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BUREAU OF CHEMISTRY AND SOILS**

**In cooperation with the Wisconsin Geological and Natural History Survey
and University of Wisconsin College of Agriculture**

**SOIL SURVEY
OF
MANITOWOC COUNTY, WISCONSIN**

BY

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and Natural History Survey**

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COUNTY SURVEYED

Manitowoc County is in the east-central part of Wisconsin, bordering Lake Michigan. The county comprises an area of 590 square miles or 377,600 acres. Manitowoc, the county seat, is 159 miles by rail from Madison and 77 miles from Milwaukee.

The land surface ranges from level to rough and hilly. The most conspicuous physiographic feature is the Kettle Range, or Kettle Moraine, a belt of irregular hills, ridges, and depressions which crosses the county from southwest to northeast. Along Lake Michigan there is a level area, several miles wide, which grades into gently rolling country before the moraine is reached. This level area is chiefly a lake terrace formation, although it merges with river terraces on Manitowoc and the Twin Rivers in the northeastern part of the county. To the west of the moraine the relief ranges from level to gently rolling, with most of the land surface gently rolling.

The highest point in the county is in T. 17 N., R. 21 E., where an elevation of 358 feet above Lake Michigan is attained. Average elevations of various towns¹ above the lake are given as follows: Mishicott 60 feet, Maplegrove 200 feet, Cooperstown 210 feet, Two Rivers 29 feet, Cato 250 feet, Manitowoc Rapids 120 feet, Manitowoc 50 feet, Meeme 200 feet, Schleswig 290 feet, and Centerville 60 feet. Numerous water-power units have been at various times developed on the various rivers and creeks.

History indicates that the Fox and Sac Indians were the first to occupy the part of Wisconsin in which Manitowoc County occurs, but these tribes were driven out by the Menominees. Within what is now Manitowoc County it seems there were representatives of many Indian tribes, including the Ottawa, Menominee, Winnebago, and Potawatami. All except the Winnebagos were of Algonquian stock. Before 1830 the Winnebagos had disappeared and other tribes had mingled to a great extent.

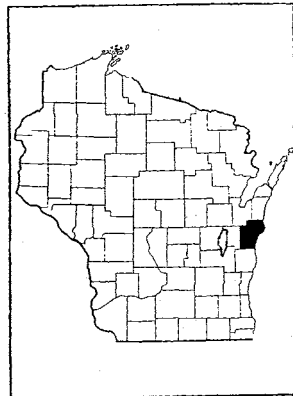


FIGURE 1.—Sketch map showing location of Manitowoc County, Wis.

¹ "Town" as used in this report is synonymous with "township."

Actual settlement of the county dates from 1833, when settlements were made at Two Rivers, Manitowoc, Manitowoc Rapids, and Shoto. The influx of German settlers started about 1846. In 1847, 15 German families settled at Mishicott and more than 40 families in Newton. In 1854 a colony of Badenese settled in Eaton Town, founding St. Nazianz under the leadership of Father Oschwald. Many Norwegians were among the early settlers. They first settled in 1843 at Manitowoc Rapids. The Irish settled mostly in Maple-grove, Rockland, Cato, Meeme, and Franklin Towns. Several English settlements were made in Kossuth and Manitowoc Towns. In 1850 the population of the county was 3,720, of which 1,378 were Germans, 246 Norwegians, 175 Irish, 129 British, 165 Canadians, and 255 other foreign-born people of different nationalities. Of the native born 409 came from Wisconsin, 376 from New York, and the remainder from several other States.

The cities of Manitowoc and Two Rivers and the smaller towns and villages of the county afford local markets for considerable farm produce, but the greater part is shipped out of the county. The largest items in the merchantable produce are the dairy products.

The Minneapolis, St. Paul & Sault Ste. Marie Railway, the Chicago & North Western Railway, and the Chicago, Milwaukee, St. Paul & Pacific Railroad systems furnish good transportation facilities. Car ferries cross Lake Michigan from Manitowoc to Ludington and Frankfort, Mich., where they join with the Pere Marquette Railway and the Ann Arbor Railroad.

The wagon roads and highways within the county are being improved under a joint State and county system, and 75 miles of improved concrete highways have been constructed representing about one-fifth of the main system. Good road-building material is abundant in the county, and poor roads are yearly becoming scarcer. County and State trunk highways are graded and crowned with gravel, crushed rock, or cement, and most of the side roads are also graveled.

CLIMATE

The climate of Manitowoc County is typical of the eastern part of Wisconsin. Climatic conditions along the lake are somewhat different from those 20 to 30 miles distant from it.

The region covered by this report is included in the "Michigan shore," which is one of eight climatic provinces in Wisconsin.² This province stretches along the western shore of Lake Michigan and extends inland as far as the influence of the lake modifies the climate to any appreciable extent, in few places more than the width of a county.

The Michigan shore possesses the most equable climate in Wisconsin. The winters are mild and somewhat more moist than elsewhere in the State, spring is retarded and cool, summer is mild and pleasant, and autumn is warmer than it is farther west. The lake shore is not especially a corn region but is excellent for pasture grasses, peas, and hay. The average frost-free season extends from May 2 to October 11, and the latest and earliest recorded killing

² WHITSON, A. R., and BAKER, O. E. THE CLIMATE OF WISCONSIN AND ITS RELATION TO AGRICULTURE. Wis. Agr. Expt. Sta. Bul. 223, 65 p., illus. 1912.

frosts, respectively, were on May 26 and September 13. The average rainfall is slightly lower than that of the State and a larger proportion falls in summer and less in winter.

Table 1 shows the normal monthly, seasonal, and annual temperature and precipitation as recorded at the Weather Bureau station at Manitowoc.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Manitowoc

[Elevation, 616 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1895)	Total amount for the wettest year (1924)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December.....	24.9	60	-24	1.78	1.54	1.50	10.4
January.....	18.7	55	-32	1.70	1.64	1.06	13.6
February.....	19.4	56	-29	1.47	.49	2.76	10.6
Winter.....	21.0	60	-32	4.95	3.67	5.32	34.6
March.....	30.3	73	-13	2.09	.42	3.68	6.9
April.....	42.2	87	8	2.49	1.52	5.40	3.4
May.....	52.1	92	18	3.06	4.42	5.40	.1
Spring.....	41.5	92	-13	7.64	6.36	14.48	10.4
June.....	62.1	98	33	3.48	1.49	3.00	.0
July.....	67.6	100	38	3.59	1.85	4.38	.0
August.....	66.4	99	38	2.93	3.51	11.07	.0
Summer.....	65.4	100	33	10.00	6.85	18.45	.0
September.....	58.7	96	26	3.22	1.16	1.89	.0
October.....	48.8	84	11	2.64	.53	.14	.5
November.....	36.1	69	-10	2.18	1.59	2.76	3.4
Fall.....	48.2	96	-10	8.04	3.28	4.79	3.9
Year.....	44.0	100	-32	30.63	20.16	43.04	48.9

AGRICULTURE

The first agricultural efforts in Manitowoc County were in the production of subsistence crops and feed for the livestock kept. Lumbering preceded agriculture in most places, and permanent settlement followed after lumbering operations had partly cleared the land. The main products of the county were pine and hemlock lumber, and it was not until about 1847 that sufficient flour and dairy products for local needs were produced in the county. During early settlement, most of the settlers worked in sawmills and in the woods and did not clear much land. About 1865 agriculture began to assume importance.

In 1840 there were produced in the county 225 bushels of wheat, 1,750 bushels of oats, 175 bushels of corn, 1,900 bushels of potatoes, and 67 tons of hay. There were then in the county 81 milk cows and 90 hogs. By 1870, the total yield of wheat had risen to more than 500,000 bushels. It continued to increase until about 1880, after which time there was a decrease in acreage. Very little rye was

grown before 1850, when 191 bushels were reported, but during the following 50 years there was a gradual increase in rye production. Oats early became an important crop and has remained so. The corn acreage increased with the growth of dairying. Potatoes have always been an important crop, and the total yield has remained rather constant.

Dairying expanded rapidly after the Civil War. In 1860 there were 1,198 milk cows in the county and in 1870 the number was 9,351. By 1880 the number was 14,505 and in 1890 it was 25,816. As dairying grew, the number of swine gradually increased until hog raising became of major importance.

The agriculture of Manitowoc County at present consists chiefly of general or mixed farming, with dairying as the most important branch. The crops grown, in order of acreage, are hay, oats, corn, barley, peas, rye, wheat, and potatoes. Crops of less importance are buckwheat, beans, clover seed, sugar beets, cabbage, and tobacco. Practically all the crops are grown to some extent for sale, but by far the greater proportion of the corn, oats, barley, and hay is used in feeding livestock and reaches the market in the form of dairy products, beef, and pork.

Hay is grown more extensively than any other crop, tame hay being grown on more than 68,321 acres in 1924, according to the 1925 census. The total yield of hay, both tame and wild, was 112,059 tons. Most of this is timothy and clover grown both together and separately, but alfalfa occupied 8,544 acres. Hay is grown on all soils but does best on the heavy types such as Superior clay loam, Kewaunee silty clay loam, and Poygan silty clay loam. Soils as light as sands and sandy loams are not well suited to hay production. Oats cut for grain were grown on 54,284 acres in 1924, when the total production was 1,783,659 bushels. Oats are grown on nearly all soils of the county but do best on soils of a fine sandy loam texture or heavier.

In 1924 corn, mainly for silage, was grown on 22,166 acres in all parts of the county. The well-drained loam and fine sandy loam soils are best suited to corn, the clay loam soils being too late and heavy and the sands too light and droughty. This is not an ideal corn country because of the cooling influence of Lake Michigan. Where corn was allowed to mature it yielded 25.5 bushels to the acre in 1924.

Barley, in 1924, was grown on 16,417 acres and gave an average yield of 26 bushels to the acre. It is grown widely over the well-drained soils, except those of sand texture. It does well on Kewaunee silty clay loam and Superior clay loam, but the loams are probably better suited to it.

Rye was grown on 9,320 acres in 1924, mostly on sandy soils. The average yield was slightly more than 19 bushels to the acre.

Wheat was grown on 3,637 acres in 1924. Wheat does best on the heavy well-drained soils, such as the heavy types of the Superior and Kewaunee series. It also does well on Bellefontaine silt loam.

Peas are grown mostly on soils as heavy as or heavier than fine sandy loam. Rather large acreages are grown on the well-drained clay loam soils and on the Bellefontaine silt loam and very small acreages on sandy or marshy soils. Potatoes, although grown on a great variety of soils, do best on well-drained sandy loam and fine

sandy loam soils. Heavy soils are well suited to sugar beets. Beans are grown to a considerable extent, chiefly on the lighter soils.

Although most of the soils of the county are heavy and best suited to general farming, some sandy soils are better suited to trucking and special crops. Such soils as Superior fine sandy loam and Plainfield fine sand can well be utilized for special crops and are so utilized to some extent. Some areas of these light soils are near Manitowoc, but the larger areas occur along East Twin and West Twin Rivers near Two Rivers. Both cities afford good markets for truck. Beans, peas, beets, carrots, tomatoes, potatoes, lettuce, cabbage, and other special crops are grown with success, and some strawberries and bush fruits are produced.

Fruit growing receives comparatively little attention, although most farmers have a small apple orchard. During favorable seasons some apples are sold locally. The best orchard sites are in the Kettle Range region. Cherries, plums, pears, and other fruits are grown to only a very small extent.

Dairying is the most extensive branch of farming in Manitowoc County. On January 1, 1925, there were in the county 61,138 cattle, of which number 42,339 were dairy cows 2 years old or older. In 1924 42,973 cows were milked, and the estimated production of milk was 29,221,640 gallons, an average of 680 gallons per cow. The value of dairy products was \$3,929,443. American cheese is the main dairy product. In 1926 there were 110 cheese factories, 3 butter factories, 1 condensery, and 4 receiving stations within the county. Among the dairy cattle, the Holsteins lead in numbers, Guernseys follow next, and there are some Jerseys, Brown Swiss, and Ayrshires. Many animals are purebred but most of them are grades.

Another important branch of the livestock industry is hog raising. In 1925 there were in the county 18,881 swine. Among the breeds represented are Duroc-Jersey, Berkshire, Poland China, and Yorkshire.

Horses are still used extensively for farm work, 11,090 horses and 32 mules having been reported in the county in 1925. Most of the work animals are heavy, as the heavy soils of the county are hard to work. Many tractors are also in use.

Sheep are not raised so extensively as in western Wisconsin, only 1,052 being reported in the county in 1925.

Every farmer keeps some poultry, and this adds materially to the farm income. In 1925 there were 241,028 chickens in the county, and egg production amounted to 1,352,408 dozen, with a value of \$392,198.

The crop rotation most commonly followed consists of corn, small grain, and hay. The hay may be grown for 2 years, and sometimes small grain is grown for 2 years, thus making a 4 or 5 year rotation. The changing of crops from year to year is common, but definite or fixed rotations are not always followed.

In 1924 only 106 farmers used commercial fertilizers, including lime, and the total amount expended was \$5,372. Superphosphate (acid phosphate) is probably more extensively used than any other kind of fertilizer, though some farmers apply mixed fertilizer on truck crops. A number of farmers have had their farms examined

and soils tested by the Wisconsin soils laboratory, and the reports show that much of the red clay soil is deficient in phosphorus. Some of the low areas and sandy soils are also deficient in potash. Stable manure is used extensively, but the amount, even in the dairying region, is not sufficient to meet the needs of the soil.

During 1924, 2,825 farmers reported a total of \$679,070 spent for feed. As the acreage of alfalfa increases this feed bill can be cut very materially.

The farms of the county are as a rule well equipped and efficiently managed. Buildings are well built and substantial. Barns are roomy and warm, and many are equipped with drinking cups for cattle, litter carriers, and other modern equipment. Many of the farm homes are modern, with electric lights, telephone, and modern household conveniences.

The State department of agriculture reports that the monthly wages of farm laborers in Wisconsin in 1925 ranged from \$42.60 to \$45.50 with board, and during the harvest season extra help was paid \$2.30 a day with board or \$3 without board. Efficient laborers are scarce. Women and children often help in the fields and with the milking, thus reducing the amount of hired help required.

In 1925 there were in the county 3,887 farms, the average size of which was 90.7 acres and in that year only 4.1 per cent of the farms were operated by tenants.

The average value of land and buildings per farm in 1925 was \$13,122, and that of the land alone was \$68.53 an acre.

Where soils are acid, lime in the amounts required should be used. Most of the soils show a deficiency in phosphorus, and the heavy soils in particular respond to the use of superphosphate. On some of the low land, corn is frequently patchy and sometimes yellowish. In such places potash fertilizer is recommended. The peat soils are deficient in potash and in places in phosphorus as well. Sandy soils are deficient in nitrogen, phosphorus, and potassium. It should be the effort of farmers to supply nitrogen and organic matter by growing legumes and using stable manure. When potash and phosphorus are needed in addition, they should be supplied in the form of commercial fertilizers.

The original timber growth in Manitowoc County consisted of maple, oak, elm, basswood, beech, ash, hickory, hemlock, and some pine. The pine grew mainly though not entirely on the sandy areas, hemlock on the loam and sandy loam soils, and oak, maple, beech, basswood, and hickory on the heavy soils. On the Poygan and Clyde soils, elm and ash were found, and in the marshes tamarack, cedar, and alder grew. Most of the merchantable timber has been cut, except on some low lands and gravelly ridges, and some of the second growth is large enough to use for fuel. Many farmers have wood lots, averaging about 4 acres in size, from which enough wood can be cut for fuel for years to come. Some farmers take good care of the wood lot, and others pay little attention to it.

According to the State census, as reported by the Wisconsin Department of Agriculture, the pasture land of Manitowoc County, which totals 99,915 acres, has been classified in three divisions.

There are 51,923 acres of plowable pasture, which includes fields cut for hay one year and pastured the next. These areas are counted as pasture lands only the year when actually pastured. This class of pasture is found on nearly all types of soil but is most extensive on the heavy types such as Superior clay loam and Kewaunee silty clay loam. A second division of pasture land is woodland pasture, of which in 1924 there were 30,798 acres. This includes practically all wood lots and timbered areas, none of which are plowed. Some of this is high and some low land. The third division is classed as other pasture, which might be called permanent pasture. Of this there are 17,194 acres including rough broken lands, rocky areas, or steep land which can not be plowed and which is not timbered, and also some lowland.

The carrying capacity of the pastures varies greatly, but probably an average of 2 acres is required for each mature animal. Some of the rough broken land is too droughty to furnish good pasturage. The wood lots should not be pastured, as the trees may be injured. The grass in the wooded areas is thin, especially where shade is dense. Some of the lowland is too wet part of the year and some is peaty and does not afford the best pasturage.

The question of maintaining good permanent pastures is one of great importance, especially in a dairying section. Pastures may be fertilized as well as any other crop, and they should not be grazed too close or when the land is too wet.

The selling value of farm land in Manitowoc County varies greatly, depending on soil conditions, improvements, and location. Kewaunee silty clay loam, Kewaunee silt loam, and Bellefontaine silt loam are probably the best and highest-priced lands in the county. Well-located and well-improved farms on these soils have a selling price ranging from \$100 to \$150 an acre. Rodman gravelly loam and Plainfield fine sand are probably the soils of lowest value, except the marsh areas. These soils command from \$15 to \$50 an acre, except near cities. Some of the marsh lands can be bought for as little as \$10 an acre. Between these extremes all variations in price can be found. The most important soil types were graded as to value on a percentage basis and the relative value of the various soils thus shown. Kewaunee silty clay loam, as one of the most desirable soils of the county, was given a percentage value of 85 to 100. The important soils of the county are valued about as shown in the following tabulation:

	Relative value (per cent)
Kewaunee silty clay loam.....	85 to 100
Kewaunee silt loam.....	85 to 100
Bellefontaine silt loam.....	85 to 100
Superior clay loam.....	80 to 85
Superior silt loam.....	80 to 90
Superior fine sandy loam.....	75 to 85
Kewaunee fine sandy loam.....	85 to 95
Coloma fine sand.....	20 to 40
Plainfield fine sand.....	50 to 60
Poygan silty clay loam (well drained).....	75 to 90
Carlisle muck (well drained).....	40 to 65
Peat.....	30 to 40

SOILS

The upland soils of Manitowoc County are classed with the gray-brown soils of the forested part of the humid region south of the Great Lakes. They developed under conditions of climate and surface features which favored the growth of forests. Light-colored surface soils developed in the forests and dark-colored surface soils on prairie areas in this same general region. There are areas of dark-colored soils in this county, but the dark color was caused primarily by poor drainage rather than by a grass vegetation. With the exception of small areas of open marsh, the whole county was forested before the region was settled by white men.

The most striking feature of the soils of the county is that the predominant soils are heavy or fine textured. The county lies within what is usually known as the red-clay section of Wisconsin.

The soils of the county naturally fall into two major classes, the well-drained, normally developed or mature soils, and the immature soils.

The first group includes soils of the well-drained uplands derived from glacial till and soils of the better-drained areas on old glacial-lake and alluvial terraces.

In this region the normally developed or mature soils are weathered to a depth of 3 or more feet, depending on the surface relief and composition of the parent materials.

The most typical mature soils in the county developed from glacial-till parent material. These soils are characterized by a consistent profile which shows a grayish-brown friable surface soil, a rather heavy light-brown or reddish gravelly clay subsoil, and a light-brown or reddish-brown glacial-till substratum, which is the parent material.

The surface soil includes the friable comparatively light-textured upper layers from which much of the clay material including the inorganic colloids has been removed. The subsoil is the rather heavy layer where much clay material, including colloids, has been deposited by percolating water in the course of weathering. This horizon has a coarsely granular structure and is neutral or slightly acid in reaction. The third main layer or horizon is the parent material, the unweathered or only slightly weathered material from which the soil has developed. This horizon has no regular structure. It contains sufficient lime to effervesce freely with hydrochloric acid.

The parent soil material consists largely of two very different kinds of glacial till, the older brown till and the more recently deposited so-called red till which overlies the brown till. Extensive areas of soil materials on glacial terraces and flood plains are from the same original sources but have been reworked and redeposited by water.

The brown till is usually considered to have been formed by the grinding up of the underlying dolomite bedrock, with some admixture from the crystalline rocks to the north. The red till is usually considered to be partly composed of rock débris and partly of glacial lake sediments carried southward from the Lake Superior region.³

³ ALDEN, W. C. QUATERNARY GEOLOGY OF SOUTHEASTERN WISCONSIN, WITH A CHAPTER ON THE OLDER ROCK FORMATIONS. U. S. Geol. Survey Prof. Paper 106, 356 p., illus. 1918.

The color of the red till is usually considered as resulting from the color of the original material rather than from weathering since deposition. The Kewaunee soils are underlain by the red till and the Bellefontaine by the brown.

The average depth of the till over the bedrock in most of the county is between 70 and 100 feet. In the northwestern part of the county, especially in parts of Cato, Franklin, and Maplegrove Towns, the bedrock is much nearer the surface. The depth to rock in Kossuth, Gibson, and Cooperstown Towns is extremely variable, and outcrops of rock are extensive, as is indicated by the shallow-phase soils and intervening areas where the depth to rock is 150 feet, like that in the northeastern part of the county near Lake Michigan. In general the bedrock lies progressively deeper to the south.

The soils developed on the well-drained river and lake terraces are included in the Fox, Plainfield, and Superior series. These soils are exceedingly variable in texture, color, and stage of maturity.

The immature soils include areas which do not show a consistent soil profile because the soil materials have not been deposited or well drained or have not been stable sufficiently long to allow weathering agencies to produce a mature profile, areas where the rock lay so near the surface as to prevent deep weathering, areas so steep that the soil eroded as fast as it formed, and areas of peat or muck where the materials are still largely in the process of deposition. The immature soils occur on the flood plains of streams, in depressed or poorly drained areas in the uplands, on poorly drained terraces, as peat and muck soils in swamps and marshes, in some sand areas, and on rough, broken areas or where the land is shallow and stony.

The Genesee, Ewen, and Wabash soils occur on flood plains subject to inundation. Members of the Poygan and Clyde series occupy poorly drained areas within bodies of Kewaunee and Bellefontaine soils. The Maumee, Granby, and Saugatuck soils have developed on poorly drained terrace lands.

The greatest consistent variation in peat and muck soils is in the stage of disintegration of original organic material and in the depth of such material over the mineral subsoil. The sand soils include Bridgman fine sand along Lake Michigan, smaller areas of Coloma fine sand farther inland, and Plainfield fine sand on the terraces. Small areas of rough broken land are scattered over the county, and small areas of Longrie stony loam were mapped on shallow rocky areas in the northern part of the county.

The soils are classified into series and types. Soils of one series are similar in the character of the subsoil, color, structure, and other features but differ in texture or coarseness of the surface soil. The series may include a number of soil types.

In the following pages of this report the soils are described in detail, and their agricultural possibilities are discussed. Their distribution is shown on the accompanying soil map, and their acreage and proportionate extent are given in Table 2.

TABLE 2.—*Acreage and proportionate extent of the soils mapped in Manitowish County, Wis.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Kewaunee silty clay loam.....	76,416	23.4	Fox fine sandy loam.....	8,320	7.8
Level phase.....	9,344		Poygan silty clay loam.....	17,152	
Rolling phase.....	2,112		Clyde silty clay loam.....	3,264	
Shallow phase.....	192		Wabash silt loam.....	2,816	
Kewaunee silt loam.....	26,624	7.4	Maumee loam.....	7,232	
Shallow phase.....	1,152		Ewen silty clay loam.....	1,280	
Kewaunee loam.....	3,392	.9	Genesee silt loam.....	3,328	
Kewaunee fine sandy loam.....	2,816		Genesee loam.....	768	
Berrien loamy fine sand.....	3,200	.8	Coloma fine sand.....	832	
Superior clay loam.....	35,008		Plainfield fine sand.....	1,920	
Superior silt loam.....	8,320	2.2	Saugatuck fine sand.....	2,240	
Superior loam.....	2,816		Granby fine sand.....	576	
Superior fine sandy loam.....	5,760	1.5	Bridgman fine sand.....	2,048	
Bellevue silt loam.....	45,632		Rodman gravelly loam.....	2,816	
Level phase.....	5,888	14.2	Carlisle muck.....	24,320	
Rolling phase.....	2,048		Shallow phase.....	5,440	
Bellevue loam.....	17,664	4.7	Peat.....	16,832	
Bellevue fine sandy loam.....	4,480		Shallow phase.....	394	
Bellevue gravelly loam.....	9,728	2.6	Rough broken land.....	1,344	
Longie stony loam.....	576		Dune sand.....	1,344	
Fox silt loam.....	3,136	.8			
Fox loam.....	5,120				
Gravelly phase.....	1,920	1.9	Total.....	377,600	

KEWAUNEE SILTY CLAY LOAM

The surface soil of Kewaunee silty clay loam, to an average depth of 3 or 4 inches, consists of dark grayish-brown smooth clay loam or silty clay loam which when moist appears somewhat darker in color. Directly below the surface soil is a brown or yellowish-brown silty clay loam layer which extends to a depth of about 8 inches. The characteristic feature of this layer is that it is lighter in color than the surface soil. It is really part of the topmost soil horizon and is mixed with the surface layer by plowing, so that in cultivated fields the grayish-brown layer extends to a depth of at least 8 inches. Cultivated fields have a distinctly red shade. The organic-matter supply is moderate or rather low, as is indicated by the light color. The surface is in most places stone free, though a few bowlders are seen in places. The true subsoil, consisting of dull-red very stiff plastic clay, occurs between depths of 8 and about 26 inches. When fairly dry, it breaks up into cubical blocks or fragments from one-fourth to one-half inch in diameter, and when wet it becomes very sticky, clinging to wagon wheels with great tenacity when roads are made through it. When dry it becomes very hard and bakes like a pavement. Below a depth of 26 inches is bright pinkish-red clay loam containing some gravel, mostly limestone. This material extends to a great depth, in places from 40 to 100 feet. Bedrock is below it.

The surface and subsurface layers have been leached and the lime carbonate removed, so that the material is generally slightly acid or neutral in reaction.

As a whole, this soil is uniform but several minor points of variation are worthy of note. A thin silt loam covering occurs in many places over the clay loam. In other places the typical grayish-brown surface soil has been washed away and the red subsoil exposed. These eroded places give cultivated fields a spotted appearance.

Along many lower slopes there is an accumulation of soil washed from higher up the slope.

Kewaunee silty clay loam is one of the important soils in the county. It occurs in association with other soils of this series in the towns of Maplegrove, Rockland, Eaton, Cato, Liberty, Meeme, Manitowoc Rapids, and parts of several other towns. The land surface on which this soil occurs ranges from undulating to gently rolling, and in only a very few places could the relief be classed as hilly. There is no sharp line between the undulating Kewaunee and the level Superior soils. Natural drainage is for the most part good, but on the more nearly level areas it is only fair, partly because of the heaviness of the subsoil. In some included draws and depressed areas, tile drains could be used to advantage.

Probably more than 90 per cent of the soil is cleared and improved farm land. This is one of the most productive soils in the county, but because of its heavy texture it is hard to work. It is well suited to general farming and dairying, and these are the types of agriculture most highly developed on it. The chief crops are hay, small grain, corn, and alfalfa, and some peas and root crops are grown as special crops. Yields are above the average for the county but the range is great, owing to variations in methods of farming and fertilization.

Kewaunee silty clay loam, level phase.—The level phase of Kewaunee silty clay loam includes areas having an average slope of less than 1°. The soil is the same as typical Kewaunee silty clay loam. It closely resembles Superior clay loam, differing from that soil in that the subsoil contains angular gravel and is derived from glacial till, whereas typical Superior clay loam is derived from water-laid material.

Only a few small scattered areas of this soil were mapped. Natural drainage is apt to be somewhat deficient, but that has largely been overcome by putting in tile on the lowest part of the areas. The crops grown, yields, and value of the land are about the same as on Kewaunee silty clay loam.

Kewaunee silty clay loam, rolling phase.—The rolling phase of Kewaunee silty clay loam was separated from the typical soil on the basis of surface relief. It includes areas with slopes of 7° or more, or a slope sufficiently steep to cause destructive erosion or to interfere with the use of ordinary farm machinery. This soil is the same as typical Kewaunee silty clay loam, except that the surface soil is thinner in cultivated areas. Clay spots where all the surface soil has been washed away are more numerous.

This soil occurs in only a few small areas scattered over the typical soil. Probably 60 per cent of it is in wood lots and permanent pastures and about 40 per cent in cultivation. Practically the same crops are grown as on Kewaunee silty clay loam, except that a large acreage is devoted to clover, timothy, and alfalfa for hay and tame pasture.

Kewaunee silty clay loam, shallow phase.—The shallow phase of Kewaunee silty clay loam is distinguished by the presence of bedrock at a depth of 2 or 3 feet. The bedrock is dolomitic limestone, and in places a thin layer of clay residual from the limestone occurs between the glacial drift mantle and the rock. This phase of soil

is not quite so desirable for agriculture as the typical soil, especially where the rock lies within 2 feet or so of the surface. The areas of this soil are small and are associated with typical Kewaunee silty clay loam.

KEWAUNEE SILT LOAM

The surface soil of Kewaunee silt loam is grayish-brown or dark grayish-brown friable heavy silt loam about 3 inches thick in the virgin state. Between depths of 3 and 12 inches there is a brownish-yellow heavy silt loam layer which in places may contain a few gravel. Between depths of 12 and 28 inches the material is dull-red heavy sticky plastic clay, commonly containing some gravel, which breaks up into rectangular granules about one-fourth inch in diameter. Below a depth of 28 inches and extending down many feet the material is dull-red or brownish-red clay loam not quite so heavy as the layer above. This layer, which is the parent material, contains considerable limestone gravel.

In cultivated fields the color of the soil is grayish brown and the first two layers are mixed by plowing so the organic matter present is mixed with the lower soil material. The total amount of organic matter is moderate or low.

In places, especially on knolls, the silt loam surface soil has been washed off and the red clay is exposed. This gives the soil a spotted appearance quite characteristic of this soil.

The topsoil layers are very slightly acid or neutral, the subsoil is nearly neutral or slightly alkaline, especially in the lower part, and the substratum or parent material contains a large amount of lime.

Although Kewaunee silt loam is an important soil, it is not nearly so extensive as the silty clay loam of the series. It occurs in irregular areas from a few acres to several square miles in extent, widely distributed over the county in more than two-thirds of the towns. The largest areas are in Cato and Kossuth Towns. This soil is closely associated with the silty clay loam of the series, and the line between the two soils is not everywhere distinct.

Tracts of Kewaunee silt loam are undulating or gently rolling, and a few areas are rolling. Natural surface drainage is for the most part good. On some of the more nearly level areas drainage is slightly deficient, owing partly to the heavy texture of the subsoil, and in some included depressions and draws tile drains would be beneficial.

More than 90 per cent of the Kewaunee silt loam is cleared and in cultivated crops. It is an excellent soil, somewhat more desirable than Kewaunee silty clay loam because it is somewhat easier to cultivate. Fall plowing is the common practice, as this makes for the best tilth. The soil is devoted to general farming and dairying, together with the growing of some special crops such as peas and sugar beets. Crop yields are about equal to those on Kewaunee silty clay loam but may average slightly higher. This is a good alfalfa soil, and the acreage of this crop is gradually increasing.

Kewaunee silt loam, shallow phase.—The areas indicated on the soil map as the shallow phase of Kewaunee silt loam are marked by the presence of bedrock at a depth ranging from a few inches to 3 feet. The bedrock is dolomitic limestone, and the lower soil

material is in places composed of residual reddish clay which has weathered in place from the rock.

This shallow soil is associated with typical Kewaunee silt loam. An area of about 1 square mile lies halfway between Cato and Valders, and three other areas, in one of which is a stone quarry, lie around Grimms. The shallowness of this soil interferes to some extent with its agricultural value and utilization, especially where the rock lies within a few inches of the surface.

KEWAUNEE LOAM

The surface soil of Kewaunee loam to an average depth of 5 inches consists of grayish-brown silty loam. Between depths of 5 and 13 inches the material is yellowish-brown loam which may contain a small amount of gravel mixed with the soil material. This is underlain to a depth of 30 inches by pinkish-red clay loam. Between 30 and 40 inches there is pinkish-red stiff clay loam, in places containing some greensand and gray calcareous mottles. A slightly columnar structure is noticeable in places, and in many places considerable gravel and some rock fragments, mostly limestone, are present. This soil is somewhat variable, and both surface soil and subsoil are commonly lighter in texture than the description indicates. The thickness of the loam covering over the red clay loam subsoil is also variable and in a few places, chiefly on knolls, the surface material has been washed off and the red clay exposed. This results in a spotted appearance, which is less marked, however, than on the silt loam and silty clay loam soils of the Kewaunee series.

Kewaunee loam is much less extensive than either the silt loam or silty clay loam. It occurs mainly in patches from a few acres to about 160 acres in extent, in close association with the silty clay loam. Areas range from undulating to gently rolling. The surface features are favorable for the use of modern farm machinery. Natural surface drainage is good, tile drains being needed in only a few included draws and depressions.

Most of this soil is in cultivated fields and is devoted to general farming and dairying. The areas are so small that but few farms are located entirely on this soil. The land is well suited to peas and sugar beets, but the acreage devoted to these crops is small.

This is an excellent soil, fully as desirable as Kewaunee silt loam. It is comparatively easy to work, retains moisture well, and responds to proper treatment. It is well suited to alfalfa. Crop yields are about the same as on the silt loam.

KEWAUNEE FINE SANDY LOAM

The surface soil of Kewaunee fine sandy loam in a representative virgin area consists of grayish-brown or brown fine sandy loam to a depth of 4 inches. The topmost inch or two of material is darker than the deeper material, and in wooded areas some leaf mold may be seen. Between depths of 4 and 7 inches the material is yellowish-brown fine sandy loam containing less organic matter than the surface layer. On cultivation these two surface layers become mixed,

resulting in a grayish-brown or light-brown surface soil. From 7 to 15 inches the material is yellowish-brown loamy fine sand, and from 15 to 20 inches it is pinkish-yellow loamy fine sand. Between depths of 20 and 36 or more inches there is dull brownish-red clay loam which may contain various amounts of gravel and small stones, mostly limestone.

The chief variation in this soil is in the depth to the red clay loam substratum, which may range from 18 inches to 3 feet. There is also some variation in the texture of the surface soil.

Kewaunee fine sandy loam is of small extent and minor importance. It is rather widely distributed, chiefly in the towns of Two Rivers, Kossuth, Newton, Meeme, and Centerville. Areas are undulating or gently rolling, and natural drainage is good.

More than 85 per cent of this soil is successfully farmed. The land is easy to cultivate and retains moisture fairly well, owing to the heavy texture of the substratum.

Although this soil is devoted chiefly to general farming and dairying, it is better suited to special crops, such as potatoes, beans, and other truck crops where rapid growth and early maturity are desirable. The land is easy to work and responds well to fertilization and careful management. Yields of general farm crops are somewhat below the average for Kewaunee loam and Kewaunee silt loam. Yields of special crops show a wide range, depending on the amounts of fertilizers used.

BERRIEN LOAMY FINE SAND

The surface soil of Berrien loamy fine sand to a depth of 6 inches consists of grayish-brown fine sand. In virgin areas darker-colored material, such as leaf mold, decayed roots, and other organic matter, an inch or so thick, is on the surface, but in plowing this is mixed with the soil and the dark color disappears. Between depths of 6 and 26 inches the material is brownish-yellow fine sand. This layer is underlain to a depth of 55 inches by pale-yellow fine sand, spotted with gray. Below a depth of about 55 inches is pinkish-red heavy clay. The depth to this clay layer is variable.

Berrien loamy fine sand is of very small extent. Small patches are found in the towns of Newton and Liberty and scattered about in association with Kewaunee fine sandy loam. The land surface is gently rolling, and natural surface drainage is good. The sandy part of the soil is generally medium acid in reaction, and the red clay substratum contains considerable lime.

Most of this land is cleared and in farms. It is used for general farm crops and to some extent for truck crops. It is best suited to truck crops.

SUPERIOR CLAY LOAM

The surface soil of virgin Superior clay loam to a depth of about 2 inches consists of grayish-brown clay loam or silty clay loam. Over the surface in wooded areas there is in many places a thin layer of leaf mold, but under cultivation this becomes mixed with the upper soil material and is soon lost by decay. Between depths of 2 and 8 inches there is grayish-brown and reddish-brown mixed clay

loam with a little gritty material in places. From 8 to 14 inches the material is dull-red heavy stiff clay. This is underlain to a depth of 24 inches by pinkish-red stiff plastic clay beneath which is pale pinkish-red clay continuous to 40 inches.

The thickness of the surface soil above the red clay is somewhat variable, owing to washing, and in places the red clay lies near or at the surface. This gives rise to a slightly spotted appearance, which is nowhere so marked as on the heavy soils of the Kewaunee series where uneven relief causes more erosion.

Superior clay loam is not so extensive as Kewaunee silty clay loam, but it is an important soil. It predominates in two chief general sections of the county, one extending about 6 miles north of Two Rivers and the other in the vicinity of Manitowoc, north of that place for about 3 or 4 miles, and southwest for 6 or 8 miles. A smaller area lies between East Twin and West Twin Rivers. Smaller tracts are associated with the Kewaunee soils.

The land surface on which this soil occurs is level or gently undulating. Because of the level surface and heavy texture of the soil, natural drainage is slow and somewhat deficient, and a considerable proportion of the soil would be benefited by tile drains.

Superior clay loam is derived from calcareous lake-laid materials very slightly modified by glacial action. The lime has been leached from the surface soil, which is slightly acid or medium acid to a depth of 15 or 20 inches. Below that depth the material is neutral and contains a little lime. The deep part of the subsoil contains considerable lime and at a depth of 3 or more feet generally effervesces with hydrochloric acid. In a few places little or no lime was present at a depth of 3 feet.

Superior clay loam is a good, strong soil well suited to grasses and small grains. More than 90 per cent of it is improved and highly developed. It is less well drained than Kewaunee silty clay loam. Some corn is grown, but as the soil is heavy and close to the lake corn usually gets a late start in spring. The land is best suited to dairying and general farming.

SUPERIOR SILT LOAM

The surface soil of Superior silt loam to a depth of 6 inches consists of grayish-brown smooth friable silt loam. Over the surface of virgin wooded areas, which are very rare in this county, there is in many places a thin layer of leaf mold and the topmost inch or so of soil is darker in color than the material below. On cultivation this layer becomes mixed with the plow soil and the dark color is lost. The supply of organic matter is rather low. Between depths of 6 and 14 inches there is yellowish-brown or brownish-yellow silt loam, and between 14 and 26 inches pinkish-red heavy stiff clay. From 26 to 40 inches the material is pale pinkish-red clay, somewhat looser than the layer above. The chief variation is in the thickness of the silt covering over the red clay which may range from 6 to 18 inches.

This soil occurs widely scattered in association with Kewaunee and other Superior soils. An area of about 1 square mile is about 6 miles north of Two Rivers. From 2 to 5 miles west of Two Rivers there are several areas and in the vicinity of Manitowoc there are patches

of this soil. Another group of small areas is along Lake Michigan in the southeastern part of the county. Tracts are level or gently undulating, and in a few places gently rolling. Natural drainage is generally good, but in some places is deficient owing to the level surface and heavy subsoil.

The silt loam surface soil and the subsoil to a depth ranging from about 14 to 18 inches are commonly slightly acid, the lower part of the subsoil is about neutral, and the substratum contains considerable lime and effervesces with hydrochloric acid.

This is a good general-farming soil well suited to grasses, small grain, peas, and other crops. Some corn is grown, but the areas are too near Lake Michigan, nights are too cold, and the soil is too late in spring to be classed as a good corn soil. Dairying is the chief farming industry.

SUPERIOR LOAM

The surface soil of Superior loam to a depth of 9 inches consists of grayish-brown medium loam. Over the surface in many virgin areas there is a covering of leaf mold and the topmost inch or two of material is darker than that below. The dark color and the leaf mold are soon lost on cultivation, by decay and mixing with the plowed layer. From 9 to 18 inches the material is heavy light-brown loam containing horizontal streaks of yellowish brown and yellow. Between depths of 18 and 26 inches there is dull-red stiff clay, which is underlain to a depth of 40 inches by pale pinkish-red stiff clay with yellow mottles in many places. The chief variation is in the depth to the heavy red clay.

Superior loam is of small extent but is widely scattered over the county. Probably most of the areas are between East Twin and West Twin Rivers, northwest of Two Rivers. Smaller areas are in the towns of Kossuth and Centerville, and in other towns throughout the region of Kawaunee and Superior soils. The land surface is level or very gently undulating, and natural drainage is fair or somewhat deficient. Tile drains can be used to advantage in some places, owing to the heavy subsoil and low level surface.

The greater part of this soil is cleared and in farms. It is a good soil and is well suited to general farming and dairying. It is easier to work than Superior clay loam and responds readily to fertilization. Some peas and sugar beets are grown, but general farming is the main industry.

SUPERIOR FINE SANDY LOAM

The surface soil of Superior fine sandy loam to a depth of 5 inches consists of dark grayish-brown fine sandy loam, the upper part of which is darkest owing to organic-matter accumulation in the virgin soil. In wooded areas there may be a thin covering of leaf mold. Under cultivation the leaf mold and dark color soon disappear, and the soil takes on a lighter grayish-brown color. Between depths of 5 and 9 inches the soil is brownish-yellow heavy fine sandy loam, and from 9 to 11 inches it is drab-brown heavy loam with faint traces of tan. From 11 to 28 inches there is pinkish-red stiff plastic clay which breaks up into angular fragments about one-fourth inch in diameter. Between depths of 28 and 40 inches the material is

brownish-yellow heavy but plastic clay with a pinkish tint. The soil is in most places free from gravel and stone.

This soil occurs chiefly in widely distributed areas ranging from a few acres to one-half square mile in extent. Areas are most numerous northwest of Two Rivers and between East Twin and West Twin Rivers, but some are in the southeastern part of the county along the shore of Lake Michigan. Small patches occur in various places in association with Kewaunee and other Superior soils. Areas are level or gently undulating. Natural drainage is fair in most places but is locally deficient where the soil occupies a lower position than usual. Superior fine sandy loam occurs on the lake plain and is derived from lake-laid material.

The upper fine sandy material of this soil is generally slightly or medium acid, but the red clay contains enough lime to cause it to effervesce when hydrochloric acid is applied.

Most of the land is cleared and under cultivation. This is a good soil, easy to work, fairly retentive of moisture, and productive. It is devoted chiefly to general farming and dairying, along with heavier soils, but is in part used for other crops, such as beans, potatoes, and truck. It is better suited to special truck crops than to general farming.

BELLEFONTAINE SILT LOAM

The surface soil of Bellefontaine silt loam to an average depth of 8 inches consists of grayish-brown silt loam. In virgin wooded areas darker-colored material an inch or two thick is at the surface and in many places there is some leaf mold, but on cultivation this is soon mixed with the underlying soil. Between depths of 8 and 16 inches the material is yellowish-brown silt loam, and from 16 to 19 inches there is in most places grayish-brown gritty loam. From 19 to 30 inches rather heavy brown gritty clay loam, in many places containing some gravel, occurs. Below a depth of 30 inches the material is reddish-brown, grayish-brown, or yellow gravelly friable clay loam.

This soil varies somewhat in thickness and color but as a whole is fairly uniform. The gravel content is subject to considerable variation. The surface soil and upper part of the subsoil are slightly acid, but the lower part of the subsoil and substratum are calcareous, the gravel and stone being largely fragments of dolomite.

This is an extensive and important soil. It occurs most extensively in the southwestern and north-central parts of the county. Between these two regions there are many smaller areas within the Kettle Range region. Tracts range from undulating to rolling, but the greater part of the land is gently rolling. It differs in surface features from Kewaunee silt loam in being more irregular, choppy, and morainic in character. Because of the uneven surface and the gravelly subsoil, natural drainage is good. Some stones are on the surface in places, and a few stone fences were seen. In most places the stones have been largely removed from cultivated fields.

Probably 85 per cent of this soil is cultivated and highly improved. It is a good soil, well suited to general farming and dairying, and crop yields are satisfactory. This is a good alfalfa soil, and the

acreage of this crop is increasing. The rotation most commonly followed is corn, small grain for one or two years, followed by hay for one or two years, after which the land is put back into corn.

Bellefontaine silt loam, level phase.—A number of level or gently undulating areas of Bellefontaine silt loam were mapped as the level phase of this soil. The soil is similar to the typical soil, but the surface layer is a little deeper and may contain somewhat more organic matter. The agriculture is similar to that on typical Bellefontaine silt loam.

A number of imperfectly drained areas, included with Bellefontaine silt loam, level phase, have a surface soil of gray heavy silt loam 8 inches thick, a subsurface layer 4 or 5 inches thick of brownish-yellow silt loam, and a subsoil of mottled gray and yellow friable silty clay containing a trace of gravel to a depth of 40 or more inches.

Bellefontaine silt loam, rolling phase.—The rolling phase of Bellefontaine silt loam was separated from the typical soil entirely on the basis of surface relief. It includes areas having a slope sufficient to make them susceptible to erosion and to interfere with the use of ordinary farm machinery. The slopes range from gentle to steep; areas having a slope greater than 15° were mapped as rough broken land. The soil of the rolling phase is the same as that of typical Bellefontaine silt loam, except that it is more stony.

This rolling soil is most common on the steep slopes bordering streams, but some areas are found on morainic hillsides. Drainage is excessive. Probably 25 per cent of the land is cleared and cultivated; the rest is in woods and permanent pasture.

Less corn and more hay and pasture crops are grown on this than on the typical soil. The average yields are about the same. Comparatively, more alfalfa is grown than on any other soil in the county. Alfalfa does particularly well because of the good drainage and calcareous subsoil, and it prevents the soil from washing. This rolling soil is used with other soils for dairy farming.

BELLEFONTAINE LOAM

The surface soil of Bellefontaine loam to a depth of 3 or 4 inches is dark grayish-brown loam containing considerable organic matter. This is underlain to a depth of 9 inches by yellowish-brown loam of somewhat laminated structure, beneath which, to a depth of 17 inches, is yellowish-brown sandy loam with a small content of gravel and some iron stains. Between depths of 17 and 22 inches the material is reddish-brown sandy clay loam, and between 22 and 27 inches it is gravelly, gritty material containing some clay. Below 27 inches is the unassorted gravelly glacial till.

This is a rather extensive soil, occurring mostly in the southwest and north-central parts of the county in association with Bellefontaine silt loam. Tracts range from nearly level to gently rolling and even rolling in places. Because of the surface features and openness of the subsoil, natural drainage is good. Practically none of this soil requires tile drains.

The parent material of this soil is made up of glacial débris composed of dolomitic limestone and mixed with other material carried

here by ice. The surface soil is generally not very acid and the substratum is commonly calcareous and will effervesce when hydrochloric acid is applied.

Most of the land is under cultivation. It is especially well suited to alfalfa, as it is high in lime. The chief crops are hay, oats, and corn, but the acreage of alfalfa is constantly increasing. The rotation of crops most commonly practiced is corn, small grain, and hay, the hay being left for about two years.

BELLEFONTAINE FINE SANDY LOAM

Where undisturbed, the surface soil of Bellefontaine fine sandy loam to a depth of 2 inches is dark grayish-brown fine sandy loam, having a rather high organic-matter content. From 2 to 8 inches there is brownish-yellow fine sandy loam. Below a depth of 8 inches and extending to a depth of 3 or 4 feet the material is variable, ranging from reddish-brown fine sandy loam to yellowish-gray fine sand. Below this there is gray fine sand with gravel or unsorted gravelly till in places. The parent material is made up of glacial till, mostly ground from underlying dolomitic limestone. The soil is slightly acid, but the gravelly substratum is calcareous.

This soil is widely distributed in small areas in the Kettle Range belt that crosses the county. It is associated with Bellefontaine silt loam and other soils of this series. Areas range from undulating or gently rolling to rolling and hilly. Because of the sandiness of the subsoil and the unevenness of the land, natural drainage is good and in some places excessive. Most of the land is cleared, considerable is in pasture, but the greater part is under cultivation. It is a fair soil, but is probably better suited to special crops than to general farming.

BELLEFONTAINE GRAVELLY LOAM

The surface soil of Bellefontaine gravelly loam to a depth of 2 inches is dark grayish-brown light-textured loam. Between depths of 2 and 9 inches there is grayish-brown light-textured loam or fine sandy loam containing considerable gravel. From 9 to 13 inches the material is slightly reddish-brown loam containing gravel. Below 13 inches there is grayish-brown gritty gravelly material containing very little clay. This gravelly material extends to a great depth.

This soil is rather inextensive but is widely distributed as small patches on gravelly ridges associated with Bellefontaine silt loam and Bellefontaine loam, chiefly in the Kettle Range. Tracts are gently rolling or hilly, bumpy, and choppy, and natural drainage is excessive.

Where not too steep, this soil is best suited to alfalfa. Where not cultivated, it is utilized chiefly for grazing.

LONGRIE STONY LOAM

To a depth of 2 inches Longrie stony loam consists of nearly black or dark-brown silty loam which in many places contains some rock fragments. Below 2 and continuing to 10 inches there is yellowish-brown clay loam with some rock fragments. This rests on limestone

rock at a depth ranging from 8 to 12 inches. The surface is thickly strewn with limestone and some granite boulders. Areas of rock outcrop, some rather large, are numerous.

An area of this soil is in sec. 20, T. 20 N., R. 24 E. Other areas lie northwest of Mishicott. The soil is of minor importance. The relief ranges from nearly level to gently rolling, and surface drainage is fair or good. The bedrock substratum does not allow water to move downward except through crevices in the rocks. As the land is too stony for cultivation, it is utilized for pasture.

FOX SILT LOAM

Under cultivation the surface soil of Fox silt loam to a depth of 8 inches consists of light-brown silt loam. Over the surface of wooded areas there may be a thin layer of leaf mold, and the 1 or 2 inch surface layer is darker than the material below, owing to its greater content of organic matter. On cultivation this layer becomes mixed with the soil to plow depth. From 8 to 14 inches the material is yellow silt loam and from 14 to 21 inches it is dull reddish-brown sticky clay or clay loam containing considerable sand and gravel. Between depths of 21 inches and 3 or 4 feet there is brownish-gray clayey gravel with small waterworn stones. The next lower material is grayish waterworn stratified gravel and sand, with which is admixed much limestone material. The chief variation in mapped areas is in the depth to the gravel, which may range from 18 inches to 3 feet.

The soil material is water-laid, and the areas occur as stream terraces or small outwash plains. The surface material is commonly slightly acid or in places neutral, but the deep subsoil contains an abundance of lime.

This soil is inextensive and patchy in occurrence. It is most extensive along East Twin and West Twin Rivers northwest of Two Rivers. Some areas are in Schleswig Town in the southwestern corner of the county, chiefly along Sheboygan River, and a few small areas are along other streams of the county. Tracts are level or very gently undulating, and natural drainage is good except where the silt covering over the gravel is more than 3 feet deep. In such places drainage may be somewhat deficient.

This is a good soil, though it is of minor importance because of its small extent. It is devoted chiefly to general farming and dairying with the Kewaunee, Bellefontaine, and Superior soils, with which it is associated.

FOX LOAM

Where cultivated the surface soil of Fox loam to a depth of 8 inches consists of brown medium loam. This is underlain to a depth of 15 inches by yellowish-brown loam beneath which, to a depth of 24 inches, is brown gravelly loam containing some clay. The next lower material is brownish-yellow stratified, calcareous sand and gravel. The depth to the gravel and sand is somewhat variable.

This soil is inextensive and of minor importance. It occurs along Manitowoc River, chiefly in the town of Manitowoc Rapids, and in small patches in southwestern Kossuth and eastern Newton Towns.

Few farms are located entirely on it. Tracts are level or nearly level, and because of the sand and gravel in the subsoil natural drainage is good.

This soil is nearly all under cultivation. It is used for general farming and dairying, though it is better suited to special truck crops. It is apt to suffer somewhat more from lack of moisture during dry spells than do the heavier soils.

Fox loam, gravelly phase.—The gravelly phase of Fox loam differs from typical Fox loam in having, on the surface and through the soil, much gravel, mostly waterworn fragments of granitic rocks and chert with limestone in the lower soil layers.

This soil is of small extent and minor importance. The largest area is in T. 20 N., R. 23 E., in sections 1 and 12. The land is for the most part level or very gently undulating, and natural drainage is good or excessive. The gravel and sand in the subsoil render drainage too free.

FOX FINE SANDY LOAM

The cultivated surface soil of Fox fine sandy loam to a depth of 10 inches consists of brown smooth fine sandy loam. The 2-inch surface layer in virgin areas is darker than the remainder of the soil owing to the presence of organic matter, and in wooded areas a little leaf mold may be present. On cultivation this is soon lost by decay and mixing with the lower soil. From 10 to 18 inches the material is yellow loamy fine sand and from 18 to 36 inches it is yellowish-brown or reddish-brown fine sandy loam. Between depths of 36 inches and 10 or more feet there is gray porous medium sand with a trace of fine gravel. The gravel is of several kinds but is mainly limestone. The texture of the surface soil is variable. A number of small areas of Fox sandy loam are included.

This soil is rather inextensive and of minor importance. The largest areas occur on the county line due north of Mishicott and in secs. 4 and 5, T. 20 N., R. 24 E. The land is level, and natural drainage is good or somewhat excessive. The soil is devoted to general farming and dairying, in conjunction with heavier adjoining soils, but it is better suited to special truck crops.

POYGAN SILTY CLAY LOAM

The surface soil of Poygan silty clay loam is generally dark-brown or black rather heavy silty clay loam averaging about 10 inches in thickness, although it may continue downward to a depth of 24 or more inches. In places a mucky layer, 1 or 2 inches thick, covers the surface. The subsoil is generally slightly mottled drab-brown, brownish-gray, or gray silty clay loam or clay which may continue to a depth of 20 or more inches, at which depth it grades into pinkish or brownish-red, stiff, plastic clay containing some gray or drab mottles and in places some specks of limonite yellow. The color varies considerably in the subsoil, owing to differences in drainage conditions; the more poorly drained the area the more gray and drab and the less pink or red there is in the lower part of this layer. Seams of fine sand and layers of drab silty clay loam occur in places in the subsoil. The surface soil is free from stones, gravel, and

coarse material. The soil is generally neutral or alkaline in reaction throughout, and the reddish clay substratum contains considerable lime carbonate.

This soil is widely distributed throughout the county, occurring in practically every town. It is associated chiefly with the Kewaunee and Superior soils, occupying depressions and other low areas. Tracts are low, level, or depressed, and natural drainage is poor. Some of the soil along streams is subject to overflow, and water collects in some ponded areas. Tile drains and open ditches have been installed in some places, but by far the greater part of the soil is undrained.

Many small areas associated with Superior and Kewaunee soils are under cultivation, but the greater part of the soil is used chiefly for hay or pasture land. Where drained, it is a good, strong soil and very productive. It is hard to work because of its heavy texture and stiff, plastic consistence. Small grains are apt to lodge because of the rankness of the growth of straw. The land is well suited to the production of hay grasses and sugar beets. Corn does well, but there is danger from frost on the low ground.

CLYDE SILTY CLAY LOAM

The surface soil of Clyde silty clay loam to a depth of 8 or more inches consists of black silty clay loam high in organic matter and in places made up mostly of vegetable matter. Below a depth of 8 inches the material is dark olive-drab silty clay loam, grading downward into mottled dull-gray and yellow silty clay. The soil typically occupies depressed areas in the glacial till, but part of the material may be lacustrine or lake laid. It is neutral or alkaline throughout. There are some variations in color, organic-matter content, and thickness of the layer, but as a whole the soil is uniform.

This soil occurs in many small areas in the region of Bellefontaine soils, chiefly in the southwestern, central, and north-central parts of the county. Tracts are low, level, or depressed, and natural drainage is poor. The land should all be tilled before cultivation is attempted. Much of the land is used for pasture. It is a strong soil where drained and is suited to a wide variety of crops.

WABASH SILT LOAM

The surface soil of Wabash silt loam to a depth of 8 or 10 inches is dark-brown heavy silt loam high in organic matter. The sub-soil is dark grayish-brown heavy clay which grades, at a depth of about 22 inches, into grayish sandy clay mottled with yellow. The soil is variable in color and texture, ranging from dark brown to black in color and from clay loam to loam in texture.

Wabash silt loam is of small extent and minor importance. It occurs in small patches along Manitowoc River and some other streams. It occupies first bottoms subject to overflow and is poorly drained.

This soil is little used because of its position. It is best suited to pasture. If areas could be drained or protected from flooding the

land would be very desirable, but drainage would not be justified under present conditions.

MAUMEE LOAM

Maumee loam to a depth of 6 or 8 inches is black heavy loam, in places containing a small amount of fine gravel. Between depths of 8 inches and about 2 feet the material is generally mottled gray and yellow in color. It varies in texture from fine sandy loam to sandy clay loam. Below a depth of about 2 feet there is mottled yellow, gray, and brown fine sand. The soil is of alluvial origin.

Maumee loam is rather variable, especially in surface texture, which ranges from clay loam to fine sandy loam. This soil is associated with the soils of the moraines and river valleys where it occupies low outwash plains or terraces which are poorly drained. Areas are low, level, and poorly drained.

Because of its small extent this soil is of little importance. If drained it would be a good soil but would be a little cold because of the wet lower subsoil. It is now utilized chiefly for pasture and hay land. Little of it is cleared and cultivated.

EWEN SILTY CLAY LOAM

Ewen silty clay loam includes areas of alluvial bottom land having a light-brown or dark grayish-brown surface soil and a dull-red or reddish-brown plastic clay subsoil containing seams of sand and gravel. The soil is largely silty clay loam, but some areas of silt loam were included in mapping. The surface soil and subsoil are stratified and vary considerably in short distances.

Tracts of this land are low and nearly level but are cut to some extent by bottoms of meandering streams. The soil is all subject to overflow. It is neutral or slightly acid in the surface soil, but the subsoil is calcareous. Practically none of the land is cultivated, but it is valuable for permanent pasture.

GENESEE SILT LOAM

The surface soil of Genesee silt loam to a depth of 8 inches consists of grayish-brown silt loam. Between depths of 8 and 17 inches the material is in most places yellow loamy fine sand, which is underlain to a depth of 24 inches by mottled gray and yellow sand. From 24 to 34 inches there is heavy fine sandy loam with brown iron splotches. This material becomes more sandy with depth. This soil is variable as mapped. In places the subsoil is silt loam or heavier material.

Genesee silt loam occurs along some part of nearly all the stream courses in the county. Areas are not continuous but are broken by patches of other soils of the same series and of the Wabash series. Tracts are low and level and are subject to overflow. Between floods, which are frequent, some of the land appears fairly well drained and could be cultivated in places. Some efforts are made to cultivate small areas, and in some years good yields are obtained. The land is best suited to pasture, however. It is rarely acid.

GENESEE LOAM

Genesee loam includes areas of alluvial bottom land having a grayish-brown or light yellowish-brown rather coarse loam or fine sandy loam surface layer about 10 inches thick. The subsoil consists of stratified layers of light-brown, gray, or yellow loam mottled with gray and rust brown and containing layers of sand and clay. The subsoil below a depth of 24 inches is largely sand or gravel. The surface soil and subsoil are variable in color and texture. The surface soil is acid in only a few places, and the subsoil is calcareous.

This soil occurs in patches along the stream bottoms. The larger areas are along Branch and West Twin Rivers. The land surface is low and flat but is cut somewhat by stream channels. The soil is subject to flooding but is fairly dry most of the summer. Most of the areas have been cleared for permanent pasture, for which use the soil is valuable. Very little of it is cultivated.

COLOMA FINE SAND

The surface soil of Coloma fine sand is grayish-brown fine sand to a depth of 4 inches. This is underlain to a depth of 12 inches by brownish-yellow fine sand with a very slight trace of red. Between depths of 12 and 36 inches the material is yellow fine sand in many places showing a brownish shade. Below a depth of 36 inches there is pale-yellow loose porous fine sand. In one place, well records showed the sand to be 85 feet deep.

Coloma fine sand is a minor soil. It occurs chiefly in the northeast quarter of the county in areas ranging from 40 to 160 acres in extent. The land surface is undulating or gently rolling, and there are a few low hills. Natural drainage is excessive, and crops suffer to some extent from drought.

Most of the land has been cleared and is now cultivated. In Manitowoc County this is a better soil than typical Coloma fine sand in other counties, owing probably to the presence of more limestone material. It is devoted to general farming and the raising of some special crops, though it is better suited to trucking.

PLAINFIELD FINE SAND

The virgin surface soil of Plainfield fine sand to a depth of 2 inches is brown loamy fine sand containing an abundance of roots and some leaf mold. In cultivated fields the dark color and much of the organic matter are soon lost. From 2 to 8 inches the soil is light yellowish-brown loamy fine sand, beneath which is bright-yellow fine sand continuous to a depth of 30 inches. Below 30 inches there is pale-yellow fine sand containing some fine gravel and coarse sand.

This soil occurs chiefly on lake and river terraces in the northeast part of the county along the shore of Lake Michigan and in the valleys of East Twin, West Twin, and Branch Rivers. The largest area is within and bordering the city of Two Rivers. The land surface is level or nearly level, and natural drainage is good or excessive. Over the lower areas the water table is not more than 8 feet below the surface and in the spring is even higher. Thus there may be an excess of moisture at times over parts of the soil. Both surface soil and subsoil are in most places slightly acid.

This soil is largely in farms, and most of it is or has been cultivated. Some is allowed to remain idle part of the time because of low yields. It is a poor soil for general farming, being best suited to special truck crops which can be highly fertilized with profit. Much of the land is used for growing wax and stringless green beans. Some potatoes, rye, and corn are grown, but yields are low. Truck growing is highly developed, as much of the soil is well located in respect to local markets and shipping facilities.

SAUGATUCK FINE SAND

The surface soil of Saugatuck fine sand to a depth of about 4 inches is dark grayish-brown loamy fine sand. Between depths of 4 and 12 inches is a gray loose fine sand layer; from 12 to 19 inches is reddish-brown fine sand; and from 19 to 27 inches is slightly compact, pale grayish-yellow medium sand mottled with rust red. At this depth a coffee-brown cemented sand or ortstein layer is found in much of this soil which is a typical water podsol. Below a depth of 27 inches there is pale yellowish-gray water-logged medium sand.

This soil is of minor importance. It occurs along Lake Michigan, chiefly in the northeast part of the county. Areas are low, level, and rather poorly drained. They occur chiefly on the first terrace above the level of Lake Michigan, in most places from 5 to 10 feet above the level of the lake. Some of the land has been cleared and farmed, but it is a poor soil and little of it is utilized at present except for pasture.

GRANBY FINE SAND

The surface soil of Granby fine sand to a depth of 4 inches is nearly black fine sandy loam with a high content of organic matter. Below this is a 2-inch layer of dark-brown or grayish-drab loam. The next lower layer, continuing to a depth of 3 or more feet, is pale yellowish-gray wet very fine sand. In places a thin layer of peaty material is over the surface, and in other places the surface soil is more sandy than typical. After cultivation this soil appears more sandy, as some of the organic matter is lost and some is mixed with the lower soil. The soil and subsoil are usually acid.

This is an unimportant soil occurring chiefly in the vicinity of Two Rivers. It occupies river and lake terraces and is often called a marsh-border soil. Tracts are low, level, and poorly drained. Most of the land is unimproved and must be drained before it can be farmed.

BRIDGMAN FINE SAND

Bridgman fine sand to a depth of 2 inches consists of dark-gray fine sand containing some leaf mold. This is underlain to a depth of 36 or more inches by light-gray loose incoherent fine sand made up mostly of quartz.

The material forming this soil has been thrown up by wave action and then acted on by the wind. The largest area is northeast of Two Rivers along the shore of Lake Michigan. The land surface is from 2 to 12 feet above the lake and has a billowy appearance.

Because of its loose consistence the soil does not retain moisture well, but the water table is sufficiently close to the surface to allow timber to grow in places. Some marshy strips are between the low

dunes. The soil is not utilized for farming, but the larger areas support a fair growth of timber.

RODMAN GRAVELLY LOAM

The 2-inch surface layer of Rodman gravelly loam is grayish-brown loam containing considerable gravel and grass roots and some leaf mold. This is underlain by an 8-inch layer of reddish-brown gravelly clay loam, beneath which is a 30-inch layer of grayish-yellow loose sand and gravel. Most of the gravel is limestone but some is crystalline. Many waterworn bowlders from 6 to 12 inches in diameter occur, and some stones are on the surface and through the soil. The soil material is calcareous.

This is an inextensive and unimportant soil. It occurs chiefly in the Kettle Range region, as kames and eskers, largely in Mishicott and Liberty Towns but to a smaller extent in several other towns. Areas are irregular, lumpy, and choppy, and natural drainage is excessive.

This land is utilized chiefly for grazing, but as the pasture dries up in summer and early fall it is of small value even for that purpose. Some efforts are made at cultivation, but results are generally unsatisfactory.

High-grade commercial gravel and sand occur under most of this soil.

ORGANIC SOILS (MUCK AND PEAT)

The organic soils are composed dominantly of plant remains and in this respect constitute a distinct class in comparison with soils which are composed principally of mineral or inorganic matter. In this region the organic soils occur in swamps and marshes. The deposits have accumulated in permanently wet situations such as swales and flat valley floors, on slopes permanently wet from seepage water, and in certain kinds of lakes, some of which have been completely filled by plant remains. The organic deposits from which these soils have been derived range in thickness from 1 foot to as much as 40 feet. Organic soils differ in the nature of the mineral substrata (whether marl, sand, or clay), in the average depth to the water table, in the age and stage of decomposition of the plant matter, in the ash content, and in the quantity of mixed foreign mineral material present. The organic soils comprise 12.4 per cent of the total area of the county.

Carlisle muck.—Carlisle muck is black or very dark-brown well-disintegrated muck to an average depth of 36 or more inches. In most places the surface layer, which is about 3 inches thick, is undecayed organic matter consisting of leaves, grass, and moss. Plant roots give the material a slightly fibrous appearance to a depth of 6 inches. Most of the material is so finely divided and well disintegrated that its source is not easily determined, but it appears to be derived largely from wood, sedges, and reeds. At a depth of 18 or more inches alternate layers of more brownish fine fibrous material may be seen. Areas along streams may contain considerable mineral matter which has been carried in and deposited as alluvium. The larger areas away from streams contain very little mineral matter. The muck averages about 5 feet in thickness but may extend 20 or more feet. It is underlain mainly by mottled gray, blue, or pinkish-red calcareous clay. The mucky layer is neutral or calcareous.

Carlisle muck is the most extensive organic soil in the county, scattered areas occurring in every town. Large areas are in Rockland, Eaton, and Maple Grove Towns. A few drainage ditches have been installed and a few tile lines have been laid in places, but most of the land is unimproved. Many areas have been cleared for pasture. A few small areas along Mud Creek and Manitowoc River are in grass.

Where cleared and drained the chief use now made of Carlisle muck is for hay and pasture land. Some corn, root crops, and small grains are grown, but grain is apt to lodge and corn to be damaged by frost. Carlisle muck, where properly drained, fertilized, and cultivated, has been found suited to such crops as cabbage, lettuce, celery, and onions. Of the general farm crops, hay does best.

In the improvement of this soil, drainage is the first and most important step. In the large marsh areas, large drainage districts will be needed.

Carlisle muck, shallow phase.—The shallow phase is similar to typical Carlisle muck, except in the thickness of the organic layer. The shallow soil is also slightly darker and more finely divided and contains more mineral material.

Peat.—Peat in Manitowoc County consists largely of alternate layers of dark-brown and brown material. The dark-brown material is very soft and is highly disintegrated, showing little trace of the original plant fibers. The brown layers contain some moderately well-disintegrated fine fibrous material. A small proportion of mineral matter is present. The organic material appears to be largely derived from sedges and reeds, some wood, and Hypnum and Sphagnum mosses.

The peat areas have all been timbered with cedar, tamarack, and hardwoods. There is more cedar and tamarack on the peat than on Carlisle muck. A few small areas have been cleared for farming, but crop yields have been very low.

Included open marsh areas consist of light-brown matted peat 36 or more inches thick, the upper part of which is rather coarse and is apparently derived from poorly disintegrated sedge grasses. The lower part, which appears to be derived from sedge grasses, moss, and wood, is somewhat finer. This is slightly acid.

Peat, shallow phase.—A phase of peat, based on a variation in the thickness of the organic deposit, is indicated on the soil map as peat, shallow phase. In areas so indicated the peat is less than 3 feet thick. In its physical characteristics it is largely better disintegrated and darker colored than typical peat.

ROUGH BROKEN LAND

Rough broken land includes areas not mapped as Rodman gravelly loam that are too rough and stony to cultivate. Most areas have a slope of more than 15°. The soil is largely light-brown rather gravelly stony clay loam underlain by red clay, light-brown gravelly stony silt loam, or reddish-brown friable clay. Rough broken land does not have the stratified gravel substratum of Bellefontaine gravelly loam.

Rough broken land occurs in narrow areas on steep slopes bordering streams and on low bluffs bordering Lake Michigan. It is mostly

covered with a scattered growth of trees and brush and is used for permanent pasture land.

DUNE SAND

Dune sand is gray, loose, porous, wind-blown sand or fine sand to a depth of 36 or more inches. It is mapped mainly in a narrow strip, ranging in width from a few rods to nearly half a mile, on the shore of Lake Michigan. The relief is hummocky or billowy. The soil is generally barren but in some places is covered with a sparse growth of sand grass. Some of it was at one time covered with white pine. This sand is too sterile to be of any value for farming. None of it is cultivated.

SUMMARY

Manitowoc County is in the east-central part of Wisconsin, bordering Lake Michigan. It comprises an area of 590 square miles, or 377,600 acres. The land surface ranges from level to rough and hilly. The most conspicuous feature is the Kettle Range, a glacial moraine crossing the county from southwest to northeast. The highest elevation in the county is about 359 feet above Lake Michigan. Drainage is all into Lake Michigan.

The climatic conditions are favorable to the high development of agriculture. The frost-free season at Manitowoc averages 162 days. Inland the season is somewhat shorter.

Manitowoc County lies wholly within the timbered region, and the soils have developed under a heavy forest cover. The soils naturally fall into two major groups, the mature soils and the immature soils. The first group includes the well-drained upland soils and the better-drained soils on old glacial-lake areas and alluvial terraces. These soils are mapped in the Kewaunee, Bellefontaine, Fox, Plainfield, and Superior series. The immature soils, which do not show a complete profile, are mapped in the Genesee, Ewen, Wabash, Poygan, Clyde, Maumee, Granby, Saugatuck, Bridgman, Coloma, and Longrie series, and in the miscellaneous classifications rough broken land, dune sand, and muck and peat.

The agriculture of Manitowoc County is highly developed. Dairying is the chief branch of farming. American cheese is the chief dairy product.

The chief crops grown are hay, corn, oats, barley, alfalfa, and peas, and some sugar beets, potatoes, and truck crops are produced. Poultry raising is rather important. Fruit is not grown extensively.

The county is well supplied with transportation facilities. The highways are for the most part well improved, most of them being surfaced with cement, crushed rock, or gravel. All parts of the county are supplied with rural mail service and telephones. Farm buildings are substantial, well built, and usually kept in good repair.

In brief, Manitowoc County is an up-to-date highly prosperous agricultural community.

[PUBLIC RESOLUTION—No. 9]

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

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Wisconsin, shown by shading