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Soil Survey
of
The Lower Flathead Valley Area Montana

By

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and

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United States Department of Agriculture

Bureau of Chemistry and Soils

In cooperation with the Montana Agricultural Experiment Station

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CONTENTS

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AREA SURVEYED

The lower Flathead Valley area, totaling 469 square miles, or 300,160 acres, is located in northwestern Montana, south of Flathead Lake (fig. 1). These measurements do not include about 30 square miles occupied by the National Bison Range and Bird Refuge. It comprises three separate or distinct physiographic divisions—namely, Mission, Jocko, and Camas Valleys—which are identified with the Flathead irrigation project developed by the Bureau of Indian Affairs, United States Department of the Interior.

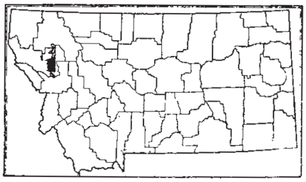


FIGURE 1.—Sketch map showing location of the lower Flathead Valley area, Montana.

The Mission Valley division, by far the largest of the three, is irregular in outline and lies entirely in Lake County. It is bounded on the east by the Mission Range of the Rocky Mountains, on the west by Flathead River, on the north by Flathead Lake and Flathead River, and on the south by a low spur of mountains extending northwestward from the Mission Range. Several stony ridges lie in the valley. Two of the larger ridges rise from 300 to 400 feet above the average level of the surrounding land and in general parallel the course of Flathead River. The northern ridge, beginning at a point about 3 miles south of Polson, extends southward about 6 miles, and the southern ridge extends about 7 miles southward from Crow Creek toward Moiese. The district west of the northern ridge is known as Valley View and that west of the southern ridge is called Moiese Valley. These ridges, consisting largely of gray quartzites and argillites, are distinctive physiographic features within the gently rolling area surveyed. The Mission Range bordering Mission Valley on the east is distinctive and imposing, rising from 6,000 to 7,000 feet above the valley, with practically no intervening foothills. The highest parts of the range are covered with snow during the greater part of the year and contain a number of active glaciers.

The Jocko Valley division, separated from Mission Valley on the north by a low range of mountains, extends northwestward along the main line of the Northern Pacific Railway from near Schley to Revais Creek, near the western boundary of the area. Jocko Valley is nearly 4 miles wide southeast of Arlee but at Ravalli narrows to a canyon. It again widens near the junction of Jocko River and Flathead River. Its western part is in Sanders County, its southern extremity extends about 3 miles into Missoula County, and the remainder is in Lake County.

The Camas Valley division is isolated from Mission and Jocko Valleys, being about 20 miles west of Polson in Sanders County. It is an enclosed basin bordered on the west by the foothills of Cabinet Mountains, on the east by Little Bitterroot River, and on the north and south by hills. Generally speaking, Camas Valley is smoothly rolling, with a range in elevation of about 130 feet.

All the drainage waters of the area eventually find an outlet through Flathead River. Mission Valley slopes toward the south and west and is drained in part by Mud, Crow, Post, and Mission Creeks. The last three streams have their sources in the Mission Range, and a large part of their water is diverted into storage reservoirs to be used later for irrigation.

Flathead River has cut a deep gorge from Flathead Lake southward, and overflow bottom land occurs only in the larger bends and in the vicinity of Dixon. Considerable erosion has taken place along the Flathead River gorge and the lower courses of Mud, Crow, and Post Creeks, which also have cut fairly deep canyons. These areas are indicated on the soil map as a steep phase of Lonepine very fine sandy loam and are largely untillable. Away from these larger streams, drainage courses have not everywhere been well established, and in such areas the relief has not been changed materially since the soil material was deposited.

South of Flathead Lake a high gravelly and sandy ridge (terminal moraine) extends westward from Mission Range to Flathead River. South of this ridge and east of the stony ridge in the vicinity of Pablo Reservoir (locally known as Reservoir Valley) the land surface is level or gently rolling and lacks distinct drainage courses. Mud Creek rises near Mission Range just south of this terminal moraine. The surface relief becomes rather rolling north and west of Ronan bordering Mud Creek and also south and east of Round Butte. North of Ronan the sandy areas lack distinct coulees or drainage courses. A large part of the ridge between Spring Creek and Mud Creek is gently rolling.

The Valley View section southwest of Polson is, for the most part, gently sloping, though a number of deep coulees have been cut back from the river into this area. Bordering these coulees is another area of Lonepine very fine sandy loam, steep phase.

Moiese Valley consists of a series of low ridges or terraces which probably represent former stream courses of Flathead River.

South of Crow Creek and north of Charlo is another gravelly ridge or moraine, and south of this ridge, in the vicinity of Charlo, is a rather large area of nearly level land, called Charlo flat, which slopes to the south and west. The only distinct drainage outlet of this flat is through Big Coulee which becomes deeply entrenched near D'Aste, but surface drainage is not entirely adequate since the advent of irrigation. Within this region, and particularly to the east in the vicinity of Ninepipe and Kickinghorse Reservoirs, are numerous " kettle holes ", shown on the soil map by intermittent lake symbols. These kettleholes, or potholes, differ greatly in size, ranging from a few feet to several hundred feet in width and from 1 foot to 75 feet in depth.

South of Charlo flat and Ninepipe Reservoir the land slopes rather sharply toward Post Creek. This gravelly slope parallels the streamcourse and appears to be another distinct glacial moraine. The V-shaped area between Post and Mission Creeks slopes gently to the west from Mission Range. South of St. Ignatius a spur of Mission Range extends northwestward separating Mission Valley from Jocko Valley.

The different parts of the area differ widely in elevation. The lowest point is west of Dixon along Flathead River. The railroad station [1] at Dixon has an elevation of 2,530 feet above sea level, and the irrigated bench south of Dixon has an elevation of about 2,600 feet. At Schley, near the upper end of Jocko Valley, the elevation is 3,579 feet, and at Arlee it is 3,094 feet. Southeast of Arlee, near the base of the mountains at the edge of the tree growth, the elevation is 3,475 feet. Here the degree of slope is about 50 feet in one fourth mile.

The elevations along the branch of the Northern Pacific Railway between Dixon and Polson are as follows: Dixon, 2,530 feet, Moiese, 2,592 feet; D'Aste, 2,777 feet; Charlo, 2,947 feet; Ronan, 3,064 feet; Pablo, 3,100 feet; and Polson, 2,949 feet.

Some of the higher peaks in the Mission Range are said to attain an elevation of more than 10,000 feet. The elevation of the Pablo Feeder Canal near the base of the mountains ranges from 3,343 feet east of St. Ignatius to 3,260 feet east of Pablo. Rocky Butte, in sec. 19, T. 22 N., R. 20 W., has an elevation of 3,417 feet, and the gravelly ridge south of Polson is about 3,300 feet above sea level.

Moiese Valley has an elevation of 2,700 feet at its northern end. West of Round Butte the average elevation is 2,875 feet, and the Valley View section is about 2,925 feet above sea level.

The natural vegetation, although largely of the prairie type, differs somewhat with the elevation, soils, and rainfall. Bordering Mission Range wheatgrass and bluegrass predominate, with some scattered balsamweed; farther west, fescues and wheatgrass are dominant, with some scattered sagebrush; bordering Flathead River the bunch grasses are dominant, with an increasing amount of sagebrush; and in the Camas Valley district a variety of bunch grass is said to have been well distributed at one time, but it has almost entirely disappeared and has been replaced by various kinds of sagebrush. Some scattered pines still grow on the sandy areas bordering Little Bitterroot River.

The forested areas occur largely east of Ronan, bordering the three forks of Crow Creek and north of Post Creek where these streams leave the mountains. The principal trees are pine, spruce, tamarack, and fir, with a few balsams and cedars. As most of this area has been cut over, it now supports a rather heavy undergrowth of brush of various kinds. Some trees and brush border the perennial streams, such as Mission, Post, Crow, and Mud Creeks, and Jocko River.

Prior to the time any county government had been established in Montana, Catholic missionaries established a mission at St. Ignatius (pl. 1, A), in 1854, and began cultivating and irrigating land along Mission Creek. Missoula County was organized in 1865 and Flathead

[1] Elevations given for railroad stations are taken from Northern Pacific Ry. folders. Other elevations given are taken from topographic maps of the U.S. Indian Irrigation Service.

County in 1892. Lake County, of which most of this area is a part, was organized from parts of Missoula and Flathead Counties in 1923.

In 1885, a treaty with the Indians set aside the Flathead Reservation, including 1,192,916 acres of land, for the Flathead Indians, and in 1906, Congress passed a bill providing for the watering of the irrigable lands on this reservation. The plans for the Flathead (Indian irrigation) project contemplated the irrigation of about 124,500 acres of land, of which about 40,000 are actually irrigated at present.

The population of Lake County in 1930 [2] is given as 9,541. The white farm population is 4,359 and the rest (mostly Indian) numbers 785. As Lake County was not organized until 1923, no United States census figures, except those for 1930, are available.

The 1929 census of the Flathead project lists 2,688 whites and 75 Indians on farms, of which 1,141 whites and 15 Indians are engaged in agriculture.

Polson, located at the southern end of Flathead Lake, is the county seat of Lake County and has a population of 1,455; Ronan, with a population of 537, Charlo, and Pablo are important trading centers along the railroad in Mission Valley; St. Ignatius is an inland town 5 miles northeast of Ravalli which is on the main line of the Northern Pacific; Arlee and Dixon are trading points in Jocko Valley; and Hot Springs and Camas are inland towns in Sanders County, serving the Camas Valley division.

The main line of the Northern Pacific Railway traverses Jocko Valley, and a branch line from Dixon to Polson serves the Mission Valley district. Two Federal highways, one a coast-to-coast and the other a park-to-park route, cross the area. As a rule the improved roads are fairly well cared for.

The principal markets for produce from this area are Butte and Missoula, Mont., and Spokane, Wash. Local enterprises and organizations, such as cream stations, cheese factories, and livestock-shipping associations, assist in marketing the products.

Lumbering is the principal industry adjacent to the area, the timber being located in the nearby mountainous country. Two small commercial fish hatcheries have been started and are doing an excellent business. Most of the schools are consolidated, and the pupils are transported by busses.

CLIMATE

The climate of the lower Flathead Valley area is continental, which is typical of the intermountain valleys of the Pacific slope. Although the extreme temperatures during the winter and summer show wide differences, the periods of extreme temperatures are never of long duration. The winters are not so severe as in eastern Montana and the average growing season is longer. The prevailing winds, which are seldom of high velocity, are from the west and southwest. The snowfall is usually considerable, especially in that part of the area bordering and in the Mission Range. A large part of the run-off from rain and melted snow is either stored or used directly for irrigation.

[2] Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given when available.

The color of the soils indicates that the greatest precipitation occurs on the borders of Mission Range and that both the precipitation and the elevation gradually decrease toward the west. The dark-colored soils occur in the areas of greatest rainfall.

The Weather Bureau records show that the precipitation is rather evenly distributed throughout the year. It may vary considerably from year to year and from month to month. Consequently, the growing of crops without irrigation, with the possible exception of grain, is very uncertain. About 43 percent of the precipitation normally occurs during the months of May, June, July, and August, and about 54 percent during the 6-month period, April 1 to October 1. A 7-year record at Lonepine (Camas Valley division) shows an average annual precipitation of 10.01 inches.

The area has a fairly long frost-free season, the different divisions averaging between 116 and 136 days. In this latitude the long period of daylight during the growing season tends to shorten the time necessary to mature crops. Temperatures seldom reach 100° F. during the summer and only rarely are they as low as 20° below zero during the winter. A 7-year record shows a mean annual temperature of 45.7° at Lonepine (Camas Valley division). At St. Ignatius the mean annual temperature is 44.6° and at Polson is 45.1°.

Tables 1, 2, and 3 give the more important climatic data as recorded by the United States Weather Bureau stations at St. Ignatius, Polson, and Lonepine.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at St. Ignatius, Lake County, Mont.*

[Elevation, 2,911 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1931)	Total amount for the wettest year (1916)	Snow, average depth
	° F.	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	25.6	62	−29	1.20	0.34	1.65	7.1
January	24.0	63	−30	.94	.54	1.57	12.2
February	27.0	61	−30	.82	.82	1.83	7.9
Winter	25.5	63	−30	2.96	1.70	5.05	27.2
March	35.5	70	−12	.95	1.14	1.63	5.6
April	45.6	89	12	1.22	.31	2.65	1.6
May	52.3	91	24	2.28	1.43	1.38	.8
Spring	44.5	91	−12	4.45	2.88	5.66	8.0
June	59.5	96	28	2.38	1.40	5.24	.4
July	66.3	102	37	1.28	.73	1.93	(1)
August	64.5	103	27	1.05	0.8	1.64	.1
Summer	63.4	103	27	4.71	2.21	8.81	.2
September	55.3	90	23	1.53	3.18	2.36	(1)
October	45.7	82	3	1.27	.43	2.35	3.2
November	34.1	75	−15	1.23	.78	.92	6.9
Fall	45.0	90	−15	4.03	4.39	5.63	10.1
Year	44.6	103	−30	16.15	11.18	25.15	45.5

1 Trace.

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Polson, Lake County, Mont.*

[Elevation, 2,927 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1931)	Total amount for the wettest year (1916)	Snow, average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December	26.9	62	−18	1.29	0.80	1.63	10.5
January	24.5	57	−18	1.01	.29	1.86	11.8
February	27.2	60	−16	.80	.49	1.13	10.3
Winter	26.2	62	−18	3.10	1.58	4.62	32.6
March	35.1	70	−7	.94	.91	2.44	4.0
April	44.7	75	11	1.20	.22	1.25	.6
May	54.0	90	27	1.68	1.08	1.15	.0
Spring	44.6	90	−7	3.82	2.21	4.84	4.6
June	60.2	98	26	2.22	1.05	5.31	.4
July	67.8	104	38	1.31	.74	1.70	.0
August	66.4	97	31	1.10	.00	1.48	.0
Summer	64.8	104	26	4.63	1.79	8.49	.4
September	56.0	88	28	1.42	3.25	1.63	.0
October	46.4	80	12	1.16	.63	.72	.9
November	34.6	65	−2	1.42	.71	.64	6.8
Fall	45.7	88	−2	4.00	4.59	2.99	7.7
Year	45.3	104	−18	15.55	10.17	20.94	45.3

TABLE 3.—*Normal monthly, seasonal, and annual temperature and precipitation at Lonepine, Sanders County, Mont.*

[Elevation, 2,875 feet]

Month	Temperature, mean	Precipitation		
		Mean	Total amount for the driest year (1931)	Total amount for the wettest year (1927)
	° F.	Inches	Inches	Inches
December	25.1	0.97	0.63	1.63
January	20.4	.81	.38	1.31
February	28.5	.48	.10	1.01
Winter	24.7	2.26	1.11	3.95
March	37.9	.59	.52	.46
April	46.2	.55	.30	.58
May	54.8	.86	.29	1.20
Spring	46.3	2.00	1.11	2.24
June	61.4	1.30	.67	1.32
July	70.0	.76	.37	.60
August	67.2	.59	(1)	1.03
Summer	66.2	2.65	1.04	2.95
September	55.7	1.29	2.30	1.64
October	45.7	.58	.25	1.58
November	34.1	1.23	1.23	3.66
Fall	45.2	3.10	3.78	6.88
Year	45.7	10.01	7.04	16.02

[1] Trace.

Table 4 gives frost data, as recorded at the United States Weather Bureau stations located at St. Ignatius, Polson, and Lonepine.

TABLE 4.—*Frost data for the lower Flathead Valley area, Montana*

Station	Average date of last killing frost	Average date of first killing frost	Average frost-free period (days)	Latest recorded date of killing frost	Earliest recorded date of killing frost
St. Ignatius	May 23	Sept. 22	122	June 25	Aug. 25.
Polson	May 13	Sept. 26	136	do	Aug. 18.
Lonepine	May 23	Sept. 16	116	June 20	Sept. 1.

The climate is favorable for raising livestock and for growing hay and grain under irrigation. Sugar beets and potatoes also do well. Moiese Valley seems to be more favorable than other parts of the area for the production of tender vegetables. Fruits, particularly cherries, do well along the border of Flathead Lake.

AGRICULTURE [3]

The agricultural history of the lower Flathead Valley area dates from 1910, when the Flathead Indian Reservation was thrown open to white settlers. The Indians had previously chosen their allotments. Previous to this time the prairie land was used for grazing large herds of livestock.

About 60 percent of the irrigable land was allotted to the Indians of the Flathead tribe, about 4 percent became the property of the State of Montana, and the remainder was thrown open for settlement. The land was disposed of by lottery, which resulted in the usual multitude of applicants from all walks of life, many of whom knew very little about agriculture. Very few had any capital, and a large proportion of the early settlers found themselves on a 40-acre tract of land, without either the knowledge or the means for its development. To make matters worse, the water expected for irrigation was not made available. Although some construction on the irrigation system was started as early as 1909 in the Jocko Valley division, only a few main canals and laterals were completed for use on the remaining parts of the area by 1917. The first settlers were thus forced either to abandon their homesteads or to try farming larger areas by dry-land methods. Fortunately a series of wet years made it possible to produce wheat successfully without irrigation, even in the drier parts of the area.

These conditions influenced the cropping practices, as also did the demand for increased food production during the World War. Wheat was the principal crop grown for a number of years and still

[3] Lake County was not organized until 1923, therefore the U.S. census data for the area are limited. Most of the statistics relative to the agriculture have been obtained from the census data taken by the Indian Irrigation Service and therefore apply only to the irrigated lands. Practically no data are available for the nonirrigated lands, as the yearly crop estimates do not separate the crops grown on irrigated land from those grown on nonirrigated land.

remains the leading crop in certain parts of the area, although definite changes are being made in crop-production practices.

A study of the irrigation census figures gathered by the Indian Service shows that wheat represented 57.9 percent of the total crop acreage in 1918, but that only 10.8 percent was used for this crop in 1928. No estimate is available on the amount of nonirrigated grain grown on the irrigable lands, although it is recognized to be a factor in many farming systems. The percentage of the total crop acreage devoted to alfalfa increased from 5.7 percent in 1918 to 49.9 percent in 1928. Irrigated pastures are also receiving much more attention than formerly.

Cultivated or intertilled crops have assumed only a minor role in the agriculture of the lower Flathead area up to the present time. A small acreage of potatoes is grown on the lighter types of soil. A few farmers have grown sugar beets successfully, and, with the recent establishment of a sugar factory at Missoula, this crop no doubt will become of greater importance, particularly on the lighter types of soil occurring within a reasonable distance from a shipping point. Crop rotations and more careful management will be necessary before consistently good yields of beets may be expected. Seed peas are grown on a small scale in Jocko Valley.

The irrigable land of the area has increased about 40 percent since 1917. The acreage actually irrigated has fluctuated closely around 30 percent of the so-called "irrigable area" since 1918, but a considerable acreage of land has not been leveled and placed in a satisfactory condition for irrigating. At the present time about 112,000 acres are said to be irrigable, and, when additional construction has been completed, about 13,000 acres will be added. A detailed land classification of the irrigable acreage will show that parts of this area are not suited for irrigation farming.

Table 5 shows the acre yields of the principal crops (by years) from 1918 to 1929 on the irrigated lands of the Flathead project.

TABLE 5.—*Acre yields of different crops (by years) and average yield 1918–29, on the Flathead project*

Crop	1918	1919	1920	1921	1922	1923	1924
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Alfalfa hay	2.30	2.02	2.00	1.95	2.18	2.03	2.30
Clover hay	2.30	1.60	1.31	1.33	1.59	1.78	1.81
Other hay	.95	1.00	1.20	1.24	1.36	1.52	1.19
Sugar beets	10.20	9.30					
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Wheat	11.20	12.30	14.00	10.80	10.10	17.40	18.20
Oats	19.40	26.50	31.00	27.00	29.80	27.80	39.40
Barley	15.70	8.60	15.00	14.80	17.70	20.40	20.60
Rye			9.00		6.60	15.00	
Potatoes	131.00	124.00	125.00	115.00	104.00	77.00	128.00
Peas	8.50	5.40	11.00			11.26	7.20
Alfalfa seed		1.90	3.00	1.47	1.54	1.54	2.53
Clover seed			5.10	4.10		2.10	3.02
Corn					25.50	32.40	20.00

TABLE 5.—*Acre yields of different crops (by years) and average yield 1918–29, on the Flathead project*—Continued

Crop	1925	1926	1927	1928	1929	Average
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Alfalfa hay		2.32	2.23	2.22	2.13	2.15
Clover hay	1.50	1.59	1.47	1.64	1.00	1.57
Other hay	1.30	1.50	1.42	1.18	1.17	1.25
Sugar beets				8.20	6.97	8.66
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Wheat	17.70	17.60	21.20	19.90	19.28	15.80
Oats	21.60	31.30	37.20	38.80	32.82	30.21
Barley	27.70	24.30	28.30	31.00	24.92	20.75
Rye		12.00		11.10		10.78
Potatoes	174.00	155.00	145.00	120.00	108.54	125.54
Peas	9.60	11.50		16.40	13.80	10.51
Alfalfa seed	2.68	1.71	3.44	1.00	2.74	2.15
Clover seed	2.06	2.15	2.91	2.57	2.83	2.98
Corn	24.70	21.40	26.00	23.70		24.81

Table 6 shows the crop census for 1929 (from the irrigated farms only) as reported by the Flathead project.

TABLE 6.—*Crop census (1929) for the irrigated farms on the Flathead irrigation project*

Crop	Area	Total yield	Acre yield
	Acres	*Tons*	*Tons*
Alfalfa hay	19,193.00	40,988	2.13
Clover hay	333.00	330	1.00
Hay (other than alfalfa and clover)	2,305.00	2,712	1.17
Sugar beets	468.75	3,268	6.97
Corn fodder	36.50	106	2.90
		Bushels	*Bushels*
Wheat	3,748.25	72,277	19.28
Barley	2,460.50	61,331	24.92
Oats	2,060.75	67,664	38.82
Potatoes	190.50	20,678	108.54
Corn	32.25	725	22.48
Peas	466.00	6,443	13.80
Alfalfa seed	203.50	588	2.74
Clover seed	393.00	1,115	2.83
		Pounds	*Pounds*
Apples	66.50	160,860	2,418.00
Gardens	252.50		
Pasture:			
Huntley mixture	1,714.75		
Sweetclover	350.50		
Timothy and clover	1,198.50		
Native grasses	3,469.25		
Miscellaneous	658.50		

The yields given for the various crops in a measure reflect the effectiveness with which the irrigated land is utilized. The yield data from the project summaries indicate that cropping systems, irrigation methods, and general farm practices have not been developed so much as could normally be expected. Progress in this direction has been retarded somewhat because of the fact that many new settlers were not familiar with conditions and also because of financial handicaps.

According to the 1928 report of the State Board of Equalization, Lake County, in which the larger part of the Flathead project is located, had 281,148 acres of agricultural land on the assessment rolls. The United States census of 1930 shows a total land area of 963,840

181296—34——2

acres in Lake County, 42 percent of which, or 404,543 acres, is in farms, so it is evident that a large part of the land is not classified as agricultural. Approximately 586,880 acres is classed as "unpatented and other land", a part of which includes land that is being farmed (a large part of the irrigated land), but, because no title has been given, it is not taxed. This class also includes land held in trust for the Indians, the National Bison Range and Bird Refuge, and the national-forest areas. About 65,000 acres are said to be irrigated, which include land irrigated by private ditches as well as that under the Federal project. About 68,700 acres are classed as nonirrigated tillable land, and it is probable that a part of this land could be irrigated if it were leveled.

Table 7 shows the acreage and acre yields of Lake County crops as reported in the Montana Farm Review, 1928 edition. These figures do not distinguish between crops grown on irrigated and nonirrigated land but include both. Although the area surveyed covers only a part of Lake County, the greater part of the agricultural land in the county is included.

TABLE 7.—*Acreage and acre yields of Lake County, Mont., crops in 1927 and 1928*

Crop	1927		1928		Crop	1927		1928	
	Area	Acre yield	Area	Acre yield		Area	Acre yield	Area	Acre yield
	Acres	*Bu.*	*Acres*	*Bu.*		*Acres*	*Bu.*	*Acres*	*Bu.*
Spring wheat	14,000	19	15,000	18	Beans	150	18	200	14
Winter wheat	22,000	24	25,000	15	Seed peas	700	21	900	18
Oats	7,000	45	6,000	41	Sweetclover seed	50	2	50	3
Barley	3,200	35	3,200	32					
Rye	1,200	16	1,700	12			*Tons*		*Tons*
Flaxseed	100	10	100	8	Sugar beets			200	7.40
Corn	1,100	30	1,000	21	Tame hay	25,000	2.30	25,400	1.95
Potatoes	500	150	500	120	Wild hay	2,700	1.35	1,900	1.15

Cherries and miscellaneous fruits were valued at $8,700 and $15,500, in 1927 and 1928, respectively; apples at $25,400 and $30,700; farm gardens, $104,500 and $89,000; truck crops, $6,000 and $6,500; strawberries, $10,000 in 1928; other crops, $1,000 and $1,100, respectively; 133,273 acres are classified as grazing land and 8,221 acres as unclassified State land.

The use of commercial fertilizers is practically unknown in this section of the country. Such limited trials as have been made cooperatively by county agents and individual farmers are considered inadequate on which to base any definite recommendations. Chemical analyses of soil samples gathered in different parts of the area in connection with this survey, indicate that with more intensive cultivation of the land and the growing of sugar beets, it will be necessary to use commercial fertilizers to increase yields to a point where they will show a greater profit. In a number of soils of the area the total nitrogen and phosphorus content of the surface soil to a depth of 1 foot is very low.

Labor is usually adequate on the farms, except during haying and harvesting seasons when a part of the labor employed comes from outside the valley. Sugar-beet workers are largely Mexicans brought in by the sugar company. Most of the labor used in growing beets is done by contract on the acre basis.

The size of the farm units differs considerably. At the time of allotment or homesteading of the irrigable lands, the units ranged from 40 to 120 acres, depending on the irrigable acreage in the unit. The 80-acre units were most numerous, but in many cases several members of a family each had a unit, so that in reality the family was actually operating not an 80-acre farm but a farm of 120 or 160 acres. Most of the crop census records are still taken on the basis of the original units.

A study of the Flathead project indicates that the more successful farmers have increased the size of their original farm holdings since 1921. An increasing amount of land is also being prepared and actually irrigated.[4]

Table 8 shows selected data from the census of the Flathead project for 1928.

TABLE 8.—*Selected data from the census of the Flathead project, 1928*

Farm operation	Camas division	Jocko division	Mission Valley division	Entire project
Area of farms operated by:	*Acres*	*Acres*	*Acres*	*Acres*
White owners	15,931	12,028	115,755	143,714
Indian owners	960	11,572	8,110	20,642
Indian land leased	80	1,170	19,845	21,095
Total	16,971	24,770	143,710	185,451
Vested rights:				
White owners		664	2,114	2,758
Indian owners	74	778	320	1,172
Indian land leased		190	98	288
Total	74	1,632	2,532	4,218
Net irrigable area:				
White owners	10,778	6,029	77,068	93,875
Indian owners	235	4,633	4,623	9,491
Indian land leased	43	719	14,518	15,280
Total	11,056	11,381	96,209	118,646
Irrigated area:				
White owners	3,976	5,807	24,701	32,484
Indian owners		924	367	1,291
Indian land leased		571	1,009	1,580
Total	3,976	5,302	26,077	35,355
Cultivated area:				
White owners	4,433	3,705	74,022	82,160
Indian owners	100	1,161	2,775	4,036
Indian land leased	30	556	13,237	13,823
Total	4,563	5,422	90,034	100,019
Area otherwise used:				
White owners	7,719	5,087	24,589	37,395
Indian owners	500	6,351	2,515	9,466
Indian land leased	50	514	3,755	4,319
Total	8,269	11,952	30,959	51,180
Area idle:				
White owners	3,779	3,236	17,144	24,159
Indian owners	360	4,060	2,720	7,140
Indian land leased		100	2,853	2,953
Total	4,139	7,396	22,717	34,252

NOTE.—A large part of the irrigable area and also some nonirrigable land is used to produce grain crops without irrigation. "Area otherwise used" is mostly dry pasture. Much of the idle land is nonirrigable.

[4] JOHNSON, S. E. AN ECONOMIC ANALYSIS OF PRODUCTION PROBLEMS ON THE FLATHEAD IRRIGATION PROJECT. Mont. Agr. Expt. Sta. Bul. 237, 88 p., illus. 1930.

General observations on the type of buildings in use on the project farms gives the impression that in this respect the area is still in the pioneer stage. Many permanent farm homes as well as outbuildings have been erected within the last few years, and it is expected that more will be built within the next few years. At present many of the farms lack necessary barns and sheds for the proper housing of livestock and machinery. Most of the farmers have practically all types of modern machinery—such as tractors, mowers, binders, and combine harvesters, as well as numerous tillage implements—but much of it remains unprotected from the weather the year round. Farmers who do not depend on tractors for their power usually maintain from 3 to 8 head of work horses.

The livestock industry has experienced a steady growth, the increase in the number of cattle having been steady and consistent since 1916. The increase in the number of sheep has been pronounced, from 11 in 1916 to more than 10,000 in 1926. Hogs, poultry, and bees have increased consistently with the development of the irrigation project. The number of horses has decreased, owing to the disposal of range horses and also to some displacement by tractors. Table 9 shows the numbers and value of livestock on the Flathead project as given in the irrigation census for 1929.

TABLE 9.—*Number and value of livestock on the Flathead project in 1929*

Kind of livestock	Number	Value	Kind of livestock	Number	Value
Horses	3,298	$134,210	Hogs:		
Dairy cattle:			Sows	1,112	$23,425
Cows	4,488	364,740	Other	4,250	59,660
Heifers	1,870	76,480	Pigs	3,307	18,497
Calves	2,063	40,651	Sheep	10,281	102,260
Beef cattle:			Fowls	53,002	58,845
Cows	1,659	114,965	Bees ... hives	838	4,158
Other	2,231	137,808			
Calves	1,260	30,010			

In general, hay is not a profitable cash crop in this area, but alfalfa and pasture may be used profitably for producing livestock and dairy products. At present more hay is produced than can be consumed by the livestock on hand, and considerable idle land is better adapted to growing alfalfa and pasture than to other crops. At an economic conference held in Polson for the purpose of framing an agricultural program,[5] it was recommended that the pasture acreage be increased to the ratio of about 1 acre of pasture for every 2 acres of hay and then make a corresponding increase in the number of livestock. This conference reported that no fundamental reason exists why the number of hogs, sheep, and beef cattle should not be increased and that hogs have probably not received the attention they deserve.

Some winter feeding of sheep and beef cattle is practiced on various parts of the project and is recommended as a desirable way of marketing surplus hay. It is reported that about 5,000

[5] MONTANA STATE COLLEGE and UNITED STATES DEPARTMENT OF AGRICULTURE, cooperating. AN AGRICULTURAL PROGRAM FOR THE FLATHEAD PROJECT. Mont. Agr. Col. Ext. (Pub.) Bul. 90, 38 p., illus. 1928.

sheep are fed annually in Jocko Valley. The western part of Mission Valley bordering Flathead River and also the Camas Valley division are favored areas for winter feeding, because of the abundance of alfalfa hay and the available summer dry-land range nearby.

The dairy industry offers an increasing opportunity for the irrigated farms that produce large quantities of alfalfa hay. The lower Flathead Valley is one of Montana's most favored dairy districts, because of the possibilities of low-cost production. The Lake County Dairy Herd Improvement Association has shown an average feed cost of about 15 cents for a pound of butterfat in the better-managed herds.[6] This low cost of production is largely due to the abundance of high-quality hay and to the excellent irrigated pastures developed in recent years. Alfalfa hay and pasture furnish the basis of the dairy feed, and home-grown grains, such as barley and oats, provide a part of the concentrates needed. Although the number of dairy cattle in the valley has more than trebled in the last 8 years and the quality of the cattle has been much improved, there is still room for further development in the dairy industry. Cream stations are located in every town, a creamery is at Polson, and cheese factories are at St. Ignatius and Pablo.

After a study, by farmers and extension workers, of agricultural conditions prevailing on the Flathead project, and a consideration of the climate and soils of the area, it has been determined that a successful farming system must be based on a livestock-feed-crop foundation, including such cash crops as may prove practical to market.

The record of crop production on the Flathead project has shown a rapid increase in the acreage of alfalfa and also in the development of irrigated pastures. That this increase is justified has been shown by the experiences of many individual farmers. Many of the heavier-textured soil areas produce better crops of alfalfa and pasture than of grain. Much of the idle land, especially that which is irrigable, is also considered better adapted to growing alfalfa or other hay crops.

The average yields of alfalfa appear to be lower than normally might be expected. This may be due in part to poor stands and poor irrigation practices and in part to the lack of available plant food. The alfalfa plant requires a large quantity of water and is a rather heavy feeder, using an especially large quantity of lime. Improper distribution of water, owing to the fact that the fields have not been thoroughly leveled so that all parts may be well irrigated, accounts for the lack of good crops on a great many farms. On gently rolling or sloping land the corrugation system of irrigation gives best results, but on flat land and the loose porous sandy soils irrigation water must be applied by flooding. Where land is not properly leveled, water may stand on alfalfa fields for long periods and seriously injure the stand.

Chemical analyses of samples of soil taken during the course of the survey indicate that a lack of available plant food, particularly lime and phosphorus, may be responsible for the rather low acre

[6] Statements by J. O. Tretsven, dairy specialist, Montana State College.

yields of alfalfa and other crops. Furthermore, field tests indicate that the open and porous soils are low in lime content. It was observed that alfalfa and mixed pastures seemed to do best on the medium-heavy porous soils. The physical condition of the very heavy soils is the main handicap in production, and any method of bringing about a more open and porous condition should improve the yields.

Sweetclover has not yet become an important crop in the lower Flathead Valley area. However, the yellow biennial variety is used to some extent in pasture mixtures, and undoubtedly the crop when turned under as green manure, will play an important part in the improvement of the light sandy and gravelly soils.

Red clover and timothy are grown more largely in that part of the area bordering the mountains, where alfalfa has not given satisfactory yields. The production of alfalfa and red clover seed is a special enterprise carried on successfully by a few farmers, more particularly in the Lonepine district. The farmers in this district have learned that the time of irrigating is an important factor in the production of seed and that only through careful observation and practice are the best results obtained.

Wheat is still a popular crop, although the acreage has been decreasing steadily on the irrigated lands since 1920. An indication of the change in acreage is shown by the figures in table 10, taken from project census reports.

TABLE 10.—*Acreage of grain crops on the Flathead project in 1920 and 1929*

Crop	1920	1929
	Acres	*Acres*
Wheat	12,415	3,098
Barley	488	2,195
Oats	4,062	1,842

Although a number of farmers are growing wheat almost to the exclusion of other crops, this practice has disappeared on the drier parts of the project. The two principal wheat-producing sections include the areas bordering the Mission Range north and east of St. Ignatius and the sandy soil areas north of Pablo. Many farmers claim that it does not pay to irrigate grain, hence the general practice is to summer fallow the grain land every second or third year, "stubbling in" being practiced to some extent. Both winter and spring wheat are grown on the project. White spring wheat is produced for feed on the dark soil areas bordering the Mission Range, where the hard red spring wheats are of poor quality. Much of the wheat now grown is badly mixed and of inferior quality. The yield and quality of wheat, as well as of the other small grains, can be improved by the use of pure seed of recommended varieties to replace the badly mixed seed now used, and by a good system of soil management.

The acreage of barley, although not large, is increasing both on the irrigated and nonirrigated land within the area. In general, the growing of grain crops on irrigated land should be limited largely to their use as nurse crops or as needed in the general rotation system.

The introduction of sugar beets, made possible by the establishment of a sugar factory at Missoula, provides an intertilled cash crop that will aid in the establishment of more satisfactory rotations on many farms. As economic studies show that yields of at least 9 tons an acre must be obtained to make the production of sugar beets a paying enterprise, great care must be exercised in the choice and preparation of the land for the crop. The best yields are produced on the more open and porous soils. Under present conditions, profitable sugar-beet production is limited to those areas which are not more than 5 or 6 miles from a railroad or loading point.

Seed peas, another special crop, are grown on about 500 acres in Jocko Valley and may have some possibilities in Mission Valley. It is considered unwise to undertake the production of peas unless the grower can make a contract with a seed company to purchase the crop at harvest time.

Only a small quantity of potatoes is grown in the area. They are best adapted to the lighter-textured soils.

Until recently very little systematic rotation of crops has been practiced. Alfalfa is allowed to remain on the land as long as the yield and stand remain good. The problems of soil fertility, weed infestation, and labor distribution are becoming more serious, and increased attention must be given to crop rotations.

SOILS AND CROPS

That the soils of the lower Flathead Valley area differ considerably in many details, is noticed on comparing the soils in one locality with those in another. Soil characteristics that are most consistent and evident on physical examination in the field constitute the bases of classification and mapping. Some of the more dominant and natural physical characteristics are the number of soil horizons or layers, in the soil profile; the color and the texture (sand, silt, loam, or clay) of the different soil layers; the structure or physical arrangement of the soil particles or aggregates; the thickness of the different layers; and the chemical composition and mineral character of the parent màterial, which may or may not dominate the development of the soil.

The general character of the soils of the lower Flathead Valley area has been influenced by the original geological material, its composition, and the manner of accumulation. Most of the parent materials were transported and deposited chiefly during the recession of the large valley glaciers which completely filled the valley of Flathead River and the valley of Little Bitterroot River.[7] As the valley glaciers receded, they left numerous terminal moraines. At times, lakes were dammed up against the ice front, and at other times large rivers carried the glacial material away almost as rapidly as it was deposited.

Since the deposition or accumulation of the original soil material the great soil-forming processes, such as leaching, oxidation, and the

[7] Personal communication from C. H. Clapp, Missoula, Mont., on the geology of the Flathead Valley.

accumulation of organic matter and lime carbonate, have been at work and have imparted many of the present soil characteristics.

The rapidity with which the soil-forming processes have worked has been influenced largely by location of the particular area, elevation, drainage, distribution of rainfall, and the range of temperature throughout the year. In Mission Valley, at the higher elevations bordering Mission Range, a fairly high rainfall and a somewhat cooler temperature have produced a rather dense grass vegetation which has resulted in a greater accumulation of organic matter and a darker-colored soil. Within a rather short distance westward, both the rainfall and the elevation decrease perceptibly, accompanied by a natural rise in mean temperature and as a result a more scattered bunch-grass vegetation. All these factors have caused natural soil differences. Under natural conditions leaching is not an important factor in the drier parts of the area, but it has been appreciable in the sections bordering the mountains and in the more open porous soils.

On the basis of dominant soil characteristics, in association with crop adaptation and agricultural possibilities, the soils of the lower Flathead Valley area are classified and described under a number of major groups and minor subdivisions as follows:

(1) Well-developed soils having permeable and friable subsoils, with favorable subdrainage, including dark-colored grassland soils of the McDonald, Millville, and Polson series; brown grassland soils of the Trenton series; and light-colored brushland soils of the Lonepine series.

(2) Well-developed soils having tough compact subsoils and heavy-textured stratified substrata, with restricted subdrainage, including dark-colored grassland soils of the Post series; brown grassland soils of the Round Butte series; light-colored brushland soils (Round Butte silty clay, heavy phase); and light-colored timbered soils of the Crow series.

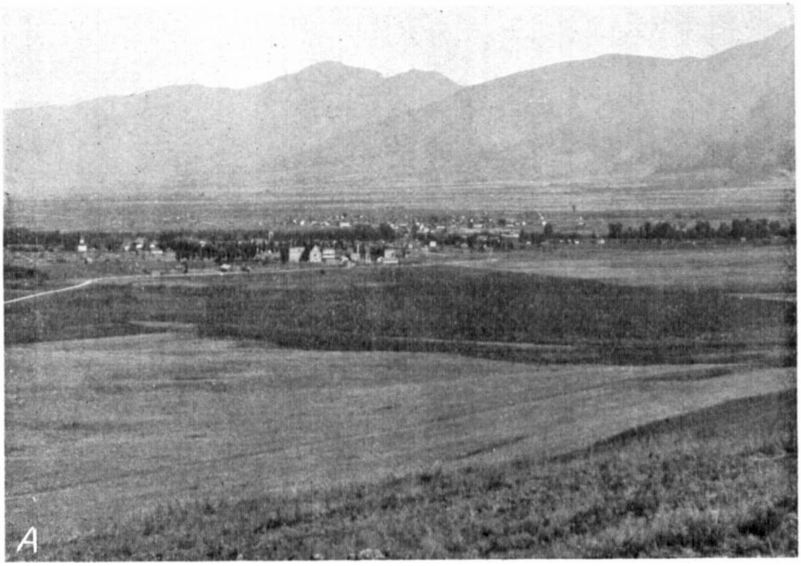
(3) Well-developed soils having loose leachy sand and gravel subsoils and substrata, with excessive subdrainage, including dark-colored grassland soils of the Flathead and Hyrum series; and brown grassland soils of the Moiese series.

(4) Imperfectly developed alluvial soils, including dark-colored soils of the Corvallis series; and light-colored soils (alluvial soils, undifferentiated).

(5) Rough mountainous areas, in which the soils are undifferentiated and are classed as rough mountainous land.

The soils of the lower Flathead Valley area which have been modified and have developed more or less distinctive profiles through weathering in place occupy nearly the entire area of arable soils. The imperfectly developed alluvial soils are confined to alluvial stream valleys and are of minor agricultural importance. The rough mountainous areas are of little or no economic importance save for such grazing as they may afford.

In the following pages the soils of the area are described in detail and their agricultural relationships are discussed, their location and distribution are shown on the accompanying soil map, and their acreage and proportionate extent are given in table 11.



A, View overlooking Mission Valley. St. Ignatius in middle distance; Mission Range in background.
B, Profile of Post gravelly silty clay loam, showing gray layer overlying tough clay, locally known as joint clay, indicated by hammer.

TABLE 11.—*Acreage and proportionate extent of the soils mapped in the lower Flathead Valley area, Montana*

Type of soil	Acres	Percent
McDonald gravelly loam	14, 080	4. 7
McDonald gravelly loam, stony phase	640	. 2
McDonald silt loam	1, 792	. 6
Millville gravelly loam	6, 336	2. 1
Millville loam	832	. 3
Millville loam, hilly phase	4, 416	1. 5
Polson silt loam	4, 928	1. 7
Polson silt loam, gravelly phase	1, 024	. 3
Polson silt loam, spotted phase	1, 152	. 4
Trenton very fine sandy loam	1, 536	. 5
Trenton stony loam	4, 480	1. 5
Trenton gravelly loam	576	. 2
Lonepine silt loam	14, 400	4. 8
Lonepine very fine sandy loam	10, 240	3. 4
Lonepine very fine sandy loam, steep phase	26, 688	8. 9
Lonepine very fine sandy loam, light-colored phase	1, 664	5
Lonepine silty clay loam	1, 984	. 7
Post silt loam	10, 880	3. 6
Post clay loam	7, 104	2. 4
Post clay loam, eroded phase	640	. 2
Post gravelly silty clay loam	16, 064	5. 3
Post silty clay loam	14, 336	4. 8
Post silty clay loam, rolling phase	5, 056	1. 7
Post silty clay loam, light-textured phase	1, 344	. 5
Post very fine sandy loam, dark-colored phase	2, 688	. 9
Round Butte silt loam	14, 336	4. 8
Round Butte very fine sandy loam	2, 048	. 7
Round Butte silty clay, heavy phase	3, 776	1. 3
Crow gravelly silt loam	8, 256	2. 7
Crow stony loam	6, 144	2. 0
Flathead very fine sandy loam	4, 352	1. 5
Flathead fine sandy loam	11, 456	3. 8
Flathead fine sand	7, 680	2. 5
Flathead fine sand, dune phase	832	. 3
Hyrum gravelly loam	3, 264	1. 1
Hyrum gravelly loam, terrace phase	3, 328	1. 1
Hyrum gravelly loam, hilly phase	3, 136	1. 0
Hyrum fine sandy loam, dark-colored phase	4, 800	1. 6
Hyrum stony loam	3, 904	1. 3
Moiese fine sandy loam	2, 880	1. 0
Moiese fine sandy loam, fine-textured phase	320	. 1
Moiese gravelly loam	4, 160	1. 4
Corvallis silty clay loam	5, 056	1. 7
Corvallis silty clay loam, gravelly phase	896	. 3
Corvallis silty clay loam, brown phase	1, 600	. 5
Alluvial soils, undifferentiated	19, 008	6. 3
Rough mountainous land	34, 048	11. 3
Total	300, 160	------

WELL-DEVELOPED SOILS HAVING PERMEABLE AND FRIABLE SUBSOILS, WITH FAVORABLE SUBDRAINAGE

DARK-COLORED GRASSLAND SOILS

The dark-colored grassland soils of this group include soils of the McDonald, Millville, and Polson series, which are dark colored and range from very stony and gravelly soils to soils that contain only a small quantity of gravel.

The ease of handling or cultivating these soils and the crops to be grown on them depend somewhat on the percentage of gravel and stone, particularly in the 10- to 12-inch surface layer. In many places the removal of the gravel and rock from the surface has simplified smoothing and leveling the land for irrigation and has also lessened the difficulties of cultivation.

The McDonald soils have very dark dull-brown surface soils which are nearly black when wet. The subsoils are of a lighter (medium-brown) color, grading into lighter-gray or pale yellowish-gray material which is moderately compact but friable and permeable. These soils are developed on glacial till or ground-moraine material under a mean annual rainfall slightly greater than in other parts of the area. They lie at an elevation of more than 3,000 feet above sea level.

The Millville soils, which are similar in general characteristics to the McDonald soils, occur in Jocko Valley, mainly south of Jocko River, and bordering Dry Creek southeast of St. Ignatius. An area of the hilly phase of Millville loam, which is rather extensive, occupies high glacial morainic ridges and slopes, occurring mainly as a belt extending in an east-west direction south of Flat-

181296—34——3

head Lake. The Millville soils differ from the McDonald soils principally in that more or less distinct permeable gravelly and sandy layers predominate in the subsoil and subdrainage is more rapid. The McDonald subsoils are of heavier texture and appear to have been derived from glacial till, whereas the parent materials of the Millville soils probably were to a greater extent deposited from glacial and other streams coming from the mountains. The Millville soils are more open and porous than the McDonald soils, and they require somewhat larger amounts of irrigation water to produce a crop.

The Polson soils are represented by a single type, Polson silt loam, with a gravelly phase and a spotted phase. Where not affected with alkali, these soils are very fertile and produce good yields of all crops normally grown in this area, such as alfalfa, sugar beets, wheat, oats, barley, potatoes, and pasture grasses. The nonirrigable areas are used almost exclusively for wheat production. From 20 to 35 bushels of wheat an acre are obtained on summer-fallowed land.

McDonald gravelly loam.—Areas of McDonald gravelly loam parallel Mission Range. The areas covered by this soil range from 1 to 3 miles in width and extend north of Mission Creek, east of St. Ignatius to Post Creek, and thence northeast of Ronan.

This soil is dark dull brown or black at the surface and gradually changes to brown porous gravelly silty loam at a depth ranging from 10 to 18 inches. The soil material is more yellow and somewhat heavier in the lower depths and is slightly compact though porous. Different quantities of rounded and angular gravel are scattered over the surface and throughout the soil. Acid tests indicate no free lime above a depth of 40 inches. The soil to a depth of 1 foot is slightly acid, according to the Truog test.

McDonald gravelly loam, stony phase.—A stony phase of McDonald gravelly loam occupies an area east of St. Ignatius. It contains a large quantity of gravel and stones on the surface and embedded in the soil material. Over much of this area the removal of the surface stones is necessary to allow effective cultivation.

McDonald silt loam.—McDonald silt loam is similar in color and general character to McDonald gravelly loam, but it is of finer smooth silty texture and contains only a few gravel and stones.

Wheat has been the principal crop grown since the opening of the reservation, and in this area McDonald silt loam is recognized as one of the most fertile soils of the valley. Because of the slightly higher rainfall and perhaps a better distribution of rainfall than in other parts of the area, dry-farming methods have been very successful, and it is natural, therefore, that wheat has remained the most important crop on this soil. Most of the soil occurs in a natural grass district and the native wheatgrasses were at one time very luxuriant. Under irrigation bluegrass, alsike, red clover, and timothy do well. Yields of alfalfa hay have not been entirely satisfactory, probably owing to a deficiency of available lime in the upper 3 feet of soil. The soil, to a depth of 1 foot, is slightly acid.

Millville gravelly loam.—The surface soil of Millville gravelly loam is very dark dull-brown or black loam. At a depth ranging from 3 to 5 inches, the subsurface soil is brown gravelly loam which gradually changes to distinctly gravelly and sandy yellowish-brown material containing free lime in the deeper part.

In Jocko Valley, alfalfa occupies the largest acreage of the crops grown on this soil, though yields are considered low. The irrigation project census reports an average yield of slightly more than 1½ tons an acre. Field tests indicate that the amount of available lime and phosphorus present probably limits the yields. Small acreages of wheat, oats, and barley are grown. Seed peas have been grown in Jocko Valley for several years, with yields ranging from 10 to 15 bushels an acre.

Millville loam.—Millville loam occurs in a few areas north of Arlee. The light-brown loamy surface soil extends to a depth of 12 or 14 inches and overlies gray calcareous very fine sand. Gravelly and sandy material is present at a depth ranging from 24 to 30 inches. Although of small extent, this is one of the better agricultural soils of Jocko Valley. Alfalfa and grain are the most important crops.

Millville loam, hilly phase.—Millville loam, hilly phase, is brown or dark brown at the surface, but within a slight depth becomes grayish-brown or chocolate-brown porous soil extending to a depth of 10 or 12 inches. This material grades into gray or yellowish-gray gravelly sandy clay which is somewhat compact but porous. The lower part of the subsoil is gravelly fine sandy loam, and loose calcareous material occurs at a depth ranging from 30 to 36 inches.

This soil, where farmed, is largely used for dry-farmed wheat. Under irrigation it would be suited to a diversified cropping system. It is of moderate extent and occurs in the northern part of the area south of Flathead Lake.

As mapped the soil includes small areas, about 2½ miles east of Polson, which are of somewhat finer or more silty texture, and a small area, covering about one half square mile 2½ miles southwest of Polson, which is of fine sandy loam texture.

Polson silt loam.—Polson silt loam is developed over lake-deposited silt and clay sediments. It occurs in the vicinities of Polson and Pablo Reservoir, south of the high moraine. The surface soil, to a depth of 10 or 12 inches, is dark dull grayish brown or chocolate brown in color, indicating a fairly high organic-matter content, and it is nearly as dark as the McDonald soils of the mountain foot slopes. It is underlain by pale yellowish-brown or light grayish-brown moderately compact silty clay loam which becomes calcareous at a depth of 16 or 18 inches beneath the surface. This layer is thin and covers the gray stratified silt, clay, and very fine sand, which are highly calcareous.

In a few places accumulation of alkali is a serious problem, especially south and west of Polson, where the land is badly seeped with water supposedly coming from the higher canals and the Pablo Reservoir. Under normal conditions subdrainage is favorable. The seepage has caused or brought about an accumulation of alkali salts near the surface on these areas of lower-lying land.

Polson silt loam, gravelly phase.—Polson silt loam, gravelly phase, contains a conspicuous amount of gravel in the surface soil.

Polson silt loam, spotted phase.—A spotted phase of Polson silt loam has also been differentiated. The areas of this phase have a slightly irregular or hummocky surface, in which many small light-colored spots formed by exposure of the lighter-colored subsurface material are apparent, particularly where the land is plowed.

BROWN GRASSLAND SOILS

The brown grassland soils of group 1 are represented by the Trenton soils which occur mainly in the Jocko Valley district bordering the foothills.

Trenton very fine sandy loam.—The surface soil of Trenton very fine sandy loam is light-brown very fine sandy loam or loam, which is loose and structureless to a depth ranging from 15 to 18 inches. It is underlain by pink or salmon-colored calcareous somewhat compact silt loam. In most places the salmon color persists to a depth of 3 feet and there changes to gray loose very fine sandy loam alternating with silt and clay materials. When irrigated this soil produces good alfalfa, although in a few spots alkali is troublesome.

Trenton stony loam.—Trenton stony loam is mapped along the slopes on the northern side of Jocko Valley, below the high-line canal, and also bordering the bench south of Dixon. The stones are largely a surface deposit which overlies the salmon-colored lake deposits. Much of the stony land is idle. As some of these slopes are steep and erode badly, careful control of irrigation water is necessary.

Trenton gravelly loam.—Trenton gravelly loam occurs in association with Trenton stony loam in Jocko Valley and south of Dixon. These gravelly areas are producing fair stands of alfalfa. This soil is less extensive than the stony loam.

LIGHT-COLORED BRUSH-LAND SOILS

The lighter-colored soils of group 1, developed under bunchgrass and sagebrush vegetation in the part of the area where lower rainfall prevails, are represented by the Lonepine soils which range from dull grayish brown to light grayish brown in the surface layers. The upper part of the subsoil is a pale-yelow or yellowish-gray friable porous silty clay loam that is only slightly compact. The lower part of the subsoil is composed of stratified coarse silt and very fine sand, as in the Round Butte and Post soils, which are almost invariably calcareous. The surface relief ranges from level to gently rolling, and the soils are well suited to irrigation farming.

Lonepine silt loam.—Lonepine silt loam is mapped in two widely separated parts of the area. The first is the Lonepine section of the Camas Valley division, and the second is in a body extending northeastward from Round Butte toward the Pablo Reservoir and merging with the darker-colored Polson soils. Small isolated areas border Flathead River.

In the Lonepine district more than 50 percent of the cropped land is used for growing alfalfa and in the Pablo-Round Butte section the alfalfa and wheat acreages are about equal. On many farms, alfalfa is irrigated but wheat is not. The physical character of this soil is almost ideal, and the land should produce all kinds of crops normally adapted to the area. Under good farm management sugar beets should do well, but much of the soil is too far from a railroad loading point.

Lonepine very fine sandy loam.—In the Camas Valley division Lonepine very fine sandy loam occupies areas lying between Lonepine silt loam and the alluvial soils of the stream bottoms. It also occurs southwest of Pablo in the Mission Valley division and in several scattered areas. This soil has essentially the same subsoil characteristics as Lonepine silt loam, but it has a very fine sandy loam surface soil. In the Pablo district, Lonepine very fine sandy loam is very rolling and a large part of the land has not been leveled or prepared for irrigation. White alkali spots occur in the eroded parts, but, as a rule, alkali interferes with crop production only in local areas. Where good drainage is provided, flushing with water would remove much of the alkali. The greater part of this soil near Pablo is used for growing wheat under dry-farming methods. In the Camas Valley division, most of the land lies more favorably for irrigation and is used largely for the production of alfalfa and pasture.

Lonepine very fine sandy loam, steep phase.—Lonepine very fine sandy loam, steep phase, includes not only rough broken and steep areas of Lonepine very fine sandy loam but undifferentiated areas of associated soils. These soils are too steep or too rough, broken, and eroded to be adapted to agriculture. They are almost wholly untillable and are of value only for grazing. Rather extensive areas occur along the course of Flathead River.

Lonepine very fine sandy loam, light-colored phase.—In the western part of the Charlo flat a light-colored phase of Lonepine very fine sandy loam is mapped. This soil has a light-brown very fine sandy loam surface soil which overlies light-gray calcareous very fine sandy loam or silt loam. Brown clay streaks, or layers, may be present at different depths.

Lonepine silty clay loam.—Lonepine silty clay loam occurs along the western border of the Camas Valley division. This soil is somewhat heavier and more difficult to cultivate than the other Lonepine soils, but otherwise it is similar. Alfalfa is the principal crop grown.

WELL-DEVELOPED SOILS HAVING TOUGH, COMPACT SUBSOILS AND HEAVY-TEXTURED STRATIFIED SUBSTRATA, WITH RESTRICTED SUBDRAINAGE

The soils of this group are characterized by very tough compact subsoils which are comparatively impervious to water or only very slowly permeable. The subsoils overlie heavy-textured but somewhat more friable stratified materials. Subdrainage takes place slowly, the soils are boggy when wet and readily puddled, and root development is more or less retarded by the tight plastic subsoil layer.

Like soils of the first group, these soils have developed under a rainfall which decreases from east to west, with a consequent similar range in vegetation, organic-matter content, and color of the surface soil material. They also include light-colored soils which have developed under a forest cover.

DARK-COLORED GRASSLAND SOILS

The dark-colored grassland soils of this group are represented by the Post soils. They are of somewhat lower organic-matter content and are not quite so dark as the soils of the McDonald and Millville series. They are dominant soils over the entire southern part of Mission Valley, extending north from St. Ignatius to Crow Creek.

The surface soils are of different textures and may be heavy clay loam, silty clay loam, gravelly silty clay loam, or silt loam. The deeper parent materials are apparently modified somewhat by superficial deposition of glacial ice-laid material, which left different quantities of glacial gravel and boulders scattered over the surface. As little of this gravel occurs in the subsoil, it is considered mainly a surface-soil modification. In places where the gravel is sufficient to interfere somewhat with cultivation a gravelly type of the Post series is mapped.

The relief of the Post soils is undulating, and in many places low mounds and shallow depressions dot the surface. Surface drainage, as well as internal drainage, is retarded in the flatter areas and slight depressions.

The eastern areas of the Post soils are invariably a shade darker at the surface than are the western areas because of the gradual decrease in the rainfall from east to west.

As in other parts of the valley, wheat was the first crop to be extensively grown on the Post soils. Because of the somewhat lower organic-matter content of these soils as compared with the soils of the mountain foot slopes, the yields of grain crops decreased more rapidly. With the development of the irrigation system the growing of alfalfa has been first in importance in the area watered in the Ninepipe subdivision, which embraces all the territory between Post Creek and Crow Creek, including the Charlo flat, westward to the southern stony ridge or butte. Also in the Mission Valley division south of Post Creek, alfalfa is the principal crop. A large proportion of the heavy clay loam soils is idle because of the difficulty in handling them and the lack of irrigation canals. Wheat is more largely grown on the darker soils bordering the Mission Range.

Where irrigation water is provided in this district, grasses start easily, and many irrigated pastures [8] are being developed on the Post soils, although it is apparent that a much wider use and development might be accomplished. The heavy character of the soils, particularly of the clay subsoils, which occur at slight depths in many places, makes it inadvisable to plow the land often. Therefore the farmers on this land grow crops that do not require frequent plowing. Feed grains, such as barley and oats, are grown on a small acreage.

Post silt loam.—The area mapped as Post silt loam is locally known as the Charlo flat. Because of the comparatively mellow and deep surface soil, the land is somewhat better adapted to irrigation farming than the other soils of the Post series. The surface soil ranges from 6 to 8 inches in thickness and from rather dark brown to dark dull grayish brown in color. Below the surface layer

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[8] HANSEN, D. IRRIGATED PASTURES. Mont. Agr. Expt. Sta. Bul. 166, 26 p., illus. 1924.

and immediately above the clay subsoil is a gray compact heavier-textured layer. At a depth ranging from 6 to 12 inches, heavy dull-brown massive columnar clay is present. This clay is locally termed "joint clay", because of its jointed upright columns. In its extreme development, the clay layer is 10 or 12 inches thick. Below this layer the material becomes spotted or mottled with gray and in most places is calcareous. A gray and brown hard stratified shalelike clay layer occurs at a depth ranging from 36 to 40 inches.

Sugar beets have been grown on a small acreage of Post silt loam in the vicinity of Charlo, but rather low yields have been obtained. Sugar beets may be grown on this soil, but success will depend largely on the development of a systematic rotation, or sequence of crops to maintain and add to the organic content of the soil. The heavy clay subsoil is not easily penetrated by sugar beets, and in some seasons it is difficult to pull the beets at harvest time.

Post clay loam.—The color of the plowed soil of Post clay loam is largely dominated by the normal gray layer that immediately overlies the joint-clay subsoil, giving the soil a distinctly gray appearance. Incipient slick spots occur, which are most evident in the area of this soil bordering Post Creek. Most of these spots are barren of vegetation, and they are probably caused by alkali salts that have accumulated or are more highly concentrated in these particular spots. Wheat grown in these areas is very spotted and irregular, both in size and development. The joint-clay subsoil and underlying soil material are much the same as in Post silt loam, except that the stratified hard layers of silty clay or clay lie at less depth. These hard shalelike layers lie at a depth ranging from 30 to 40 inches beneath the surface.

Post clay loam, eroded phase.—Post clay loam, eroded phase, differs from typical Post clay loam in that it has little or no dark-colored surface soil.

Post gravelly silty clay loam.—Post gravelly silty clay loam occurs largely in two belts, one bordering the dark gravelly McDonald soils of the mountain foot slopes, and merging rather imperceptibly with them, and the second comprising the sloping land between the higher Charlo flat and Post Creek. The latter area has the appearance of a smoothed escarpment or moraine. Smaller and scattered isolated areas of this soil occur on the borders of some of the larger kettle holes in the vicinity of Ninepipe Reservoir, and bordering the stony ridges or buttes.

The soil material is very similar to that of the other soils included in the Post series (pl. 1, B). The depth of the surface soil, or organic layer, is intermediate between that of the Charlo flat area and that of the Post clay loam which occurs largely between the lower courses of Post and Mission Creeks.

Post silty clay loam.—Post silty clay loam is very similar to Post gravelly silty clay loam, except that the gravel is less abundant. It is an extensive and agriculturally important soil. As mapped it includes a few small areas in T. 20 N., R. 21 W., covering in the aggregate about 1 square mile, in which the surface soil consists of a thin layer of very fine sandy loam material.

Post silty clay loam, rolling phase.—A rolling phase of Post silty clay loam is mapped in the vicinities of Ninepipe and Kickinghorse

Reservoirs, south of Crow Creek. The soil material is very similar to the other Post soils, but the land surface is so broken with pot or kettle holes, ranging in diameter from 5 to 200 feet and in depth from a few feet to 80 feet, that it is considered too rough for irrigation. In most areas the rim surrounding the larger kettle holes contains much gravel and many large boulders. The land under cultivation is dry farmed.

Post silty clay loam, light-textured phase.—A light-textured phase of Post silty clay loam occurs mainly in one large area 3 miles north of Charlo. The surface is covered with small hummocks, with intervening flats or depressed spots. The hummocks consist of deeper and sandier soil material and the depressions of heavier-textured soil, with none or only a thin layer of the sandier surface material. Under cultivation, the sandier material will become incorporated with the heavier-textured material and will give rise to a lighter-textured soil of more open structure.

Post very fine sandy loam, dark-colored phase.—Post very fine sandy loam is represented in this area only by a dark-colored phase. The subsoil material is somewhat less tough and impervious than is typical of soils of the Post series. This soil is not extensive, but it gives promise of becoming of some agricultural importance when irrigated.

As mapped the soil includes areas having a thin surface soil in which many light-colored spots occur when the land is plowed and the light-colored subsurface material is exposed.

This soil occupies a fair-sized area in the vicinity of Ronan. The surface soil consists typically of dark grayish-brown very fine sandy loam ranging from 6 to 12 inches in thickness. It overlies a thin gray layer which is abruptly underlain by heavy dull-brown or yellowish-brown columnar silty clay or clay. This material is compact and dense in the upper 4 or 6 inches and gradually becomes more porous and friable with depth. The lowest part of the layer is distinctly calcareous. Below a depth ranging from 20 to 24 inches the subsoil consists of stratified gray and yellowish-brown silty clay in the upper part, and gray coarse silt and very fine sand predominate at a lower depth.

This soil is not irrigated at present, but it will come under the proposed Ronan lateral system. Wheat, the principal crop, has been grown by summer-fallow methods. With irrigation water available, this soil should be well adapted to a diversified cropping system. Before an attempt is made to grow sugar beets on an extensive acreage, the soil should be built up by the addition of organic matter.

BROWN GRASSLAND SOILS

The brown grassland soils of group 2 have compact heavy-textured subsoils. These soils have developed under somewhat lower rainfall and less abundant grass cover than the dark-colored prairie soils. They are represented by the Round Butte soils, exclusive of Round Butte silty clay, heavy phase.

The Round Butte soils are intermediate in character between the Post soils, which have extremely heavy subsoils, and soils which have more porous and friable soil structures throughout, which will be described in subsequent pages of this report.

These soils are naturally low in organic-matter and nitrogen content but under irrigation their productive capacity should be comparatively easily improved by growing alfalfa and other leguminous crops. At present a large proportion of these soils is used in the production of alfalfa and for irrigated pastures. The soil improvement that has already been accomplished makes this area one of the outstanding districts of the irrigation project. The combined acreages of oats, wheat, and barley total from 15 to 25 percent of the land cropped.

Some fruit trees, mainly crab and McIntosh apples, are grown with fair success. Small fruits, such as strawberries and raspberries, can be grown for home use. These soils could probably be developed and built up for successful sugar-beet production, but most of the areas are too far from railroad shipping points.

Round Butte silt loam.—Round Butte silt loam occurs largely west of Ronan in the Round Butte district and in the Valley View district about 6 miles north of Round Butte.

This soil occurs in extensive areas, and it appears to be developed on old lake-deposited sediments. The surface soil is light grayish-brown or dull grayish-brown friable noncalcareous silt loam, which becomes lighter gray when dry, ranging from 6 to 8 inches in thickness. The upper subsoil layer, ranging from 3 to 6 inches in thickness, is noncalcareous compact brown or light grayish-brown clay having dark-brown organic-matter stains covering the columnar clods. This layer is underlain by gray and light grayish-brown stratified partly weathered compact but finely porous silty materials which become calcareous at a depth ranging from 15 to 24 inches below the surface. The lime content increases with depth. The deeper soil material consists of well-stratified coarse silt and very fine sand.

Round Butte very fine sandy loam.—Round Butte very fine sandy loam is mapped in the northern part of Moiese Valley and about 2 miles northwest of Moiese. This soil is similar to Round Butte silt loam, except that the surface soil averages very fine sandy loam in texture and that the silty clay subsoil is not so compact but is more friable and porous. The lower part of the subsoil consists of stratified alternate layers of brown silty clay and gray coarse silt or very fine sand. Alfalfa is the principal crop grown.

LIGHT-COLORED BRUSH-LAND SOILS

The light-colored soils of this group, which have developed under a comparatively low rainfall, are represented by Round Butte silty clay, heavy phase. This soil occurs under more arid conditions than the typical Round Butte soils, and in future soil surveys it may be recognized as representing a distinct series of soils.

Round Butte silty clay, heavy phase.—Round Butte silty clay, heavy phase, occurs in the southern part of the Camas Valley division, east of Hot Springs. As this is a dry section, the soil is low in organic matter. The color of the surface soil ranges from light grayish brown to gray. The texture of the surface soil is silty clay or clay, which ranges from 5 to 7 inches in thickness. The underlying material is gray compact stratified clay mottled or streaked with brown organic stains along root passages, and it is largely noncalcareous. Below a depth of 14 or 15 inches is a dull-brown and gray mottled layer of calcareous clay which appears to be only partly weathered. Below a depth of 30 inches, alternating strata of silt and clay extend to an undetermined depth.

Over most of the area of this soil the surface relief is level or gently rolling, but bordering shallow stream courses the land is rather flat for adequate drainage of excess irrigation water. The compact somewhat impervious subsoil also greatly retards the downward movement of water. Some of the poorly drained areas contain sufficient alkali to interfere with crop growth.

Only a small proportion of this soil is under cultivation. Alfalfa is practically the only crop grown, and, although the yields are low, the soil is probably better suited to alfalfa than to any other crop. A large part of the land remains covered with the native black sage and rabbitbrush.

LIGHT-COLORED TIMBERED SOILS

The light-colored timbered soils include light grayish-brown or light-gray soils having a thin veneer of dark-colored organic soil material only about 1 inch thick. Like the other soils of this group, they are underlain by a compact columnar heavy-textured layer which becomes somewhat more friable in the deeper part.

This subgroup includes two soils of the Crow series, Crow gravelly silt loam and Crow stony loam. These soils parallel the Mission Range north of Post Creek and extend northward, bordering the several forks of Crow Creek, with a break east of Pablo, and continuing to, and including a part of, the terminal moraine. That part of the area near the base of the Mission Range ranges from gravelly to very stony.

Very little of the Crow soils has been cleared for farming purposes, but most of the areas are used for grazing. As much of the area of these soils has been cut over, a rather large quantity of underbrush is mixed with the small standing timber. Pine, tamarack, and fir are the principal trees.

Crow gravelly silt loam.—Crow gravelly silt loam is characterized by a dark organic mulch which covers the immediate surface, but the mineral soil material is light grayish-brown or light-gray heavy silt loam 10 or 12 inches thick. Below this is an 8- to 12-inch layer of gray cloddy silty clay overlying grayish-yellow columnar or joint clay. Dull-brown and grayish-brown friable silty clay underlies the joint clay. The soil material is not calcareous above a depth of 40 inches.

Crow stony loam.—Crow stony loam areas near the mountains are much more porous than the gravelly silt loam areas, as they contain less clay material. Here the columnar and joint clay horizon is absent in most places.

WELL-DEVELOPED SOILS HAVING LOOSE LEACHY SAND AND GRAVEL SUBSOILS AND SUBSTRATA, WITH EXCESSIVE SUBDRAINAGE

The soils of group 3 are characterized by loose sandy and gravelly subsoils and substrata. They are of low water-holding capacity, and subdrainage conditions are excessive where the land is not subject to seepage water from adjacent canals or ditches or from higher-lying irrigated land.

This group includes the dark-colored soils of the Flathead and Hyrum series and the lighter-colored soils of the Moiese series.

These soils are widely scattered but are apparently related as regards the time and manner of their deposition. A small area of these soils is north of the Polson terminal moraine, and a large and more or less continuous area of deep sandy soils and sandy soils having distinctly gravelly subsoils extends south from the terminal moraine through Pablo and borders the course of Mud Creek to Flathead River. It is probable that a large body of water followed this course during and following the glacial period. Moiese Valley is made up largely of sand and gravel deposits and may represent the former channel of Flathead River. Jocko Valley is also an area of extensive sand and gravel deposits.

DARK-COLORED GRASSLAND SOILS

Flathead very fine sandy loam.—Flathead very fine sandy loam is probably the most productive agricultural soil of this group. It occurs in many scattered bodies throughout the area occupied by the sandy and gravelly soils. It ranges from dark grayish-brown to very dark dull grayish-brown very fine sandy loam, the darker areas occurring near Flathead Lake. The texture of the subsoil material gradually becomes coarser and the color becomes lighter brown with depth, and at a depth of 18 inches the material is grayish-brown or yellowish-brown fine sand. Gray calcareous fine sand is reached in most places at a depth below 3 feet.

Flathead very fine sandy loam under irrigation is adapted to a much wider range of crops than the soils of the Post series, which have heavy-textured compact subsoils. Potatoes, sugar beets, and truck crops may be successfully grown, and some farmers obtain good yields of wheat.

Flathead fine sandy loam.—Flathead fine sandy loam is much more extensive than Flathead very fine sandy loam. A large area is just south of the Polson terminal moraine, one is north of Ronan paralleling the general course of Mud Creek, and scattered areas lie southwest of Ronan.

North of Ronan this soil is dark grayish brown or chocolate brown to a depth of 12 inches, and below this depth the soil material is yellowish-brown loose fine sandy loam. Calcareous sand is not present above a depth of 40 inches. Near Flathead Lake and north of Pablo the surface soil is somewhat darker colored than elsewhere.

A large proportion of the land is summer fallowed and sown to wheat. The yields of wheat have declined somewhat, probably owing to the depletion of organic matter. Chemical analysis of the surface soil to a depth of 1 foot shows a rather low content of both nitrogen and phosphorus. The proposed Ronan lateral system will provide irrigation water for much of this soil, and it will then be possible to build up the organic content by growing leguminous crops. The looseness and porousness of the soil allow oxidation to progress rapidly, and the need of replenishing the organic-matter content is continuous.

Flathead fine sand.—Flathead fine sand is mapped in the more rolling and hilly areas. This soil has a tendency to blow or drift badly, and, as it is very loose and porous, its water-holding capacity is rather low. Most of the land cannot be irrigated from the gravity system of water supply, therefore the crops grown are largely wheat or other cereals.

Flathead fine sand, dune phase.—A dune phase of Flathead fine sand borders Moiese Valley northwest of Moiese. The soil in this area has been considerably shifted and modified by winds. It is not farmed, and but little vegetation grows on it. Its only value is for the scant grazing it provides.

Hyrum gravelly loam.—Hyrum gravelly loam and its terrace phase are mapped mainly in Jocko Valley in the vicinity of Arlee.

Hyrum gravelly loam has a thin dark-brown organic surface layer from 3 to 5 inches thick, which grades into brown, light-brown, or yellowish-brown gravelly and sandy loam. Lime-coated gravel and sand occur at a depth of 15 inches beneath the surface. The gravel mixed with some sandy material continues to an undetermined depth.

At one time, all this soil was broken out and grain farmed, but the land is now practically abandoned. The surface soil is very shallow, and the subsoil is practically nothing but gravel. A few farmers are attempting to grow alfalfa, but the land is so porous that excessive amounts of irrigation water are required to keep it moist throughout the growing season.

Hyrum gravelly loam, terrace phase.—The terrace phase of Hyrum gravelly loam occurs on terraces bordering Mission Creek, Finley Creek, and Jocko River. It is dark grayish brown at the immediate surface and is brown gravelly loam to a depth of 8 or 9 inches. Yellowish-brown gravelly sandy loam, including lime-coated gravel, continues to a depth ranging from 20 to 24 inches, below which is calcareous gravelly sandy loam. Soil of this phase is perhaps slightly darker and has less gravelly material near the surface than typical Hyrum gravelly loam, and it is somewhat more productive. Alfalfa and some seed peas are grown.

Hyrum gravelly loam, hilly phase.—Hyrum gravelly loam, hilly phase, contains a high percentage of gravel, even at the surface, making the land difficult to cultivate. The soil is rather porous, and its moisture-holding capacity is low. Some wheat is grown.

Hyrum fine sandy loam, dark-colored phase.—Hyrum fine sandy loam in this area is represented only by a dark-colored phase. This soil lies mainly north and east of Pablo Reservoir. The surface soil is very dark grayish brown, and it ranges in thickness from 3 to 12 inches. Yellowish-brown gravelly fine sandy loam material is present at a depth ranging from 7 to 19 inches beneath the surface. Loose gravel and sand strata invariably occur at a depth ranging from 15 to 20 inches. In some areas the gravel beds are only a few inches below the surface. Lime-coated gravel occurs in places at a depth of 40 or more inches below the surface, though the fine soil material is distinctly noncalcareous. The gravel consists mainly of quartzite and argillite.

Although a large part of this soil is below the high-line irrigation canal, very little of it is irrigated. It is reported that the soil is so porous that very large quantities of water are necessary and that it is difficult to spread because it soaks away so rapidly. It is also reported that it does not pay to irrigate wheat. Most of the farmers living in this area are grain farmers and do not use irrigation water. A few farmers grow a small acreage of alfalfa, but yields are lower than those obtained on the heavier-textured and less porous soils. The deficiency of lime in the upper 3 feet of soil may be a limiting factor in alfalfa production.

Hyrum stony loam.—Hyrum stony loam occurs in only a few small areas along the east side of Mission Valley in association with the McDonald soils. It is somewhat less open and leachy than those soils but in character of profile and agricultural possibilities approaches them.

BROWN GRASSLAND SOILS

The brown grassland soils of this region include members of the Moiese series, which are mapped in Moiese Valley and in smaller areas in the lower part of Jocko Valley west of Ravalli. These soils are similar to the Hyrum soils in texture and structure, but they are considerably lighter in color. As they occupy an area of lower rainfall than the Hyrum soils, the organic-matter accumulation is less and free lime occurs nearer the surface.

The sandy soils of the Moiese series are low in both nitrogen and phosphorus, according to chemical analyses of samples of the 12-inch surface layer.

Moiese Valley is more favorably situated than other parts of the lower Flathead Valley area for growing tender vegetables. Its comparatively low elevation, slightly longer growing season, and the early sandy soils are favorable for growing melons, pumpkins, cucumbers, other vegetables, and apples. Potatoes and alfalfa also do well, and the cropped land is devoted largely to alfalfa.

Moiese fine sandy loam.—Moiese fine sandy loam is medium grayish brown, dull grayish brown, or light grayish brown in color, and the areas differ considerably in depth, depending on their location. In Moiese Valley this soil occurs in conjunction with Moiese gravelly loam, most of the higher ridges being gravelly at or near the surface, and most of the lower depressions are occupied by the fine sandy loam. The light grayish-brown surface soil grades into yellowish-brown fine sandy loam which, in turn, overlies stratified layers of gravel and sand. Calcareous material occurs in most places at a depth ranging from 12 to 15 inches beneath the surface.

Moiese fine sandy loam, fine-textured phase.—Moiese fine sandy loam, fine-textured phase, occurs in the lower part of Jocko Valley west of Ravalli and near Agency north of Dixon. The area west of Ravalli has a light-brown very fine sandy loam or silt loam surface soil overlying light-colored rather compact silt loam. Below a depth ranging from 20 to 24 inches is a gray calcareous layer, and the deeper part of the subsoil is calcareous gravelly fine sand. This area is largely devoted to growing alfalfa.

Moiese gravelly loam.—The larger part of Moiese Valley is occupied by Mioese gravelly loam. Much of this soil, particularly that in the vicinity of Flathead River, has a shallow surface soil overlying stratified loose gravel and sand.

It is reported by farmers that some of the more gravelly areas require 10 acre-feet of irrigation water to produce a crop, and even after such heavy irrigation the yields are low.

IMPERFECTLY DEVELOPED ALLUVIAL SOILS

The imperfectly developed alluvial soils occur only in the bottoms of the larger streams. They consist of recently deposited stream-laid sediments of variably stratified character. They are comparatively inextensive and unimportant. A large proportion of these soils is unused, and they are of little or no economic importance under present agricultural conditions.

Many of these areas consist of loose sandy or gravelly material or are swampy and affected by accumulations of alkali salts. Much of the land, particularly a large part of the Jocko, Mission, Post, and Crow Creek bottoms, supports a dense growth of brush.

The soils of this group are represented by the dark-colored soils of the Corvallis series and by light-colored soils which have been classified as alluvial soils, undifferentiated.

DARK-COLORED SOILS

Corvallis silty clay loam.—Areas of Corvallis silty clay loam are mapped in Jocko Valley bordering Finley Creek, in the lower part of Mission Valley along Mission and Post Creeks, and along Garden Creek in the Camas Valley division. This soil represents the prairie bottoms that are being used to some extent for farming. The soil ranges from dark dull grayish-brown to nearly black loam or silty clay loam. In poorly drained areas the soil material is distinctly gray below a depth of 7 or 8 inches, whereas in other areas the dark-colored soil may continue to a depth of more than 2 feet. In Jocko Valley, gravelly and sandy strata are present in most places within a depth of 3 feet.

Corvallis silty clay loam, gravelly phase.—A gravelly phase of Corvallis silty clay loam is mapped in Jocko Valley where gravel is scattered through the surface soil as well as the subsoil. Soil of this phase is, in general, calcareous even at the surface.

Corvallis silty clay loam, brown phase.—A brown phase of Corvallis silty clay loam occurs in the better-drained areas. Soil of this phase is brown in the surface soil and becomes yellowish brown in the subsoil. Most of the land is farmed, and grain and alfalfa are the principal crops.

LIGHT-COLORED SOILS

Alluvial soils, undifferentiated.—Soils of this classification consist of undifferentiated alluvial stream-bottom soils which are mainly light gray or gray in color and are of variable texture. They include areas of sandy and gravelly materials supporting little vegetation, which occupy stream beds and channels during periods of low water. This soil classification is similar to river wash as mapped in other parts of the Western States. Much of the material is, however, of finer texture, of gray or light-gray color, and it occupies swampy or marshy and alkali-affected areas. Such areas are prominent in the vicinity of Dixon and bordering Flathead River. Some of them support a heavy growth of brush and small trees.

Most of the areas of this material are subject to overflow during flood periods and are of value principally for the grazing they provide.

ROUGH MOUNTAINOUS AREAS, IN WHICH THE SOILS ARE UNDIFFERENTIATED

The unclassified and undifferentiated soil materials of the rough mountainous areas, which are mainly nonagricultural, are designated as rough mountainous land.

Rough mountainous land.—This classification of material includes two types of land differing in surface relief and vegetative cover. It includes in part areas of steep and rough surface relief and stony character, with a shallow covering of soil. The more prominent of these areas are confined to stony buttes north of Moiese and north of Round Butte post office. The National Bison Range and Bird Refuge west of St. Ignatius is also in part of this character, but here the soil is of somewhat greater depth and the material is less stony. These rough grass areas have a fairly good grass cover and afford considerable grazing during the early part of the summer.

The more elevated mountainous areas, which are mostly forested, border Mission Valley on the east and Jocko Valley on the north and south. They are mainly of steep and rough relief and are unsuited to farming but may include small scattered and rather isolated areas of arable soils.

INTERPRETATION OF CHEMICAL ANALYSES OF SOIL SAMPLES [9]

It has already been suggested that the yields of certain crops are not so large as are normally to be expected under irrigation. Although very little information is available regarding the use of commercial fertilizers in this area, chemical analyses of the soils indicate that with the more intensive cultivation which accompanies the development of an irrigated project, it may become necessary to use commercial fertilizer, in addition to applying manure, if satisfactory yields are to be obtained. The chemistry department of the Montana Agricultural Experiment Station has determined the percentage of nitrogen and phosphorus in a number of samples of soil taken in the lower Flathead Valley area, as set forth in table 12.

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[9] The authors are indebted to Edmund Burke, chemist, Montana Agricultural Experiment Station, for assistance in preparing this section of the report.

TABLE 12.—*Chemical analyses of soil samples from the lower Flathead Valley area, Montana*

Sample no.	Soil type	Depth	Location	Nitrogen		Phosphorus	
				Per cent	Pounds per acre-foot [1]	Per cent	Pounds per acre-foot [1]
		Inches					
1171	McDonald gravelly loam	0–12	SW¼NW¼ sec. 9, T. 18 N., R. 19 W	0.256	9,060	0.0825	2,887
1172	do	0–12	SE. cor. sec. 6, T. 18 N., R. 19 W	.140	4,900	.0644	2,254
1205	do	0–12	NE¼NW¼ sec. 17, T. 18 N., R. 19 W	.314	11,090	.0758	2,653
1218	McDonald silt loam	0–12	SW. cor. sec. 31, T. 21 N., R. 19 W	.163	5,705	.1020	3,570
1173	Post gravelly silty clay loam	0–12	SE. cor. sec. 1, T. 18 N., R. 20 W	.111	3,885	.0554	1,939
1188	do	0–12	SW. cor. sec. 15, T. 19 N., R. 20 W	.116	4,060	.0641	2,243
1190	do	0–12	SE. cor. sec. 20, T. 19 N., R. 20 W	.102	3,570	.0658	2,303
1191	do	0–12	SW¼SE¼ sec. 19, T. 19 N., R. 20 W	.102	3,570	.0622	2,177
1174	Post silty clay loam	0–12	NE. cor. sec. 2, T. 18 N., R. 20 W	.109	3,715	.0588	2,058
1175	do	0–12	NE. cor. sec. 3, T. 18 N., R. 20 W	.112	3,920	.0655	2,292
1219	do	0–12	SW¼NE¼ sec. 11, T. 19 N., R. 20 W	.166	5,810	.0992	2,682
1222	do	0–12	SE¼NE¼ sec. 26, T. 21 N., R. 21 W	.148	5,180	.0922	3,227
1189	Post silt loam	0–12	NE. cor. sec. 16, T. 19 N., R. 20 W	.118	4,130	.0619	2,166
1206	do	0–12	NE¼NW¼sec. 19, T. 19 N., R. 20 W	.151	5,285	.0624	2,184
1220	do	0–12	SE. cor. sec. 31, T. 21 N., R. 20 W	.098	3,430	.0572	2,002
1176	Post clay loam	0–12	NE. cor. sec. 4, T. 18 N., R. 20 W	.092	3,220	.0644	2,254
1177	do	12–24	do	.024	840	.0852	2,982
1178	do	24–36	do	.018	630	.0686	2,401
1179	do	36–48	do	.012	420	.0490	1,715
1180	do	0–12	NE. cor. sec. 25, T. 19 N., R. 20 W	.099	3,465	.0591	1,968
1181	do	12–24	do	.021	735	.0691	2,418
1182	do	24–36	do	.014	490	.0674	2,359
1183	do	36–48	do	.016	560	.0636	2,226
1184	do	0–12	SW¼NE¼ sec. 23, T. 19 N., R. 20 W	.130	4,350	.0764	2,674
1185	do	12–24	do	.026	910	.0747	2,614
1186	do	24–36	do	.014	490	.0691	2,418
1187	do	36–48	do	.015	525	.0780	2,630
1192	Round Butte very fine sandy loam	0–12	NW. cor. sec. 28, T. 19 N., R. 21 W	.068	2,380	.0585	2,047
1193	do	0–12	SE¼NE¼ sec. 20, T. 19 N., R. 21 W	.066	2,310	.0468	1,638
1209	Round Butte silt loam	0–12	NW. cor. sec. 6, T. 21 N., R. 21 W	.140	4,900	.0641	2,243
1223	do	0–12	SE¼SW¼ sec. 31, T. 21 N., R. 20 W	.106	3,710	.0691	2,418
1224	do	0–12	NW¼NE¼ sec. 2, T. 21 N., R. 21 W	.148	5,180	.0803	2,810
1225	do	0–12	SE¼NE¼ sec. 21, T. 21 N., R. 21 W	.116	4,060	.0844	2,954
1226	do	0–12	SW¼NW¼ sec. 22, T. 21 N., R. 21 W	.096	3,360	.0908	3,178
1227	do	0–12	NW. cor. sec. 3, T. 21 N., R. 21 W	.113	3,955	.0752	2,632
1228	do	0–12	SW. cor. sec. 27, T. 22 N., R. 21 W	.086	3,010	.0708	2,478
1229	do	0–12	NE. cor. sec. 35, T. 22 N., R. 21 W	.132	4,620	.0745	2,607
1202	Post very fine sandy loam, dark-colored phase	0–12	NW¼SW¼ sec. 11, T. 20 N., R. 20 W	.145	5,075	.0496	1,736
1208	Lonepine silt loam	0–12	NW¼SE¼ sec. 19, T. 18 N., R. 21 W	.063	2,205	.0496	1,736

1210	do	0–12	SE¼NE¼ sec. 34, T. 21 N., R. 21 W	.124	4,340	.0554	1,939
1211	Polson silt loam	0–12	NE¼SW¼ sec. 34, T. 22 N., R. 20 W	.136	4,760	.0496	1,736
1230	do	0–12	SW¼NW¼ sec. 3, T. 21 N., R. 20 W	.146	5,110	.0870	3,045
1221	Lonepine very fine sandy loam, light-colored phase	0–12	SW. cor. sec. 36, T. 21 N., R. 21 W	.100	3,500	.0686	2,401
1207	Trenton very fine sandy loam	0–12	SW¼NW¼ sec. 19, T. 18 N., R. 21 W	.172	5,920	.0702	2,457
1214	Flathead very fine sandy loam	0–12	NW. cor. sec. 8, T. 22 N., R. 19 W	.232	8,120	.0627	2,194
1197	Flathead fine sandy loam	0–12	NE. cor. sec. 30, T. 19 N., R. 21 W	.058	2,030	.0360	1,260
1203	do	0–12	NW¼SE¼ sec. 25, T. 21 N., R. 20 W	.068	2,380	.0365	1,277
1216	do	0–12	SW. cor. sec. 19, T. 22 N., R. 19 W	.072	2,520	.0396	1,386
1217	do	0–12	SE¼SW¼ sec. 24, T. 21 N., R. 20 W	.078	2,730	.0618	2,163
1215	Hyrum fine sandy loam, dark-colored phase	0–12	SW¼SE¼ sec. 20, T. 22 N., R. 19 W	.251	8,785	.0875	3,062
1204	do	0–12	NE¼SE¼ sec. 25, T. 22 N., R. 20 W	.078	2,730	.0460	1,610
1194	Moiese fine sandy loam	0–12	NE¼SW¼ sec. 17, T. 19 N., R. 21 W	.038	1,330	.0435	1,522
1195	do	0–12	SW. cor. sec. 8, T. 19 N., R. 21 W	.062	2,170	.0429	1,501
1196	do	0–12	SW. cor. sec. 6, T. 19 N., R. 21 W	.086	3,010	.0557	1,949
1201	Moiese fine sandy loam, fine-textured phase	0–12	SE¼SW¼ sec. 27, T. 18 N., R. 21 W	.110	3,850	.0661	2,313
1198	Millville loam	0–12	SE¼NE¼ sec. 36, T. 17 N., R. 20 W	.165	5,775	.0512	1,792
1199	Millville gravelly loam	0–12	SW. cor. sec. 30, T. 16 N., R. 19 W	.262	9,170	.0677	2,369
1200	Hyrum gravelly loam, terrace phase	0–12	NE¼SW¼ sec. 35, T. 17 N., R. 20 W	.181	6,335	.0748	2,618
1212	Millville loam, hilly phase	0–12	NE¼SE¼ sec. 24, T. 22 N., R. 21 W	.150	5,250	.0507	1,774
1213	do	0–12	NE. cor. sec. 12, T. 22 N., R. 20 W	.164	6,240	.0563	2,270

[1] Pounds per acre-foot calculated from percentages, on the assumption that an acre-foot of soil weighs 3,500,000 pounds. Volume weights for different soils not determined.

The analyses given in table 12 deal with samples from the surface foot of soil, although a few samples were obtained from the second, the third, and the fourth foot. The percentages of nitrogen and phosphorus are the totals contained in the sample and do not indicate the amount that is readily available to the plant. In other words, chemical analyses do not always reveal the productiveness of the land. They are, however, an index to the potential fertility of the land and, with a knowledge of the soil type, should be of value in determining or considering the crops or rotations of crops best suited to the land. In general, it may be stated that plant foods do not become available as rapidly in the heavy-textured soils as in the lighter-textured soils, most of which are more open, porous, and easier to cultivate.

The McDonald soils are mountain foot slope soils located in the most favored section so far as rainfall is concerned. These soils are well supplied with nitrogen, and the phosphorus content seems to be sufficient, with proper cultivation, for good crop growth. The four samples of McDonald soils proved to be slightly acid but not sufficiently so to interfere with plant growth. It is possible, however, that the calcium carbonate in these soils will become depleted before any of the other elements of plant food. This may account for the comparatively low yields of alfalfa obtained on these soils. Field tests with acid indicate that free lime in quantities is not present above a depth of 40 inches.

Post gravelly silty clay loam and Post silty clay loam contain sufficient nitrogen to produce good crops if the land is properly cultivated and legume crops are used systematically in the rotation. These soils are fairly well supplied with phosphorus. The phosphorus content of samples 1173 and 1174 is lower than in many fertile soils. It must also be remembered that these soils have an extremely heavy, tough columnar clay subsoil which comes rather close to the surface in places. Plant foods may not become available in these soils as readily as in lighter-textured and more porous soils. Field tests indicate quantities of lime at a depth ranging from 15 to 20 inches below the surface.

Post silt loam on the Charlo flat contains fair quantities of both nitrogen and phosphorus. In a few places poor drainage and the consequent accumulation of alkali is a factor to be considered. A good rotation of crops should be followed in farming this land, particularly that which has produced wheat for several years. This soil has a subsoil similar to the subsoil of Post gravelly silty clay loam, but it usually has a deeper silty surface soil, and lime is present at a slightly greater depth.

In general the nitrogen content of Post clay loam is less than for other members of the Post series, and it occurs largely in the topmost 3 or 4 inches of surface soil. The phosphorus content is fair. The physical character of this soil makes it less desirable than other members of the Post series, and the land will be difficult to bring into a productive state. Some incipient slick spots occur. Probably the best use for this land at first will be for the production of alfalfa and for permanent pasture.

Round Butte very fine sandy loam, northwest of Moiese, is somewhat low in nitrogen as well as phosphorus. Although fairly good alfalfa yields are now obtained, it may be necessary and desirable to use some kind of phosphatic fertilizer to maintain production, particularly if a diversified cropping system is planned. The use of manure and the growing of legumes should aid materially in maintaining the nitrogen content.

Round Butte silt loam contains a fair quantity of nitrogen, though one or two samples are somewhat low in this element. The phosphorus content also appears to be good. However, good farming methods and a crop rotation including alfalfa or some other legume is desirable to maintain the productive capacity of the soil. Lime carbonate is present at a depth ranging from 10 to 15 inches beneath the surface.

The nitrogen content of Post very fine sandy loam, dark-colored phase, the Lonepine soils, the Polson soils, and the Trenton soils, with the exception of sample 1208, are sufficient to produce good crops under proper methods of rotation. Samples 1202, 1208, 1210, and 1211 are somewhat low in phosphorus content. It is probable that a good response would be obtained from the use of phosphate fertilizers on these soils, particularly where sugar beets are grown. The low yields that have been obtained may be due in part to the lack of readily available phosphorus. It is recommended that trials be made to determine the response to phosphorus under field conditions. The physical character of these soils is in general good.

Most areas of Flathead very fine sandy loam are fairly well supplied with nitrogen, particularly those areas near the mountains, but in Flathead fine sandy loam the nitrogen content is low. This is to be expected, as the fine sandy loam is a loose porous sandy soil in which oxidation proceeds rapidly. The nonirrigated areas will be more difficult to build up in this respect than the irrigated areas, and it will be necessary to add organic matter almost continually to maintain a good content of nitrogen. Samples 1197, 1203, and 1216 are decidedly low in phosphorus. The continuous cropping of the land to wheat probably has reduced the phosphorus content considerably, and it is not likely that satisfactory crop yields will be obtained without some effort being made to replenish or increase the supply of phosphorus. It is also likely that these soils are low in lime, as field tests with acid indicate the absence of free lime in the upper 3 feet of soil.

The Moiese soils are low in both nitrogen and phosphorus. As considerable lime carbonate occurs in most areas within 12 or 15 inches of the surface, alfalfa is grown successfully. By growing legumes and returning all manures and crop residues to the land, the nitrogen content probably can be built up considerably, but it may be desirable and necessary to apply phosphorus from time to time in order to maintain yields.

The Millville soils have sufficient nitrogen and a fair phosphorus content, but, like the McDonald soils, they are likely to be slightly acid to a depth of 1 foot. These soils contain different quantities of gravel throughout the soil profile, hence their desirability and productiveness under irrigation is dependent to a large extent on the percentage of soil material as compared to the gravel content. Bordering the mountains, however, the soil is deep and dark colored.

The phosphorus content of Millville loam, hilly phase, is not high, and the lime content has not been determined. This soil is largely nonirrigable, as it occurs on glacial moraines.

The Hyrum soils, like the McDonald soils, contain fair quantities of nitrogen and phosphorus, but the surface soils are likely to be slightly acid. Some of the more gravelly areas are too gravelly to be well adapted to farming purposes. Hyrum fine sandy loam, dark-colored phase, has a fairly good nitrogen content in areas near the mountains, but it becomes lower in areas farther west. The phosphorus content is low in areas where the gravel strata of the subsoil are near the surface. The lime content also is low. This soil, like the soils of the Flathead series, has been cropped to wheat almost continuously, which probably has greatly reduced the supply of available plant food. It is believed that a change from the present dry-farming methods to that of irrigation, with some replenishment of the phosphorus content, will be necessary in building up the soil.

IRRIGATION

Although a rather large part of the cultivated land in the lower Flathead Valley area is dry farmed, irrigated land is much more important because of the diversity of crop production that is made possible. Less than one half of the total area mapped is irrigable from the present canal construction. Rather large areas are nonirrigable because of rough surface relief, and other areas are too high to be reached by the gravity system of water supply. The natural rainfall is sufficient for the successful production of wheat and other grains in the eastern half of the area where summer fallowing is practiced, but in the rest of the area summer fallowing is a practice of doubtful value even for grains.

As the three physiographic divisions which comprise the lower Flathead Valley area are distinct, each division receives its irrigation water from different sources. In addition several individuals have prior water rights and irrigate their land from private ditches.

The water supply for the Mission Valley division is derived largely from streams that rise in the Mission Range. Early flood water from a tributary of Jocko River is brought to Mission Valley through the Tabor Feeder Canal and is emptied into Tabor Reservoir, also known as St. Mary's Lake. The principal storage reservoirs now in use are the Tabor, Lake McDonald, Ninepipe, Pablo, Kickinghorse, and Horte. The present and ultimate storage capacities of these reservoirs are given in table 13.

TABLE 13.—*Present and ultimate storage capacities of reservoirs in Mission Valley*

Reservoir	Present capacity	Ultimate capacity	Reservoir	Present capacity	Ultimate capacity
	Acre-feet	*Acre-feet*		*Acre-feet*	*Acre-feet*
Tabor	12,500	22,000	Kickinghorse	7,000	7,000
Lake McDonald	8,200	10,500	Horte	250	250
Ninepipe	15,150	15,150			
Pablo	13,000	25,000	Total	56,100	79,900

Other storage reservoirs planned are the Lower Crow, Twin, and Mission, to be constructed with capacities of 5,000, 970, and 6,000 acre-feet, respectively.

All the water for the Jocko Valley division comes as direct flow diverted from Jocko River, Finley Creek, and Revais Creek. As yet no storage has been provided.

The Camas Valley division receives its water supply from Little Bitterroot River and its tributaries. The principal storage reservoirs are Little Bitterroot Lake, Hubbart Reservoir, and Dry Fork Reservoir. The storage capacities are 18,000, 12,000, and 3,500, acre-feet, respectively. The Dry Fork Reservoir is situated near the northern end of the project, and the other two are located high in the mountains.

Sink holes have developed in the Camas Valley division and also to some extent in the Round Butte, Valley View, and Reservoir Valley sections, southwest of Polson. Where they have occurred in canal banks, they have entailed much loss of water. When moistened to the proper consistence, the floury silty horizon of the subsoil melts down, settles, and if further wetted is carried away by drainage. Thus a tunnel, or cavern, is formed at a depth ranging from 2 to 6 feet below the surface. With further moistening of the soil the roof drops in, forming a sink hole which, unless water is shut off, increases in size with surprising rapidity. These sink holes cause much annoyance in fields, but they are much more serious when they occur along the main canals.

The modified system of flooding is most commonly used in irrigating land on the Flathead project. This method is better adapted to the rolling and uneven surface of much of the land than are the border-dike or border-check systems. Flooding of the land, however, causes the heavier soils to bake and crust over.

The uneven surface relief of much of the land makes it necessary to exercise great care in the location of the field ditches, distributing laterals, and pick-up ditches, in order to spread the water uniformly over the field. Leveling and grading the land has had the effect of reducing the labor of irrigating from 10 to 20 percent. Although many farms have been leveled to some extent, so that the furrow or corrugation system can be used, much more leveling is necessary on most farms.

The duty of water for alfalfa ranges from 10 to 54 inches applied in two to six irrigations, depending on the porosity and water-holding capacity of the soil. The average is about 21 inches applied in three irrigations. Wheat is irrigated from 1 to 3 times, and the total quantity of water applied during the season ranges from 6 to 30 inches. Oats and barley are irrigated once or twice, the quantity of water applied ranging from 4 to 19 inches.

Irrigating heads are small, as a rule, except on level land or very sandy or gravelly porous soils where large heads are necessary to get the water over the land. The size of the stream ranges from 0.25 to 4 cubic feet a second, the average being between 1.5 and 1.75 cubic feet a second, or between 60 and 76 miner's inches.[10]

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[10] Information on irrigation methods and duty of water supplied by O. W. Monson, assistant agricultural engineer, Montana Agricultural Experiment Station.

DRAINAGE AND ALKALI

Under the natural rainfall for this area, the project land for the most part is fairly well drained. The exceptions are on some of the more level heavy-textured soil areas where percolation of water through the soil is very slow. In the sandy and gravelly areas drainage is excessive, allowing the soil to dry out soon after moisture is received, particularly during the summer.

Since the irrigation system has been developed, however, more water has been brought to the land than the natural drainage will care for, and some areas have become water-logged, owing to a rise in the ground-water level. In some areas alkali salts have accumulated on the surface through evaporation.

Because of the rather level surface relief, the lack of well-defined drainage courses, and the heavy impermeable character of the soil, a part of the irrigated area surrounding Charlo now shows the need of drains to remove excess water, and, with an increase in the use of irrigation water, still larger areas will require drainage. It is fortunate, however, that the soils in this district do not contain large quantities of alkali salts. The lowland west of Dixon is flooded during high water and also receives some seepage from the irrigated bench to the south, and here considerable evidence of alkali can be seen. A part of this area is swampy and has a high water table during part of the year. Another area that has become badly affected by seepage and the resultant accumulations of alkali is south and west of Polson. It is apparent that this condition has occurred since the Pablo Reservoir and the high-line canals to the south were constructed. A drain to Flathead River is now taking care of much of the seepage water, but the problem of reclaiming the land is more difficult and will probably require a long time to accomplish.

The Camas basin, and also a large part of the lower Flathead Valley, was formerly a lake. The parent soil materials of these areas were for the most part transported to the area and deposited by glacial streams or settled out of the turbid lake waters. As the water evaporated a certain amount of dissolved salts was left in the soil. The salts have become concentrated and more or less localized, forming the small bodies of alkali land that are now in the area. Since the development of irrigation the alkali salts in these areas may have become concentrated through poor drainage, seepage, or the development of a high water table, and in certain places the salts may have become concentrated previous to irrigation.

The areas in which alkali has seriously affected the soil constitute only a small proportion of the irrigated land of the project, although evidence of slight accumulations is observed in many parts of the area surveyed. Except in a few local spots, however, the uplands are comparatively free from alkali, as the soil contains less than 0.2 percent of salts. The lower swales and coulees are natural receptacles for water, and, if drainage is retarded, gradual accumulation of salts in these areas is likely to occur. The drying of swampy and seeped areas leaves the salts at or near the surface in a concentrated form.

In 1923, A. E. Kocher, then connected with the Bureau of Soils, United States Department of Agriculture, collected a number of soil samples on the Camas division and determined the approximate percentage of alkali by the use of the electrolytic bridge. The character of the salts was determined by the chemistry department of the Montana Agricultural Experiment Station. The results of these determinations are shown in table 14.

TABLE 14.—*Approximate percentage of alkali salts in soil samples from the Camas division, Flathead irrigation project*

Sample no.	Location	Depth	Alkali	Carbonates	Bicarbonates	Sulphates
		Inches	*Percent*	*Percent*	*Percent*	*Percent*
1	NE¼SW¼ sec. 34, T. 23 N., R. 24 W	0–12	<0.20			
		12–26	<.20			
		26–36	<.20			
		36–72	<.20	--------	0.025	0.058
2	NW. cor. SE¼NW¼ sec. 34, T. 23 N., R. 24 W	0–12	<.20			
		12–26	<.20			
		26–36	<.20			
		36–72	<.20	--------	.028	.195
4	NW. cor. NW¼NW¼ sec. 35, T. 23 N., R. 24 W	0–12	<.20			
		12–24	<.55			
		24–36	<.43			
		36–48	<.28	0.036	.097	.211
5	SE. cor. SE¼SE¼ sec. 3, T. 22 N., R. 24 W	0–12	<.20			
		12–24	<.53			
		24–36	<.47			
		36–48	<.24	--------	.350	.329
6	NE. cor. SE¼SE¼ sec. 15, T. 22 N., R. 24 W	0–12	<.20			
		12–24	<.20			
		24–36	<.20			
		36–48	<.20	--------	.046	.050
7	SW. cor. SW¼SE¼ sec. 13, T. 22 N., R. 24 W	0–12	<.20			
		12–24	<.20			
		24–36	<.20			
		36–48	<.20	.010	.055	.015
8	NE. cor. SE¼SE¼ sec. 26, T. 22 N., R. 24 W	0–12	<.24			
		12–24	<.30			
		24–36	<.30			
		36–48	<.32	.360	.122	.090
11	SE. cor. sec. 23, T. 22 N., R. 24 W	0–12	<.20			
		12–24	<.20			
		24–36	<.20			
		36–48	<.20	--------	.040	.014
12	NW. cor. sec. 6, T. 21 N., R. 23 W	0–12	<.20			
		12–24	<.20	.006	.036	.069
13	NE. cor. sec. 6, T. 21 N., R. 23 W	0–12	.63			
		12–24	.50			
		24–36	.47			
		36–48	.46	.039	.052	.226
14	NW¼SE¼ sec. 12, T. 21 N., R. 24 W	0–12	.43			
		12–24	.58			
		24–36	.63			
		36–48	.58	.016	.030	.342
15	SE. cor. sec. 10, T. 22 N., R. 24 W	0–12	<.30			
		12–24	<.30			
		24–36	<.30	--------	.025	.011
16	SW. cor. NW¼NW¼ sec. 23, T. 22 N., R. 24 W	0–12	<.20			
		12–24	<.20			
		24–36	<.20			
		36–48	<.20	--------	.018	.019
17	SW¼NW¼ sec. 26, T. 22 N., R. 24 W	0–12	.45			
		12–24	.25			
		24–36	.33			
		36–48	.25	.016	.021	.026
18	NW. cor. NW¼ sec. 26, T. 22 N., R. 24 W	0–12	<.20			
		12–24	<.20			
		24–36	<.20			
		36–48	.20	.006	.030	.051
19	NW. cor. NW¼SW¼ sec. 1, T. 21 N., R. 24 W	0–12	<.20			
		12–24	<.22			
		24–36	<.27			
		36–48	<.31	--------	.025	.163
20	NE. cor. NW¼NW¼ sec. 12, T. 21 N., R. 24 W	0–12	.21			
		12–24	.43			
		24–36	.34			
		36–48	<.20	.006	.028	.177

TABLE 14.—*Approximate percentage of alkali salts in soil samples from the Camas division, Flathead irrigation project*—Continued

Sample no.	Location	Depth	Alkali	Carbonates	Bicarbonates	Sulphates
		Inches	*Percent*	*Percent*	*Percent*	*Percent*
21	NE. cor. sec. 12, T. 21 N., R. 24 W.	0–12	<.20			
		12–24	<.20			
		24–36	<.38			
		36–48	<.38	------	.043	.128
22	SE cor. SE¼ sec. 1, T. 21 N., R. 24 W.	0–12	<.20			
		12–24	<.20			
		24–36	<.20			
		36–48	.28	.030	.049	.053
23	NW. cor. NE¼SE¼ sec. 3, T. 21 N., R. 24 W.	0–12	------			
		12–24	<.20			
		24–36	<.20			
		36–48	<.20	------	.018	.023
24	SW. cor. NW¼NE¼ sec. 3, T. 21 N., R. 24 W.	0–12	.22			
		12–24	.22			
		24–36	.39			
		36–48	.39	.090	.182	.072
25	SE. cor. SW¼NE¼ sec. 3, T. 21 N., R. 24 W.	0–12	<.20			
		12–24	<.20			
		24–36	<.20			
		36–48	<.20	.006	.064	.035
26	NE. cor. SE¼SW¼ sec. 35, T. 22 N., R. 24 W.	0–12	<.20			
		12–24	<.20			
		24–36	<.34			
		36–48	<.25	.009	.036	.134

SOILS AND THEIR INTERPRETATION

The lower Flathead Valley area is characterized by a comparatively moderate annual precipitation. In this valley, as in other intermountain areas of western Montana, adjacent high mountains influence the amount of annual precipitation so that it differs from 2 to 5 inches in different parts of the valley. This is clearly indicated by the natural vegetation and differences in soil color.

In a belt 2 or 3 miles wide bordering the base of Mission Range, the color of the soils approaches that of the prairie soils of the Central West, but elsewhere it is, in general, lighter, owing to a smaller percentage of organic matter in the soils. Most of the soils are fairly rich in mineral plant food but are low in nitrogen and humus. They have been leached to a greater extent than the soils in the drier Great Basin region or the Snake River plains to the southwest. They hold a position intermediate between the humid and the arid soils, both as regards organic-matter content and soluble mineral content.

In Flathead Valley the parent material of practically all the agricultural soils has been transported to the area. This material [11] was deposited chiefly during the recession of a large glacier which completely filled Flathead Valley and Little Bitterroot Valley. From the ice cap covering the mountains, valley glaciers descended, and, as they receded, they left terminal moraines, at times with lakes dammed up against the ice front, and at other times large rivers carried the glacial material away from the ice front almost as rapidly as it was deposited. The differences in the material as deposited are largely attributable to differences in sorting and distance from the source of supply. This material includes very fine clay, which dominates the soils of the southern part of Mission Valley; the

[11] See footnote 7, p. 15.

lighter silts and clays of the Round Butte, Valley View, and Lonepine sections; and sands and gravel of the Pablo, Jocko, and Moiese sections.

Since the deposition or accumulation of soil material, the great soil-forming processes, such as leaching, oxidation, and the accumulation of organic matter, have been at work and have imparted to the soils of this area many of their present characteristics. The rapidity with which the soil-forming processes have worked has been influenced greatly by the texture of the soil material itself, by location, surface relief, elevation, distribution of rainfall, and the range of temperature throughout the year.

In a general way the soils may be divided into those having rather definite soil layers with compact tight claypans, those having more friable and only slightly modified profiles, and those having no true soil profiles. With the exception of the small areas of alluvial soils, very few soils in the area may be regarded as strictly recent, as most of them show some horizonal modification and compaction and an accumulation of lime in the subsoils. The heavy-textured compact and comparatively impervious subsoil materials of the southern part of Mission Valley dominate the soil profiles of that part of the area, and, although rather distinct layers have developed, oxidation and leaching processes have not thoroughly penetrated the clay layer. Impeded percolation is probably responsible for the gray horizon immediately above the claypan. The Post and Round Butte soils, which are more or less dominated by partly weathered clay subsoils, form a large part of this section. The Crow soils are apparently derived from similar soil materials but are developed under a forest cover in contrast to the prairie or grass cover that has existed over most of the area.

The well-drained soils of the area are of variable texture and range in color from gray or light brown to rather dark dull brown. The difference in color expresses a corresponding difference in the content of organic matter in the soil, which is dependent largely on the moisture supply that determined the luxuriance with which grasses grew under natural conditions. In the lower and more westerly parts of the area the soils are light brown or light gray, whereas on the higher areas and on the western slopes of the mountains, where the precipitation is greater, the soils are brown or dark brown.

The differences in the color of the soils are in a measure correlated with the depth to which lime has been leached. In the drier and light-colored soil areas bordering Flathead River and in the Camas Valley division the depth to lime ranges from 15 to 24 inches beneath the surface, whereas, in the dark-colored mountain-slope soils and the more open sandy soils, free lime does not occur above a depth of 3 feet.

In considering the differences in soil color and the differences in the soil materials, a typical soil profile representative of the greater part of the area does not exist. However, rather typical soil profiles may be considered to represent certain arbitrarily defined districts.

In the area of heavy-textured compact subsoils of Crow Creek and extending to St. Ignatius, occupied by the Post soils, the topmost layer, or organic mulch, is very dark dull-brown laminated very fine sandy loam. The second layer, which extends to a depth of 4 or 5 inches, is grayish-brown massive and firm though friable silt, loam, clay loam, or silty clay loam. This grades into a lighter-colored heavier compact and vesicular layer which becomes distinctly gray in the lower part and extends to a depth of 8 or 10 inches. Below the gray horizon, which ranges from 1 to 3 inches in thickness, is distinctly massive and columnar, or joint, clay, in which the tops of the columns are well rounded. Brown organic stains occur along cleavage and root lines. The clay becomes streaked or spotted with lime and is more friable below a depth of 20 or 24 inches, and the soil material is slightly calcareous. Below a depth ranging from 30 to 36 inches, dull-brown and gray stratified hard calcareous shale-like clay layers occur.

The Round Butte soils have profiles somewhat modified from those of the Post soils heretofore described. They have slightly lighter colored surface soils than the Post soils. The clay layer of the Round Butte soils is from 4 to 8 inches beneath the surface and ranges from 3 to 5 inches in thickness. This mottled gray and brown material is somewhat columnar, noncalcareous, and only partly disintegrated or weathered. The lower part of the subsoil consists of calcareous stratified layers of silty material and very fine sand.

In contrast to the soils having a heavy clay layer, the more permeable normally developed soils of the Lonepine, Polson, and Trenton series are friable and porous throughout their soil profiles. The Polson soils have dark dull-brown surface soils, and the Lonepine and Trenton soils are brown or light grayish brown. Although the upper subsoil layers are slightly heavier in texture than the surface soils and in some places are compact, they are everywhere friable. Lime occurs just below this heavier layer, in most places at a depth of 14 or 16 inches beneath the surface.

The dark-colored mountain foot slope soils bordering the base of Mission Range have been included in the McDonald and Millville series. These soils are dark dull brown or black. The subsoils of the McDonald soils become brown, yellowish brown, and dull brown in color and also become heavier in texture with depth, though they remain friable and fairly porous. Lime is present below a depth of 36 inches. The subsoils of the Millville soils become brown and yellowish brown in color and are coarser in texture than are the surface soils. The depth to lime is more than 30 inches.

The soils having loose porous sandy and gravelly subsoils present profiles that are mainly color and texture profiles, as the horizons are indistinct. The porosity of these soils has allowed rather deep percolation of the rainfall, and the lime has been leached or carried down to a depth ranging from 14 inches in the Moiese soils to 30 or more inches in the Flathead and Hyrum soils. The Flathead and Hyrum soils are dark dull brown or very dark dull brown at the immediate surface, and the Moiese soils are lighter grayish brown. The subsoils are grayish brown or yellowish brown, and they consist of either coarse sandy material or sand and gravel.

The timbered soils are included in the Crow series. These soils have a thin dark-colored organic layer at the immediate surface, but the underlying material has the characteristic light grayish-brown color of timbered soils. The upper subsoil material is grayish-yellow columnar heavy silty clay, becoming dull-brown columnar material at a depth of 24 inches. Below a depth of 40 inches the material is more friable and calcareous. The soil material in the timbered areas seems to be, in part, similar to the heavy prairie soils of the Post series. The natural vegetation, however, has given the surface soils a lighter color. The stony areas bordering the mountains have more friable subsoils than the gravelly or silty areas to the west.

The alluvial soils of the Corvallis series and the undifferentiated alluvial soils do not have true soil profiles. They range in color from dark brown or black to light gray, depending on the amount of organic matter accumulated, drainage conditions, and the concentration of alkali. Most areas of the light-colored poorly drained soils have some concentration of alkali at or near the surface.

Following is a profile description of Post silt loam as observed in the NE¼NW¼ sec. 9, T. 19 N., R. 20 W.:

From 0 to 1 inch, brown laminated very fine sandy loam.
From 1 to 5 inches, grayish-brown massive firm silt loam.
From 5 to 8 inches, light grayish-brown heavy silt loam.
From 8 to 12 inches, gray silty clay which is massive in the upper part and in the lower part becomes columnar.
From 12 to 24 inches, dull-brown massive columnar clay, with dark stains along cleavage and root lines.
From 24 to 36 inches, dull-brown or grayish-brown silty clay streaked or spotted with lime. All the material is slightly calcareous.
From 36 to 48 inches, dull-brown and gray calcareous stratified hard shale-like clay.

The above profile shows more distinct layers above the so-called "joint clay" than generally occurs over the Charlo flat. A thin gray layer everywhere immediately overlies the clay layer, but the depth to the columnar clay is more apt to be 8 or 10 inches beneath the surface than 10 or 12 inches.

Following is a profile description of Post clay loam as observed in the NW¼NW¼ sec. 4, T. 18 N., R. 20 W.:

From 0 to 1 inch, a gray-brown silty laminated organic mulch.
From 1 to 6 inches, light-brown coarsely laminated silty clay or clay loam that is somewhat vesicular.
From 6 to 8 inches, a gray leached subsurface layer.
From 8 to 16 inches, brown noncalcareous columnar silty clay or clay.
From 16 to 30 inches, brown silty clay streaked with gray or white spots. All the material is calcareous and the white spots are highly calcareous. The material is only partly disintegrated.
From 30 to 42 inches, brown stratified shalelike layers of calcareous material.
From 42 to 48 inches, light-gray stratified calcareous very fine sand or silty material.

This soil contains many incipient slick spots that are bare of vegetation. Some eroded sloping areas north of Post Creek have a very shallow surface soil overlying the columnar clay layer.

Following is a profile description of Round Butte silt loam as observed in the NE. cor. sec. 1, T. 20 N., R. 22 W.:

From 0 to 1 inch, a light grayish-brown laminated silty mulch which is light gray when dry.
From 1 to 7 inches, gray laminated silt loam.
From 7 to 10 inches, gray and brown mottled hard columnar clay which is only partly disintegrated. Brown organic stains dominate the color along cleavage lines.

From 10 to 26 inches, yellowish-brown and gray stratified partly weathered calcareous silt.
From 26 to 36 inches, brown and gray stratified layers of calcareous silt and clay.

The profile is characteristic of the soil in much of the Round Butte and Valley View sections.

Following is a profile description of Lonepine silt loam as observed in the SW¼NW¼ sec. 14, T. 22 N., R. 24 W.:

From 0 to 1 inch, dull brownish-gray laminated very fine sandy loam or silt loam.
From 1 to 8 inches, grayish-brown coarse silt loam of single-grain structure.
From 8 to 14 inches, yellowish-gray friable noncalcareous silty clay loam which breaks up somewhat cloddy.
From 14 to 36 inches, light-gray calcareous coarse silt loam or very fine sandy loam.
Below a depth of 36 inches, stratified light-gray silty sand and very fine sand.

Following is a profile description of Lonepine silt loam as observed in the SE¼NE¼ sec. 34, T. 21 N., R. 21 W.:

From 0 to 1 inch, grayish-brown laminated very fine sandy loam.
From 1 to 6 inches, light grayish-brown coarse silt loam.
From 6 to 16 inches, yellow friable silt loam or silty clay loam which is somewhat compact.
From 16 to 30 inches, gray calcareous silt containing thin layers of brown material.
From 30 to 36 inches, partly disintegrated gray and brown stratified silty material.

Lonepine silt loam mapped north of Round Butte appears to be slightly darker at the surface than similar soil mapped in the Lonepine section, and chemical analyses also show a slightly higher nitrogen content in the area north of Round Butte.

Following is a profile description of Trenton very fine sandy loam as observed in the SW. cor. sec. 21, T. 17 N., R. 20 W.:

From 0 to 1 inch, dull grayish-brown laminated loam or very fine sandy loam.
From 1 to 10 inches, a layer of brown very fine sandy loam or silt loam, which is slightly laminated.
From 10 to 18 inches, light grayish-brown noncalcareous silt which is of single-grain structure.
From 18 to 28 inches, light pinkish-gray calcareous silt loam.
From 28 to 40 inches, salmon-colored loose calcareous very fine sandy loam.
From 40 to 48 inches, gray calcareous coarse stratified silt loam.
From 48 to 54 inches, stratified layers of reddish-brown silty clay and very fine sandy loam.

As mapped this soil includes a very small area of Trenton silt loam, northwest of Arlee, in which the color profile is very similar to the profile described, but the texture profile is much heavier, the material being more compact. The horizon overlying the calcareous zone is composed of rather tight silty clay or clay.

Following is a profile description of McDonald gravelly loam as observed in the NE¼NW¼ sec. 17, T. 18 N., R. 19 W.:

From 0 to 3 inches, a very dark-brown or black silty organic mulch which is laminated in the immediate surface layer and granular below.
From 3 to 10 inches, dark grayish-brown gravelly loam.
From 10 to 18 inches, brown porous mellow silt loam.
From 18 to 24 inches, light-gray faintly columnar heavy silty clay.

From 24 to 36 inches, light grayish-brown gravelly silty clay.
From 36 to 50 inches, light yellowish-brown silty clay which is slightly calcareous in the lower part.

Following is a profile description of Hyrum gravelly loam as observed in the SE¼ sec. 7, T. 16 N., R. 19 W.:

From 0 to 5 inches, brown or dark dull-brown gravelly loam.
From 5 to 16 inches, brown or yellowish-brown very gravelly loam.
From 16 to 30 inches, gray lime-coated gravel. Otherwise the material is noncalcareous.
Below a depth of 30 inches, a mass of gravel.

Following is a profile description of Moiese fine sandy loam, fine-textured phase, as observed in the SE¼SW¼ sec. 27, T. 18 N., R. 21 W.:

From 0 to 2 inches, dull grayish-brown somewhat laminated fine sandy loam.
From 2 to 12 inches, dull grayish-brown very fine sandy loam or silt loam, which breaks up cloddy.
From 12 to 24 inches, light brownish-gray noncalcareous silt loam.
From 24 to 34 inches, light-gray calcareous loose silt loam.
From 34 to 42 inches, light-gray calcareous gravelly fine sandy loam.

Gravelly and sandy strata occur at much slighter depths where areas of this soil border the lower valley land.

The soil material and profile of Moiese gravelly loam are similar to those of the other Moiese soils described, but this soil contains a rather large quantity of gravel, even at the surface, and is, therefore, much more porous. It requires more irrigation water to produce a crop than do the other Moiese soils.

Following is a profile description of Flathead very fine sandy loam as observed in the NW. cor. sec. 8, T. 22 N., R. 19 W.:

From 0 to 2 inches, a very dark dull-brown faintly laminated organic mulch.
From 2 to 18 inches, very dark grayish-brown very fine sandy loam.
From 18 to 36 inches, grayish-brown very fine sandy loam.
From 36 to 50 inches, gray calcareous fine sand.

Following is a profile description of Crow gravelly silt loam as observed in the SE. cor. sec. 32, T. 21 N., R. 19 W.:

From 0 to 1 inch, a dark organic surface mold.
From 1 to 12 inches, light grayish-brown or light-gray heavy gravelly silt loam.
From 12 to 16 inches, gray heavy cloddy silty clay.
From 16 to 24 inches, grayish-yellow columnar silty clay containing some brown organic stains along root lines.
From 24 to 40 inches, dull-brown columnar clay with colloidal stains.
From 40 to 60 inches, light grayish-brown friable silty clay loam which is calcareous in places at a depth of about 40 inches.

This soil is forested with pine, tamarack, and fir. Some angular and more or less rounded gravel are scattered over the surface and also mixed with the surface soil. The amount of gravel and rock increases as the base of the mountains is approached. Stony areas parallel the mountains, and, as the stone and gravel increase, the soil material becomes more porous and the columnar-structured clay disappears.

Following is a profile description of Corvallis silty clay loam as observed in the SW¼SE¼ sec. 21, T. 18 N., R. 21 W.:

From 0 to 8 inches, very dark grayish-brown or black calcareous silty clay loam.
From 8 to 20 inches, gray calcareous silty clay loam.
From 20 to 30¼ inches, brown gravel and sand.

The alluvial soils bordering the main streams, such as Jocko River and Post, Mission, Mud, and Crow Creeks, have been grouped in one classification, alluvial soils, undifferentiated. This group includes sand and gravel or river wash material, and swampy and alkali-affected areas, with some silty and clay materials. A large part of these overflow bottom lands now supports a dense growth of brush and small trees. In its present condition, this land is not agricultural land, and its only value is for grazing.

SUMMARY

The lower Flathead Valley area covers 469 square miles in northwestern Montana and is identified with the Flathead Indian irrigation project. It includes three main divisions—Mission Valley, Jocko Valley, and Camas Valley—with adjacent intervening mountainous and hilly areas. It is mainly in Lake County and includes parts of Missoula and Sanders Counties.

The area is drained by Flathead River and its tributaries. In those parts of the area in the vicinity of the larger streams, drainage is well established and erosion is active; in other parts the relief is dominated by parent glacial materials, and drainage is not everywhere established.

The elevation ranges from about 2,500 feet to about 3,500 feet above sea level.

Early settlement was established at St. Ignatius Mission in 1854, previous to political organization. Polson is the county seat of Lake County and the largest town in the area. Lake County was organized from previously existing counties in 1923. The present population consists mainly of whites, with some Indians.

Railway transportation is furnished by the main line of the Northern Pacific Railway and its Dixon-Polson branch. The cities of Butte and Missoula, Mont., and Spokane, Wash., constitute the principal markets for farm products which consist mainly of grain, flour, lumber, dairy products, and livestock.

The climate is of the continental type and is characterized by a mean annual rainfall in the valley areas, ranging from about 12 to 17 inches, fairly uniformly distributed throughout the year. The frost-free season ranges from 116 to 136 days.

The soils which have developed in place by weathering of parent materials are classified in three main groups based on differences in profile and permeability of subsoil materials. These are further subdivided on the bases of organic-matter content and color, which reflect environmental conditions of rainfall and vegetation.

The dark-colored soils of the first group having permeable but firm subsoils are represented by soils of the McDonald, Millville, and Polson series. They have developed under a comparatively heavy prairie-grass vegetation and a moderate rainfall. They are well adapted to agriculture, except the areas of excessively gravelly or stony character, and they constitute the most important grazing and wheat-producing soils of the area. Wheat is grown with and without irrigation, and alfalfa and other crops are grown to some extent. Of the dark-colored soils of this group the Millville soils are somewhat more permeable than the McDonald soils, and they require more frequent and copious irrigation. The Polson soils, represented by a single type, have less permeable subsoil materials and less well developed subdrainage.

The brown grassland soils of the first group are developed under slightly lower rainfall and less abundant grass cover. They are represented by the Trenton soils which have weathered from old glacial-lake sediments of fine texture and highly calcareous character. Alfalfa is an important crop on these soils.

The lighter-colored soils of this group include the Lonepine soils. Exclusive of a steep phase, these are important soils in the production of grains and alfalfa.

The soils of the second group are characterized by the presence of a tough and comparatively impervious clay layer in the subsoil. These soils are more difficult to handle, have a narrower range of adaptability to crops, and surface drainage and subdrainage are less well developed than in soils of the first group.

The darker-colored grassland soils of this group are represented by the Post soils; the lighter-colored soils developed under lower rainfall and prairie and semidesert-land vegetation by the Round Butte soils; and the light-colored timbered soils by the Crow soils.

The Post soils are extensive. Wheat, grown largely without irrigation under a system of summer fallow in alternate years, and alfalfa, grown under irrigation, are the most important crops. Yields average somewhat lower than on the dark-colored soils of the first group.

The Round Butte soils have somewhat less impervious and intractable subsoils. These soils are of low organic-matter and nitrogen content but are capable of improvement in this respect, under irrigation.

The Crow soils are mainly timbered or include cut-over but unbroken areas, and they are used mainly for pasture.

The soils of the third group are characterized by loose sandy and gravelly subsoils and substrata of low water-holding capacity. They are represented by the dark-colored soils of the Flathead and the Hyrum series, and by the lighter-brown soils of the Moiese series. They are of low value for dry-farmed crops but under irrigation are adapted to a wider range of crops than the soils of the other two groups. Potatoes, sugar beets, alfalfa, and truck crops are grown on these soils.

Flathead very fine sandy loam and Flathead fine sandy loam are extensive, and they are productive under irrigation, though at present they are utilized in part for dry-farmed crops.

The Hyrum soils consist mainly of gravelly and stony soils which are subject to drought and require large quantities of water in irrigation. They are of little agricultural importance.

The Moiese soils are developed under conditions of low rainfall and are of low organic-matter content. They are poorly adapted to dry farming and require much water in irrigation but are of favorable character and well located for the production of early truck crops and potatoes, under irrigation. At present they are used mainly for alfalfa.

The imperfectly developed alluvial soils consist of recently accumulated stratified stream-laid sediments. They are comparatively inextensive and unimportant. They consist of dark-colored soils of the Corvallis series, used to a small extent for farming, and a group of undifferentiated alluvial soils of light color and of variable texture, which are subject to overflow, are poorly drained, and are utilized mainly for grazing.

The livestock and dairy industries are developing and are capable of extension. Increase in the production of alfalfa and pasture in connection with livestock raising and dairying is recommended. Winter feeding of sheep and cattle is practiced to some extent.

Sweetclover, red clover, and timothy are grown to some extent, and the production of seed peas and sugar beets is successful in some places. Sugar-beet growing is of value in connection with a more general and systematic crop-rotation program where nearby shipping points are available.

In general, the yields of irrigated crops are somewhat lower than normal. Analyses of selected soil samples suggest that the use of commercial fertilizers, in addition to available organic manures, may become necessary. The lighter-textured soils, particularly the Round Butte and Flathead soils, are rather low in nitrogen, and some of them are low in phosphorus.

Most of the subsoil materials are of moderate or high lime content, but the surface soils are in general leached of lime, and the darker-colored soils, particularly the Hyrum, McDonald, and Millville soils, tend to become somewhat acid.

More effective use of stable manure, combined with good farming methods and systematic crop rotation, including alfalfa or some other legume, will materially aid in building up and maintaining soil fertility and in deferring the necessity of purchasing commercial fertilizers.

Less than one half the total area included in the surveyed area is irrigable under present storage and distributing systems. A part of the unirrigable area is so rough that it is suitable only for grazing. Additional facilities for storage and distribution of the water to be provided will greatly extend the area capable of irrigation. A system of modified flooding is the prevalent method of irrigation. Much of the irrigated land is of uneven surface configuration and is poorly leveled and prepared, rendering irrigation difficult and inefficient.

Some of the more level and low-lying areas, particularly of the soils having heavy-textured compact subsoils, have become subject to water-logging and accumulation of alkali salts. Drainage has been provided in part, but processes of reclamation of water-logged and alkali areas are difficult and slow.

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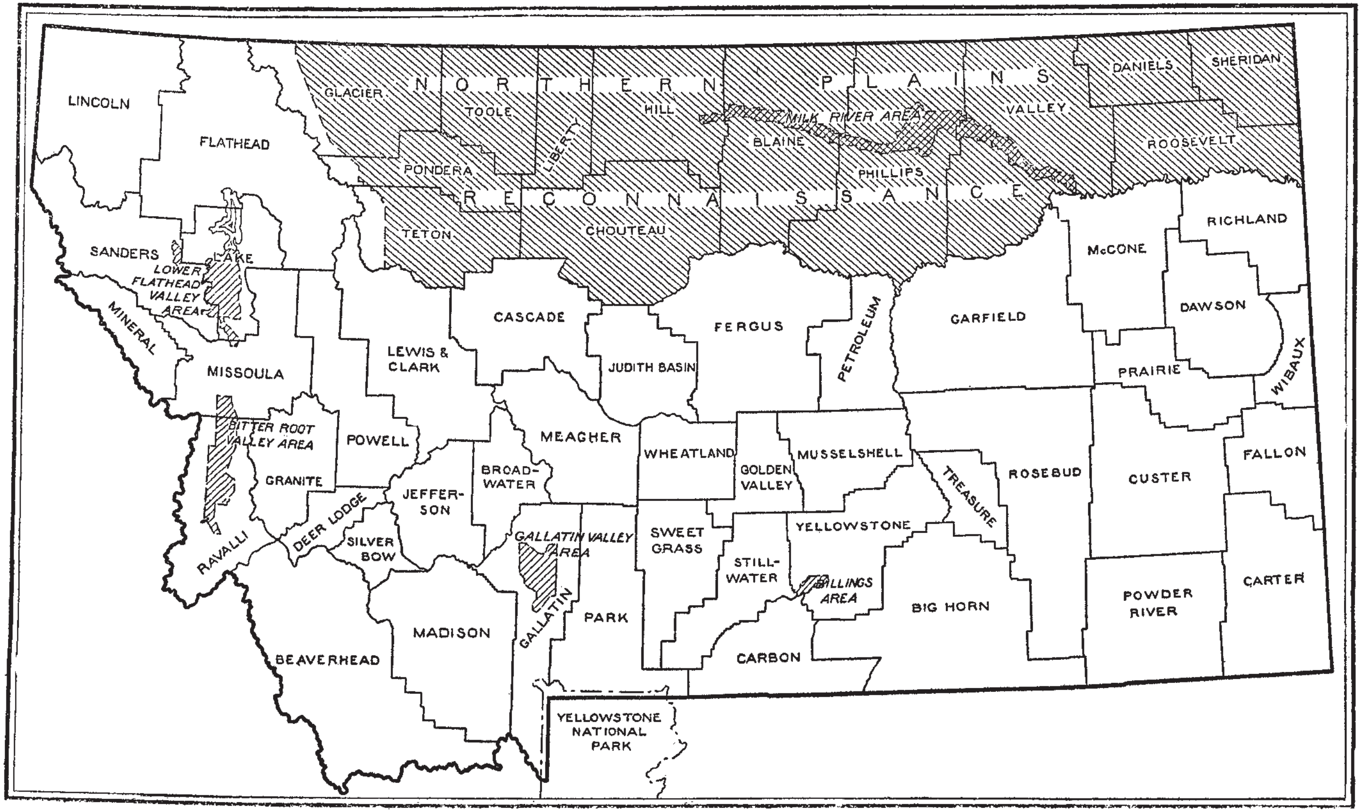

Areas surveyed in Montana, shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching; crosshatching indicates areas covered in both ways

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