

Issued November 6, 1915.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE STATE OF WASHINGTON, M. E. HAY, GOVERNOR;
HENRY LANDES, STATE GEOLOGIST.

SOIL SURVEY OF STEVENS COUNTY,
WASHINGTON.

BY

CORNELIUS VAN DUYNÉ, 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, 1913.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1915.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., March 25, 1915.

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

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

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

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Soil map, Stevens County sheet, Washington.

SOIL SURVEY OF STEVENS COUNTY, WASHINGTON.

By CORNELIUS VAN DUYNÉ, of the U. S. Department of Agriculture, and
FRED W. ASHTON, of the Washington Geological Survey.

DESCRIPTION OF THE AREA.

Stevens County, Wash., was created in 1860 and named in honor of Isaac Stevens, the first territorial governor of the State. The county embraces a part of the northeastern section of the State of Washington. It is 84 miles long and has an average width of about 32 miles. It includes townships 27 to 40 north and ranges 35 to 42 east. The county has an area of 2,393.5 square miles, or 1,531,840 acres.¹ As originally created it comprised all the counties of the eastern part of the State. With the creation of Pend Oreille County, the last to be separated from its original area, the present boundaries of Stevens County were established.²

The forty-ninth parallel of latitude, the International Boundary, forms the northern boundary of the county. The Kettle River for about 25 miles and the Columbia River for over 50 miles separate it from Ferry County on the west, and the Spokane River separates it from Lincoln and Spokane Counties on the south. The eastern boundary, which sets off this county from Pend Oreille and Spokane Counties, follows range, section, and township lines, conforming in a general way to the divide between the Columbia and Colville Rivers on the west and the Pend d'Oreille on the east.

In the extreme southwestern corner of the county the Spokane Indian Reservation occupies an area of approximately 240 square miles. It is bounded on the north by the forty-eighth parallel of latitude, on the west by the Columbia River, on the south by the Spokane River, and on the east by Chamokane Creek.

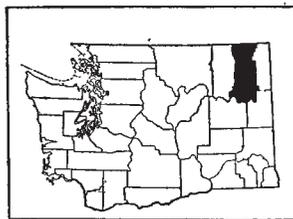


FIG. 1.—Sketch map showing location of the Stevens County area, Washington.

¹ This does not include 100 square miles of the Colville National Forest, which was not surveyed.

² The latest available county map, on the scale of 1 inch to the mile, is used as a base map in this survey. This map has been compiled from the original township plats of the United States Land Office and from data obtained by more recent county surveys. There were many errors and omissions in the original surveys and in many instances the map was found to be inaccurate in regard to roads and drainage. Practically all the roads in the valleys and the main roads in the upland portions of the county were traversed and tied to section corners whenever possible. The drainage was corrected so far as possible in a survey of this character. Other data were obtained from the county surveyor's office.

TOPOGRAPHY AND DRAINAGE.

Stevens County occupies a part of the physiographic province known as the Okanogan Highlands, and its topography is characteristic of northeastern Washington. A tongue of the basaltic Columbia Plateau of Central Washington extends for more than 20 miles northward from the Spokane River into the southern part of the county.

This county includes parts of the Columbia-Kettle River Valley, of the Colville Valley, of the Columbia Valley north of Marcus, the Huckleberry Mountains between the Columbia and Colville Valleys, the Calispell Mountains east of the Colville Valley, the mountains between the Kettle and Columbia Valleys, an extension of the Huckleberry Mountains, and the Spokane Plateau.

The Columbia River eventually receives the drainage of the entire county. The Pend d'Oreille River, into which Cedar Creek and its East Fork empty, joins it just before it enters the county. In the northern part of the county it receives from the north the waters of Nigger, Sheep, Rattlesnake, Crown, Flat, and Fifteen Mile Creeks, and from the south the waters of Deep and Onion Creeks. Just below Marcus the Kettle River empties into it, and a mile below Kettle Falls it is joined by the Colville River. Farther south Rickey, Quillascut, McGees, Stranger, Lake, Harvey, Hunters, Alder, and Cottonwood Creeks flow into it. The creeks have narrow valleys and steep gradients, especially after they emerge from the hills. Together with its main tributaries, Deep, Sand, and Toulon Creeks, the Kettle River drains an area of about 100 square miles of the county.

The Colville River and its tributaries drain the central and east-central sections of the county, or an area of approximately 1,100 square miles. This river rises in springs which emerge from the glacial outwash deposit east of Springdale, flows west, and is known as Sheep Creek until it reaches the floor of the Colville-Chamokane Valley, where it turns abruptly north and is known as the Colville River. The largest tributary of the Colville River, the Little Pend d'Oreille River, which is over 30 miles in length, joins it near Arden. Mill Creek, next in size, empties into the Colville about 3 miles northwest of the town of Colville. Other tributaries are Chewelah, Cottonwood, Grouse, Heller, Stranger, Deer, Smiths, and Sherwood Creeks. These streams are from 10 to 25 miles in length. They have deep, narrow valleys and numerous tributaries. Clungsten and Bruce Creeks sink upon emerging into Echo Valley.

Chamokane Creek rises in the Huckleberry Mountains, and flows in a general easterly direction across Camas Prairie until it reaches the floor of the Colville-Chamokane Valley, where it turns abruptly south and continues to the Spokane River. The turning points of the

Colville River and Chamokane Creek are about a mile apart, and it is possible to walk from one stream to the other without crossing any perceptible divide. Chamokane Creek drains the south-central part of the county, or about 200 square miles, and empties into the Spokane River. It has no large tributaries. For several miles it is deeply entrenched in the gravelly terraces along its course.

The Spokane River drains about 500 square miles of the southern part of the county. The largest tributary of this river is Chamokane Creek. Other tributaries are Little Chamokane, Sand, and Blue Creeks. The drainage of the southeastern corner of the county reaches the Spokane through Dragoon Creek and the Little Spokane River.

Small glacial tarns or lakes are widely distributed over the glaciated uplands of the county. They occur in high depressions or amphitheaters. The larger lakes occupy depressions in the valleys or on outwash plains. Cedar and Deep Lakes in the northeastern part of the county, Pend d'Oreille Lake in the upper course of Little Pend d'Oreille River, Lake Pierre in the northwestern part, and Waits Lake west of Valley, are typical of the small lakes, and Deer, Loon, and Jumpoff Joe Lakes in townships 29 and 30 north, range 41 east, are examples of the large lakes, impounded by gravel dams. Viewing the county as a whole, the areas of metamorphic rocks have a rugged topography and occupy the highest elevations of the region. The areas of granitic rocks have a more rounded outline and occupy low to high positions. Slate and limestone rocks apparently underlie areas of low elevation.

The elevations used in this report are based on data compiled by the United States Geological Survey and the North Transcontinental Survey.

PHYSIOGRAPHIC DIVISIONS.

The county comprises six general physiographic divisions: (1) The Columbia-Kettle River Valley, (2) the Colville-Chamokane Valley, (3) the Spokane River Valley, (4) the Spokane Plateau, (5) the Calispell Mountain Range, and (6) the Huckleberry Mountain Range.

Columbia-Kettle River Valley.—The Columbia River occupies a narrow mountain valley extending across the northwestern part of the county to the western boundary at the village of Marcus. Thence southward the river forms the western boundary of the county. Northward from Marcus the western boundary of the county is formed by the channel of the Kettle River, the valley of this stream being seemingly the main continuation of the valley of the Columbia south of Marcus. The Columbia Valley floor is narrow and of irregular width. The river runs over a number of rocky barriers in the county, not having reached a profile of equilibrium. The width of the alluvial

deposits, including terraces, varies from a quarter of a mile or less to upward of 3 miles. The mountains often rise from the valley in rather steep but rarely precipitous slopes. Definite, sharply cut river bluffs bordering a flood plain of even approximately uniform width do not occur. The valley boundaries are mountain slopes which show the effects of intense glacial abrasion in their abundant exposures of bedrock, always smoothed and rounded in outline. Knolls and ridges of the same shape occur over the valley floor, where in places they have been buried by river deposits now occurring as terraces. Some of the terraces seem to be remnants of deposits laid in quiet water, while others were laid by currents. The cross profile of the valley is that of a rather wide, open V, rounded at the bottom, or a U with upwardly spreading arms. The mountains rise to elevations of several thousand feet above the river within a few miles.

The river has an elevation of about 1,300 feet at the International Boundary, 1,200 feet at Marcus, and about 1,050 feet at its junction with the Spokane River. It has a total length of over 100 miles within and along the county.

The Kettle River Valley enters the United States at the northwestern corner of the county, follows a general southerly direction for a distance of about 27 miles, and joins the Columbia near Marcus. This valley is narrow and deep, the river flows swiftly, and the terraces are from one-fourth mile to $1\frac{1}{2}$ miles in width and not so high above the river level as those of the Columbia and Spokane Rivers. The country rises by abrupt and rocky slopes to elevations of 4,000 to 5,000 feet within a few miles of the river.

Colville-Chamokane Valley.—The Colville-Chamokane Valley extends northward approximately through the middle of the county from the Spokane River to Colville, a few miles more than halfway from the southern to the northern boundary of the county. From here it turns northwestward and unites with the Columbia Valley near Meyers Falls. A branch leaves the main valley 2 miles north of Colville, extending northward and uniting with the Columbia Valley a few miles northeast of Marcus. There are some additional short branch or loop valleys in the same region, all shorter and narrower than the one mentioned. These are all accordant, or nearly so, in the elevation of their floors, with the Colville-Chamokane Valley. The floor of the latter lies in the southern part of the county at an elevation of about 1,700 feet above sea level. At Colville it has an elevation of about 1,580 feet, while the elevation of the Columbia River at the nearest point, Kettle Falls, is about 400 feet less or 1,170 feet.

Unlike the Columbia, the Colville-Chamokane Valley has a flat-bottomed floor with a width ranging from 1 to 3 miles. The floor of the valley is made up throughout its entire length of water-laid depos-

its of unknown but considerable thickness. The rock of the original valley bottom has been covered with clay, sand, and gravel to the present level. The width of the valley floor is not the width of the original flood plain, but is determined by the fact that the existing floor lies between valley slopes widened by weathering and well above the level of the river which occupied the valley floor. The valley sides are much like those of the valley of the Columbia. They slope gradually upward, never presenting the appearance of river bluffs bordering the flood plain of a vigorously eroding river, but rather that of the weathered valley slopes of an aggrading stream or the high slopes of a stream still deepening its valley.

One of the most conspicuous topographic features of the central part of the county is Colville Mountain, or Old Dominion, 5,667 feet in elevation, about 7 miles east of Colville. Other lofty elevations in the same division are Douglass Mountain, 5,212 feet, northeast of Colville, and Addy Mountain, 4,869 feet, east of Addy. These mountains are isolated from the main ranges by minor stream valleys. They are very rugged in character, have abundant rock outcrop, and consist of nonagricultural land.

The streams now occupying the Colville-Chamokane Valley are small, do not occupy the valley throughout its whole extent, and are wholly unable to distribute the material that is being carried into the valley by the tributary streams.

Spokane River Valley.—In contrast to the other large valleys of the region, the Spokane Valley has a general east-west direction, following a circuitous course along the southern border of the county for about 50 miles. The river terraces vary from one-fourth mile to $1\frac{1}{2}$ miles in width, and lie from 50 to 500 feet above the river. The river marks the boundary in a general way between the Okanogan Highlands on the north and the Spokane Plateau of central Washington on the south. In places the precipitous, rocky slopes of the mountainous regions extend nearly to the river; in other places the stream is bordered by perpendicular bluffs of water-laid material. Back of the latter there is a rolling to hilly country which merges into the Huckleberry and Calispell Mountain Ranges. Much of the area drained by the Spokane River is rolling and less hilly and broken than areas of equal size in the other valleys.

Spokane Plateau.—The Spokane Plateau division is included in the Spokane and Colville drainage basins, but its distinct character warrants a brief description. It is a remnant of a basaltic tongue that projected up an old valley from the Columbia plain. The largest unbroken area lies west and southwest of the town of Springdale. Remnants occur on each side of the Colville-Chamokane Valley as far north as Valley, and, on the east side, to within 5 miles of Chewelah. These were doubtless once connected with each other

and with the large area southwest of Springdale, as well as with the main plain south of the Spokane River. The plateau is characterized by a level to undulating surface, broken by perpendicular bluffs of basalt which face the stream courses and adjoining soil types. Basaltic rock is found in places on the north side of the Spokane River from the Columbia River to the eastern boundary of the county.

Calispell Mountain Range.—The high mountain range which forms the divide between the Colville-Columbia and the Pend d'Oreille drainage systems is known as the Calispell Range. Prominent elevations are Calispell Peak, 6,905 feet high, which is just east of the county line and Chewelah Mountain, which has an elevation of 5,743 feet. The average elevation of the divide is between 5,000 and 5,500 feet. Its crest follows a sinuous line which crosses and recrosses the eastern county line a number of times. The western slope, lying almost wholly within this county, is traversed by numerous lateral streams which rise far up the mountain side, flow in deep, V-shaped valleys, and have narrow, rocky divides between them. The range as a whole is believed to be composed mainly of metamorphic rocks. In places the hilly divides between tributaries of the Colville River merge gradually into the mountainous regions; in others there is a marked line of demarcation between them. A spur of the main divide extends southwest from Deer and Loon Lakes, and is separated from the main range by a pass at the south end of the latter lake at an altitude of about 2,400 feet. This spur reaches an elevation of 4,000 feet, is composed of granitic rocks, and has a less jagged outline than the main range.

Huckleberry Mountain Range.—The Huckleberry Range extends from the Canadian boundary nearly to the Spokane River. Its continuity is broken by the Columbia and the Colville River valleys. The southern division forms the divide between the drainage systems of the Columbia and the Colville Rivers and is a distinctive topographic feature of the county. It attains elevations of 3,200 to 6,200 feet, with an average of about 4,500 feet. Stensgar Peak, about 12 miles west of Valley, is the highest point. Other high peaks are Dunn and Rice Mountains, with elevations of 5,200 and 5,494 feet, respectively. Several roads cross the range at elevations of 3,200 to 4,200 feet. The slopes are quite steep and rocky, and the ridges often sharp and narrow. The range varies in width from 2 to 7 miles, being widest in the southern part. The descent on the Columbia side is shorter and steeper than toward the Colville River. The former river is from 400 to 500 feet lower than the latter. There is very little agricultural land in the higher and rougher portions of this range. Plate I shows the characteristic appearance of the upper foothills of this range.

In the triangular area south of the International Boundary, between the Kettle and Columbia Rivers, a continuation of the Huckleberry Range forms the watershed between these two streams. It has a lofty and rugged character in the northern part of the county, and is mainly included in the Colville National Forest.

SETTLEMENT.

Prior to the establishment of Fort Colville on the Marcus Flat by the Hudson Bay Company in 1825, this region was inhabited by roving bands of Indians. The men of the company were hunters and trappers rather than actual settlers. The Columbia River furnished an outlet for all this country, through Astoria. Catholic missionaries are known to have worked among the Indians as early as 1845. Pending the settlement of the dispute over the location of the international boundary, the territory was occupied jointly by Americans and Englishmen. Between 1855 and 1865 reports of valuable mineral deposits were responsible for immigration from every direction. The river deposits along the Columbia were early worked for gold. The Hudson Bay Company post was later abandoned and established farther up the river in the vicinity of Sheep Creek. On account of the demands of the settlers for protection, U. S. Fort Colville, also known as Pinkney City, was built in 1859 on Mill Creek, near the north side of what is locally known as Garrison Flat. After the organization of the county this became the county seat. Early in the eighties Colville was made the county seat and Fort Colville, or Pinkney City, was abandoned.

Since its earliest settlement Stevens County has been known as a mineral country, and its early development was marked by alternate periods of prosperity and depression. In 1871 the vast territory then included in the county had a voting population of less than 300 and a total population of less than 1,000, including Indians. Miners and prospectors comprised the majority of the population and the earliest permanent settlers were miners or prospectors who remained to establish homes. Later a number of homeseekers came into the county and settled in the main valleys.

The Spokane Falls and Northern Railway was completed to Marcus in 1889, and extended to Northport and into British Columbia in 1892. A branch was later built north from Northport to connect with Canadian ore fields. About 1905 the Republic branch of the Spokane Falls and Northern Railway was constructed along the Kettle River. The construction of these railroads gave another impetus to settlement and development.

At different times nearly all of the county has been included within Indian reservations. In 1872 the Colville Reservation was confined to the region north and west of the Columbia River, and in

1900 the "North Half" was opened, but the opening was not marked by a great rush of settlers. At present the Spokane Reservation is the only one in the county.

According to census reports the population of Stevens County was 1,245 in 1880, 4,341 in 1890, and 10,543 in 1900, and 25,297 in 1910.¹ The present population is widely scattered. The remote and mountainous districts are sparsely settled. The Colville Valley is the most populous, with the Columbia Valley next. Other small valleys are relatively well settled.

CHIEF TOWNS.

Colville, the county seat, is the largest town. Its population in 1910 is reported as 1,533. It is situated on a terrace about 60 feet above the floor of the Colville Valley, about 10 miles south of the junction of the Colville River with the Columbia. Chewelah, the second largest town, with a population of 823, is the center of a good farming and mining district. Marcus is the third town in size, with a population of about 500. It is located near the junction of the Columbia and Kettle Rivers and is the first division point on the Spokane Falls & Northern Railway north of Spokane. The town is the junction of the Republic branch, the Nelson branch, and the main line of the Spokane Falls & Northern Railway, and is the center of a small agricultural section.

Northport is a town of some importance in the northern part of the county. Its population is given in the 1910 census as 476. It was once the largest town in the county, but the discontinuance of smelting caused a marked falling off in population. It is a port of entry and the distributing point for a large section. Kettle Falls, on the Columbia River, 3 miles from the railroad, has a population of 377. It is a distributing point for the rapidly developing country to the south. Other smaller towns are Springdale, Clayton, Addy, Meyers Falls, Loon Lake, Bossburg, Valley, and Bluecreek. These are supported by agricultural districts and by lumbering and other industries. A brick and terra-cotta plant is operated at Clayton. The small towns and villages in the Columbia Valley below Kettle Falls have stage connections with railroads at Meyers Falls on the north and at Davenport on the south.

TRANSPORTATION.

The railways of the county include a line running from Spokane entering the county near Clayton and following the Colville Valley to Marcus. Thence northward there are two diverging lines, one following the valley of the Columbia, the other the valley of the Kettle

¹ Includes population of present Pend Oreille County, which has been created since the 1910 enumeration was made.

River. Both lines cross the International Boundary. A branch runs northward from Northport on the Columbia River into Canada and a local road runs from Springdale to the Spokane River. Excepting the latter all are operated by the Great Northern Railway Co.

The western and southwestern sections and a part of the eastern section of the county are without adequate railroad facilities. Lines have been projected and surveyed in the Columbia Valley south of Marcus. A branch of the Northern Pacific is graded to Lincoln, at the junction of the Columbia and Spokane Rivers, in Lincoln County.

Water transportation on the Columbia River has never assumed commercial importance in this part of the State. During certain seasons a boat runs between Kettle Falls and the Spokane Rapids in the Columbia, near its junction with the Spokane River. The Kettle Falls and the Little Dalles offer the greatest obstacles to water transportation on the Columbia River. There are other less formidable rapids which could be avoided at a comparatively low cost. It is said that connection with railroad points farther down the river is practicable. Water transportation on the Columbia would greatly benefit points on the river between Daisy and Gerome, which are at present from 20 to 40 miles from railroads.

Four private ferries afford connection with parts of the county on the opposite side of the Columbia River and six ferries afford communication with Ferry County. There are no wagon bridges across the Columbia, but there are several across the Kettle and Spokane Rivers.

The sections of the county not reached by railroads are connected with railroad points by stage lines which carry passengers and mail. Some of the stages run daily, others two or three times a week. The longest route is in the Columbia Valley between Meyers Falls, Kettle Falls, and old Fort Spokane, the latter in Lincoln County, a distance of over 64 miles. Two routes cross the Huckleberry Mountains, one between Springdale and Fruitland and the other between Addy and Gifford. Another route extends from Colville to Aladdin and Park Rapids in the eastern part of the county. Middleport receives mail from points in Pend Oreille County and Wellpinit from Reardan in Lincoln County. A route extends from Springdale to Ford and Curby.

Road building has always been a serious problem in Stevens County. The system of county roads has been extended until the more accessible portions of the county now have fairly good road facilities. Owing to the rough and diversified topography, the grades are long and often steep, and the roads are frequently narrow and indirect. They follow the section lines in only a few places. Only a few miles of State road have been built. There is a pressing need for improved roads in many sections, especially in the Columbia Valley and between

Columbia River points and railroad towns in the Colville Valley. An abundance of good road-building material, including gravel, limestone, and basalt, is available, and considerable attention is being given to road construction and improvement.

Formerly the excess supply of farm crops found a ready market at good prices at local and Canadian points where mining and logging operations were carried on. As production increased it became necessary to find additional markets. The present excess of farm products is shipped to Spokane and tributary points. Fruit is shipped to cities in the East and Middle West. Lumber and other forest products are sent to all parts of the country.

WATER POWER.

The streams of this general region offer excellent opportunities for water-power development. The tributary streams of the main rivers of Stevens County have numerous falls and rapids, some of which are quite high. Meyers Falls, 135 feet high, in the Colville River, is already the site of a power plant which furnishes light and power to the neighboring towns of Kettle Falls, Meyers Falls, Marcus, Colville, and other points. There is promising opportunity for power development at Kettle Falls, on the Columbia River. A power plant is in operation at Little Falls on the Spokane River, and a large plant is under construction at Long Lake on the same river. The possibility of water-power development has an important bearing on the development of the county. Through the use of the streams for this purpose, power for transportation facilities in various parts of the county, as well as light and power for farm operations and for pumping water for irrigation, may be made available.

MAIL AND TELEPHONE SERVICE.

Rural free delivery routes extend into various parts of the county from Colville, Chewelah, Northport, Cedonia, and other points. The stages carry mail to farmers along their routes. Telephone lines serve the more thickly settled portions and extend into many of the remote sections.

CLIMATE.¹

GENERAL CLIMATIC CONDITIONS.

The location of this area on the western slope of the Coeur d'Alene Mountains in the eastern part of the Columbia River Basin gives it a climate with many of the characteristics of the continental interior and entirely different from that of western Washington, only 150 miles distant. The moderating influence of the westerly winds from

¹ Prepared by E. J. Saunders, of the University of Washington,



TYPICAL TOPOGRAPHY AND CHARACTERISTIC VEGETATION ON THE HUCKLEBERRY SILT LOAM.

[Looking northeast from near the summit of the foothills of Huckleberry Mountains.]

the Pacific, which is such an important factor in the climate of western Washington, is only slightly felt in this section, on account of the high Cascade Range to the west. Although protected to some extent by the Rocky Mountains and the Selkirks from the cold northerly and easterly winds, it lacks the additional protection afforded by the Cascade Mountains, and is therefore much more subject to continental extremes of climate than portions of the State lying west of that range.

Its location on the western slope of the Coeur d'Alene Mountains gives this area a more abundant rainfall than the central part of the Columbia River Basin, but a lower rainfall than the greater part of western Washington. The moist air moving from the Pacific loses much of its moisture in passing over the Cascade Mountains, and in descending on the east slope it is dynamically warmed so that it moves over central Washington as a dry wind able to take up moisture rather than cause precipitation. When, however, it is forced to ascend the slopes of the Coeur d'Alenes in this section of the State, increased precipitation results, and this belt has been described as the eastern moist belt of Washington.

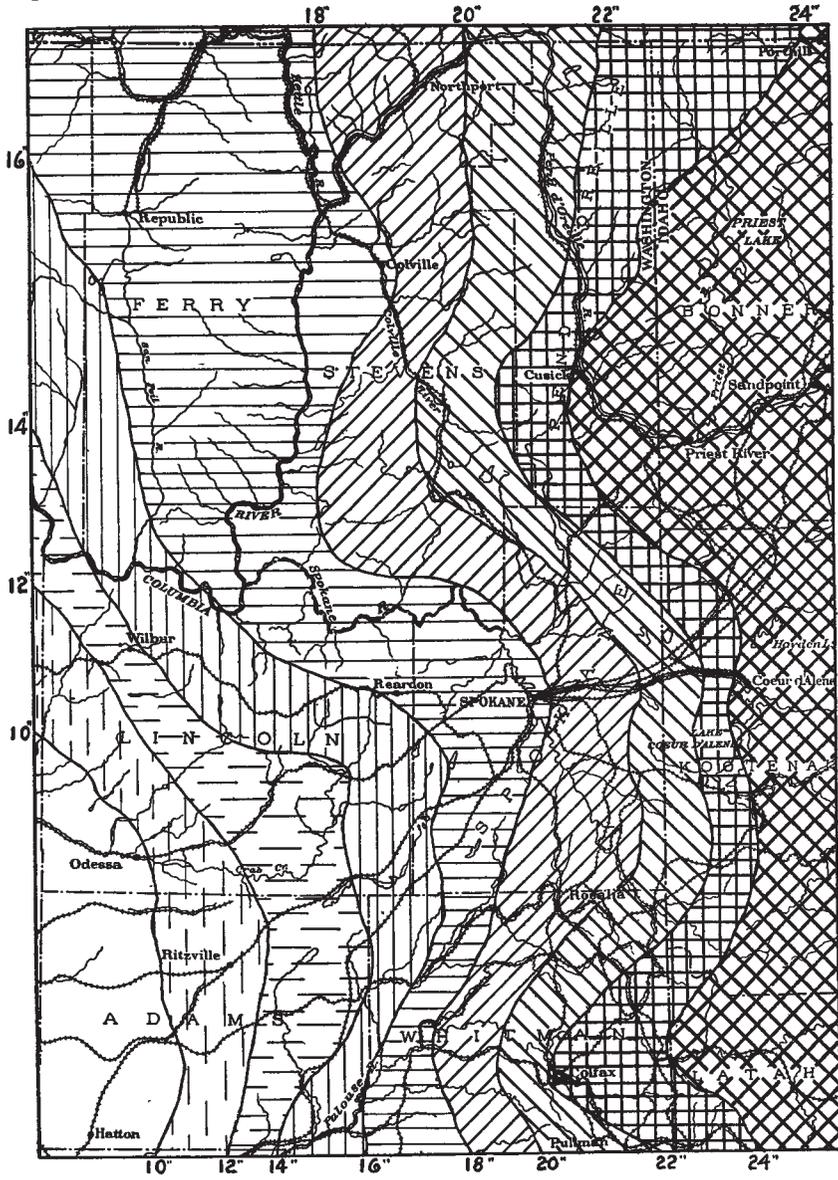
In preparing the sketch maps to represent climatic conditions so few stations with long-period records were found in the area covered by the survey that it was necessary to use the data from stations in northeastern Washington and in the western part of Idaho to give any adequate idea of general conditions in this particular area.

PRECIPITATION.

The average annual precipitation for the stations in and about Stevens County is shown in figure 2. The rainfall increases from 10 inches in the southwestern part of the area in irregular belts eastward to 24 inches at some of the stations in Idaho nearest the eastern border of the area. The greater part of Stevens County has between 16 and 20 inches annually. The maximum rainfall recorded for any year at Colville is 32.83 inches, in 1875; at Northport, 24.93 inches, in 1900; Spokane, 25.99 inches, in 1882; Wilbur, 18.20 inches, in 1906; and at Republic, 19.07 inches, in 1900. The minimum rainfall recorded for a year at Colville is 8.84 inches, in 1873; at Northport, 15.10 inches, in 1910; Spokane, 11.86 inches, in 1911; Wilbur, 9.70 inches, in 1908; and at Republic, 14.29 inches, in 1908.

The low annual precipitation here, as compared with 60 to 100 inches in the Puget Sound Basin and on the western slopes of the Cascade Mountains, less than 140 miles west of this section, is explained by the fact that eastern as well as western Washington depends on the moisture-laden winds from the Pacific Ocean for its supply of rain and snow. This warm, moist air, traveling east-

ward as a part of the general eastward drift, or more commonly moving into the cyclonic storms, is cooled to such an extent by forced



AVERAGE ANNUAL PRECIPITATION

- - ▤
 - ▥
 - ▧
 - ▨
 - ▩
 -
 -
- Below 10" 10 to 12" 12 to 14" 14 to 16" 16 to 18" 18 to 20" 20 to 22" 22 to 24" Above 24"

FIG. 2.—Sketch map showing average annual precipitation.

ascend in passing over the Cascade Mountains that the greater part of its moisture is deposited on the western slopes. In descending the

eastern slope it is dynamically warmed by increase of pressure at lower levels and its capacity for moisture rapidly increases, thus favoring clear skies and scant precipitation. As a result of this change in humidity the annual rainfall decreases rather quickly as the air moves toward the Columbia Valley, and increases gradually as the air is forced to higher levels in moving up the slopes toward the Coeur d'Alene Mountains. This causes the increase in irregular belts from west to east as shown, and if longer-period records for a greater number of stations were available, a much more marked effect of increase in elevation and general topography than is here shown would probably be found.

The monthly distribution of rainfall at the various stations is shown in figure 3. The effect of the proximity of the western coast is shown in the decided winter maximum, dividing the year into a wet season from October to March, inclusive, and a dry season from April to September, inclusive. But the contrast between the two seasons is much less marked than in western Washington. The total rainfall at Colville for the wet season is 10.54 inches, and for the dry season it is 7.12 inches, while at Seattle the total for the wet season of six months is 25.51 inches and for the dry season only 9.05 inches, a very little more than the amount for the same period in this section.

The winter maximum is accounted for by the greater intensity and frequency of the cyclonic or storm areas during the winter months, and the movement of the moist air from the warmer ocean over a cooler continent. Even after its passage over the Cascade Mountains it is cooled to a lower temperature as it moves eastward over this section, and thus yields additional precipitation. A very noticeable secondary maximum occurs in May and June, in most cases not so high as the November, December, and January precipitation, but higher than the rest of the year. This is accounted for by the rather common heavy summer showers, thunderstorms, or even "cloud-bursts," so-called, that occur during or near the close of a prolonged warm spell as regular convectional storms. These showers bring the summer average up much nearer the winter average than for stations west of the Cascade Mountains. On the other hand, the early spring and summer maximum is characteristic of stations east of the Rocky Mountains in the continental interior, where the summer rainfall is always greater than the winter precipitation.

In this section, then, there is evidence of two distinct controls, the oceanic or west coast, which is characterized by a winter maximum of precipitation, and the continental or interior, with a decided summer maximum, the former in this case being slightly more pronounced in its effects because of the proximity of the Pacific Coast.

The average snowfall throughout the area varies from 27.3 inches at Wilbur to 40.4 inches at Colville and 58 inches at Northport.

Spokane, farther east, has 37.5 inches. The absolute annual maximum for recorded years varies from 44 inches at Wilbur to 74.6 inches at Colville, and 99.5 inches at Northport. The lowest snowfall in the northern part of the area for any year is at Colville, where only 23.4

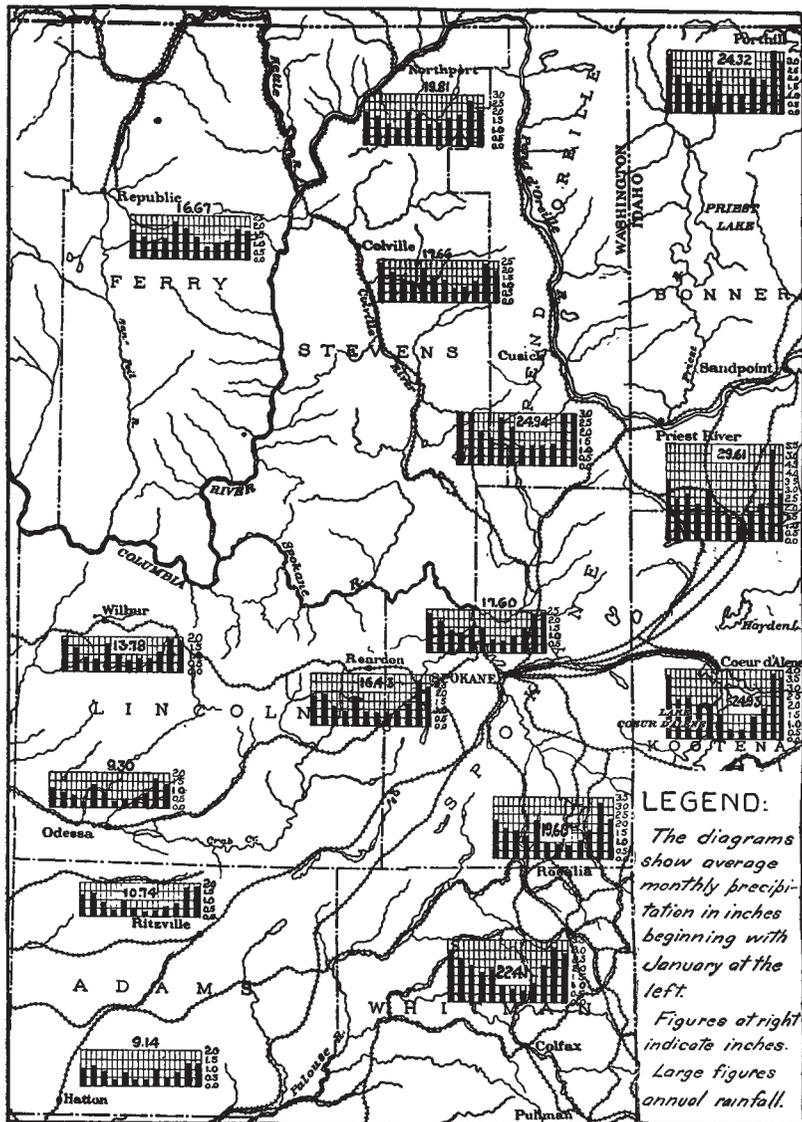


FIG. 3.—Diagram showing average monthly precipitation.

inches fell in 1901. At Spokane the least snowfall recorded in any year is 11.1 inches in 1904. The snow usually remains on the ground for several weeks and longer in the higher and more northerly parts of the area. Occurring in the winter months, it serves as a protective

blanket during the severe cold spells to which this section is subject and prevents the freezing of the roots of trees and plants. Melting in the spring, it supplies moisture slowly enough to be absorbed and retained by the soil and vegetal cover, furnishing an abundant supply of moisture when most needed by plant life.

Another very important factor in the climate of this area, especially in the ripening of grains and fruits, is the large number of clear days in the year. (See table below.) The records for Colville show an average of about 164 clear days, 64 partly cloudy days, and 138 cloudy days, with 91 days in which the precipitation is more than 0.01 inch. At Northport records give an average of 138 clear days, 107 partly cloudy days, and 120 cloudy days, with 117 days of rain. This gives about 236 days a year with considerable sunshine and 100 days with precipitation, as compared with 106, more or less, clear days and 147 rainy days in the Puget Sound country.

Table of climatic data.

Station.	Elevation.		Days with rain, .01 inch or over.	Cloudy days.	Partly cloudy days.	Clear days.	Average July temperature.		Average last killing frost.	Average first killing frost.	Days without frost.
	<i>Fect.</i>	<i>In.</i>					<i>° F.</i>	<i>° F.</i>			
Wilbur.....	2,203	27.3	72	133	72	160	64.7	23.7	June 18	Sept. 15	89
Republic.....	2,028	45.3	89	122	60	183	64.6	24.7	June 15	Sept. 3	80
Colville.....	1,635	40.4	91	138	64	164	68.1	21.9	June 5	Sept. 7	94
Northport.....	1,350	58	117	120	107	138	67.5	21.2	June 11	Sept. 9	90
Laurier ¹	1,644	62	.....	185	68	112	.....	.....	May 4	Sept. 11	130
Newport ¹	2,400	73	112	112	122	131	.....	.....	June 10	Sept. 11	93
Spokane.....	1,943	37.5	116	156	112	97	68.8	26.7	April 14	Oct. 11	180

¹ Three-year record only.

TEMPERATURE.

The mean annual temperature in this section ranges from 43° for the northern to 48° for the southern stations. In this case, even more than in the case of precipitation, more comprehensive data would probably indicate a wider variation on account of the irregular topography.

The range between the coldest and warmest month is 46.2° at Colville, or from 21.9° for January to 68.1° for July, as compared with a range of 20° in western Washington, or from 40° in January to 60° in July. The average for the coldest month varies from 21.9° at Colville to 26.7° at Spokane and 31° at Colfax. For the warmest month the average varies from 68.1° at Colville to 68.8° at Spokane and 64.8° at Colfax.

The records of the highest and lowest temperatures for different stations show an absolute annual range of 132°, or from 103° as a

maximum at Colville to -29° as a minimum. As low as -32° has been recorded at Republic and -30° at Spokane, and as high as 102° at Republic and 104° at Spokane. These extremes, however, are not at all common in this area and, on account of the low relative humidity of the air, are not felt as they would be if the air were moist. During even the warmest summer weather the nights are pleasantly cool and during the coldest periods in the winter the days are bright, clear, and crisp.

The cold spells of the winter are the result of well-developed anticyclonic or high-pressure areas to the north and east of the section, spreading out and sending cold air over this section in spite of the protection afforded by the mountains to the east. They are quite commonly followed by warm, dry winds from the southwest, known as "Chinooks," which break up the cold spell, melt the snow quickly, and often dry it up as it melts.

The daily range of temperature in this section is much greater both in summer and in winter than in western Washington, especially under anticyclonic conditions.

The explanation of the strong annual, monthly, and daily range of temperature lies in, first, the very slight moderating effect that the ocean winds exert here on account of the barrier Cascade Mountains to the west; second, the fact that this section is protected from the continental extremes only by the different ranges of the Rocky Mountains and is open to influx of air from the north; third, the air deprived of moisture allows of much greater radiation of heat during the nights and the winter, thus increasing the daily and seasonal variation. The effect of the Pacific Ocean winds is felt in the fact that neither the warm spells of summer nor the cold spells of winter are so prolonged or so frequent as in sections of the eastern interior.

KILLING FROSTS.

From the dates at which the earliest killing frosts in the fall and the latest killing frosts in the spring have occurred at the different stations, the average dates at which frosts may be expected are worked out in a general way in figures 4 and 5. Since the date of first and last frosts for any year depends largely on the passage of a well-developed anticyclonic or high-pressure area, the actual date will vary considerably from year to year. The irregularities in topography and the short-period records for many of the stations also cause many variations from these general frost belts.

The northeastern counties may be described topographically as a series of north-and-south ridges 4,000 to 5,000 feet high, separated by valleys, the floors of which range in elevation from 1,000 to 1,500 feet. One might suppose the uplands were subject to frost earlier in the spring and later in the fall than the lowlands, but frequently

the lower flat valleys have heavy frosts when the adjacent slopes and uplands are free from frost because of the drainage of cold air

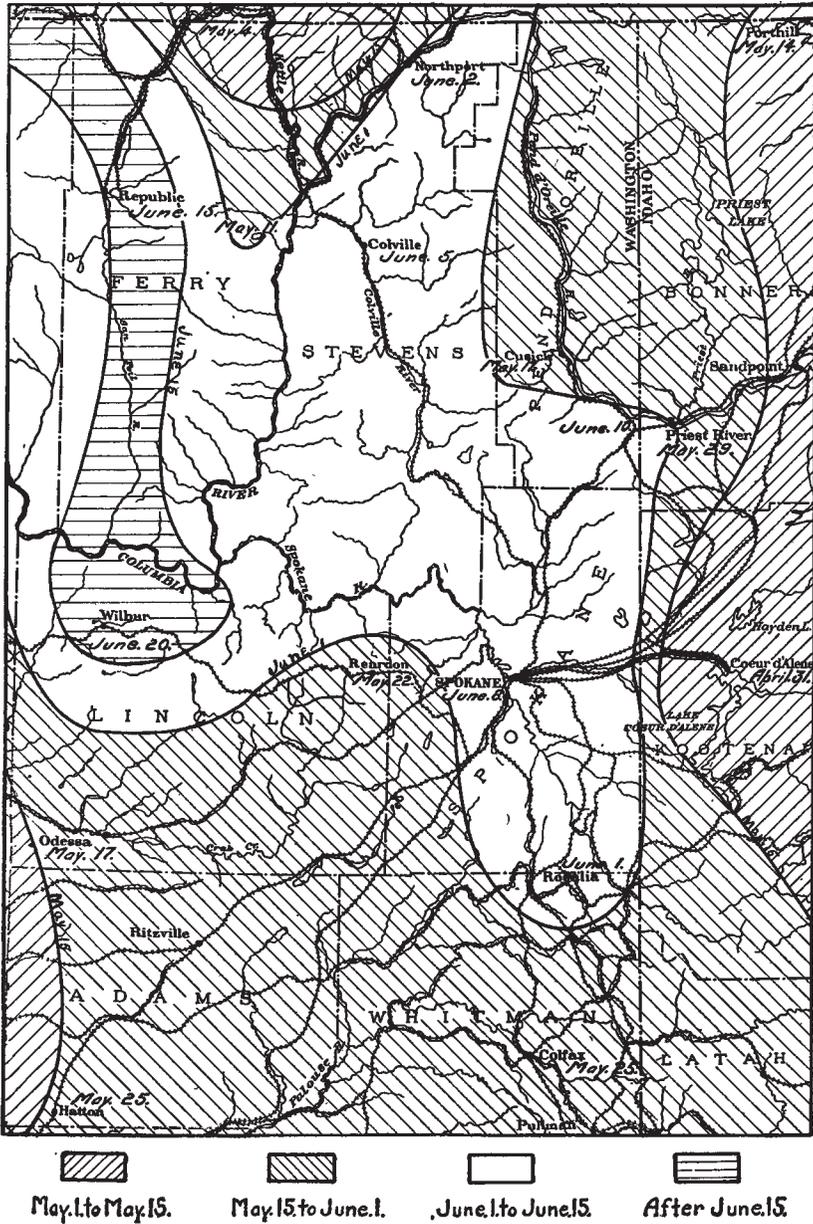


FIG. 4.—Sketch map showing average dates of latest frosts in spring.

down the slopes to the valleys, where its collection, if outlet is not afforded, favors frost. Thus the terraces along the rivers often escape

The earliest frost in the fall occurs on the average between September 5 at Republic and Wilbur and October 11 at Spokane, i. e., killing frost may be expected in a large part of this section at any time after September 5, but in Spokane and some of the other more southerly points, between October 1 and October 15. On the other hand, killing frosts have occurred as early as August 17 at Wilbur, August 19 at Northport, August 24 at Colville, and September 7 at Spokane.

The average date for the latest killing frost in the spring is between April 14 at Spokane and June 18 at Wilbur. That is, killing frost may be expected in many parts of the section up to June 18, but at Spokane and other stations the average date of the last killing frost is April 14. Killing frosts have occurred at Wilbur and Northport as late as July 29, and at Colville as late as July 26, but at Spokane not later than June 8.

WINDS.

Owing to great topographic irregularities, the prevailing direction of the winds varies considerably for different stations, as well as in different seasons. The main controls, aside from the topography, are the passage of the low-pressure and high-pressure areas and the general eastward drift of air in this belt. In general, the winds are from a westerly quarter, southwest in some cases, northwest in others. At Colville, for instance, the prevailing direction for the year is southwest, at Republic it is northwest, at Spokane southwest; but at Wilbur in the winter months it is southeast and in the summer months it is southwest. The highest velocity recorded at Spokane is 52 miles, and that for a short time on only one occasion. Tornadoes are unknown and thunderstorms are rare.

East winds are felt occasionally when a well-developed anticyclone to the east of the section causes the air to flow in from this center of high pressure. Coming from the northeast in the winter, these winds usually cause a cold wave, and coming from the southeast in the summer they are frequently the cause of whatever short hot spells this section is subject to.

SUMMARY.

The climate of this section of the State is the result of a combination of oceanic, continental, and mountain climatic characteristics. The high temperatures of summer, the low temperatures of winter, and the secondary maximum of precipitation in May and June are all characteristic of interior climate. The winter maximum of precipitation and the fact that the summer warm waves and the winter cold waves are not severe, nor of so long duration as farther east, are evidences of the oceanic influence. The clear, dry, exhilarating air,

the strong mountain winds, and the increasing precipitation toward the north and east are the result of the location of the section on the westward-facing slope of the Coeur d'Alene Mountains.

AGRICULTURE.

The agricultural development of the county began when a number of the miners and prospectors in this new country established homes in parts of the Columbia and Colville Valleys. The areas with smooth topography, light cover, good water, and fertile and easily cultivated soil were first chosen. Such locations were found on alluvial fans where the streams emerge from the hills into the main valleys. Agriculture never developed beyond the most primitive stage until the advent of homeseekers. While many of these were not trained farmers, they were not miners and did not look upon agriculture merely as a means of acquiring a scant living in the intervals between the working out of mining claims. The settlers were for the most part without funds, and many found employment in mills or cut wood, railroad ties or poles for sale at the nearest market. Consequently the development was slow, and has been closely associated with the logging operations since the building of the railroads. Some of the sites of sawmills later developed into towns and became the centers of farming districts.

As in all forested regions, the problem of clearing the land for crops is a serious one. The average settler has not the capital required for clearing on a large scale, nor does he wish to clear extensively unless there is a sale for the standing timber. On logged-off areas the situation is different, as the land is producing no revenue. The settler clears small areas at a time, gradually extending his cultivated land. The clearing is done largely by the labor of the family. Wood, railroad ties, and possibly poles are sold from the farm at times partially to defray the cost of clearing. No definite cost of clearing can be given, as it depends upon the stand and character of the timber, as well as upon the methods used in clearing. The cost ranges from about \$40 to \$100 an acre. If allowed to remain for some time after the timber has been removed, the smaller stumps decay and the cost of clearing is lessened. In some cases the stumps are removed immediately after the timber is cut; in others crops are grown between them for one season or more. In some cases the soil is so severely heated in the burning of the slashings that the humus content is partly destroyed and the productive capacity lessened. In such cases extra effort is required to bring the soil to its natural state of productivity. Data on this subject have been collected by both the United States Department of Agriculture and the Washington Agricultural Experiment Station.

The clearings on some homesteads in forested areas are from 2 to 25 acres in extent. The clearing is often too small to afford a livelihood. In the valleys and on the prairie areas the size of the cultivated areas is much larger, and they often cover fairly extensive continuous tracts. Usually for a few years it is necessary for the settlers to haul forage for their stock.

The farms average about 160 acres in size, and over 90 per cent of them are occupied by the owners. The ownership of large tracts of timber and logged land by individuals and companies has in some sections retarded development. An idea of the percentage of improved farm land may be had from the 1910 census, which reports a total area of 521,259 acres in farms, of which 116,872 acres are reported improved.¹

The agriculture of the county consists mainly of the growing of grain and hay, together with live-stock farming on a moderate or small scale. Only the most accessible, smoothest, and most productive lands have been put under cultivation.

According to the 1910 census,¹ the important crops grown in 1909, not including fruit, were, in order of their acreage, timothy, grains cut green for hay, oats, wheat, timothy and clover, alfalfa, and potatoes. A considerable acreage of wild hay is cut each year. The crops are grown for feed rather than to be sold directly for cash. The potato crop is small, little of it being sold. Wheat is the only crop grown exclusively as a cash crop. A large part of the oat crop, however, is sold for cash, and a part of the hay, both grain hay and timothy.

The acreage devoted to the production of alfalfa is rapidly increasing. This crop is grown both for hay and pasturage. From one to three cuttings are obtained, with an average yield of 2 to 4 tons per acre. The bulk of the crop is grown without irrigation. The first cutting is heavy, but later ones are usually smaller as the result of insufficient moisture. The first crop is cut in June and is often delayed or the hay discolored by rainy weather. The use of canvas covers for protecting haycocks is not practiced.

A large acreage of the agricultural land of the county is apparently well suited to the production of alfalfa. Well-drained, but not excessively drained, soils are suited to it without irrigation, while with irrigation many of the excessively drained soils are successfully used in its production. Bacterial inoculation of the soil has not been necessary in many places where the crop has been grown in this county. The use of lime in the preparation of land for this crop is not practiced.

¹ The census figures include the present Pend Oreille County.

Alfalfa adds humus and nitrogen to the soil, is a good feed for cattle and hogs, and is a sure and profitable crop. It is a very valuable crop for the dairy type of farming. There is a demand for northern-grown nonirrigated seed, the supply of which is inadequate. The growing of alfalfa in orchards is increasing.

As a rule clover succeeds on soils of the same character as those suited to alfalfa. Well-drained but not excessively drained soils of the uplands, alluvial fans, and terraces are usually adapted to its production. Individual areas of the crop are small, but the total acreage is fairly large when compared with the area under cultivation. The yields are usually large. Similar difficulties are often encountered in its curing, as in the case of alfalfa, but with proper methods it may be easily and cheaply saved. The stand is sometimes injured by late summer droughts.

Besides alfalfa, clover is a valuable crop in the development of the dairy industry. Less care seems to be necessary in the preparation of the seed bed than for alfalfa, and the clover combats weeds better. Clover is a better crop for short rotations than alfalfa. The stand usually deteriorates after three or four years, while alfalfa is more permanent. Alfalfa is much better adapted to pasturage. Clover is a good preliminary crop for alfalfa and is usually sown in the spring with grain. It is a legume and adds nitrogen to the soil. Fields that have produced one or two crops of clover are in good physical condition for the growing of other crops. Clover has an important place in the rotation of crops.

Timothy is grown extensively on the heavier soils of poorly drained character and on Muck and Peat. It does best on a silt loam or soil of heavier texture. Well-drained upland soils where fairly deep give good yields. Timothy has replaced the wild grasses of the natural meadows to a large extent, and it is in such places that the heaviest yields are harvested, as the soils are naturally adapted to the production of grasses and have a good supply of moisture. Some of the heaviest yields are obtained on recently broken areas of Muck and Peat, but the feeding quality is not so high as that of grasses grown on hard ground. Timothy hay commands a good market price and finds a ready sale. It matures long enough after clover and alfalfa to insure moderately fair weather for its curing. The bulk of the crop is stacked in the field and later baled and hauled to market. Timothy is not grown under irrigation.

Other tame grasses are not extensively grown. Wild grasses on the natural meadows are cut for hay. The native grasses of the meadows and uplands are used for pasturage.

A large part of the county seems to be well suited to the production of oats. Medium to good yields are obtained on all except the excessively drained soils. The crop is sowed in the spring as early as

conditions permit. The soils of the uplands permit earlier sowing than those of the bottoms and terraces. In average seasons the crop suffers very little from drought. On areas of Muck and Peat and of other insufficiently drained soils late sowing is often necessary and occasionally the yields are lessened by the damage from early fall frosts. These soils produce a rank growth of straw which often lodges and prevents the proper filling of the grain. The yields are higher, however, than on the uplands and the grain is fairly heavy. On such soils a reduction in the yields naturally follows after several seasons. The upland soils produce heavy straw and good yields of grain.

A large acreage of oats each year is cut green for hay, and good yields of excellent hay are common. This is fed mainly on the farm and makes a good substitute for other hay. By some it is claimed to be superior for certain purposes. Oat straw is extensively baled and sold. The average yield of oats for the county is 36.1 bushels¹ per acre.

Winter wheat is grown quite extensively on the upland and terrace soils. Where sowed after the fall rains it makes a good growth and matures early in the summer. It is a valuable crop in a rotation, but yields decline when it is sowed in the same field several years in succession. The yields on the whole are medium to good. Summer fallowing is practiced by some farmers on the terrace soils. Good yields are obtained by this method, but the use of the land is lost for one season. The yields are a little heavier than where the land is cropped annually and less labor is required, but it is probable that a larger income could be had by planting other crops. Sowing wheat in the fall relieves the pressure of spring work.

Spring wheat is grown to a small extent. It is apparently less profitable than winter wheat. Medium yields are obtained. Blue-stem is one of the main varieties. Quite an acreage of wheat is cut green for hay. By many farmers it is considered better for this purpose than oats. Wheat straw is baled and sold at near-by markets. The average yield of wheat for the county is a little more than 20 bushels per acre.

The production of potatoes is widely distributed and not confined to any section or to any soil type. The total acreage is not great. Potatoes do not succeed on excessively or poorly drained soils. The heavy soils also do not produce good yields. Potatoes are a valuable crop to include in a rotation. The tubers are usually free from scab and are of good quality. In average seasons the yields are satisfactory. The commercial production of potatoes would seem to offer excellent opportunities in this county.

The development of the trucking industry has not advanced beyond the first stages. Strawberries and other berries are grown to

¹ Census, 1910.

supply local markets. Cabbage is grown to some extent on Muck and Peat soils south of Chewelah, and good yields are obtained. The profits are not always what might be expected, on account of undeveloped markets for the crop. Good yields of beans are had, and the production of this crop is profitable.

Many attempts at growing corn have been made, but failure has resulted for several reasons, chief among which is the short growing season. According to the Weather Bureau records there is a normal growing season of approximately 100 days, which is too short for the maturing of corn grown from seed not acclimated to the region. It is a well-recognized fact that as much care should be exercised in the selection of the location of the corn field as that of the orchard in regions of this character. Comparative freedom from late spring and early fall frost is essential to the maturing of the crop. Owing to soil and climatic conditions, this is not a natural corn country, and extra precautions are necessary to assure success. The use of home-grown selected seed or that from similar climates greatly increases the prospects of maturing grain. The large varieties commonly used for silage in the Middle West do not mature. The bulk of the corn now grown is produced on the Stevens silt loam and on certain of the terrace soils.

Orcharding started with the planting of a few trees to supply fruit for home use. Some of these early planted trees which have received care are still in bearing. Very little attention was given in the setting out of orchards, to the selection of the site, or of varieties. As a commercial undertaking the industry has developed within the last 10 years, until at present it is specialized in many districts, which are known by local names, as the Upper Columbia Orchards, Bonnyvale, Edendale, Hunters, etc. These districts are in the Columbia and Colville Valleys. The bearing orchards are located on both terraces and uplands. The greater part of the recent planting has taken place on the terrace lands. (See Pl. II.)

Many of these later orchards show care and judgment in the selection of the site and the soil, while in the case of others, especially some of those planted by irrigation companies, less attention was given to these important details. Naturally there are instances where for some reason proper care is not given the orchards, but as a rule they have careful attention. In the last two years there has been a marked decrease in the extent of plantings, especially of smaller orchards. At present there is a tendency toward the planting of pears. There are in round numbers 250,000 apple trees and 20,000 pear trees in bearing. Cherries, plums, prunes, peaches, and crab apples follow, in the order named. They are grown for home use and for market. Few make a specialty of their production, but the total income

derived from their sale is large. They have been planted in nearly all sections where fruit is produced.

The varieties of apples commonly grown are the Jonathan, Grimes, Esopus, Spitzenberg, Rome, Wagener, Winesap, Yellow Newtown, and Arkansas Black; of pears, the Bartlett; of peaches, the Early Columbian and Elberta.

The soil requirements in the growing of orchard crops are few but important: Good drainage, sufficient depth and proper texture, and productiveness. On upland sites bedrock is often near the surface. It should not be nearer than 4 feet, except where the tract is under irrigation, when a slightly shallower soil will do if carefully irrigated. Many of the terrace soils are from 8 to 15 inches in depth, and underlain by a bed of gravel. Unless these are under irrigation it is not probable that orchards will be successful on them. Orchards have been set out on some of these gravelly terraces where there is very little fine material. Thus far the trees are growing satisfactorily, but it is probable that even with irrigation best results will not follow. The very sandy, dry soils, and the heavy clay soils are not well suited to fruit production. Alkali is not a troublesome factor. The upland soils, particularly of the Stevens series, are fairly productive. The lighter colored upland and terrace soils are less so. The adaptation of the various soils to particular fruit varieties has not been determined.

The failures that occur in fruit growing are due to several factors, important among which is improper selection of the site. The orchard may be located where there is imperfect air drainage or an excessively drained soil. Lack of care and toleration of plant diseases also result in failures. It is usually necessary to give attention to increasing the organic matter and the nitrogen in the soils, which are as a rule normally low in these elements. Smudging or firing to prevent injury of trees by late spring frosts is not generally practiced, and in many localities this practice is not necessary. In other places it is advantageous. The majority of the fruit growers are not prepared to combat a threatening frost, but the damage from frosts is said to be slight. Various publications of the Weather Bureau and of the State experiment station give detailed information in regard to frosts and frost protection.

Opinions apparently differ as to the advisability of growing inter-tilled crops in the orchards. Chief among the crops so grown are potatoes, beans, alfalfa, corn, turnips, peas for seed, and rye. In some orchards clean cultivation is practiced.

The practice of growing intertilled crops in the orchard until it comes into bearing is quite common in Stevens County. In some cases it is necessary for the owner to utilize the land between the

rows of trees for crops which will pay living expenses. In other cases the owner believes it to be the proper method. A strip 4 to 6 feet wide is usually left on each side of the row of trees, and this is given frequent cultivation during the growing season. Alfalfa is successful in irrigated orchards, being grown usually in rows or in drills.

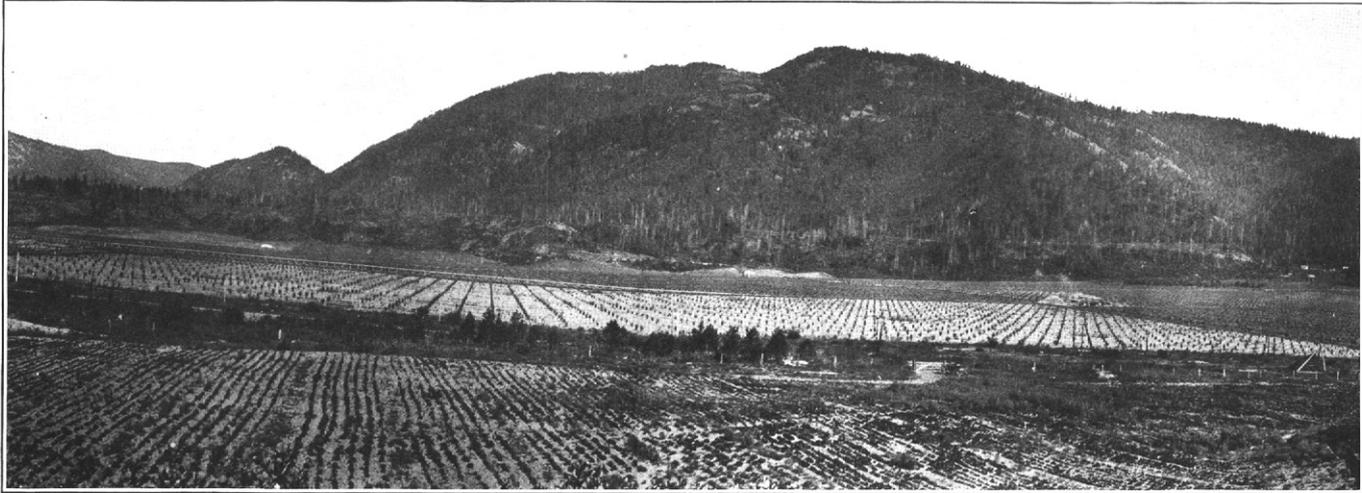
Intertilled crops are grown only in the younger orchards, and in many with proper management they do not seem to impair the growth of the trees. In the vicinity of Marble the growing of crops, such as turnips, peas, etc., for seed is practiced on a large scale. In the case of turnips the seed is drilled in during the fall, and the crop is harvested and thrashed the following summer. Peas are planted in rows in early spring, given clean cultivation, and harvested in July. These crops are often alternated. The demand for northern-grown nonirrigated seed is strong and the yields and returns are said to be good. These crops apparently do not impair the growth of the young fruit trees.

In some cases filler trees are used in the orchards, and the practice is profitable, if the trees are removed before they do serious injury to the permanent orchard. They may be left for several years. Early bearing commercial varieties or standard varieties of apples and peaches, pears, and other fruits are used in this way. The use of winter cover crops is not generally practiced.

The care of the orchard varies with the individual owners. All orchards are given cultivation of some sort during the summer months in order to retain all possible moisture and to kill the weeds. Both fall and spring plowing are practiced. Where intertilled crops are not grown, cultivation to kill weeds and to maintain a soil mulch is given. Where winter cover crops are grown the land is plowed in the spring and thoroughly harrowed. The irrigation where practiced is largely a matter of judgment on the part of the growers. A study of the water requirements of the soil and trees is advantageous.

The fruit is marketed through a selling organization composed of local associations, which supervise the packing and shipping. This organization was formed recently. It insures better markets and prices and facilitates distribution of the fruit. Some of the orchards are far from railroad transportation, and bad roads interfere with the hauling of the fruit.

The average cost of bringing an orchard into bearing is \$50 per acre. This figure is based on information given by different orchardists of the county. This cost is subject to variation on account of local conditions and the practices of different growers. The age at which a tree will come into bearing depends upon the soil, variety, character of pruning, and other factors. The trees have a tendency to bear too young. Under average conditions they do best where not permitted to bear before they are 5 years old.



MAIN TERRACE IN COLUMBIA RIVER VALLEY AT MARBLE, LOOKING WEST.

[Shows alluvial fan on the right and a higher terrace on the left. Orchards in the middle distance; navy beans in the foreground field.]

The spraying of orchards for codling moth and other orchard pests and for scab and scale is practiced throughout the county, and the methods are fairly efficient. The disease known as "fire blight" occurs in practically all of the apple-growing districts of the State and has required large expenditures and the services of many experts in attempts to control and eradicate it. In many of the districts it is under control, but its complete eradication has not been accomplished. In this county the disease has never become so prevalent as in some other districts, but it is present to a sufficient extent to warrant extreme measures for its control and complete eradication. It is known to attack even forest trees and shrubs.

The dairy industry is not developed to the extent that conditions warrant. Several creameries are located in different parts of the county, but they do not have a large output of butter. Many of the farmers have small herds and make butter at home or ship the cream to Spokane and other points. As a specialized industry very little advancement has been made. Dairying can be satisfactorily practiced on a large scale only where there is sufficient land under cultivation to produce forage for the winter months. The grade of the stock is rapidly improving. Pure-blooded stock of various dairy breeds is being introduced.

A large part of the county is well adapted to this type of farming. Very few, however, of the settlers came from a dairy country, and the farmers, as a rule, do not appreciate the opportunities offered by the dairy industry. Clover and alfalfa can be grown in abundance, and pasturage may be had at small cost. In the vast acreage of hilly land so widely distributed throughout the county there are quite extensive areas, closely associated with land suited to general farming, that are best adapted to pasturage. These classes of land are so intermingled that nearly every farmer has some land suitable only for pasturage.

At the present time there are only a few silos in the county. Corn constitutes a good silage crop. Besides corn, green pea vines, clover, alfalfa, and root crops make good silage.

The raising of cattle and hogs is a source of considerable income in certain parts of the county. Bulky farm crops and grain find a profitable market in this way, especially in districts remote from railroad transportation. Alfalfa is used to some extent for the pasturage of hogs, which are finished on grain. Cattle raising is not engaged in as a special industry.

The use of commercial fertilizers has never become common. The better farmers use all the available stable manure. The growing and plowing under of green-manuring crops receives but little attention. In the preparation of land for alfalfa, lime is not used to any great

extent, and on the upland and many of the terrace soils it is not needed to correct acidity. On some of the poorly drained soils its use is beneficial.

There is an adequate supply of fairly efficient farm labor. Many of the homesteaders in remote districts leave their farms during the haying season to work on the large farms of the valleys. Wages are fairly high. The family performs all necessary labor on many farms.

Land values in Stevens County are quite variable. Adjoining farms sell for widely different prices. This condition arises from differences in character of soil, topography, acreage in cultivation, and improvements, such as buildings and fences. Another factor which influences the value of farms is their location with respect to railroads and markets. Forested areas are valued according to the character and stand of timber when bought and sold for speculative purposes.

For farms having very little improved land in fairly remote sections the price ranges from \$10 to \$35 an acre; in more thickly settled sections, with a medium acreage of cleared land, farms sell for \$30 to \$50 an acre; farms with good improvements, near markets, and with a high percentage of improved and good agricultural land are held at \$50 to \$100 an acre. Orchards in various stages of development are on the market at \$200 to \$500 an acre. The demand for farming land is not very active, but seems to be steady.

SOIL MAP AND LAND CLASSIFICATION MAP.

This report is accompanied by a soil map and a land classification map. The extent and location of the different soil types are shown by means of colors on the former, and in a like manner the agricultural classification of the land is shown on the latter.

In the valley bottoms and on the glacial outwash, lake and river terraces, and flats the soils as indicated on the soil map are worked out in considerable detail. In the undeveloped hilly and mountainous areas, where the settlement is sparse, the soils are shown in much less detail, but even here in sufficient detail to show the general nature of the soil of any particular locality. The comparative inaccessibility of many parts of such areas and the lack of time available prevented more detailed mapping. In a country of such diversified topography and of such wide local differences in the depth of soil material to the underlying rock, there are phases and in places distinct soil types which it is not practicable to separate on the map in a survey of this kind. The more important and extensive of these variations are described in the report.

The classification of the land as indicated on the land classification map follows the same plan as the mapping of the soils, being more detailed in the valleys and more general in the upland sections of the

county. The land has been separated into five different classes, to show in a general way the relative agricultural value and the type of farming to which the land is best adapted. This classification takes into consideration the topography, drainage, moisture-holding capacity, and adaptability to irrigation; or, in other words, the factors which determine the agricultural possibilities of the land.

The first three classes of land shown on the land classification map may be grouped as smooth lands. This group is not necessarily limited to lands of level character, those without steep slopes where intrenched by streams or eroded, or to those devoid of minor surface irregularities, but includes broadly those areas in which the topography in general is not irregular enough seriously to interfere with tillage operations.

The last two classes of land are included in a second broad group which may be called hilly or mountainous lands. In this group the topography has an important bearing upon accessibility, cultural operations, and the type of agriculture to which the lands are suited. The classes are as follows:

Class I: Poorly drained areas. Consists mainly of recent lake bottoms; normal drainage poorly established. Well adapted to general farming when drained.

Class II: Well-drained areas. Comprises mainly recent alluvial, alluvial and outwash terrace lands, and footslopes; drainage well established. Moisture supply generally favorable. Well adapted to general farming and to intensive agriculture.

Class III: Excessively drained areas. Consists mainly of glacial outwash, river and lake terraces. Subject to drought during the latter part of the season, owing mainly to excessive subdrainage. Adapted to intensively cultivated orchard or other crops. Less well adapted to general farming. Capable of irrigation.

Class IV: Hilly areas. Mainly tracts of moderately hilly or rolling character. Adapted mainly to general farming and dairying, but can be utilized for intensive agriculture where not too shallow, steep, or rough.

Class V: Rough, stony, or mountainous areas. Largely non-agricultural. Includes local areas suitable for intensive agriculture, dairying, and general farming. Remainder adapted to forestry and grazing.

The first class includes soils of high organic-matter content, occupying recent lake basins in which the drainage is normally poor. These occur both in the valleys and uplands, and are shown on the accompanying soil map under the type names of Colville silt loam, Colville silty clay loam, and Muck and Peat. The soils are naturally productive where sufficiently drained and properly handled, and are adapted to the production of general farm crops, particularly oats

and timothy. Much of the land is used for the production of these crops and the remainder is devoted to wild grasses. Its crop-producing power justifies a sufficient expenditure to insure adequate drainage, in order that seeding may be done earlier and that there may be less danger of loss or damage of crops through excessive moisture or early frosts. Most of the land of this class occurs in the Colville Valley, where the organization of drainage districts and the dredging and straightening of the channel of the river have made valuable land out of areas that were swamp only 2 or 3 years ago. The construction of other ditches and laterals would further improve the drainage conditions. Smaller areas of this class in the uplands are often more difficult to drain.

The second class embraces water-laid soils whose topography, drainage, and moisture-holding capacity render them adapted to intensive agriculture and to general farming. They have a medium organic-matter content. Early maturing cultivated crops, such as grain, hay, and potatoes, give good results, but late-maturing crops sometimes suffer from drought. Much of the class is suitable for irrigation. The soils are naturally productive and with efficient management give profitable yields. They are capable of sustaining a more intensive agriculture. The recent alluvial part of the class is mainly forested. This class includes types belonging to the Garrison, Waterloo, Chamokane, and Chewelah series, and also the more favorably located areas of the Springdale loam.

The third class of lands includes the soils of the glacial outwash, and lake and river terraces. These differ widely in character of soil, subsoil, and underlying material or substratum.

The nongravelly types of soils, and particularly those of finer texture, such as are classed with the Mission and the Hunters series, which are characterized by a substratum of material relatively heavier in texture and more compact in structure, have good drainage and favorable topography, but are better adapted to intensively cultivated and orchard crops than to general farming. The latter, however, is successful in many instances. Summer fallowing is practiced in places for winter wheat. The soils are productive, but frequently their organic-matter content is low and late-maturing crops suffer from drought in the latter part of the growing season. The heavier types are better adapted to the production of hay and grain. In many cases irrigation is needed, especially on the lighter types of the class. Both the topography and soil are suited to intensive farming. The Clayton series, though ice-laid, is underlain by lake-laid material and is included in this class.

The class also includes soils of sandy and gravelly texture, mainly of the Springdale series, which are underlain at shallow depths by porous, gravelly subsoils and substrata. These soils are low in

organic-matter content, and are excessively drained. In one or two types the gravel content is sufficient to interfere with cultivation. These soils are not retentive of moisture, and are better adapted to intensive agriculture than to general farming. The surface is favorable for irrigation, which is necessary for the successful production of crops over the greater part of these types. The deeper sandy types are mainly devoted to orchards and intertilled crops. The finer and gravelly types are largely used for grazing and forestry. The forest growth usually consists of a scattering of yellow pine. These soils are quite extensive and can be developed by providing water for irrigation by storage and otherwise, and would be adapted to a wide range of crops under irrigation. The class also includes some non-agricultural land occurring on steep slopes and eroded portions of terraces.

The third class also includes the comparatively limited areas of soils of wind-blown origin mapped with the Marble series. They have a hummocky to dune topography and occur on either lake, outwash, or river terraces. The organic-matter content is low. Where shallow and fine textured, they hold moisture fairly well under cultivation, but normally they are excessively drained. Irrigation is generally necessary for the successful production of crops. Local areas are naturally well suited to intensive farming. The surface, as a rule, is not suited for irrigation and some leveling is required. With leveling and irrigation, this land is adapted to alfalfa, orchard, and intensively cultivated crops.

The fourth class comprises areas of mixed agricultural and non-agricultural land, as determined by topography and depth and rock content of the soil. This is the most extensive and most widely distributed of the five classes, and includes the rolling to hilly and rough portions of the county. In general, this land has a more regular topography and a lower elevation than that of the fifth class. The percentage of agricultural land within this class varies from low to high in different sections of the county, but it was not practicable to make a more detailed classification in the extensive upland districts. The class embraces soils having a fairly wide range in crop-producing capacity and adapted to the same type of farming. The hilly topography interferes with the development of extensive grain and hay farms in all parts of the class. The steep slopes and stony areas can not be thoroughly cultivated and are best suited to pasturage, while the more nearly level portions may be used for general farm or forage crops. It seems, therefore, that areas of this class would reach their highest development under a system of dairy farming. There are a few fairly extensive areas which are devoted to the production of hay and grain, but without a rotation of crops or the practice of dairying the yields soon begin to decrease. With the exception of the greater

part of the Stevens series, the class formerly supported or now supports a fairly heavy forest growth.

The soils of this class are well drained and carry an abundance of good water for home and farm use. Their moisture-holding capacity ranges from low to good, and early-maturing crops seldom suffer from drought. Portions of the class are adapted to orchard crops. The class embraces mainly soils of the Stevens, Waits, Loon, and Hessel-tine series, and also the Empey silt loam. The description of these types in subsequent pages gives more detailed information as to their character and farm value. It should be briefly mentioned that portions of the Waits silt loam vary somewhat from the above description of the class. Such areas occupy a broad table-land, which is cut by a number of narrow canyons and is adapted to the same general type of farming as the other series of the class.

In the fifth class are grouped areas of such diversified and mountainous topography that the percentage of agricultural land is low. The slopes are steep and often stony, and rock outcrop is usually abundant. The class includes the highest elevations of the county and areas which are remote and inaccessible. It includes small areas which are suitable for intensive agriculture, dairying, and general farming. The class is quite extensive, and in general the lands are adapted to grazing and to forestry. The areas mapped as Rough stony land and as Rough mountainous land belong to this class. The class also comprises small areas, mapped as Rock outcrop, the slopes of which are steep and stony and often devoid of soil.

The following table gives the actual and relative extent of the different classes of land:

Areas of different classes of land.

Grade of land.	Acres.	Per cent.
Hilly areas.....	606,592	39.6
Rough, stony or mountainous areas.....	599,680	39.2
Excessively drained areas.....	231,936	15.1
Well-drained areas.....	55,552	3.6
Poorly drained areas.....	38,080	2.5
Total.....	1,531,840	.....

SOILS.

CLASSIFICATION.

Stevens County lies mainly in the Rocky Mountain Soil Region as defined by the Bureau of Soils in Bulletin 96. An area in the extreme southern part of the county lies within the Northwest Inter-mountain Soil Region.

The rocks underlying the former region consist mainly of faintly metamorphosed and metamorphosed sedimentaries, with a few

areas of massive granite. The metamorphosed sedimentary rocks consist of quartzites, shales, slates, and crystalline limestones, the product of metamorphic processes acting on sandstones, shales, and limestones. Quartzite seems to be the predominant rock of the county. The shales and limestones are rather widely distributed over it, and since they are less resistant to erosion they occur in the less mountainous parts of the county, while the more resistant quartzites with some areas of the granites form the rougher areas. All these rocks have been intricately folded and eroded, so that they outcrop as the upturned edges of the originally horizontal beds. Granite areas occur in several parts of the county, one of the two most important occurrences lying east of the Colville-Chamokane Valley and the other west.

The rocks underlying the Intermountain Region of the southern part of the county consist of basalt.

In recent geological time this region was invaded by the ice of the Glacial Period. It covered all the rocks, with the possible exception of the highest points, and mixed the preexisting soils of the area with one another and with material carried from regions farther north. This was redeposited, on the retreat or melting of the ice, as glacial deposits consisting of sand, silt, clay, and stones heterogeneously mixed, except in those areas covered by materials dropped from water flowing from the ice. The existing soils of the region have been formed from these deposits through weathering and from stream and lake deposits laid down since the disappearance of the ice.

Lakes, some of them of considerable size, undoubtedly existed during the closing stages of glacial action and for a short time afterwards, but they were mainly in narrow valleys and formed few distinct beach lines. The deposits laid down within them have in some cases been covered by younger water-laid deposits, and the streams have cut valleys into them, so that they now occupy the position of terraces and the soils formed from all the deposits exposed within them are grouped with other and well-defined river terraces as glacial lake and river terrace soils. Relatively small areas lying mainly in the southern and western parts of the county are occupied by soils of residual origin, derived from the underlying rocks. Narrow strips of recent alluvial soils occur along some of the smaller streams, while inextensive areas of wind-blown soils occupy some of the river terraces. The valleys of the larger streams include but little or no present flood-plain deposits, and the latest alluvial terraces, most of which are well elevated above the present channel, are included with the soils of the glacial lake and river terraces. Some of this material is probably post-glacial in date of deposition, but consists of reworked and redeposited material of the glacial drift or of glacial water-laid material.

The soils of the county, therefore, are derived from glacial drift, from water-laid deposits, and from wind-laid deposits. The water-laid soils are the terrace, lake-laid, and recent alluvial soils.

The agencies of weathering acting on these deposits have produced the soils now found in the county. They are broadly separated, on the basis of the derivation and the process of accumulation of the soil material, into the following groups:

(1) Residual soils, or those derived mainly from the weathering of underlying rocks in place.

(2) Soils derived from glacial drift. These may be further divided into (a) soils derived from deep glacial drift and (b) soils derived from thin glacial drift.

(3) Soils derived from glacial lake and river terrace deposits, including lake-laid sediments occupying both terraces and recent lake basins, terrace deposits of glacial streams, later alluvial terrace deposits derived mainly from glacial material, and local glacial stream delta and outwash deposits. This group may be subdivided into (a) soils of glacial terraces underlain by sands and gravel, (b) soils of glacial terraces underlain by silts and clays, and (c) soils of recent glacial-lake basins.

(4) Soils derived from eolian or wind-laid material.

(5) Soils derived from alluvial-fan and footslope material.

(6) Soils derived from alluvial flood-plain deposits.

(7) Soils resulting from the accumulation of organic matter.

(8) Miscellaneous, nonagricultural material.

The above eight groups are further separated into soil series and the series into types. The latter is the smallest unit of classification and is determined by the texture, or the relative proportion of the different sized particles of mineral matter which make up the soil mass. The matter of texture is judged by field examination, and the results are checked by mechanical analyses in the laboratory of typical samples of each type. The soil types similar in origin, mode of formation, color, structure, topography, and agricultural value form a soil series, which is either correlated with series previously mapped in other areas or is given a local name and is assigned to a place in the key of the soils of the soil region or province in which it occurs.¹

Eighteen distinct series, embracing 50 soil types, with several phases, and 4 kinds of miscellaneous material, have been recognized in the survey of Stevens County. Only one of these series has been correlated with soil series previously mapped. The extent and distribution of the soil types are indicated by means of colors on the accompanying map.

Residual soils.—The soils of this group are formed mainly through the weathering of the underlying rocks, in areas which the ice sheet

did not cover or where the original glacial drift has been removed by erosion, and where conditions have been favorable for the accumulation of sufficient weathered rock material to form the soils.

The soils of this group are not extensive, and occur principally in the southern part of the county. They are grouped into two series, the Moscow series, derived from granitic rocks, and the Huckleberry series, derived from metamorphic rocks. Rock outcrop, a miscellaneous nonagricultural type, might properly be classed with this group.

Soils from glacial drift.—The division of this group into (a) soils derived from deep glacial drift and (b) soils derived from thin glacial drift is based mainly upon the extent to which the types of the series have been modified by the weathering of the underlying rocks. This separation is a rather arbitrary one, especially where the series is made the unit of classification.

Soils derived from deep glacial drift.—The soils of this subdivision occur in the more hilly and mountainous parts of the county. For the most part they are composed of unsorted accumulations of boulders, cobbles, gravel, and fine earthy material, which are derived both from preglacially weathered and from glacially ground rock material and were deposited during the advance and retreat of the Cordilleran ice sheet. Its character and topography also indicate that the bulk of the material was deposited as a ground moraine rather than as lateral and terminal moraines.

The soils of this subdivision, exclusive of the upland prairies, have a thick two-story forest cover of fir, tamarack, and brush. They are markedly similar in texture but vary widely in color. They are predominantly silty and usually carry some rounded gravel. Boulders are especially abundant in places and are present in nearly all parts of the glaciated section. Outcrops of local rocks are common. The types have adequate surface and subsurface drainage, owing to their topography and the generally porous character of both the surface soils and subsoils.

The soils of the Stevens, Waits, Loon, and Clayton series belong in this group. The various types, and even parts of each type, are not of equal depth, but there has been little modification of the soil material by the weathering of the underlying rock. The Clayton series is derived from a comparatively thin deposit of glacial till which overlies lake-laid sediments.

Soils derived from thin glacial drift.—The extent of the soils of this subdivision is much less than that of the soils derived from deep glacial drift. They are confined mainly to areas bordering the valley floor of the Colville-Chamokane Valley from a few miles south of the town of Chewelah to the Spokane River, and to an area between the Fruitland Valley and the Spokane River in the southwestern part of

the county. The soils occupy dissected to hilly portions of the county, and are composed of unsorted boulders, cobbles, gravel, and fine-earth material, mainly similar in origin to those derived from deep glacial drift. In addition, there has been a noticeable modification by the weathering of underlying rocks. More extensive and frequent outcrops of rocks occur than in the case of the soils derived from deep glacial drift. The types are forested and are well to excessively drained.

The soil types of the Hesseltine series belong to this class. Rough stony land and Rough mountainous land, two miscellaneous classifications, also might properly be included. In this connection it should be mentioned that the type of undifferentiated soils designated as Rough mountainous land occurs under both the deep and thin glacial till subdivisions.

Glacial-lake and river-terrace soils.—The soils of the glacial-lake and river-terrace group are best considered under three principal heads or subdivisions based upon differences in topography, drainage, and in character of underlying material. These may be designated as soils of the glacial terraces underlain by porous sands and gravel and at least mainly of glacial-stream-laid origin, soils of the glacial terraces underlain by compact silts and clays, and soils of the recent glacial-lake basins.

Soils of glacial terraces underlain by sands and gravel.—The soils of the glacial-stream terraces as typically developed occupy terraces mainly in the Columbia, Colville-Chamokane, and Spokane Valleys and along their larger tributaries either as remnants of glacial deltas, glacial-stream terraces, or local glacial outwash plains, the material having been deposited while these valleys were serving as outlets for glacial waters. Other areas occur along tributaries of the Columbia River and in old glacial valleys not traversed at present by stream courses. As a rule the soil types have subsoils and substrata consisting of more or less stratified deposits of gravel, cobbles, and boulders, with small quantities of interstitial sands. A surface mantle of fine material from 8 to 20 inches or more in depth, which carries in some places large quantities of rounded gravel, covers the coarse material. These soils have a typical terrace topography, with almost level tops and steep fronts toward adjoining lower terraces and stream courses. The drainage of the soil types is always adequate and often excessive.

With this typical development of the glacial outwash soils have been included as river-terrace phases, along the large rivers, soils occupying well-defined alluvial terraces which are usually above overflow. These present terraces are probably remnants of formerly more extensive deposits. They have fine sandy soils and gravelly subsoils and substrata. The drainage is often excessive. The parent

soil material of these river terraces is derived mainly or at least in part from glacial outwash or reworked glacial material, though some of the lower terraces may not have been formed until after the close of the glacial period.

The group also includes small areas in which the surface soil has been modified or covered by later alluvial-fan deposits derived from adjoining uplands and distributed by minor streams. The more important of these are differentiated on the soil map as an alluvial-fan phase of the type with which they occur.

The material forming the various types of this group is derived from a variety of rocks, and much of it has been transported from points outside the county. The coarse material is all well rounded and washed clean of silt and clay. The types are classed with three series, the Springdale, which is the most extensive, and the Garrison and Waterloo.

Soils of glacial terraces underlain by silts and clays.—The soils of the glacial-lake terraces are derived from a series of deposits which are generally underlain by stratified sediments of fine texture and rather compact structure, as compared with the gravelly, porous material underlying the glacial outwash deposits. The deposits are well drained, and while the surface is usually gently sloping or undulating, they are slowly undergoing removal by erosion.

The soils have a wide distribution as elevated terraces in glacial basins in the valleys of the Columbia, Spokane, Kettle, and Colville Rivers and of several of their larger tributaries. They seem for the most part to have been deposited in basins near the ice front during the retreat of the glacial ice.

This group is represented by three series of soils, the Mission, Hunters, and Empey. The soils are of fairly high agricultural value, depending upon the moisture supply and moisture-retaining capacity as affected by the depth to the underlying substratum of silts and clays.

Soils of the recent glacial-lake basins.—The soils of the recent glacial-lake basins are derived from comparatively recent lake-laid material. They occupy principally the low-lying, flat bottoms of recent lake basins, which have been developed in various ways in the valleys of the Colville River and of Chamokane Creek. Other small, isolated areas occur in depressions on outwash terraces and as "meadows" in the glaciated uplands of the county. In places the soils have been modified by the accession of recent alluvial material along the stream courses traversing them. The recent lake-laid soils are as a rule poorly drained. They are classed with the Colville series. When drained they have a high agricultural value.

Eolian or wind-laid soils.—The soils of this group consist of wind-laid material having the typical topography of wind-blown sands.

At present grasses and other forms of vegetation largely protect them from blowing. These soils occur on the outwash, lake, and river terraces, and consist of eolian reworked material derived from the terrace soils. The soils are loose and porous, and rather excessively drained.

The wind-laid soils are composed mainly of sand of different grades and are classed with the Marble series. The types are not farmed to any extent. With frequent cultivation they are fairly retentive of moisture. One of the difficulties in their cultivation is the drifting of the surface.

Alluvial-fan and footslope soils.—The soils of this group occur in the broad valleys around the mouths of smaller tributary valleys. Only a small part of the material is of typical footslope origin. The material consists of reworked glacial till, glacial outwash, or lake terrace sediment, usually modified by the weathering, erosion, and transportation of fragments of local rock. While there is evidence of the assorting power of water, the material is seldom well stratified. In topography there is a range from the broad, gently sloping alluvial fan to the steeply sloping alluvial cone. The drainage is usually adequate but seldom excessive. These soil areas were early recognized as good agricultural land, a condition due partly to their well-watered nature during all seasons of the year. The surface flow of the streams usually sinks near the head of the fans during the late summer and early fall months. Along the steep rocky slopes small quantities of talus material are sometimes present.

Minor areas of soils of similar topography, drainage conditions, and mode of origin have, however, owing to the limited areas involved and for greater simplicity in soil classification, been included with some of the soils of the glacial outwash terraces. The soils of this group are classed in the Chewelah series.

Soils of the recent river flood plains.—Along certain of the smaller streams there are in places comparatively narrow areas of flood-plain deposits, which as a rule annually receive small accessions of material during high stages of water. This material is derived principally from reworked glacial till deposits which have been subjected to rather restricted drainage. It is mapped as the Chamokane and Narcisse series and Riverwash.

The recent alluvial soils are naturally productive and have a fairly high agricultural value. Their total area is small.

Soils formed from organic accumulations.—In certain small basins and depressions in several old valleys where swampy or poorly drained conditions have prevailed for a long period, the accumulation of vegetable matter in various stages of decomposition has taken place. These accumulations range from the brownish fibrous material

known as Peat to the black, well-decomposed fine material known as Muck. A small percentage of mineral matter is incorporated in these deposits. Conditions do not warrant a separation of these two types in this survey, and they are combined under the head of Muck and Peat.

The soils composed of organic accumulations are poorly drained, but with artificial drainage produce good crops of hay and grain.

Miscellaneous, nonagricultural material.—This group includes inextensive and unimportant areas of Riverwash, Rock outcrop, Rough stony land, and Rough mountainous land. These areas are mainly nonagricultural.

The following table gives the classification and the actual and relative extent of the various soils in Stevens County:

Classification and area of soils.

Soil groups and types.	Acres.	Per cent.	Soil groups and types.	Acres.	Per cent.
Residual soils:			Soils of the glacial lake and river terraces—Contd.		
Moscow series—			Springdale series—Contd.		
Moscow sandy loam..	1,664	0.1	Springdale coarse sandy loam.....	16,448	} 1.2
Huckleberry series—			Light phase.....	1,984	
Huckleberry silt loam.	86,720	5.7	Springdale gravelly sandy loam.....	11,392	.7
Glacial drift soils:			Springdale sandy loam.....	3,776	.3
Stevens series—			Springdale fine sandy loam.....	16,448	1.1
Stevens loam.....	17,728	1.1	Springdale loam.....	57,984	} 3.9
Stevens gravelly loam.	18,880	1.2	Alluvial-fan phase	960	
Stevens silt loam.....	162,368	} 10.8	Springdale silt loam..	2,368	.2
Limestone phase..	2,496		Springdale gravelly silt loam.....	9,536	.6
Waits series—			Garrison series—		
Waits sandy loam....	57,856	3.8	Garrison gravelly sandy loam, alluvial-fan phase.....	3,200	.2
Waits fine sandy loam	9,472	.6	Garrison sandy loam.	2,816	} .2
Waits silt loam.....	179,520	} 12.3	Alluvial-fan phase	576	
Heavy phase.....	7,168		Garrison gravelly fine sandy loam, alluvial-fan phase.....	4,608	.3
Dark phase.....	448		Garrison gravelly loam.....	3,840	.3
Loon series—			Garrison loam.....	1,344	.1
Loon sandy loam....	98,752	6.4	Garrison silt loam....	704	.1
Loon fine sandy loam.	31,360	2.0	Waterloo series—		
Clayton series—			Waterloo gravelly loam.....	10,496	} .9
Clayton sandy loam..	2,688	.2	Alluvial-fan phase	2,624	
Clayton fine sandy loam.....	1,728	} .8	Waterloo loam.....	1,792	.1
Light phase.....	7,872		Soils of the glacial lake and river terraces:		
Heavy phase.....	2,432		Springdale series—		
Hesseltine series—			Springdale gravelly coarse sand.....	2,240	.1
Hesseltine silt loam..	25,408	1.7	Springdale sand.....	3,968	.3
Soils of the glacial lake and river terraces:			Springdale fine sand..	11,392	.7

Classification and area of soils—Continued.

Soil groups and types.	Acres.	Per cent.	Soil groups and types.	Acres.	Per cent.
Soils of the glacial lake and river terraces—Continued.			Soils of the alluvial fans and footslopes:		
Mission series—			Chewelah series—		
Mission sand.....	2,176	0.6	Chewelah sandy loam.....	1,792	0.1
Heavy phase.....	7,616		Soils of the recent river flood plains:		
Mission fine sand.....	5,952	.4	Chamokane series—		
Mission fine sandy loam.....	2,432	.2	Chamokane loam.....	8,192	.5
Mission very fine sandy loam.....	5,120	.3	Chamokane silt loam.....	1,216	.1
Mission loam.....	12,864	.8	Narcisse series—		
Mission silt loam.....	20,160	1.3	Narcisse fine sandy loam.....	1,216	.1
Mission clay.....	11,520	.7	Soils derived from organic accumulations:		
Empey series—			Muck and Peat.....	10,048	.6
Empey silt loam.....	1,984	.1	Miscellaneous, non agricultural material:		
Hunters series—			Rough mountainous land.....	217,920	14.2
Hunters very fine sandy loam.....	3,520	.2	Rough stony land.....	290,240	18.9
Hunters silt loam.....	576	.1	Rock outcrop.....	7,936	.5
Colville series—			Riverwash.....	512	.1
Colville silt loam.....	8,512	.5	Total.....	1,531,840	.....
Colville silty clay loam.....	17,600	1.1			
Eolian or wind-laid soils:					
Marble series—					
Marble sand.....	3,840	.3			
Marble fine sand.....	3,840	.3			

RESIDUAL SOILS.

MOSCOW SERIES.

The Moscow series includes the residual soils formed by the accumulation of weathered products of granodiorite and other granitic rocks. The soils of the series are in this area of yellowish brown to light grayish brown color, and have a loose, friable structure and sandy texture.¹ The subsoils are similar in texture and in color, except that when fairly well weathered they assume a reddish tint. The rock substratum frequently closely approaches the surface and its outcrops have a rounded outline. Subangular boulders and gravel are present in small quantities.

The topography ranges from sloping to steep and mountainous. The drainage is usually excessive. The forest growth consists principally of yellow pine, with some tamarack. The topography and character of the soils are not favorable for agricultural development. They are used for grazing.

¹ As encountered in other surveys the Moscow series of soils seems to be predominantly of somewhat darker color, and it is possible that the material correlated in the present survey with this series may prove in future more detailed work to warrant recognition as a distinct series of soils.

MOSCOW SANDY LOAM.

All of the residual granitic soil of the area is mapped as the Moscow sandy loam. As mapped the type thus includes some areas of undifferentiated material which if more extensive or in a more detailed survey would be recognized and mapped as distinct soil types. This soil varies from a coarse sand to a sandy loam, but is prevailingly a light sandy loam. The soils are of yellowish-brown or light grayish brown color, often appearing gray in the dry surface, and have a loose friable structure and a low organic-matter content. The subsoil is predominantly yellowish brown or light grayish brown, except where weathering is fairly well advanced, in which case it has a reddish tint. As a rule it consists of loose, porous, angular granitic fragments of decomposed granitic rocks, which rest upon bedrock at varying depths. This rock substratum is often near the surface and outcrops of it are common. Subangular boulders and some gravel occur in a few places.

This type is encountered in the extreme southern part of the county. The largest area occurs north of Tumtum. Small bodies are found within areas of the Loon soils. At least some of these would be separated in a more detailed survey.

The soil is mainly residual from the underlying granitic rocks, which seem to have disintegrated without thorough weathering of the component mineral crystals. In places the slope is too steep for the accumulation of these weathered products and a part of the type is colluvial in origin. As mapped it includes small quantities of glacial till.

The topography of the type as a whole is steep and mountainous, while that of small areas within the larger bodies is often sloping to hilly. The surface and subsurface drainage is excessive.

A sparse growth of yellow pine and tamarack, with a small quantity of underbrush, comprises the forest cover. The type is not cultivated. Its topography and general nature render it unsuitable for the growing of general and of most special crops. Some fields could be farmed, but their small extent and inaccessibility prohibit their development under present conditions. The land is used, if at all, for grazing, and it is best adapted to this or to forestry.

No definite value can be given for this type separately. It is usually held in connection with adjoining soils.

HUCKLEBERRY SERIES.

The soils of the Huckleberry series have a light grayish brown or yellowish-brown color, the surface sometimes assuming a dark-brown tint. They are moderately friable in structure and as encountered in this survey are silty in texture. The subsoils are light brown or yellowish brown in color, fairly compact, and underlain at shallow

depths by bedrock. The material of the series is mainly residual, resulting from the weathering in place of metamorphic rocks, mainly schists and quartzites. In places the slope is too steep for the accumulation of the weathered material to any great depth, but the movement of the material favors the formation of deeper soil, partly of colluvial origin, at or near the foot of such steep slopes. Angular fragments of schist and quartzite, both large and small, are abundant on the surface and in the soil and subsoil, and rock outcrop is common. The topography ranges from hilly to mountainous, and the greater part of the series is excessively drained. Upon removal of vegetation the soil is subject to erosion.

The forest growth consists of fir and tamarack. Agricultural development is confined to those areas which adjoin the streams. The percentage of land suitable for farming is very low. During the summer months some areas afford pasturage for cattle and sheep.

HUCKLEBERRY SILT LOAM.

The Huckleberry silt loam is the only type of the Huckleberry series mapped in this survey. The soil to a depth of 10 inches has a yellowish-gray to light grayish brown or yellowish-brown color, but the immediate surface, with its high content of organic matter, is frequently of a darker-brown tint. The soil is moderately friable and contains a rather small to moderate quantity of organic matter. The subsoil has a light-brown to yellowish-brown color, with frequently a reddish tint. It extends to a depth of 3 feet or more, except where underlain by bedrock at less depth. Small, angular quartzite and schist fragments are abundant on the surface and throughout the soil mass. Large to medium rock fragments of angular outline are usually conspicuous on the surface and in the soil and subsoil material. Outcrops of similar rocks occur at irregular intervals. The depth to bedrock is quite variable.

The type as mapped includes irregularly occurring areas of stony loam or stony silt loam, which are neither sufficiently extensive nor important to be differentiated from the typical soil on the map. The fine earth in such places is similar in color and character to that of the typical soil material, and the difference lies in the higher gravel and rock content.

The Huckleberry silt loam occupies a continuous area in the southern part of the Huckleberry Mountains, between the Colville and the Fruitland and Hunters Valleys.

This is a residual soil, resulting mainly from the weathering of metamorphic rocks, chiefly quartzite and schist. Small outcrops of granitic rocks occur on some of the higher peaks, and minor areas of undifferentiated glacial or alluvial soils and of soil material from limestones, slates, etc., may be included, but the soil seems to have



FIG. 1.—RECENTLY OPENED FARM ON THE LOON SANDY LOAM, 10 MILES EAST OF COLVILLE.

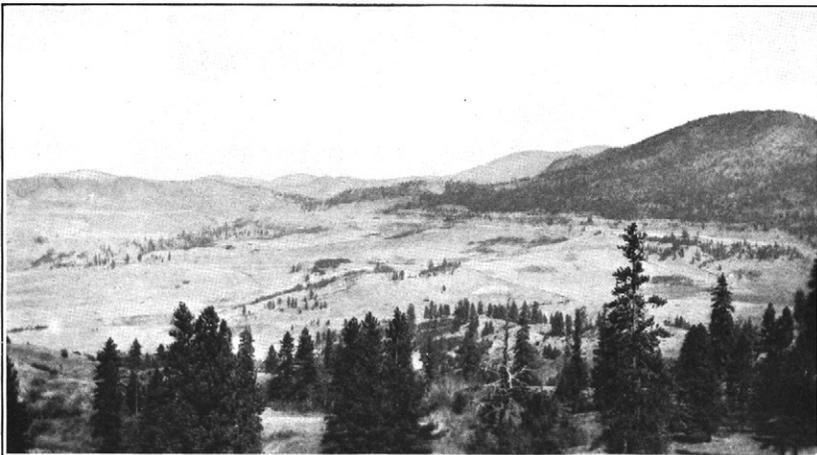


FIG. 2.—LOOKING NORTHEAST ACROSS THE UPPER END OF FRUITLAND VALLEY.
[Huckleberry Mountains on the right with terraces at their foot. Soil in valley below terraces is mainly Stevens silt loam.]



FIG. 1.—OATS ON STEVENS SILT LOAM, NEAR RICE, IN THE COLUMBIA RIVER VALLEY.

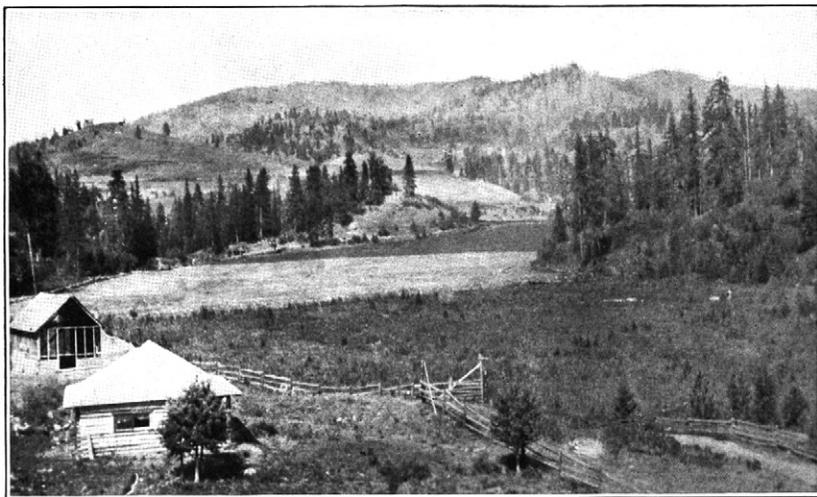


FIG. 2.—TOPOGRAPHY OF LAND FARMED ON THE EAST SLOPE OF THE COLUMBIA VALLEY,
15 MILES SOUTHWEST OF COLVILLE.

[Stevens silt loam in foreground; Rough stony land in background.]

been modified very little by material from such sources. In its present position some of the material is doubtless colluvial. The topography and the apparent absence of glacial boulders and gravel indicate that the area occupied by this type has not been extensively glaciated. A more detailed examination would doubtless reveal the presence of some ice-laid material within the type.

In elevation the type ranges from 2,500 to 5,000 feet above sea level, and the topography varies from hilly to mountainous. Practically none of the type is under cultivation, the only farmed areas being those along the streams. Only a small part of it supports merchantable timber. (See Pl. I.)

Although the problem of soil erosion is not a serious one in this county, the slopes of this type are so steep that they would be subject to severe washing by the rapid run-off of the surface waters upon removal of the native vegetation. Much of it is too steep for the use of modern farm machinery. It affords fair grazing for cattle and sheep during some parts of the year. This land is essentially nonagricultural, the percentage of it suitable for farming being very low. It is best kept in forest. Much of it is still public land. Several formerly productive mines and many mining claims are located on the type.

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

Mechanical analyses of Huckleberry 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>
5510121.....	Soil.....	6.0	5.6	4.4	4.8	11.6	53.2	14.5
5510122.....	Subsoil.....	7.3	8.4	3.9	7.4	14.2	48.0	11.0

GLACIAL DRIFT SOILS.

STEVENS SERIES.

The soils of the Stevens series are of dark grayish brown or dark-brown to black color. They have a friable structure and a high humus content, and are 10 to 20 inches in depth. The subsoils are light yellowish brown or light brown in color, and often carry large quantities of glacial gravel, cobbles, and small boulders. Glacial boulders are infrequent on the surface in the county. Small angular to subangular fragments of quartzite and slate are present in variable quantities on the surface and in the soil.

The soils of the series were formed through the weathering of glacial till derived from a large variety of rocks, consisting in this area mainly

of limestone, slate, and quartzite. Similar rocks usually underlie the series. While the ice-laid material is usually fairly deep, these rocks frequently outcrop, and the weathering of the outcrops has in some places modified the soils. Some of the material included in this series in this survey is underlain by andesitic or related igneous rocks and has been modified to some extent by the weathering in place of this material.

The topography is sloping to roughly rolling and often hilly and broken. The drainage is always well developed except in a few small glacial lake basins. The south slopes are mainly prairie, while the north slopes are forested with fir, tamarack, and brush.

The dark color of this series as compared with the light color of the other series derived from glacial till is due in part to the character of the parent rock and partly to the higher humus content resulting to some extent probably from the relatively high lime content of the soils of the series.

The soils of the Stevens series are probably adapted to the widest range of crops of any of the soils of the area. They produce good yields of hay, timothy, clover or alfalfa, grain, fruit, and potatoes. Corn does well in favorable locations.

STEVENS LOAM.

To a depth of 10 to 16 inches the soil of the Stevens loam is a medium to dark grayish brown loam which usually carries some mica and a small quantity of decomposed granitic or andesitic rock of coarse sandy or finer texture. The subsoil is a grayish-brown to light yellowish brown loam to fine sandy loam, carrying mica, sand, and gravel in small quantities. The soil is mellow and friable, works up into an excellent seed bed, and is easily maintained in good tilth. Its organic-matter content is rather high. Boulders seldom occur on the surface, but a few are encountered in the subsoil. Outcrops of granite, the underlying rock, are rare.

The texture varies somewhat, and ranges from a fine sandy loam to a loam or gravelly loam depending upon the percentage of coarse granitic or of finer soil material or of rock fragments in the soil. The loam texture predominates except near outcrops and in the shallow areas. The type closely resembles the Stevens silt loam in color, texture, and topography, but differs in the slight influence of granitic material and in the character of the underlying rock. It also carries less angular gravel than the Stevens silt loam, which it adjoins on the north. A large part of the material of the two types is probably identical. They have practically the same agricultural value and are adapted to the same crops.

The Stevens loam occupies an area several square miles in extent southeast of Colville in township 35 north, range 40 east. It also

occupies a rolling to rough area immediately south of the Fruitland Valley in township 29 north, range 37 east.

The type is derived, through weathering, from glacial till deposits composed mainly of slate, limestone, andesite, granite, and quartzite material. The included granitic material consists both of that weathered prior to the advance of the ice sheet and that ground up by the pressure of the ice. A large part of the material was brought from the slate and limestone belt to the north. The type has been little influenced by the weathering of the underlying rock since its deposition.

The topography is not so rugged as that of much of the Stevens silt loam on account of the characteristic rounded outline of the areas of glaciated granitic rock. It varies from sloping to hilly. The drainage is well established, though a few local depressions are insufficiently drained.

A scattering forest growth of pine and fir formerly covered a part of the type. The remainder was prairie and supported a fairly thick growth of native grasses. Only a small acreage of the type is still in forest.

Hay, grain, potatoes, and corn are the principal crops. The yields average rather high for the upland soils and are practically the same as on the Stevens silt loam. Oats yield from 60 to 90 and wheat from 25 to 35 bushels per acre, and timothy and oats produce from 1 to 4 tons of hay per acre. Large areas are utilized for grazing. Other crops give good yields but are seldom produced on a commercial scale. Alfalfa does well but is not grown extensively. No orchards of any size are located on the type, though portions of it are adapted to apples and pears. The high organic-matter content is favorable to the production of corn.

This is a desirable soil for general farming and for dairying. Its adaptation to various crops is recognized, but there is a general need for the practice of crop rotation. Its location with respect to markets is unfavorable for commercial orcharding. Good farm buildings and well-kept farms indicate a generally prosperous condition on this type. The value of this land ranges from \$10 to \$80 an acre.

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

Mechanical analyses of Stevens 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>
551087, 5510109.....	Soil.....	9.6	9.8	5.5	10.3	14.6	39.5	10.8
5510110.....	Subsoil.....	12.2	14.0	7.4	12.8	15.6	30.9	6.9

STEVENS GRAVELLY LOAM.

To a depth of 8 to 10 inches the Stevens gravelly loam is typically a dark grayish brown silty loam, carrying large quantities of angular and some rounded gravel. This is underlain by similar material of lighter brown color, often very gravelly and stony. The angular gravel consists mainly of fragments of local rock, slate, limestone, and quartzite, while the rounded gravel consists of granite, schist, quartzite, etc. There are occasional boulders and rock outcrop is encountered in places. Areas of shallow soil are common. The soil is friable and has a high organic-matter content.

The type occurs in rugged areas of the county in close association with the Stevens silt loam. In a strictly detailed survey a larger acreage of this soil would be mapped, as it frequently occurs within areas of the other members of the series. Even on a map drawn on the scale of one inch to the mile the separation would be difficult on account of the variation in the gravel content within short distances.

The weathering of glacial till deposits, composed mainly of slate and limestone material with a small quantity of quartzite, has given rise to the Stevens gravelly loam. It has been modified by the weathering of the underlying slate and limestone rock and to some extent by colluvial agencies. Its higher gravel content, as compared with the silt loam of the series, is due to the presence of more rock outcrop and to its derivation from shallower areas of glacial till. Its characteristic dark color is discussed under the description of the series.

In topography the type varies from hilly to rough and mountainous. Its general relief is greater than that of rock outcrop areas of the Stevens silt loam, but it does not have the rugged appearance of those areas. Its drainage is for the most part excessive, although some areas retain sufficient moisture for early-maturing crops.

There is a small, scattered forest growth of fir, tamarack, and pine on some areas of the type, while other parts are practically devoid of tree growth. Native grasses are usually abundant.

Practically none of the type as mapped is farmed. Some patches of this soil included in other types of the series are farmed in connection with those soils. Much of it is too steep to hold sufficient moisture for crop growth and to permit the use of farm machinery. Other areas are isolated and inaccessible and can not be used for grain and hay farming. While the best part of the type may be farmed, most of it is suited only to pasturage and forestry.

Land of this character is valued at \$10 to \$40 an acre. The latter figure obtains only where it is held in connection with better land.

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

Mechanical analyses of Stevens gravelly loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
5510163.....	Soil.....	7.1	9.0	4.9	11.5	11.9	41.5	14.3
5510164.....	Subsoil.....	9.8	9.4	5.3	12.0	14.8	40.9	8.1

STEVENS SILT LOAM.

The soil of the Stevens silt loam to a depth of 12 to 20 inches is typically a dark brownish gray or dark grayish brown to nearly black silt loam. It has an average depth of 15 inches, a rather compact but friable structure and a high organic-matter content. In places, especially on north slopes, the color is more characteristically brown. Small slate and quartzite gravel of angular to flattened shape are present on the surface and in the soil in varying quantities. Glacial gravel and boulders are of infrequent occurrence. Rock outcrops occur at irregular intervals. The subsoil is a yellowish-gray to light yellowish brown loam to silt loam or clay loam. It contains glacial gravel, cobbles, and boulders in such quantities that it is often impossible to reach a depth of 3 feet with the soil auger. The subsoil material is porous to compact in structure and is underlain by medium to deep deposits of glacial till.

The type is found in the central, northern, and western parts of the county. Together with its limestone phase it occupies extensive continuous areas.

This soil is the result of weathering of glacial till deposits, composed mainly of material from slate, limestone, and quartzite rocks. Some of this material was doubtless weathered before the glacial period and was mixed with the rock material ground up by the pressure of the ice and deposited during the advance and occupancy of the region by the ice sheet. As mapped the type includes small areas of undifferentiated material derived from lake sediments, alluvial-fan and footslope material, and stream or glacial-outwash deposits. Slate, which often carries a low percentage of lime, limestone, and less frequently quartzite, underlies the till deposits at varying depths.

The topography is moderately to steeply rolling or hilly. (See Pl. III, fig. 2, and Pl. IV, figs. 1 and 2.) The regional drainage is well established. Springs and local seepage areas are common to all parts of the type. Small, poorly drained depressions with small lakes or areas of muck or of lake-laid silts are distributed throughout the type. Intermittent streams of steep gradient traverse the type in shallow valleys.

A large part of the Stevens silt loam is practically treeless and is locally known as "prairie." Other areas support a scattering growth of pine and fir, while still others, usually north slopes, have a thick stand of fir, tamarack, and underbrush. The prairie areas occur on slopes of southern exposure.

The Stevens silt loam was among the first, if not the first, of the upland soils to be farmed, partly because of its productive capacity and partly on account of the absence of forest on many of the south slopes. Grain and timothy hay have always been the leading crops. Potatoes, corn, fruit, clover, alfalfa, vegetables, and berries are other crops grown. Oats yield from 60 to 90 bushels per acre. (See Pl. IV, fig. 1.) Wheat yields from 25 to 35 bushels per acre, timothy hay from 1 to 3 tons, and oat hay from 2 to 4 tons per acre. All crops give good yields in average seasons.

In years of late spring when the yield of oats is likely to be decreased by the dry weather of summer, a large part of the crop is cut for hay while green. A part of the wheat crop is often utilized in the same way. Both produce hay of good feeding qualities which finds a ready market at good prices. Clover grows well in the early part of the summer but late crops are often light. Alfalfa does well without inoculation or the application of lime. The first cutting of the season is the heaviest, with a marked decrease in the second and third on account of lack of moisture. The stand of clover and of alfalfa is often injured by dry weather in the late summer months. This seems to be a natural grass soil, all kinds giving good yields.

With careful selection of locations which have good air drainage, the growing of apples, pears, and some stone fruits is successful and profitable. Several large commercial orchards are located on this type. The trees have made a satisfactory growth and produce medium to heavy yields of fruit of good quality without irrigation where they are properly managed. In places the soil is too droughty for orchards even with proper cultivation. Pears are a profitable crop on this soil.

The area under cultivation is slowly increasing as steeper slopes and small tracts in pockets between rock outcrops are being broken. Owing to the porous character of the soil, the danger of erosion under ordinary conditions of rainfall is not great, and the degree of slope which may be successfully cultivated depends upon the possibility of using farm machinery. At present it is doubtful if such machinery can be used on some of the fields.

This is a valuable and desirable soil for general farming and also for some special crops. An abundance of forage in the form of hay may be grown for winter feeding, and there is medium to good pasturage during a large part of the year. Much of the type is located at some distance from markets and at quite an elevation above the railroad

towns. The type seems best adapted to dairying. Its development along this line has been retarded mainly by the uncertainty of the corn crop. Fair crops of corn are grown in high-lying areas which have good air drainage and are fairly immune from early frosts. By planting acclimated seed as early as possible in the spring the prospects of maturing the crop properly are good. Alfalfa can be grown in rows if cultivated so as to retain moisture for the second and third cuttings.

As mapped the Stevens silt loam includes some rather prominent areas in which rock outcrop is frequent and which differ somewhat from the soil in its typical occurrence. These areas are indicated on the soil map by the rock-outcrop symbol. The soil in these bodies consists of a medium to dark grayish brown silty loam to silt loam carrying gravel and underlain by a gray to light yellowish brown loam to clay loam carrying gravel, cobbles, and boulders. The features which distinguish these areas from the typical soil as described above are their lighter color, higher gravel content, larger and more frequent outcrops, and the more frequent occurrence of areas of shallow soil. The gravel content is not so great as in the case of the Stevens gravelly loam.

These rock-outcrop areas are closely associated with the typical Stevens silt loam, and usually occupy higher and more rugged localities in the same vicinity. In places the soil between the outcrops is as deep as in any other situation. In a strictly detailed survey the respective location of many of the soil and outcrop areas would be worked out. The lighter color of the soil is due to the lower organic-matter content, resulting from less moisture and vegetation. The higher percentage of gravel is due in part to colluvial fragments from higher lying outcrops. The material is mainly derived in the same way and from the same source as that of the prevailing soil. The material of the soil and subsoil has been modified to a greater degree by the weathering of the underlying rock.

The surface of the rock outcrop areas ranges from rolling to hilly and rough. They usually have a higher elevation than the remainder of the type and have more local variations in topography. The drainage is thorough and in places where the soil is shallow it is excessive. The native vegetation consists of fir and tamarack and native grasses distributed as on the typical Stevens silt loam. Irregular and sometimes isolated areas of gently sloping to roughly rolling surface are farmed to grain and hay. The areas of deep soil are as productive as any of the type and the yields and methods of farming are practically the same as on the typical areas.

The value of land of this type ranges from \$25 to \$100 an acre.

Stevens silt loam, limestone phase.—A limestone phase of the Stevens silt loam is mapped in two places in the county, one east of Colville, on

the lower southwestern slope of Old Dominion Mountain, and the other about 4 miles northwest of Addy. While it is believed that limestone has entered into the composition of the Stevens silt loam as mapped in this county, and while outcrops occur in places, the greater part of the type seems to be underlain by slates. The areas mapped as the limestone phase are underlain by massive limestone and have numerous outcrops of the same rock. The soil varies somewhat from the typical. It is slightly lighter in color and heavier in texture, and contains less organic matter. Boulders are uncommon and there is comparatively little gravel.

Pockets between the outcrops and larger fields where the outcrops are less numerous are cultivated to grain, hay, and alfalfa, with good yields.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Stevens silt loam:

Mechanical analyses of Stevens 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>
5510187.....	Soil.....	3.1	4.8	3.0	8.6	11.9	54.3	14.3
5510188.....	Subsoil.....	5.0	7.2	4.8	13.5	16.0	42.8	10.6

WAITS SERIES.

The Waits series includes soils of ice-laid origin, and of light-brown to brown color, sometimes of grayish cast at the surface. The brown color becomes more pronounced with increase in the moisture content. As encountered in this survey these soils are predominantly of fine texture and are of friable structure, underlain by subsoils of similar character and color, or of somewhat lighter tint. Except in the immediate surface soil the content of organic matter is rather low. The substratum is similar in character to the subsoil material, and is replaced or underlain by metamorphic or basaltic rocks.

This series differs from the Loon series in that the latter is of lighter color, overlies granitic rocks, and shows a more marked influence of such rocks.

The Waits series occupies areas of comparatively deep glacial till deposits, derived from mixed rocks, which in this survey seem to be mainly light-colored rocks such as quartzite, with some granite and schist. It is probable that small areas of undifferentiated lake-laid sediments and glacial outwash deposits are included in the series.

The surface of the series varies from undulating or gently sloping to rough and hilly. These soils support a forest growth of fir, tamarack, and brush. Areas of favorable topography are moderately productive and well suited to the growing of hay and grain.

WAITS SANDY LOAM.

The Waits sandy loam to a depth of 8 to 14 inches consists of a grayish-brown or light-brown sandy loam of rather fine and heavy texture. This is underlain by a light grayish brown to light yellowish brown fine sandy loam to loamy sand, which extends to a depth of 3 feet or more, except where a bedrock substratum is encountered at a depth of less than 3 feet. The soil is moderately friable and has a medium organic-matter content. A few boulders occur on the surface, but otherwise the type is comparatively free from rock and gravel. Granitic rock underlies the whole area occupied by the type, and rounded outcrops of granite occur in places.

This type represents the transitional or intermediate stage between the dark-colored soils in the northern part of the survey, which seem to be derived mainly from slate and limestone rocks, and the lighter colored soils to the south, in which a greater proportion of granitic and quartzitic material occurs. It is subject to considerable variation in color and texture, resulting in part from the relative proportion of the materials from these two sources.

The largest area is located between Onion and Deep Creeks in the northern part of the county. Two other areas lie east and southeast of Colville, both north and south of the Little Pend d'Oreille River.

The Waits sandy loam owes its origin to the mixing of slate, limestone, and quartzite till with that derived from granitic rocks. Small areas have probably been modified by the weathering of the underlying rocks. Small areas of undifferentiated soils derived from lake-laid sediments are included with this type.

The type is characterized by a sloping to hilly and rough topography. It lies at elevations of 2,500 to over 3,200 feet above sea level. Its surface is cut by numerous tributaries of the larger streams, but the diversity in topography is not so marked as in the case of some of the other upland types of the county. The drainage is adequate to excessive, depending upon the degree of slope and the character of the soil. A few poorly drained, mucky areas occur.

The type supports a thick stand of fir, tamarack, and brush, with some pine. Cedar is found in draws and moist places on north and east slopes. Only a comparatively small part of the type has been logged off, and but little of this land has been cleared for farming. Scattered settlers are clearing as fast as their resources will permit and crops of hay, grain, fruit, etc., for home and family use are

grown. There is no ready market for much of the timber on account of the inaccessibility of the type and the distance to markets, and the owners are reluctant to cut and burn it. The development of this land for farming is therefore slow, and dependent on the progress of logging. The greater part of the type is adapted to the production of annual farm crops, and is regarded as a moderately productive soil, suited to the growing of grasses, grain, potatoes, fruit, etc. With careful attention to the preparation of the seed bed alfalfa should do well except in the excessively drained areas.

The value of the type depends upon its timber. Sales are not common. The settlers are mainly homesteaders, and many of them when they have secured title sell to companies or to speculators.

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

Mechanical analyses of Waits 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>
5510183.....	Soil.....	9.3	11.6	6.4	11.2	13.2	40.7	7.7
5510184.....	Subsoil.....	7.6	12.7	7.2	13.0	14.3	37.2	7.4

WAITS FINE SANDY LOAM.

The soil of the Waits fine sandy loam is a brown to light grayish brown or yellowish brown fine sandy loam of rather heavy character to a depth of 12 to 15 inches. It has a loose and porous structure and a moderately low organic-matter content. The subsoil is a loose, yellowish-brown or light grayish brown fine sandy loam to a depth of 3 feet or more. The soil contains but little angular and rounded gravel and practically no boulders. In places it grades into finer textured material. The color of the soil when moist and in its natural state is light brown; when dry after cultivation it has at the surface a light yellowish gray color. The substratum is a continuation of the subsoil material. Outcrops of underlying bedrock are infrequent.

Two areas of the type are mapped. The larger is in North Basin about 6 miles southwest of Colville, and the other occurs about 2 miles west of Colville.

The weathering of glacial till in which quartzite seems to be the predominating material has given rise to the Waits fine sandy loam. Granite, schist, and other rocks have probably contributed to its formation. To the north, northwest, and west of the largest development there is a high, mountainous area of quartzite rocks from which a large part of the material was doubtless derived. The type prob-

ably includes some small areas of undifferentiated alluvial-fan and footslope and of glacial-outwash deposits.

The main area occupies a well-defined basin several square miles in extent. The type is not a basin soil in the strict meaning of the term, but it is largely confined to the drainage basin of one stream, which from certain directions has the appearance of a large basin. The detailed topography varies from sloping and rolling to steeply rolling. The drainage is well established.

The forest growth consists of a thick stand of fir and tamarack. A valuable belt of cedar grows along the draws and stream courses. A large part of the type has been logged off, but the clearings are scattered and only a few acres in extent. Some areas have a thick stand of pine and fir poles, and others have been recently burned over by forest fires.

Land of this type after clearing is devoted to the production of hay, grain, and other crops for home use. It is in its early stages of development. Clover and alfalfa do fairly well. Grain is probably the best crop at the present time. With an increase in the organic-matter content the moisture-holding capacity is improved, and this in turn results in increased crop production. The position of the greater part of this type is not favorable to the production of fruit or corn. The "basin" in which the type occurs is doubtless subject to frosts earlier than higher lying and more open country. There is a belt on the west and north sides, lying slightly higher than the remainder of the type, which is probably well adapted to fruit.

So far as the topography and soil are concerned, irrigation is possible on much of the type, but the available water supply is limited to small streams which rise in the mountainous area to the north and west and traverse the "basin" occupied by the type. Under present conditions this soil seems best suited to dairying and the growing of general farm crops.

The value of land of this type ranges from \$15 to \$40 an acre, depending on the area of available agricultural land, clearing, and improvements.

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

Mechanical analyses of Waits 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>
551037.....	Soil.....	8.2	8.5	5.0	11.9	14.6	43.9	8.1
551038.....	Subsoil.....	6.6	11.6	7.9	17.6	18.2	32.5	5.7

WAITS SILT LOAM.

The soil of the typical Waits silt loam is a light-brown to brown silt loam to a depth of 10 to 14 inches. The surface when dry frequently has a grayish appearance. The subsoil consists of a yellowish-brown to light grayish brown or gray silt loam or clay loam to very fine sandy loam, which extends to a depth of 3 feet or more. The soil is moderately compact and is low in organic matter. The subsoil as a rule carries small to large quantities of cobbles and boulders. Angular to rounded gravel particles are sometimes present, but are not characteristic of the more typical bodies of the type. Boulders do not usually occur on the surface except in local areas, usually along steep slopes, where the soil and subsoil are sometimes very stony. Rock outcrop is uncommon. The substratum is similar to the subsoil material and rests upon metamorphic or basaltic rocks at varying depths.

The color is quite uniform throughout the extent of the type. The texture, however, is subject to some variation, and the soil ranges from a very fine sandy loam to a silt loam and silty loam. No attempt is made to separate these minor phases in this survey. The type also includes a stony variation, which would be recognized as a distinct type in a more detailed survey. This phase consists of a light-grayish brown or light-brown silt loam which carries large quantities of small, rounded cobbles and boulders in both soil and subsoil. It occurs southwest of Old Eagle Mountain and east of Chewelah. That part of the type occurring on the basaltic tableland in the southern part of the area includes undifferentiated narrow strips of the Hesseltine silt loam, bordering the canyons of the streams which traverse the type and occurring along the northern and eastern margins of the plateau. In many instances these strips include a perpendicular or steep cliff of basalt facing the adjoining and lower-lying types.

Areas of this type are located northeast of Chewelah, about $1\frac{1}{2}$ miles west of Valley and 4 miles north of Clayton. Other bodies occupy rolling to hilly areas on the east side of the Colville Valley, in the tributary valleys of Cottonwood, Huckleberry, and Grouse Creeks. Inextensive bodies occur in valleys or stream basins on the west side of the Colville Valley in townships 32, 33, and 34 north, ranges 38 and 39 east. Another inextensive area occurs about 2 miles west of Echo. Quite extensive and important areas of this type which are underlain by basaltic bedrock occupy portions of the generally level basaltic tableland south of Camas Prairie and west of the outwash terraces in the Chamokane Valley. In these areas the soil material does not seem to have been influenced to a noticeable extent by the intermixture of basaltic material or by the weathering

of the underlying rock. The greater part of these areas lies within the boundaries of the Spokane Indian Reservation.

The Waits silt loam is derived through weathering from glacial till deposits which seem to have been formed from light-colored quartz-bearing rocks, mainly quartzite, granite, and schist. The light color of the material is due in part to its deficiency in organic matter and in part to the color of the original material. Limestone and slate have not contributed appreciably to its formation. In places the type includes some areas of undifferentiated glacial outwash and recent lake sediments. The weathering of the underlying rock has not influenced the character of the soil to any extent.

This type differs from those of the Loon series in that granitic material has entered more largely into the formation of the Loon soils, which overlie granitic rocks, and in that the Loon soils are typically of slightly lighter color.

Outside of those areas occurring on the basaltic plateau, the topography varies from sloping and rolling to rough and hilly. The elevation ranges from that of the floor of the Colville Valley to over 4,000 feet above sea level. Areas in the vicinity of Cottonwood, Huckleberry, and Grouse Creeks seem to have a semiterraced topography, the land having a general level into which these streams have cut deep, narrow valleys. Some of the country occupied by the type is quite inaccessible and soil boundaries are in some places rather arbitrarily drawn. Both the surface drainage and underdrainage are well established. Only the local depressions have poorly drained soils. The soil apparently is not retentive of moisture. Under normal conditions of rainfall there is little danger of destructive soil erosion.

In the areas occurring upon the basaltic plateau the topography of the type is level to undulating, with precipitous slopes along the stream courses and toward adjoining soils to the east and on each side of Camas Prairie. To the west are the low, rounded granitic foothills of the Huckleberry Mountains, several low spurs of which extend out into the type. Areas of the type receive drainage waters from the hills to the west, and these waters move slowly through shallow courses until they reach the canyons. The drainage is slow but adequate except in seasons of unusually heavy rainfall.

The Waits silt loam supports a forest cover consisting mainly of a rather thick growth of fir, pine, and tamarack, with underbrush. Native grasses grow in the open spaces. The development of the type is only begun. A small part is farmed to hay and grain. Alfalfa is grown to a limited extent, and orchards have been planted for producing fruit for home use. Potatoes and vegetables are grown locally. Timothy and oats apparently do best under the present methods of farming. Clover succeeds in well-chosen places. That

part of the type lying within the Indian reservation is largely in Indian allotments, but practically none of it is being farmed. Only a few of the Indians are living on these allotments or making any attempt to farm them.

It is probable that the application of lime and the inoculation of the soil would be beneficial in the production of alfalfa. Deficiency in moisture would doubtless decrease the yields of the second and third cuttings in many seasons. Where properly managed the soil usually retains sufficient moisture for early maturing crops. Deep plowing and the compacting of the subsurface of the seed bed enables the soil to conserve moisture for the growing season.

In the case of this type organic matter has never been supplied by a heavy fall of leaves from deciduous trees each autumn. Consequently there is a general need for increasing the organic-matter content by the use of green-manuring crops, such as rye, vetch, etc., sowed in the early fall and plowed under the following spring. With the turning under of the green crops the application of lime is beneficial. This addition of organic matter increases the moisture-retaining capacity of the soil and improves its general physical condition. The rotation of crops is necessary to maintain the productivity of the type.

Small areas are suited to irrigation, but the type as a whole is not. Water is available for only small areas adjoining streams, and is used to best advantage by individual farmers.

The value of land of this type ranges from \$10 to \$60 an acre. Some of it is still public land. The areas within the Indian reservation are not for sale or subject to homestead entry.

Waits silt loam, heavy phase.—The Waits silt loam, heavy phase, consists of a grayish-brown or light-brown heavy silt loam, underlain at a depth of 8 to 10 inches by a light-brown to yellowish-brown silt loam to silty clay loam which extends to a depth of 3 feet or more. In places the soil carries a few boulders and some rounded gravel. The subsoil is very compact and contains gravel, cobbles, and boulders of quartzite, granite, and schist. The surface soil has a gray color when dry. The soil is compact and upon drying out becomes hard. When plowed under proper moisture conditions it is friable and easily worked.

In places there is a large quantity of cobbles in the soil and subsoil, and in a more detailed survey such areas would be shown on the map as another phase or as a distinct type. Small areas of alluvial-fan material are encountered where the streams emerge from the mountainous sections.

Two fairly extensive areas of this phase are mapped. The larger occurs about 9 miles southwest of the village of Addy, in the central part of the county, and the other just west of Arden.

Deep deposits of glacial till cover the areas where this phase of the type occurs. This material is derived mainly from areas of quartzite, schist, and granite rock to the north, and was laid down by the ice during the Glacial Period. It has been modified by erosion since that time. The topography varies from rolling to hilly. The drainage is well established, and there is little or no danger of destructive soil erosion.

This phase supports a growth of fir, tamarack, and underbrush, only a small part having been cleared for farming. A rather large acreage has been logged off. The Waits silt loam, heavy phase, is devoted to the production of crops mainly for home and family use. Hay and grain are the leading crops, and are fed on the farm. Potatoes and fruit are grown to a small extent. Of the grass crops, timothy seems to do best. Alfalfa and clover do not do so well as on the other types of the series. Oats yield from 40 to 75 bushels per acre. They are often cut when green for hay. The position of the larger area of this phase is such that it is not, as a whole, adapted to fruit or other crops subject to injury by early frosts.

Water for irrigation is not available for much of the phase, but with proper management, including rotations and the use of green and stable manures to increase the organic-matter content, irrigation is not necessary for the production of hay and grain crops, to which the soil seems best adapted.

The value of land of this phase ranges from \$15 to \$40 an acre.

Waits silt loam, dark phase.—The dark phase of the Waits silt loam consists of 12 to 14 inches of a dark grayish brown silt loam of light texture underlain to a depth of 3 feet or more by a dark grayish brown to brown silt loam. The soil has a friable structure and a relatively high organic-matter content and moisture-holding capacity. The phase carries a few gravel particles and boulders.

This soil is encountered in only one area, just southwest of Ford, on the east side of the Chamokane Valley. It has the same elevation as the typical Waits silt loam on the other side of the valley. The surface is undulating to gently sloping, and drainage is well established.

The phase is underlain by basalt and is bordered on three sides by basalt areas, but the underlying rock seems to have contributed very little to its formation. It is probably derived from glacial till, similar to that giving rise to the typical soil. The difference in color is mainly due to a higher organic-matter content and a slight difference in component material, which probably includes some slate and limestone.

Nearly all of the phase is under cultivation to hay and grain, and good yields are obtained. Cultivated crops are not grown. Alfalfa as well as fruit should be successful. Land of this phase is valued at \$50 to \$75 an acre.

In the following table are given the average results of mechanical analyses of samples of the soil and subsoil of the typical Waits silt loam, and the results of mechanical analyses of samples of the soil and subsoil of its heavy phase:

Mechanical analyses of Waits silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
5510129,5510137.	Soil.....	2.9	3.9	2.2	7.1	17.6	54.6	11.6
5510130,5510138.	Subsoil....	3.6	4.2	2.4	7.8	19.6	51.2	11.1
Heavy phase:								
5510127.....	Soil.....	1.6	3.8	2.2	5.6	11.4	57.9	17.7
5510128.....	Subsoil....	1.4	3.4	3.0	7.0	13.1	53.6	18.6

LOON SERIES.

The soil types of the Loon series are yellowish-gray or light yellowish brown in color and friable in texture. The subsoils are yellowish-brown to grayish-brown and porous, generally carrying conspicuous quantities of fine angular particles of disintegrated granitic rocks. The soils of the series are derived from glacial till, which is recognized as an admixture derived from a variety of rocks. The organic-matter content is rather low. Rounded boulders of granite occur on the surface and are embedded in the soil and subsoil. Small quartzite boulders are of much less frequent occurrence. Gravel, other than small angular granitic fragments, is uncommon. The surface ranges from gently rolling to hilly. The drainage is always adequate and sometimes excessive.

The native growth consists mainly of fir, tamarack, and small brush. In this county the Loon series is represented by two types, the sandy loam and fine sandy loam.

LOON SANDY LOAM.

The Loon sandy loam consists of a light yellowish gray to light yellowish brown sandy loam, underlain by a yellowish-gray or yellowish-brown loamy sand to sandy loam. The soil has an average depth of about 12 inches. It is loose and porous in structure, and rather low in organic matter. Angular granitic fragments ranging in size from coarse sand to fine gravel are fairly abundant. Glacial gravel, cobbles, and boulders of subangular to rounded shape are present in varying quantities. These are derived from granitic and quartzitic rocks. Rounded rock outcrops and areas of shallow soil are not uncommon.

This type is subject to a rather wide variation in texture on account of its pronounced modification by the weathering of the

underlying rock and its consequently higher percentage of coarse granitic material. In places the subsoil consists of decomposed granite. The type as mapped probably includes small areas of undifferentiated Moscow sandy loam and larger areas of the very fine sandy loam and sandy loam of the same series, a number of which would be separated in a strictly detailed survey.

One area comprising about 15 square miles is located in the southeastern part of the county, 8 miles south of Clayton. A smaller area lies just north of the same town. Other areas occur north and south of Turtle Lake on the Spokane Indian Reservation and southwest of Turk. The type also occupies an almost continuous area extending from the South Fork of Bear Creek to the North Fork of Chewelah Creek and from Narcisse Creek on the west to the eastern county line.

Granitic rock underlies the entire type. The character of this rock is such that it decomposes quite readily when subjected to the various agencies of weathering. This process had doubtless reached an advanced stage before the Glacial period. During the advance and occupancy of the county by the ice sheet, this material, together with the rock material ground up by the ice and some from outside sources, was deposited as glacial till, which has given rise to the Loon sandy loam. By subsequent weathering of the underlying rock more granitic material has been added in places.

The topography is more rolling than that of the fine sandy loam of the series, and ranges from sloping to roughly rolling. (See Pl. III, fig. 1.) The soil absorbs the surface water and the subsoil permits adequate to excessive subdrainage. The surface does not readily erode.

Fir, tamarack, yellow pine, and underbrush form the forest cover, and only a small part of this in the more heavily timbered areas has been logged off. Cedar grows in the bottoms of draws and moist places. It is cut for poles and hauled to the nearest railroad point. In places the timber is small and thin on account of comparatively recent forest fires or droughty conditions of the soil.

The agricultural development of this type, as found in the southeastern part of the county, has progressed further than that of the other type of the series. The leading crops are hay, grain, potatoes, and fruit. The yields are medium to good. Agriculture on portions of the type, however, is confined to a few small clearings on more or less isolated homesteads, and consists mainly of growing forage crops for winter feed. In areas of the type lying at some distance from market and in thickly timbered and somewhat inaccessible localities, development is necessarily slow. Much of the type is best adapted to the growing of winter wheat and other early maturing crops, as it does not retain sufficient moisture for late-season crops.

It is necessary to so cultivate this type as to enable the soil to absorb as much moisture as possible during seasons of precipitation and to store it for the use of plants during dry periods. This is accomplished in several ways, including disking before plowing, deep plowing, and thorough harrowing before seeding. The use of stable manure and the turning under of green crops to increase the organic matter is beneficial. The type in the better improved localities is highly prized for general farming and for dairying, and is valued at from \$25 to \$60 an acre. Even in the uncleared and unsettled localities a large part of this soil is suited to farming. The steep and rough areas, however, are suitable only for forestry.

Land values on the type as a whole are rather low. The settlers are mainly homesteaders, and many of them have not yet secured title to their land.

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

Mechanical analyses of Loon 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>
551011, 5510115....	Soil.....	8.1	14.6	14.2	21.0	12.5	24.0	6.0
551012, 5510116....	Subsoil.....	9.9	17.8	11.7	15.7	13.1	25.6	6.5

LOON FINE SANDY LOAM.

The soil of the Loon fine sandy loam consists of 10 to 14 inches of a yellowish-gray or yellowish-brown fine sandy loam of fine silty character, which carries but few granitic fragments and little other material coarser than fine sand. It is loose and mellow after breaking and has a rather low organic-matter content. The mica content is noticeable. The subsoil is a light grayish brown to light yellowish brown fine sandy loam to sandy loam, usually extending to a depth of 3 feet or more. It contains some gravel, cobbles, and bowlders, which are mainly granitic, with some of quartzite. The fragments of the subsoil are sharp and the material binds so that it is often difficult to pull out the soil auger. The texture of the soil is fairly uniform except near the infrequent rock outcrops and in areas of thin soil. The type is underlain at varying depths by granitic bedrock. Large granitic surface bowlders are of rare occurrence.

This type is encountered only in the southern part of the county, mainly north and west of the village of Clayton, southeast of Wellpinit, southwest of Turtle Lake, and northeast of the junction of the Columbia and Spokane Rivers. Small undifferentiated bodies probably occur within the more extensive areas of the sandy loam member of the series.

The Loon fine sandy loam is the result of the weathering of glacial till, composed mainly of glacially ground and preglacially weathered granitic material. It contains considerable fine earth material because of its proximity to other fine-textured soils and to rock other than granite on the north.

The surface is gently sloping to rolling, and the drainage is well established. The type retains moisture fairly well under efficient cultivation. Owing to its rather open structure, it is not subject to destructive soil erosion under the conditions of rainfall common to this region.

A forest cover of fir, tamarack, and brush, which formerly covered the area of the type near Clayton, has practically all been removed for lumber and fuel. Portions of the type have been burned over since the logging operations. A small shrub locally known as buckbrush now grows abundantly. The development of the type for farming has not kept pace with the removal of the timber. Large tracts are owned by lumber companies or by individuals, who are holding it at a high price, considering the cost of clearing. The part within the Indian reservation is not logged or farmed to any extent.

Small fields on scattered farms have been cleared and are being cropped to hay, grain, and potatoes. The yields are only fair, but are easily increased by proper management. On those farms where the acreage in crops is small, the grain is either fed in the straw or cut while green for hay. Small orchards have been set out for home use. The crops produced on this soil are usually fed on the farm.

Owing to the topography and nearness to market, portions of this type are desirable for farming. It is adapted to the growing of grain and grasses for hay and pasturage and should bring good returns where used for dairy farming. It is doubtful whether alfalfa would succeed without irrigation. Fruit should do fairly well in the higher-lying areas. Oats and wheat are good crops for a rotation. Early maturing crops, such as grain and hay, do best under the present system of farming.

The soil and surface features are suitable for irrigation, but the type is unfavorably situated with respect to a possible water supply. Land of this type may be purchased for \$35 to \$75 an acre.

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

Mechanical analyses of Loon 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>
551009.....	Soil.....	3.6	5.2	4.2	15.9	21.3	41.6	8.0
551010.....	Subsoil.....	15.8	13.2	5.0	5.4	12.9	39.2	8.7

CLAYTON SERIES.

The soils of the Clayton series are of yellowish-gray to yellowish-brown color, and of friable structure. The material when moist usually has a quite pronounced brown tint, but the dry exposed surface is light gray. The subsoils are similar in color to but usually lighter in texture than the soil. A stratum of unassorted coarse granitic sands lies between the subsoil and a substratum of stratified clay, silt, and sand. The soils are practically free from gravel. Scattering bowlders indicate that the parent material is a thin deposit of glacial till overlying glacial or preglacial lake sediments.

The surface of the types of the series is level to undulating. While water does not stand on the surface for any length of time, the underdrainage is slow and the water table is comparatively close to the surface. Small areas are farmed to hay, grain, and potatoes or set to orchards.

Two types of the Clayton series, the sandy loam and fine sandy loam, are recognized in Stevens County.

CLAYTON SANDY LOAM.

The soil of the Clayton sandy loam is a sandy loam of light texture, having the appearance in the field of a sand of loamy character. It extends to a depth of 10 to 12 inches, the brown color being more pronounced when the soil is moist. The soil has a loose and porous structure and a low organic-matter content. The subsoil is a pale-yellowish to light grayish brown loamy sand to light sandy loam, and extends to a depth of 3 feet or more. No bowlders occur on this type, and few angular granitic fragments coarser than sand are present. The soil carries small quantities of mica. The type is mapped in one area about 6 miles south of the town of Clayton.

The Clayton sandy loam is probably derived from glacial till, which consists mainly of granitic material and seems to be underlain by lake-laid sediments. The surface is generally level, the only variations being the moderately deep and narrow stream channels traversing the type. The structure is such that there is good surface drainage but the underdrainage is restricted by the slight relief and the compact structure of the substratum. The water table rises and falls with the seasons. The type receives considerable drainage water from the region to the west.

The native timber consists of fir, tamarack, and pine, but a considerable acreage has been logged off. A considerable acreage of the type is farmed to grain, hay, and potatoes, which produce fair yields. More extensive removal of the timber would permit better air drainage and the earlier warming of the soil, with greater immunity from frost. The soil is deficient in organic matter, which may be supplied by turning under green crops. The growing of legumes in the rota-

tion supplies nitrogen. With proper preparation of the soil alfalfa can be grown profitably. Grain and hay are the principal crops. The type is suited to fruit production. The value of land of this type ranges from \$40 to \$75 an acre.

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

Mechanical analyses of Clayton 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>
551003.....	Soil.....	1.6	18.4	20.2	24.0	10.0	19.4	6.6
551004.....	Subsoil.....	1.2	17.4	22.0	26.7	10.7	16.5	5.3

CLAYTON FINE SANDY LOAM.

The surface soil of the typical Clayton fine sandy loam consists of 10 to 12 inches of a light-grayish or yellowish-brown to yellowish-gray fine sandy loam, the structure of which is loose and friable. The soil has a brownish cast when moist, but the exposed dry surface has a light-gray color. The subsoil is a light yellowish brown to pale-yellow fine sandy loam to loamy fine sand, which is quite compact, and in some places shows faint brown mottlings. Like the Clayton sandy loam, this type is deficient in organic matter, and carries noticeable quantities of mica. The substratum to a depth of several feet consists of material similar to that of the subsoil. Glacial boulders are present but are not common.

The type occupies the flat south of Clayton, and covers an area of 2.7 square miles. Like the other type of the series, it is supposed to overlie lake-laid sediments. These are not exposed in any part of the area covered by this type. The presence of glacial boulders on the surface and the structure of the underlying sands indicate that the type is derived from ice-laid material.

The surface is level to gently undulating and has practically the same elevation as that of the other member of the series. While water does not stand on the surface after rains, the subdrainage is somewhat retarded by the low position and level character of the type and is sometimes inadequate in the early spring months.

The greater part of the type supports a thick stand of young fir, tamarack, and pine. Farming operations are limited to a few small clearings. Improved drainage would result in the earlier warming of the soil in the spring and enable the earlier planting of crops. With soil inoculation and applications of lime a good stand and good yields of alfalfa are possible. The soil and surface favor irrigation, but this apparently is not necessary for general farm crops under efficient management. Small undifferentiated areas of Muck within the type

are used for the production of celery and other truck crops. Under present conditions grain and hay promise to continue the leading crops. The type seems well suited to the growing of fruit.

Land values depend on the development of adjoining types, and range from \$40 to \$60 an acre.

Clayton fine sandy loam, light phase.—To a depth of 10 to 12 inches the soil of the light phase of the Clayton fine sandy loam is a yellowish-gray to yellowish-brown fine sandy loam of light texture, which carries a noticeable quantity of mica flakes and has a loose, porous structure. This grades below into a gray loose fine sand, which is uniform in character and free from gravel, and continues to a depth of 8 to 10 feet before the clay and silt substratum is reached. The soil is relatively low in organic matter.

This phase occupies an area of 12.3 square miles along the eastern boundary of the county south of Clayton. The material apparently is derived from thin glacial till, mainly of granitic origin, and is underlain by stratified deposits, probably of lake-laid origin.

The gently undulating topography is either the result of erosion since the deposition of the soil or it may represent the original surface of the ice-laid material. The surface drainage is good, on account of the porous character of the soil. The subdrainage is slow, and crops seldom suffer from poor or excessive drainage where the soil is properly handled. No streams traverse the phase.

The present forest growth consists mainly of second-growth fir, tamarack, and pine. Grasses and buckbrush cover the portion from which the timber has been removed.

A small acreage has recently been set to apple trees, which show a satisfactory growth. In one orchard rye is grown between the rows. Another is given clean cultivation. With an increase in the organic matter and efficient management this soil should retain enough moisture for most crops in average seasons without irrigation. The liberal use of stable manure and green-manuring crops is beneficial. The growing of legumes also is advantageous, and there is a general need for the rotation of crops.

The value of this land varies from \$40 to \$60 an acre. Orchards for sale in large or small tracts are held for \$400 to \$600 an acre.

Clayton fine sandy loam, heavy phase.—The heavy phase of the Clayton fine sandy loam consists of a yellowish-gray or yellowish-brown fine sandy loam of fine, silty character underlain at a depth of 10 to 12 inches by a pale yellowish-brown fine sandy loam, which extends to a depth of 3 feet or more. The soil, while of somewhat compact structure, is loose and mellow after cultivation. It has a low organic-matter content. While the soil is practically free from gravel, occasional boulders are encountered, and the soil contains some mica. No rock outcrops or areas of shallow soil occur. The

subsoil rests upon a bed of sharp coarse granitic sands, free from rounded gravel and unstratified. This in turn is underlain by strata of clay, silt, and sand. In places, however, the subsoil rests directly upon a clay substratum.

This phase is confined to that portion of the county immediately south and southwest of Clayton. The presence of occasional glacial boulders, the apparent lack of stratification, and the sharp, angular character of the material indicate that it is of ice-laid origin. It is probably derived by weathering from a thin glacial-till deposit composed of granitic material which has been carried only a short distance, and overlies lake-laid sediments.

The surface is level to gently sloping, and the phase is traversed by streams which flow in narrow, shallow valleys. These streams have a sluggish current, and narrow undifferentiated areas of Muck occur along them. Owing to their porous nature, the soil and subsoil are absorptive of water. The subsurface drainage is slow, on account of the level surface and the deep, impervious substratum. The water table is close to the surface during a part of the year and keeps the soil "cold" until rather late in the spring. It lowers in the late summer, so that in exceptionally dry seasons late crops are likely to suffer from lack of moisture.

The forest growth consists of a thick stand of fir, tamarack, and pine. From some areas all the timber has been removed, and a thick growth of buckbrush covers the surface.

Large holdings by companies and individuals have retarded the development of this phase. A small but slowly increasing acreage on scattered farms is used for the production of hay, grain, fruit, and potatoes. Fair yields are obtained.

This soil is low in organic matter, which is effectively supplied by growing crops to be turned under as green manures. With liming and soil inoculation it is adapted to alfalfa. Irrigation is practicable and a small supply of water is available from Loon Lake. This land is valued at about \$40 to \$60 an acre.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Clayton fine sandy loam, and of its heavy phase:

Mechanical analyses of Clayton fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
551005.....	Soil.....	0.5	5.4	14.2	36.6	13.9	23.9	5.5
551006.....	Subsoil.....	.4	5.1	19.0	41.4	9.8	19.8	4.8
Heavy phase:								
551001.....	Soil.....	.7	3.1	7.8	26.9	15.7	38.3	7.7
551002.....	Subsoil.....	.5	3.5	11.3	38.1	16.9	25.6	4.6

HESELTIME SERIES.

The Hesseltine soils are of light-brown to yellowish-brown or reddish-brown color and moderately friable structure. The subsoils are of yellowish-brown or light-brown color and moderately friable structure and carry bowlders of various sizes.

The series includes soil types derived from ice-laid material, of which the greater part has been contributed by basaltic rocks. The series overlies a basaltic rock substratum and carries numerous bowlders of basalt on the surface and in the soil and subsoil. Other contributing sources represented to a minor extent are metamorphic and granitic rocks. In the shallower areas the material has been modified to some extent by weathering of the underlying basalt in place. Gravel is not abundant. Outcrops of the underlying bedrock of basalt are common, while in places the soil is comparatively deep. The content of organic matter is moderate or even low.

The topography varies from gently undulating to rough. In the latter case vertical cliffs of basalt are of frequent occurrence. The drainage is excessive in the shallow areas, adequate in the moderately deep areas, and insufficient and slow in the depressions, or small "meadows," which are quite common to the series.

Fir, tamarack, and brush constitute the forest growth. Small clearings, where the soil is moderately deep, produce fair to good yields of hay and grain.

The series is represented in Stevens County by a single member, the Hesseltine silt loam.

HESELTIME SILT LOAM.

Typically the soil of the Hesseltine silt loam to a depth of 8 to 12 inches is a light-brown to reddish-brown silt loam of friable to moderately compact structure, and low in organic matter. The subsoil is a yellowish-brown to light-brown silt loam or loam, friable in structure, and extending to bedrock or to a depth of 3 feet or more. Numerous subangular glacial bowlders of basalt, and of other rocks to less extent, occur in variable quantities on the surface and throughout the type. In places smaller rock fragments of similar character are fairly abundant. Outcrops of basalt occur at frequent intervals. The depth of the glacial till ranges from a few inches to several feet.

The type as mapped includes small, undifferentiated areas of very fine sandy loam and stony silt loam, which would be separated in a more detailed survey. The very fine sandy loam consists of a light-brown very fine sandy loam to a depth of 12 inches, underlain by a light-brown friable, silty loam to loam, which extends to bedrock or to 3 feet or more. It carries gravel and bowlders similar to the typical soil. The stony silt loam is similar to the main type, except for the larger and more abundant bowlders and gravel. The type

also includes small undifferentiated areas of Rough stony land, where the outcrops of basalt are large and numerous. A number of small "meadows" are included in this type. These are of heavy texture and compact structure, are poorly drained, and probably in need of lime.

This type occurs in the southern part of the county. For the most part it follows closely the course of the Spokane River, occurring at higher elevations immediately north of the high terraces along the river. An extension follows the Colville-Chamokane Valley and terminates about 5 miles south of the village of Chewelah. The areas of the type which occur along this extension are remnants of much larger areas at one time connected with the Columbia Plain on the south.

The Hesseltine silt loam results from the more or less advanced weathering of glacial till, consisting mainly of material derived from basalt. A part of this was probably preglacially weathered and merely reworked by the advancing ice sheet. Another part is glacially ground basalt rock, and still another is postglacially weathered material derived from the boulders and bedrock.

The elevation of the type ranges from 2,000 to 2,500 feet above sea level. The general appearance from a distance is that of level to gently rolling bench land, but the topographic details are obscured by the forest cover. Dome-shaped outcrops of basaltic rock and small canyons furnish numerous local variations from this general level. As a whole, the type is well to excessively drained. It is only in the local depressions that drainage is poor. Most of these could be cheaply drained, improved, and used for the production of hay and grain.

No extensive areas of this type favorable for agricultural development occur within the county, but there are many small, irregular areas suitable for such purpose. The type varies widely in depth; probably more than one-half of it is stony, shallow, and not adapted to the production of farm crops. Some of the small areas produce good crops of hay, grain, and fruit, while others give low yields, and still others have been abandoned. As a rule the deep areas are moderately productive, are retentive of moisture, and adapted to timothy, clover, small grains, and fruit. The rough and stony areas furnish some pasturage. It is sometimes difficult to procure an adequate supply of good water in some parts of the type.

No extensive areas are suitable for irrigation, and but little water is available for this purpose. The type seems best adapted to the production of fruit, small grains, and hay. It is suitable for dairying.

The value of land of this character ranges from \$10 to \$50 an acre, depending upon the possibility of agricultural development and improvements.

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

Mechanical analyses of Hesseltine 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>
5510141.....	Soil.....	7.4	6.6	4.3	8.4	14.2	51.9	7.4
5510142.....	Subsoil.....	3.2	9.0	7.0	13.4	16.0	44.1	7.5

SOILS OF THE GLACIAL LAKE AND RIVER TERRACES.

SPRINGDALE SERIES.

The Springdale series includes light-brown to light yellowish brown soils with yellowish-gray or light yellowish brown subsoils, and underlain by a substratum of porous, assorted sands, gravel, and cobbles. This stratum is practically free from fine material, and the coarser fragments are well rounded. With the sands it extends to a depth of many feet. The content of organic matter in the soils of the series is generally low. Some of the soil types carry gravel in the surface material, while others are free from it. Boulders are infrequent on the surface and in the soil, but occur occasionally in the subsoil and substratum.

These soils are composed of material laid down as glacial outwash, or glacial stream or delta deposits, and include also, as recognized in this survey, quite extensive areas of river-terrace soils occupying the lower terraces along the Columbia, Spokane, and Kettle Rivers. While these terraces occur along present rather than former glacial streams, and in some cases represent the most recent period of stream deposits, they lie above overflow and consist to a large extent of reworked and redeposited glacial material.

Small but important areas of more recent alluvial-fan deposits also are included with the Springdale series. These are in most cases indicated as an alluvial-fan phase and are described separately. The material of this alluvial-fan phase is largely the result of erosion of the glacial till and the underlying rocks, and it has been deposited where streams intermittent or fluctuating widely in volume meet the level to gently sloping outwash, lake, and river terraces.

The soils of this series have a terraced topography with level to gently undulating surfaces and steep gravelly fronts toward adjoining lower lying soils. The internal drainage is excessive owing to the porous character of the subsoil and substratum. In some cases the surface soil material in the lighter-textured types has been modified somewhat by wind action.

The series supports a scattered growth of yellow pine with small clumps of pine reproduction. Native grasses occupy the spaces between the trees and give the appearance of a natural park. The present agricultural development is confined to the areas having a fairly deep soil and a location favorable for the accumulation and retention of moisture. Grain, potatoes, and fruit give fair yields in favorable seasons. The topography is suitable for irrigation.

Ten members of the Springdale series are mapped in the Stevens County survey.

SPRINGDALE GRAVELLY COARSE SAND.

The soil of the Springdale gravelly coarse sand is a light grayish to light-brown coarse sand, sometimes of loamy character and approaching a sandy loam, and carrying large quantities of rounded glacial gravel. It has a depth of 8 to 10 inches. The sand content decreases and the gravel content increases with depth, so that the subsoil and substratum are composed of well-rounded gravel, cobbles, and small boulders with very little interstitial fine material to a depth of several feet. In places the type approaches a coarse sandy gravel. The soil material has settled together so that it is of very firm compact structure. The type is darker in color than some of the others of the series, and has a moderately low organic-matter content.

This type occupies areas on the lower terraces in the Columbia River Valley below Kettle Falls. It is not extensive, but is quite conspicuous on account of the character of its material.

The Springdale gravelly coarse sand is derived from a variety of rocks, including granite, slate, schist, quartzite, and dark-colored igneous rocks. The sands have possibly been blown over the surface of the gravelly terraces and in time filled the interstitial spaces. The coarser material was deposited by swiftly flowing water. Much of the material has been transported from distant points.

The type has a smooth surface, with steep terrace fronts on the river side. It lies from 30 to 75 feet above the normal level of the river, and is excessively drained.

The forest growth consists of yellow pine. There is a sparse growth of native grasses between the trees. The type is utilized for apple orchards, which are given clean cultivation and are irrigated frequently during the summer months. The trees are young but seem to be making a fair growth. With proper irrigation this soil should produce good yields of alfalfa. The cultivation of the soil is rather difficult and the type is best devoted to crops which do not require tillage.

The value of land of this character depends chiefly upon the possibility of development, as the present crop production is not sufficient to furnish any basis of valuation. Undeveloped land of the type is

valued at \$25 to \$50 an acre. In orchard tracts, not yet bearing, the price is much higher.

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

Mechanical analysis of Springdale gravelly coarse sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551067.....	Soil.....	9.6	18.5	19.6	22.6	8.2	15.5	5.5

SPRINGDALE SAND.

The Springdale sand consists of a light-brown to light grayish brown medium sand, underlain by a light brownish gray or yellowish-brown sand to a depth of 30 inches or more. The type is underlain by the typical gravelly substratum of the series. The slight change in color between the soil and subsoil is gradual, and mainly due to decrease in the organic-matter content with depth. Both soil and subsoil have an open, porous structure. Neither contains gravel.

The Springdale sand occupies small areas on terraces in the Columbia and Kettle River Valleys and an area of less than 1 square mile on a high terrace in the Chamokane Valley about 2½ miles southwest of Ford.

The type is the result of the deposition of a sand bar or a sandy stratum along with the coarser material of the glacial stream terrace or of later alluvial terrace deposits along the larger present streams.

The surface is level to gently undulating. Drainage is well established. The lower alluvial river terraces included with the type in the Columbia and Kettle River Valleys have an elevation of 50 to 100 feet above the streams. Under cultivation the type retains moisture fairly well.

Yellow pine and a growth of native grasses give the type the appearance of a natural park. Several acres on the high terrace in the Chamokane Valley near Ford are under cultivation to grain, fruit, corn, and potatoes. Fair to good yields are obtained. A large part of the type on the terraces of the Columbia and Kettle Rivers is cleared and set to orchards. None of these orchards are in bearing, but the trees are making a good growth. Intertilled crops, such as potatoes, beans, etc., are sometimes grown and give medium yields.

Although the structure of the type is loose, with deep plowing and frequent cultivation the soil retains sufficient moisture for crops in seasons of average rainfall. The organic-matter content is increased by the use of stable and green manures, which also increase the

moisture-retaining capacity of the soil. This soil is not so droughty as the finer and shallower types of the series. The surface is sometimes subject to wind drifting. The use of legume crops in rotation is needed. In character of soil and topography the type is well adapted to irrigation, but water for this purpose is available for only a small part of it. The value of land of this type ranges from \$15 to \$50 an acre.

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

Mechanical analyses of Springdale sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551095, 5510155....	Soil.....	4.3	21.4	21.9	19.1	8.2	11.2	13.7

SPRINGDALE FINE SAND.

The Springdale fine sand consists of a light grayish brown to pale yellowish brown, loose fine sand or loamy fine sand, with little change in color and texture from the surface downward until the gravelly substratum of the series is encountered, at depths of 30 inches or more. The soil is sometimes slightly compact, but is always friable and loose under cultivation. It is rather low in organic matter. The occurrence of gravel and boulders is not typical. In places this soil closely resembles the Marble fine sand, but it differs from the latter in the extent of the influence of wind action.

This type occurs on the lower series of terraces in the Columbia, Spokane, and Kettle River Valleys, where it has a wide distribution,

The material is derived from a variety of rocks, including among others granite, quartzite, schists, and slate, and was deposited by the rivers in whose valleys it occurs, probably after the glacial period. The material of the Spokane River terraces seems to be derived largely from dark-colored basaltic material. The terraces were doubtless more extensive at one time. The soil material has been more or less modified by wind action since its deposition, but the characteristic topography of wind-laid material is not sufficiently developed to warrant the classification of this soil with the Marble fine sand. As mapped the type includes some small areas of undifferentiated alluvial-fan material derived from the terrace fronts.

The type has a terrace topography, and the surface is smooth to gently undulating. The loose nature of the soil and the porous character of the substratum induce good or excessive subsurface drainage. The terraces lie from 25 to 100 feet above the normal level of the

rivers. Certain areas are overflowed at times of extremely high stages of the rivers, mainly by backwater from sloughs which traverse these areas. These overflows are infrequent and of short duration, and deposit very little sediment.

The Springdale fine sand supports a vigorous but scattered growth of yellow pine, with a reproduction in occasional small clumps. Alders and willows grow along the sloughs. Native grasses are abundant in open areas. A large acreage is set to orchards. The trees are young, but are making a satisfactory growth. Potatoes, alfalfa, berries, corn, and vegetables are grown both as intertilled and as field crops, with medium yields. The percentage of the type under cultivation is relatively low but is increasing quite rapidly. Upon some of the Spokane River terraces peaches are grown to some extent and seem to thrive. A large acreage of the type along this river will be flooded upon the completion of the water-power dam now under construction on the Spokane River.

The soil holds moisture fairly well under frequent cultivation and proper methods of tillage. Early maturing crops seldom suffer severely from insufficient moisture, but the yields of late maturing crops are often lessened by the dry weather of the late summer months. Through a part of the type a ditch supplies water for the areas now under cultivation. Irrigation is apparently essential for success with most crops, and it is probably under this system of farming that the type will reach its highest state of development. Water is not available for much of the type unless pumped from the Columbia, Spokane, and Kettle Rivers. With irrigation the soil is adapted to a wide range of crops and to intensive farming. For successful crop production without irrigation, it is necessary to increase the normally low organic-matter content by the use of stable and green manures.

The value of land of this type depends upon the state of development of the particular tracts or sections, and ranges from \$15 to \$75 an acre. Small orchard tracts sell for \$100 to \$300 an acre.

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

Mechanical analysis of Springdale fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
5510223.....	Soil.....	0.0	0.6	2.4	43.2	35.6	15.5	3.0

SPRINGDALE COARSE SANDY LOAM.

In its typical development the soil of the Springdale coarse sandy loam to a depth of 8 to 12 inches is a yellowish-brown or light grayish brown coarse sandy loam of compact structure, sometimes carrying a small percentage of fine gravel. It has a low organic-matter content, and becomes mellow with cultivation. The subsoil consists of a bed of rounded gravel and cobbles, with some interstitial sand. In places this is not encountered at less than 20 inches from the surface. A thick substratum of water-laid gravel and cobbles underlies the type.

A dark phase of this type is encountered in Echo Valley between Lake City and Echo. This consists of a brown, loose, coarse sandy loam to a depth of 12 to 14 inches, underlain by a loose loamy sand to sand, slightly lighter in color. At a depth of 30 to 36 inches a stratum of gravelly sand is encountered, and this extends to a depth of several feet. The darker color of this part of the type is due to a higher organic-matter content and to slight accessions of local rock and soil material from the adjoining hills. A stony phase, indicated on the map by stone symbols, occurs in upper Echo Valley. This phase has an undulating surface and carries a number of small boulders. It is not extensive.

Areas of this type and its phases are found in Echo Valley north of Echo, and in various other parts of the county on high outwash terraces, and quite extensive bodies occupy terraces extending along the Spokane River from near the eastern boundary of the county to Scotts Valley, a distance of 7 miles or more.

This material is derived from glacial outwash deposits of great depth, which are composed of a variety of rock material. The terraces along the Spokane River are, however, derived largely from basaltic material.

The surface is smooth to gently undulating, with steep terrace fronts, and the drainage is usually excessive. In the vicinity of Lake City there are several small, round lakes from 1 to 2 acres in extent, some of which are fringed with Muck, where the surface of the water is not far below the level of the type. These have no visible outlet and are fed by an underground flow through the valley. The moisture-holding capacity of the type is low, while that of the phases is slightly higher.

The forest covering consists mainly of yellow pine. Native grasses grow in the open spaces. Much of the type has been logged off, but only a small part of it has been cleared for farming. A few acres in the upper part of Echo Valley and on the Spokane River terraces are cleared and set to orchards or utilized for the growing of grain, hay, and corn. Much of the type is of loose, porous character and

deficient in moisture-holding capacity, and it is doubtful whether sufficient moisture would be retained for the successful production of crops by dry-farming methods. In places where they receive some seepage from streams and adjoining hillsides small areas are adapted to the production of crops. A small part of the stony phase is farmed to hay and grain. Under irrigation, to which it is well suited, the type should be fairly productive when farmed to alfalfa, potatoes, hay, grain, etc. By a system of water storage in some of the tributary valleys, irrigation of portions of the type is possible. The streams traversing these valleys are perennial, but their flow is not normally sufficient without storage. Irrigation by pumping from streams or underground sources should be feasible, but it is problematical whether the returns which could be reasonably expected would justify the expense.

This type is sold in connection with other soils for \$10 to \$35 an acre.

Springdale coarse sandy loam, light phase.—The soil of the light phase of the Springdale coarse sandy loam is a light grayish brown to light-brown coarse sandy loam of light texture to a depth of 10 to 12 inches. In its natural state it is compact and seems to be bound together by the small quantity of silt and clay present. Where broken and cultivated, however, it is loose and mellow. The organic-matter content is low. The subsoil is a light grayish brown, loose coarse sand, and is underlain by a coarse sand and fine gravel substratum extending to a depth of many feet. The soil material carries some rounded gravel in places.

Areas of the light phase of this type occur in the valley of the Spokane River. They are inextensive and have a small total area.

This soil is derived from old stream deposits, composed mainly of basaltic material. Metamorphic and igneous rocks have also contributed to its formation.

The topography is gently undulating and the drainage is excessive. A native forest growth of yellow pine covers nearly all of the phase.

The soil of this phase is droughty and not well adapted to the production of crops under present dry-farming methods. Under irrigation it should be adapted to a variety of crops, including alfalfa, grasses, grain, fruit, and potatoes.

The value of the light phase of the Springdale coarse sandy loam for farming under present conditions is quite low. If sold, it would bring \$10 to \$35 an acre, the price depending largely on its timber and the possibility of development.

The following table gives the average results of mechanical analyses of samples of the soil of the typical Springdale coarse sandy loam:

Mechanical analyses of Springdale coarse sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
551057, 5510151....	Soil.....	<i>Per cent.</i> 18.5	<i>Per cent.</i> 26.9	<i>Per cent.</i> 8.8	<i>Per cent.</i> 8.9	<i>Per cent.</i> 9.2	<i>Per cent.</i> 21.7	<i>Per cent.</i> 5.9

SPRINGDALE GRAVELLY SANDY LOAM.

The soil of the Springdale gravelly sandy loam consists of a light-brown to light grayish brown gravelly sandy loam. It has a depth of 8 to 12 inches and is underlain by a light grayish brown gravelly sand or fine sand to fine sandy gravel, which extends to a depth of 3 feet or more. The soil is very compact when dry and is deficient in organic matter. The subsoil is less compact than the soil and is underlain by fine gravel and sand to great depths. The gravel content of both soil and subsoil is very high and consists of small rounded to flattened fragments, which are derived from a variety of rocks. Medium and large gravel particles are uncommon. A few boulders occur in the eastern areas.

The type occurs mainly as a single area. This is located in secs. 6, 7, 8, 13, and 16, T. 27 N., R. 40 E., and covers approximately 4 square miles. It owes its origin to deep glacial outwash deposits derived from a variety of rock material. The level character of the surface is interrupted in this area by a number of low swells. These occur at irregular intervals and have the same structure as the remainder of the type.

The type includes small areas of a steep phase, occupying steeply sloping fronts and eroded tops of the outwash terraces. Much of the material has gravitated to its present position and is really colluvial in origin. In a more detailed survey small areas of this type now mapped with other terrace types would be shown separately. The texture of the soil and subsoil of the steep phase is subject to wide variation, depending upon the character of the outcropping or exposed material along the terrace fronts. Variations in texture from a stony sandy loam to a gravelly sand occur. There has been no agricultural development, and this phase of the type has little value for farming.

The soil of the type readily absorbs all the surface water, and, owing to the porous character of the subsoil and substratum, the subdrainage is excessive.

The Springdale gravelly sandy loam supports a sparse forest growth of yellow pine. Native grasses cover a part of the open spaces. The type is not used for crops. It affords early pasturage. With frequent and copious irrigation the level or undulating bodies of the type should produce fair yields of alfalfa, grains, and fruit.

The value of this type separately can not be given. It is held, with other land, for \$10 to \$35 an acre.

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

Mechanical analysis of Springdale gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
5510105.....	Soil.....	11.0	15.9	4.4	8.2	16.5	35.4	8.3

SPRINGDALE SANDY LOAM.

The soil of the Springdale sandy loam consists of a light grayish brown sandy loam to a depth of 10 inches. It has a rather loose structure and low organic-matter content. Its texture is subject to some minor variation. The subsoil consists of coarse material and ranges from yellowish gravelly sand to gravel and cobbles, with a few small bowlders. The substratum is a continuation of this material.

This type is not extensive and occurs mainly in two areas, one about 2 miles east of Colville and the other about 2 miles west of Addy.

The Springdale sandy loam is derived from outwash or delta deposits of glacial streams and is composed of material from a variety of rocks.

The topography is smooth to undulating. East of Colville the type has a rather hummocky surface in places. A number of kettle holes occur on the surface. The natural drainage is excessive and the moisture-retaining capacity is rather low.

The forest growth consists of yellow pine with some fir. Grasses grow where the forest cover permits. The type affords grazing in the spring and early summer. Portions of it are suited to irrigation and if irrigated would be fairly productive. Water for such purpose is not available. The type is not cultivated.

Its value is similar to that of adjoining soil types. The stand of timber also influences its sale value.

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

Mechanical analysis of Springdale sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
5510185.....	Soil.....	10.0	19.3	10.4	6.8	9.0	35.9	8.6

SPRINGDALE FINE SANDY LOAM.

The soil of the typical nongravelly areas of the Springdale fine sandy loam is a light grayish brown fine sandy loam, grading at 8 to 10 inches into a yellowish-brown or light brownish gray very fine sand, which extends to a depth of 10 to 18 inches. The dry surface material is usually of distinctly light grayish color. The material has a moderately compact but friable to somewhat porous structure and a low to medium organic-matter content. The soil is underlain by the typical gravel and cobble subsoil and substratum of the series. In places the soil material grades into a yellowish-brown or light brownish gray fine sand below 15 inches, and this extends to a depth of 30 inches or more before the gravelly stratum is reached.

In the gravelly areas the soil to a depth of 8 to 10 inches is a light grayish brown very fine sandy loam, which carries varying quantities of small, rounded gravel. The fine material in places has a rather high silt content. Small bowlders occur infrequently on the surface. The soil is, as a rule, shallow, compact, and low in organic matter. The subsoil is a more or less stratified mass of gravel and cobbles, extending to a depth of 3 feet or more, with a substratum of similar character. In the upper part the subsoil contains some fine earth material which has filtered into the gravelly stratum.

The type occupies terraces in the valleys of the Columbia, Kettle, and Spokane Rivers. In places along the latter river the surface is covered with small, regular mounds of very fine sand with shallow soil in the intervening spaces, where the underlying gravel is often exposed. The mounds are from 2 to 5 feet high and from 15 to 25 feet across. In these areas along the Spokane River the material seems to be of a more pronounced grayish color than in other areas of the type. On the Marcus Flat undifferentiated narrow strips of heavy soil in old stream channels, occupied by water only during flood periods, are included with the type.

The gravelly areas usually occur as long, narrow bodies on the lower series of terraces along the Columbia and Kettle Rivers. The type consists of stream-laid material, which is derived from a variety of sources and from various kinds of rocks. The coarser material of the subsoil and substratum includes rounded fragments of granite, quartzite, schist, slate, and other rocks. Movement of the material by wind action has probably been a minor agency in the formation of the type in its present state.

The surface is level to gently sloping or gently undulating. The terrace fronts are steep and sometimes stony. The porous nature of the type and its substratum insures good drainage. Ordinarily the type is above overflow, but in years of extremely high water small areas of it are flooded for short periods. This results in many cases

from the backing up of the water in the sloughs which traverse the areas. It lies from 25 to 75 feet or more above the normal level of the rivers.

The forest growth is light and probably never has been heavy. It consists of yellow pine with willow and alder along the old channels and sloughs. Native grasses flourish. Among the more important cultivated areas of the type are those on the Marcus Flat south of the village of Marcus. This was the site of the Hudson Bay Company settlement and was one of the first sections of the county to be used for farming. The leading crops are wheat, oats, hay, corn, and alfalfa. All bring good returns in favorable seasons. It is common for crops to be seriously damaged by overflow. In June, 1913, portions of the flat were overflowed and farmers lost quite an acreage of crops. This was said to be the highest water since 1894.

Areas of this type in the Bonnyvale District south of Kettle Falls have been set to orchards. In some of the younger orchards inter-tilled crops are being grown with success. The trees have a thrifty appearance. Those in bearing produce profitable yields of fruit of good quality. Irrigation is practiced in this district. Potatoes, alfalfa, and berries are also grown. The development of the areas along the Kettle River is not advanced. Many of them are in their native state.

While irrigation is not generally necessary for the production of crops on the Marcus Flat there are other areas of the type which are in need of irrigation. These have a lower water table and receive less seepage from adjoining higher soil types. Under cultivation the soil retains moisture fairly well, but the porous and open structure of the substratum does not permit the storage of much moisture within the reach of crops. This is particularly true of the gravelly areas.

With irrigation the type is adapted to the growing of alfalfa, corn, grain, vegetables, fruit, etc. The supply of available water is usually deficient. The organic-matter content is easily increased by the use of green and stable manures. There is need for the practice of crop rotation. The value of land of this type ranges from \$15 to \$100 an acre.

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

Mechanical analyses of Springdale fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551045, 5510222....	Soil.....	0.2	0.6	0.9	26.1	39.3	27.8	5.1

SPRINGDALE LOAM.

The surface soil of the Springdale loam, as typically developed in this area, to a depth of 8 to 15 inches is a light grayish brown or light yellowish brown loam containing a large quantity of silt, fine gravel, and coarse sand. It is compact when unbroken and dry and moderately loose and mellow after cultivation. The gray color predominates when the soil is dry and the brown color when it is moist. The average depth of the soil is about 12 inches and its organic-matter content is low. Gravel in varying quantities is generally present in the soil, and boulders occasionally occur on the surface.

In the typical areas the soil is underlain by porous, assorted sands and gravel, which extend to depths ranging from 25 to 100 feet or more. In the first few inches of the subsoil there is a small quantity of fine material from the surface soil. The subsoil material is fairly uniform in character over large areas. In places, however, it is much coarser than usual and contains cobbles and small boulders. In other places sand predominates. The coarse material is well rounded and is derived from various rocks, among them granite, quartzite, schist, and slate.

Either on the surface or immediately beneath a thin layer of white, fine, gritty material is often found. The origin of this has not been definitely fixed, but it is believed to be volcanic ash. This is common to other soil types, especially in the southern part of the county.

The Springdale loam as mapped probably includes some areas of sufficiently high gravel content to be mapped as a gravelly type, and there are scattered and irregular areas, usually in small depressions, in which the material approximates a silt loam in texture. The color of this silty variation is prevailingly gray and the structure compact. Its subsoil has the same structure and character as the typical soil.

This type occupies fairly extensive flats or terraces in the Colville-Chamokane and Echo Valleys. A continuous area extends from Deer Lake to Loon Lake. Other areas are found in the vicinity of Northport along Deep Creek.

The Springdale loam is derived from deep glacial outwash or glacial stream deposits of a variety of rock material. The subsoils were laid down by swiftly moving, heavily laden streams, and the surface soil was deposited by more quiet waters and may have been shifted to some extent by wind action. The type seems to have been little influenced by material from adjoining types at the time of its deposition. It has been modified, however, by the washing of other material over its surface as alluvial fans, etc. The type may include some areas of undifferentiated ice-laid material.

The topography of the type is level and smooth to gently undulating. While the surface of all the type is terraced, this character is more marked in some places than in others. Draws ranging from shallow to deep traverse some areas. The surface water is quickly absorbed by the soil and the subsurface material. Subdrainage is excessive. Streams from the adjoining hills sink upon reaching this type, and even the main streams disappear for short distances during certain seasons of the year. Small lakes are partly or wholly inclosed by the type. A scattered growth of yellow pine and a carpet of native grasses give the surface a parklike appearance.

The present agricultural development of the Springdale loam is confined mainly to tracts which lie in coves or adjoin the uplands at a point where a draw or an intermittent or perennial stream emerges from the hills. In places these streams have built up alluvial-fan deposits, but these are not so common on this type as on the recent and old lake-laid deposits. The water of these streams sinks soon after reaching the terraces except in seasons of greatest flow, and increases the quantity of moisture available for plant growth. Even where no surface flow is visible there is some seepage from the hills which follows the course of the streams. Where there is no typical alluvial fan, a thin deposit of sediment is often present, and this has a beneficial effect on the crop-producing power of the type.

The crop yields of the favorably situated areas are fair to good. Grain and hay are the principal crops. Winter wheat does well. It is believed that the type, as a whole, is too subject to drought for the successful continuous production of crops by dry-farming methods. The rainfall is more than adequate for the practice of dry farming if it were possible to conserve enough of it.

The type is well fitted for irrigation, but the available water-supply is deficient. Small tracts could be irrigated at slight expense by using the water of the upland streams. A storage system for the water of Sheep or Chamokane Creeks would furnish sufficient water to irrigate a large acreage of the type lying south of Springdale. The soil would doubtless require frequent and copious irrigation, but would then be adapted to the production of grain, hay, alfalfa, fruit, and other crops. By increasing the organic-matter content, the moisture-holding capacity of the soil is improved and it is made more productive.

The value of this land from a crop-producing standpoint on the basis of present yields is low for most of the type. It is usually sold as a part of farms on the adjoining uplands and is held for \$25 to \$50 an acre.

Springdale loam, alluvial-fan phase.—The soil of the alluvial-fan phase of the Springdale loam is a light grayish brown to yellowish-gray or light brownish gray loam of light silty texture, which carries

subangular and rounded gravel in small quantities. The material becomes lighter in color and texture with increasing depth, and at 15 to 20 inches a bed of assorted gravel and sands is encountered. This carries some fine material in the first few inches and extends to a depth of 3 feet or more. The substratum is similar to this material. A few bowlders are found on the surface.

This phase of the type comprises gently sloping fan-shaped deposits, where the streams from the hills emerge into the larger valleys. The material is derived from reworked glacial till, mainly of the Waits series. The areas are from 20 to 200 acres in extent and occur in the Columbia and Colville Valleys. The drainage is always sufficient and in places excessive. Small undifferentiated areas of this phase of the type are included with the terrace and upland soils where they are not of sufficient importance to warrant separation. Some of these would be mapped separately in a strictly detailed survey.

Areas of this soil were early selected as sites for fields and farmsteads on account of the favorable topography and location with respect to water supply. The phase is farmed to a variety of crops, including hay, grain, fruit, and potatoes. Clover and alfalfa do well and are grown more extensively than timothy. The soil is adapted to irrigation, which is necessary for successful second and third crops of alfalfa. As a rule, water is available, and many farmers are using the small streams which furnish an inexpensive supply.

The value of this land depends upon the value of surrounding types and ranges from \$25 to \$75 an acre.

The following table gives the results of mechanical analyses of samples of soil of the typical Springdale loam and of the alluvial-fan phase:

Mechanical analyses of Springdale loam.

Number.	Descrip- tion.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>				
551069.....	Soil.....	9.0	17.6	5.0	6.0	11.6	44.6	6.4
Alluvial-fan phase:								
551043.....	...do.....	7.0	9.3	5.0	8.5	14.2	45.2	11.0

SPRINGDALE SILT LOAM.

The soil of the Springdale silt loam to a depth of 10 inches is a loose silt loam of light grayish brown color, changing to yellowish-gray with depth. In some places rounded gravel is abundant; in others it is entirely absent. Rounded bowlders of igneous and metamorphic rocks are common on the surface and in the soil. The subsoil apparently consists mainly of subangular and angular frag-

ments of dark-colored rocks, with some fine earth material in the upper part. From records of attempted wells and from inspection of exposures along the steep front toward the adjoining lower types it is believed that material of the same character extends to a depth of 100 feet or more. Outcrops of dark-colored igneous rocks occur in the northern part of the type.

This type occurs on the terrace which forms the wide entrance to what is known as Fruitland Valley, near Fruitland, and also north of Cedonia, in the Columbia Valley. It has the topography of a terrace, is excessively drained, and has a low organic-matter content.

The exact origin of the type is in doubt. It has a distinctly terraced topography, and along its contact with the lower or lake-laid sediments of the Mission series there are a number of fairly large springs. The presence of glacial boulders on the surface indicates a glacial influence in its formation. Several kettle holes occur on the surface of the type.

Practically none of the type is farmed. Some of it is adapted to the production of crops under irrigation. The land is valued at \$10 to \$25 an acre.

The results of a mechanical analysis of a sample of the soil of this type are given in the following table:

Mechanical analysis of Springdale silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
5510196.....	Soil.....	0.3	0.8	1.2	4.0	17.1	66.0	10.6

SPRINGDALE GRAVELLY SILT LOAM.

The soil of the Springdale gravelly silt loam to a depth of 8 to 10 inches is a light grayish brown or light-brown, compact silt loam of rather light fine sandy texture, carrying large quantities of rounded gravel of medium size on the surface and in the soil. The subsoil is a bed of rounded gravel with a small quantity of interstitial yellowish-gray fine sand, and the substratum is similar in structure and character and extends to a depth of many feet.

In places the soil is very compact and hard, but this character is not typical of any large area. In other cases the texture is slightly coarser than typical, sometimes approaching that of a fine sandy loam to gravelly sandy loam. These variations are not sufficiently important to warrant their separation as distinct types or phases.

A stony phase of the type, indicated on the soil map by stone symbols, occurs in secs. 16, 17, and 20, T. 27 N., R. 40 E., and in secs. 11 and 14, T. 27 N., R. 39 E. In these areas the soil consists of the usual material with the addition of numerous small and medium

sized boulders. The subsoil is a bed of boulders, with some cobbles and gravel. This phase has a low agricultural value.

The Springdale gravelly silt loam occupies high terraces in the valleys of the Spokane River and Chamokane Creek. The largest area extends from east of Curby to the mouth of Chamokane Creek. In derivation and formation this type is similar to the other members of the series. In places the soil contains a small quantity of dark-colored material which is probably of basaltic origin.

The type has level to gently sloping surface, and sometimes occupies several adjoining terraces. The fronts of the terraces are steep and stony. The soil absorbs all the surface water, and the subsoil and substratum permit excessive drainage.

A scattered growth of yellow pine constitutes the forest growth, and native grasses flourish. Attempts at farming on the type have never been very successful. Small depressions in the Chamokane Valley are farmed with fair results. Efforts have been made to grow grain under dry-farming methods, but the fields have been abandoned to native grasses. Much of the type has a soil and topography favorable for irrigation, but an abundance of water is required to produce a crop, and at present water for this purpose is not available. Pumping from the Spokane River appears impracticable. Under irrigation the type would probably be adapted to the production of grain, alfalfa, and fruit. Land of this character is valued at \$10 to \$35 an acre.

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

Mechanical analysis of Springdale gravelly silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551055.....	Soil.....	1.9	3.0	5.0	13.6	16.8	51.5	8.1

GARRISON SERIES.

The soils of the Garrison series are typically of a rather dark brown to dark grayish brown or nearly black color and friable structure, and generally carry small to medium rounded gravel. The subsoils consist of stratified sands and gravel, with fine earth material of lighter brown or yellowish-brown color only in the upper part. The substratum is a continuation of the subsoil material to a depth of many feet. The soils have a relatively high organic-matter content and a fairly good moisture-holding capacity considering the character and structure of the material. As typically developed the series is derived from deep glacial stream terrace and delta deposits having their source in a wide variety of rocks, including granite, quartzite, slate, limestone, and schists. In places there is a white coating on the coarse gravel material.

As mapped in this survey small areas of alluvial-fan deposits of similar color and character of soil material are included with the Garrison soils. These areas consist of later fan-shaped deposits, derived from the adjoining uplands which are usually occupied by the glacial till soils, and distributed over the glacial outwash, lake, and river terraces by minor streams. The surface of these areas is gently and uniformly sloping, smooth and well adapted to irrigation where necessary. The normal moisture content is, however, generally more favorable to agriculture without irrigation than is the case of the typical soils of the series, the soil bodies frequently being well supplied with subsoil moisture from streams and springs. The more important of the alluvial-fan areas are differentiated and discussed separately as alluvial-fan phases of the types with which they are associated. If more extensively encountered in further detailed work they may be recognized under one or more distinct series heads.

The Garrison series differs from the Springdale in color of soil and subsoil and, in this survey, in its higher percentage of slate and limestone material.

The soils have a terraced topography with steep, gravelly fronts. Occasional irregularities, such as small mounds and kettle holes, occur. The drainage of the series is well established and sometimes excessive. The Garrison soils originally supported a native growth consisting mainly of pine, fir, and brush. Both soils and topography are well suited to irrigation. They are producing profitable crops under the present system.

GARRISON GRAVELLY SANDY LOAM, ALLUVIAL-FAN PHASE.

The typical gravelly sandy loam member of the Garrison series is not developed in the area included within this survey. It is represented only by the alluvial-fan phase. This soil comprises fan-shaped deposits on terraces in the main valleys. The parent material consists of reworked glacial till together with material from glacial outwash terraces.

The soil to a depth of 10 to 12 inches consists of a rather dark brown to lighter brown sandy loam, carrying variable quantities of rounded glacial gravel. The soil is friable and rather low in organic matter. The subsoil consists of rounded, fine to medium gravel with interstitial sands of different grades. This material, though deposited by water, is not well stratified. It is underlain by a substratum of similar material.

The soil areas are not extensive. The phase includes a number of small areas of undifferentiated material, which in a more detailed survey would be shown separately. The gently sloping surface and porous character render the drainage excessive in places.

Yellow pine, fir, and brush comprise the native growth. Nearly all of the soil bodies have been logged off, and a small area has been

prepared for farming. In agricultural value and in character of crops to which it is adapted, the soil is similar to the alluvial-fan phase of the Springdale loam. It is well suited to irrigation, and a supply of water for this purpose is usually available. There is a good supply of water for crops during the greater part of the season, but irrigation would insure profitable yields every year. The type is valued at \$10 to \$40 an acre.

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

Mechanical analysis of Garrison gravelly sandy loam, alluvial-fan phase.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
5510133.....	Soil.....	8.2	18.9	12.0	11.5	8.0	35.5	6.2

GARRISON SANDY LOAM.

To a depth of 10 or 12 inches the soil of the Garrison sandy loam as typically developed in this survey is a dark grayish brown to brown sandy loam of light texture, sometimes approaching a loamy coarse sand, and carrying rounded glacial gravel of different grades. It is underlain by grayish-brown or light-brown gravelly sand also of various grades, extending to a depth of 3 feet or more. The soil has a loose, porous structure and a medium organic-matter content. The soil of the lower lying portions of the type approaches a gravelly sand.

Two areas of this type occur along creeks or valleys tributary to the Colville River from the east, one 3 and the other 5½ miles north of Addy.

This type is included in the Garrison series, although it differs somewhat from the other types of the series in character of material, and occurs at much higher elevations and has a different structure and topography. The sand content consists mainly of granitic fragments and the gravel is derived from a variety of rocks. The material finer than sand is similar to that of the other types of the series. The type is composed of material deposited by glacial waters, flowing either directly from the front of a melting glacier or through a temporary outlet.

Within a distance of 2 miles the elevation of the type rises at least 700 feet. The present streams are deeply intrenched, and there are a number of small tributary draws as well as terraces. The surface is fairly irregular. The drainage is excessive.

Small areas of favorable topography are cultivated and give fair returns. Irrigation from the small streams is practiced to a limited extent. The grazing afforded by the type is poor. Yellow pine was

formerly the chief timber growth, but nearly all of this has been logged off. The value of the type ranges from \$10 to \$50 an acre.

Garrison sandy loam, alluvial-fan phase.—The alluvial-fan phase of the Garrison sandy loam consists of a dark brownish gray or dark grayish brown to lighter grayish sandy loam underlain at a depth of 10 or 12 inches by a bed of rounded gravel with interstitial gray to yellowish sands. Some gravel, both angular and rounded, occurs in the soil. The soil is loose and porous and has a rather low organic-matter content. Local areas occur in which the soil material is of somewhat lighter color and less loamy texture than described above. Two areas of alluvial-fan deposits derived mainly from soils of granitic origin have been included in this phase. They differ from the typical phase in having a compact micaceous fine sandy loam subsoil.

This phase of the type occupies gently sloping alluvial-fan areas mainly in the Colville Valley, where minor streams of reduced velocity have distributed material over the terraces. It is also encountered in the vicinity of Walkers Prairie. It is derived mainly from reworked material of the Waits series and of outwash terraces and from reworked granitic glacial till and residual soils. The drainage is well established except in a few local areas in which the subdrainage is inadequate on account of seepage from streams traversing the areas.

A small area of darker soil occurs on Walkers Prairie, adjoining the heavier prairie soils on the south and west. This body probably overlies lake-laid sediments, and could be correlated with the Chelwah series if it were of sufficient extent and importance or in a more detailed survey.

A part of the forest cover of fir, yellow pine, and tamarack, with a growth of brush, has been removed, and portions of the phase are farmed to hay, grain, and potatoes, which give good yields under proper management. Crops which do not mature before late summer need irrigation, and water for such purpose is available.

The value of this phase of the Garrison sandy loam ranges from \$10 to \$60 an acre.

The results of mechanical analyses of a sample of the typical soil and of samples of the soil and subsoil of the alluvial-fan phase are given in the following table:

Mechanical analyses of Garrison sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
5510157.....	Soil.....	11.2	17.5	10.4	21.1	17.2	18.7	4.1
Alluvial-fan phase:								
551013, 551014&a.	Soil.....	11.7	18.1	9.1	11.2	9.1	30.5	10.4
551014.....	Subsoil....	2.8	5.4	4.7	22.0	19.7	36.1	9.4

GARRISON GRAVELLY FINE SANDY LOAM, ALLUVIAL-FAN PHASE.

Like the Garrison gravelly sandy loam, the Garrison gravelly fine sandy loam is represented in this survey only by its alluvial-fan phase.

The surface soil is a medium to dark grayish brown gravelly fine sandy loam of friable structure and medium organic-matter content. It has a depth of 10 to 12 inches and is underlain by a bed of gravel, with interstitial brownish sands, which extends to a depth of 3 feet or more. The gravel is subangular to rounded and is mainly quartzite. Medium to large fragments and boulders of quartzite are common on the surface, especially in the footslope areas.

This soil is encountered in the main valleys, usually adjoining quartzite slopes or mountains. It has been deposited by streams or by sheet water where the streams emerge from the hills. The material is derived from reworked glacial till deposits overlying rough to mountainous areas of quartzite and has doubtless been modified by accessions of weathered and unweathered quartzite rock. A small part of the material mapped is colluvial in origin and is found along rather steep slopes.

The topography is gently sloping, and the areas have a fan-shaped outline, the apex pointing upstream. The soil bodies have the most distinctly conical or fan-shaped outline of all the alluvial-fan phases of the series. The drainage is usually excessive.

Alfalfa, clover, potatoes, and fruit are the principal crops. The yields vary from fair to good, depending on the seasons and the methods of farming. The areas receive considerable water from the adjoining hills and slopes, and crops do not suffer from drought so much as might be expected on a soil of this structure. Irrigation may be provided at slight expense and would insure regular yields. The value of land of this type is \$10 to \$40 an acre.

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

Mechanical analysis of Garrison gravelly fine sandy loam, alluvial-fan phase.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
5510135.....	Soil.....	5.4	7.5	8.2	26.4	16.7	26.3	9.3

GARRISON GRAVELLY LOAM.

The Garrison gravelly loam consists of a dark grayish brown gravelly silty loam, underlain at a depth of 10 to 12 inches by a light-brown gravelly sand which extends to a depth of 3 feet or more. The soil is friable and has a rather high organic-matter content. The

gravel of the type ranges in size from small to large and is derived from a variety of sources. Occasional boulders occur on the surface.

The type occupies high-lying terrace areas or areas of deposits which fill glacial stream channels. It is developed mainly in an area 3 to 5 miles northeast of Colville. Another area occurs in the old glacial channel south of White Mud Lake in secs. 30 and 31, T. 35 N., R. 40 E.

The Garrison gravelly loam owes its origin to the deposition of material by glacial waters. It occurs at elevations of 500 feet or more above the bottom of the Colville Valley and covers portions of an elevated glacial stream terrace which served as an outlet for water during some period of the glacial age.

The type includes a series of terraces on which there are several small lakes, including White Mud and Hatchs Lakes. The surface of other areas is practically level but not smooth. Kettle holes of small size occur. The drainage is well established. The water table is near the surface in places, as is indicated by the presence of the lakes, whose water is always fresh although they have no visible outlet. The drainage of a large part of the type finds its way through the bed of gravel and sand which forms the substratum of the type.

The native timber has been removed, and part of the type is farmed to hay and grain. Winter wheat seems to be the leading crop. Cultivated crops are not grown to any extent. There is sufficient moisture for the production of early maturing crops. The surface and soil are adapted to irrigation, and water is doubtless available for pumping or it could be supplied by storage systems in the tributary valleys. The type is valuable for the production of alfalfa under irrigation.

The value of land of this type ranges from \$40 to \$75 an acre.

The results of a mechanical analysis of a sample of the soil are given in the following table:

Mechanical analysis of Garrison gravelly loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
5510173.....	Soil.....	22.6	17.2	3.2	4.0	8.4	35.2	9.2

GARRISON LOAM.

The Garrison loam consists of from 6 to 12 inches of a dark grayish brown silty loam, underlain to a depth of 3 feet or more by a light-brown gravelly sand, which carries a few cobbles and some boulders. The soil is moderately friable and has a medium organic-matter content. Wherever the soil is shallow, small, rounded gravel is

present. The substratum is merely a continuation of the subsoil material. The gravel fragments in the subsoil and substratum often have a white coating.

The type occupies the greater part of the Church and Garrison Flats, which lie on the first terrace east and northeast of Colville. These flats are separated from each other by an area of lake-laid silts.

The Garrison loam occupies a lower elevation than the other members of the series, but in character and structure it seems to be identical with the other Garrison soils. It was laid down by glacial water either as an outwash plain or as a delta, and shows the influence of material derived from near-by sources, especially in the soil.

The surface is approximately 250 feet above the bottom of the Colville Valley and is fairly smooth, except for small kettle holes in a few places. The drainage is always adequate and in certain seasons excessive.

The forest cover was removed early in the history of the county, for the area occupied by this type was among the first to be cultivated. The soil has long been used for crop production, and yields are fair to good. It is devoted mainly to winter wheat. Oats and potatoes also are grown, with some garden and truck crops. Late-season crops and some cultivated crops suffer from lack of moisture during the latter part of the growing season. This is a productive and desirable soil. It can be developed to its greatest capacity only under irrigation, with which it is adapted to the production of alfalfa, clover, potatoes, grain, fruit, and certain vegetables. Land of this type is valued at \$50 to \$80 an acre.

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

Mechanical analysis of Garrison loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
5510175.....	Soil.....	<i>Per cent.</i> 10.4	<i>Per cent.</i> 10.5	<i>Per cent.</i> 5.0	<i>Per cent.</i> 6.4	<i>Per cent.</i> 11.4	<i>Per cent.</i> 48.9	<i>Per cent.</i> 7.2

GARRISON SILT LOAM.

The soil of the Garrison silt loam is a dark grayish brown friable silt loam which has a depth of 12 to 18 inches, with an average of 15 inches. The color grades into lighter shades of brown as the subsoil is approached. The soil has a moderately high organic-matter content, and is underlain by assorted rounded gravel and sand deposits many feet in thickness. A small quantity of fine earth material has found its way from the overlying soil into the first few inches of this substratum. The gravel varies in size from small to medium and large, and is derived from a variety of rocks.

The type occupies a comparatively inextensive area in secs. 30 and 31, T. 35 N., R. 40 E., about 6 miles southeast of Colville. Deep stream-laid or delta deposits of glacial streams, derived mainly from material which has been transported for some distance but modified to a considerable extent in both soil and subsoil by the influence of local material, have given rise to the Garrison silt loam. The component rock material consists of slate, granite, quartzite, limestone, and similar formations. The type occupies a part of the floor of a glacial stream channel. The gravel fragments often have a thin white coating of calcareous material.

The topography is level to gently undulating, and drainage is well established. The type is not subject to destructive erosion.

The Garrison silt loam is devoted mainly to wheat and oats, which produce good yields. Corn is sometimes grown and does fairly well.

This is an early and productive soil and holds moisture better than its structure indicates. It is capable of producing a heavy first cutting of alfalfa, with light second and third cuttings because of a lack of moisture. The type is adapted to irrigation, but water is not available without a pumping or a storage system. A rotation of crops suited to the type is necessary to maintain its productiveness. The value of land of this type varies from \$60 to \$80 an acre.

The following table gives the results of a mechanical analysis of a sample of the soil of the Garrison silt loam:

Mechanical analysis of Garrison silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551083.....	Soil.....	3.0	3.4	1.5	3.7	16.6	59.5	12.2

WATERLOO SERIES.

The soils of the Waterloo series have a grayish-brown to dark-gray color, a friable structure, and a moderate to high organic-matter content. The subsoils are composed of more or less stratified sands and gravel with some interstitial fine earth in places. Small slate, quartzite, and limestone gravel of angular to flattened outline are common to the greater part of the series. Boulders are not present in these soils. The Waterloo soils are derived from old glacial stream, delta, or outwash deposits of local origin and extent and are composed mainly of slate and limestone material. Rounded glacial gravel is not abundant. In Stevens County the soils occur as inextensive areas in the western part along tributaries of the Columbia River.

The surface is level to gently sloping. The drainage is always adequate and is sometimes excessive. The native timber consists of pine and fir, with some brush. The soils are productive with proper

management, and under favorable moisture conditions. They are farmed to hay and grain.

This series differs from the Garrison in having a dark-gray color, instead of the dark-brown to nearly black color of the latter series, and a lower percentage of rounded glacial gravel in the soil and subsoil material.

Like the Springdale and the Garrison series, the Waterloo series includes small areas of alluvial-fan soils, the more important of which are differentiated as alluvial-fan phases of the types with which they are associated.

WATERLOO GRAVELLY LOAM.

To a depth of 10 to 12 inches the soil of the typical Waterloo gravelly loam is a grayish-brown to dark-gray silty loam, carrying large quantities of slate, limestone, and quartzite gravel of angular to flattened outline. The soil though naturally compact becomes mellow when cultivated. It has a moderately high organic-matter content. The subsoil ranges from a light-brown gravelly loam to a rather imperfectly assorted mass of angular, rounded, and flattened slate, quartzite, and limestone fragments in the upper part of which some fine material from the soil has gravitated. As a rule, the percentage of glacial gravel is low. Sand seems to occur in pockets. Boulders are not common.

The Fruitland Valley areas of the type have small but conspicuous mounds of material identical with that of the soil. They also have more sand and glacial gravel than that part of the type having a greater elevation.

The occurrence of this type is much the same as that of the loam of the series. The areas are probably larger and the type is more extensive. It occupies high-lying flats or terraces along tributary streams of the Columbia River. These streams have a steep gradient and the deposits along them occur as steps or small terraces instead of narrow areas of uniform grade corresponding with that of the stream.

The material is local in extent and origin, and was not deposited by a large torrential volume of water. The individual areas along a stream closely resemble delta formations, deposited at different stages of the water level.

The surface is either flat or sloping and each area is crossed by a stream which flows in a deep draw or gully. The drainage ranges in different places from adequate to excessive.

Some areas are farmed to grain. The remainder of the type supports a thick to scattering forest growth, or where treeless is used for pasture. In the latter case the grass is sparse and dries up early in the summer.

Winter wheat and oats are the leading crops. Fair yields are obtained. Potatoes and orchard crops also are grown. Irrigation could be practiced at slight expense by utilizing water from the streams which traverse the type. The soil is productive, and under irrigation would produce yields of alfalfa, grasses, fruit, grain, and similar crops. The soil holds moisture moderately well considering its structure. Unless it were possible to irrigate adjoining types under the same system, it is doubtful whether the extent of this type is sufficient to warrant the outlay of any considerable time or expense. The value of the type ranges from \$25 to \$50 an acre.

Waterloo gravelly loam, alluvial-fan phase.—The alluvial-fan phase embraces the gravelly soils which occur where streams traversing areas covered by soils of the Stevens series distribute the material as alluvial-fan deposits. It consists of a grayish-brown to dark-gray gravelly loam underlain by a gray gravelly clay loam which extends to a depth of 3 feet or more. The gravel content is made up mainly of angular to flattened fragments of slate. Quartzite cobbles and bowlders occur infrequently. The texture of the fine material varies from that of a loam to a silt loam or a clay loam. The soil is fairly friable when dry but quite sticky when wet, and has a relatively high organic-matter content.

The alluvial-fan phase of this type occupies gently sloping fan-shaped deposits, is well drained, and is considered a strong and desirable soil for general and some special crops. It is practically all under cultivation to grasses, fruit, grain, and corn. Fair yields are had. Crops seldom suffer from drought except late in dry summers. Areas of this phase were selected for the location of many groups of farm buildings as well as for the growing of crops in the early settlement of the county. Its irrigation is practicable, but as a rule is not required on account of the water from the streams and the seepage water from adjoining areas. The value of undeveloped land of this phase ranges from \$10 to \$40 an acre.

A mechanical analysis of a sample of the soil of the typical Waterloo gravelly loam gave the following results:

Mechanical analysis of Waterloo gravelly loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551091.....	Soil.....	13.3	8.0	4.1	10.6	10.9	44.2	8.6

WATERLOO LOAM.

The surface soil of the Waterloo loam is a dark-gray loam grading below into a grayish-brown or light-brown, light-textured loam, which extends to a depth of 10 to 12 inches. The soil is friable,

moderately high in organic matter, and carries some gravel. It is underlain by more or less assorted or stratified sands and gravel. The latter comprises mainly angular to flattened fragments of dark-colored rocks. There is also an admixture of rounded glacial gravel.

This type occurs as elevated flats or terraces along some of the main tributaries of the Columbia River between its junctions with the Colville and the Spokane Rivers. It is derived from stream, delta, or outwash deposits apparently of glacial but of local origin and extent, composed mainly of slate, limestone, and quartzite material. It is developed within areas of Stevens silt loam or of kindred soils and rocks, sometimes far up the courses of the streams where it is often difficult to determine its exact origin.

The individual areas though comparatively small may be made up of more than one terrace. As a rule, they are level and cut by one deep, V-shaped gully through which the present stream flows. The drainage ranges from good to excessive at different times of the year. Erosion of the soil is not serious on this type.

The Waterloo loam is farmed to hay and grain. Alfalfa and clover do well when there is sufficient moisture for the later crops. Cultivated crops are not grown to any extent. Irrigation at slight expense is feasible for much of the type, and is practiced to a certain degree. The soil is productive and only lacks moisture to make it adapted to all the crops grown in this region. The yields of grain and hay are good. The value of land of this type ranges from \$25 to \$50 an acre.

The following table gives the results of a mechanical analysis of a sample of the soil of the Waterloo loam:

Mechanical analysis of Waterloo loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551081.....	Soil.....	15.3	11.2	3.2	5.4	8.8	43.8	11.9

MISSION SERIES.

The Mission series includes the light-colored terrace soils which rest upon light-colored stratified silts and clays. The types consist of light yellowish brown to light grayish brown soils underlain by subsoils of similar color and texture. The lighter textured members of the series have fairly loose sandy soils and subsoils underlain by the heavier substratum, while the heavy members have compact soils and subsoils of silt and clay texture. These soils as a rule have a low organic-matter content. They are practically free from gravel and boulders.

The series is regarded as derived from old valley filling material consisting of stratified fine sediments which were probably deposited

in glacial lakes. Some modification of the surface material by later alluvial agencies has doubtless taken place, however, in the formation of the lighter members.

The soils occur upon remnants of terraces well elevated above the later alluvial or lacustrine deposits of adjoining stream valleys or recent lake basins.

Uneroded areas have a level to undulating topography with abrupt fronts toward the adjoining terraces. Other areas which have been modified by erosion are gently to roughly rolling. Drainage is generally well developed, but the soils are retentive of moisture when properly cultivated, and are adapted to a wide variety of crops, including grain, potatoes, alfalfa, fruit, vegetables, and beans.

MISSION SAND.

The Mission sand consists typically of a light grayish brown or light-yellow medium sand to a depth of 10 to 12 inches, underlain by a light grayish brown to pale yellowish brown sand, which extends to a depth of 3 feet or more. There is usually a slight difference in the color of the soil and subsoil. The dry surface is generally of light-gray cast. The type has a loose and porous structure and a low organic-matter content, and admits air and water freely. The heavy substratum of silt and clay is usually encountered at greater depths than in the case of the finer textured types of the series.

The most extensive areas of this type are located southeast of Bossburg, northeast of Evans, and northeast of Kettle Falls. The material is derived from a fairly thick stratum of medium sand which occupies portions of the same terrace as the types of finer texture belonging to the same series, or of other terraces of equal elevation. It is not always possible to determine the presence of the heavy substratum in all cases. Slight modification of the surface has resulted from wind action.

The surface is smooth to gently sloping, and the drainage is well established. There is no danger of soil erosion.

The forest growth consists of a fairly heavy stand of yellow pine with small clumps of a second growth in places. A thin growth of native grasses and buckbrush occurs in the intervening spaces.

Very little of the type is under cultivation. It is regarded as having too low a moisture-holding capacity to mature farm crops. Young fruit trees seem to be making a satisfactory growth under frequent and thorough cultivation of the soil during the summer months. The soil is well adapted to irrigation, and requires very little leveling. At present there is no available water supply. Under irrigation it should produce profitable crops of alfalfa, short-season vegetables, and fruit. Like other members of the series it is in need of manure to increase its

organic-matter content. The plowing under of winter cover crops in the spring supplies vegetable matter, and increases the moisture-retaining capacity and the crop-producing power of the soil. The value of land of this type ranges from \$25 to \$50 an acre.

Mission sand, heavy phase.—The soil of the heavy phase of the Mission sand is a light yellowish brown to light grayish brown loamy sand having a depth of 10 to 12 inches. The dry surface has a light-gray color. It is loose and friable but compacts under pressure and is underlain by a light yellowish brown to light grayish brown sand to a depth of 3 feet or more. The type is deficient in organic matter and free from gravel and boulders. The typical substratum of the series is usually encountered at a depth of several feet. In some cases the substratum consists of compact fine sands. Stratified deposits of gravel often occur at greater depths.

The heavy phase of the Mission sand occupies high terraces in the Columbia and the Kettle River Valleys in the northern half of the county. It is composed of uniform material derived from a variety of rocks. It was deposited apparently in moderately quiet waters, probably of a glacial lake. The material is identical with that of the typical Mission sand, with the addition of small quantities of the fine grades of sand and silt. The surface shows little or no effects of wind action. The type has received no marked accessions of alluvial material from the adjoining slopes.

The topography is characterized by the smooth to gently sloping tops and steep fronts of typical terraces. Its normally smooth surface is sometimes broken by V-shaped draws extending back from the front of the terrace. The phase is well drained. Some rather narrow terraces are excessively drained.

Yellow pine, with some second growth, constitutes the forest cover. The open spaces support a growth of grasses and buckbrush.

A small part of the type is under cultivation to grain, potatoes, and fruit, with fair results. The type permits the early seeding of spring crops, and holds moisture moderately well with efficient cultivation. The use of stable and green manures is needed to increase the organic-matter content. The growing of cover crops in orchards to be plowed under the following spring is a good means of supplying the needed humus. Irrigation water for portions of the type is available from the tributary streams by the construction of canals starting at some distance back from the Columbia River. The expense in some cases would be prohibitory. Under irrigation the type is adapted to alfalfa, grain, fruit, potatoes, etc. Without irrigation it is best suited to those crops which mature early or those which permit frequent cultivation during the growing season. Land values on this type range from \$25 to \$50 an acre.

The results of a mechanical analysis of a sample of the typical soil are given in the following table:

Mechanical analysis of Mission sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
5510215.....	Soil.....	0.1	6.0	39.7	44.0	4.4	3.1	2.9

MISSION FINE SAND.

The Mission fine sand consists of a pale yellowish gray or light yellowish brown fine sand underlain at a depth of 8 to 10 inches by a light yellowish gray or yellowish-brown fine sand which extends to a depth of 3 feet or more. The soil is loose and porous, deficient in organic matter and free from gravel and bowlders. The substratum of silt and clay typical of the series occurs at varying depths.

This type is found on high terraces in the Columbia and Kettle River Valleys in the northern part of the county. Wind action has modified the surface in places. It has received a little addition of alluvial material from adjoining higher types.

The surface is sloping to very gently undulating. The soil is well drained and admits air and water freely. Springs occur along the terrace fronts. The type doubtless receives some seepage water from the adjoining hillsides, and to a certain extent is subirrigated where the impervious substratum does not lie too far below the surface.

A part of the type is farmed to alfalfa, potatoes, and fruit. On the virgin soil the yields are fairly good, but they seem to decline as the soil is depleted of its small supply of humus. It is necessary to give careful attention to maintaining and increasing the organic-matter content by the use of manures. The growing and plowing under of green-manuring crops, such as rye and vetch, in addition to the use of stable manure, the supply of which is usually scant, is an effective means to supply organic matter. The use of lime and soil inoculation are beneficial in securing a stand of alfalfa. The soil holds moisture moderately well where given proper cultivation.

It is probable that the greater part of the type is capable of producing profitable yields without irrigation where given proper cultivation. Water for irrigation is not now available. The value of the type ranges from \$25 to \$75 an acre.

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

Mechanical analyses of Mission 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>
5510205.....	Soil.....	0.0	0.9	5.9	47.0	25.9	16.2	4.0
5510206.....	Subsoil.....	.0	.6	6.9	50.5	24.4	15.5	2.2

MISSION FINE SANDY LOAM.

The Mission fine sandy loam consists of a light grayish brown fine sandy loam to a depth of 10 to 12 inches, underlain by a pale yellowish-brown to yellowish-gray fine sand to a depth of 3 feet or more. The dry surface is usually light gray in color. The type is underlain by very compact strata of fine sands and silts and in some places clay. This in turn rests upon a bed of assorted gravel and cobbles. The soil is loose and friable, and deficient in organic matter. Gravel and bowlders do not occur in the type. In places its texture is a loamy fine sand.

This type is encountered on the highest terraces in the Columbia River Valley above Marble. Its material is uniform in texture and character and was probably laid down in comparatively quiet waters of lakes which existed in the Columbia Valley during the disappearance of the ice sheet. Very little modification of the surface has been effected by colian agencies.

The surface is smooth to gently sloping with steep fronts toward adjoining lower terraces. It lies from 300 to 600 feet above the level of the river. The drainage is well established, and the type is not subject to erosion.

The native vegetation consists of yellow pine, with some second growth, and of buckbrush and grasses. Only a small acreage of the type is under cultivation, and most of its area is still forested. The type is well suited to irrigation, but it is doubtful whether water can be supplied at a reasonable cost.

Together with other types of the series in the Columbia Valley this soil is held in large tracts, and its development is thus retarded. It has a value of about \$25 to \$60 an acre.

MISSION VERY FINE SANDY LOAM.

The surface soil of the Mission very fine sandy loam is about 10 to 12 inches deep, and consists of a yellowish-gray or yellowish-brown very fine sandy loam. This grades into a pale yellowish gray or yellowish-brown very fine sand to silt loam which extends to a depth of 3 feet or more. The soil, though fairly compact, is porous and deficient in organic matter. The presence of gravel and bowlders is not typical. The silt and clay substratum is encountered at slightly greater depths than in the case of the loam of the series.

Like the Mission loam, this type occupies high terraces in the Columbia Valley south of township 35 north. One area occurs south of Williams, above the junction of the Kettle River.

The type is composed mainly of moderately deep accumulations of fine grades of sand and silt overlying strata of silt and clay. The material was deposited in rather quiet waters, probably of glacial lakes, which existed in the valleys of the Columbia River and its largest tributaries during the recession of the ice sheet. In places there has been some shifting of the surface material by wind action.

The surface features are characteristic of all the types of the series, consisting of level to gently sloping tops and steep fronts of terraces. The drainage is well established. Some seepage water is received from the adjoining hills. This, however, is beneficial to crops. Soil erosion is not serious.

Yellow pine formerly covered the type, but this has been largely removed to permit farm operations. In places buckbrush and native grasses flourish. This type, like the loam of the series, is farmed quite extensively to grain, alfalfa, corn, clover, and potatoes. Fruit is grown, but there are no large orchards on the type. Oats give yields of 50 to 75 bushels per acre. For winter wheat the soil needs summer fallowing before the crop is sowed. The high terraces seem to be in a temperature belt which is protected from early fall frosts, and are adapted to corn growing where the soil is properly prepared. The yields of corn are fair. The type dries quickly in spring and permits seeding early enough for sown crops to mature before the fall frosts. Grass crops do best under irrigation.

One of the first requisites is the incorporation of organic matter by the use of stable and green manure. For the latter rye, vetch, or cowpeas may be used. Winter cover crops are beneficial in preventing leaching during the winter and in adding humus when plowed under in the spring. Best results are had where crops are properly rotated. Irrigation is practicable from the soil standpoint, but is not necessary in order to obtain profitable crops. In certain seasons and for some crops it would be beneficial. The type lies above one irrigation ditch, and water could be made available either by pumping from that ditch or by storage systems in the courses of small streams.

The value of land of this type is from \$25 to \$75 an acre.

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

Mechanical analyses of Mission 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>
5510219.....	Soil.....	0.0	0.1	0.2	23.9	51.6	21.0	3.2
5510220.....	Subsoil.....	.0	.1	.1	14.6	60.0	23.5	1.8

MISSION LOAM.

The Mission loam consists of a light yellowish brown or light grayish brown loam of light silty texture, grading between 12 and 18 inches below the surface into a light brownish gray or yellowish-brown very fine sand to silty loam which extends to a depth of 3 feet or more. The soil apparently carries a percentage of clay, low for a very fine sandy loam but high for a very fine sand. It has a rather compact structure but is very friable and loose where cultivated. The organic-matter content is rather low. The type is free from gravel and boulders, and is underlain at 4 to 10 feet by the silt and clay deposit which is typical of the series. Stratified coarse material is encountered at depths of 25 to 50 feet.

The type is confined mainly to the high terraces on the east side of the Columbia Valley below its junction with the Kettle River. The largest area lies on both sides of the Colville River in the vicinity of Meyers Falls. Another occurs in the Kettle River valley about 4 miles north of Napoleon. Other areas are found in the Columbia Valley south of Harvey.

The deep accumulations forming the substratum and consisting of sediments of very fine sand, silt, and clays, showing evidence of stratification and free from gravel and boulders, are believed to have been deposited in old glacial lakes. In that event they are composed of sediment carried by glacial streams and consist of various kinds of rock material.

It is believed that the terraces occupied by this as well as other types of the series were once much more extensive. They probably extended across the valley, and have been eroded to their present size and shape.

The difference in color between some of the material of the Springdale loam and the Mission loam is not marked. The former tends toward brown and the latter toward yellowish gray. The characteristic features which distinguish the types are the gravelly subsoil and substratum of the Springdale and the fine-textured subsoil and substratum of the Mission.

The terraces have smooth to very gently sloping tops with steep scarps toward the adjoining lower terraces. Tributaries of the Columbia have cut through the terrace and flow in narrow V-shaped valleys or in deep canyons. The type is well drained in this locality, although in regions of greater rainfall artificial drainage might be necessary. It receives some seepage from adjoining hills. This type is not subject to destructive erosion and there are no harmful accumulations of alkali.

There was formerly a forest cover of yellow pine on the type, but practically all of this has been removed.

The type is used for quite a wide variety of crops. Winter wheat yields from 30 to 40 bushels after summer fallowing. Early oats produce yields of 40 to 70 bushels per acre. Corn gives fair yields in favorable seasons. Alfalfa produces a good first crop, but the later cuttings are light because of a lack of moisture. Potatoes, clover, and other crops are grown for home use. A small acreage is devoted to the production of fruit.

The use of green manures for increasing the organic-matter content is beneficial, resulting in an increased moisture-holding capacity with consequent larger yields. Rotations containing a legume are advantageous. The type is well adapted to irrigation, but as a rule it lies above the available water supply. Although there is a good supply of water for wells, it is doubtful whether there is sufficient water for pumping or whether the net returns from crops would justify this practice. Some of the type could be irrigated by storage systems along the small streams. It is believed that farming can be profitably practiced without irrigation. The farmers seem to recognize the adaptation of this soil to certain crops. More intensive cultivation during the summer months is needed.

The value of this type depends to a large degree upon its location with respect to market. It sells for \$25 to \$80 an acre.

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

Mechanical analyses of Mission 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>
551031.....	Soil.....	0.0	0.2	0.6	20.4	28.3	45.9	4.5
551032.....	Subsoil.....	.0	.2	.6	20.6	33.2	40.8	4.5

MISSION SILT LOAM.

The Mission silt loam consists of a light yellowish brown to light brownish gray silt loam to a depth of 8 to 12 inches, underlain by a compact light brownish gray to yellowish-brown silt loam. The substratum is a stiff silty clay loam to silty clay, and is frequently encountered within the 3-foot soil section. Small to large lime concretions are found in the substratum of this type, as in that of the other types of the series. The type is practically free from gravel and carries only occasional bowlders. The soil is sticky when wet and is compact and hard when dry. It has a low organic-matter content. The soil clods badly if plowed when too moist or too dry.

Scattered areas occupying individual terraces or portions of terraces occur in various parts of the Columbia, Kettle, Colville, and Spokane River Valleys. A few small bodies occur on the lower terraces, occupied in part by the lower terrace areas of the soils of the

Springdale series. These areas have been included with this type, as they are of silty texture and appear to be fairly deep deposits of silty material derived mainly from the adjoining soils of the Mission series. They are underlain, however, by the porous substratum typical of the Springdale series.

The Mission silt loam is derived from silts probably deposited in old glacial lakes which existed during the recession of the Cordilleran ice sheet. The surface material has been modified by erosion to some extent and in places by the addition of small quantities of alluvial-fan sediments from the adjoining types. The surface varies from level to gently rolling. The drainage is moderately well established over the greater part of the type. Certain areas, by reason of their position and level surface, drain slowly and are in need of artificial drainage by open ditches or tile.

The forest growth consists of pine and fir, with some brush. Much of this has been removed for lumber and in preparing the land for farming.

Potatoes, grain, hay, alfalfa, and fruit are the leading crops. The type seems particularly adapted to timothy and small grain, especially oats. Oats yield from 40 to 75 bushels and timothy from 1 to 3 tons of hay per acre. Clover and alfalfa do best after the soil has been properly cultivated for several seasons. Crops sometimes suffer from drought in dry seasons. By increasing the normally low organic-matter content the soil is made more retentive of moisture and more productive. With proper preparation the soil holds sufficient moisture for early maturing crops. Such crops as alfalfa do best in irrigated areas. Water for irrigation is available for only a small part of the type. The value of this type varies from \$25 to \$60 an acre.

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

Mechanical analyses of Mission 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>
5510179.....	Soil.....	0.1	0.3	0.4	2.4	11.0	70.9	15.0
5510180.....	Subsoil.....	.1	.6	.8	2.9	9.4	71.3	14.9

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO₃): No. 5510180, 14.34 per cent.

MISSION CLAY.

The surface soil of the Mission clay is a compact light brownish gray or light grayish brown clay of silty texture, 8 to 10 inches deep. It is sticky when wet and is rather low in organic matter. This surface soil is underlain by a stiff light brownish gray or light grayish brown clay, which extends to a depth of 3 feet or more. The subsoil often has a faint greenish tinge, is only slightly plastic when

wet, and checks or breaks into cubes when exposed to the air and dried. The substratum consists of stratified silts and clays and is several feet in thickness. The type carries no gravel except that washed over it by upland streams. Small glacial boulders occur in a few places. Clods form if the soil is worked when too wet or too dry.

This type is encountered on high terraces in the Columbia and Colville Valleys. It is probable that it formerly occupied much more extensive areas, which were reduced by erosion.

The material of the type consists of glacial stream sediments, which were laid down in glacial lakes formed during the recession of the ice sheet by the blocking of drainage channels by the main body of the ice, or by remnants left here and there in the valleys. These sediments are over 100 feet thick in places. A part of the type is derived from the subsoil and substratum of eroded terraces of the Mission silt loam.

The topography ranges from gently rolling to rolling and roughly rolling. The character of the surface varies according to the degree to which the type has been eroded. The surface drainage varies according to the surface features from slow to rapid, and the subdrainage is usually slow. Spots known as "salt licks" occur infrequently.

The forest growth is rather thick and consists of fir, tamarack, and pine, with an undergrowth of brush. It is not typical of the series.

Cleared areas of the type produce good yields of hay and grain. Timothy does particularly well, producing from 1 to 3 tons of hay per acre. Oats are grown and cut for grain, with yields of 40 to 75 bushels an acre. The soil is rather difficult to handle, especially when first put in cultivation. It is improved by the plowing under of rough material to increase the organic-matter content. A crust forms over the surface after rains. If given frequent cultivation, the soil holds moisture fairly well. After several years of such cultivation as will improve the physical condition of the soil, clover and alfalfa should do well. Clover is grown at present to a very small extent. In rather wet places it heaves and freezes out. Land of this character is valued at \$25 to \$75 an acre.

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

Mechanical analyses of Mission clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
551071.....	Soil.....	0.2	0.3	0.3	2.0	3.1	42.6	51.5
551072.....	Subsoil.....	.0	.2	.2	1.6	1.9	37.9	58.7

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO_3): No. 551072, 10.59 per cent.

EMPEY SERIES.

The Empey series comprises soil types having brown to moderately light brown soils and subsoils, underlain by a mottled gray and brown to gray clay substratum. Basaltic rock is encountered at depths of 50 to 100 feet. Gravel and boulders are not typical of the series. The parent material is probably lake laid and consists of glacial or preglacial sediments derived from a wide variety of rocks.

The topography is sloping to rolling, and the drainage is adequate. The forest cover consists of tamarack and fir, with an undergrowth of brush.

The series differs from the Mission and from the Hunters series in the color of soil and subsoil. It is represented in Stevens County by a single member, the Empey silt loam.

EMPEY SILT LOAM.

The soil of the Empey silt loam is a light-brown to brown compact silt loam which becomes slightly lighter in color with depth. At about 15 inches it is underlain by a light-brown to slightly reddish brown stiff silty clay loam to silty clay. The substratum consists of mottled gray and brown to gray silty clay and extends to basaltic bedrock which is encountered at depths of 20 to 50 feet or more. The type is apparently free from glacial gravel and boulders, though a few angular fragments of quartzite are present on the surface of areas adjoining mountain slopes.

The type occupies gently sloping to rolling areas between the base of Empey Mountain and the Waits silt loam on the south and east. It is encountered about 10 miles west of Springdale. The surface drainage is good but the subsurface drainage takes place slowly, although crops do not suffer from an excess of moisture. The texture of the subsoil renders the type slightly subject to erosion.

The origin of this soil is not definitely known. The character and structure of the subsoil and substratum indicate that it is derived from lake-laid sediments. According to records of one well the underlying rock is more than 100 feet from the surface. The brown color may be due to the influence of quartzite rocks on the north.

This type differs from the Waits silt loam in its freedom from glacial cobbles and boulders and in the character of the subsoil and substratum, and also in the color of the soil and in the texture and structure of the subsoil and substratum. It differs from the Mission soils in the color of soil and subsoil.

A part of the type supports a growth of tamarack, fir, and brush. This is a strong soil and produces good yields of hay, wheat, and oats, to which quite a large part is farmed. Land values range from \$35 to \$50 an acre.

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

Mechanical analyses of Empey 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>
5510197.....	Soil.....	0.5	1.8	1.5	3.5	12.1	63.0	17.4
5510198.....	Subsoil.....	.2	1.5	1.8	3.6	11.0	61.8	20.1

HUNTERS SERIES.

The soils of the Hunters series are of grayish brown to dark grayish brown color and of moderately compact but friable structure. They are fairly high in organic matter. The subsoils are light grayish brown or yellowish brown to yellowish gray in color and similar in character to the soils. A thin stratum carrying gravel and cobbles is often encountered in the lower part of the subsoil. Boulders are practically never present. The substratum consists of light-colored stratified silts and clays. In the heavy members of the series no gravel and cobble stones occur, and the subsoil and substratum consist of a greenish-gray to drab silty clay to a depth of several feet.

The series consists of old lake sediments modified by the addition of organic matter through imperfect drainage and probably by accessions of, or the original inclusion of, material from the dark-colored upland soils usually adjoining the types of this series.

The soils of the series have a terraced topography, with gently undulating tops and steep terrace fronts. The lighter members are well drained, while the subdrainage of the heavier types is slow and restricted.

Practically all of the soil of this series is cleared, and a fairly large acreage is cultivated to fruit and hay. The soils are productive and are adapted to a variety of crops. The soils of this series are distinguished from those of the Empey and the Mission series by their predominantly darker color.

HUNTERS VERY FINE SANDY LOAM.

The soil of the Hunters very fine sandy loam is typically a medium dark grayish brown very fine sandy loam, grading below 6 to 8 inches into a lighter grayish brown very fine sandy loam which extends to a depth of 14 to 16 inches. As mapped, however, it includes minor areas in which the soil is of lighter or sandier character. The soil has a moderately compact but friable structure and a relatively high organic-matter content. To a depth of 3 feet or more the subsoil is a light yellowish brown to grayish-brown or yellowish-gray very fine sandy loam or sandy loam, lighter in texture than the soil. In places some gravel and some small cobbles are

encountered below 30 inches, and the sandy material is coarser than that above. The gravel has a white coating of limy material. The stratified deposits of silt and clay which underlie the type at depths of 4 to 10 feet, and which form the Mission clay at lower levels, are really the substratum of this series. Between the soil section and the substratum the material is fairly uniform. It contains gravel and cobbles in places.

This type occupies the highest terraces along the Columbia River in the vicinity of Hunters, Cedonia, and Bissell. One area occurs in the Colville Valley, partly within the city limits of Colville.

The Hunters very fine sandy loam is quite similar, except in color, to the loam member of the Mission series, and is derived from old lake sediments or from a thin later alluvial deposit over old lake sediments. In either case the color seems to have been influenced by material from the near-by dark-colored upland soils as well as by the accumulation of organic matter.

The surface has a terraced topography, and there are a number of draws and stream courses which have cut deeply into the underlying silts and clays, dividing into several bodies a once continuous area along the Columbia River. The drainage is well established with the exception of local seepage areas near springs.

Practically all of the type is cleared and utilized for the production of farm and orchard crops. The part in the Columbia Valley is nearly all set to orchards of apples and pears. These trees make a steady and vigorous growth. In most cases the orchards are given clean cultivation with a fine soil mulch on the surface to aid in conserving soil moisture. With proper cultivation the type holds sufficient moisture for the maturing of crops in average seasons. Potatoes give good yields. Corn, grain, and vegetables also are grown. The type is adapted to irrigation, and water is available from Hunters and Harvey Creeks. An irrigation system for lands near Hunters has been constructed. The owners do not find it necessary to use water during the entire season, but a system of irrigation protects crops from drought in unusual seasons. Alfalfa does well, and irrigation is not necessary for the first crop but greatly aids the second and third. This is a productive soil, but care is necessary not to exhaust its supply of humus and nitrogen. It requires a system of cropping which will maintain and increase the supply of these necessary elements. Crop rotations including a legume, and green-manuring crops, are beneficial. The soil is adapted to as wide a range of crops as any in the county.

The value of land of this type, exclusive of orchard tracts, ranges from \$40 to \$75 an acre. Greater distance from markets tends to lower the prices. On the basis of its productive capacity the prices would be relatively higher.

HUNTERS SILT LOAM.

The Hunters silt loam consists of a dark grayish brown to black silt loam sometimes of rather heavy character, underlain at 12 to 14 inches by a greenish-gray to drab or brown silty clay which extends to a depth of 3 feet or more. The soil has a high organic-matter content, and is sticky when moist. The subsoil is plastic when wet, and stiff and brittle when dry. The type is free from gravel and boulders.

This type is inextensive in this county. It occurs on the terrace occupied by the town of Colville. The surface is nearly level, and the type is from 20 to 25 feet above the Colville silty clay loam, which occurs in the bottom of the valley. The surface and subsurface drainage is retarded, and the area receives considerable moisture from springs on the east side of the type.

The character of the material, the topography, and the color of the subsoil indicate that the type is composed of lake-laid material deposited during glacial times and subjected to imperfect drainage conditions, which have resulted in the accumulation of organic matter in the soil.

All the type lies within the city limits of Colville, and the agriculture on it is confined to gardening. The soil is productive, and adapted to a wide range of crops.

The value of the Hunters silt loam soil depends upon the demand for town lots.

COLVILLE SERIES.

The soils of the Colville series are of dark-gray to black color and compact structure, and have a high organic-matter content. The subsoils are typically dark gray to light gray in color and are slightly plastic when wet. In places uncultivated areas have from 2 to 4 inches of partially decomposed vegetable matter on the surface. The series occupies level to very gently sloping bottoms of comparatively recent lake basins. The material probably includes some glacial sediments as well as recent sediments derived from a wide variety of rocks. In some places the soil material has been modified by recent alluvial deposits of streams traversing the valleys in which the type occurs.

The level character of the surface and the compact, heavy structure of the subsoil render the surface and the subsurface drainage slow and imperfect, and low, wet, mucky, or swampy areas frequently occur. The native forest growth consists of pine, fir, and tamarack, with an undergrowth of brush. Some areas of the series were never forested. Where drained and properly handled the soils are productive and well suited to the production of hay and grain.

COLVILLE SILT LOAM.

The Colville silt loam consists of a dark-gray to black, moderately friable silt loam, underlain at a depth of about 12 inches by a gray compact silt loam to silty clay loam which extends to a depth of 3 feet or more. In places the subsoil has a dark-brown to nearly black color. The type is free from gravel and bowlders and is rather high in organic matter.

This type occupies local basins or depressions in valleys traversing terraces or uplands, and has a fairly wide though not extensive distribution in the county. Many small areas are doubtless included with the upland glacial soils and with the silty clay loam of the Colville series.

The Colville silt loam is one of the most recently formed soils in the county, and in places it is still in process of formation. It is made up of sediments deposited in local depressions, and owes its dark color to the presence of decayed organic matter resulting from restricted drainage. The material is the result of deposition of fine material eroded from the surrounding country. Some of it may have been deposited during glacial times.

The surface of the type is level, and broken only by shallow channels usually occupied by sluggish streams. The natural drainage is slow and restricted, but has been improved by the construction of open ditches across nearly every area of the type. These assist in carrying off excess water but do not drain the areas sufficiently to insure early spring planting. It is believed that the subsoil in places carries injurious quantities of lime and alkali.

A part of the type was forested, but the greater part is now in cultivation. Hay and grain are the leading crops, and practically the only ones grown. Both produce good yields in favorable seasons. Crops seldom suffer from drought, but planting in the spring is often delayed by inadequate drainage. The use of open-ditch or tile laterals to connect with a main ditch which is deeper and wider would insure the earlier planting of crops so that there would be no danger of damage by fall frosts. The rotation of crops is needed.

The value of land of this character ranges from \$40 to \$75 an acre, depending upon its location and condition.

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

Mechanical analyses of Colville 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>
5510213.....	Soil.....	2.9	3.5	2.6	9.5	13.7	53.3	14.6
5510214.....	Subsoil.....	3.8	5.6	4.6	12.2	13.7	43.9	16.3

The following samples contained more than one-half of 1 per cent calcium carbonate (CaCO₃): No. 5510213, 26.22 per cent; No. 5510214, 25.95 per cent.

COLVILLE SILTY CLAY LOAM.

To a depth of 12 to 18 inches the soil of the Colville silty clay loam is a dark-gray silty clay loam of heavy texture, frequently approaching a silty clay. It is sticky when wet, and hard and compact when dry. The subsoil is a grayish, rather stiff clay loam or silty clay to a depth of 3 feet or more. Under certain conditions of moisture it seems to assume a granular structure. The type is practically free from glacial gravel and boulders and the organic-matter content is high. The change from soil to subsoil is abrupt.

In places in unbroken fields there is a surface layer of 2 to 4 inches of partially-decayed vegetable matter, underlain by a few inches of dark silty clay loam, resting upon the gray subsoil. In a few instances the layer of vegetable matter rests directly upon the subsoil. This layer when plowed, harrowed, and cropped becomes incorporated with the soil.

A light-colored phase of the type occurs about $1\frac{1}{2}$ miles south of Chewelah and consists of gray to dark-gray silty clay loam underlain by a gray silty clay to a depth of 3 feet or more. It is lighter colored, slightly heavier in texture, and lies a little higher than the typical soil.

The areas of the type in Camas and Walkers Prairies consist of a dark-gray to black silty clay loam which carries some mica and a few fine grains of granitic sand, underlain by a brown, compact, and stiff silty clay loam which becomes lighter colored with depth. This rests upon the gravelly substratum of the Springdale series at depths of from 5 to 10 feet. This phase has been formed in a depression on the terrace and shows modification by local material. Chamokane Creek disappears under the surface of the type for a large part of the year. In the Camas Prairie the Colville silty clay loam has a dark-colored subsoil which is underlain by a dark-colored substratum. It does not overlie gravel so far as known. Small strips of Muck are included with the type as mapped on this prairie.

The type occupies flat areas of bottom land in the Colville Valley between Meyers Falls and Gray. It occurs in the Chamokane Valley in Camas and Walkers Prairies.

The Colville silty clay loam consists of comparatively recent lake-laid sediments which were deposited in temporary shallow basins in the Colville and Chamokane Valleys. This material was derived from a variety of sources, but is mainly the result of erosion of the mantle of glacial till and of the rocks in the basins of the streams tributary to the main valley. A part of the component material was probably derived from glacial sediments. Immediately adjoining the banks of the Colville River, which traverses the type, there have been

in places slight additions of alluvial material. That this is not universal is indicated by the presence in places of the superficial vegetable layer close to the banks of the river.

Material has also been deposited over the surface of the type in some places as alluvial-fan sediments by streams from the uplands. The largest of these have been mapped as distinct types, but there are small and shallow ones which are not differentiated. In some cases the sediment has been carried beyond the margin of the real fan and deposited over the type.

A more or less continuous area extends from Valley to north of Colville, a distance of more than 25 miles. The elevation at the former place is 1,670 feet and at the latter 1,580 feet, making a fall of 90 feet in about 25 miles. The Colville River formerly followed a somewhat meandering course across this part of the type. Its course has been straightened by dredging, and drainage of the type thereby greatly benefited. A large acreage, which was formerly covered with water until late summer and produced only a rank growth of coarse grasses and tule, in one season has produced sufficient returns to pay for the cost of dredging. The drainage is still restricted and inadequate for the best results. The dredging has greatly reduced the overflow of the Colville River, but does not provide outlets for the smaller tributary streams and springs. The construction of laterals or, if necessary, ditches parallel to the main channel would provide better drainage and permit the earlier seeding of crops, thus decreasing the danger of loss or damage of crops by frosts. The soil is doubtless in need of lime. The white spots commonly observed do not indicate alkali, but the nearness of the gray subsoil.

The greater part of the type is under cultivation to hay and grain. The remainder is used for wild hay or for pasturage. Very little of the type was originally forested.

Oats make a rank growth of straw and often lodge badly. The yields range from 85 to 125 bushels per acre, depending upon the season and the length of time the land has been used. Timothy is either sown with the grain crop or without a cover crop in the fall. The yields vary from 1 to 3 tons of hay per acre. In places the stand continues good for several seasons; in others the frost heaves the roots out of the ground and the field must be reseeded. Alfalfa, corn, and wheat are not grown on this type. Spring plowing and seeding is sometimes delayed as late as the first two weeks in July. Late-sown crops are injured by early fall frosts in some seasons. If possible the land is plowed in the fall for spring grain and seeded as early as the soil is sufficiently drained. Oats are seldom cut for hay. Lateral ditches or tiles are needed in order to properly drain the type.

Land values of this type have advanced rapidly since the dredging of the river channel. Well-improved land is valued at \$50 to \$100 an acre, depending upon location and character of farm buildings.

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

Mechanical analyses of Colville silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
551093.....	Soil.....	0.1	1.0	1.2	4.2	4.8	58.2	30.5
551094.....	Subsoil.....	.0	.8	2.7	5.6	5.0	57.1	28.4

EOLIAN OR WIND-LAID SOILS.

MARBLE SERIES.

The Marble series includes soil types of wind-blown or eolian origin and consists of outwash, lake, or river terrace material which has been transported, rearranged, or modified by winds. Both soil and subsoil are of yellowish-brown to light grayish brown color, have a porous structure, and are free from gravel and boulders. The parent material is derived from a wide variety of rocks. The surface is of undulating to hummocky character and is protected from drifting by native grasses. No extensive areas of the series are under cultivation, but with proper management crops on small areas indicate that the soils are fairly productive where protected from drifting. Subdrainage is excessive in the types thus far encountered, and as a rule the soils require irrigation, for which the surface is not naturally suited without extensive leveling. The humus or organic-matter content is low.

MARBLE SAND.

The Marble sand is a yellowish-brown to light grayish brown, loose, porous sand. There is little or no variation in color, structure, or texture to a depth of several feet. The immediate surface often has a rather dark gray color, due to a slight increase in the normally low organic-matter content. The type is free from gravel and boulders.

This type occupies portions of terraces in the Colville-Chamokane and Columbia River Valleys. Its total area is comparatively small. Bodies of the type occur southwest of Ford and along the Spokane River southwest of Wellpinit. The latter areas have a slightly darker soil on account of a small quantity of included basaltic sand grains. Other areas are encountered in the extreme southwestern part of the county along the Columbia River. The Marble sand con-

sists mainly of quartz sand of different grades, which has been reworked by eolian agencies subsequently to its deposition as the surface stratum of outwash or lake-laid terraces.

The surface is hummocky to choppy, and the porous character of the type and its substratum favor naturally rapid and excessive drainage.

The type supports a scattered growth of yellow pine, with buckbrush and native grasses. It is not cultivated to farm crops. The soil is not retentive of moisture. This deficiency must be minimized, preferably by increasing the organic-matter content through the use of stable and green manures, before profitable crops can be produced. It is believed, however, that irrigation is necessary to the successful farming of this soil, and the labor and cost of leveling for irrigation may prevent the agricultural development of the greater part of the type. Areas of favorable topography could be prepared at a relatively low cost. Water for irrigation is not readily available. Under irrigation land of this kind should be adapted to alfalfa, certain vegetables, and fruit.

With adjoining types this soil is valued at \$25 to \$40 an acre.

MARBLE FINE SAND.

The Marble fine sand consists of a yellowish-brown to light grayish brown or yellowish-gray loose, incoherent fine sand, which shows practically no variation in color, structure, or texture to a depth of 3 feet or more. It has a low organic-matter content and is underlain by a sandy substratum which extends to a depth of several feet.

The type occupies areas of undulating to hummocky topography on terraces in the Columbia and Colville River Valleys. A typical sand-dune topography is unusual. The soil absorbs surface water freely and the subsoil and substratum afford good to excessive under-drainage.

The reworking of sandy terrace deposits by wind action has resulted in the formation of this type. The material consists of either lake-laid sediments or river deposits. The character of the type seems to be the same in either case. The largest area lies a little west of the town of Meyers Falls.

The type supports a growth of buckbrush and native grasses, which prevent drifting. The forest cover consists of a scattering of yellow pine. For the most part the type is not under cultivation.

An area near Marble has been cleared and set to fruit trees, and intertilled crops are grown with good results. With proper management to prevent blowing and to conserve moisture, the cultivation of the type is practicable. Careful attention is required in maintaining and increasing the organic-matter content of cultivated areas by the

use of manure and green-manuring crops, in order to increase crop yields, to conserve the moisture, and to prevent the drifting of the soil. Frequent cultivation during the summer months to conserve all the moisture possible, and the growing of legumes to increase the nitrogen content are beneficial. The chief problem is to prevent the drifting of the surface. The moving sand quickly cuts the tender growing crops or covers them too deeply for future growth. On the other hand, this constant shifting of the surface forms a dry mulch which aids in retaining moisture. On the whole, however, the best practice is to keep the surface covered with crops during as much of the windy season as possible, or to scatter straw or similar material over it.

The greater part of the type requires irrigation for profitable yields, but the surface features require almost prohibitive outlays for leveling, under present conditions.

This land is held, in connection with adjoining soils, for prices ranging from \$25 to \$75 an acre.

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

Mechanical analysis of Marble fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551047.....	Soil.....	0.0	1.2	14.7	68.4	12.9	2.1	1.0

SOILS OF THE ALLUVIAL FANS AND FOOTSLOPES.

CHEWELAH SERIES.

The soils of the Chewelah series are derived from alluvial-fan deposits which have been distributed by minor streams over comparatively recent sediments occupying basins of recent lakes. The soils are derived from a variety of materials, including glacial till and glacial terrace deposits and representing in mineral character a wide range of rocks. The soils are of dark grayish brown to black color and have a high organic-matter content. The subsoils are of grayish color and friable structure and are underlain by a substratum of sands or of lake sediments.

The surface is smooth and very gently sloping. The fans are comparatively broad, are traversed by several streams, and frequently have a high water table, owing to influence of surface or seepage waters from the adjoining uplands. The internal drainage is slow.

The larger part of the single soil type representing this series in Stevens County is under cultivation. The soil is productive and well adapted to such crops as grain and hay.

CHEWELAH SANDY LOAM.

The Chewelah sandy loam consists of a dark grayish brown to black friable sandy loam to a depth of 10 to 14 inches, underlain by a light-gray to gray loamy sand to sandy loam to a depth of 3 feet or more. The soil has a friable structure and a high organic-matter content. The subsoil is of porous, friable structure and is underlain by a substratum of sands and lake sediments.

The soil of this type varies slightly in texture, grading from a sandy loam near the stream channels to a silt loam near the outer boundary of the areas. It adjoins areas of Peat, and in places has a thin layer of peaty material on the surface. The subsoil material varies from coarse to fine, and in places it is quite near the surface.

The largest area of the Chewelah sandy loam is near the town of Chewelah. Another area occurs near the junction of the Mill Creek and Colville River Valleys, and other bodies occur in various parts of the Colville Valley. Some of these are not shown separately on the map because of their small extent.

The type is an alluvial-fan deposit distributed by streams over comparatively recent lake sediments. Glacial till and terrace deposits have contributed the greater part of the material of the type. Granitic material is prominent.

The fans are low and broad and have a very gently sloping surface. They are traversed by several streams, only the larger of which are perennial. The streams flow in rather shallow channels and the water table is fairly close to the surface. The drainage ranges from deficient to adequate. Although crops seldom suffer from drought, some areas are in need of artificial drainage.

Practically all the type has been cleared and is farmed to hay and grain. Timothy yields from 1 to 3 tons per acre, oats from 50 to 75 bushels, and wheat from 25 to 40 bushels per acre. This soil is regarded as productive and desirable for general farm crops. Irrigation is practicable but is not essential for profitable yields. The outlying areas would be benefited by open or tile drainage. The type does not warm up early in the spring on account of slow drainage.

The value of the type ranges from \$25 to \$100 an acre. The higher prices are for land immediately adjoining the town of Chewelah.

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

Mechanical analysis of Chewelah sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
5510101.....	Soil.....	<i>Per cent.</i> 6.2	<i>Per cent.</i> 11.8	<i>Per cent.</i> 9.6	<i>Per cent.</i> 19.8	<i>Per cent.</i> 16.6	<i>Per cent.</i> 27.1	<i>Per cent.</i> 9.3

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO_3): No. 5510101, 0.65 per cent.

SOILS OF THE RECENT RIVER FLOOD PLAINS.

CHAMOKANE SERIES.

The soils of the Chamokane series are brown to light brown in color and are underlain by light-brown or yellowish-brown subsoils. The gravel content is usually fairly high in the soil, subsoil, and substratum. Boulders occur infrequently. These soils are formed mainly of reworked glacial till derived from a wide variety of rocks, not including granite. They are recent alluvial in origin, but have been modified somewhat locally by the admixture of colluvial material along steep slopes. The types occupy first bottoms along small streams traversing the glaciated uplands and are subject to overflow during high-water stages.

The types occupy narrow strips which slope gently in the direction of the stream flow. The drainage ranges from poor to good. It is in general well established, but lower-lying areas are subject to overflow. The forest growth consists of pine, fir, and tamarack with an undergrowth of brush. The soils are productive and are adapted to a wide range of crops, including hay, grain, and vegetables.

CHAMOKANE LOAM.

The soil of the Chamokane loam consists of a brown to dark grayish brown loam to heavy loam, extending to a depth of 12 inches. It is underlain by a brown or light-brown loam to gravelly loam extending to a depth of 3 feet or more. The soil is moderately friable, has a medium organic-matter content and often carries small quantities of both rounded and angular gravel.

This type is inextensive, though widely distributed. It occupies narrow areas along some of the larger tributaries of the Columbia, Colville, and Spokane Rivers. Many of these are too narrow or too small to show on the soil map and are included as undifferentiated material with the adjoining upland types. Such areas, however, are from 1 to 8 or 10 acres in extent and are often important agriculturally.

The material is derived mainly from sediments deposited by the streams along which the type is mapped. These sediments are largely the result of erosion of the types of the Waits series. There are some small, local accumulations of colluvial material.

The surface has a gentle slope in the direction of stream flow and is traversed by shallow stream channels. The drainage is usually well established, although some areas are subject to short periods of overflow in the spring months. Some of the streams are intermittent, others perennial.

The type supports a thick growth of tamarack, fir, spruce, pine, and brush. Cleared areas are farmed to hay, grain, and alfalfa with good results. Crops seldom suffer from drought, and irrigation is not

necessary in average seasons. Fields are rarely composed wholly of this type, and estimates of crop yields can not be given. The value of this land ranges from \$10 to \$40 an acre.

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

Mechanical analysis of Chamokane loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
551099.....	Soil.....	4.0	3.9	2.1	11.8	21.8	42.2	14.3

CHAMOKANE SILT LOAM.

The Chamokane silt loam consists of a light-brown silt loam, 10 to 12 inches deep, underlain by light-yellowish to light grayish brown silt loam or silty clay loam. The soil is sticky when wet and has a moderately high organic-matter content. The subsoil ranges from friable to compact in structure. The type in places contains some angular gravel.

This type occupies the first bottoms along creeks which receive drainage water mainly from the areas covered by the soils of the Waits series.

The type has a level surface, and is dissected by stream channels. The drainage is often sluggish. During periods of high water the streams sometimes overflow.

A thick forest growth covers much of the type. Small fields are cleared and farmed to hay. Timothy gives heavy yields of a good quality of hay. Land of this type is valued at \$10 to \$40 an acre.

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

Mechanical analyses of Chamokane 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>
5510119.....	Soil.....	1.2	2.1	1.2	4.1	15.1	60.3	16.2
5510120.....	Subsoil.....	.6	1.4	1.1	5.0	16.5	60.1	15.2

NARCISSE SERIES.

The Narcisse series includes gray to dark-gray soils with light-gray or light brownish gray subsoils. The types are practically free from gravel and boulders, have a fairly open structure, and a relatively high organic-matter content. They are alluvial in origin, formed by the reworking of material from granite-bearing glacial till.

The soils are level and rather poorly drained on account of their low topographic position. Fir, tamarack, pine, and brush constitute the native growth. These soils are inextensive. They are farmed to hay and grain.

NARCISSE FINE SANDY LOAM.

The Narcisse fine sandy loam consists of a gray to dark-gray fine sandy loam, underlain at a depth of 10 to 12 inches by a compact light brownish gray fine sandy loam to fine sand which extends to a depth of 3 feet or more. As mapped it may include unimportant areas in which the soil material approaches a sandy loam or coarse sandy loam in texture. The soil is fairly high in organic matter and has a friable structure. The substratum is similar in character to the subsoil. The type is free from gravel and boulders, but carries noticeable quantities of mica.

This is an inextensive soil type. It occupies the first bottoms of streams traversing areas of granitic bedrock, particularly Narcisse Creek and Little Pend d'Oreille River. One area is encountered south of Clayton. The material is derived from soils of the Loon and Stevens series and in part from the underlying granite.

The type lies only slightly above the normal stream level, has a fairly smooth topography, and is subject to overflow at flood seasons.

The forest growth is mainly fir, tamarack, and pine, with a growth of underbrush. Portions of the type are farmed to hay and grain with fair results.

The value of the type depends on that of the adjoining types, and ranges from \$10 to \$40 an acre.

SOILS DERIVED FROM ORGANIC ACCUMULATIONS.

MUCK AND PEAT.

The growth and decay of water-loving vegetation flourishing in poorly drained areas gradually forms an accumulation of more or less decomposed organic matter, which when only partially decomposed and practically free from mineral matter is classed as Peat, and when quite thoroughly decomposed and modified by additions of mineral matter is classed as Muck. The former has a brownish color and a tough, fibrous structure, while the latter is usually dark gray to black in color and friable in structure. In the survey of this county Muck and Peat are not separated.

The type as mapped has quite a wide distribution as small bodies, from a few acres to more than 200 acres in extent, occupying basins in nearly all parts of the glaciated uplands of the county. It also occurs as long, narrow areas in old glacial stream valleys where it is the indirect result of restricted drainage. The most extensive area

is in the Colville Valley between Gray and Chewelah, a continuous body nearly 9 miles in length. The greater part of this area more closely resembles Peat than Muck. In breaking the land in this area a fine white substance is often exposed, and in harrowing a dry surface a cloud of white dust rises. The strata of this white material are seldom an inch in thickness and are not continuous for any great distance. It appears to be the same as the white layer found in other soils in the vicinity, and is thought to be volcanic ash. Other fairly large areas of Muck and Peat occur in the Cedar-Deep Creek Valley, at the head of Deer Lake, on the Haviland Meadows and along the middle course of Little Pend d'Oreille River. Still other areas have resulted from similar accumulations in swampy places near old beaver dams and are locally known as "beaver-dam land." The latter are characterized by the presence of limbs and trunks of trees as well as stumps.

The term "meadow" is locally applied to land of this type. The material varies in depth as well as in character, and as far as known is underlain at 18 inches to 6 feet by a bluish, plastic clay, in which small shells are sometimes found.

In its natural state the type produces a rank growth of coarse grasses, tule, and mosses. As a rule the timber growth consists only of a few small willows. An area east of Northport supports a growth of cedars of large size.

Undrained and unimproved land of this kind is used for the cutting of wild grasses for hay and also affords a natural harbor for wild water fowl and some fur-bearing animals. The hay is of rather poor quality and has a low market value. Artificial drainage is necessary for successful crop production on this type. In small areas this may be accomplished by individual effort, but over large areas it can best be done by cooperation of the land owners. Through the formation of drainage districts the large area in the Colville Valley has been drained by dredging and straightening the river channel. In most cases the cost of this improvement was paid by the first crop produced on the reclaimed land. Drainage can be rendered most effective by the construction of open or tile laterals.

Where drained the type is farmed to hay and grain. Good yields are reported, but the feeding quality is often not equal to that of the same crops grown on hard land. The development of the type in this county has taken place in the last three or four years, and much of it is still in its natural state. Yields exceeding 100 bushels of oats or 4 tons of hay per acre are reported. For the first few breakings the peat land is rather difficult to plow, but the labor decreases with succeeding cultivations. The practice of burning off land of this character is wrong. It destroys much vegetable matter and tends to leave only ashes to incorporate with the underlying refractory clay to form a

soil. Clover and alfalfa are not grown. Good yields of cabbage are produced.

Improved land of this kind is valued at \$50 to \$100 an acre. Unimproved land in connection with other types sells for \$25 to \$50 an acre.

MISCELLANEOUS, NONAGRICULTURAL MATERIAL.

ROUGH MOUNTAINOUS LAND.

Extensive areas of undifferentiated soils, occupying rough and hilly portions of the county, are classed as Rough mountainous land. This comprises areas of varied topographic, soil, and rock conditions and includes areas of rough stony land mainly of certain types of the Stevens and Waits series, with smaller areas of residual soils. In a more detailed survey many of these areas might be differentiated and mapped under the proper series and types.

This class of land occupies in part some of the highest mountain ridges and peaks, the upper portions of which are at an altitude too high for successful farming even if other conditions were favorable. The remainder occupies hill and valley slopes, varying in extent, where agriculture is possible but where there has not yet been any marked agricultural development. Much of the area mapped as Rough mountainous land has been taken up as homesteads and farming operations are conducted in small clearings.

In many instances this type of soil though deep enough is too steep for continuous cultivation. In others where the topography is favorable the soil is too stony or too shallow for growing profitable crops.

There is a forest cover, ranging from thick to scattered, of fir, tamarack, cedar, and brush. Much of this timber is quite valuable but at present is inaccessible. The less stony and rugged areas are best devoted to dairying and to cattle raising. By clearing a sufficient acreage to provide forage for the winter, the remainder of the farms could be used for grazing. Other areas of this land are suitable only for forestry.

ROUGH STONY LAND.

Rough stony land comprises those areas having such a rough or stony character that their development for farming is practically impossible. It includes both glacial and residual material from a variety of sources. The rock content consists of loose fragments on the surface and outcrops of bedrock.

The rock outcrop is more abundant and the topography more diversified than in any of the soil types in the county. In occasional small areas the topography and character of the soil would permit farming. Such areas are isolated and, being located at quite an elevation between larger areas of Rough stony land, are quite inaccessi-

ble. The soil occurs in pockets and is often shallow and stony. The pockets vary from a fraction of an acre to several acres in extent.

There are occasional small clearings where homesteads have been located on this kind of land. It furnishes grazing for a few cattle and sheep. The greater part of it is covered with a scattered to moderately thick growth of pine, fir, tamarack, and underbrush. On the higher elevations and stony slopes the forest growth is small and scattering. Forest fires have destroyed large areas of the timber.

ROCK OUTCROP.

Rock outcrop includes barren rocky slopes, hills, and cliffs, which are practically devoid of soil and of forest growth. Such areas are widely distributed over all the uplands of the county, and occur mainly within or near areas of Rough stony land or of Rough mountainous land. Many of them are too small to be shown separately on the soil map. They occur mainly in the Columbia Valley in the northern part of the county as barren hills and cliffs. This land has practically no value for farming or grazing purposes. Some small areas support a scant growth of timber.

RIVERWASH.

Riverwash comprises areas of gravel and cobbles which have very little fine material and are overflowed during high water stages of the rivers. The material is similar to that of the substrata of the types of the Springdale series and was deposited by moving water.

Areas of Riverwash occupy low-lying positions along the Columbia River, usually from 5 to 15 feet above its normal level. They are traversed by sloughs and channels which are filled with water during flood periods. Some of the areas are mapped on flats along the river in the vicinity of Hunters and Gerome, and others, too narrow or too small to be shown on the map, occur in various places along the Columbia River and are included with the adjoining soil type. At low stages of the river there is a larger total area of this material.

Riverwash is practically devoid of vegetation, and has no agricultural value.

CHEMICAL ANALYSES OF SOILS.¹

In order to correlate the work of the present area with other areas surveyed and to gain more complete data regarding the soils of the area, representative samples of the principal types found were sent to the University of Washington for chemical analysis.

It has come to be generally recognized that the mineral elements in the soil which are of the most interest to the agriculturalist are

¹ Prepared by Fred W. Ashton, of the Washington Geological Survey. The chemical work was done entirely by the State of Washington. The Bureau of Soils claims no credit therefor, and assumes no responsibility for the conclusions.

calcium, potassium, phosphorus, and nitrogen. For technical reasons, which need not be explained here, these are generally spoken of as lime (CaO), potash (K₂O), phosphoric acid (P₂O₅), and nitrogen (N), which is sometimes called ammonia. The last is undoubtedly present in the soil in various combinations, as are also calcium, potassium, and phosphorus. Nitrogen, potash, and phosphoric acid are the constituents which it is sought to add to the soil in commercial fertilizers, calcium going in incidentally as a carrier of phosphoric acid and sometimes of nitrogen. Lime, gypsum, ground limestone, etc., are, however, regarded as a fertilizer by most farmers. The role of lime in the soil will be briefly referred to presently. Other mineral elements are undoubtedly needed by growing plants, but they have been considered always abundantly present in the soil and to have no great importance in fertilizer practice, although the chemical, physical, and physiological action of these in the soil and in the plant furnish a wide field for investigation.

The action of the lime is probably quite complex in most cases, neutralizing any acids which may be present, inducing a much better flocculation or crumbling of the soil, and improving its tilth, aeration, etc., which functions are most important for the growth of desirable kinds of bacteria in the soil, and especially those which gather nitrogen from the air and grow in "symbiosis," or association, with certain leguminous crops, as alfalfa, the clovers, peas, etc. Moreover, it is possible that lime may have a specific effect on some plants, and it is held by many fruit growers that an ample quantity of lime will cause the production of sweeter fruit. The formation of humus in the soil from the organic remains of plants or other organisms is supposed to be facilitated by lime, and this view is supported by the figures in the following analyses:

Effect of lime on the formation of humus.

Type.	Lime.	Phosphoric acid.	Potash.	Loss on ignition.	Humus.	Lime requirement.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sand.....	0.08	0.10	0.10	2.51	0.25	0.0214
Sandy loam.....	.54	.24	.52	7.96	3.68	.0114

Potash is largely active in the production of stem and is believed to be of special importance in the production of starch in the growing plants, and phosphoric acid to be important mainly in the formation of seeds or grain, although undoubtedly having other functions in the growing plants. Nitrogen is believed to be taken from the soil mainly in the form of nitrates. It is especially active in the production of foliage and is elaborated or made over in the plant

into various substances, especially the proteids—substances which are best known in the muscular tissues of animals. No substance in the soil produces a more rapid or decided response in the crop than does nitrogen. A ready supply of nitrates is of the utmost importance to green crops, especially during the periods of most rapid growth, and it is desirable to have nitrogenous organic substances in the soil to furnish nitrates by the process of decay, especially for plants other than leguminosæ, and even for these a small quantity of available nitrogen is considered advantageous in the early stages of growth.

In these analyses the methods used were those followed in previous years in the same laboratory. They follow closely those of the Association of Official Agricultural Chemists as found in Bulletin 107, Revised, U. S. Department of Agriculture, with only slight variations which our experience seems to justify.

Lime (CaO), potash (K_2O), phosphoric acid (P_2O_5), and nitrogen (N) were determined. In addition a determination of the loss on ignition as a clue to the quantity of organic matter in the soil was made. Objection is often made to this latter determination on account of the fact that the presence of limestone (CaCO_3) or moisture in the soil may cause rather wide variations, yet the results obtained seem to have justified its use. Since practically none of the soils of the types here represented are acid, the "lime requirement" as determined in previous years was omitted.

The results given below are based on analyses of the fine earth, that passing through a 1 mm. sieve only, but since the samples analyzed were duplicates of those of which mechanical analyses were made by the Bureau of Soils, reference to their results tabulated under the descriptions of the various types will show the relation between the chemical analyses of sample and the soil as it occurs in the field. To facilitate this reference, the numbers of the corresponding bureau samples are given in the column headed "Field numbers."

Chemical analyses of soil types in Stevens County, Wash.

Number.		Type.	Location.	Lime (CaO).	Phos- phate (P ₂ O ₅).	Potash (K ₂ O).	Nitrogen (N.).	Loss on ignition.
Lab.	Field.							
1	551085	Stevens silt loam.....	NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 28, T. 30 N. R., 37 E.....	1.71	0.16	0.62	0.35	8.27
2	5510178	Stevens silt loam, limestone phase.....	NW. $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 27, T. 35 N., R. 39 E.....	1.38	.29	.55	.13	13.76
3	551061	Stevens silt loam.....	NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 11, T. 38 N., R. 37 E.....	1.71	.29	.43	.58	21.17
4	5510161	Stevens gravelly loam.....	NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 33, T. 30 N., R. 37 E.....	.89	.18	.38	.16	7.95
5	5510163	Stevens gravelly loam.....	SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 20, T. 32 N., R. 38 E.....	1.06	.31	.49	.20	9.39
6	551019	Waits silt loam.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 33, T. 30 N., R. 42 E.....	.54	.14	.36	.03	5.35
7	5510107	Waits silt loam.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 19, T. 33 N., R. 41 E.....	.71	.21	.31	.07	6.90
8	551039	Waits fine sandy loam.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 16, T. 34 N., R. 38 E.....	.55	.40	.11	.06	7.08
9	5510123	Waits silt loam.....	SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 14, T. 32 N., R. 39 E.....	.74	.20	.32	.11	8.73
10	5510147	Waits loam.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 20, T. 31 N., R. 41 E.....	.59	.14	.25	.09	8.57
11	551035	Waits silt loam, heavy phase.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 16, T. 34 N., R. 39 E.....	.71	.18	.31	.11	8.63
12	5510127	Waits silt loam, heavy phase.....	NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 3, T. 32 N., R. 38 E.....	.74	.14	.42	.09	8.06
13	5510181	Waits sandy loam.....	SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 25, T. 35 N., R. 39 E.....	1.04	.20	.62	.13	8.15
14	5510109	Stevens loam.....	NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 35, T. 35 N., R. 40 E.....	.87	.21	.41	.20	11.77
15	551011	Loon sandy loam.....	SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 24, T. 28 N., R. 41 E.....	.45	.17	.30	.04	3.98
16	5510113	Loon sandy loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 8, T. 35 N., R. 41 E.....	.52	.49	.18	.04	5.22
17	5510115	Loon sandy loam.....	NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 27, T. 35 N., R. 41 E.....	.58	.35	.12	.05	6.83
18	551009	Loon fine sandy loam.....	NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 25, T. 29 N., R. 41 E.....	.49	.39	.33	.06	7.45
19	551029	Loon fine sandy loam.....	SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 35, T. 29 N., R. 41 E.....	.55	.38	.23	.08	10.63
20	551089	Hesseltine silt loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 2, T. 29 N., R. 39 E.....	.66	.16	.32	.07	10.67
21	5510141	Hesseltine silt loam.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 8, T. 30 N., R. 40 E.....	.48	.27	.24	.09	8.22
22	551063	Huckleberry silt loam.....	NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 3, T. 31 N., R. 38 E.....	.51	.12	.25	.10	8.07
23	551053	Moscow sandy loam.....	SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 19, T. 28 N., R. 41 E.....	.60	.15	.80	.05	5.29
24	551001	Clayton fine sandy loam, heavy phase.....	SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 2, T. 28 N., R. 41 E.....	.41	.31	.20	.04	5.83
25	551003	Clayton sandy loam.....	NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 18, T. 28 N., R. 42 E.....	.49	.18	.24	.04	3.39
26	551005	Clayton fine sandy loam.....	NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 1, T. 28 N., R. 41 E.....	.30	.25	.23	.04	5.41
27	551007	Clayton fine sandy loam, light phase.....	SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 6, T. 28 N., R. 42 E.....	.30	.13	.30	.03	4.09
28	551049	Garrison sandy loam, alluvial-fan phase.....	NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 10, T. 34 N., R. 39 E.....	.52	.12	.16	.03	2.27

29	551013	Garrison sandy loam, alluvial-fan phase.....	SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 9, T. 28 N., R. 40 E.....	.64	.17	.07	.10	7.24
30	5510131	Garrison sandy loam, alluvial-fan phase.....	NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 9, T. 28 N., R. 40 E.....	.87	.21	.04	.21	9.06
31	551043	Springdale loam, alluvial-fan phase.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 9, T. 34 N., R. 39 E.....	.54	.13	.23	.06	7.13
32	5510133	Garrison gravelly sandy loam, alluvial-fan phase.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 26, T. 31 N., R. 40 E.....	.43	.14	.15	.08	6.93
33	5510147	Garrison sandy loam, alluvial-fan phase.....	NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 11, T. 32 N., R. 40 E.....	.40	.27	.06	.15	11.40
34	5510135	Garrison gravelly fine sandy loam, alluvial-fan phase.....	NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 13, T. 33 N., R. 39 E.....	.57	.10	.11	.20	10.75
35	5510201	Waterloo gravelly loam, alluvial-fan phase.....	NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 32, T. 39 N., R. 39 E.....	.34	.17	.24	.09	5.65
36	5510101	Chewelah sandy loam.....	NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 13, T. 32 N., R. 40 E.....	1.05	.11	.10	.23	10.74
37	551099	Chamokane loam.....	NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 10, T. 31 N., R. 41 E.....	.67	.18	.22	.19	12.61
38	5510119	Chamokane silt loam.....	NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 5, T. 32 N., R. 39 E.....	.45	.16	.31	.01	9.16
39	551095	Springdale sand.....	SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 1, T. 27 N., R. 39 E.....	.46	.06	.22	.02	3.25
40	551097	Springdale sand.....	NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 1, T. 27 N., R. 39 E.....	.38	.09	.36	.01	2.80
41	551059	Springdale loam.....	NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 16, T. 27 N., R. 41 E.....	.43	.08	.29	.03	4.80
42	5510151	Springdale coarse sandy loam.....	NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 11, T. 37 N., R. 38 E.....	.56	.18	.20	.05	4.98
43	5510153	Springdale coarse sandy loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 6, T. 36 N., R. 39 E.....	.57	.17	.17	.03	4.60
44	5510165	Springdale gravelly sandy loam.....	SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 14, T. 30 N., R. 40 E.....	.38	.12	.16	.07	5.90
45	5510171	Springdale gravelly sandy loam.....	SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 10, T. 35 N., R. 39 E.....	.59	.17	.23	.04	4.80
46	551017	Springdale gravelly sandy loam.....	NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 5, T. 27 N., R. 40 E.....	.46	.05	.30	.02	3.72
47	551057	Springdale coarse sandy loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 9, T. 27 N., R. 41 E.....	.39	.06	.16	.04	4.20
48	551024	Springdale gravelly silt loam.....	NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 28, T. 29 N., R. 40 E.....	.49	.21	.29	.13	11.10
49	551015	Springdale loam.....	SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 14, T. 28 N., R. 39 E.....	.64	.13	.27	.07	9.05
50	551069	Springdale loam.....	NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 28, T. 30 N., R. 41 E.....	.37	.24	.22	.09	9.40
51	5510105	Springdale gravelly sandy loam.....	NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 13, T. 27 N., R. 40 E.....	1.03	.08	.45	.06	6.35
52	5510103	Springdale gravelly sandy loam.....	SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 7, T. 27 N., R. 40 E.....	.61	.06	.40	.05	5.59
53	5510195	Springdale gravelly silt loam.....	SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 17, T. 27 N., R. 40 E.....	.49	.09	.63	.16	8.05
54	551081	Waterloo loam.....	SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 31, T. 31 N., R. 38 E.....	.37	.16	.31	.18	10.22
55	551091	Waterloo gravelly loam.....	SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 20, T. 30 N., R. 37 E.....	.59	.12	.51	.16	7.05
56	5510175	Garrison loam.....	SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 34, T. 36 N., R. 39 E.....	.97	.19	.24	.18	10.21
57	5510170	Garrison gravelly loam.....	NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 30, T. 35 N., R. 40 E.....	1.05	.20	.36	.29	12.92
58	5510173	Garrison gravelly loam.....	NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 11, T. 35 N., R. 39 E.....	.71	.20	.18	.04	11.84
59	551083	Garrison silt loam.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 31, T. 35 N., R. 40 E.....	.92	.21	.33	.20	9.62
60	5510157	Garrison sandy loam.....	SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 18, T. 34 N., R. 40 E.....	.51	.12	.28	.07	3.50
61	551087	Stevens loam.....	NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 18, T. 29 N., R. 37 E.....	.69	.16	.30	.09	7.46
62	5510196	Springdale silt loam.....	SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 36, T. 30 N., R. 36 E.....	.58	.07	.43	.07	6.17

Chemical analyses of soil types in Stevens County, Wash.—Continued.

Number.		Type.	Location.	Lime (CaO).	Phos- phate (P ₂ O ₅).	Potash (K ₂ O).	Nitrogen (N.).	Loss on ignition.
Lab.	Field.							
63	5510197	Empey silt loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 28, T. 30 N., R. 39 E.....	0.64	0.14	0.40	0.13	9.32
64	5510143	Waits silt loam, dark phase.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 32, T. 28 N., R. 40 E.....	.62	.16	.39	.16	8.90
65	5510137	Waits silt loam.....	NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 16, T. 28 N., R. 38 E.....	.40	.08	.23	.09	7.21
66	551073	Hunters very fine sandy loam.....	SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 12, T. 30 N., R. 36 E.....	.72	.19	.29	.20	6.17
67	551075	Hunters very fine sandy loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 7, T. 30 N., R. 37 E.....	.81	.16	.35	.14	7.26
68	551023	Marble sand.....	SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 23, T. 28 N., R. 39 E.....	.25	.07	.12	.03	2.34
69	551025	Marble sand.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 28 N., R. 38 E.....	.34	.07	.27	.04	3.25
70	551047	Marble fine sand.....	SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 4, T. 37 N., R. 38 E.....	.33	.13	.06	.04	1.90
71	5510212	Marble fine sand.....	NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 32, T. 39 N., R. 39 E.....	.43	.08	.15	.06	4.00
72	5510211	Marble fine sand.....	NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 32, T. 39 N., R. 39 E.....	.53	.12	.16	.04	2.84
73	5510117	Narcisse fine sandy loam.....	SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 23, T. 35 N., R. 41 E.....	.58	.08	.21	.14	7.47
74	551048	Springdale gravelly coarse sand.....	SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 12, T. 36 N., R. 37 E.....	.59	.19	.12	.23	8.08
75	551067	Springdale gravelly coarse sand.....	SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 15, T. 29 N., R. 35 E.....	.52	.13	.09	.10	6.42
76	551041	Springdale fine sandy loam.....	SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 32, T. 38 N., R. 38 E.....	.58	.19	.14	.09	5.42
77	551065	Springdale fine sandy loam.....	SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 9, T. 37 N., R. 38 E.....	.60	.22	.16	.13	8.99
78	5510222	Springdale fine sandy loam.....	SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 2, T. 37 N., R. 37 E.....	.76	.23	.29	.06	3.41
79	5510225	Springdale fine sandy loam.....	SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 34, T. 36 N., R. 37 E.....	.57	.59	.21	.06	3.42
80	551046	Springdale fine sandy loam.....	NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 1, T. 36 N., R. 37 E.....	.59	.30	.13	.06	3.40
81	551021	Springdale fine sandy loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 27, T. 27 N., R. 38 E.....	.64	.12	.23	.10	4.90
82	5510155	Springdale sand.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 5, T. 38 N., R. 39 E.....	.41	.64	.05	.08	5.03
83	5510229	Springdale fine sand.....	SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 28, T. 35 N., R. 37 E.....	.46	.13	.19	.05	2.94
84	551071	Mission clay.....	SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 11, T. 33 N., R. 39 E.....	.48	.12	.61	.12	7.74
85	551079	Mission clay.....	SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 12, T. 30 N., R. 36 E.....	1.12	.20	.07	.01	9.37
86	5510149	Mission silt loam.....	SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 10, T. 32 N., R. 40 E.....	.74	.25	.31	.21	3.25
87	5510179	Mission silt loam.....	SE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 3, T. 35 N., R. 39 E.....	.71	.19	.52	.04	6.30
88	5510215	Mission sand.....	NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 13, T. 36 N., R. 37 E.....	.44	.12	.05	.03	1.93
89	551033	Mission sand.....	NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 33, T. 38 N., R. 38 E.....	.51	.20	.06	.03	3.14
90	551077	Mission fine sand.....	NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 25, T. 40 N., R. 40 E.....	.55	.29	.11	.05	2.37

91	5510217	Mission very fine sandy loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 4, T. 34 N., R. 37 E.....	.70	.25	.29	.06	3.05
92	5510219	Mission very fine sandy loam.....	SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 17, T. 34 N., R. 37 E.....	.55	.24	.19	.06	3.39
93	551031	Mission loam.....	NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 29, T. 36 N., R. 38 E.....	.72	.24	.35	.06	3.62
94	5510221	Mission loam.....	NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 17, T. 34 N., R. 37 E.....	.60	.21	.33	.06	4.17
95	5510227	Mission fine sandy loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 32, T. 34 N., R. 37 E.....	.70	.26	.22	.05	2.50
96	5510207	Mission fine sandy loam.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 12, T. 40 N., R. 40 E.....	.46	.17	.10	.07	4.06
97	5510209	Mission sand, heavy phase.....	NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 20, T. 40 N., R. 40 E.....	.79	.32	.18	.07	5.55
98	5510199	Mission sand, heavy phase.....	SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 27, T. 39 N., R. 39 E.....	.57	.26	.16	.04	3.20
99	551093	Colville silty clay loam.....	NE $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 35, T. 32 N., R. 40 E.....	1.18	.18	.34	.33	4.78
100	5510189	Colville silty clay loam.....	NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 8, T. 35 N., R. 39 E.....	10.04	.38	.34	.35	22.07
		Average.....		.6255	.1928	.2737	.1024	6.82

In interpreting the results of a soil analysis comparison is usually made with analyses of other soils under similar climatic conditions and of known productiveness. Hilgard, in *Soils*, page 377, gives the average of 109 samples of eastern Washington soils and also the average of 573 soils of the arid regions of the United States. These, together with the averages of the results on 35 samples of soil from the Quincy area (*Soil Survey of the Quincy Area, Washington; U. S. Department of Agriculture, 1913*), are given in the following table. The averages of the results on the soils in this area are also given for comparison.

Data from—	Soils from—	Lime (CaO).	Phos- phoric acid (P ₂ O ₅).	Potash (K ₂ O).	Loss on ignition.	Nitro- gen (N).
Hilgard.....	Arid regions of United States.....	1.43	0.16	0.67	5.15	0.13
Do.....	Eastern Washington.....	1.25	.21	.65	5.77	.....
Ashton.....	Quincy area.....	1.42	.10	.50	4.62	.....
Do.....	Stevens County.....	.73	.19	.27	6.82	.10

Attention should be called to the fact that the method of digestion used by Hilgard will increase the per cent of potash (K₂O) found, without, however, a corresponding increase in the percentage of lime or phosphoric acid. Hilgard (*Soils*, p. 342) shows an increase from 0.35 per cent to 0.63 per cent in the quantity of potash found by increasing the time of digestion from one day to five days, and by far the larger part of the data from Hilgard in the above table is based on the five-day digestion, while that of the writer is based on a digestion period of 10 hours.

Averages of the series.

Lime.	Phos- phate.	Potash.	Series.	Lime.	Phos- phate.	Potash.
1.19	0.229	0.454	Stevens.....	H	H	H
.664	.185	.332	Waits.....	M	M	H
.518	.298	.238	Loon.....	L	H	M
.670	.215	.280	Hesseltine.....	M	M	M
.375	.217	.243	Clayton.....	L	M	M
.544	.175	.245	Springdale.....	L	M	M
.690	.176	.235	Garrison.....	M	M	M
.765	.175	.320	Hunters.....	H	M	H
.376	.094	.152	Marble.....	L	L	L
.643	.235	.237	Mission.....	M	H	M
5.81	.28	.34	Colville.....	H	H	H

H=High; M=Medium; L=Low.

While the variation between different types of the same series is greater than the differences between the several series, yet reference to the above table will show some interesting relationships. This

table gives the averages of the analyses of the samples of the more important series and their relation to the general average for the area.

The Stevens series is consistently high in the three main mineral elements of plant food—lime, phosphoric acid, and potash—while the more sandy members of the Garrison series run low. These characteristics are also apparent in actual crop yields. The Springdale series, with its more sandy texture, is also rather low in lime and phosphoric acid, although about the average in potash, as would be expected from a consideration of its origin. Low volatile matter and nitrogen indicate an immediate need of organic matter. Here again the actual crop yields seem to bear out this relationship. Soils of the Mission series run medium to high, with the exception of potash in the sandy types, the excessive drainage of which might be expected to produce low potash content.

The Hunters series shows itself chemically well adapted to the raising of fruits and grains, the two main crops now growing on that soil. The soils of the Marble series seem to respond well to irrigation, but require constant fertilization or crop rotation, a fact which would seem to be indicated by the low percentage of lime, phosphoric acid, potash, and particularly of organic matter, as shown by the low nitrogen and loss on ignition.

SUMMARY OF RESULTS.

(1) The lime content of the soils of the area is as a whole sufficient, although the addition of ground limestone with green manuring would probably be beneficial in converting the latter into a form more accessible to the growing crops.

(2) The phosphoric acid and potash content are fairly high in all except the sandier series, such as the Marble and the sandy members of the Garrison series.

(3) The low loss on ignition and low nitrogen on all but the loamy soils is one of the characteristics of an arid climate and is indicative of the prime need of green manuring. A judicious crop rotation which includes a year of rye or vetch and occasionally two years of clover, seems to give good results in this respect.

(4) The soils of the sandier series should respond readily to the moderate application of commercial fertilizers or barnyard manure.

SUMMARY.

Stevens County lies in the northeastern part of the State of Washington and comprises a total area of 2,393.5 square miles, or 1,531,840 acres. The portion of the county included in the Colville National Forest, an area of about 100 square miles, is not covered by the survey.

Two maps accompany the report. The land classification map shows the location and extent of the several classes of land based on the physical factors influencing the agricultural value of the soils of the county. The soil map shows the location and relative extent of the different soil types.

In the land classification map five groupings are used: Poorly drained areas, well adapted to general farming when drained; well-drained areas with favorable moisture supply, well adapted to intensive agriculture; excessively drained areas subject to occasional drought, but adapted to intensively cultivated orchard or other crops, and well suited to irrigation; hilly lands, adapted mainly to general farming and dairying but in places utilizable for intensive agriculture; and rough stony or mountainous areas, largely nonagricultural.

The county embraces a part of the physiographic province known as the Okanogan Highlands, which is characterized by a rolling to hilly or rough or mountainous topography with more or less extensive terraced areas in the main valleys. A comparatively small part of the county lies in the physiographic province known as the Columbia Plain. The elevations in the county range from 100 to 6,200 feet above sea level.

Stevens County may be divided into six general physiographic divisions: The Columbia-Kettle River Valley, the Colville-Chamokane Valley, the Spokane River Valley, the Spokane plateau, the Calispell Mountain range, and the Huckleberry Mountain range.

The drainage water of the entire county eventually reaches the Columbia River. The greater part of the county is well drained; a small total area is excessively drained, and a still smaller part is poorly drained.

The central and northern parts of the county are well supplied with railroad facilities considering the density of population. The Spokane Falls and Northern Railway extends through the county northward to Marcus, where it branches, one branch following the Kettle River, the other the Columbia River to the International Boundary. Water transportation is not of commercial importance, although the Columbia River is navigable for stretches.

A fairly extensive county road system covers all but the rough sections of the county. These roads range from good to poor. Stage routes afford mail service and transportation to sections not reached by railroads.

The market facilities are fair for the greater part of the county. General farm crops find a ready market in local towns and at Spokane. Truck products are shipped to points in the Middle West and East.

The summers are rather short and are characterized by long and moderately warm days; the winters are marked by short days, mod-

erate temperatures, and heavy snowfall. The average length of the growing season is about 100 days. The mean annual precipitation is about 18 inches, and the mean annual temperature about 45° F.

The early agriculture consisted of the production of farm crops for home and local use. The greatest development has taken place in the last 10 years. At present agricultural progress is fairly rapid. Grain and hay are the leading crops. The acreage in orchards is quite extensive, but only a small percentage of the trees are in bearing.

Potatoes, corn, beans, and other vegetables are grown to a small extent. Stock raising and dairying do not receive the attention warranted by soil and market conditions.

Fifty types of soil, including a number of phases, and 4 classes of miscellaneous material are mapped in this county. This number includes 2 types of residual soil, 11 types derived from glacial till, 30 types occupying glacial lake and river terraces, 2 of which are derived from recent lake-laid sediments; 1 occurring on alluvial fans and footslopes, 3 occupying recent river-flooded plains, and 2 of eolian deposition, and in addition 1 type consisting of organic accumulations is mapped.

The residual soils cover a part of the upland section of the county. The glacial till soils occupy the remainder of the uplands. Of the terrace soils the glacial-lake and river-terrace group is the most extensive, the old valley filling material covering eroded lake terraces occupying the next largest area. The soils of wind-blown origin are inextensive.

The residual soils are classed with two series, the Moscow and the Huckleberry, each represented by a single type. The Moscow soil is light brown, with a subsoil of similar color and character. It is used mainly for grazing and forestry.

The Huckleberry series includes one type, which has a yellowish-gray to light-brown soil and light-brown or yellowish-brown subsoil. This type is mainly nonagricultural and is best used for forestry.

Of the soils of the glacial drift, the Stevens series is represented by 3 types, indicated on the soil map. They consist of dark grayish brown soils with light yellowish brown or light grayish brown subsoils, and are well suited to general farming, fruit production, and dairying.

The Waits series comprises 3 types having brown to light-brown or light grayish brown soils and yellowish brown to light brown subsoils. These soils are well adapted to general farming and to dairying.

The Loon series embraces 2 types, which are characterized by yellowish-gray or light yellowish brown soils and yellowish-brown subsoils, and are underlain by granitic bedrock. The Loon soils are adapted to the production of general farm crops and to dairying.

Two members of the Clayton series are recognized. They consist of yellowish-gray to yellowish-brown soils, with subsoils of the same color underlain by lake-laid material.

The Hesseltine series is represented by a single type. The soil is light-brown to reddish-brown. The subsoil is yellowish-brown in color and is underlain by basaltic bedrock. Where the topography permits this type is adapted to general farm crops, fruit, and dairying.

The soils of the glacial lake and river terraces are classed in 7 series. The Springdale series comprises 10 types which are characterized by light grayish brown to light-brown soils and light grayish brown to light-brown gravelly subsoils, with gravelly substrata. These soils are derived from a wide variety of material, are excessively drained, and adapted to a wide range of crops under irrigation.

The Garrison series embraces 6 types, 2 of them represented only by phases. These soils have dark grayish brown surface soils, brown to light-brown gravelly subsoils, and gravelly substrata. They are adapted to general farm crops and to intensive farming.

The Waterloo series is represented by 2 types which have grayish-brown to dark-gray soils and lighter brown subsoils. They are of local origin and carry large quantities of slate and quartzite material. The soils are well suited to general farm crops, fruit, and intensive farming.

The Mission series includes 7 types which are characterized by light-colored to yellowish-gray soils and light-gray subsoils, with substrata of stratified silts and clays. They are suited to general farm and intensively cultivated crops.

The Empey series is represented by only 1 type. This consists of a brown soil with a brown subsoil, underlain by a gray silty clay substratum. It is adapted to general farm crops.

The Hunters series embraces 2 types, having brown to dark grayish brown soils and light to yellowish-brown subsoils, with substrata of gray silts and clays. The soils are suited to general farm crops, fruits, and intensive farming.

The Colville series, representing the soils of the recent lake basins, comprises 2 types. These have dark-gray to black soils and lighter gray subsoils. They are well adapted to the production of hay and grain.

The soils of the recent alluvial fans and footslopes are represented by the Chewelah series. This series comprises only 1 type, with a dark-gray to black soil and light-gray to gray subsoil. It is adapted to general farm and intensively cultivated crops.

The eolian or wind-laid soils are classed in the Marble series. Two members are mapped, and these have light grayish brown or

yellowish-brown soils, with yellowish-gray subsoils. These types have a hummocky surface, and are naturally excessively drained.

The Chamokane and the Narcisse series include the recent alluvial stream bottoms. The Chamokane series is represented by 2 types, which have brown soils and subsoils and are well adapted to general farm crops.

The Narcisse series is represented by only 1 type, having a gray to dark-gray soil and light brownish gray subsoil. The material is of granitic origin. This type is well suited to general farming.

Muck and Peat consists of a more or less thoroughly decomposed accumulation of organic material, and is adapted to the production of hay and grain where properly drained.

Rough mountainous land consists of mixed agricultural and non-agricultural land which occupies areas of high and mountainous topography.

Rough stony land and Rock outcrop are miscellaneous types of little or no agricultural value. Riverwash includes overflowed areas of gravel and cobbles which are barren of vegetation.



[PUBLIC RESOLUTION—No. 9.]

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

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

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

Approved, March 14, 1904.

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

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