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Soil Survey

The Big Horn Valley Area Montana

By

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Montana Agricultural Experiment Station

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
Montana Agricultural Experiment Station

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HOW TO USE THE SOIL SURVEY REPORT

SOIL SURVEYS PROVIDE a foundation for all land use programs. This report and the accompanying map present information both general and specific about the soils, the crops, and the agriculture of the area surveyed. The individual reader may be interested in the whole report or only in some particular part. Ordinarily he will be able to obtain the information he needs without reading the whole. Prepared for both general and detailed use, the report is designed to meet the needs of a wide variety of readers of three general groups: (1) Those interested in the area as a whole; (2) those interested in specific parts of it; and (3) students and teachers of soil science and related agricultural subjects. Attempt has been made to meet the needs of all three groups by making the report comprehensive for purposes of reference.

Readers interested in the area as a whole include those concerned with general land use planning—the placement and development of highways, power lines, urban sites, industries, community cooperatives, resettlement projects, and areas for forest and wildlife management and for recreation. The following sections are intended for such users: (1) Description of the Area Surveyed, in which location and extent, physiography, relief, and drainage, climate, water supplies, vegetation, early history, organization and population, transportation and markets, and industries are discussed; (2) Agriculture, in which a brief history and the present status of the agriculture are described; (3) Estimated Yields, in which the estimated productivity of the soils is given; and (4) Land Uses and Soil Management, in which the present uses of the soils are described, their management requirements discussed, and suggestions made for improvement.

Readers interested chiefly in specific areas—as some particular locality, farm, or field—include farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real estate agents, land appraisers, prospective purchasers and tenants, and farm loan agencies. These readers should (1) locate on the map the tract with which concerned; (2) identify the soils on the tract by locating in the legend on the margin of the map the symbols and colors that represent them; and (3) locate in the table of contents in the section on Soils of the Area the page where each type is described in detail and information given as to its suitability for use and its relations to crops and agriculture. They will also find useful specific information relating to the soils in the sections on Estimated Yields and Land Uses and Soil Management.

Students and teachers of soil science and allied subjects—including crop production, forestry, animal husbandry, economics, rural sociology, geography, and geology—will find their special interest in the section on Morphology and Genesis of Soils. They will also find useful information in the section on Soils of the Area, in which are presented the general scheme of classification of the soils and a detailed discussion of each type. For those not already familiar with the classification and mapping of soils, these subjects are discussed under Soil Survey Methods and Definitions. Teachers of other subjects will find the sections on Description of the Area Surveyed, Agriculture, Estimated Yields, and Land Uses and Soil Management and the first part of the section on Soils of the Area of particular value in determining the relations between their special subjects and the soils of the area.

This publication on the soil survey of the Big Horn Valley area, Mont., is a cooperative contribution from the—

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SOIL SURVEY OF THE BIG HORN VALLEY AREA, MONTANA

By F. K. Nunns, Montana Agricultural Experiment Station

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United States Department of Agriculture in cooperation with the Montana Agricultural Experiment Station

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SUMMARY

The Big Horn Valley area lies in the semiarid western part of the Great Plains physiographic province and in the south-central part of Montana. It comprises a total area of 178 square miles and includes (1) the Big Horn River Valley, northward from a point where the river emerges from Big Horn Canyon to its junction with the Yellowstone River, a distance of about 65 miles, and (2) the Little Horn River Valley, southeastward for a distance of about 20 miles from the junction of the Little Horn River with the Big Horn River. The area

[1] The field work for this survey was done while the Division of Soil Survey was a part of the Bureau of Chemistry and Soils. Dr. Hayes died May 13, 1941.

ranges from 1 to 3 miles in width in the Big Horn Valley and from 1 to 2 miles in the Little Horn Valley. It includes the bottom lands and terraces bordering the streams and the adjacent valley slopes and some of the high benches and uplands that border the valleys.

The climate is continental and is characterized by abundant sunshine, low relative humidity, moderate wind movement, light rainfall, hot summers, cold winters, and wide daily variations in temperature. The normal monthly, seasonal, and annual temperature and precipitation as recorded at two Weather Bureau stations, Foster and Crow Agency, give the more important climatic data pertaining to the area. More than one-half of the annual precipitation falls during the growing season, May 1 to September 1. The mean annual temperature is approximately 45° F.

The agriculture of the area surveyed is based on the irrigation of approximately 47,000 acres of alluvial lands, 65 percent of which lies within the Crow Indian Reservation. Low rainfall and soils poorly adapted to dry-land farming make crop production unprofitable without irrigation. The cost of irrigation and the comparatively small farm units require a fairly intensive type of agriculture to meet the needs for cash income. The short-term lease system employed on the Crow Indian lands also has been instrumental in stimulating the production of a high percentage of cash crops. The present farm economy is centered chiefly around the production of sugar beets, wheat, and beans, as cash crops. Alfalfa is an important soil-improvement crop, and the hay not fed on the farm is sold to nearby cattle and sheep ranchmen. Oats, barley, potatoes, and corn are minor crops. The raising of livestock is important on only a few farms.

The soils are developed from light-colored limy dominantly silty or clayey alluvial sediments on the bottom lands and terraces along the rivers, and in rather recent colluvial and alluvial deposits on fans and aprons at the edges of the valleys. They have developed under the influence of a short-grass vegetation and, in common with nearly all of the soils in the drier parts of the Great Plains region, are light-colored and alkaline or calcareous, have only a moderate supply of organic matter in their surface layers, and are low in nitrogen. Soluble salts are present in various quantities in nearly all of the soils, and they are sufficiently concentrated in places to injure or prevent the growth of all vegetation except the most salt-tolerant plants.

The outstanding soil problem of the area is the improvement of the poor tilth of the large acreage of heavy clayey soils. These soils are moderately well supplied with plant nutrients, but they drain slowly, puddle easily, and are not very productive when first put into cultivation, because of their poor tilth. Under good management over a period of years, however, they may be brought into satisfactory crop production. Operators who have generously applied barnyard manures and practiced crop rotations containing some legume have greatly improved the tilth and productive capacity of the soils. The use of superphosphate gives marked increases in yields of most crops and especially improves yields of sugar beets. Some of the soils are naturally high in soluble salts, whereas others, which were naturally well drained and had a low content of salts, have become seeped and salty from uncontrolled irrigation water and leaky canals. Deep drainage ditches have been dug in various areas and have proved to be of considerable value in relieving conditions of poor drainage and excessive salt.

The Billings soils include most of the slowly drained, intractable clayey soils of comparatively high soluble salt content, which require special effort and considerable time to be brought into good tilth and high production. Many areas of these soils have already been brought into satisfactory production, although they are restricted somewhat in their crop adaptations.

The Glendive, Manvel, Cherry, and Fort Collins soils are friable and have permeable subsoils that allow adequate drainage. They are desirable soils for irrigation, except in places where they are affected by seepage and excess salts.

The Havre soils, which occupy the bottom lands and terraces, have good tilth and permeable subsoil layers, and they respond readily to good management. The chief problem in connection with these soils is the control of seepage and salts from higher irrigated areas.

The Laurel soils are best suited for pasture land because of their poor tilth, poor drainage, excess of salts, and high water table. The Banks soils are generally unsuited to irrigation and the production of crops because of their slight depth above loose sands and gravels and their irregular relief. Production is low without intensive fertilization.

Riverwash is essentially wasteland, and rough broken land has a low value for grazing land.

DESCRIPTION OF THE AREA SURVEYED

LOCATION AND EXTENT

The Big Horn Valley area is in the south-central part of Montana (fig. 1). It comprises 178 square miles, or 113,920 acres, and includes (1) an irregular elongated area about 65 miles long and from 1 to 3 miles wide, traversed in its longer, general northeast-southwest axis

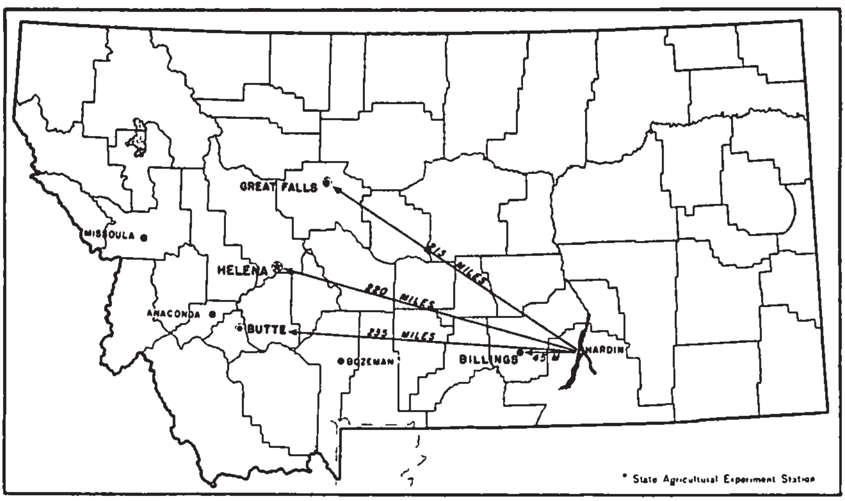

FIGURE 1.—Location of the Big Horn Valley area in Montana.

by the Big Horn River; and (2) a similar elongated area 1 to 2 miles wide, continuing about 20 miles along the Little Horn River in a southeasterly direction from its junction with the Big Horn River near Hardin. The southern extremity of the area is at the point where the Big Horn River emerges from Big Horn Canyon in the vicinity of St. Xavier; and the most northerly point is in the vicinity of Custer, where the Big Horn River joins the Yellowstone River. The southern limit of the southeastern extension along the Little Horn River is at the head of the Reno irrigation supply canal, about 3 miles south of Garryowen.

The area lies within Big Horn County, with the exception of the extreme northern tip, which continues for a short distance into the northeastern and western edges respectively of Yellowstone and Treasure Counties. It embraces the entire width of the more recently formed alluvial lands, or the valley proper of the Big Horn and Little Horn Rivers, which comprise a major portion of the irrigated land in Big Horn County. In addition to the alluvial lands, the area includes part of the rough broken land, rocky escarpments, and smooth high benches that border the valley.

Hardin, the county seat of Big Horn County, is near the center of the area. It is about 50 miles north of the Montana-Wyoming State line and about 45 miles east of Billings, the principal city in the south-central part of the State.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

This area is in the unglaciated part of the Missouri Plateau section of the Great Plains physiographic province, lying adjacent to the mountains at the western edge of the plains. The broader physiographic aspects of the area are those of a valley that emerges from the mountains and enters the plains to the north and east. The southern boundary of the area is at the foot of the Big Horn Mountains, a spur of the Rocky Mountains. The Big Horn Mountains rise sharply within a few miles to the south to elevations of more than 9,000 feet above sea level. The Rosebud Mountains to the east of the area rise abruptly to elevations of more than 5,000 feet. West of the area is a range of rough hills and high mesas having steep slopes. The most prominent land feature in this section is Pine Ridge, which rises to an elevation of slightly more than 4,000 feet above sea level northwest of Hardin. The land slopes gently to the north and northeast.

In detail, the surface features of the area are nearly level bottom lands and low benches or terraces adjacent to the Big Horn and Little Horn Rivers, and a series of higher benches at different levels above these, representing the various stages of entrenchment and temporary base leveling by the present or former streams. West of the Big Horn River the benches are at five distinct levels. The benches are mantled with gravelly mountain outwash, valley-filling material, and old alluvium, which is underlain at varying depths by sandstone and shale bedrock. South of Foster the bedrock consists predominantly of shales of the Colorado and Montana groups of geological formations, the valley is wider, the benches are better defined, and the slopes between the different bench levels are less steep than north of this point where the Big Horn River is entrenched in comparatively hard sandstone of the Lance formation. Here the valley sides are abrupt, in some places precipitous and rock walled.

The present drainage is entrenched 150 to 250 feet below the high gravelly benches and mesas that border the area. The irrigated terraces and bottom lands are 100 feet or more below the benches and mesas. Lateral drains crossing the terraces are rather deeply entrenched, and the high benches are merely remnants of the former comparatively broad and fairly continuous terraces that bordered ancient streams flowing at nearly the same level.

The elevation of the Big Horn Valley at the diversion head gate of the Big Horn ditch, near the south end of the area, is 3,200 feet above sea level. Northward, at St. Xavier, the elevation is approximately 3,050 feet; at Hardin it is 2,902 feet, and at Big Horn, near the north end of the area, 2,712 feet. The drop in elevation from south to north for the length of the valley is approximately 500 feet, or about 7.5 feet to the mile. Crow Agency, near the center of the surveyed part of the Little Horn Valley, is at an elevation of 3,036 feet above sea level, and Garryowen, near the south end of the area, in this valley, lies at an elevation of 3,121 feet.

The area is drained by the Big Horn River and its principal tributary, the Little Horn River. The former drains a large area in northwestern Wyoming and carries a comparatively large volume of water throughout the year. Runoff from melting snow in spring and early summer greatly increases the flow. The water is turbid at all times and is heavily laden with silt when the river is at flood stage. Stream flow in late summer and fall is chiefly from springs and snow fields high in the Big Horn Mountains. The Little Horn River has its source in the Big Horn Mountains just south of the Montana-Wyoming State line. Its flow is perennial, but it carries a much smaller volume of water than the Big Horn River. Most of the small tributaries entering these streams within the area become dry or carry very little water after midsummer.

CLIMATE

The climate of this area is continental and semiarid, marked by abundant sunshine, low relative humidity, moderate wind movement, low precipitation, and wide daily and seasonal variations in temperature. Midsummer days are hot but not oppressive, because of the low humidity. Summer temperatures are tempered by cool nights. The winters are moderately cold. Cold waves occur almost every winter with varying intensity, but as a rule they are not prolonged and are broken frequently by comparatively long periods of mild weather, which coincides with chinook winds that blow over the area.

Weather conditions have been recorded at Foster, which is near the northern end of the area, and at Crow Agency, near the center. The climatic data for these two stations are shown in tables 1 and 2, respectively.

May and June are the months of highest rainfall. Quick local showers, ranging from very light to almost the proportion of a cloudburst, are characteristic of the summer precipitation. Precipitation increases with the rise in elevation southward and is about 2 inches greater on the high benches in the vicinity of Crow Agency than in the lower part of the valley in this general vicinity.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Foster, Big Horn County, Mont.*

[Elevation, 2,800 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year (1929)	Total for the wettest year (1912)	Average snowfall
	°F.	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	21.2	66	−49	0.46	0.47	0.01	4.7
January	18.3	61	−45	.51	.49	.11	5.5
February	22.6	77	−40	.37	.41	.31	2.7
Winter	20.7	77	−49	1.34	1.37	.43	12.9
March	33.8	85	−37	.40	.08	.23	3.0
April	45.4	91	−5	.89	.25	2.28	.8
May	54.8	102	15	1.88	.86	3.47	(1)
Spring	44.7	102	−37	3.17	1.19	5.98	3.8
June	64.6	107	28	2.16	1.35	3.57	0
July	71.0	108	36	1.48	.73	3.70	0
August	68.4	105	27	.71	.24	.56	(1)
Summer	68.0	108	27	4.35	2.32	7.83	(1)
September	57.8	98	19	1.10	.39	2.66	(1)
October	46.2	94	−15	.95	.97	2.57	.6
November	33.4	79	−26	.67	.87	.60	4.3
Fall	45.8	98	−26	2.72	2.23	5.83	4.9
Year	44.8	108	−49	11.58	7.11	20.07	21.6

[1] Trace.

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Crow Agency, Big Horn County, Mont.*

[Elevation, 3,030 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year (1889)	Total for the wettest year (1912)	Average snowfall
	°F.	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	23.4	71	−48	0.88	0.80	0.07	6.6
January	19.7	62	−45	.84	.20	.54	7.2
February	22.2	68	−46	.78	.56	.62	6.2
Winter	21.8	71	−48	2.50	1.56	1.23	20.0
March	33.6	81	−31	1.16	.25	1.17	9.4
April	46.4	89	−8	1.43	.95	2.38	4.3
May	55.0	101	18	2.56	1.59	3.91	1.0
Spring	45.0	101	−31	5.15	2.79	7.46	14.7
June	65.4	107	28	2.30	.90	3.66	0
July	72.6	110	36	1.42	.76	3.96	0
August	70.8	109	27	.89	.89	1.74	(1)
Summer	69.6	110	27	4.61	2.55	9.36	(1)
September	58.6	100	15	1.44	.51	3.65	.5
October	47.6	89	−18	1.52	.50	2.78	3.3
November	33.8	78	−26	.98	.12	.77	5.5
Fall	46.7	100	−26	3.94	1.13	7.20	9.3
Year	45.8	110	−48	16.20	8.03	25.25	44.0

[1] Trace.

January is normally the coldest month at both stations, and July is the hottest month.

The direction of the wind varies with the season. In general, westerly and northwesterly winds prevail at Foster, and westerly, northwesterly, and easterly winds prevail at Crow Agency.

The average frost-free season at Foster is 122 days and at Crow Agency is 135 days. The average date of the last killing frost is May 18 at Foster and May 13 at Crow Agency, and the average date of the first is September 17 and September 25, respectively. Killing frosts have occurred in late June and in early August in some years.

The growing season is sufficiently long for most small grains, hay crops, and sugar beets to mature. Corn is damaged at times by early fall frost. The commonly low and often uncertain precipitation renders general farming a hazardous undertaking except by the use of supplemental irrigation. The production of small grain over a long period of years under dry-farming methods has been generally unsuccessful. The production of alfalfa and sugar beets is unprofitable except under irrigation. Some damage by hail is done to crops in most years and rather severe damage over limited areas in some years. Crop losses due to windstorms are uncommon.

WATER SUPPLIES [3]

The domestic water supply is obtained chiefly from wells. The quantity and quality of the ground water for a given locality depends principally on the character of the underlying geological formation. The sandstone and coal beds of the Fort Union and Lance formations commonly yield an adequate supply of water of fair to good quality for domestic use. The supply is limited and the quality of the water generally is poor in wells terminating in the Montana and Colorado groups of formations. A few wells drilled in these structures, however, are producing water of fair quality. Water is plentiful in the gravel underlying the terraces and bottom lands of much of the Big Horn and the Little Horn Rivers, but the quality is variable and the water is highly mineralized in places. Artesian pressure raises the water considerably in nearly all of the wells that are drilled into bedrock. Water for irrigation is taken from the Big Horn and Little Horn Rivers, and these streams supply much of the water for the livestock that are kept in the valleys. At times water for household use is taken from the streams.

VEGETATION

The vegetation of the area is typical of the short-grass plains. The dominant grasses are western wheatgrass (*Agropyron smithii* Rydb.) and blue grama (*Bouteloua gracilis* (H.B.K.) Lag.), but they are more abundant on the medium-textured or loamy soils. Niggerwool (*Carex filifolia* Nutt.) and western needlegrass (*Stipa comata* Trin. and Rupr.) are more common on the sandy uplands. Matchweed (*Gutierrezia sarothrae* (Pursh) Britt. and Rusby) is abundant on the shallow overgrazed soils and abandoned farm lands of the uplands. Black sage (*Artemisia tridentata* Nutt.), western wheatgrass, meadow barley

[3] THOM, W. T., JR., HALL, G. M., WEGEMANN, C. H., and MOULTON, G. F. GEOLOGY OF BIG HORN COUNTY AND THE CROW INDIAN RESERVATION, MONTANA. U. S. Geol. Survey Bul. 856, 200 pp., illus. 1935.

(*Hordeum nodosum* L.), sunflower (*Helianthus* sp.), cockleburs (*Xanthium commune* Britt.), gumweed (*Grindelia squarrosa* (Pursh) Dunal), and foxtail (*Hordeum jubatum* L.) are characteristic vegetation of the heavy soils. The saline soils support saltgrass (*Distichlis stricta* (Torr.) Rydb.), greasewood (*Sarcobatus vermiculatus* Torr.), atriplex (*Atriplex* sp.) and suaeda (*Suaeda erecta* (S. Wats.) A. Nels.).

Scattered stands of western yellow pine (*Pinus ponderosa* Laws.) occur in the rough uplands. Cottonwood (*Populus* sp.), Chokecherry (*Prunus melanocarpa* (A. Nels.) Rydb.), buffaloberry (*Elaeagnus utilis* A. Nels.), and buckbrush (*Symphoricarpos* sp.) are abundant along the streams.

EARLY HISTORY

The area was first visited by white men in 1743, when Chavalier de la Verendrye sought a route to the Pacific. The next white men known to enter the territory came in 1804 and surveyed the fur resources. Captain Clark and party, of the Lewis and Clark Expedition, passed eastward through the northern edge of the area in 1806. Except for a few traders and an occasional gold prospector, the area was rarely visited by whites until the opening of the Bozeman Trail in 1864, which was a short cut between North Platte and Three Forks. Many miners and settlers passed over this trail. They crossed the Big Horn River at the site of Fort C. F. Smith and followed a northwesterly course toward the Yellowstone River. The Indians resented this intrusion, and the Government temporarily appeased them by abandoning Fort C. F. Smith in 1868 and ordering the miners and settlers to keep out of the area. Disregarding this agreement, the miners and settlers continued to encroach on Indian territory, and the Indians resisted until 1876, when Federal troops were sent to control them. In the ensuing campaign General George A. Custer and his entire troop were annihilated in the battle of the Little Horn. After this reversal the Government took effective action against the Indians, and Fort Custer was established at the junction of the Big Horn and Little Horn Rivers in 1877. Four or five years later extensive livestock operators entered the area.

The first railroad transportation was made available to the area in 1882, when the Northern Pacific Railway, extending its lines westward along the Yellowstone River Valley, reached the Big Horn River at a point about 30 miles north of the present town of Hardin.

ORGANIZATION AND POPULATION

The Crow Indian Reservation was established by an Act of Congress in 1868. Roughly, it embraced the triangular area lying between the 107th meridian, the Yellowstone River, and the southern boundary of Montana and included all the area now comprising Big Horn County, of which the present surveyed area is a part. The size of the reservation was successively reduced in 1880, 1890, and 1904 to its present area of approximately 2,119,530 acres.

Big Horn County was created in 1913 from parts of Rosebud and Yellowstone Counties. It embraces 5,033 square miles. The Federal census for 1940 gives the population of the county as 10,419. Of this number, 74.6 percent are listed as native-born whites, 6.2 percent foreign-born whites, 18.5 percent Indians, 0.1 percent Negroes, and 0.6 percent other races. A large proportion of the population is of Russian, German, and Scandinavian extraction, in the order of predominance. In 1940 the foreign-born population included 267 Russians, 81 Scandinavians, and 34 Germans.

Hardin, the principal town in the area and the county seat of Big Horn County, was settled in 1907, and in 1940 it had a population of 1,886. Hardin serves as the chief trading center for much of the irrigated section of the Big Horn and Little Horn Valleys and extensive grazing areas in the rolling plains, hills, and mountains adjacent to the valleys. The town is well supplied with facilities for handling farm products and the shipping of livestock. Standard grade and high schools, several churches, and a hospital are located here. It is supplied with natural gas, electricity, and modern municipal water and sewer systems. Crow Agency, headquarters for the Crow Indian Reservation, and Lodge Grass, outside of the area, 12 and 33 miles respectively southeast of Hardin, are important towns, which serve chiefly as local trading centers for the surrounding irrigated farming sections. Rural schools and churches are conveniently located in all districts outside of the populated centers.

TRANSPORTATION AND MARKETS

The Big Horn Valley area has ample railroad transportation facilities. The main line of the Northern Pacific Railway traversing the Yellowstone River Valley crosses the Big Horn River near the north end of the area, about 30 miles north of Hardin. The Lincoln-Billings line of the Chicago, Burlington & Quincy Railroad traverses the Little Horn River Valley as far north as Hardin. From this point it crosses the area westward to enter the Yellowstone River Valley at Ballantine. A spur line of the Burlington extends about 12 miles northward from Hardin, along the valley of the Big Horn River. These railroads handle east-west freight shipments and connect with the principal outside markets of Chicago, Omaha, Minneapolis, and St. Paul, also with Billings, the principal market within the State.

United States Highway No. 10 crosses the north end of the area, and United States Highway No. 87 connects westward from Hardin with Billings, Mont., and southward to points in Wyoming. Aside from Federal highways, the area is well supplied with graded county roads.

INDUSTRIES

No industry of note is developed within the area except those for the processing of agricultural products. Chief among these is the manufacture of sugar from beets at a plant located near Hardin. This plant is estimated to have facilities for handling 1,500 tons of sugar beets daily. Two creameries located in Hardin buy and process most of the commercial milk produced in the area.

Large quantities of semibituminous coal are known to occur in the uplands adjacent to the area,[3] but little commercial mining is carried on in the general region at present. The quality of the coal is consid-

[3] ROGERS, G. SHERBURNE, and LEE, WALLACE GEOLOGY OF THE TULLOCK CREEK COAL FIELD, ROSEBUD AND BIG HORN COUNTIES, MONTANA. U. S. Geol. Survey Bul. 749, 181 pp., illus. 1923.

ered equally as good as the commercial varieties sold in neighboring markets. In some places coal is taken from small openings for local use; but the natural gas from wells in the vicinity of Hardin and timber from the hills and breaks and wooded areas adjacent to the streams supply most of the fuel used in the area.

AGRICULTURE

EARLY AGRICULTURE

The first permanent white settlers in the general region of the Big Horn Valley area were cattlemen who began to move in their herds during the early part of the decade 1880–90, soon after the danger from Indian raids had passed. Ranch headquarters were established adjacent to the Big Horn and Wolf Mountains, south of the main valleys of the Big Horn and Little Horn Rivers. The early ranches were operated chiefly by companies with large holdings of cattle, some of the herds including as many as 30,000 head. Sheep raising in the area had its beginning in 1901, when large company-owned flocks were brought in to graze the extensive area north of Fort Custer, extending to the Yellowstone River. The raising of cattle and sheep under open range conditions continued to be the sole agricultural enterprise until 1906.

Indian lands adjacent to the Yellowstone River, including much of the lower Big Horn Valley, were ceded to the Federal Government in 1904 and opened to homesteading in 1906. Within a few years most of the land was taken up by settlers, and a large acreage was placed in cultivation under dry-farming methods. For a period of nearly 10 years (until 1917) seasons were favorable, crop yields were good, and the homesteaders prospered. After this, a series of poor crop years resulted in many failures and much abandonment of farms. During the period of abandonment in the dry-farming areas the acreage in cultivation under irrigation farming in the Big Horn Valley area steadily increased.

DEVELOPMENT OF IRRIGATION

The earliest development of irrigation in this area was the construction of the Reno supply canal by the Federal Government in 1885, as a means of irrigating land on the Crow Indian Reservation. Later construction of canals on the reservation by the Government and construction by private agencies on lands outside the reservation has brought the total of irrigation projects to seven.

Table 3 lists the canals and gives pertinent data regarding them, such as length of the canal, capacity of flow, source and supply of water, and acreage irrigated from each canal.

Roughly, 47,000 acres of irrigated lands are served by the seven canals listed in table 3. About 65 percent of the irrigated acreage lies within the Crow Indian Reservation, and about 95 percent of the total is in Big Horn County and includes a major portion of the irrigated land in the county. Although the first three canals listed were constructed by private organizations, the Two Leggin canal serves some 5,642 acres of Indian lands. The cost of the construction of this canal was charged proportionately to the Indian lands and to the privately owned lands on a basis of the irrigable acreage in each part of the project.

TABLE 3.—*Name, length, flow, and source of water for the seven canals supplying irrigation water, and the irrigable acreage and acreage irrigated in the district served by each canal in the Big Horn Valley area, Mont.*

Name of supply canal	Length	Length of laterals	Flow	Irrigable land	Irrigated land	Source of water	Water supply
	Miles	*Miles*	*Second-feet*	*Acres*	*Acres*		
Two Leggin	30		400		[1][2]20,000	Big Horn River	Adequate.[3]
Low Line	15				[4]5,000	do	Adequate.
Victory	7				[4]1,500	do	Do.
Big Horn [4]	35	98.2	720	28,714	15,679	do	Do.
Soap Creek [4]	7.5		50	1,814	544	Soap Creek	Limited.
Reno [4]	9.8	13.1	85	3,612	1,707	Little Horn River	Generally adequate.
Agency [4]	10.9	32.5	40	6,135	2,940	do	Do.

[1] Includes 5,642 acres of Indian reservation
[2] Approximate irrigated acreage
[3] During two extremely dry years additional water was purchased from the supply allotted to an irrigation project in Wyoming
[4] Serves irrigation projects on Crow Indian Reservation.

All the irrigation projects taking water from the Big Horn River commonly have an adequate supply for use throughout the irrigating season. The water for the Reno and Agency canals is diverted from the Little Horn River. The supply is commonly adequate, but in years of light snowfall in the Big Horn Mountains the stream flow is low. There has been, however, no material lowering of crop yields on these projects because of lack of irrigation. The Soap Creek canal takes water from Soap Creek, in which the supply is limited and in years of low precipitation may become exhausted.

CROPS

The first crops grown under irrigation in this area were mainly alfalfa and native hay, produced as winter feed for livestock, which ranged on the adjacent uplands and in the mountains. After 1910 the population in the valleys and the acreage of land under irrigation increased rapidly and the farm units became smaller. A larger acreage was planted to alfalfa, and such crops as wheat, oats, and barley were produced for feed and for sale. Wheat later became the principal cash crop. About 75 percent of the wheat crop is planted in the spring.

Table 4, taken from the Federal census, gives the acreage of the leading crops grown under irrigation in Big Horn County for the census years of 1919, 1929, and 1939. Alfalfa, originally planted as a feed crop in connection with large-scale livestock ranches, continues to occupy the largest acreage of any single crop. It is now produced as a soil-improvement and hay crop, chiefly on small farm units, and it serves as an important source of farm income through the sale of hay to ranchmen operating in the adjacent uplands. Much of the hay is also fed on the farm.

Two cuttings of alfalfa hay, as a rule, are obtained, but in some years the second cutting is allowed to mature as a seed crop.

Oats, barley, and corn, although occupying a considerable acreage, are minor crops and are produced chiefly as a farm supply of grain and forage. The acreage planted to edible beans varies greatly from year to year, depending on the market demands and the prices received for the crop. Although the acreage in wheat has continued to increase and is still an important source of income, the value of the sugar-beet crop far exceeds the value of wheat and all other crops combined.

TABLE 4.—*Acreages of the principal crops grown on irrigated lands of Big Horn County, Mont., in stated years, as shown by the Federal census*

Crops	1919	1929	1939	Crops	1919	1929	1939
	Acres	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*
Wheat, total	4,187	5,006	8,430	Alfalfa	8,996	10,205	12 641
Winter wheat	925	1,101	2,210	Corn	120	131	2,770
Spring wheat	3,262	3,905	6,220	Sugar beets	697	2,682	10,423
Oats	1,490	2,591	5,092	Beans [1]	1	4,648	350
Barley	116	3,823	2,643				

[1] Includes all kinds of edible beans, but chiefly the Great Northern variety.

Sugar beets were first grown in the area in 1915, and the acreage planted each year gradually increased over a period of two decades (pl. 1, *A*). During this period and until 1937 the crop was shipped to a beet-sugar factory in Sheridan, Wyo., for processing. Since the establishment of a factory near Hardin in 1937, the production of beets has expanded rapidly and in 1939 it comprised a total of more than 12,000 acres in Big Horn County.

The use of superphosphates is generally necessary in order to obtain the best yields of sugar beets. The production of this crop requires a large amount of hand labor, which is supplied as a rule by transient Mexican and Filipino laborers, who come into the area in the spring and move out after the beet crop is harvested.

Native hay and potatoes, not listed in table 4, occupy a rather small acreage. The former occupies wet areas commonly not suited to cultivation, and the latter are produced chiefly for home use, any surplus being sold locally.

Table 5 lists all crops shown in table 4, with potatoes in addition, and gives the average number of acres of each crop to the farm and the average acre yield, for the 4-year period 1932–35, by irrigation units for irrigated lands in the Crow Indian Reservation.

The figures in this table include only about one-half of the acreage and production of crops grown on irrigated lands in Big Horn County; nevertheless they are fairly representative of the county and of the Big Horn Valley area as a whole. The average yields however are probably a little lower than similar figures would be for the rest of the area, because of conditions of land tenure described under Farm Tenure.

Table 6 gives the acreage of sugar beets harvested and the average acre yield by districts for stated years in the Big Horn Valley area and the approximate distance from Hardin of the beet dump serving each district.

The variations in average yields from one district to another may be attributed to two factors—(1) a general difference in soils between the districts, or (2) the tilth of the soil, which is determined in large measure by the length of time the land has been under cultivation. The Mission, St. Xavier, Big Horn, and Halfway districts are in the most recently developed beet-producing areas. Average yields in these districts show a decided upward trend for the 3 years 1937, 1938, and 1939, whereas the differences in yields in the remaining districts

A, Irrigated sugar-beet field in the Big Horn Valley. The soil is largely of the Manvel series. *B*, Wheat on irrigated Billings silty clay in the Big Horn Valley. Beet-sugar factory in background.

TABLE 5.—*Average number of acres to the farm and average acre yields for selected crops*[1] *grown on irrigated lands of the Crow Indian Reservation, Big Horn County, Mont.*

[4-year averages, 1932–35, unless otherwise indicated]

Irrigation unit	Wheat		Sugar beets		Potatoes		Beans	
	Acres	*Bushels*	*Acres*	*Tons*	*Acres*	*Hundred-weight*	*Acres*	*Bushels*
Agency	21.2	19.8	24.9	12.5	1.4	68.4	8.6	21.3
Reno	18.2	17.4	20.0	12.9	1.3	69.6	11.9	14.4
Big Horn and Soap Creek	32.2	14.9	[2] 23.0	[2] 7.4	[2] 1.6	[3] 125.5	35.7	6.2
Two Leggin	24.7	14.0	[2] 23.4	[2] 9.4	[3] 2.0	[3] 90.0	[3] 10.5	[3] 13.4

Irrigation unit	Barley		Oats		Alfalfa		Other hay		Corn	
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Tons*	*Acreas*	*Tons*	*Acres*	*Bushels*
Agency	19.2	26.3	14.0	27.9	27.5	2.0	19.4	0.9	7.0	15.8
Reno	11.6	15.5	18.8	33.5	24.4	1.82	17.3	.6	8.0	10.4
Big Horn and Soap Creek	28.2	20.0	24.0	24.8	53.8	1.3	40.0	.7	19.2	15.7
Two Leggin	21.6	16.5	[2] 16.5	[2] 18.8	30.6	1.49	29.0	.8	15.3	14.7

[1] Taken from figures compiled by the Works Progress Administration, project Nos. OP-65-91-1775 (WP772) and OP-165-91-6999 (WP6000-1127).
[2] 3-year average
[3] 2-year average.

are a fluctuation from the average rather than a trend either upward or downward. Once the soils are brought up to a fair state of production and reasonably good management practices are maintained, any variation in yields from year to year will probably be near the average yield or be due largely to local seasonal climatic differences.

TABLE 6.—*Acreage of sugar beets harvested and average acre yield, by districts, in the Big Horn Valley, Mont., in stated years*

District	Approximate distance and direction of beet dump from Hardin[1]	1937		1938		1939	
		Acres	*Tons*	*Acres*	*Tons*	*Acres*	*Tons*
Victory	30 miles north	0.0	------	384.79	11.9	399.23	13.45
Sorrel Horse	20 miles north	316.79	13.64	264.29	13.82	234.28	12.83
Kingley	12 miles north	1,497.88	14.29	1,512.16	[2] 8.99	1,332.37	13.59
Holly	8 miles north	848.70	11.87	683.52	[2] 9.0	789.96	12.6
Factory	1¼ miles north	2,865.35	12.24	2,676.48	[2] 10.8	2,345.54	11.08
Halfway	12 miles south	555.16	8.59	670.81	9.8	732.79	10.86
Big Horn	18 miles south	1,714.87	9.44	1,223.34	11.12	1,347.95	12.17
St. Xavier	26 miles southwest	942.92	10.59	1,006.49	13.4	937.92	12.49
Mission	34 miles southwest	607.90	10.57	833.85	10.71	483.62	12.02
Dunmore	6 miles southeast	565.69	12.83	687.58	13.15	625.67	12.16
Garryowen	18 miles southeast	647.92	14.66	754.03	15.06	637.17	13.12
Petzoldt	33 miles southeast	284.10	11.76	261.53	14.79	269.78	11.85
Average			11.83		11.30		12.18

[1] Sugar factory near Hardin. [2] Yield reduced by hail

LIVESTOCK

The raising of livestock in this area is a major farm enterprise on only a few farms. Table 7 lists the percentage of farms having specified livestock and the average number of livestock on each farm, by irrigation units, for the irrigated lands in the Crow Indian Reservation. These figures are about representative for farms in the area as a whole.

TABLE 7.—*Percentage of farms having specified livestock*[1] *and the 1932–35 4-year average number on each farm, by irrigation units, for the irrigated lands in the Crow Indian Reservation, Big Horn County, Mont.*

Irrigation unit	Percentage of farms keeping indicated livestock, and average numbers of such animals to the farm											
	Horses		Dairy cattle		Beef cattle		Hogs		Sheep		Poultry	
	Pct	*Av No*	*Pct*	*Av. No*	*Pct*	*Av No*	*Pct*	*Av No*	*Pct*	*Av No*	*Pct*	*Av No.*
Crow Agency	93.2	5.4	74.5	6.2	57.5	24.7	68.0	14.3	[2] 3.9	----	74.3	85.3
Reno	87.1	5.5	60.4	6.4	23.0	13.8	43.2	15.0	8.4	64.8	76.0	55.4
Big Horn and Soap Creek	65.1	8.3	29.6	5.4	34.1	31.0	38.4	14.8	4.5	113.0	47.8	57.1
Two Leggin	48.0	5.7	[2] 14.0	[2] 5.4	34.9	49.2	25.6	11.1	[3] 9.0	[3] 30.0	30.2	44.6

[1] Taken from figures compiled by the Works Progress Administration, project Nos OP-65-91-1775 (WP 772) and OP-165-91-6909 (WP6000-1127)
[2] 3-year average.
[3] 1-year average.

Horses are kept on nearly all farms and average about 6 head to the farm. They are used chiefly for draft purposes, but much of this type of work is done with tractors.

About one-half of the farmers keep small dairy herds and sell milk or cream to supplement the farm income; others have milk cows to supply home needs. Small herds of beef cattle are kept on 20 to 50 percent of the farms, chiefly to utilize the grass on lands not suitable for irrigation. In other words, this practice is a means of marketing the surplus hay, through the sale of beef or feeder cattle.

Hogs are raised chiefly for a home supply of meat and for local sale. Sheep are raised in small flocks on a few farms. Most farms keep flocks of poultry, usually from 50 to 100 head, to supply home needs. The surplus of eggs and fowls are sold or bartered locally. The production of honey is confined to a small number of farms that keep a few colonies of bees.

CHANGES IN LAND USE

Prior to 1910, development of irrigation in the Big Horn Valley area had not made any material headway. The land was held as unappropriated public land or in comparatively large ranches and dry-farming units or as undeveloped Indian land. Following the introduction of sugar beets in 1915 and many crop failures and the abandonment of dry-farming areas, there was a decided shift to irrigation farming and an increase in the number of farms. The demand for irrigated acreage and the more intensive use of land in connection with the production of sugar beets, other cash crops, and alfalfa has resulted in a marked decrease in the size of farms.

In 1938 there were approximately 460 farms within the area surveyed; 445 of this number were in Big Horn County. About 75 percent of the farms comprised 160 acres or less, ranging in size as follows: 20 percent included 40 acres of land; 25 percent, 80 acres; 20 percent, 120 acres; and 10 percent, 160 acres.

Table 8 shows the acres and present status of irrigable lands for the four irrigation units in the Crow Indian Reservation, as classified by the Indian Irrigation Service. Roughly, there are 40,000 acres of irrigable land in the four units, of which only 21,000 acres, or slightly more than one-half, is now under irrigation. An additional 15,000 acres has lateral irrigation outlets and is irrigable without additional reclamation. The remaining 4,000 acres has no laterals constructed to the land or needs the removal of brush or drainage before it will be irrigable.

The analysis of table 8 indicates that in the Crow Indian Reservation there is still a considerable acreage of irrigable land that is not irrigated. The supply of water available for irrigation limits the expansion of irrigation. With the present water supply, it is doubtful whether the irrigated areas of the Agency and Reno units can be materially expanded. The nonirrigated land in the area is used chiefly as dry-land pasture. Wild hay is harvested from a small acreage.

TABLE 8.—*Land classification*[1] *showing irrigable acreage, present status of irrigation development, and acreage irrigated on the 4 irrigated units of the Crow Indian Reservation, Big Horn Valley area, Mont.*[2]

Unit	Total acres	Class [3] (acres)						Acres irrigated [4]
		A	AC	AD	B	BC	BD	
Big Horn	28,714 20	25,710 07	628 38	129 91	1,255 29	824 46	166 09	15,679
Soap Creek	1,814 62	1,687 93	3 55	2 71	92 06	28 37		544
Agency	6,134.61	5,309 09	172 19	184 30	265 94	198 47	4 35	2,940
Reno	3,612 39	2,919 51	142 26	9 14	305.97	235 51		1,707

[1] This classification does not include 5,642 acres of irrigated Indian land served by the Two Leggin canal.
[2] Classification made by Indian Irrigation Service, Crow project
[3] A, lands to which laterals have been constructed, B, lands to which no laterals have been constructed; C, following A and B, indicates that the lands are covered with brush or trees and cannot be farmed until the land is cleared, D, following A and B, indicates that the lands require drainage before they can be successfully farmed The law provides that no ditch assessments can be made against any farm unit until water has been actually delivered to the land This provision applies only to lands in class A.
[4] Figures from table 3.

FARM TENURE

Table 9 shows the farm tenure status on certain lands of the Crow Indian Reservation during the 4-year period 1932–35. In 1935 some of these areas had as high as 84 percent of renter-operated farms. That part of the Big Horn Valley area not in the reservation probably has a higher percentage of owner-operated farms. About 65 percent of the irrigated land in the area is in the reservation, however, and this fact gives to the area as a whole a high percentage of renter operators.

TABLE 9.—*Land tenure (percentage of farms operated by owner, renter, and owner-renter), 4-year average, 1932–35, by irrigation units, for irrigated land in the Crow Indian Reservation, Big Horn County, Mont.*[1]

Irrigation unit	Farms operated by—		
	Owner	Renter	Owner-renter [2]
	Percent [3]	*Percent* [3]	*Percent* [3]
Big Horn and Soap Creek	24 5	66 9	8.6
Agency	44.7	44 6	10 7
Reno	17 6	68 6	13.8

[1] Taken from figures compiled by the Works Progress Administration, project Nos. OP-65-91-1775 (WP772) and OP-165-91-6999 (WP6000-1127)
[2] Owner-renter is used here in the sense of an operator who has contracted for the purchase of the land but does not yet have title
[3] Percentage of total number of farms.

Of the irrigated land in the Indian reservation, 29 percent is owned by whites and 71 percent by Indians. Most of the Indian-owned land is leased to white operators, which accounts for the large number of renter-operated farms. Governmental and tribal policies dominate the rental practices, which are commonly short-time leases, consummated on a basis of competitive bidding. In many respects this kind of farm tenure is not conducive to good soil management and prevents the development of a stable farm population.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field and the recording of their characteristics, particularly in reference to the growth of various crops, grasses, and trees.

The soils and the underlying formations are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied at regular intervals. Each excavation exposes a series of layers or horizons, and the entire section from the surface down to the weathered but otherwise unmodified parent material is known as the soil profile or the solum. The classification is based on such internal characteristics of the soil profile as thickness, color, structure, texture, consistence, reaction, lime and salt content, and content of organic matter, and such external features as drainage, relief, and stoniness. The plant cover—both native vegetation and farm crops—is observed, and its relation to the soils is studied. In this way the productivity of the soils can be determined or estimated with a fair degree of accuracy. In classifying virgin lands, which may later be brought under cultivation, the observation of like soils now being farmed is an important part of the work.

Some of the terms mentioned in the preceding paragraph are in common use and need no explanation. Others have special meanings in soil science. For example, structure means the arrangement of the individual soil particles or grains within the soil mass. Hence, it affects the tilth of the soil and the rate at which moisture can be absorbed. Common soil structures are granular, cloddy, platy, columnar, and prismatic. Soil material having no definite structure is designated as single grain if incoherent and as massive if coherent. Texture is concerned with the coarseness or fineness of the soil mass as determined by the relative percentages of silt, clay, and the various grades of sand. Clay, silty clay, silty clay loam, silt loam, loam, very fine sandy loam, and sandy loam, named in the order of an increasing content of coarse material and a decreasing content of clay, are the main soil textures represented in this area. Consistence is concerned with the relative firmness or looseness of the soil mass and its resistance to crushing or distortion. Incoherent (as in sand), friable (as in most silt loams), and dense or compact (as in many clay soils) are common terms applied to consistence. The presence or absence of lime is determined by means of dilute hydrochloric acid, and the total content of readily soluble salts is determined when necessary by the use of the electrolytic bridge.

On the basis of their internal and external features the soils are grouped into classification units. The three principal units are (1) series, (2) type, and (3) phase. In some places two or more of these principal units may be in such intimate or mixed pattern that they cannot be indicated clearly on the map but must be mapped as (4) a complex. In addition, some areas of land—such as dune sand, riverwash, and stony mountainsides—that have no true soil are called (5) miscellaneous land types.

The most important of these groups is the series, which includes soils that have developed from similar, although not necessarily, identical, kinds of parent material, and that have the same genetic horizons, arranged alike in the soil profile. Thus, a series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture in that part of the soil commonly plowed may differ within a series. The series are given geographic names taken from localities near which they were first identified. Billings, Cherry, Manvel, Havre, Glendive, Laurel, and Fort Collins are the names of some soil series in the Big Horn Valley area.

Within a soil series are one or more soil types, defined according to the texture in the upper part of the soil, generally to about the depth of plowing. The name of the soil texture to this depth, such as silt loam, loam, clay loam, or fine sandy loam, is added to the series name to give the complete name of the soil type. For example, Billings clay, Havre very fine sandy loam, and Havre silt loam are types within the Billings and Havre series. Except for differences in the texture of surface layers, all types of the Billings series have similar external characteristics. The same holds true for all types within the Havre or any other series. The soil type is the principal unit of mapping, and because of its specific character it is usually the unit to which agronomic data are definitely related.

A phase of a soil type is a soil that differs from the type in some minor feature, generally external, that may be of special practical significance. A soil type may be almost uniform throughout its distribution in all important profile features, but slight variations in its gravel content or in the relief may cause marked differences in the use capabilities of the soil in different localities. For example, within the range of relief of a soil type there may be areas that are adapted to the use of machinery and the production of cultivated crops and other areas that are not. Even though there may be no important differences in the soil itself or in its ability to produce the native vegetation, there may be important differences in respect to the growth of cultivated crops, owing to variations in relief. In such instances the different kinds of relief not normal for the soil may be segregated on the map as level, sloping, or hilly phases. Similarly, soils having differences in stoniness or slight differences in the color of the surface soil may be mapped as phases, even though these differences have no influence on the more important properties of the soil or on the growth of native plants.

The soil surveyor makes a map of the area to be surveyed on an accurate base—either aerial photographs, United States Geological Survey topographic sheets, or plane-table traverse. The map shows

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the location of each of the soil types, phases, complexes, and miscellaneous land types in relation to roads, houses, streams, lakes, section and township lines, and other cultural and natural features of the landscape.

SOILS OF THE AREA

GENERAL DESCRIPTION, CLASSIFICATION, AND RELATIONSHIPS

The Big Horn Valley area comprises the alluvial lands of the Big Horn and Little Horn River Valleys, the adjacent valley slopes, and some of the uplands, high gravelly benches, steep slopes, and escarpments that border the valleys. The soils have developed or are developing chiefly under the influence of a short-grass vegetation from limy, clayey, silty, and sandy alluvial sediments on the bottom lands and low terraces; from gravelly mountain outwash or valley-filling material on the high benches; and from silty shales and sandstone on the uplands. On the valley slopes the soils are forming from colluvium and local alluvium washed from the adjacent uplands and high benches. The soils range in color from brownish gray to dark grayish brown, but they are dominantly brownish gray. Their light color is due to the type of soil formation associated with a semiarid climate and a sparse vegetation. The annual return of organic matter to the land under these conditions is not sufficient to darken the soils appreciably except in places where they receive supplemental moisture from seepage or runoff from higher levels.

The Beaverton soils are the only ones mapped on the small areas of high benches included in the Big Horn Valley area. These soils are friable and loamy or only slightly sandy in their surface layers. They contain considerable gravel through the entire profile, are underlain by thick beds of loose gravel, and have a well-developed zone of lime accumulation in their subsoil. The valley slopes immediately below the high benches are commonly steep and in some places precipitous. Little or no soil has accumulated on the steep slopes, and the bedrock is exposed on the steeper parts. Moderately dark soils belonging to the Cushman series have developed from soft shales on the high slopes of mild gradient. The Cushman soils are silty and friable in all layers and contain an abundance of accumulated lime in the lower part of the subsoil.

The Glendive, Manvel, Neville, and Cherry soils on the lower valley slopes are commonly silty or only slightly sandy and as a rule friable. They occupy positions favorable for the continued accumulation of local alluvium washed from the higher lands. This renewal of the surface soil accounts in a large measure for their lack of profile development, the presence of lime at or near and beneath the surface, and the absence of a marked zone of lime accumulation in their subsoil.

A rather large proportion of the soils of the bottom lands and terraces are developing in comparatively deep deposits of heavy rather clayey alluvium. The surface soils are dominantly brownish gray. Both surface drainage and internal drainage are slow or imperfect. These conditions are especially prevalent in the general region of occurrence of the Billings soils in the Big Horn Valley south of Hardin. North of Hardin the deep clayey soils are interspersed with larger areas of better drained soils that have a friable, silty, or slightly sandy subsoil. In the Little Horn Valley the soils are commonly more silty and sandy and have more friable subsoils and better internal drainage than in the rest of the area. Most of the soils on the bottom lands and the lower lying parts of the terraces over the entire area have a gravel or sand substratum at a depth of 1 to 4 feet below the surface. All the soils in the valley proper are imperfectly developed or show no development of a profile, except the Fort Collins soils, which occupy the better drained positions and have friable subsoil layers, in which there is a definite zone of lime accumulation.

The heavy soils and the more poorly drained areas commonly have poor tilth and contain different quantities of "alkali" [4] salts. The salts in places are sufficiently concentrated to injure growing vegetation, the concentration depending on the quantity of salts originally present in the soil, the extent to which leaching has taken place, the quantity of salt carried in seepage water that affects some of the land, and the condition of drainage that would tend to remove or concentrate the excess of soluble salts.

All the soils, except those on the uplands, high benches, and higher valley slopes, occupy positions below the irrigation ditches. Most of those below the ditches are suited to irrigation farming, except the Banks and Laurel soils. The Billings soils are generally acceptable for irrigation farming but have difficult problems of production and management during the initial years of reclamation. The Banks soils are adjacent to the larger streams and have uneven relief, excessive internal drainage, and a comparatively low content of available plant nutrients. The Laurel soil generally occurs in depressed situations, is imperfectly to poorly drained, and contains an excess of soluble salts.

Prior to the development of irrigation, the agricultural use of the heavy soils of the area was restricted chiefly to grazing, and those soils having friable, silty, or loamy profiles were used largely in the production of wild hay and small grains under dry-farming methods. Under irrigation the friable soils are adapted to a wide variety of grain and forage crops, fruits, vegetables, and root crops. The tilth of the heavy soils, provided the content of salts is not excessive, gradually improves under irrigation and management practices that include the use of manures and fertilizers and the incorporation of crop residues into the soil. Under similar practices the soils of lighter texture are productive for nearly all of the crops adapted to the area. Sugar beets and alfalfa, with adequate irrigation, have proved to be better adapted to the moderately salty heavy soils than are most of the other crops produced.

Table 10 lists the soil series recognized and mapped in this area, arranged in the first column into groups according to their physiographic distribution. Succeeding columns list the topographic range of each series, their chief identifying physical and chemical characteristics, and the origin of the parent material in which each soil has formed.

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[4] "Alkali," as used in this report, refers to a harmful accumulation of soluble salts without regard to chemical reaction There are two general types of excess salts in soils "White alkali" is composed mainly of sodium chloride (table salt) and sodium sulfate (Glauber's salt), both of which are white crystalline substances that are neutral in reaction Strictly speaking, soils high in content of these salts are more properly termed saline soils rather than alkali soils High concentrations of these salts in the soils are injurious to plants. "Black alkali" is composed chiefly of sodium carbonate (sal soda) This substance is a true alkali and has a very toxic effect on plants. It also causes the fine particles in the soil to puddle or "run together" when wet.

TABLE 10.—*Key to the soil series of the Big Horn Valley area, Mont., showing their physiographic distribution and the limitations of their principal identifying characteristics*

Physiographic position	Soil series	Topography	Surface-soil color	Consistence and texture	
				Surface soil	Subsoil
Smooth terraces	Fort Collins	Nearly level to gently undulating	Grayish brown	Friable, silty	Friable, silty.
	Billings	Nearly level	Brownish gray	Compact, clayey	Compact, clay.
Valley slopes	Glendive	Gentle slopes and sloping fans.	do	Friable, loamy to sandy	Friable, sandy.
	Manvel	do	do	Friable, silty	Friable, silty to moderately clayey.
	Cherry	Gentle terracelike slopes	Grayish brown	do	Friable. silty.
	Neville	Gentle slopes and sloping fans	Reddish brown	do	Friable, silty to moderately clayey.
	Cushman	Gentle slopes (high on valley sides)	Dark grayish brown	do	Do.
High terraces	Beaverton	Nearly level to undulating	Brown or moderately dark brown.	Friable, loamy to sandy	Friable, sandy to gravelly.
Bottom lands and low terraces.	Havre	Level to gently undulating	Grayish brown	Friable, silty to slightly sandy.	Friable, silty to moderately sandy
	Banks	Gently undulating to slightly hummocky.	Brownish gray	Slightly coherent, sandy	Incoherent sands.
	Banks-Havre complex	do	do	Moderately coherent, sandy	Moderately coherent, silty to sandy
	Laurel	Level or slightly depressed	do	Compact, clayey	Compact, clayey.
Miscellaneous	Riverwash	Nearly level to hummocky	Gray	Incoherent sands	Incoherent sands and gravel.
	Rough broken land	Steep	Undifferentiated	Undifferentiated	Undifferentiated.

Physiographic position	Soil series	Natural drainage	Depth to lime	Content of injurious salts [1]	Total depth of soil [2]	Parent material
Smooth terraces	Fort Collins	Good surface and internal	8 to 10 inches	Low or none	22 to 30 inches	Old alluvium.
	Billings	Slow surface, very slow internal.	From surface downward	Medium to high	16 to 24 inches	Do.
Valley slopes	Glendive	Good surface and internal	do	Very low or none	18 to 30 inches	Local alluvium or colluvium.
	Manvel	do	do	Low or none	18 to 24 inches	Do
	Cherry	do	do	Very low or none	18 to 26 inches	Local alluvium.
	Neville	do	do	Low or none	14 to 20 inches	Local alluvium or colluvium.
	Cushman	do	20 to 24 inches	None	32 to 38 inches	Weathered shale, partly reworked by colluvial action.
High terraces	Beaverton	Good surface, excessive internal.	6 to 10 inches	do	30 to 48 inches	Mountain outwash or ancient valley alluvium.
Bottom lands and low terraces.	Havre	Good surface, restricted internal.[3]	From the surface downward.	Low	16 to 24 inches	Recent alluvium.
	Banks	Good surface, excessive internal.	do	Low or none	12 to 14 inches	Do.
	Banks-Havre complex.	do	do	do	12 to 20 inches	Do.
	Laurel	Slow surface, poor internal	do	Medium to high	14 to 20 inches	Do.
Miscellaneous	Riverwash	Good surface, restricted internal [3]	do	None	No soil	River sands and gravel.
	Rough broken land.	Excessive	do	Low or none	0 to 12 inches	Sandstone, shale, and gravel

[1] The salt content is expressed in general terms and does not refer to included salty spots resulting from seepage.
[2] Depth of developed soil horizons and, as on bottom lands and some colluvial slopes, depth of darkened layers.
[3] High water table prevents complete internal drainage.

In the following pages the soil series and types are described in detail, their differences and similarities are pointed out, and their place in the agriculture of the area and their crop adaptations are discussed. The map accompanying the report shows the distribution of the soils, and table 11 gives their acreage and proportionate extent.

TABLE 11.—*Acreage and proportionate extent of the soils mapped in the Big Horn Valley area, Mont*

Soil type	Acres	Percent	Soil type	Acres	Percent
Fort Collins silt loam	3,840	3.4	Neville silt loam	64	0 1
Fort Collins silty clay loam	3,200	2.8	Cushman loam, deep phase	384	3
Billings silty clay	24,704	21 7	Beaverton loam	448	.4
Billings silty clay loam	8,320	7 3	Havre very fine sandy loam	6,976	6 1
Billings clay	1,792	1 6	Havre silt loam	8,896	7 8
Billings clay, saline phase	704	6	Havre silty clay loam	2,752	2.4
Glendive fine sandy loam	2,560	2 2	Banks fine sand	8,960	7 9
Glendive fine sandy loam, brown phase	192	2	Banks very fine sandy loam	3,008	2 6
Glendive silt loam	3,712	3 3	Banks-Havre complex	448	4
Glendive silt loam, brown phase	768	.7	Laurel silty clay loam	1,984	1 7
Manvel silt loam	6,208	5 5	Riverwash	6,272	5 5
Manvel silty clay loam	3,584	3 1	Rough broken land	11,072	9 7
Cherry silt loam	3,072	2 7	Total	113,920	100 0

FORT COLLINS SERIES

The soils of the Fort Collins series occupy a comparatively large acreage throughout the Little Horn Valley and in the Big Horn Valley south of St. Xavier in the vicinity of Soap Creek. The Fort Collins soils comprise some of the most desirable lands in the area for irrigation farming. Soils of this series have developed on smooth well-drained terraces from calcareous alluvial deposits of moderately fine texture. They are characterized by grayish-brown surface soils and friable lighter colored subsoil in which there is a fairly well developed zone of lime accumulation. They have darker surface soils than the Billings, Glendive, and Manvel soils. Their subsoil is more silty than that of the Glendive and more friable and permeable than that of the Billings soils.

Fort Collins silt loam.—This type comprises a fairly large total acreage of the soils on the smooth terraces in the Little Horn Valley and in the upper or southern part of the Big Horn Valley, commonly occupying areas having a slope of less than 2 percent.

The 7- or 8-inch surface soil consists of grayish-brown friable silt loam of soft crumb structure in the upper part and grayish-brown or light-brown friable silt loam of weak prismatic structure in the lower part. The subsoil is light brownish-gray highly calcareous friable silt loam or silty clay loam to a depth of 18 or 20 inches. This is a zone of lime accumulation. This layer merges with the substratum, which is composed of alternating layers of friable calcareous light brownish-gray loam and silt loam, which continue downward to a depth of several feet. A sand and gravel substratum commonly underlies the soil at a depth of less than 10 feet.

In the Big Horn Valley many areas of this soil have thin layers of reddish-brown silts in the subsoil, and when moistened the surface soil may have a faint red tint. Other local variations or inclusions of other soils are in secs. 16 and 17, T. 3 S., R. 33 E., where there is a claypan in the subsoil and soil tilth is poor. The claypan areas are indicated on the soil map by special symbols.

Seepage from irrigation canals, excessive irrigation, and uncontrolled waste water have created wet conditions or a high water table, resulting in the accumulation of excess salts in secs. 10 and 11 and the NW¼ sec. 24, T. 2 S., R. 34 E., and in the south half of sec. 13, T. 3 S., R. 34 E. No measures were being taken to correct this condition at the time the survey was made. The locally poorly drained spots are indicated on the soil map by special symbols.

Fort Collins silt loam is naturally well drained and is permeable to air, plant roots, and moisture. Its smooth surface allows ease of irrigation, and the soil retains a good supply of moisture for plant use. On the whole, this is one of the most desirable soils in the area for irrigation. Under good management, improved areas produce from 11 to 15 tons of sugar beets, 2 to 2½ tons of alfalfa hay, and 25 to 35 bushels of wheat to the acre. On relatively unimproved tracts crop yields are about as follows: Sugar beets, 9 tons; alfalfa hay, 1½ tons; wheat, 15 bushels.

Fort Collins silty clay loam.—This soil is widely distributed in all parts of the area in association with Fort Collins silt loam and the Billings soils. It is slightly heavier in all layers than Fort Collins silt loam, and water infiltration is a little slower; otherwise the two soils do not differ significantly. The surface soil is grayish-brown soft granular silty clay loam to a depth of 3 to 4 inches, beneath which is brown or moderately dark grayish-brown silty clay of firm cloddy or prismatic structure, commonly containing no free lime. The subsoil, beginning at a depth of 8 to 9 inches below the surface, consists of thin alternating layers of calcareous firm brownish-gray silty clay loam and clay loam, which continue down to unaltered alluvium at a depth of about 30 inches below the surface. The surface layer of most areas of this soil in the Big Horn Valley have a slight red tint when moist, and the subsoil commonly contains somewhat red silty layers at a depth of 2 feet or more. Surface drainage is good, and in most places internal drainage is adequate although movement of water through the soil is comparatively slow.

Considering its heavy texture, Fort Collins silty clay loam is fairly friable, and with proper management under irrigation it is a productive soil, yielding 10 to 15 tons of sugar beets, 1½ to 2¼ tons of alfalfa hay, and 20 to 32 bushels of wheat to the acre. Areas that have had little improvement or have only recently been put into cultivation produce about 8.5 tons of sugar beets, 1¼ tons of alfalfa hay, and 15 bushels of wheat to the acre.

BILLINGS SERIES

The Billings series includes light-colored immature heavy soils developed on terraces that lie 10 to 50 feet above stream level. The parent material consists of gray calcareous alluvial deposits brought down chiefly from areas of light-colored alkaline shales. The soils have a low content of organic matter and a high content of lime and other salts.

The Billings soils have brownish-gray silty clay loam or clay surface soils that are hard and compact. The material breaks into hard clods when dry and is sticky and plastic when wet. The subsoil, beginning at a depth of 6 to 8 inches, is gray or light-gray silty clay or clay containing white streaks and spots of salts. Surface drainage in general is slow, but it is adequate considering the low rainfall of the area. Internal drainage is very slow. In most places these soils are calcareous from the surface down but have no zone of lime accumulation in their subsoil.

The Billings soils occur in large and small bodies in nearly all parts of the area and comprise a larger total acreage than the soils of any other series. They are used widely for the production of sugar beets and alfalfa. They require much more careful management than the more friable soils, and crop yields are commonly lower. Even though they are not particularly productive when first cultivated, skillful management has brought many tracts into satisfactory production. A first requisite to successful production is the improvement of the naturally poor tilth. Recently cultivated areas of Billings soils between St. Xavier and the Two Leggin bridge are less improved in tilth than areas of associated soils of heavy texture.

Areas containing higher than average quantities of salts are unsuited to the production of crops. Such areas are likely to have growing on them salt-tolerant plants, such as greasewood, saltgrass, and meadow barley.

Billings silty clay.—This soil has the largest total acreage of the soils in this area. It occurs in large and small bodies in the Big Horn Valley south of Hardin and in numerous but generally smaller bodies in other parts of the area.

In an undisturbed condition, the surface soil consists of a gray loose clay loam mulch about 1 inch thick, over a brownish-gray laminated or platy silty clay layer of about the same thickness, which is abruptly underlain by brownish-gray massive intractable silty clay of low organic-matter content. The subsoil, beginning at a depth of 8 to 10 inches, consists of gray massive silty clay or clay that shows little weathering or soil development except in the upper 8- to 12-inch layer. At a depth of 24 to 30 inches the heavy clay commonly grades quickly into more friable material—alternating layers of gray calcareous sandy loam, loam, and clay loam. These layers continue down to the alluvial sands and gravel at a depth of 8 feet or more. The soil throughout is mildly to rather strongly calcareous. White streaks and spots of salts are present at all depths except in the surface mulch but appear to be more concentrated in the lower part of the subsoil.

Surface drainage is slow, owing to the nearly level surface, but it is adequate for a region of generally low rainfall. Moisture infiltration and internal drainage are very slow because of the heavy, dense character of the subsoil. The soil becomes puddled readily, and the tilth is poor unless the soil is carefully managed. Most of this soil south of Two Leggin bridge along the eastern side of the Big Horn Valley occupies areas having a slope of 1 to 2 percent, and the surface drainage is a little better than is common for the soil as a whole.

Imperfect drainage and the accumulation of surface water have resulted in the concentration of an excess of salts in certain areas of this soil in secs. 26, 27, and 34, T. 2 N., R. 33 E., the east half of sec. 28, T. 1 N., R. 33 E., and sec. 19, T. 3 S., R. 33 E. In the general area between Hardin and Foster, deep drainage ditches have been constructed to increase the rate of drainage and removal of soluble salts.

Most areas of Billings silty clay are under irrigation and in different stages of improvement. Crop yields vary considerably, depending on the length of time the land has been under cultivation and on how well the soil has been managed or its present state of tilth. Areas recently put into cultivation or those that have had little or no additional organic matter incorporated in the soil produce about 8 tons of sugar beets, 1 ton of alfalfa, and 12 bushels of wheat to the acre. Other tracts that have been improved through the incorporation of manure and crop residues into the soil, with proper tillage and irrigation, may give acre yields of 10 to 14 tons of beets, 1½ to 2 tons of alfalfa hay, and 17 to 27 bushels of wheat (pl. 1, *B*).

Billings silty clay loam.—This type differs little from Billings silty clay except in having a little less clay in the surface soil. Under cultivation it requires the same careful management, but satisfactory tilth can be maintained a little easier because of the slightly lighter texture of the soil. The surface soil to a depth of about 10 inches is brownish-gray mildly calcareous massive silty clay loam that is plastic when wet and breaks into irregular hard clods when dry. Under virgin conditions the 1- or 2-inch surface layer is loose and mulchlike or platy loam or clay loam. The subsoil is gray massive silty clay loam or silty clay, grading into lighter textured more friable material at a depth of about 20 inches. White streaks and spots of accumulated salts are present below the surface mulch and are more abundant in the lower part of the subsoil. A sand and gravel substratum underlies much of this soil at a depth of 6 to 8 feet. Water penetrates very slowly through the subsoil but moves rather freely through the underlying more friable layers.

The silty clay loam is the most satisfactory Billings soil for the production of crops. Average acre yields of all crops probably are 10 percent higher than those obtained on Billings silty clay.

Billings clay.—This soil occupies small tracts on the smooth nearly level terraces throughout the area, in association with the other Billings soils. Below a thin mulchlike gray surface layer it is brownish-gray dense intractable clay to a depth of about 12 inches, where it is underlain by compact gray clay, which continues to a depth of about 3 feet. Below this it is silty or slightly sandy and more friable and is generally underlain by a sand and gravel substratum at a depth of 6 to 8 feet. When dry the soil is very hard and cracks into irregular hard blocks; when wet it is very sticky and plastic. White streaks and spots of salts are commonly present from a few inches below the surface downward, becoming more abundant in the lower part of the subsoil. Surface drainage is not so well established as in the other Billings soils, and as a rule the content of injurious salts is higher. Greasewood and saltgrass are dominant in the natural vegetation in the areas of highest salt concentrations; and western wheatgrass (or bluestem), locally called bluejoint, is more common on the better drained less saline areas.

Little of this soil is under cultivation, because of its heavy intractable character, which makes it very difficult to manage under ordinary tillage practices. A few acres have been improved and seeded to small grains, but yields, as a rule, are unsatisfactory. Some areas are irrigated for the production of native hay.

Billings clay, saline phase.—This phase occupies small widely separated areas and commonly occurs at the edge of the terraces adjacent to the shale bluffs, in positions favorable for the accumulation of local alluvium from the uplands. The surface soil consists of a mixture of clay and silt containing some fine sand. It differs from Billings clay chiefly in that it contains an excess of injurious salts in most areas. It has an uneven, billowy surface, and most areas are incised by local drains and gullies that collect runoff from the hills. Salt concentrations are sufficiently high in 40 to 50 percent of the areas to prevent the growth of natural vegetation.

The saline condition of the soil and the generally uneven relief make it unsuited to irrigation and for the production of crops. The best use of the land is for the sparse pasturage it affords.

GLENDIVE SERIES

The soils of the Glendive series comprise a comparatively large total acreage, and they include some of the more desirable irrigated soils. The largest areas of these soils are in the Big Horn Valley north of Hardin. Bodies occur in nearly all parts of the area. They occupy smooth terracelike slopes and gently sloping fans formed on the terraces, which lie from 10 to 50 feet above the larger streams. These soils are formed in silty or moderately sandy colluvial material washed down from the adjacent uplands or deposited by floodwaters from small intermittent streams that spread out on the terraces.

The Glendive soils have light grayish-brown or brownish-gray surface soils, with a moderately low content of organic matter, and gray or light brownish-gray coherent sandy subsoils, which in most places are underlain by loose or only slightly coherent sands. They are friable, comparatively young, immature soils and are limy from or near the surface downward but have no zone of accumulated lime in their subsoils. They have good surface and internal drainage and in general are free of injurious salts.

Most areas of the Glendive soils occupy slopes of less than 2 percent gradient and are well suited to irrigation farming. All crops adapted to the region do well on these soils. Yields of small grains are not high at present. The soils respond readily to good practices of management, and if the soils are properly managed, yields of all crops should eventually be higher than those now obtained.

Glendive fine sandy loam.—This soil occupies gently sloping alluvial fans chiefly in the Big Horn River Valley. The 5-inch surface soil is friable light brownish-gray fine sandy loam of low organic-matter content. Below this the subsoil, to a depth of 18 to 20 inches, is light-gray friable very fine sandy loam. The underlying material consists of gray loose fine sands, which continue to a depth of several feet. The soil is limy from or near the surface downward. Surface and internal drainage are good, and the soil is free of injurious salts.

Nearly all of this soil is free of seepage. It occupies positions favorable for irrigation and is an excellent soil for farming. It is deficient in some of the essential plant nutrients, however, and the generally low supply of nitrogen can easily be increased by plowing under legumes, manure, and crop residues. Areas of this soil under cultivation for a number of years, with good management and irrigation, produce from 10 to 15 tons of sugar beets, 2 to 2¼ tons of alfalfa hay, and 25 to 35 bushels of wheat to the acre. Some areas are above the level of present irrigation ditches and are used as pasture land.

Glendive fine sandy loam, brown phase.—This phase occupies similar positions and has developed in the same kind of parent material as typical Glendive fine sandy loam. The total area of soil of this phase is not large. It occurs chiefly about 3 miles south of Hardin. It differs from the typical soil mainly in having a browner surface soil, which is a little more advanced in its stage of development, and it commonly contains no lime to a depth of 6 to 8 inches.

In an undisturbed or virgin condition the topmost 3- or 4-inch layer is light grayish-brown fine sandy loam, mulchlike to a depth of about 1 inch and laminated or platy below. It is underlain to a depth of 7 to 8 inches by brown weakly prismatic friable fine sandy loam that generally contains no free lime. Under cultivation, mixing of the two layers produces a brown or light-brown surface soil of good tilth. The subsoil, beginning at a depth of about 8 inches, consists of alternating layers of brownish-gray mildly calcareous friable fine sandy loam and sandy silt, which continue down to underlying sands and gravel at a depth of 30 or more inches.

This soil is well drained, free of injurious salts, and easily tilled. It responds readily to good management and is suitable for the production of all the crops commonly grown. Crop yields do not vary significantly from those obtained on typical Glendive fine sandy loam.

Glendive silt loam.—This type differs from Glendive fine sandy loam chiefly in having slightly heavier, more silty surface layers and a little less sand in the subsoil. The subsoil is only semicoherent. The 8-inch surface soil is brownish-gray weakly calcareous silt loam of soft crumb structure; the subsoil, which continues to a depth of 24 to 30 inches, is light-gray calcareous loam or very fine sandy loam and is underlain by a sand substratum. This soil has good surface and internal drainage and retains a good supply of moisture for growing plants. It is easily irrigated and is one of the best soils in the area for crops. Yields of all crops are as high as or slightly higher than those obtained on Glendive fine sandy loam and about the same as those obtained on Fort Collins silt loam.

Glendive silt loam, brown phase.—This soil occurs chiefly in the general area 3 miles south of Hardin, in association with Glendive fine sandy loam, brown phase. It differs little from typical Glendive silt loam except in having a definitely brown rather than a grayish-brown or brownish-gray surface soil. Aside from the heavier surface soil, it is nearly identical with Glendive fine sandy loam, brown phase, in most features of the profile. Surface and internal drainage in most places are good, but the body in sec. 3, T. 2 S., R. 33 E., has become rather wet, chiefly through seepage from higher lying irrigated land. This body is used for the production of native hay.

Most of this soil is under cultivation. Similar practices of soil management are used as with the other Glendive soils, and yields of crops are about the same.

MANVEL SERIES

The Manvel series includes immature friable light-colored limy soils that have developed on smooth gentle slopes and on sloping fans and aprons in the valleys of the larger streams. The parent materials are sediments brought down from silty areas in the higher uplands. They differ from the Glendive soils in having silty, coherent rather than sandy subsoil layers, and from the Cherry soils in having lighter colored surface soils and poorer development. They have grayish-brown or brownish-gray calcareous surface soils that merge with the subsoils or slightly altered parent material at a depth of 6 to 10 inches. The rest of the material shown in the profile is rather uniform gray calcareous silt or silt loam to a depth of 30 to 36 inches, below which is more sandy material.

The soils are permeable and well drained and hold a good supply of moisture for plant use. In most places they contain but small quantities of injurious salts and are among the most productive soils for all crops adapted to the area

Manvel silt loam.—This occupies numerous mostly small areas distributed throughout the entire length of the Big Horn River Valley. The surface soil, a light grayish-brown or brownish-gray calcareous friable silt loam, merges imperceptibly with the subsoil at a depth of about 8 inches. The subsoil consists of little-altered rather uniform gray calcareous silt or silt loam to a depth ranging from 30 to 36 inches. Below this the substratum consists chiefly of loamy fine sand or fine sandy loam. In most places the soil is well drained throughout, and it contains only small quantities of or no injurious salts. The land lies well for irrigation, and after a few years in cultivation under good management practices it produces 10 to 15 tons of sugar beets, 2 to 2¼ tons of alfalfa hay, and 25 to 35 bushels of wheat to the acre. Nearly all of this soil is under cultivation.

Manvel silty clay loam.—In virgin or undisturbed areas Manvel silty clay loam, beneath a thin gray loamy or slightly sandy mulch, is grayish-brown mildly calcareous silty clay loam to a depth of 9 to 11 inches. The material in this layer breaks into irregular firm clods when dry and into a soft crumblike or granular mass when moist. Below this is brownish-gray or gray calcareous silty clay loam that gradually becomes lighter in texture downward until it merges with the substratum of loamy fine sand or fine sandy loam at a depth of 24 to 36 inches. Little or no soil development is apparent below a depth of 18 inches.

Manvel silty clay loam is naturally well drained. As some of it lies at lower levels than the adjacent irrigated land, there is a possibility of spots becoming wet or poorly drained from seepage. One such area of this soil is in the vicinity of Nine Mile School.

Most areas of this soil occupy slopes favorable for irrigation, and in general the land is under cultivation. Infiltration of moisture is slower than in Manvel silt loam and in the silty or sandy soils of other series. It absorbs water much more readily, however, than the Billings soils, and it holds a good supply available for plant use. Improved and well-managed areas produce 11 to 15 tons of sugar beets, 1½ to 2¼ tons of alfalfa hay, and 20 to 32 bushels of wheat to the acre. Comparatively unimproved areas produce about 8½ tons of beets, 1¼ tons of alfalfa hay, and 15 bushels of wheat.

CHERRY SERIES

The Cherry series includes developed soils on high first bottoms, low terraces, natural levees, and outwash fans. The parent material, consisting of heavy silt loam or clay loam, is largely local alluvium derived from areas of fine-grained shales. These soils differ from the Manvel soils in having slightly darker surface layers that show a slight development of prismatic structure, and from the Glendive soils in the same way and in having a silty rather than a sandy subsoil and substratum. They have moderately dark grayish-brown friable surface soils from 5 to 7 inches thick. The subsoils are grayish brown and have ill-defined prismatic structure in the upper part, and they are grayish brown and without definite structure in the lower part. The surface soil and the upper part of the subsoil are alkaline or mildly calcareous but generally contain no visible lime. The lower part of the subsoil as a rule is strongly calcareous.

Cherry silt loam is the only type belonging to this series that is mapped in this area. As a whole it is not quite typical of the Cherry series, and it occupies slightly higher positions than is common for Cherry soils.

Cherry silt loam.—This soil occupies gently sloping fans and local alluvial deposits in the Big Horn and Little Horn River Valleys, where small intermittent streams entering the valley spread out on the valley floor, depositing their burden of silt and clay brought down from the adjacent uplands.

The 5- to 6-inch surface soil is grayish-brown friable alkaline or slightly calcareous silt loam, which, under virgin or undisturbed conditions, is a mulchlike loam or fine sandy loam in the upper 1-inch layer, laminated or platy loam in the second 1-inch layer, and in the lower 3- or 4-inch layer is a firm silt loam or clay loam that breaks into irregular prism-shaped clods when dry. Below this material the subsoil is gray friable highly calcareous silt loam to a depth of 18 or more inches, where it is underlain by a silty or slightly sandy substratum that contains less lime than the layer above.

Cherry silt loam is well drained and free of injurious salts, and under irrigation and proper management it is, with a few exceptions, equally as productive as any other medium-textured soil of the valley slopes and terraces. A few small areas containing considerable gravel are included with this soil in mapping. These areas are not so suitable for irrigation and tillage as are areas free of gravel, and for this reason they are indicated on the accompanying soil map by conventional gravel symbols.

A few small areas on moderately steep slopes in places along the Little Horn River Valley are not typical but are included with Cherry silt loam for convenience in mapping. These areas are difficult to irrigate and are not so profitable to farm as the areas on less steep slopes. Much of this soil in the Big Horn River Valley lies above the level of present irrigation ditches. In the general area west and south of Hardin some of the high-lying areas are cultivated under dry-farming methods and are used chiefly for the production of wheat.

NEVILLE SERIES

The Neville series includes reddish-brown or red immature soils formed on colluvial-alluvial slopes and fans. The parent material is washed down chiefly from areas of sandstone and red shale uplands. These soils have reddish-brown friable calcareous surface soils 4 to 18 inches thick. In most places the subsoil and the substratum are reddish brown or light red. As mapped in the Big Horn Valley area they are nearly typical to a depth of about 18 inches, but in most areas they are underlain by gray rather than red or reddish-brown lower subsoil layers and substratum.

The Neville soils are nearly identical, in most features of their profiles, with the Moffat soils mapped in the Basin area of Wyoming, which lies chiefly in the Big Horn River Valley. The Moffat soils, however, have developed in an arid climate under a desert type of vegetation, whereas the Neville soils are in semiarid districts and have developed under the influence of a short-grass vegetation.

Only one type of this series, Neville silt loam, is mapped in the Big Horn Valley area.

Neville silt loam.—This soil occurs at the upper or southern end of the Big Horn Valley area. It has developed on local alluvium on the slopes of fairly high well-drained limy terraces. The parent material is washed mainly from red sandstones and red sandy shale uplands. None of this soil within the area is irrigated at present, but outside this area, west of the Big Horn River, there is a comparatively large area of this soil under irrigation. Without irrigation it is used entirely as pasture land.

Beneath a thin surface mulch, the 10- to 12-inch surface soil is reddish-brown calcareous friable silt loam. The upper part of the subsoil, about 6 inches thick, is reddish-brown firm or moderately compact but friable strongly calcareous loam. Below this and continuing to a depth of about 48 inches is gray highly calcareous interstratified loam and very fine sandy loam. The lower part of the substratum consists chiefly of a mixture of limestone and sandstone gravel. This soil has good moisture-holding capacity, and under irrigation it is productive of all the crops commonly grown.

CUSHMAN SERIES

The Cushman series includes soils having moderately dark friable surface soils and light-colored friable subsoils. These soils are developed from weathered clays and silty or moderately sandy shales and are commonly underlain by the partly weathered bedrock at a depth ranging from 30 to 40 inches. They have noncalcareous surface soils and upper subsoil layers, and moderately to strongly calcareous lower subsoil layers, in which a zone of accumulated lime has formed.

Only one type belonging to this series is mapped in the Big Horn Valley area, and this is not typical, in that it occupies slopes on which there is a considerable accumulation of colluvial material from higher land and the soil is deeper over bedrock than is general for Cushman soils.

Cushman loam, deep phase.—This soil occurs chiefly in a general area just north of Soap Creek and occupies gentle slopes adjacent to and just below areas of rough uplands. It has developed in silty and moderately sandy material washed or rolled down from the higher slopes.

The surface soil, beneath a thin dark-brown mulch, is dark grayish-brown friable loam to a depth of about 8 inches. Below this is the subsoil of brown or light-brown noncalcareous friable loam having a cloddy or ill-defined prismatic structure to a depth of 20 to 24 inches, where the material changes abruptly to gray highly calcareous loam, which continues down to the yellowish-gray moderately calcareous parent soil material at a depth of 36 to 38 inches below the surface.

Surface and internal drainage are good, and the soil is free of injurious salts. In all respects it is well suited to irrigation, and it produces excellent yields of all the crops commonly grown. Much of the soil, however, lies above the level of present irrigation ditches. Areas not in cultivation support a fair to good stand of grasses and are used as pasture land and for the production of native hay.

BEAVERTON SERIES

The Beaverton series includes soils developed on gravelly water-transported material on well-drained terraces. These soils in general have brown or moderately dark grayish-brown surface soils, brown noncalcareous moderately coherent upper subsoil layers, and gray calcareous sand and gravel lower subsoil layers and substrata.

In the Big Horn Valley area the Beaverton soils have slightly lighter colored surface soils, lime is present in the upper part of the subsoil, and there is less gravel in the subsoil than is typical of these soils in areas farther east where they are more normally developed. In this area they closely resemble the Gilcrest soils, which are normal soils on gravelly terraces in the drier parts of the Great Plains region.

Beaverton loam.—This soil occupies smooth nearly level benches or high terraces bordering the Big Horn River Valley. These terraces are 50 to 100 feet above the terraces on which the Fort Collins and Billings soils have developed and about 150 feet above the present level of the Big Horn River.

The surface soil of Beaverton loam is brown firm but friable loam from 6 to 10 inches thick. In a virgin or undisturbed condition the 2-inch surface layer is sandy, loose, and mulchlike in the upper part and laminated or platy in the lower part. The subsoil is firm or moderately compact, but it is friable gray or grayish-brown highly calcareous loam or very fine sandy loam to a depth ranging from 28 to 34 inches. Below this is a gray or grayish-brown sandy gravelly transitional layer that rests on the sand and gravel substratum at a depth of 38 to 48 inches. In most places considerable gravel is scattered over the surface and through the soil. As a rule, however, it is not in sufficient quantities to interfere with tillage operations or to render the soil droughty.

The total acreage of Beaverton loam is small. This soil occurs mostly in widely separated bodies. The texture of the surface soil varies from place to place, and areas of very fine sandy loam and fine sandy loam, too small to show on the map, are included with Beaverton loam. In places the lower part of the surface soil or the upper part of the subsoil is firm enough to be hardpanlike in character. Wind erosion has removed the friable surface soil and exposed the hard layer in places in areas that have been cultivated under dry-farming methods.

All this soil lies considerably above the level of present irrigation canals, and none of it is now under cultivation. Formerly nearly all of it was cultivated under dry-farming methods. Native grasses are now becoming reestablished, and all the land is included in pastures.

HAVRE SERIES

The Havre series includes moderately dark or rather light colored alluvial soils occupying bottom lands and low terraces along the larger or perennial streams. The alluvium is light colored, limy, and friable. It is composed mainly of silt but generally includes thin sedimentary layers of sandy or clayey material, and in places it is mixed with enough sand to give it a rather semicoherent consistence below a depth of 18 to 24 inches. These soils differ from the associated Banks soils in having darker surface layers and more coherent subsoils. They occupy lower positions than the adjacent Fort Collins soils, and they have much less profile development and are much more friable than the Billings soils. They have grayish-brown surface soils to a depth of 5 to 7 inches, grading into brownish-gray or gray subsoil layers, which merge with the gray sandy alluvium at an average depth of about 24 inches. In most places the soils are calcareous from the surface downward.

In this area the Havre soils have slightly undulating and hummocky relief, and most areas require a certain amount of leveling before they can be successfully irrigated. As they occur on low terraces below the Billings, Glendive, and Manvel soils, the Havre soils in this area in many places are subject to seepage from the higher irrigated lands and to the accumulation of excess salts. Deep drainage ditches might be used to reclaim many such areas. The Havre soils are used at present chiefly as pasture land and for the production of native hay, partly because other soils occupying higher positions and more easily prepared for irrigation have been available for cropping. As a whole, they have good surface drainage and fair internal drainage, except in areas that have a high water table. The content of soluble salts is low except in areas subject to seepage. These soils are productive of most crops, although they are not so well suited to small grains as some of the soils occupying higher positions.

Most of the Havre soils lying below the Victory Canal and those in the vicinity of War Man School are under irrigation and are producing crops satisfactorily. These areas are not menaced by seepage from higher land.

Havre very fine sandy loam.—This soil is distributed in nearly all parts of the area, on bottom lands and low terraces along the Big Horn and Little Horn Rivers. It comprises a fairly large total area and includes a large proportion of the Havre soils. The 5- to 6-inch surface soil is grayish-brown friable mildly calcareous very fine sandy loam of soft-crumb structure and a moderately low content of organic matter. The subsoil consists of alternating layers of gray calcareous loam and very fine sandy loam to a depth that in most places exceeds 18 inches. Below this the material becomes lighter colored and lighter textured with increasing depth and is underlain by loose sand and gravel at a depth ranging from 2 to 5 feet, but generally below 4 feet.

The soil is permeable to plant roots, air, and moisture, and it is well drained to a sufficient depth for the normal development of most crops, except for spots having a high water table or subject to seepage. In these spots deep drainage ditches may be helpful. Much of the soil has become salty and influenced by seepage from canals and from higher lying irrigated land. Little effort has been made to remedy this condition, and unless adequate drainage protection is provided much of this soil eventually will become too seepy and too salty for use in the production of cultivated crops. Where free from the influence of seepage or excess salts, Havre very fine sandy loam is a productive irrigated soil. Areas that are well drained and have been under cultivation for several years under reasonably good management practices produce from 11 to 15 tons of sugar beets, 2 to 2½ tons of alfalfa hay, and 25 to 36 bushels of wheat to the acre. Land recently put into cultivation produces about 9 tons of beets, 1¼ to 1½ tons of alfalfa hay, and 15 bushels of wheat to the acre.

Some leveling is necessary on nearly all areas of this soil before they can be successfully irrigated.

Havre silt loam.—This type comprises a comparatively small total acreage in the Big Horn Valley area. It occurs in small bodies associated with Havre very fine sandy loam. It differs from the very fine sandy loam in having a heavier, more silty, and slightly thicker surface soil. Aside from this difference the two soils are nearly identical in all features of the profile. Drainage conditions, salt content, and the productive capacity of these soils are not significantly different, and the same practices of management are applicable to both.

Havre silty clay loam.—This soil occurs in small widely separated bodies in nearly all parts of the area. It occupies nearly level or slightly depressed areas in which surface drainage is lacking or not well established. In most places internal drainage is restricted by the presence of a water table at comparatively slight depths—4 to 8 feet below the surface in most areas. The height of the water table results from the generally low position of most of the soil with relation to stream levels, and to the general rise in ground water levels in the lower part of the valleys due to drainage from irrigated lands on the higher terraces and slopes.

The 8- to 10-inch surface soil is grayish-brown or light grayish-brown mildly calcareous silty clay loam. The subsoil, to a depth of 16 or 18 inches, is gray calcareous silt loam that grades into the little altered parent material of sandy and clayey alluvium, which is generally underlain by a sandy and gravelly substratum at a depth of several feet. The surface soil is moderately friable when moist but breaks into irregular rather hard clods when dry. The rest of the soil as a rule is friable.

Much of this soil remains in a virgin condition and is used as pasture land and native-hay meadows. A fairly large acreage in the vicinity of War Man School is under cultivation, also several areas in the south half of sec. 29 and the north half of sec. 32, T. 2 S., R. 33 E., and in the area immediately below the higher terrace level in the west half of sec. 17 and the north half of sec. 20, T. 5 S., R. 32

E. The soil in the latter location has better surface and internal drainage than is common for most of Havre silty clay loam.

The areas of this soil now under cultivation produce from 10 to 15 tons of sugar beets, 1¾ to 2¼ tons of alfalfa hay, and 20 to 30 bushels of wheat to the acre. Other areas would be equally as productive with little or no additional drainage. As a whole, however, successful tillage of this soil will necessitate the construction of deep drainage ditches to intercept seepage and to prevent a further rise in the water table.

BANKS SERIES

The soils of the Banks series occupy about the same general position as the Havre soils, but as a rule they lie closer to the streams and are developed in more recently deposited alluvium. Their surface is dissected by numerous high water channels, and many areas support a natural vegetation of trees and brush. The Banks soils consist of a thin layer of light grayish-brown surface soil over loose sand and gravel. They contain little organic matter, and drainage to the water table is excessive. Only a very small acreage is farmed, because of their comparatively low natural fertility, excessive water requirements, and the large amount of leveling necessary in order to apply irrigation water. These soils are used chiefly as pasture land and are among the less desirable soils of the area for the production of crops.

Banks fine sand.—This soil is developed on areas of alluvial sands adjacent to the larger streams and on islands in the rivers. To a depth of 12 to 14 inches it consists of light brownish-gray mildly calcareous fine sand, the topmost 3- or 4-inch layer of which is slightly darkened by the accumulation of a small quantity of organic matter. The rest of the soil is composed chiefly of loose sand and gravel.

Most of this soil is subject to overflow during periods of high water, but the soil drains rapidly when the floods subside. It has low water-holding capacity and low natural fertility and is droughty for most farm crops. Only low and generally unprofitable yields, as a rule, are obtained from areas of this soil that have been farmed. This soil is best used for the sparse pasturage it affords. The brush and timber cover supported by much of this soil affords protection for livestock.

Banks very fine sandy loam.—This soil occupies areas of alluvium similar to those in which Banks fine sand is developed. The 5-inch surface soil is light grayish-brown mildly calcareous friable very fine sandy loam, low in content of organic matter. The subsoil is gray weakly calcareous fine sandy loam to a depth of about 12 inches. Below this is loose sand and gravel.

The management requirements and the productive capacity of this soil are similar to those of Banks fine sand. The land is poorly suited to irrigation agriculture, and native pasturage is its present use. This soil generally has a better grass cover than Banks fine sand.

Banks-Havre complex.—This complex of soils includes sandy Banks and Havre soils occupying bottom lands, chiefly along Soap

Creek. The individual areas of each of the included soils are too small and too intricately associated to be shown separately on the soil map. Because the Banks soils are dominant in the complex, the areas included in this separation, as a whole, are not suited for the production of cultivated crops. A few small areas of the included Havre very fine sandy loam occupy positions favorable for irrigation and could be cultivated. At present nearly all of this soil complex is used for pasture land and probably should remain in such use.

LAUREL SERIES

The Laurel series includes light-colored calcareous soils developed in fine-textured or only slightly sandy alluvium in the drier parts of the Great Plains region. These soils differ from those of the Havre series in having slightly lighter colored surface soils, heavier subsoil layers, and a higher content of soluble salts. Surface and internal drainage are slow, and in most places there are poorly drained spots. These soils have gray or dull grayish-brown surface soils and gray subsoils that are generally mottled with brown and rust-brown organic and iron stains in addition to white streaks and spots of accumulated salts.

In the Big Horn Valley area the Laurel soils are more poorly drained than is common for soils of this series, and they include numerous small slightly depressed and swampy spots. Only one type, Laurel silty clay loam, is mapped.

Laurel silty clay loam.—This type occupies imperfectly to poorly drained areas of heavy soils on the bottom lands and low terraces. These areas are characterized by a natural vegetation of moisture-loving and salt-tolerant sedges and grasses, including saltgrass and suaeda.

The 5-inch surface soil is dull grayish-brown massive calcareous silty clay loam mottled with rust spots and stains caused by partly decayed organic matter. The subsoil and the substratum consist of calcareous gray or bluish-gray compact massive silt loam or silty clay loam in the upper part and stratified clay, silt, and very fine sandy loam in the lower part. Rust stains and white salt accumulations are common to a depth of 2 to 3 feet.

Most areas of this soil were imperfectly to poorly drained and contained considerable injurious salts prior to the development of irrigation. Seepage from irrigated areas has served to intensify these conditions, and most of this soil eventually will become swampy if artificial drainage is not established. In its present state of poor drainage none of it is suitable for the production of crops.

MISCELLANEOUS LAND TYPES

Riverwash and rough broken land are placed in the general classification of miscellaneous land types, which is essentially a grouping of wastelands. They have little or no agricultural value except that some areas of rough broken land furnish sparse to fair pasturage.

Riverwash.—Riverwash occurs adjacent to stream channels and includes sand bars and gravelly sandy areas that are subject to shifting and change with each succeeding overflow. Much of it is bare of vegetation, and any vegetative cover consists chiefly of willow brush and scattered bunches of coarse grass. It is used only for the small amount of browse or grazing it affords.

Rough broken land.—Areas of rough broken land include three general types of nonarable land, namely, (1) gravelly escarpments, (2) sandstone-capped shale hills, and (3) shale bluffs. The sandstone-capped shale hills occur chiefly above the level of the high gravel benches and terraces and have a bold, sharp relief. They support a fair grass cover and a scattered growth of western yellow pine. The shale bluffs in some places rise abruptly from the valley floor, but as a whole their slopes are smoother than those of the sandstone hills and their gradients are not so steep. Most of the bluffs are mantled to varying depths with gravelly material washed or rolled down from the high gravelly benches. Only thin stands of grass are on these areas.

Areas of rough broken land are of value only for the sparse pasturage they afford.

ESTIMATED YIELDS

In table 12 the soils of the Big Horn Valley area are listed alphabetically and estimated average acre yields of the principal crops are given for each soil under the prevailing farming practices.

Yields of crops are necessarily estimated because of a lack of specific yield data by soil types and management practices. In the column headed "Remarks," statements are made concerning characteristics and use capabilities of the soils. The yields are estimated according to the prevailing practices of management, but it should be realized that the estimates may not apply directly to each specific tract of land for any particular year, inasmuch as the soil areas shown on the map may vary somewhat, management practices may differ slightly, and climatic conditions may fluctuate from year to year. The variations in management practices in irrigation farming, from farm to farm especially, may affect the yields obtained, because differences in the amount of water applied, the time of application, the kind of fertilizer used, and the sequence of crops are significant factors that may affect productivity.

LAND USES AND SOIL MANAGEMENT

The soils in the Big Horn Valley area that are suitable for cultivated crops are used in the production of nearly all the crops commonly grown, although some crops are better adapted to certain soils than to others. As a result of practical experience, the farmers plan to produce crops on the soils best suited to them, so far as this is possible on a given farm.

Sugar beets and alfalfa are adapted to a rather wide range of soil conditions and are comparatively tolerant to salt or alkali conditions; consequently they are grown on practically all of the soils. Small grains have nearly as wide an adaptation but do not produce so well on saline soils as beets and alfalfa. Corn and beans are best suited to the medium-textured friable soils that are comparatively free of salts.

Yields of the principal crops grown in the area are generally satisfactory where reasonably good management practices have been followed over a period of several years. The soils respond to careful management and are generally of moderate productivity. On the whole, the soils have a good supply of plant nutrients, but in many places the natural physical properties, resulting from the climatic influences under which the soils have developed, are not favorable to crop plants and must be improved. The low rainfall is favorable for the growth of only a sparse vegetation under natural conditions; therefore the content of organic matter in the soil is naturally low. Organic matter has a pronounced influence on the structure and tilth of soils. A soil containing considerable clay but deficient in organic matter has a tendency to run together when wet and become hard when dry, and it lacks the granular or crumb structure associated with good tilth.

Not only does organic matter furnish nitrogen to the soil and improve soil structure, but the decomposition of this material aids in the release of other plant nutrients that might be present in the soil in relative abundance but in a comparatively unavailable form.

Chemical studies of the soils in the Big Horn Valley area and of the same soils in other areas, made by the Chemistry Department of the Montana Agricultural Experiment Station, indicate a deficiency of nitrogen in most soils, but a relative abundance of most other essential plant nutrients. Some of the essential nutrients, however, are considered to be relatively unavailable because of the fact that a marked increase in crop yields is obtained from the application of phosphatic fertilizers.

The chief problem of soil management in this area is one of improving the physical condition or tilth of the soils. This is especially true of the heavy soils. Improved structure in the heavy soils allows more efficient use of irrigation water and the intake of larger quantities of water for leaching the soluble salts from the soils and rendering them more favorable for the growth of plants.

Any practice that would tend to increase the content of organic matter in the soils is considered necessary to improve the tilth and bring the soil into a good state of production. The most common practices now are the application of farm manures, the plowing under of crop residues, and the following of a rotation of crops that includes some legume, commonly alfalfa. Where this system has been in practice for a period of several years, crop yields have shown a definite upward trend. Alfalfa is especially good in the rotation because of its deep root system, which is effective in loosening the clayey subsoil; and the decaying roots leave organic matter in the soil and channels for the movement of air and water.

Soil conditions are generally favorable for fall plowing, and this practice is followed with most soils and is nearly indispensable for those of heavy clayey texture. The action of freezing and thawing breaks down the hard clods and creates favorable conditions for tillage and seeding operations in the spring.

The problems of drainage and the removal of an excess of injurious salts from the soils is no less important than the improvement of soil tilth and increasing the amount of available plant nutrients. These problems, however, apply chiefly to a few imperfectly or poorly drained soils and others that are moderately salty, except as they apply to the removal of excess irrigation water and salts accumulated through seepage.

TABLE 12.—*Estimated acre yields of the more important crops on soils of the Big Horn Valley area, Mont., under prevailing practices*

Soil	Yields under irrigation [1]			Remarks
	Wheat	Alfalfa	Sugar beets	
	Bushels	*Tons*	*Tons*	
Banks fine sand				Unsuited to irrigation agriculture. The soil is shallow and has a low water-holding capacity. Fertility is comparatively low. The areas are cut by numerous deep high-water channels and are used principally for dry-land pasture. Trees and brush dominate the cover.
Banks very fine sandy loam				Although soil characteristics are more favorable, this soil is still poorly suited for irrigation agriculture.
Banks-Havre complex				Topography unsatisfactory for irrigation. Areas are small and cut by numerous drainageways. The water-holding capacity is low. Commonly used for dry-land pasture.
Beaverton loam				Lies above present irrigation levels, but soil characteristics are favorable for irrigation. Now used for dry-land grazing. At one time it was dry-farmed, but later it was abandoned.
Billings silty clay loam	20–30	2–3	12–16	This is the most productive member of the Billings soils in the area, largely because of improved subdrainage.
Billings silty clay (newly cultivated tracts)	12	1	8	Tilth is naturally poor. The soil puddles easily, subdrainage is slow, and frequent light irrigation is required. Yields are generally low.
Billings silty clay (older improved areas)	17–27	1.5–2	10–14	The addition of considerable quantities of manures and crop residues improves soil tilth, and yields are higher after several years of careful irrigation management.
Billings clay				Very little is cultivated, as poor tilth, poor drainage, and soluble salts make it poorly suited for cultivated crops.
Billings clay, saline phase				Unsuited for cultivated crops, because of the excessive amount of soluble salts.
Cherry silt loam				Generally well suited to irrigation, but largely nonirrigable because of position. Some places are gravelly and others are sloping. Certain areas are occasionally dry-farmed, under an alternate crop-fallow system.
Cushman loam, deep phase	25–35	2.0–2.5	10–17	Well suited to irrigation agriculture. Friable, well drained, and free of accumulated soluble salts. Supports good pasture where it is not irrigated.
Fort Collins silt loam (newly cultivated tracts)	15	1.5	9	One of the more desirable soils of the area for irrigation. Some areas are affected by seepage and accumulated soluble salts.
Fort Collins silt loam (older improved areas)	25–35	2.0–2.5	11–15	The productivity is increased through careful irrigation farming practices.
Fort Collins silty clay loam	20–32	1.5–2.25	10–15	This is a productive soil under careful irrigation management. Some areas are affected by seepage and accumulated soluble salts.
Glendive fine sandy loam	25–35	2.0–2.25	10–15	Well suited for irrigation agriculture. The soil is friable, well drained, and free of alkali. The addition of organic matter is a beneficial practice.
Glendive fine sandy loam, brown phase	25–35	2.0–2.25	10–15	Do.
Glendive silt loam	25–35	2.0–2.25	10–15	Do.
Glendive silt loam, brown phase (areas not subject to seepage)	25–35	2.0–2.25	10–15	Well suited for irrigation agriculture except for certain areas where seepage from higher lying irrigated land limits the use to wet pasture or native-hay meadows.
Havre very fine sandy loam	25–35	2.0–2.5	11–15	This is a desirable soil for irrigation agriculture, except that some areas are affected by seepage and accumulated soluble salts.
Havre silt loam	25–35	2.0–2.5	11–15	Do.

Havre silty clay loam	20-30	1 75-2 25	10-15	Surface drainage is commonly slow because of the slight swalelike position. Accumulated soluble salts and seepage also adversely affect some areas. With good drainage and management the areas of this soil give satisfactory to high yields under irrigation.
Laurel silty clay loam				Generally unsuited for irrigation because of soluble salts and poor drainage. Used as wet pasture
Manvel silt loam	25-35	2 0-2 25	10-15	One of the better soils of the area for irrigation farming. It is friable, well drained, and easily irrigated
Manvel silty clay loam	20-32	1. 5-2. 25	10-15	Do.
Neville silt loam				Nonirrigable at present, because of position. Soil characteristics are favorable. The soil is very inextensive in the Big Horn Valley area.
Riverwash				Unsuited for irrigation Consists of shifting gravel and sand bars Generally covered by water during flood periods.
Rough broken land				Unsuited for irrigation. Sharp relief prohibits irrigation.

[1] Blank spaces indicate that the crop is not commonly grown.

Chemical analyses of the water from the Big Horn River show that it carries a moderately high content of sodium and magnesium salts. The use of irrigation water from this stream only in amounts needed by the growing crops tends to add to the content of salts in the soil. Frequent irrigations and the use of water in excess of that needed by the crops are necessary in order to maintain a downward movement of water for the removal of excess soluble salts.

The alkali conditions are more acute in the Billings soils, and proper drainage is harder to maintain in them than in the more friable soils of medium texture, which are commonly underlain by sandy or gravelly substrata at comparatively slight depths. Practically, the only method of reducing the salt content is by leaching and the removal of the excess of salt-laden water by deep drainage ditches. The construction of this type of ditch requires community cooperation or the cooperation of the entire irrigation district. This type of cooperation was not in effect at the time the soil survey was made (1938), except in the Big Horn River Valley in an area between Fairview School and Two Leggin bridge.

Drainage in much of the area is largely a matter of properly placed ditches to intercept seepage from irrigation canals and underflow from irrigated lands where the water moves along the porous substrata. Without this type of drainage, a considerable part of the land now in cultivation or suitable for cultivation will eventually become too wet and salty for the production of most crops. These conditions of seepage and increasingly poor drainage, at present, are more evident along the Agency and Reno canals in the Little Horn Valley and along the Big Horn canal in the Big Horn Valley in places where these canals lose considerable water in transit.

A wider use of shallow ditches to remove field waste water and the installation of drainage outlets to borrow pits adjacent to roads would in many places improve drainage conditions. Undrained barrow pits in a number of places have impounded waste water and are responsible for local conditions of poor drainage.

In the common practice of laying out irrigation systems the ditches are located along legal land lines. As a result, in some places the ditches have a comparatively steep gradient and the flow of water is rapid enough to cause erosion or entrenchment of the ditches. On slopes where erosion is likely to occur it would be better to place the ditches near the contour level.

The Billings soils on the smooth nearly level terraces include most of the clayey soils having notably poor structure, slow internal drainage, and a moderate to high content of salts or alkali. They respond more slowly to good management practices than the associated friable medium-textured Fort Collins soils occupying similar terrace positions. After a period of years, however, the Billings soils become nearly if not equally as productive for most crops as the Fort Collins. The Glendive, Manvel, Cherry, Neville, and Cushman soils—the friable soils on the valley slopes—all respond readily to good management. Additions of organic matter to these soils improve their tilth and moisture-holding capacity, with a resulting increase of yields. The Havre and Banks soils have good tilth but a low content of organic matter, and they respond readily to additions of this material. The Banks, however, is loose and sandy in all layers, has a low water-holding capacity, and commonly does not produce crop yields sufficiently high to warrant extensive improvement. The Laurel soils occupy low positions, are poorly drained and salty, and do not lend themselves to improvement except where they are thoroughly drained.

MORPHOLOGY AND GENESIS OF SOILS

The Big Horn Valley area is in the semiarid western part of the Great Plains physiographic province and lies within the zone of Brown soils of the great soil groups. The area surveyed consists chiefly of bottom lands and terraces at several levels, colluvial slopes, and outwash fans in the Big Horn and Little Horn River Valleys.

Climate and native vegetation do not vary sufficiently within the area to produce marked differences in the soils; nevertheless on the high benches and high valley slopes the soils are a little darker than for the area as a whole. The soil differences are closely related to differences in the parent material and local relief. Within short distances outside the area, however, the rise in elevation toward the mountains is accompanied by marked climatic changes and a quick transition in soils from the Brown to the Chestnut soils.

The soils have developed chiefly from light-colored calcareous parent material, under the influence of a dominant short-grass vegetation. They are relatively light-colored and are nearly neutral or calcareous from the surface downward. Most of the soils are developed in recently formed or redeposited parent material, and their principal differences are due to the differences in composition and lithologic character of their parent material and local drainage conditions. In the soils of heavy clayey texture there may be enough soluble salts to hinder or injure the growth of vegetation. The more salty areas are a result of external flooding and seepage, which tends to concentrate the salts.

The Beaverton soils on the high benches and the Cushman soils on the high valley slopes have lain undisturbed longer than any other soils in the area and show the most advanced profile development. Their profiles are transitional between those of the Brown soils and those of the Chestnut soils, as they occupy a transitional position between the Brown soils in the valleys and the darker Chestnut soils of the adjacent uplands.

The Fort Collins soils, formed from medium-textured friable alluvium on well-drained terraces, have a normal Brown soil profile. A representative profile may be described as follows:

1 (A). 0 to 4 inches, grayish-brown friable silt loam, of fair organic-matter content, that breaks into irregular firm clods when dry and into a soft crumblike mass when moist. It contains no free lime.

2 (B). 4 to 8 inches, grayish-brown silt loam having an ill-defined prismatic structure. Under slight pressure, when moist, the prisms break into a friable mass. In most places there is no free lime.

3 (C_{ca}). 8 to 20 inches, light brownish-gray firm but friable highly calcareous silt loam. This is a layer of lime accumulation. The lime is chiefly in finely divided form.

4 (C). 20 inches +, slightly altered parent alluvium, consisting of thin alternating layers of brownish-gray calcareous loam and silt loam to a depth of 10 feet or more, where it is generally underlain by a gravel and sand substratum.

The Billings soils occupy terraces similar in position to those on which the Fort Collins soils have developed. The Billings, however, are developed from dense compact highly colloidal clays that contain moderate quantities of salts including sodium carbonate. The heavy clays are slowly permeable to air and moisture and not easily penetrated by plant roots. Soil-forming processes have acted on the clays very slowly, and the soils are young, almost azonal in character.

The Glendive, Manvel, Cherry, and Neville soils occupy gentle valley slopes consisting of colluvial or local alluvial deposits washed from the adjacent uplands. All these soils have medium-textured friable surface layers and moderately friable silty or incoherent sandy subsoil layers. They are immaturely developed and calcareous from or near the surface downward. Aside from slight variations in the color of the surface soil, they differ chiefly in the origin, character, and mode of deposition of their parent materials. The immature development is a result of frequent additions of calcareous alluvium from the uplands.

The Havre, Banks, and Laurel soils are azonal soils on recently deposited alluvium in the bottom lands and low terraces, which are subject to overflow or are only slightly above high flood levels. The Havre and Banks are on calcareous friable alluvium similar to but much younger than that giving rise to Fort Collins soils. Successive deposits of fresh alluvium have kept the soils young and without true soil development except a slight darkening of the surface layers by small quantities of organic matter. The Laurel soils are formed from imperfectly to poorly drained heavy clayey alluvium. Even in places where these soils have been above overflow for some time, there is little or no profile development, because of slow drainage and the presence of comparatively large quantities of soluble salts.

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