation to wheat. Those in T. 11 N., Rs. 31 and 32 E., have been in cultivation and are now abandoned. Like other soils of the same texture in the county, the moisture and organic-matter contents are not sufficient to overcome its tendency to blow on exposed surfaces. In favorable seasons wheat yields from 15 to 20 bushels per acre, but the average for a number of years is much lower. The yields are for a period of two years, during one of which the land is in summer fallow.

It is doubtful whether the production of wheat by dry-farming methods will continue to be the practice on this type. The tendency to drift increases as more of the fine material is removed each year. Not enough organic matter is incorporated with the soil, nor does sufficient weathering of the soil material occur to overcome the removal of this fine material by the wind. Irrigation is essential for the best development of this type.

The surface is well adapted to irrigation methods of farming, and the type is suited to a wide range of general and special crops. The availability of water for irrigation of this type is a distant prospect.

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

Mechanical analyses of Ritzville 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> |
| 551160..... | Soil..... | 0.2 | 2.4 | 2.2 | 14.0 | 45.4 | 31.9 | 3.6 |
| 551161..... | Subsoil..... | .2 | 1.4 | 1.5 | 11.0 | 47.2 | 35.4 | 3.4 |

RITZVILLE SILT LOAM.

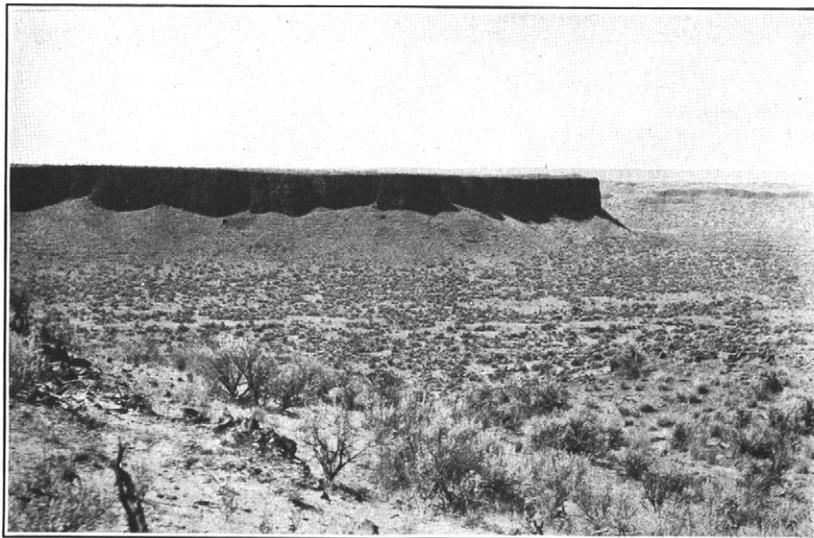
The Ritzville silt loam is a light-brown, compact silt loam of uniform texture to a depth of 6 feet or more. The underlying material is of similar character and extends to basaltic bedrock, which is encountered at a depth of 50 to 100 feet or more. The soil is 12 to 15 inches deep, although this depth is arbitrarily assumed and is not based on distinct changes in color, texture, or structure. Even the slight amount of moisture present in the soil under ordinary field conditions emphasizes the brown color. Dusty or dry exposed surfaces are grayish. The light-brown color of the upper subsoil undergoes a slight but gradual change between 24 and 36 inches, and the lower subsoil is a lighter grayish brown to brownish gray.

This type is easily cultivated. The surface quickly absorbs all the rainfall and much of the water from melting snow, so that very little moisture is lost through run-off and evaporation. Owing to the compact structure of the type, water does not sink rapidly beyond the reach of plants, and a large part of the scant precipitation is available for the use of crops.

There are a few minor departures from the typical material of this type. One of these is in color, and is not of sufficient importance to be indicated on the soil map. A slightly darker color is typical of a belt of country of undetermined width north of the Snake River Canyon. Examination of the soil in the field and the comparison of air-dry samples show very little difference in color, but the surface of fields in summer fallow when viewed from a distance and at a certain angle appear to be darker than the typical areas. Further investigation of the type in the counties to the east and north of the present survey may show that this is the typical color of the type rather than a departure, or that it is the beginning of a gradation from the light-brown soils of the Ritzville series to the dark soils of the Walla Walla series, which were not recognized in this survey, but which are of extensive occurrence in the well-known Palouse wheat-growing region lying to the east.

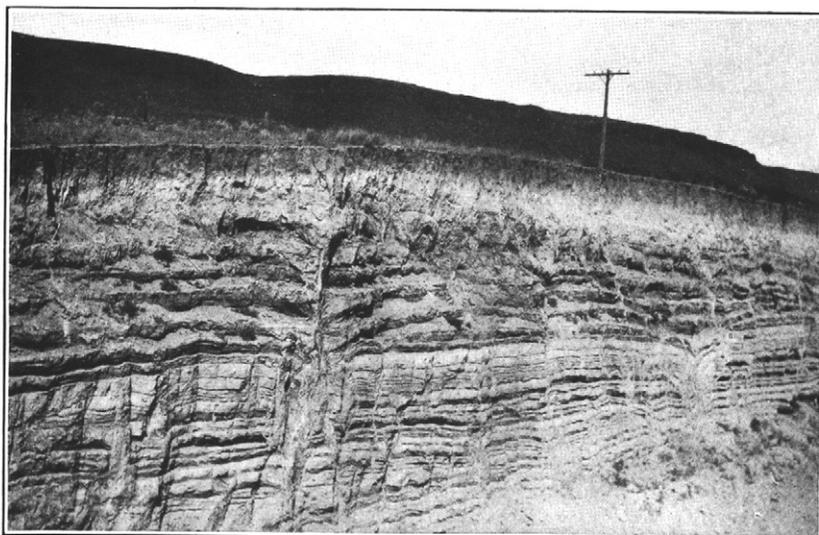
Eastward, across extensive areas, the silt content of the type increases, the texture of the western portions approaching that of a very fine sandy loam and that of the eastern sections a silt loam of high silt content. In places where, on account of certain topographic features, wind action is especially effective, very fine sandy loam and very fine sand textures have resulted from the removal of the finer material. Such areas usually are small and not well defined.

This type closely resembles in many respects some of the loessial soils of the Great Plains. Its material is derived from a variety of rocks and is apparently of uniform composition through its depth



8 7810

FIG. 1.—COULÉE NEAR EAGLE LAKE, SHOWING DESERT VEGETATION AND SHALLOW STONY SOILS WITH PERPENDICULAR BASALTIC CLIFFS ON SCABLAND AREAS.



8 7811

FIG. 2.—SECTION SHOWING STRATIFIED SEDIMENTS IN OLD VALLEY-FILLING MATERIAL, GIVING RISE TO SOILS OF THE SAGEMOOR SERIES, NEAR LEVEY.

Shows crumpled condition of beds with transverse veins, and weathered condition of the surface material.

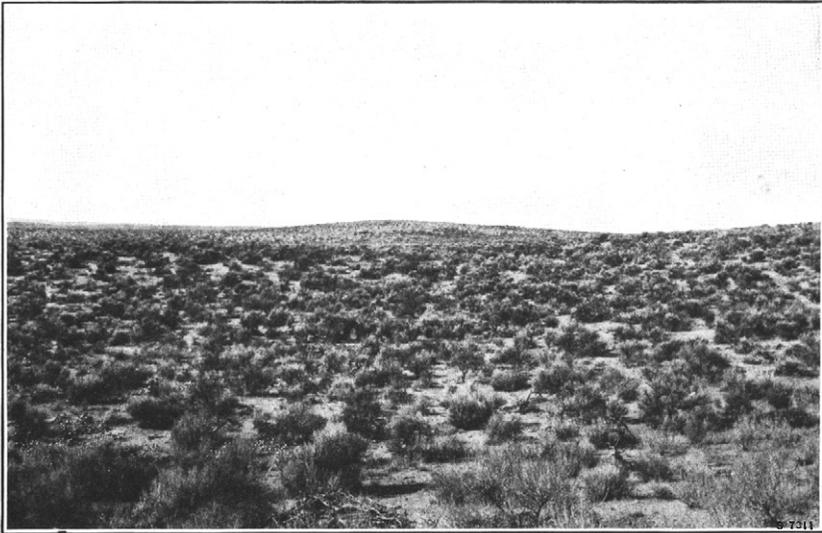


FIG. 1.—TOPOGRAPHY AND NATIVE VEGETATION ON SOILS OF THE QUINCY SERIES.

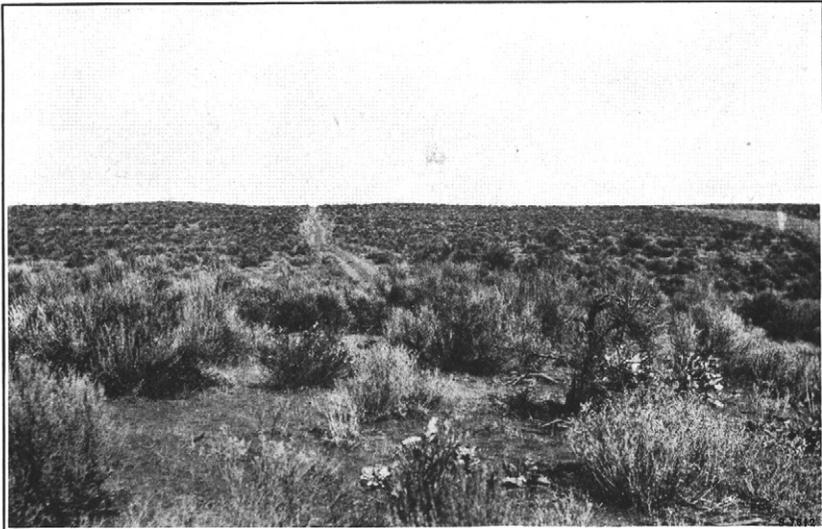


FIG. 2.—TOPOGRAPHY AND NATIVE VEGETATION ON SOILS OF WINCHESTER SERIES, OCCUPYING HIGHER TERRACES NEAR PASCO.

and extent. The slightly more brownish color of the upper part may be due in part to weathering since its deposition. Modification by wind movement of material along the surface is not common.

This is by far the most extensive soil type mapped, covering an area of 384.9 square miles. In general, it occupies all the eastern half of the county, except the portions included in the Washtucna Coulée and in the Snake and Palouse River Canyons. Three large areas are mapped. The largest is included by the Washtucna Coulée on the north, the Esquatzel Coulée on the west, the Snake River on the east, and the line between townships 10 and 11 on the south. Another area occurs between the Washtucna Coulée and the Connell Northern branch of the Northern Pacific on the south and the northern boundary of the county. The third area is between the Washtucna Coulée and the Snake River Canyon, east of Devils Canyon. Several small, isolated areas occur in T. 13 N., R. 36 E.

The characteristic rolling to hilly topography of this type closely resembles that of the Palouse country of southeastern Washington and adjoining parts of Idaho. It has resulted partly from erosion and partly from the structural features of the surface of the underlying basalt. The surface was originally a high, sloping plateau, covered with material of uniform character. The elevation ranges from 800 feet in the southwestern to over 1,800 feet in the northeastern portions of the type. As the elevation increases the diversity of relief becomes more pronounced. To the east the V-shaped valleys and tributary draws are short and numerous, the slopes are short and moderately steep to steep, and the divides are narrow. To the west a series of long coulées, having an east-west or a north-east-southwest direction, receives many tributaries from each side. Here the slopes are generally longer and less steep, the main and tributary valleys wider, and the divides broader than farther east. South and southeast of Connell many of the slopes on the north side of the coulées and their larger tributaries are short and steep, while on the south side the slopes are long and gentle.

An extensive drainage system, mainly the result of erosion during a former period of more humid climatic conditions, covers all portions of the type. The valleys opening toward the Snake River are short and steep and have cut deeply into the underlying basalt. In the western part of the type each coulée and its tributaries formed at one time an extensive drainage system. Some of these, including Rye Grass Coulée, South Fork of Smith Canyon, and several unnamed coulées of equal importance, are 20 miles or more in length. There are no perennial streams within the limits of the type. The only run-off is that occurring when the sudden thawing of snow supplies water faster than the soil can absorb it.

This type formerly supported a cover of sagebrush and bunch grass. As a rule the sagebrush was smaller and more scattered, and the growth of bunch grass thicker and more luxuriant than on the lighter textured soils in the western part of the county.

Nearly all this type either is or has been in cultivation. The original cover of bunch grass remains only on portions too steep and rough for farming. Such areas are used for grazing. Wheat is the money crop and is used also for feed. Only a small acreage of rye is grown. Potatoes, vegetables, and fruit are produced for home use. The farms on this type generally are large. Summer fallowing is universally practiced. This is the principal wheat-growing soil of the county. The yields of wheat range from a few bushels to 35 bushels per acre, depending upon the season. A large acreage of this type formerly farmed to wheat is now abandoned and supports a growth of Russian thistle, mustard, and other weeds.

Under irrigation the type would be adapted to a wide range of general and special crops, but water for this purpose is not available either by pumping or by a gravity system.

Results of mechanical analyses of samples of the soil and subsoil follow:

Mechanical analyses of Ritzville silt loam.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|-------------|--------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|  |  | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | <i>Per cent.</i> |
| 551113..... | Soil..... | 0.0 | 0.1 | 0.2 | 7.6 | 37.3 | 50.8 | 4.2 |
| 551114..... | Subsoil..... | .0 | .1 | .2 | 10.4 | 36.0 | 50.3 | 2.8 |

QUINCY SERIES.

The soil types of the Quincy series are characterized by their light-brown to brown color, loose, porous structure, and undulating to ridged and choppy topography. (Pl. II, fig. 1.) The texture, color, and structure are uniform as a rule throughout the soil section. Quartz is the predominating mineral. The dark-colored grains are mainly small fragments of basaltic rock, and the relative percentage of these determines the color of the soil material of the series.

This series overlies deposits of loessial material recognized as the Ritzville series of soils in this county, and of old valley-filling material which is free from calcareous hardpan, but which may be calcareous in character and may be included in the Sagemoor series. Basaltic rock occurs at great depths.

The soils are of eolian origin. The prevailing direction of the wind and the location of the series to the east and north of the main river channel indicate that the river sands are the main source of the material. The soils have a wide range in elevation and are non-

calcareous. The deep, fine, stratified, calcareous substratum of the series differentiates it from the Winchester series, which has a substratum of waterworn, current-laid material. The soils are droughty and require irrigation for their agricultural development.

QUINCY SAND.

The Quincy sand is a light-brown to brown sand extending to depths of 18 inches to 6 feet or more with but little variation in the material. It has a loose and incoherent structure. The type overlies fine, stratified or unstratified material of the Sagemoor and Ritzville series, which is usually of more or less calcareous character and which rests upon basalt.

The boundary between the soil and subsoil is arbitrarily placed at a depth of 10 to 12 inches. The soil contains a slightly higher percentage of coarse particles than the subsoil, owing to the removal of some of the fine material by the wind. As more of the coarse sand grains are derived from basaltic rock than from quartz, which is the predominating mineral of the type, wind action also results in a slightly darker color in the soil. In a few exposed places the color of the surface material is dark gray to nearly black. Its texture departs from the typical in places and grades toward both the coarse and fine sands of the series. Such variations are of very small extent and of minor importance. They are common to types of similar origin.

With the exception of one area in T. 13 N., R. 28 E., this type occurs wholly in the southern part of the county, where it is closely associated with the fine sand of the same series and with the soils of the Sagemoor series.

The surface of this type characteristically consists of a series of nearly parallel, narrow ridges, extending in a general northeast-southwest direction. The ridges are from 2 to 15 feet or more in height and usually are separated from each other by long, narrow areas of other soils. In places sand of similar character covers the intervening area and is included with this type, giving the whole an undulating topography. In general the Quincy sand has the characteristic topography of eolian or wind-laid material. It lies unconformably upon the underlying formations of very fine sands, silts, and clays and has been modified in places by the erosive action of the wind. The prevailing direction of the wind coincides with that of the ridges, and the character of the sand is similar to that carried at present by the rivers. These facts indicate that most of the material is derived from the sandy bars and beaches of the rivers. In the eastern part of the area occupied by the type the topography is rolling and even hilly. This is due to the uneven surface of the underlying formation modified by the irregular

features of the surface sands. In elevation the type ranges from 500 to 1,000 feet. Present drainage channels are not common to areas of this type. There are a number of old channels, which are partly obliterated by the surface deposit of sand.

The native vegetation consists of rabbit brush, scattered sagebrush, bunch grass, and other desert vegetation. The type is not in cultivation, on account of the insufficient supply of moisture for growing crops and the tendency of the soil to drift when the native vegetation is removed. Small tracts have at different times been cleared of brush and cultivated by homesteaders, and later abandoned. The present use of the type is for grazing sheep during the late fall and winter months.

This type is believed to be equal in productiveness to similar sands of central and south-central Washington, now under irrigation and producing crops of alfalfa, fruit, berries, grain, etc. The more even areas are adapted to irrigation with a moderate amount of leveling, but the rougher parts are practically impossible of leveling and too sandy to irrigate by gravity systems. Even with irrigation, the prevention of blowing and the resultant destruction of crops would be necessary for the successful cultivation of this type. It should give good returns on a moderate investment for land and for a water right.

QUINCY FINE SAND.

The Quincy fine sand consists of a light-br \ddot{u} wn or brown, porous, incoherent fine sand with but little variation in subsoil material. The depth ranges from 18 inches to 6 feet or more. As in the case of the sand of the series, it is underlain by material giving rise to the soils of the Sagemoor and Ritzville series. With the exception of a few fragments of "white rock" or limestonelike material in bodies which are near the soils of the Koehler and Burke series, the surface material of the type is noncalcareous. The texture and color of this type are more uniform than in the case of the Quincy sand. The color is a lighter brown, owing to admixture of a smaller quantity of the coarser basaltic fragments.

This type is confined to the western half of the county. Its greatest extent is in the southwestern section, where it is closely associated with the Quincy sand and also with the soils of the Sagemoor series. Other areas occur in the western and northwestern parts. A few small areas occur in the Snake River Valley.

Typically the surface of the type consists of a series of low, rounded ridges, some of which are connected by areas of similar soil, while others are separated by long, narrow areas of comparatively firm soils of the Sagemoor series. These ridges run parallel in about a

N. 55° E. direction, are from 2 to 25 feet in height, and continue for several miles unless interrupted by irregularities of the underlying formations. A few steep slopes covered with fine sand are included with the type. The surface rises quite rapidly as the eastern limit of the type is approached and the topography becomes rolling to hilly. The soil absorbs water rapidly and there is no run-off. No drainage ways have been developed.

Fine sand blown by the wind over formations of very fine material is responsible for the location and present characteristics of this type. At present the reworking of the material is confined to the immediate surface and is having no appreciable effect on the type. A very high percentage of this material has doubtless been blown from sand bars and beaches along the Columbia and Snake Rivers and carried in a northeasterly direction over the adjoining parts of the county.

The surface soil supports a sparse growth of rabbit brush, thorny sage, bunch grass, and desert plants. Farm crops are not grown at the present time, and only a few small tracts have ever been cleared and farmed. Some attempts were made by homesteaders to farm this type, and the returns were unsatisfactory, as the type receives insufficient moisture for the growing of crops and does not retain enough to prevent the surface from blowing. During a part of the year sheep graze on the nutritive bunch grass, but overgrazing has severely injured the range.

The agricultural development of this soil is dependent upon the availability of water for irrigation. In nearly all parts of the type a large expenditure would be required to make it suitable for crop production under methods of irrigation farming. The surface of certain portions is so uneven that the cost of preparation would be prohibitive of such development. The type is regarded as a productive one when watered. The greatest care would be required to prevent or to control drifting. Under irrigation this soil should be adapted to the production of alfalfa, fruit, potatoes, and berries.

QUINCY VERY FINE SAND.

The Quincy very fine sand is a light grayish brown very fine sand extending to a depth of 2 to 6 feet or more without distinct change. It is uniform in texture, moderately compact in structure, and low in organic-matter content. It is composed mainly of fine quartz particles and is noncalcareous. Prevaingly the color is grayer than that of other types of the series, on account of a much lower percentage of black fragments of basalt, and under air-dry field conditions the grayish color is pronounced. The soil is given an arbitrary depth of 12 inches for sampling, but there seems to be no change from soil to subsoil. The depth of the material to the underlying

heavier formations is from 2 to 10 feet, the thickness decreasing as the material spreads out toward adjoining bodies of heavier soils. The moisture-retaining power of this type is higher than that of the other members of the series.

The Quincy very fine sand occurs principally in the southern part of the county. The largest and most typical development, which roughly forms a border for the coarser sands to the north and west, extends in a nearly continuous belt from the center of sec. 16, T. 9 N., R. 31 E., to the southwestern corner of sec. 18, T. 11 N., R. 32 E. A small area occurs at Martindale and two others in sec. 22 and secs. 29, 30, 31, and 32, T. 11 N., R. 29 E.

This type differs from the other types of the series in having a typical hummocky and choppy topography. Its general surface features conform to those of the underlying material, and range from undulating to rolling. Only a small part may be considered hilly. There is no drainage from this type, as all the precipitation is quickly absorbed.

The natural vegetation of rabbit brush, sagebrush, and grass has not been removed from a large part of the type. Its present use is for grazing.

The preparation of this type for irrigation would be less expensive than the preparation of other types of the series, and less difficulty would be experienced from the blowing of the soil. The type is not adapted to crop production by dry-farming methods, as it retains insufficient moisture. With water available for irrigation the production of a wide variety of crops would be possible.

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

Mechanical analyses of Quincy very fine sand.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|--------------|--------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|  |  | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | <i>Per cent.</i> |
| 5511106..... | Soil..... | 0.0 | 0.2 | 0.4 | 17.0 | 72.0 | 9.1 | 1.1 |
| 5511107..... | Subsoil..... | .0 | .1 | .3 | 7.8 | 73.2 | 17.6 | 1.4 |

KOEHLER SERIES.

The soils of the Koehler series consist of light grayish brown or light-brown to brown soils and subsoils underlain by a white calcareous formation at a depth of 18 inches to 6 feet. This is a dense hardpan or limestonelike material locally known as "white rock." The soil material consists mainly of small particles of quartz and of basaltic rock. Under air-dry field conditions the light-grayish

tint is sometimes prominent, but when moist the brown color is accentuated. The subsoil frequently is of somewhat lighter color than the surface soil. Small and medium-sized fragments of the "white rock" occur on the surface and throughout the soil material in varying quantities. These constitute the calcareous material of the soils. The depth of the "white rock" varies widely even within short distances. The "white rock" is underlain by fine stratified sediments of lacustrine character which are more or less calcareous. No alkali is present in these soils.

The surface is hummocky to undulating and is not dissected by drainage ways. The soil and subsoil material of this series is derived mainly from river sands which have been carried by the wind from the river courses and have drifted into their present position. Some modification by reworking of local material has taken place.

This series is distinguished from the Quincy series by the presence of the calcareous hardpan.

KOEHLER SAND.

The Koehler sand is a light grayish brown sand underlain at a depth of 12 to 15 inches by a light grayish brown to light-gray sand to fine sand. This extends to an average depth of 2 to 3 feet, where a white, calcareous hardpan is encountered. The hardpan in turn rests upon fine, stratified calcareous sediments. The surface soil is loose and generally incoherent. The texture of this type ranges in places toward a fine sand and rarely toward a coarse sand. The fine character is less common to the soil than to the subsoil, which is usually slightly lighter in color and often more loamy in texture. The only variations in color in the surface soil are due to difference in the proportion of light and dark colored sand grains. A characteristic feature of the type is the presence of fragments of the underlying calcareous formation on the surface. The quantity of these varies with the depth of the sandy material above the hardpan. It is least on the ridges and hillocks and greatest in the rather flat areas between them. While the usual size of these fragments is from one-half to 1 inch in diameter, some are as fine as sand grains. The depth of the sandy material varies with the character of the surface; it is deepest on the ridges and shallowest between them.

The white calcareous substratum may be best described as a hardpan, although in its present state it is neither impervious to water nor to plant roots. It appears to be more or less fragmentary, yet it seems to have been modified to only a slight extent by weathering. Upon exposure it breaks up quite readily into fragments from 3 to 6 inches in diameter, but these are rather hard and weather very slowly. The thickness of this substratum varies from 1 foot to 5 feet or more.

The Koehler sand is confined to the northwestern corner of the county, where it occupies a large part of the desert plain known as the Columbia Flat.

The general features of the country occupied by this type are those of a plain. In detail its surface is choppy to undulating. The elevation is from 1,100 feet to 1,200 feet above sea level. With the exception of one fairly well defined old channel or coulée extending across T. 14 N., Rs. 28 and 29 E., no former or present drainage channels traverse the type. All the surface water is quickly absorbed.

The greater part of this type supports a native growth of rabbit brush, sagebrush, bunch grass, and other desert plants. Tracts of varying size were cleared by homesteaders and farmed probably for a few years. With the exception of a few fields, which are sown to rye, the type is not now in cultivation. The abandonment of this land was due to several factors, chief among which were its insufficient moisture supply and its tendency to drift. The loose surface is favorable to the retention of moisture, but the total precipitation is not sufficient for crop production, if all of it were available for that purpose. Under very favorable conditions for seeding rye gives fair yields of hay or grain. Although the growth of bunch grass is quite scattered, the best use of this type is for grazing.

Irrigation is necessary for the successful production of crops on this type. Pumping from wells is impracticable on account of the depth of the water table. Water for irrigation by a gravity system is not available on account of the high position of the type. It probably will be used mainly for grazing.

KOEHLER FINE SAND.

The Koehler fine sand consists of a light-brown, loose fine sand 12 to 15 inches deep, underlain by a more compact, light-brown to light grayish brown fine sand extending to the hardpan substratum common to the series. The average depth to the calcareous hardpan substratum is about 24 inches, somewhat less than in the case of the sand of this series. The soil material consists mainly of grains of quartz and basaltic sand, together with fragments of white rock, which are more abundant than in the case of the sand. Granite boulders, apparently of glacial origin, though not common, are sometimes found between the ridges.

In places the texture approaches a sand, in others a very fine sand; but such areas are irregular and impracticable of separation. This is a more uniform type than the Koehler sand. The depth of the fine material overlying the white rock varies with the irregularities of the surface, ranging from 1 foot to 6 feet. The white-rock fragments are less abundant on the ridges than between them. The hardpan is similar to that underlying the Koehler sand.

While it has a wider distribution than the Koehler sand, this type has a smaller total area. Areas are mapped only in the western quarter of the county in T. 14 N., Rs. 28 and 29 E., T. 13 N., Rs. 28 and 29 E., T. 12 N., Rs. 29 and 30 E., and T. 11 N., R. 29 E.

The surface of the type is hummocky to undulating when considered in detail. With associated types it occupies a broad desert plain having a generally level surface, with a gradual slope toward the south. Its elevation ranges from 900 feet to nearly 1,300 feet on the extreme northern side of the county, where it covers a part of the eastern extension of the Saddle Mountain anticline. Its average elevation is about 1,100 feet. The boundaries between this type and the Koehler sand to the west are more or less arbitrary.

No drainage courses have been developed on this type, as all the rainfall and water from melting snow is quickly absorbed by the soil.

The native vegetation is similar to that of the other portions of the desert plain and consists of rabbit brush, sagebrush, and bunch grass, with other sand plants. Rye is the only crop grown on this type, and under favorable conditions fair yields of hay or grain are obtained. The chief handicap to its cultivation is the tendency of the soil to drift before the plants are sufficiently large to protect the surface. Other areas have been cleared for the production of wheat, but the attempts to grow this crop have nearly always resulted in failure. The abandoned land supports a scanty growth of desert shrubs and weeds. Some areas are used for pasture.

Like the sand of the series, this type is adapted to irrigation, but water for that purpose is not available. Until land becomes much more valuable than at present the type will remain in its present condition.

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

Mechanical analyses of Koehler fine sand.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|-------------|--------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|  |  | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | <i>Per cent.</i> |
| 551177..... | Soil..... | 0.0 | 0.8 | 4.2 | 67.5 | 22.0 | 3.2 | 2.2 |
| 551178..... | Subsoil..... | .2 | 1.2 | 5.0 | 62.0 | 21.3 | 7.9 | 2.2 |

KOEHLER VERY FINE SAND.

The Koehler very fine sand is a light grayish brown or light-brown, loose very fine sand, underlain at a depth of 8 to 10 inches by a light-gray to light grayish brown, rather compact very fine sand, which rests upon the typical calcareous hardpan of the series. The hardpan occurs at depths of 18 inches to 5 feet. In places an

intermediate stratum of very fine sandy loam lies between the surface material and the hardpan. Fragments similar to the material of the hardpan are encountered on the surface and in the soil and subsoil, but in smaller quantities than in the case of the sand and fine sand of this series. In texture and color the type is uniform.

Several areas of this type occur in the western part of the county, mainly in T. 13 N., Rs. 28 and 29 E., and T. 11 N., R. 29 E. It is the least extensive type of the series. It occupies parts of the desert plain. The individual areas have a hummocky surface. The average elevation is between 900 and 1,000 feet above sea level. No drainage courses have been developed in this type.

The material of the type consists of the finer grades of sand blown from the other members of the series. Some of it consists of material of the Burke very fine sandy loam reworked by wind action. It is distinctly a wind-laid type.

While at some time a considerable acreage of this type has been cleared and farmed, only a comparatively small percentage of it is now cultivated. Rye and wheat are grown, and in favorable seasons fair yields are obtained. The type holds moisture fairly well, and with protection from blowing and a somewhat heavier rainfall would produce good crops where properly farmed. The chances of success by dry-farming methods are not good enough to warrant its cultivation. To conserve a sufficient supply of moisture by summer fallowing and protection from blowing is almost impossible. An increase in the organic-matter content would improve the moisture-holding power and decrease the tendency to drift, but it is doubtful whether the results would justify the expense and labor required to provide an adequate supply of organic matter. At present the chief use of the type is for grazing, but its value for that purpose has been greatly decreased by the removal of much of the original vegetation. With the availability of water for irrigation the type would produce good yields of many general and special crops.

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

Mechanical analyses of Koehler very fine sand.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|-------------|--------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|  |  | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | <i>Per cent.</i> |
| 551191..... | Soil..... | 0.1 | 0.4 | 1.5 | 33.4 | 54.2 | 8.2 | 2.0 |
| 551192..... | Subsoil..... | .0 | 1.0 | 2.2 | 23.0 | 43.0 | 27.6 | 3.4 |

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO₃): No. 551192, 1.27 per cent.

WINCHESTER SERIES.

The soils of the Winchester series consist of dark-gray or grayish-brown wind-laid material extending to a depth of 6 feet or more and generally underlain by a gravel substratum. The soil grains consist mainly of small fragments of basaltic rock and quartz. The former predominates in the case of the coarser grains and imparts to the sandy types their characteristic dark-grayish color. The surface is undulating to choppy. The drainage is excessive. Rabbit brush, sagebrush, and other desert plants comprise the native vegetation. (Pl. II, fig. 2.) Irrigation is necessary for the agricultural development of the types of this series.

WINCHESTER SAND.

The Winchester sand consists of a gray to dark-gray sand, extending to a depth of 6 feet or more. Under the mantle of loose sand which usually covers the surface, the material is firm, as the more or less angular sand grains seem frequently to bind together. The type includes small, undifferentiated areas of coarse sand. Typically the Winchester sand is underlain by a bed of water-laid fine gravel or gravel and cobbles, carrying interstitial sands. Often the soil material is composed of nearly equal proportions of material coming from crystalline and from basaltic rocks. The type has a loose surface and a porous structure.

The percentage of basaltic fragments determines to a large extent the color and texture of the type, which grades toward a dark coarse sand with an increased content of basaltic-rock fragments and toward a fine sand with a decreased content of the same material. Such conditions occur within the limits of the type as mapped, and are due to the removal of a part of the fine material by the wind. Their occurrence is irregular and inextensive and gives the type no greater range of color and texture than is common to types of similar character and origin.

As the material of this type is a surface deposit over older soil types, its depth is variable. It is deepest on the crests of the ridges and hillocks and shallowest where these merge with the adjoining soil types. The range in depth is from a few inches to 6 feet or more. The average depth is doubtless over 6 feet. The areas of shallow soil are irregular and impracticable of separation. Gravel and boulders are not typical of the surface material of the type, but may occur in the narrow areas of shallow soil between the ridges and hillocks. Patches of a loamy variation of this type, too small to be shown separately on the soil map, are included in areas of the typical soil.

The Winchester sand covers extensive areas in the southwestern part of the county in Tps. 9, 10, and 11 N., Rs. 29, 30, and 31 E.

Several areas occur in Tps. 13 and 14 N., Rs. 27 and 28 E., in the northwestern part of the county. Another area is mapped in secs. 16, 17, 19, and 20, T. 12 N., R. 29 E., and another in secs. 1, 2, and 3, T. 14 N., R. 29 E. Two small bodies are developed about 1 mile north of Connell.

The topography of this type depends upon its relative extent within a given area. Where it constitutes the predominating type the surface is choppy or undulating. Where it is associated with other types the surface consists of a series of parallel ridges, separated by bodies of other soils. The ridges are from 2 to 15 feet or more in height. The general topography of sections in which this type occurs is that of a level to undulating plain with elevations ranging from 400 to 900 feet. In the northwestern corner of the county the type attains an elevation of over 1,100 feet.

Drainage courses have not been developed on this type, and the draws that formerly existed have in many cases been almost obliterated by the drifted sand. A few old channels which carry water at infrequent intervals traverse some areas. These are continuations of drainage courses from the Esquatzel Coulee. The surface quickly absorbs all the precipitation, but the soil holds little moisture within reach of plants. Accumulations of alkali do not occur.

There is no appreciable movement of material at the present time, as the surface is sufficiently protected by the sparse covering of vegetation. The trend of the ridges, the prevailing direction of the wind, and the character of the material indicate that at least a large part of the material has been blown from the sandy bars and beaches of the Columbia River. The type doubtless includes some fine wind-borne dust, which has settled on the surface and has been mixed with the soil material.

The native growth mainly consists of rabbit brush, sagebrush, and cactus. Certain varieties of bunch grass also thrive, and desert plants grow in season.

Many attempts have been made to farm this type without irrigation, mainly by homesteaders. Their efforts were largely unsuccessful, owing to insufficient moisture and to drifting of the soil rather than to any inherent unproductiveness of the soil, and many fields have been abandoned. A few small areas are under irrigation, but there is practically no settlement within the limits of the type.

Results obtained by the cultivation of this and similar types under irrigation indicate that the soil is productive and is adapted to a wide range of crops, including alfalfa, fruit, berries, grapes, potatoes, and vegetables. The greatest obstacle to its successful development, after water is available for irrigation, is the tendency of the soil to drift where the natural cover is removed. To prevent this great care in

the preparation and cultivation of the soil is required. The uneven character of the surface will make leveling and terracing for irrigation expensive.

Winchester sand, loamy phase.—The loamy phase of the Winchester sand, which is indicated on the soil map by cross lines, consists of 12 to 15 inches of a brown loamy sand underlain by a light-brown sand extending to a depth of 6 feet or more. It differs from the main type only in having a higher percentage of fine material in the surface soil. The surface is fairly firm, in contrast to the loose surface of the main type. Small areas of the typical soil are included within areas of the phase. In places it grades toward the Winchester sand, and in others toward a coarse sandy loam.

This phase occurs in all parts of the county where the main type is found. Its greatest extent is in Tps. 13 and 14 N., Rs. 27 and 28 E., in the northwestern part of the county, and in Tps. 9 and 10 N., Rs. 29 and 30 E., in the southern part of the county.

The topography is undulating and, on the whole, less diversified than that of the typical Winchester sand. Moisture is readily absorbed by the soil. Much of it either evaporates or quickly sinks beyond the reach of vegetation. The drainage is excessive and no alkali is present.

Small accumulations of wind-borne dust and fine material give the phase its characteristic loamy texture. It is probable that areas in which this phase occurs have been subjected to comparatively little shifting of the surface material, allowing the fine material to accumulate. The topography is typical of soils of wind-laid origin.

Sagebrush is the predominating vegetation. In this respect the phase resembles the loamy rather than the sandy soil types. Its cultivation by dry-farming methods has not been successful, and it is not being farmed in that way at the present time. When the sagebrush is removed and the soil broken, the wind removes some of the fine material and the texture approaches that of the typical Winchester sand. The preparation of this soil for irrigation is comparable with the preparation required by the main type, with slightly less difficulty in regard to soil drifting. When leveled the texture will be much lighter than at present, on account of the mixing of subsoil material with the soil. The adaptation of this phase to crops is similar to that of the typical Winchester sand.

WINCHESTER FINE SAND.

The Winchester fine sand is a grayish-brown to brown fine sand extending to a depth of 6 feet or more. This material is underlain by a substratum of water-laid gravel. In places there is an intervening stratum of somewhat heavier material. This soil is given an

arbitrary depth of 12 inches, but there is little or no change in color or texture throughout the soil section. With the exception of a few inches of loose fine sand on the surface, the structure of the type is moderately compact.

The texture of this type grades toward a sand in places and small, undifferentiated areas of soil of that texture are included within its limits. As a rule, the soil carries more sand grains coarser than fine sand than does the subsoil. The texture of this type is more uniform than that of the sand of the same series, on account of the smaller quantity of sand of basaltic origin. Small undifferentiated bodies of soil types of the Ephrata and Beverly series are also included with the Winchester fine sand, being too small to map separately.

The depth of the sandy material of this type is subject to the same variations as that of the Winchester sand, being greatest on the crests of the ridges and hillocks and thinning out toward the adjoining soil types. The average depth is probably over 6 feet, with a range from a few inches to 20 feet or more.

This type differs from the fine sand of the Winchester series as described in the Quincy area, Washington, soil survey report¹ in having a brown color instead of the dark-gray color as encountered in this earlier survey. It is differentiated from the Quincy fine sand in having a gravelly substratum instead of a substratum of stratified silts and clays.

The greater part of this type occurs in the western part of the county in T. 12 N., Rs. 29 and 30 E.; T. 11 N., R. 30 E.; T. 10 N., Rs. 28 and 29 E.; and in T. 9 N., Rs. 29 and 30 E. In the northwestern part of the county an area lies in secs. 20, 21, 27, 28, 33, and 34, T. 14 N., R. 29 E., and in sec. 4, T. 13 N., R. 29 E., and another in secs. 2 and 3, T. 14 N., R. 29 E. A small body is mapped in sec. 4, T. 13 N., R. 34 E. The extent of this type is not so great as that of the Winchester sand, but its distribution is fully as wide.

In general the sections in which this type occurs have an undulating topography. In detail, the surface varies from ridged to choppy and undulating, the former topography prevailing where the type occurs as narrow bodies separated by areas of other soils, and the latter where this type is the predominating one of the section. The elevation ranges from 350 to 900 feet in the southern part and from 1,000 to 1,100 feet in the northern part of the county. The ridges rise from 2 to 15 feet above the intervening flats of other types.

The soil quickly absorbs all the precipitation, and no drainage ways are developed. Certain areas are crossed by continuations of drainage channels of the Esquatzel Coulée, but these seldom contain water. The loose character of the surface enables the type to retain

¹ Field Operations of the Bureau of Soils, U. S. Department of Agriculture, 1911.

some moisture, but the drainage is excessive. The soil does not contain injurious quantities of alkali.

There is no appreciable drifting of the soil, owing to the protection afforded by its sparse growth of vegetation. The prevailing direction of the wind, the character of the material, and the trend of the ridges indicate that much of this soil has been blown from the river bars and beaches. Some wind-borne dust from more distant sources is doubtless included.

Rabbit brush, sagebrush, cactus, and bunch grass constitute the native vegetation. Other desert plants common to sandy soils are abundant in their season.

A large acreage of this type has been cleared for cultivation, but at present the only portions under cultivation are in secs. 22, 23, 25, 26, and 28, T. 9 N., R. 29 E., where the type is devoted to orchards.

Interplanted crops of alfalfa, berries, potatoes, rye, etc., are grown. The water for the irrigation of these tracts is obtained by pumping from the Snake River, a few miles above Pasco. The orchards are young and appear to be in a flourishing condition. The interplanted crops yield well with proper care and management.

The production of crops on this type by dry-farming methods is not successful, on account of insufficient moisture and tendency to drift. Irrigation is essential to its development for agriculture, but water for this purpose is available for only a small part of the type at the present time. Considerable care is necessary to prevent the soil from drifting. Some areas require very little leveling, while others can be prepared for irrigation only at considerable expense. With irrigation the type is adapted to a wide range of crops, including alfalfa, berries, grapes, fruit, potatoes, and vegetables.

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

Mechanical analysis of Winchester fine sand.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|-------------|--------------|-------------------------|-------------------------|-------------------------|--------------------------|--------------------------|-------------------------|-------------------------|
| 551198..... | Soil..... | <i>Per cent.</i> 1.2 | <i>Per cent.</i> 2.1 | <i>Per cent.</i> 4.4 | <i>Per cent.</i> 53.2 | <i>Per cent.</i> 32.4 | <i>Per cent.</i> 4.8 | <i>Per cent.</i> 2.1 |

BURKE SERIES.

The Burke series includes light-brown soils having light grayish brown or brownish-gray variations and light grayish brown or yellowish-brown subsoils. A white, calcareous hardpan of more or less fragmentary limestonelike material occurs at depths of 1 foot to 6 feet. This is similar to the stratum underlying the soils of the

Koehler series, and rests upon a substratum of fine, stratified calcareous sediments, usually extending to a great depth. Fragments of the hardpan occur on the surface and in the soil material. The surface is level to broadly undulating, the drainage is good, and the series is free from alkali.

The series probably is derived from material of mixed origin, and consists mainly of weathered material of fine, stratified deposits of lake-laid origin. It is recognized, however, that it has been modified to some extent by the admixture of wind-transported material. The series corresponds to a part of the hardpan phase of the Quincy series, as recognized in the soil survey of the Quincy area, Washington, and is grouped with soils derived from old valley-filling material.

BURKE FINE SANDY LOAM.

The soil of the Burke fine sandy loam is a grayish-brown to light-brown fine sandy loam extending to a depth of about 12 inches. The subsoil is a light grayish brown fine sandy loam extending to a depth of 36 to 40 inches, where it is underlain by a grayish fine sand which rests upon a white, calcareous hardpan at 4 to 6 feet. Fragments of the hardpan are fairly common on the surface, and may occur in the soil and subsoil. The surface usually is firm and the structure of the type is moderately compact. The hardpan fragments are the only calcareous part of the soil, while the material of the subsoil is calcareous both above and below the hardpan.

The texture of the surface soil ranges from a loamy fine sand to a sandy loam. In places, where this type adjoins sandy soils, a thin mantle of loose fine sand covers the surface. The subsoil strata are as a rule of uniform texture. The lower or fine sand stratum is absent in places, the fine sandy loam of the upper subsoil resting directly upon the hardpan. The latter lies a little deeper on the average than in the very fine sandy loam of the series. The Burke fine sandy loam corresponds to the hardpan phase of the Quincy fine sandy loam, and is recognized in the earlier survey of the Quincy area. Some areas of this type have doubtless been reworked to a considerable extent by wind action. The presence of the hardpan differentiates it from other types of similar texture of associated series, and its firm surface, loamy texture, and topography from the typical wind-laid soils of the Koehler series.

The Burke fine sandy loam is less extensive and less widely distributed than the Burke very fine sandy loam. It occurs mainly in association with the sandy types of the Koehler series, in the western part of the county, in T. 14 N., Rs. 28 and 29 E.; T. 13 N., Rs. 27, 28, and 29 E.; T. 12 N., Rs. 29 and 30 E.; and T. 11 N., R. 29 E.

A broadly undulating topography is characteristic of the individual areas of this type, which is confined to the broad desert plain known as Columbia and Owen Flats. Its elevation ranges from 900 to 1,200 feet. All precipitation is quickly absorbed by the soil and no further surface or subsurface drainage is necessary.

The natural vegetation of sagebrush and bunch grass has been removed from much of the type. Many attempts to farm it have been unsuccessful, on account of its tendency to drift when the surface is broken. A few of the larger areas are farmed to wheat with fair results. The yields are lower than the average for the wheat-growing soils of the county because of the lower moisture-holding capacity of the type. Practically no other crops are grown.

The type is naturally productive, and with irrigation would produce good yields of grain, alfalfa, potatoes, and vegetables. Water, however, for irrigation is not available.

BURKE VERY FINE SANDY LOAM.

The soil of the Burke very fine sandy loam as typically developed is a light grayish brown or light-brown very fine sandy loam, with a depth of about 12 inches. The subsoil, to depths of 18 inches to 4 feet, consists of material of the same or somewhat lighter color and similar texture. Below this occurs the white calcareous hardpan, which rests on fine, stratified deposits of lake-laid origin. Small fragments of the hardpan occur on the surface and in the soil material. The structure of both soil and subsoil is compact. The surface is firm in its natural state; when broken and harrowed it becomes loose and mellow. The soil is noncalcareous except for the hardpan fragments, but the subsoil is calcareous.

The light-brown color of this type is much more pronounced even under its natural low moisture content than in the air-dry samples. The color becomes slightly lighter with depth, but does not under ordinary field conditions, except in case of the deeper portions of the type, have a pronounced grayish color. In places a thin stratum of sandy material immediately overlies the hardpan.

The white calcareous formation, or hardpan, is a more or less fragmentary, rocklike stratum from 2 to 5 feet thick. Its lime content is rather high. The fragments on the surface are most noticeable in the fallow. Their distribution is not uniform; they are so numerous in places that they cover the surface, and frequently they afford protection from drifting.

This type has a fairly wide distribution in the western part of the county. It is mapped in T. 14 N., Rs. 29 and 30 E.; T. 13 N., Rs. 27, 28, 29, and 30 E.; T. 12 N., Rs. 28, 29, and 30 E.; T. 11 N., Rs. 28, 29, and 30 E.; and in T. 10 N., Rs. 28 and 29 E. The most extensive area

lies just south of the Koontz Coulée. Originally the type covered a larger part of Columbia and Owens Flats, but its area has been reduced by the deposition of wind-laid sand.

The surface of this type is level to broadly undulating. The underlying hardpan acts as a cap or rim rock, and the line between this and associated lower-lying types usually is well defined. The break toward the Columbia River is abrupt and steep. The elevation of the type ranges from 800 to 1,100 feet above sea level. The soil absorbs all the precipitation, and there is no run-off. No drainage channels or coulées traverse the type. The character of the surface indicates little reworking by the wind in recent times.

Little of this type retains its original growth of sagebrush and bunch grass. A considerable acreage which was farmed at one time is abandoned and covered with weeds. Some areas are cultivated to wheat, which is cut for hay or thrashed. The yields range from a few bushels to 25 bushels per acre. The acreage of wheat on this type ranks next to that on the Ritzville silt loam. Rye is grown to a small extent. Potatoes, fruit, and vegetables are grown for home use.

Crops are often injured and sometimes destroyed by the drifting of the soil. The tendency to drift seems to be greater in some sections than in others, probably because of a slightly lighter texture. To prevent drifting, straw and trash are left on the surface, and fields are plowed as infrequently as possible. Harrowing while the fields are in fallow is avoided except when absolutely necessary. Russian thistles grow luxuriantly and are a serious hindrance in carrying out the dry-farming methods necessary to success in this region. The surface of this type is in most cases well adapted to irrigation; little leveling would be required. With water available the type would produce good yields of many general and special farm crops.

Burke very fine sandy loam, deep phase.—This phase differs from the typical Burke very fine sandy loam only in the depth at which the hardpan is encountered. In the typical soil the greatest depth to this hardpan is about 4 feet, in the phase the hardpan occurs at or below a depth of 6 feet. In this phase the material overlying it is similar to that of the main type, except that it has a slightly grayer color as the hardpan is approached. Fragments of the hardpan are uncommon on the surface and in the soil material.

This phase is mapped only in T. 14 N., Rs. 30 and 31 E., northwest of Connell. It occupies an extensive flat, nearly a township in extent. The surface is level to broadly undulating. The drainage is good.

Practically all the phase is in cultivation. Wheat yields from a few bushels to 35 bushels per acre. The phase is regarded as a better wheat soil than the soil of many areas of the main type.

Mechanical analyses of samples of the soil and subsoil of the typical Burke very fine sandy loam gave the following results:

Mechanical analyses of Burke 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> |
| 551126..... | Soil..... | 0.2 | 0.4 | 1.0 | 12.3 | 40.5 | 43.4 | 2.3 |
| 551127..... | Subsoil..... | .1 | .6 | 1.2 | 12.8 | 34.4 | 46.2 | 4.6 |

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO₃): No. 551127, 1.68 per cent.

SAGEMOOR SERIES.

The soils of the Sagemoor series have light-brown surface soils, with light grayish brown variations, while the subsoils are lighter brown or light grayish brown to light gray. The light-gray color is most pronounced under dry conditions, the browner color being more pronounced when the material is moist. The surface material and substrata are made up of stratified fine material, mainly very fine sand and calcareous silt and clay. (Pl. I, fig. 2.) The series lies below the elevation of the area occupied by the white calcareous hardpan of the Burke and Koehler series. Occasional boulders, apparently glacial erratics, are found on the surface or embedded in the soil material.

The surface is undulating to rolling and drainage is good. The weathering of semiconsolidated, lake-laid very fine sands, silts, and clays has resulted in the formation of the soils of this series. Accessions of material transported by the wind have contributed to their formation. The series is correlated with the old valley-filling material. It differs from the Burke series in the absence of hardpan and from the Ritzville in being derived from and underlain by stratified material.

SAGEMOOR FINE SANDY LOAM.

The soil of the Sagemoor fine sandy loam is a light-brown to light grayish brown fine sandy loam, with a depth of about 12 inches. The subsoil is a light-gray to light grayish brown fine sandy loam, slightly lighter in color than the soil, extending to a depth of 3 to 4 feet. Below this the stratified material of the substratum, consisting of calcareous silts and clays, is encountered, and this material extends to depths of many feet.

The soil of this type grades toward a loamy fine sand rather than toward a heavy fine sandy loam. Some of the soil areas have a

rather firm surface and compact structure. In places a thin mantle of fine sand covers the surface, and as a rule the texture becomes heavier and finer with depth, the loose structure of the immediate surface giving way to the compact structure of the remainder of the soil section. Boulders are of rare occurrence. Grayish fragments of the compact material, traversing the substratum as transverse veins, apparently similar to the generally horizontal sedimentary beds, frequently are brought to the surface by burrowing animals.

In occurrence the Sagemoor fine sandy loam is closely associated with the Quincy fine sand and sand in the southwestern part of the county. A long area is mapped in T. 13 N., Rs. 28 and 29 E. Other areas occur in secs. 11 and 15, T. 12 N., R. 29 E., and in secs. 3, 4, and 5, T. 14 N., R. 28 E.

The surface of this type ranges from undulating to sloping and rolling. The latter topography, which is of small extent, is due to the presence of small valleys or draws. Where associated with the sandy soils of the Quincy series the bodies of this type are long and narrow, occupying the flats of hard land between the sand ridges. The elevation of the type ranges from 500 to 1,100 feet. There is no run-off, and all drainage courses are the result of former climatic conditions. The removal of fine material and the reworking of the surface by winds accounts for the lighter and coarser texture of this type as compared with the very fine sandy loam. The presence of the occasional boulders may be due to deposition from drift ice in a temporary glacial lake. In places the type is underlain at some depth by a bed of gravel and cobbles of various kinds of rocks.

Agriculture on this type is confined to the production of wheat and rye. The acreage of each crop is small, and the yields are rather low. A sparse growth of bunch grass affords some pasturage. The agricultural development has been retarded by association with sandy soils which drift freely when the native vegetation is removed. The sand from the ridges blows over the intervening flats of this type, giving entire fields a sandy surface, which in this section is not adapted to the successful production of wheat and rye by dry-farming methods. This type when broken drifts more readily than the types of finer and heavier texture.

Irrigation is essential to the best development of the Sagemoor fine sandy loam. A large part of it lies within one of the pumping units of the proposed Palouse project, which is discussed elsewhere in this report. For the remainder, the probability of water being made available for irrigation is more remote. The type is regarded as a productive soil, and with irrigation is adapted to nearly all the general and special crops common to the region.

SAGEMOOR VERY FINE SANDY LOAM.

The soil of the Sagemoor very fine sandy loam is a light-brown to light grayish brown very fine sandy loam, about 12 inches deep. Its texture and color are uniform. The type has a firm surface, and its structure is compact. The subsoil is a light grayish brown or light brownish gray very fine sandy loam to a depth of 30 to 48 inches, where it passes into a gray to yellowish-gray very fine sandy loam to silt loam, extending to a depth of 6 feet or more. The lower subsoil and the substratum—that is, the layer below 6 feet—shows stratification. The compact structure of the soil material continues throughout the subsoil. The material of both the subsoil and the substratum are distinctly calcareous. Boulders are present but uncommon. The type holds moisture fairly well under dry-farming methods.

The texture of this type grades toward a silt loam. Small undifferentiated areas of very fine sand occur. The type lies below the level of the white, calcareous hardpan formation of the Burke and Koehler series.

Every township west of the Esquatzel Coulée and the Northern Pacific Railway, except T. 14 N., Rs. 27 and 28 E., and T. 9 N., Rs. 28 and 29 E., contains areas of this type. It adjoins and lies just below the Burke very fine sandy loam, and is the intervening type between this member of the Burke series on the one hand and the lower terrace soils and Scabland on the other.

A moderately rolling topography is characteristic. The surface features vary with the position; the parts immediately adjoining the Burke very fine sandy loam are often steeply sloping, while farther away from that type the diversity in topography decreases. A few areas are moderately sloping. The greater part of the type lies between 800 and 1,100 feet above sea level.

The surface readily absorbs all the rainfall, but in case of a sudden thaw of snow the fine-textured surface quickly becomes saturated and allows some run-off. Old drainage courses cross parts of the type, and have fairly well developed valleys and draws in places. These are in no case the result of recent erosion.

Nearly all this type has at some time been farmed to grain. At present only areas of favorable topography and location are in cultivation. Dry-farmed wheat and rye are practically the only crops grown. The yields vary with the seasons, and range from a few bushels to 30 bushels per acre. Much of this type is remote from markets, but this is not considered a serious handicap in wheat farming.

Irrigation would bring out the full possibilities of this type, but leveling and the distribution of irrigation water would be expensive.

The cost of pumping from the deep wells would be prohibitive, even if the supply were known to be adequate. The possibility of obtaining water from some other source is very remote.

The soil has a strong tendency to drift when broken. The moisture supply and organic-matter content are not sufficient to prevent drifting.

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

Mechanical analyses of Sagemoor 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> |
| 551195..... | Soil..... | 0.0 | 0.2 | 0.3 | 10.6 | 50.4 | 33.8 | 4.4 |
| 551196..... | Subsoil..... | .2 | .4 | .6 | 10.0 | 42.4 | 42.4 | 3.7 |

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO_3): No. 551196, 1.22 per cent.

SAGEMOOR SILT LOAM.

The soil of the Sagemoor silt loam is a light grayish brown or light-brown silt loam, about 12 inches deep. It has a compact structure, and the surface is firm. The grayish color is most pronounced in air-dry cultivated surfaces, the brown predominating under average conditions of moisture. The subsoil is a light grayish brown silt loam, underlain at a depth of about 3 feet by a light-gray very fine sand to very fine sandy loam, which extends to a depth of 6 feet or more. The substratum consists of irregularly stratified silts and fine sands, extending to a depth of many feet. Occasional granitic boulders and fragments of many kinds of rocks occur on the surface. In cuts boulders are sometimes exposed in the stratified material.

The type has a soil of fairly uniform texture, except immediately adjoining areas of the Quincy fine sand and very fine sand, where material of slightly lighter texture or a thin mantle of fine sand is sometimes found. Material of vein structure extending transversely across the stratified beds of the substratum is frequently brought to the surface by burrowing animals, and cuts show that these veins extend to the surface.

This type is encountered only in the southern part of the county, in Tps. 9 and 10, Rs. 30, 31, and 32 E. Several isolated areas occur in the Snake River Canyon.

An undulating to rolling topography has been developed by water erosion under previously existing climatic conditions. The valleys are short and narrow and are tributary to the Snake River. None of them carry water at the present time. The range in elevation is from 400 to 700 feet.

Much of this type has been farmed, but at present only a few small isolated tracts are in cultivation. The uncleared areas are used for pasture, and the areas formerly farmed support a growth of weeds.

The soil does not drift badly, but is rather droughty and as a rule does not retain sufficient moisture for the successful production of crops by dry farming. Irrigation is necessary for its development, but water for this purpose is not available at present. The surface would require little preparation for irrigation. With irrigation the type should produce good yields of many of the crops commonly grown in this section. Most of this type lies near shipping points.

EPHRATA SERIES.

The soils of the Ephrata series are of light-brown or light yellowish brown color and carry some waterworn gravel on the surface and throughout the soil material. When dry the material may have a grayish color. The subsoil is uniform to a depth of 24 to 36 inches, where it is underlain by a porous bed of rounded gravel, cobbles, and boulders, with interstitial sands, extending to depths of many feet. While the coarse material is mainly basaltic, some material from crystalline rocks is present. The fine material of the soil and subsoil is derived from a variety of rocks and is usually calcareous.

The series occupies terraces, with a level to gently undulating topography. The underdrainage is excessive. The series is free from alkali. The material is mainly current laid and was probably deposited by glacial streams. As mapped, however, small quantities of undifferentiated stream-laid material of nonglacial origin may be included. In the sandy members the surface has been modified somewhat by winds.

EPHRATA SANDY LOAM.

The soil of the Ephrata sandy loam is a light-brown to light grayish brown sandy loam of somewhat compact structure, 12 to 15 inches deep. The subsoil has two divisions; the upper is a brown loamy sand to sandy loam, extending to a depth of 24 to 36 inches; the lower a gray to dark-gray, porous coarse sand to fine gravel, which continues to a depth of 6 feet or more. This is underlain by the coarser gravelly substratum. Basaltic bedrock is encountered at varying depths.

Particles of basalt of the sand and coarse sand grades are mixed with the soil and upper subsoil. It is the greater proportion of this material that distinguishes this type from the very fine sandy loam of the same series. As a rule, the quantity of these sand particles increases with depth, and imparts to the upper subsoil a texture lighter than that of the soil. Fragments of basalt frequently are scattered over the surface. The boundary between the upper and

lower subsoil is sharp and distinct. The latter consists mainly of basaltic fragments, with little or no material of finer grade than sand. Frequently these have a white, calcareous coating, which sometimes cements the fragments into a semiconsolidated mass. The presence of coarse gravel and bowlders on the surface is uncommon.

The type as mapped includes small undifferentiated areas of the very fine sandy loam and the fine sandy loam of the series, as well as some bodies of coarse sandy loam, a type not mapped in this area. The latter occurs on rather steep terraced slopes.

The largest continuous area of this type occurs in the southwestern part of the county. Other areas lie in T. 9 N., Rs. 29 and 30 E., and in T. 10 N., R. 31 E., in the southern part of the county. Several bodies are mapped along the Washtucna Coulée, and other areas occur along the Snake River.

The surface of the terraces of this type is level to undulating. The terraces occupied by this soil vary from small and isolated to broad and continuous. They range in elevation from 400 feet in the southern part of the county to 1,000 feet or more in the northern part, and in topography from level to undulating. A few small areas have short, narrow draws traversing them; but these are the only drainage courses. Internal drainage is excessive.

Sagebrush constitutes the greater part of the native vegetation, though there is a scattered growth of bunch grass, and in their season other desert plants.

A considerable proportion of this type has been cleared and farmed for short periods. These attempts were made by homesteaders, and were generally unsuccessful on account of insufficient moisture. At present only a small acreage in the vicinity of Pasco is farmed. Water for irrigation is obtained by pumping from the Snake River.

Alfalfa, orchard crops, and vegetables are grown, but practically no products are marketed. With the extension of irrigation a much larger acreage of this type probably will be developed. The soil does not drift badly and requires comparatively little leveling and other preparation for irrigation. This is a desirable soil for the production of alfalfa, fruit, berries, potatoes, and vegetables.

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

Mechanical analyses of Ephrata 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> |
| 5511137..... | Soil..... | 8.2 | 22.0 | 4.6 | 13.4 | 29.4 | 19.2 | 3.0 |
| 5511138..... | Subsoil..... | 10.7 | 21.2 | 4.0 | 15.2 | 30.4 | 15.6 | 2.8 |

EPHRATA FINE SANDY LOAM.

The soil of the Ephrata fine sandy loam as typically developed is a light-brown to light grayish brown or yellowish-brown fine sandy loam to a depth of about 12 inches. The subsoil has two divisions, the upper a light grayish brown to gray loamy fine sand to fine sandy loam extending to an average depth of 3 feet, and the lower consisting of a bed of coarse sand and fine gravel, with some interstitial sand of fine grades. The color of this lower stratum is dependent upon the quantity of fine quartz sand present and upon the abundance of the white, calcareous coating on the basaltic sand and gravel. With the presence of one or both of these, the material has a gray color; without either in any appreciable quantity the color is dark gray to black. The deeper subsoil rests upon bedrock or upon fine material belonging to the formation from which the Sagemoor series is derived. Occasional boulders and some gravel occur on the surface. The immediate loose surface of the type is underlain by compact material.

This type includes a variation which is indicated on the soil map by symbol. It is distinguished from the typical soil by its shallow depth and the presence of rock outcrop. The depth of the soil and subsoil material varies from a few inches to several feet, and the shallow areas are of frequent but irregular occurrence, on account of the uneven character of the surface of the underlying rock. The rock outcrops are small but rather numerous.

The surface soil of the Ephrata fine sandy loam is less uniform in texture than that of the other types of the series. This is due to the location of much of the type between ridges of the Winchester fine sand and sand. In such places the soil has been modified by accessions of some wind-blown material, and ranges in texture from a loamy fine sand to a fine sandy loam. In places, usually in small areas which adjoin sand ridges, the surface is covered with 2 or 3 inches of loose fine sand or sand.

There is also a greater range in depth to the lower subsoil than in the case of the other types of the series. The lower subsoil is encountered at 18 to 48 inches, with an average depth of about 3 feet. As the soil grades into the upper subsoil there is merely a gradual change to a slightly lighter color, but the line of separation between the upper and lower subsoil is distinct.

This type occurs in Tps. 12 and 13 N., Rs. 30 and 31 E.; T. 11 N., Rs. 30 and 31 E.; T. 10 N., Rs. 28, 29, 30, and 31 E.; and T. 9 N., Rs. 29, 30, and 31 E. Large, continuous areas are infrequent, but long, narrow bodies between ridges of Winchester sand and fine sand are of common occurrence. The rock outcrop variation occupies an area of about 6 square miles in T. 13 N., Rs. 29 and 30 E.

While the localities in which this type occurs have a general terraced topography, the surface as a rule is level or very gently sloping to undulating. The precipitation is readily absorbed by the soil, and no drainage courses have been developed.

In some places sagebrush, and in others rabbit brush, predominates. Other desert plants common to the section flourish in season. Although quite an acreage of the type has at some time been cleared and farmed, only a few acres, lying in secs. 21 and 22, T. 9 N., R. 29 E., are now in cultivation. These are irrigated by water pumped from the Snake River. Grazing is the principal use of all other portions of the type. Alfalfa, fruit, and potatoes are produced in small quantities on the irrigated land. The soil is regarded as a productive and desirable one. The agricultural value of the rock outcrop variation of this type is considerably lower than that of typical areas.

Irrigation is essential to agricultural development, as the type is too droughty to produce profitable crops with dry-farming methods. It requires very little leveling or other preparation for irrigation, but at present water is available for only a small part of it. Pumping from wells seems impracticable, on account of the great depth to water. The irrigation of the higher lying portions of this type is being urged. A small percentage of the rock outcrop variation is devoted to the production of wheat and rye. The results are not satisfactory.

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

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> |
| 551180..... | Soil..... | 3.9 | 2.6 | 3.2 | 40.6 | 30.2 | 16.6 | 2.9 |
| 551181..... | Subsoil..... | 4.8 | 3.4 | 2.0 | 17.1 | 33.0 | 35.8 | 3.8 |

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO_3): No. 551181, 2.18 per cent.

EPHRATA VERY FINE SANDY LOAM.

The Ephrata very fine sandy loam consists of a light-brown very fine sandy loam, with a depth of 12 to 36 inches, underlain by a mass of porous gravel, boulders, and sand, extending to a depth of 50 to 100 feet or more. The soil and subsoil are generally somewhat calcareous and the gravel is often coated with lime. The sand in the subsoil is mainly quartz. Low, broad mounds carrying a higher percentage of gravel than the average soil are characteristic of portions

of the type. The soil, though rather compact, is friable and easily tilled.

The texture of the type is fairly uniform, though it grades in places toward a fine sandy loam, and in cultivated fields, where some of the fine material has been removed by the wind, toward a very fine sand. Outcrops of basalt are of infrequent occurrence in typical areas.

The Ephrata very fine sandy loam is an extensive and widely distributed soil in this county. It is found in the Washtucna and Esquatzel Coulées, in the Snake and Palouse River Canyons, and in the associated areas of Scabland.

The areas mapped in the northern part of T. 14 N., Rs. 29 and 30 E., extend northward to the broad section of Scabland in the vicinity of lower Crab Creek in the Quincy area.

This type has a broad, level, terraced topography, but in most cases steep, gravelly slopes separate it from lower lying soils of other series as well as from other terraces of the same type. The elevation ranges from 700 to 1,100 feet. In places the surface is very gently sloping to undulating. Old drainage channels or coulées cross some areas of the type. The internal drainage is excessive and the soil has a low moisture-holding capacity, although areas in which the fine material is at least 20 inches in depth hold moisture fairly well where good methods of dry farming are followed. Fragments and boulders of granite are of infrequent occurrence.

Sagebrush and bunch grass constitute the greater part of the native vegetation. Areas once in cultivation and now abandoned support a growth of Russian thistle, mustard, and other weeds. A large part of the type is cleared and farmed to wheat and rye. In favorable seasons average yields are obtained, and the yields are subject to greater variation than on the deeper and heavier upland types. A yield of 20 bushels per acre is regarded as good. Summer fallowing is practiced in all cases in order to preserve a sufficient supply of moisture. In its natural state the firm surface and the vegetation prevent blowing, but some difficulty is experienced in protecting the cultivated soil, and fields that have been in cultivation for a period of years drift more readily than those recently broken. In development and crop adaptation the type more closely resembles that part of the series mapped east of the southern end of Moses Lake in the Quincy area than it does the shallower and coarser soil farther north in the same area.

The intensive development of this type can be accomplished only under irrigation, but the depth to ground water practically precludes irrigation by pumping, and except for a small area other sources of supply are not at present available. A part of the area in sec. 18,

T. 9 N., R. 29 E., is under irrigation and produces good crops of alfalfa, fruit, potatoes, and vegetables. The cost of leveling is comparatively small. Some of this type is included in the proposed Palouse reclamation project, but by far the greater part lies too high to be supplied with water. The deeper areas of the type would doubtless produce profitable yields of wheat under dry-farming methods, but the shallower areas hold insufficient moisture for the successful production of this crop except in very favorable seasons.

Like the Ephrata fine sandy loam, the Ephrata very fine sandy loam includes a rock outcrop variation, which is indicated on the soil map by rock outcrop symbols. The areas so indicated differ from the typical portions of the type in the presence of rock outcrop and in having a shallower depth to bedrock. The soil is a light-brown very sandy loam, grading to a silt loam in a few places in the eastern part of the county. The subsoil is a continuation of the soil material, but is calcareous and when dry has a lighter gray color. At 24 to 36 inches it is underlain either by the deep, gravelly substratum of the series or by bedrock. Though the surface of areas of this variation is practically level, there is a wide range in depth, as the upper surface of the basalt is very irregular. The rock may outcrop, or may lie at any depth from a few inches to many feet. The deep gravelly subsoil where present is usually not so well developed as in typical areas of the type.

The variation of the Ephrata very fine sandy loam is closely associated with areas of Scabland, as well as with bodies of the typical soil. Small, undifferentiated areas occur within areas of the typical soil, and some small, irregular bodies are included with areas of Scabland. These can not be separated satisfactorily on the soil map and are unimportant agriculturally.

Very little of this rock outcrop variation has ever been in cultivation, and it is not farmed at the present time. It is more droughty than the typical soil and is not adapted to the production of dry-farmed crops. Until water can be made available for irrigation its best use is for grazing.

Ephrata very fine sandy loam, alluvial-fan phase.—The alluvial-fan phase of the Ephrata very fine sandy loam, which is indicated upon the soil map by crosslines, is a grayish-brown or light-brown to brown very fine sandy loam with a depth of about 36 inches, underlain by a grayish-brown to light-brown fine gravelly sand extending to a depth of 6 feet or more. There is no line of distinction between the soil and upper subsoil, and a depth of 12 inches for the surface soil is arbitrarily assumed. In places a change to a slightly lighter color occurs near that depth. The line between the upper and lower subsoils is fairly well defined and occurs at depths of 24 to 40 inches. The deep substratum of coarse material rests upon basaltic bedrock

at unknown depths. The coarse material of the soil, subsoil, and substratum is mainly basaltic.

The texture of the soil is subject to some variation, being coarser near the apex of the fans, or the point where the stream courses emerge into the valleys, and grading finer toward the lower limits of the deposits of this character. Textures ranging from a loamy coarse sand to very fine sandy loam occur, but the latter texture predominates and the others are of small extent.

This phase of the Ephrata very fine sandy loam occurs mainly in the Washtucna Coulée. One area is mapped along the Snake River, in the eastern part of the county. Small areas which can not be shown satisfactorily on the map are included as undifferentiated material with the typical soils of the Ephrata series.

The large area in the Washtucna Coulée is made up of a series of alluvial fans on both sides of the coulée, and its topography is gently sloping to undulating. As a rule, these fans are covered by one or more stream channels. These carry water only after the sudden thawing of snow and overflow if the volume of water is exceptionally large. At all other times drainage is good.

Sediment from the adjoining upland and terrace soils of the Ritzville and Ephrata series, carried by intermittent streams traversing those soils and deposited when the current of the water is checked upon reaching the coulée floor, have formed the soil. Recent accretions are unimportant. Small quantities of material of colluvial and wind-borne origin have been mixed with the alluvial material.

Parts of this phase are dry-farmed to wheat with fair results in favorable seasons, but irrigation is necessary to its successful development, on account of its low moisture-holding capacity. At present an adequate supply of water is not available. Under irrigation alfalfa, potatoes, and grain crops could be profitably produced.

Mechanical analyses of samples of the typical soil and subsoil and of the alluvial-fan phase follow:

Mechanical analyses of Ephrata very fine sandy loam.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|---------------------|--------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Typical: | | <i>Per cent.</i> | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| 551143, 551186..... | Soil..... | 2.4 | 1.0 | 0.6 | 14.7 | 52.2 | 25.4 | 3.4 |
| 551144, 551187..... | Subsoil..... | 3.4 | 1.0 | .6 | 12.7 | 47.1 | 31.5 | 3.2 |
| Alluvial-fan phase: | | | | | | | | |
| 5511114..... | Soil..... | .8 | 1.4 | 1.0 | 8.6 | 39.2 | 47.4 | 1.8 |
| 5511115..... | Subsoil..... | 1.4 | 1.9 | 1.4 | 11.6 | 40.3 | 41.8 | 2.0 |

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO₃): No. 551187, 1.45 per cent.

BEVERLY SERIES.

The Beverly series consists of 6 to 30 inches of brown to light-brown material, comprising the soil and subsoil, underlain by river-laid deposits of coarse gravel and cobbles. Gravel occurs on the surface and throughout the finer material in varying quantities. Both fine and coarse material are derived from crystalline and basaltic rocks, and the soil material is often distinctly micaceous. The gravel and boulders are well rounded.

The series occupies comparatively recent river terraces and first bottoms. It usually lies above overflow, though some low-lying areas are occasionally subject to flooding. Owing to their position and the porous substratum the soils are excessively drained. A growth of sagebrush and desert shrubs and plants forms the vegetation. The surface material of the lighter members of the series has been modified by admixture of material by the wind.

BEVERLY GRAVELLY FINE SAND.

The soil of the Beverly gravelly fine sand to a depth of 12 inches is a light-brown or brown, porous fine sand carrying fairly large quantities of rounded gravel. The material continues with increasing quantities of gravel to a depth of 30 inches, where it is underlain by the typical deep subsoil and substratum of the Beverly series, a bed of current-laid gravel and cobbles and sand. The coarse material consists of a mixture of crystalline and basaltic rock fragments. The surface material is loose and generally micaceous.

Small, low hummocks of wind-drifted fine sand, with very little gravel, are a typical feature. Between these low hummocks the soil is a gravelly fine sand, the surface of which is practically covered with gravel. In places the deep subsoil contains a larger quantity of sand and less cobbles than the typical subsoil of the series. The type differs from the Winchester fine sand mainly in the depth of the sandy material of the hummocks and in the presence of gravel.

This type is confined to terraces along the Columbia River. It is found about 3 miles north of Ringold on Savage Island; in sec. 12, T. 9 N., R. 28 E.; in secs. 20, 21, 22, 26, 27, and 28, T. 9 N., R. 29 E.; and in secs. 32 and 33, T. 9 N., R. 30 E.

The topography is gently undulating to sloping, the surface being thickly dotted with the small, low hummocks and small, intervening, gravelly flats. The elevation is 20 to 50 feet above the lower water level of the river. Porosity of the material gives excessive drainage.

The native vegetation consists of a mixture of sagebrush and rabbit brush, with a sparse growth of bunch grass. The covering of brush has been removed from a large part of the type, but only a few acres are in cultivation. These are set to orchards, crops being

grown between the trees while they are young. The type requires comparatively little leveling for irrigation, but great care is required to prevent drifting. With an abundance of water and careful handling, the type is adapted to the production of nearly all the crops grown under intensive farming methods in this section. It has a favorable location with respect to transportation.

BEVERLY VERY FINE SANDY LOAM.

The Beverly very fine sandy loam consists of a light-brown to brown very fine sandy loam to an average depth of about 20 inches, underlain by a bed of well-rounded gravel, cobblestones, and sand. This material extends to a depth of 6 feet or more. In places gravel occurs on the surface and throughout the fine material. The coarse material of the type consists of waterworn fragments of crystalline and basaltic rocks in almost equal proportion. The fragments in places have a white, calcareous coating, and sometimes they are cemented into a hardpan. A distinct boundary between the fine material of the soil and the gravel stratum occurs at 12 to 30 inches below the surface. At a depth of about 12 inches there is a slight change in color. The depth of the surface soil is arbitrarily placed where this change to a lighter color takes place.

The light-brown color and the shallow depth to the gravelly substratum differentiate this soil from the very fine sandy loam of the Pasco series. The Ephrata and Beverly very fine sandy loams are similar in color of soil and depth to the gravelly substratum, which in the former is coarse sand and fine gravel of basaltic origin and in the latter a mixture of coarse, rounded crystalline and basaltic rock fragments. Also the former occupies high terraces while the latter is found on low terraces.

This type is confined to terraces along the Columbia and Snake Rivers. The surface is level to gently undulating or sloping and from 20 to 50 feet above the normal level of the river. The soil is excessively drained.

The native vegetation is principally sagebrush, with some desert shrubs and a scattering of bunch grass and other desert plants.

Agriculture on this type is possible only with irrigation. A large acreage has been cleared of brush, but only a small part of it is now in cultivation. Orchard crops, berries, alfalfa, grapes, and potatoes are produced. Development here is recent, and crop yields can not be given accurately. The young orchards are making a satisfactory growth. Other crops, with a good supply of water for irrigation and with proper care, give promising yields. The extent of development by irrigation is probably greater on this type than on any other soil in the county. Most of this is in T. 9 N., Rs. 28 and 29 E.

The type requires very little preparation for irrigation and is not subject to excessive drifting when cleared and broken. It is regarded as a productive and desirable soil for intensive farming under irrigation and is for the most part well located with respect to transportation.

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

Mechanical analyses of Beverly 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> |
| 5511134..... | Soil..... | 1.6 | 1.6 | 1.0 | 7.5 | 46.4 | 38.4 | 3.4 |
| 5511135..... | Subsoil..... | 7.1 | 8.9 | 2.6 | 18.4 | 39.4 | 18.6 | 5.2 |

PASCO SERIES.

The Pasco series embraces soil types of recent alluvial origin having soils of medium to dark-brown or dark grayish brown color, underlain by subsoils of slightly lighter color. At a depth of 6 to 15 feet a gravel substratum occurs. The soils and subsoils are noncalcareous and in many places distinctly micaceous. The surface is nearly level and the drainage good, except at times of exceptionally high water, when some areas are subject to overflow. The parent material is derived from a variety of rocks.

The series differs from the associated Beverly series in color, being a darker brown, in its less extensive modification of surface material by winds, and also in depth to the gravel substratum. In the case of the Beverly series the gravel substratum usually is encountered at 12 to 24 inches below the surface; in this series it is encountered at depths of 6 to 15 feet.

PASCO FINE SAND.

The Pasco fine sand is a brown to rather dark brown or dark grayish brown fine sand with a slightly lighter colored subsoil, extending to a depth of 6 feet or more, and underlain by a gravel substratum at depths of 6 to 15 feet. The type is uniform in color and texture, fairly loose in structure, and is composed of fine alluvial material derived from crystalline and basaltic rocks. Flakes of mica are fairly numerous. In many places the subsoil shows successive strata of different grades of sand, with an occasional layer of heavier material.

This type is confined mainly to the islands in the Columbia and Snake Rivers, which are just above the average high-water level. At low-water stages it is surrounded by fairly extensive areas of river gravel.

The surface of the Pasco fine sand is practically level, though the type is traversed in places by overflow channels. The drainage is adequate, except when the rivers reach their highest stages, when parts of the type are overflowed for short periods.

The native vegetation is black sage and other desert shrubs. Along the banks of sloughs and rivers there is a sparse growth of small cottonwood.

Very little development has taken place on this type. A few areas are farmed to grain and alfalfa; other small tracts have been farmed and are now abandoned. Its location on islands renders it rather inaccessible during a part of the year. Irrigation is necessary for the successful production of crops. Water is available by pumping from the rivers, and the irrigation of the type would not be very expensive, but the individual areas are rather small and isolated. The danger of injury or loss of crops by overflow and the isolation of the type have retarded its development.

Results of mechanical analyses of samples of soil and subsoil follow:

Mechanical analyses of Pasco fine sand.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|-------------|--------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|  |  | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | <i>Per cent.</i> |
| 551158..... | Soil..... | 0.0 | 0.6 | 4.8 | 51.8 | 26.2 | 14.3 | 2.1 |
| 551159..... | Subsoil..... | .0 | 1.0 | 7.9 | 66.2 | 14.8 | 8.1 | 1.9 |

PASCO VERY FINE SANDY LOAM.

The Pasco very fine sandy loam consists of a brown to rather dark brown or dark grayish brown very fine sandy loam, underlain at a depth of 12 to 15 inches by a slightly lighter colored very fine sandy loam subsoil. This rests upon a gravel substratum at depths of 6 to 20 feet. The soil is rather compact and fairly uniform. The subsoil is made up of successive strata of very fine sand, very fine sandy loam, and silt loam, all of which are quite compact and have an average texture of very fine sandy loam. In places along the river channels small quantities of coarser material are encountered. Both soil and subsoil carry noticeable quantities of mica, and the subsoil sometimes shows faint mottlings of yellow.

The type occupies flats along the Columbia, Snake, and Palouse Rivers, lying between the gravel of the river channels and the higher terraces. These areas are small and often widely separated. In places the type is covered by Winchester fine sand.

Areas of this type have a typical river flood plain topography, with a perceptible slope from the river bank toward adjoining types.

It is higher on the river side than where it adjoins the higher terraces. There is also a slope in the direction of stream flow. Otherwise the surface is practically level. The type lies from 10 to 20 feet above the normal level of the rivers, from which it is separated by perpendicular bluffs, and is adequately drained, except at times of excessively high water, when it may be overflowed for short periods. In places old channels are found on the margins of the areas away from the river. These contain water when the river is high. Accumulations of alkali do not occur.

The type supports a native growth of black sage, which grows more luxuriantly than on the soils of other series, with a scattering of bunch grass.

Portions of this type are used for the production of alfalfa, potatoes, berries, and vegetables, and good yields are obtained. Water for irrigation is obtained by pumping from the river. All the type has a favorable location for irrigation by this means. Subirrigation takes place during the higher stages of the river, so that irrigation is not necessary for some crops during a part of the growing season. The soil is easily tilled and is adapted to a wide range of crops under irrigation. Some areas are remote from railroad points, but water transportation is convenient.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil and a single analysis of a sample of the lower subsoil of this type:

Mechanical analyses of Pasco 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> |
| 551149, 551117..... | Soil..... | 0.1 | 0.7 | 0.8 | 16.5 | 39.9 | 37.4 | 4.8 |
| 551150, 551118..... | Subsoil..... | .2 | .8 | 1.2 | 35.5 | 30.0 | 28.2 | 4.2 |
| 551119..... | Lower subsoil... | .1 | .4 | 1.2 | 17.6 | 28.3 | 46.6 | 5.9 |

RINGOLD SERIES.

The Ringold series is characterized by a light-gray or yellowish-gray soil and subsoil, with brownish-gray variations, and by a substratum of light-gray, compact silts and clays. The material is of local alluvial-fan and foot-slope origin. It is derived by erosion and deposition from unconsolidated fine deposits of lake-laid character. The material of this series is calcareous. The surface is gently sloping, and surface drainage is well established. Injurious accumulations of alkali do not occur. Under irrigation the series is used for growing fruit, alfalfa, potatoes, berries, and garden crops.

RINGOLD CLAY LOAM.

The soil of the Ringold clay loam is a light-gray or yellowish-gray clay loam, to a depth of 12 inches. It is very compact in structure, and is deficient in organic matter. The subsoil is a light-gray to yellowish-gray silty clay loam, which becomes heavier with depth until it passes into a light-gray silty clay below a depth of 3 feet. A substratum of similar material is encountered at a depth of 6 feet and extends to depths of several feet. It is probably underlain at great depth by stratified fine sediments. Fragments of rock and of partly consolidated material are sometimes found on the surface of areas adjoining steep slopes or bluffs. The material is highly calcareous.

This type lies between the foot of the "White Bluffs," mapped as Rough broken land, and the Columbia River, in the western part of the county. In places narrow areas of river terrace intervene between this type and the river; in others the type extends to the river bank.

The surface has a gentle slope from the foot of the White Bluffs toward the river. The change in slope between this type and the Rough broken land to the east is very marked. The type lies from 15 to 100 feet above the level of the river. The surface drainage is good, except at times of heavy rains, when large quantities of water from the higher Rough broken land to the east and north carry wash over portions of the type. Such rains, however, are infrequent and of short duration. The movement of water in the subsoil is slow and the irrigation of large areas of this type will doubtless require some attention to drainage.

The native vegetation is mainly sagebrush. The type does not retain sufficient moisture for the successful production of crops by dry-farming methods. Its surface receives as much moisture as, or more than, the lighter upland types which are farmed to wheat, but the surface run-off is much greater. A large acreage is irrigated by pumping from the Columbia River. The irrigated fields are devoted to the production of alfalfa, apples, and other fruits and garden crops. Good yields are obtained. Several ranches along the Columbia River are located on this type. Power for pumping is obtained by electricity or gasoline. The type seems to be well adapted to the production of alfalfa. The texture is sufficiently heavy to allow irrigation by gravity without the washing of the soil, and the soil does not drift readily. Comparatively little preparation for irrigation in the way of leveling is required. The type is near the river, and its position between the river terraces and the higher lying desert plain decreases the danger of loss of fruit crops by frost.

The type lies at some distance from railroad transportation, but water transportation is very convenient.

WASHTUCNA SERIES.

The Washtucna soil has a light-brown soil and subsoil and occupies flat, playalike depressions in the floors of old stream valleys or coulées. The subsoil usually is of slightly lighter brown or more yellowish brown color than the surface soil. Both soil and subsoil are uniform in texture, and fairly compact in structure. The subsoil is underlain by a substratum of similar material. Locally, however, beds of basaltic gravel are often encountered 15 to 30 feet below the surface. The surface is practically level, and the series is subject to overflow at certain seasons. At all other times the drainage, while poorly developed, is adequate under present climatic conditions. Accumulations of alkali are found within areas of this type. The material of this series is derived mainly from the soil types of the adjoining uplands and terraces. Wheat is the principal crop, and is grown without irrigation.

WASHTUCNA SILT LOAM.

The Washtucna silt loam consists of a brown to light-brown silt loam to a depth of 15 inches, underlain by a slightly lighter colored silt loam extending to depths of 6 feet or more. Although the material shows little or no stratification, cuts in areas of the type indicate that in places at least it is underlain by stratified fine sediments, including strata of white material resembling diatomaceous earth. A gray color predominates where accumulations of alkali salts occur. In dug wells the deep, gravelly substratum is encountered at depths of 15 to 30 feet.

Near the margin of the type, adjoining the steep and rocky sides of the coulées, small areas of coarser material frequently occur. Areas of the type in T. 9 N., R. 29 E., and in the southern part of T. 11 N., R. 30 E., have a silt loam soil 5 to 10 inches deep, underlain by a light-brown fine sand. In such places the soil is of similar origin to that of the typical areas, but the subsoil is doubtless a wind-blown sand.

The Washtucna silt loam occurs mainly in Washtucna and Esquatzel Coulées. One large area and several small areas lie in the northern part of T. 14 N., R. 30 E. Other areas are mapped in Tps. 12 and 13 N., Rs. 29 and 30 E.

The surface is practically level, and usually lower than that of adjoining soil types. Some of the areas of the type are crossed by channels, while others have channels extending only short distances. The surface run-off, occasioned by the sudden thawing of snow in

the surrounding country, often covers these areas to depths of a few inches to several feet. This water is removed either by evaporation or by percolation. At other times the precipitation is readily absorbed by the soil. While seldom present in injurious quantities, alkali is known to occur in places within the type.

The Washtucna silt loam occupies depressions in the floors of coulées and other playalike areas. It lies beyond and below the sloping alluvial-fan deposits of the alluvial-fan phase of the Ephrata very fine sandy loam, some small undifferentiated areas of which are included with this type. Accessions of fine wind-borne material have contributed to its formation. Modification of the surface material by wind action is very slight.

A fairly dense growth of black sage formerly covered the greater part of this type. Much of this has been removed in order to cultivate the land to wheat and rye. At present, however, only a small part of the type is in cultivation. Wheat gives moderate yields in favorable seasons. A small acreage near the head of Washtucna Lake is devoted to alfalfa, and good yields are obtained. Water for irrigation is obtained from Harder Spring. Several attempts have been made to grow alfalfa by dry-farming methods, and although the results were discouraging, scattered plants in such fields indicate that on a part of the type this crop could be successfully grown with slightly more moisture.

The irrigation of this and surrounding types would doubtless be accompanied by a rise in the water table and later by accumulations of injurious quantities of alkali, owing to the low position and slow drainage of the type. In many cases this could be avoided by the construction of drainage channels. Under proper methods of irrigation a wide range of crops, including alfalfa, grain, vegetables, etc., could be grown successfully. The surface requires little preparation for irrigation, but an adequate supply of water is not available at the present time.

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

Mechanical analyses of Washtucna silt loam.

| Number. | Description. | Fine gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Clay. |
|-------------|-----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|  |  | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | <i>Per cent.</i> |
| 551107..... | Soil..... | 0.0 | 0.2 | 0.3 | 8.0 | 35.4 | 52.1 | 4.1 |
| 551108..... | Subsoil..... | .0 | .1 | .2 | 5.4 | 29.5 | 61.4 | 3.5 |
| 551109..... | Lower sub-soil. | .0 | .1 | .2 | 5.5 | 32.2 | 59.4 | 2.7 |

ESQUATZEL SERIES.

The Esquatzel series includes first-bottom, stream-laid soil of light-brown color and fine texture, 6 feet or more in depth. It usually is underlain by a deeper gravelly substratum, which in turn rests upon basaltic bedrock. Both soil and subsoil are moderately compact. The surface has a very gentle slope in the direction of stream flow, and is traversed by winding stream channels which seldom carry water. The series is subject to short periods of overflow, following sudden thawing of snow in the surrounding hills. The material of this series is derived mainly from the Ritzville series. In places it has been slightly reworked by the wind and modified by accessions of wind-borne material.

The light-brown color of the soil of this series distinguishes it from the medium to dark-brown soils of the Pasco series; it is differentiated from the Beverly series on account of its deeper gravel substratum and better moisture-holding capacity.

ESQUATZEL VERY FINE SANDY LOAM.

The soil of the Esquatzel very fine sandy loam is a light-brown to light grayish brown very fine sandy loam, extending to a depth of 12 to 15 inches. It is uniform in texture and moderately compact in structure. The subsoil is a light-brown to light grayish brown or light yellowish brown very fine sandy loam to fine sandy loam. This usually is underlain at depths of 2 to 3 feet by material of lighter texture and color. As a rule, the fine material extends to a depth of 6 feet or more, and is underlain by a gravelly substratum which rests upon basaltic bedrock. The structure of the subsoil and substratum ranges from moderately compact to compact. The material of this type is noncalcareous. Gravel occurs in places on the surface and in the soil. The subsoil frequently shows irregular stratification of fine material.

This type occupies narrow areas in some of the larger coulées of the central and eastern parts of the county. Fairly extensive areas occur in the Esquatzel and Rye Grass Coulées and in the South Fork of Smith Canyon.

The surface slopes gently in the direction of stream flow, but is otherwise practically level. The winding stream channels traversing the type carry water after the sudden thawing of snow in the surrounding hills. Often the channels are unable to carry the entire volume of water and the type is overflowed for short periods. Except during periods of overflow, the drainage is good. No injurious accumulations of alkali occur.

The type has been slightly modified in places by accessions of material of wind-borne and colluvial origin. In places the surface has been partially reworked by wind action.

Very little of this type retains its original vegetation of desert shrubs and grasses. A very small part of it, however, is used for farming. Many acres formerly farmed with adjoining upland types are now abandoned, and support a growth of thistles, mustard, and other weeds. Wheat is the only crop grown. In favorable seasons fair yields are obtained. The soil drifts excessively when broken and holds less moisture than the heavier upland types.

The judicious use of irrigation water on this type would result in good yields of the general farm crops common to the region, as the soil is naturally productive and easily tilled. The irrigation of this type and the adjoining uplands would doubtless give rise to poorly drained areas and result in the accumulation of injurious quantities of alkali if not prevented by artificial drainage. Water for the irrigation of this type is available only by pumping from deep wells, and the cost of this is prohibitive at the present time.

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

Mechanical analyses of Esquatzel 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> |
| 551132..... | Soil..... | 0.6 | 2.2 | 1.6 | 17.6 | 39.1 | 35.8 | 3.1 |
| 551133..... | Subsoil..... | 3.0 | 12.6 | 6.9 | 28.8 | 29.8 | 15.6 | 3.2 |

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO₃): No. 551133, 2.52 per cent.

MISCELLANEOUS MATERIAL.

DUNESAND.

Dunesand consists of a gray to light-brown, uniform sand extending to a depth of 6 feet or more. The surface is comparatively firm, is practically devoid of vegetation, and is subject to movement by the wind. The constant shifting of the immediate surface aids in the retention of moisture, but the moisture supply is not sufficient to prevent the drifting of the sand by strong winds or to permit the growth of vegetation. Areas of similar character too small to show separately on the map occur within types of the Quincy and Winchester series, but practically no other soils occur within the areas of Dunesand.

While it is not extensive, Dunesand is widely distributed in the sandy sections of the western part of the county. The largest area

lies in the southwestern part of T. 11 N., R. 32 E. It is approximately 5 square miles in extent and is near the northeastern end of a large continuous area of sandy country extending southwestward to the Columbia River. Another prominent Dunesand area, a ridge about 3 miles in length, occurs in sec. 12, T. 9 N., R. 28 E., and secs. 5, 6, and 7, T. 9 N., R. 29 E. Small, isolated areas occur elsewhere in the western part of the county.

In T. 11 N., R. 32 E., the Dunesand comprises a succession of bare, sandy hillocks and short ridges with gradual windward and steep leeward slopes. The topography is very uneven and broken. The long axis of other areas are either parallel with or transverse to the prevailing direction of the wind. The Dunesand areas range from 10 to 50 feet in height and from a few acres to about 5 square miles in extent. The drainage is excessive, and no alkali occurs.

Dunesand has resulted from wind action on loose, sandy material, and is in process of formation. The dunes are slowly advancing in a northeasterly direction.

The surface is either barren or has only a very sparse vegetation near the margin of the dunes. This land is not used for farming or grazing. It is considered nonagricultural, and its reclamation by irrigation is impracticable under present conditions.

SCABLAND.

Scabland as recognized and mapped in this survey includes areas of shallow soil, rock outcrop, and rough, stony land, so intermingled that their separation is impracticable under existing conditions. The term is a descriptive one and is widely used and well understood in this and other sections of the Columbia Plains.

In the areas of fine material the soil ranges in depth from a few inches to 4 feet or more and rests either upon bedrock or upon an intervening bed of basaltic gravel. Its color is light grayish to light brown, and its texture varies from a fine sandy loam to silt loam. Gravel occasionally is found on the surface and in the soil. Rock outcrops of both small and large extent are very frequent. Areas of rough, stony land are common. The areas of soils within bodies of Scabland belong mainly to the Ephrata series. The more important of these, where capable of separation, are mapped as the rock outcrop variations of the Ephrata fine sandy loam and very fine sandy loam. In the case of most of these soil areas, however, the agricultural value is so low and the chances of development so remote that their separation is not warranted.

Scabland occurs extensively in the Washtucna and Esquatzel Coulees and in the Snake and Palouse River Canyons. The largest continuous areas are mapped in Tps. 13 and 14 N., Rs. 29 and 30 E., and in Tps. 13 and 14 N., Rs. 36 and 37 E.

The general elevation of the surface of the extensive areas is fairly uniform. In detail, however, there are many precipitous bluffs and steep slopes. Small, steep-sided coulées are numerous. In general the most broken areas are found in the main coulées and the river canyons. (Pl. I, fig. 1.)

Old drainage channels are quite frequent occurrences, but there are no channels that carry water except after sudden thaws of snow. A few springs occur within the areas of Scabland, and also a small number of shallow-water areas. Skootenay Springs, in T. 14 N., R. 29 E., is a well-known watering place. Its importance is not so great now as in the days of more extensive grazing.

The areas of Scabland were formerly covered either by the stratified sedimentary deposits of the western part of the county or by the loessial wind-borne material of the eastern part. They occur wherever this has been removed by erosion to such an extent that outcrops of the underlying basalt are frequent. The removal of this material was doubtless accomplished by water action, as is indicated by the location of the Scabland areas with respect to river courses and both large and small coulées or old channels. It is believed that the fine material now found in areas of this character is mainly of current-laid and wind-borne or loessial origin, and that little, if any, of the original overlying material remains.

In places adjoining rock outcrop some weathering has taken place. This is indicated by the reddish-brown color of the material in such areas. Weathering, however, has contributed only slightly to the formation of the fine surface soil material.

The native growth consists of a scattering of sagebrush and bunch grass. The latter is larger and more abundant in the eastern part of the county. This vegetation has not been removed, except in a few cases for firewood.

Scabland is used only for grazing. A large part of it, where it occurs as large areas, is still in Government or railroad ownership and is leased for a term of years by cattle and sheep men, who pay a small grazing fee. The small areas of soil within bodies of Scabland are not adapted to the production of crops by dry-farming methods.

In other sections where land of this character is found and water for irrigation is available, small tracts are being cultivated, mainly to fruit and alfalfa. Land suitable for such development occurs within the areas of Scabland in this county, and if water is made available there will be an opportunity for some agricultural development. At present, however, the prospects of such development are quite remote.

RIVERWASH.

Riverwash consists of a mixture of gravel and cobbles with a small percentage of sand, extending to a depth of several feet and

occupying bars or narrow areas adjoining the larger streams. In places a few inches of wind-blown river sand covers the surface. The surface slopes very gently toward the river. Only the larger areas, which are exposed at normal stages of the rivers, are mapped. Some narrow undifferentiated areas are included with adjoining stream-terrace soils. At low-water stages the extent of Riverwash is very much greater than at high-water stages, when practically all of it is covered by water. Material of this character occurs along the Columbia and Snake Rivers. It has no vegetation and is of no agricultural value.

ROUGH BROKEN LAND.

Rough broken land as mapped in this county consists of exposures of unconsolidated, stratified material, mainly very fine sand, silt, and clay, occupying slopes or bluffs along the Columbia River and some of the larger coulées in the western part of the county. A continuous area of this character extends along the Columbia River from the northern boundary of the county to Byers Landing, about 15 miles northwest of Pasco. This is widely known as the White Bluffs and is a prominent topographic feature of south-central Washington. Other narrow areas occur in T. 13 N., R. 29 E., and T. 12 N., Rs. 29 and 30 E. There is also included with Rough broken land a steep, gravelly slope or bluff extending southward from Byers Landing to sec. 12, T. 9 N., R. 28 E. This body breaks abruptly either to the river or to a lower terrace occupied by the soils of the Beverly series. The material is a mass of gravel, with a few cobbles and interstitial sands.

The largest area of Rough broken land ranges from less than one-fourth mile to more than one-half mile in width. Within this distance the surface rises 350 to 550 feet. In places the Rough broken land rises from the river bank, while in others a narrow river terrace or areas of foot-slope material or both intervene between the river bank and the foot of the steep slope.

The surface is steep and gullied, and in places carries gravel and fragments of the calcareous formation, which outcrop along the top of the slopes like cap or rim rock. Drainage is excessive, and at times of heavy rains the run-off is rapid, the material being eroded and carried out and deposited over the lower areas at the foot of the bluffs.

The areas of Rough broken land either have a scanty vegetation or are barren. They are nonagricultural.

IRRIGATION AND ALKALI.

The greatest acreage of irrigated land in Franklin County occurs in T. 9 N., Rs. 29 and 30 E. Water for this is supplied by pump-

ing from the Snake River about 3 miles above Pasco and is distributed by a pressure system. This is known as the Pasco Reclamation Co.'s project. It covers an area of less than a township and approximately 1,500 acres are now producing crops. Nearly half of this land is being developed by one company, and is for sale in small tracts. The remainder consists of a number of small tracts, operated by their owners. The project is developing slowly, partly because of the comparatively high cost of water rights and of improved land.

Tracts ranging in size from a few acres to 150 acres or more on the river terraces and coulée bottoms are under irrigation. Along the Columbia River such tracts occur on the flat opposite the town of White Bluffs, near the northwestern corner of the county, on the flat extending southeastward from a point opposite the town of Hanford in Benton County, and on Ringold Flat. Another irrigation area lies in sec. 12, T. 9 N., R. 28 E. These are irrigated by water pumped with a 10 to 50 foot lift from the river by electric or gasoline power. An area near Page post office is irrigated by pumping from the Snake River.

A small ditch carries water for a limited acreage in the Wash-tucna Coulée near Kahlotus. Some water for irrigation is pumped from Washtucna Lake by gasoline power, and a tract near the head of Washtucna Lake is irrigated by water from Harder Spring. There is practically no irrigation by water pumped from deep wells, on account of the depth to water and the question of adequate supply.

The quality of the water used for irrigation is good, except in the case of that from Washtucna Lake, which has no visible outlet and is fed by a large spring near its head. Water in this lake is more or less alkaline, depending upon the season and the water level, and a thorough examination of this water should be made before it is used for irrigation to any extent. Water from this source, however, is available for only a comparatively small acreage.

Along the Columbia River only a small part of the land that may be irrigated with a lift of 50 feet or less is being developed, but the irrigated area is being gradually extended. This development is retarded mainly by the high cost of electric power. In the Snake River Valley land susceptible of irrigation by pumping is much less extensive. The areas are small and isolated. Their development is a more remote prospect.

The principal crops grown under irrigation are alfalfa, orchard fruits, grapes, berries, potatoes, melons, and vegetables. The yields indicate that the soils used are productive and well adapted to farming by irrigation. They give profitable returns on a small initial investment for the land and a reasonable payment for a water right.

Outside of the area within the proposed Palouse project, discussed elsewhere in this report, and of those mentioned above, the prospects of development by irrigation are remote, although water for this purpose, other than from deep wells, may possibly be made available at some future time.

The possibility of the development of poorly drained areas being followed by the accumulation of alkali salts in harmful quantities should always be kept in view in considering the irrigation of arid lands. In its present condition the greater part of the land of Franklin County is free from injurious accumulations of alkali. Alkali salts occur as surface accumulations in a few small areas, the most conspicuous of which is in the Washtucna Coulée just above the head of Washtucna Lake. In every case their occurrence has resulted from poor drainage conditions.

For the lands already irrigated, there seems to be little prospect of the development or extension of alkali conditions resulting from the judicious use of water, as the soils are underlain usually at shallow depths by beds of gravel which insure good subsurface drainage. In coulées and other depressed areas, of minor extent and not at present irrigated, however, such conditions may be expected to develop.

It is believed that in this county there is less danger of the accumulation of alkali in land, the irrigation of which is practicable, than in many other irrigated sections, owing to the prevailing porous gravel subsoils and substrata.

PROPOSED PALOUSE PROJECT.

The proposed Palouse irrigation project of the United States Reclamation Service embraces all or parts of Tps. 8, 9, 10, and 11 N., Rs. 28, 29, 30, and 31 E., in the southern part of Franklin County, below an elevation of approximately 700 feet. It does not include an area of about 15,000 acres in the vicinity of Pasco, which is under the project of the Pasco Reclamation Co. Its estimated size, from 50,000 to 75,000 acres, depends upon the number and size of the available storage reservoirs. Water for irrigation is to be supplied by the Palouse River. The natural flow of the river is to be regulated by the construction of storage reservoirs in its valley and along the main canal in Idaho and Washington.

Investigations covering a number of years by the United States Reclamation Service and the State of Washington have resulted in the compilation of considerable data on the water supply, the cost of construction, and other details. Topographic surveys of the area under consideration and surveys of available dam sites for the storage of water and of canals for conveying the water to the project and for its distribution over the project have been com-

pleted. Such data are now available, and the feasibility of the project from an engineering standpoint or from that of the cost per acre is not discussed in this chapter. Existing conditions of topography, drainage, and soil are discussed in the preceding pages of this report. In order to apply this information specifically to the portion of the county included in the project, it is briefly summarized in this chapter.

Reference to the accompanying soil map shows that a great variety of soil conditions exists even within small areas, and that the distribution of the different soil types is such that only general statements can be made regarding their location. A characteristic feature of the project is the long, continuous ridges of wind-blown soils with intervening flats of soils of other origin.

The different soil types have been classified into (*a*) soils of wind-laid origin comprising the Quincy and Winchester series and Dunesand; (*b*) soils of stream-laid origin including the Ephrata, Beverly, Pasco, and Washtucna series; (*c*) soils derived from old valley-filling material, probably lake-laid, forming the Sagemoor series. Scabland also occurs to a limited extent. In general the characteristic ridge and flat relation exists between the Quincy and the Sagemoor series on the higher benches or levels and between the Winchester and the Ephrata or Beverly series on the lower benches. In nearly all parts of the project sandy soils predominate. The deeper and more abundant the sand the less the regularity of the above relation.

The sand and fine sand of the Quincy series have light-brown soils and subsoils of porous structure. Their surface is ridged to choppy. These soils consist of wind-blown sands probably derived from the sandy bars and beaches along the Columbia River. They are now protected from further drifting by a growth of sagebrush, bunch grass, and other desert vegetation. A distinguishing feature of this series is the presence of a substratum, many feet in thickness, of stratified silts and clays. The depth of the sandy material ranges from 2 to 25 feet. These types are not adapted to the production of crops by dry-farming methods on account of insufficient moisture and of destructive blowing when the natural cover is removed. At present there is no development of these types under irrigation. Attempts to farm them without irrigation have been unsuccessful. The results obtained under irrigation farming on similar soils on projects where similar climatic conditions prevail indicate that they are productive and are adapted to a fairly wide range of crops.

The Winchester fine sand and the Winchester sand, with its loamy phase, constitute the most extensive soils of the project. These types are characterized by medium-grayish to light-brown soils and sub-

soils, underlain at a depth of 2 to 25 feet by the coarse water-laid material of the Ephrata and Beverly series. The surface is ridged to choppy and undulating. The material of these types consists of wind-blown sand, carrying slightly greater quantities of dark-colored sand grains from basaltic rock than the soils of the Quincy series. The native vegetation consists of sagebrush, rabbit brush, bunch grass, and other desert plants, which protect the surface from drifting. Insufficient moisture and the tendency toward excessive drifting forbid their use for dry farming. Small areas on the lower benches are producing crops of alfalfa, berries, and fruit under irrigation. Good yields are obtained, and the trees are making a satisfactory growth. The soils evidently are productive and worthy of development.

The soils of the Beverly series are confined to a belt along the Columbia River. They consist of 12 to 24 inches of light-brown fine material, underlain by waterworn gravel and cobbles to a depth of many feet. The surface is level to very gently undulating. The material comprising these types consists mainly of stream-laid deposits, derived from a variety of rocks. The results of farming by irrigation indicate that the soils are productive, and with an abundance of water are adapted to a variety of crops.

The Ephrata series comprises a sandy loam, fine sandy loam, and very fine sandy loam. The soils of these types are of light-brown color and fairly compact structure. The deeper subsoils or substrata are deposits of coarse sand and fine gravel, consisting mainly of basaltic rock fragments, extending to great depth. The material is mainly of stream-laid origin, with the addition of a small quantity of wind-blown material in the surface soil. The surface is level to very gently undulating. There is a scattered growth of sagebrush and other desert shrubs. The types of this series occupy small to large areas on the lower benches and on some of the higher benches in the Esquatzel Coulée. The soils do not drift badly when the native cover is removed, but the low moisture supply prohibits their use for dry farming. Only a very small acreage is farmed under irrigation.

The Sagemoor series includes types of fine sandy loam and very fine sandy loam texture, derived from stratified fine sediments of probable lake-laid origin. The soils are light brown in color and compact in structure. The subsoils are only slightly lighter in color and have the same texture as the soils. Similar material extends to great depths. The surface is gently undulating to rolling. The types occupy the long, narrow flats between the sandy ridges of the soils of the Quincy series. The production of crops by dry-farming methods would be profitable in extensive areas of these

types in favorable seasons, but within the project the soils do not occur in sufficiently extensive areas to be used for such purpose. Attempts to farm these soils in connection with the associated sandy types have resulted as a rule in the drifting of the sandy soils over the surface of the intervening flats, with a consequent destruction of crops. Irrigation is not practiced on these types, but their productiveness and topography are favorable to the profitable production of crops under irrigation methods.

The soils of the Pasco series are of minor extent and are confined to a narrow strip along the Columbia River. They are of relatively little importance considered by themselves, but are very productive and with irrigation are adapted to a wide range of crops.

The silt loam of the Washtucna series is found mainly in the Esquatzel and tributary coulees. It is of small extent and minor importance. At present it is not farmed under either irrigation or dry-farming methods. The surface is generally level. The native growth is sagebrush.

Scabland occurs to a very small extent within the limits of the project. It is confined to areas in the Esquatzel Coulee and is nonagricultural.

Viewed as a whole, the greater part of the country within the project consists of several level to gently undulating and sloping benches or plains. Narrow belts of rolling to hilly country occur along the breaks between these benches. In Tps. 9, 10, and 11 N., R. 31 E., the topography is much more diversified. In detail the surface is undulating to sloping on account of the modification by drifting sand. The accompanying sketch map shows the approximate outline of the proposed project, the 700-foot contour, and the location of the several subdivisions of the project based upon position, topography, and soils. (Fig. 6.)

In subdivision 1 the elevation ranges from 350 to 450 feet. There is a general slope toward the Columbia River, with a more or less level belt as the river is approached. The general smoothness is broken by a number of ridges and other areas of sand. The soils consist of types of the Winchester series, with less sandy areas of the Ephrata and Beverly series, also a small area of Pasco very fine sandy loam. With the exception of the soils of the Beverly series, a considerable amount of leveling will be necessary in preparing for irrigation. Excellent underground drainage is afforded by the deep stratum of coarse, stream-laid material underlying the whole subdivision. Artificial drainage will be necessary in only a few low-lying areas. There are no evidences of alkali. Practically all this division is susceptible of irrigation.

Subdivision 2 is a gently undulating plain about 500 feet in elevation. Its eastern half is very sandy, while in the western half there

are quite extensive areas of firm land. The soils are classified with the Ephrata and Winchester series. One extensive area of Dunesand occurs. The entire plain is underlain by deep gravel deposits and has excellent underground drainage, and there are no traces of alkali. It is believed that little or no drainage trouble will result from the irrigation of this division. A part will require considerable leveling, but the leveling needed is no greater in proportion than that required in other subdivisions.

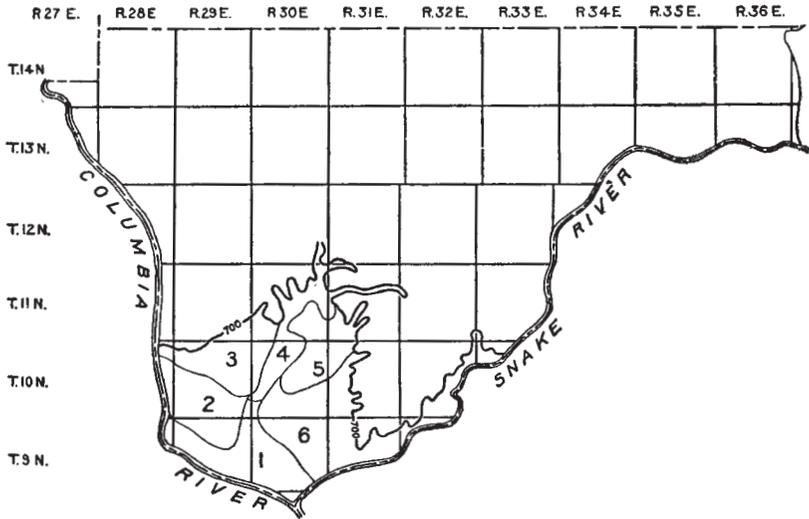


FIG. 6.—Sketch map showing proposed Palouse Irrigation project. The figures 1 to 6 indicate the several subdivisions of the project.

Subdivision 3 lies between the elevations of 500 and 700 feet. Its surface varies from undulating to rolling, the latter topography occurring along the coulées and the break toward the lower lying subdivisions. The soils belong to the Sagemoor series, consisting of fine stratified material to great depths and to the Quincy series, formed of wind-blown sands over the former series. All portions will require expensive preparation for irrigation, and some portions are too rough to use successfully. Extensive irrigation operations will doubtless result in the development of poorly drained areas on account of the fine substratum of heavy material. There are at present no traces of alkali.

Subdivision 4 comprises the portion of the Esquatzel and associated coulées within the project. The floor of the coulée is level to very gently sloping, while the sides are sloping. North of the center of T. 11 N., R. 30 E., they are more abrupt and rock outcrops are numerous. The soils belong to the Ephrata and Winchester series, with a small acreage of the Washtucna silt loam. With the

exception of the last, all are underlain by gravel at shallow depths and are well drained. The Washtucna silt loam occupies low positions and will doubtless be poorly drained when the surrounding land is irrigated. No alkali in injurious quantities exists at present, although accumulations may appear with the rise of the water table in the lower lying sections.

The highest part of the project is designated as subdivision 5. Its elevation ranges from 650 to slightly over 700 feet. The surface is level to gently sloping, with steeper slopes toward the adjoining country. Wind-blown sand ridges and outcrops of rock in the northern part break its generally smooth surface. The soils belong to the Ephrata and Winchester series. Small areas of Scabland occur. All parts of this subdivision are well drained and deep deposits of coarse material under the soil types insures adequate drainage under irrigation. No traces of alkali occur. The greater part of this subdivision is susceptible of irrigation and will not require so much leveling as many other parts of the project.

The soils of subdivision 6 are classed with the Quincy and Sage-moor series. The former comprises wind-blown sands overlying the fine stratified deposits which form the latter series. Topographically, the subdivision may be divided into two parts. The portion in R. 30 is a gently undulating to rolling plain, while the part in R. 31 is rolling to hilly, the elevation increasing toward the east. The original surface has been greatly modified by drifting sand. The soils are well drained and free from alkali. Upon the development of irrigation over large areas the drainage will be somewhat retarded by the heavy and compact underlying material and some accumulations of alkali may appear. The eastern part is not well adapted to irrigation, although there are areas which have a favorable topography.

Subdivisions 1, 2, and 5 are similar in including deep deposits of water-laid material over which sand from other sources has been deposited by wind action. Portions not covered by these later deposits are typically stream-laid soils with fine soils and coarse subsoils and substrata. Subdivisions 3 and 6 consist of fine lake-laid sediments which are now covered in many places by wind-blown sands. Subdivision 4 includes the portion of Esquatzel Coulee within the project and has the greater percentage of nonagricultural land.

The preparation of the land by leveling will necessarily result in most cases in the elimination of the loamy soils of the intervening flats. The greatest difficulty in development of this country under irrigation is the preventing of the drifting of the soils and the consequent destruction of crops. Careful and scientific methods will be required. While nearly all sections require leveling, the amount is probably not greater than in other projects that have proved suc-

cessful. The natural underground drainage of the greater part of this project, as well as all the more favorable portions, is excellent on account of the deep deposits of coarse material. Alkali in appreciable quantities does not occur. Hardpan, except a few instances of a cemented gravel, is not present.

The successful production of alfalfa, fruit, and berries on lands now under irrigation on the project of the Pasco Reclamation Co. and on private lands along the Columbia River, as well as on similar soils on the opposite side of the river, indicates that the soils generally are productive and that the climate is suitable to the growth of a wide range of garden and farm crops. The long growing season is favorable to crop production, and the transportation facilities are excellent. The development of hog and cattle raising and of dairying is practicable, and should prove profitable.

Considered as a whole, soil, topographic, and drainage conditions are favorable for a successful irrigation project. The question of its feasibility, aside from water supply, depends upon whether the income which may reasonably be expected will justify the estimated cost per acre.

SUMMARY.

Franklin County is in the southern part of central Washington. It has an area of 1,229 square miles, or 786,560 acres. The eastern part of the county is included in the high rolling plateau of southeastern Washington and adjoining parts of Idaho. The western part lies within what might properly be termed the desert plain, and has an undulating surface. Fairly extensive areas of terrace land occur in the southern part. The altitude ranges from 350 to 1,800 feet above sea level. The Columbia River on the west, the Snake River on the southeast, and the Palouse River on the east comprise the only present perennial watercourses. Former stream courses are found in all sections of the county.

The settlement of the county is of comparatively recent date, the greater part since 1900. Every alternate section was formerly railroad land. The remainder was Government or State land. The former was subject to homestead entry, and practically all has passed into private ownership. In the 1910 census the population of the county is reported as 5,153. Deducting the population of Pasco, reported as 2,083, the density of rural population is about 2.5 per square mile. Pasco, the county seat, is an important railroad center. Connell, with a population of about 600, is the next town in importance. There is but little water transportation, although the Columbia River will be made navigable by the completion of the Celilo Canal at The Dalles. The roads are natural ones, and are in bad condition during a large part of the year.

Main and branch lines of the Northern Pacific Railway, the Spokane, Portland & Seattle Railway, and the Oregon-Washington Railroad & Navigation Company afford transportation to all parts of the northwest.

Wheat is practically the only product exported. It is shipped by rail to Pacific-coast ports for milling or further shipment to California, eastern or foreign markets.

The climate is temperate; the summers are long and warm, the winters moderately short and marked by light snowfall. The mean annual temperature is about 50° F., and the mean annual precipitation varies with location and ranges from less than 7 inches to over 22 inches. There is a normal growing season of 107 to 140 days, depending largely upon elevation.

This county occupies a part of the former extensive open range of the Columbia Plains. The high rolling plateau of the eastern part is now devoted to the production of wheat; the western and southern portions require irrigation for the development of agriculture. Irrigated crops of alfalfa, fruit, berries, potatoes, grapes, and vegetables are produced in scattered areas near the Columbia and Snake Rivers. The 1910 census reports 50.2 per cent of the total area of the county in farms, and 70.5 per cent of the land in farms as improved. The average size of the farms is given as 625.5 acres, and 89.7 per cent of the farms are reported operated by the owners. Except in irrigated areas, crops are produced by dry-farming methods. The yields vary widely with the seasons. The value of farm land is comparatively low, except in the more intensely farmed irrigated tracts. The average value is reported in the 1910 census as \$17.88 per acre.

The soils of Franklin County are derived from a mantle of lake-laid, wind-laid, loessial, and current-laid material. The extent of recent-alluvial soils is small. The entire county is underlain to great depths by basaltic rock.

Twenty-six soil types, belonging to 12 distinct series, and 4 classes of miscellaneous material are mapped.

The Ritzville series, represented by three types, covers the upland portions of the eastern half of the county. The soils are light brown in color and of uniform structure and texture throughout their extent. They are derived from loessial material. Their surface is rolling to hilly. They comprise the greater part of the wheat lands of the county.

The Quincy series, with three types, consists of wind-laid soils deposited over fine stratified old valley-filling or sedimentary material. The soils are light brown, and have a porous structure. They are adapted to the production of crops under irrigation.

The Koehler series, including three types, is similar to the Quincy series, with the exception of the presence of a white, calcareous hardpan within the soil section of the Koehler. The soils are adapted to agriculture with irrigation.

The Winchester series includes wind-blown sandy soils of gray to dark-gray or dark-brown color. Two types are mapped. Under irrigation these soils are productive.

The Burke series is represented by two soil types. These are derived from old sedimentary deposits, and occur in the western part of the county. The soils are light brown and compact and are underlain by a white, calcareous hardpan. A considerable acreage is farmed to wheat.

The Sagemoor series derived from early unconsolidated sedimentary deposits is mapped in the western and southern parts of the county. It is represented by three members. The soils are light grayish brown to light brown, compact in structure, and free from the hardpan of the Burke series. Portions of the series are farmed to wheat.

The Ephrata series, represented by three soil types, occupies terraces of glacial outwash material in the eastern, central, southern, and western parts of the county. Light-brown, fine-textured soils, underlain by subsoils and substrata of coarse, rounded rock fragments are typical of the series. Where the fine material is at least 3 feet in depth the soil holds sufficient moisture for the production of moderate yields of wheat. With irrigation the series is adapted to a wide range of crops.

The Beverly series includes light-brown, fine-textured soils and subsoils of alluvial origin, with substrata of coarse, rounded gravel and cobbles of crystalline and basaltic rocks. The two types of this series occupy moderately low river terraces. Irrigation is essential for the production of crops.

The Pasco series, represented by two soil types, includes the medium-brown to dark grayish brown soils of the recent river flood plains or lower terraces. The types are inextensive and are farmed both with and without irrigation. They are productive and adapted to a wide range of crops.

The Ringold series includes light-gray, calcareous soils and subsoils, with a substratum of calcareous silts and clays. It comprises local alluvial-fan and foot-slope material, derived from fine, stratified lake-laid deposits. One type is mapped along the base of the White Bluffs, adjoining the Columbia River. This soil is adapted to the production of alfalfa, fruit, grain, and vegetables where irrigated.

The Washtucna series occupies local flat depressions in coulées or abandoned stream channels. The soil of the only type of this series

mapped is light brown, deep, and of compact structure. It is derived from recent alluvial valley-filling material. Some alkali occurs in places.

The Esquatzel series comprises light-brown soils and subsoils, of recent alluvial origin, occupying minor stream bottoms. One type is mapped. Some areas are farmed to wheat, but irrigation is necessary to insure the successful production of crops.

Scabland consists of areas of shallow soils, rock outcrop, and rough, stony land, so intermingled that their separation is impracticable. It includes small areas capable of producing crops under irrigation. It is used for pasture. Dunesand and Rough broken land are nonagricultural, and are mapped only in the western half of the county. Riverwash consists of narrow areas of stream gravel along the Columbia and Snake Rivers.

Irrigation is mainly confined to areas lying within short distances of the Columbia and Snake Rivers, and water is obtained by pumping from the rivers. The development of irrigation farming is of comparatively recent date, and is being gradually extended. A large total area is suitable for development in this way. Injurious accumulations of alkali are uncommon. They may appear with the extension of the irrigated area.

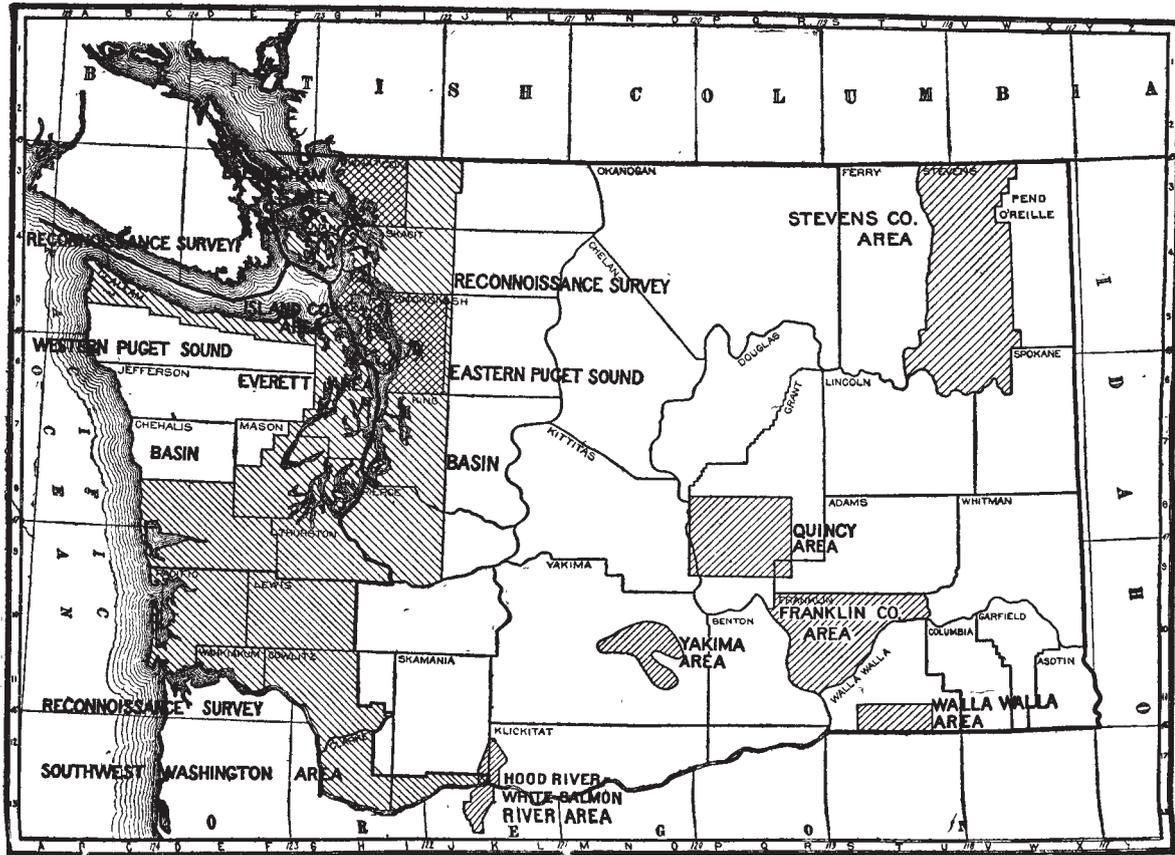
[PUBLIC RESOLUTION—No. 9.]

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.

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