SOIL SURVEY OF

Charlevoix County, Michigan

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Michigan Agricultural Experiment Station

Issued May 1974

Major fieldwork for this soil survey was done in the period 1959–62. Soil names and descriptions were approved in 1966. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1966. This survey was made cooperatively by the Soil Conservation Service and the Michigan Agricultural Experiment Station. It is part of the technical assistance furnished to the Charlevoix Soil Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Charlevoix County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area, if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetical order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the woodland suitability group and capability unit in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units and woodland suitability groups.

Foresters and others can refer to the subsection "Woodland," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the subsection "Wildlife."

Community planners and others can read about soil properties that affect the choice of sites for nonindustrial buildings and for recreation areas in the subsection "Town and Country Planning."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation, Morphology, and Classification of Soils."

Newcomers in Charlevoix County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Nature of the County."

Cover picture: **Typical rolling landscape of Emmet-Leelanau association. Erosion is controlled by use of strip-cropping and contour cultivation. Many areas are still in northern hardwoods.**

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE MICHIGAN AGRICULTURAL EXPERIMENT STATION

CHARLEVOIX COUNTY lies in the northwestern part of the Lower Peninsula of Michigan (fig. 1). The county is bordered on the north by Emmet County, on the east by Cheboygan and Otsego Counties, on the south by Otsego and Antrim Counties, and on the west by Lake Michigan. In addition, Charlevoix County includes the Beaver Island group of offshore islands.

The county is 32 miles from east to west and 18 miles from north to south and has a land area of about 264,960 acres. Charlevoix, the county seat, is in the northwestern part of the county.

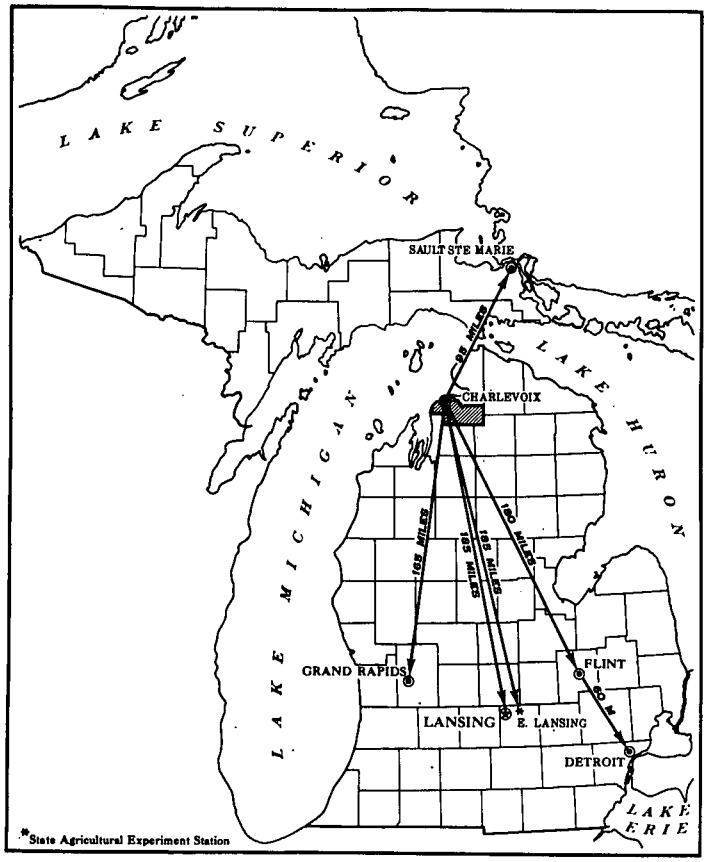

Figure 1.—Location of Charlevoix County in Michigan.

About 27 percent of the county is in farms. Large areas are in woods. The major crops are wheat, corn, oats, hay, and several fruit crops, including apples and cherries. Dairy cows and other livestock are on most farms.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Charlevoix County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes; the size and speed of streams; the kinds of native plants or crops; the kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* (*5*) [1] are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Emmet and Leelanau, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name

[1] Italic numbers in parentheses refer to Literature Cited, p. 120.

of a soil phase indicates a feature that affects management. For example, Rubicon sand, 0 to 6 percent slopes, is one of several phases within the Rubicon series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Three such kinds of mapping units are shown on the soil map of Charlevoix County: soil complexes, soil associations, and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Charlevoix-Mackinac loams, 0 to 6 percent slopes, is an example.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the dominant soils, joined by a hyphen. Leelanau-Emmet association, rolling, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Alpena, Kiva and East Lake soils is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Lake beaches is a land type in Charlevoix County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Charlevoix County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The 11 soil associations in Charlevoix County are discussed in the following pages. The terms for texture used in the title for several of the associations apply to the surface layer. For example, in the title for association 1, the word "sandy" refers to texture of the surface layer.

1. Kalkaska-Leelanau association

Well-drained, mainly sloping to very steep sandy soils on moraines

This association consists of some of the most hilly areas in the county. A few valleys and numerous, small, wet, depressional areas are scattered among the hills.

This association makes up about 11 percent of the county. About 45 percent is Kalkaska soils, 40 percent is Leelanau soils, and the remaining 15 percent is minor soils.

Kalkaska soils are mainly sloping to steep on the hilly moraines and are well drained. Their surface layer is very dark brown sand 4 inches thick. The subsurface layer is light brownish gray sand 6 inches thick. The subsoil consists of three parts. The upper part is dark-brown, loose, slightly cemented sand 6 inches thick. The middle part is dark yellowish-brown, loose sand 6 inches

thick. The lower part is yellowish-brown, loose sand 11 inches thick. The underlying material is at a depth of 33 inches and is light yellowish-brown sand.

Leelanau soils are mainly sloping to very steep on the hilly moraines and are well drained. Their surface layer is very dark brown loamy sand 4 inches thick. The subsurface layer is grayish-brown loamy sand 4 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, very friable loamy sand 7 inches thick. The middle part is pale-brown, loose loamy sand 5 inches thick. The lower part is thin, interbedded layers of dark yellowish-brown, friable sandy loam and pale-brown, loose loamy sand 22 inches thick. The underlying material is at a depth of 42 inches and is grayish-brown loamy sand.

The minor soils are Rubicon, Au Gres, and Roscommon soils. The well-drained Rubicon soils are on hilly moraines and on valley sand plains. The somewhat poorly drained Au Gres soils are on the foot slopes of hilly areas and on valley sand plains. The poorly drained Roscommon soils are in wet, depressional areas.

The major soils are droughty, low in fertility, and susceptible to soil blowing and water erosion. Most of these soils are covered with northern hardwood forests. Much of the cleared land is idle or is used for pasture. These soils are generally poorly suited to farming. In most areas they are well suited to the planting of pine and for extensive recreationl uses. The less sloping areas have few limitations for nonfarm uses.

2. *Emmet-Leelanau association*

Well-drained, nearly level to very steep loamy and sandy soils on moraines

This association consists mainly of gently undulating to hilly areas. There are several large lakes and numerous drainageways and streams.

This association makes up about 29 percent of the county. About 40 percent is Emmet soils, 40 percent is Leelanau soils, and the remaining 20 percent is minor soils.

Emmet soils are nearly level to very steep on hilly moraines and are well drained. Their surface layer is very dark grayish-brown sandy loam 8 inches thick. The subsurface layer is brown sandy loam 4 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, friable sandy loam 4 inches thick. The middle part is grayish-brown, friable sandy loam 4 inches thick. The lower part is brown, friable loam 16 inches thick. The underlying material is at a depth of 36 inches and is a brown sandy loam.

Leelanau soils are nearly level to very steep on hilly moraines and are well drained. Their surface layer is very dark brown loamy sand 4 inches thick. The subsurface layer is grayish-brown loamy sand 4 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, very friable loamy sand 7 inches thick. The middle part is pale-brown, loose loamy sand 5 inches thick. The lower part is thin, interbedded layers of dark yellowish-brown, friable sandy loam and pale-brown, loose loamy sand 22 inches thick. The underlying material is at a depth of 42 inches and is light grayish-brown loamy sand.

The minor soils are Rubicon, Kalkaska, Angelica, and Ensley soils. The well-drained Rubicon and Kalkaska soils are in small hilly areas throughout this association. The poorly drained Angelica and Ensley soils are in the swales, low concave areas, and natural drainageways.

The major soils are susceptible to water erosion (fig. 2). Most of the gently undulating to gently rolling areas are farmed. The steeper sloping areas are used for pasture or are wooded. The soils in this association are moderately suited to well suited to farming and woodland. The less sloping areas have few limitations for nonfarm uses. These soils are well suited to extensive recreational uses.

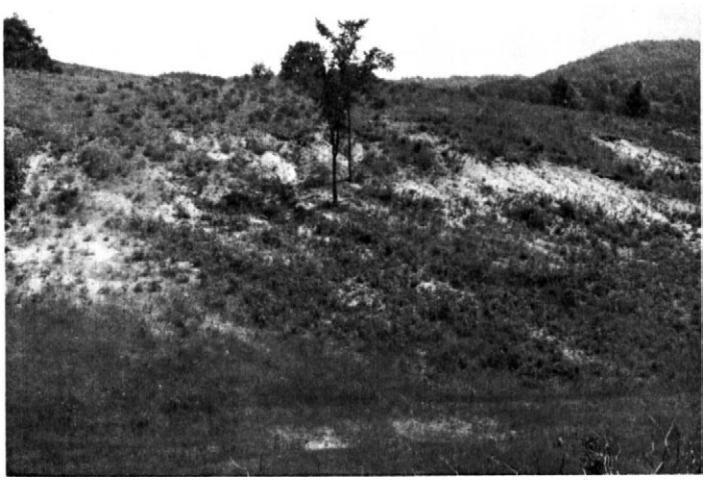

***Figure 2.*—Area of Leelanau loamy sand, 18 to 25 percent slopes. Erosion has resulted from overgrazing.**

3. *Emmet-Onaway association*

Well-drained, nearly level to very steep loamy soils on drumlins and moraines

This association consists mainly of undulating to hilly areas on moraines and drumlins. Steep slopes commonly occur on the sides of drumlins next to drainageways. Narrow, nearly level ridges occur on the top of the drumlins. In some areas there are lakes in the lower areas between the drumlins.

This association makes up about 11 percent of the county. About 55 percent is Emmet soils, 15 percent is Onaway soils, and the remaining 30 percent is minor soils.

Emmet soils are nearly level to very steep on drumlins and moraines and are well drained. Their surface layer is very dark grayish-brown sandy loam 8 inches thick. The subsurface layer is brown sandy loam 4 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, friable sandy loam 4 inches thick. The middle part is grayish-brown, friable sandy loam 4 inches thick. The lower part is brown, friable loam 16 inches thick. The underlying material is at a depth of 36 inches and is brown sandy loam.

Onaway soils are nearly level to very steep on drumlins and moraines and are well drained. Their surface layer is very dark grayish-brown sandy loam 8 inches thick. The subsurface layer is brown sandy loam 2 inches thick. The subsoil consists of three parts. The upper part is

brown, friable sandy loam 3 inches thick. The middle part is grayish-brown, friable sandy loam 4 inches thick. The lower part is brown, firm clay loam 9 inches thick. The underlying material is at a depth of 26 inches and is brown loam.

The minor soils are Angelica, Ensley, Charlevoix, and Mackinac soils. The somewhat poorly drained Charlevoix and Mackinac soils are between the drumlins and on the foot slopes of the sloping to steep areas. The poorly drained Angelica and Ensley soils are in the swales and lower areas.

The major soils are susceptible to water erosion. Most areas are used for crops or pasture (fig. 3). Livestock and dairy enterprises are important, and near Lake Michigan, fruit production is important. Wooded areas are small farm woodlots. The less sloping areas are well suited to farming and woodland. They have few limitations for nonfarm uses. They are well suited to recreational uses.

4. Nester-Emmet association

Well drained or moderately well drained, nearly level to very steep loamy soils on till plains and moraines

This association consists mainly of gently undulating to gently rolling areas on till plains and hilly to steep areas on moraines.

This association makes up about 1 percent of the county. About 60 percent is Nester soils, 20 percent is Emmet soils, and the remaining 20 percent is minor soils.

The Nester soils are gently sloping to strongly sloping on till plains and moraines and are well drained or moderately well drained. Their surface layer is very dark brown loam 4 inches thick. The subsurface layer is brown loam 3 inches thick. The subsoil consists of two parts. The upper part is dark yellowish-brown, friable loam 6 inches thick. The lower part is brown, very firm heavy silty clay loam with pinkish-gray splotches 11 inches thick. The underlying material is at a depth of 24 inches and is brown silty clay loam.

Emmet soils are nearly level to very steep on till plains and moraines and are well drained. Their surface layer is a very dark grayish-brown, sandy loam 8 inches thick. The subsurface layer is brown sandy loam 4 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, friable sandy loam 4 inches thick. The middle part is grayish-brown, friable sandy loam 4 inches thick. The lower part is brown, friable loam 16 inches thick. The underlying material is at a depth of 36 inches and is brown sandy loam.

The minor soils are Charlevoix, Kawkawlin, Menominee, and Ubly soils. The somewhat poorly drained Charlevoix and Kawkawlin soils are on foot slopes on higher areas and on the lower lying areas throughout the association. The well drained or moderately well drained Menominee and Ubly soils are on foot slopes, knolls, and low ridges.

The major soils are highly susceptible to erosion. They require a high level of management to control erosion and keep good soil tilth. About half of the acreage in this association is used for crops or pasture, and the rest is wooded. Livestock raising is the main farm enterprise. The less sloping areas are well suited to farming. The soils in this association are well suited to hardwoods. Nester soils have moderate to severe limitations for nonfarm uses. The less sloping areas of the Emmet soils have slight limitations for nonfarm uses.

Figure 3.—Typical landscape in the Emmet-Onaway association.

5. *Emmet-Barker association*

Well drained or moderately well drained, gently sloping to steep loamy soils on moraines

This association consists of several, small, gently undulating to rolling morainic areas. These areas are underlain by shale bedrock, and shale fragments are common in the Barker soils.

This association makes up about 1 percent of the county. About 60 percent is Emmet soils, 30 percent is Barker soils, and the remaining 10 percent is minor soils.

Emmet soils are gently sloping to steep on moraines and are well drained or moderately well drained. Their surface layer is very dark grayish-brown sandy loam 8 inches thick. The subsurface layer is brown sandy loam 4 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, friable sandy loam 4 inches thick. The middle part is grayish-brown, friable sandy loam 4 inches thick. The lower part is brown, friable loam 16 inches thick. The underlying material, at a depth of 36 inches, is brown sandy loam.

Barker soils are gently sloping to steep on moraines and are well drained or moderately well drained. The surface layer is very dark grayish-brown loam 8 inches thick. The subsurface layer is brown silt loam 4 inches thick. The subsoil consists of two parts. The upper part is grayish-brown, firm heavy silt loam. The lower part is light olive-brown, very firm silty clay loam. The underlying material, at a depth of 26 inches, is light olive-brown silty clay loam that contains many shale fragments. In some areas, mainly south and west of East Jordan, the Barker soils are only 20 to 40 inches thick over shale bedrock and in places are slightly wetter than Barker soils in other parts of the association.

The minor soils are Leelanau, Charlevoix, and Mackinac soils. The well-drained Leelanau soils are in the higher areas throughout the association. The somewhat poorly drained Charlevoix and Mackinac soils are on foot slopes and in low areas scattered throughout the association.

The major soils are highly susceptible to water erosion. They are used mainly for hay and pasture, but many of the steeper areas are in woods. The less sloping areas of Emmet soils are well suited to farming. The soils in this association are well suited to woodland. The less sloping areas of Emmet soils have few limitations for nonfarm uses. Because of shale bedrock, most areas of the Barker soils have moderate to severe limitations for nonfarm uses.

6. *Kalkaska-Mancelona association*

Well drained or moderately well drained, nearly level to gently sloping sandy soils on lake plains and valley trains

This association consists of nearly level to gently undulating, sandy lake plains and long, narrow valleys. It includes some steeply sloping escarpments at the edges of the lake plains.

This association makes up 19 percent of the county. About 35 percent is Kalkaska soils, 20 percent is Mancelona soils, and the remaining 45 percent is minor soils.

Kalkaska soils are nearly level to gently sloping on lake plains and in valleys and are well drained. Their surface layer is very dark brown sand 4 inches thick. The subsurface layer is light brownish-gray sand 6 inches thick. The subsoil consists of three parts. The upper part is dark-brown, loose, slightly cemented sand 6 inches thick. The middle part is dark yellowish-brown, loose sand 6 inches thick. The lower part is yellowish-brown, loose sand 11 inches thick. The underlying material is at a depth of 33 inches and is light yellowish-brown sand.

Mancelona soils are nearly level to gently sloping on lake plains and in valleys and are well drained or moderately well drained. Their surface layer is very dark grayish-brown loamy sand 8 inches thick. The subsurface layer is pale-brown loamy sand 3 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, very friable loamy sand, contains some cemented chunks, and is 3 inches thick. The middle part is brown, loose loamy sand 4 inches thick. The lower part is brown, friable sandy loam 8 inches thick. The underlying material, at a depth of 26 inches, is pale-brown very gravelly sand.

The minor soils are Blue Lake, Au Gres, Gladwin, and East Lake soils. Small areas of the well-drained Blue Lake and East Lake soils are intermingled with Kalkaska and Mancelona soils. The somewhat poorly drained Au Gres and Gladwin soils are in low, depressional areas scattered throughout the association.

The major soils are droughty and susceptible to soil blowing. They are low in nutrients and available water capacity. A large part of this association is used for pasture, pine trees, or is idle. The Kalkaska soils are poorly suited to very poorly suited to farming, but the Mancelona soils are moderately suited. The major soils are well suited to the planting of pine. They have few limitations for nonfarm uses.

7. *Alpena-Kiva-East Lake association*

Well-drained, nearly level to gently sloping loamy and sandy soils that are gravelly in places; on beach ridges, lake terraces, and lake plains

This association consists of nearly level to gently sloping high lake terraces and lake plains of a former glacial lake that is associated with the present Lake Michigan. It includes small hilly to steep areas and small dune areas.

This association makes up about 5 percent of the county. About 40 percent is Alpena soils, 25 percent is Kiva soils, 20 percent is East Lake soils, and the remaining 15 percent is minor soils.

Alpena soils are mainly nearly level to gently sloping on old lake beaches, terraces, and lake plains and are well drained. Their surface layer is very dark brown gravelly sandy loam 8 inches thick. The subsoil is dark yellowish-brown, friable gravelly sandy loam 2 inches thick. The underlying material, at a depth of 10 inches, is brown very gravelly sand.

Kiva soils are mainly nearly level to gently sloping on old lake beach ridges and gravelly lake terraces and are well drained. Their surface layer is very dark brown gravelly loamy sand 7 inches thick. The subsurface layer is light brownish-gray loamy sand 3 inches thick. The subsoil is dark-brown, friable sandy loam 8 inches thick. The underlying material, at a depth of 18 inches, is light brownish-gray gravelly sand.

East Lake soils are mainly nearly level to gently sloping on old beach ridges, broad lake plains, and lake ter-

races and are well drained. Their surface layer is very dark grayish-brown loamy sand 7 inches thick. The subsurface is grayish-brown sand 4 inches thick. The subsoil is dark-brown to brown, very friable loamy sand 21 inches thick. The underlying material, at a depth of 32 inches, is brown very gravelly sand.

The minor soils and land types are Deer Park, Dune land, and Lake beaches. The well-drained, nearly level to very steep Deer Park soils and Dune land are on beach ridges and sand dunes near the shores of Lake Michigan. The Lake beaches occur in strips along the shores of Lake Michigan. These beaches consist of sand and gravel.

The major soils are droughty, low in fertility, and are susceptible to soil blowing. Most areas are idle or wooded. Small, scattered areas are farmed. Many areas are used for recreational purposes. These soils are poorly to very poorly suited to farming. They generally are poorly suited to woodland, except for the East Lake soils, which are well suited to pine and aspen. They have few limitations for most nonfarm uses.

8. *Deer Park-Dune land-Eastport association*

Well-drained, nearly level to very steep sandy soils on beach ridges and dunes

This association consists mainly of beach ridges and hilly dunes along Lake Michigan. Small areas of limestone outcrops are included south of the city of Charlevoix.

This association makes up about 5 percent of the county. About 50 percent is Deer Park soils and Dune land, 10 percent is Eastport soils, and the remaining 40 percent is minor soils.

Deer Park soils are nearly level to very steep on the higher and steeper dunes away from the Lake beaches and are well drained. Their surface layer is very dark grayish brown fine sand 3 inches thick. The subsurface layer is grayish-brown fine sand 4 inches thick. The subsoil is brown and yellowish-brown, loose sand 13 inches thick. The underlying material, at a depth of 20 inches, is brown sand.

Dune land is well-drained sand. It lacks distinct soil horizons because of the periodic movement of the sandy material.

Eastport soils are nearly level to sloping on the lower dunes and beach ridges above the shoreline of Lake Michigan and are well drained. Their surface layer is very dark grayish-brown sand 5 inches thick. The subsurface layer is grayish-brown sand 3 inches thick. The subsoil is brown, loose sand 12 inches thick. The underlying material, at a depth of 20 inches, is light brownish-gray sand.

The minor soils are Alpena, Summerville, Ruse, and Lake beaches. The well-drained Alpena soils are in small areas of old lake beaches and lake terraces. The well-drained Summerville soils are less than 20 inches thick over limestone bedrock. They are in small areas on lake terraces. The poorly drained Ruse soils are less than 20 inches thick over limestone bedrock.They are in depressions, swales, or flat areas. The Summerville and Ruse soils are south of the town of Charlevoix along Lake Michigan. The Lake beaches occur along the shoreline of Lake Michigan and the larger inland lakes.

The major soils are droughty, low in fertility, and are susceptible to soil blowing. Most areas are wooded. These soils are moderately suited to pines. They are used for woodland, wildlife habitat, and for recreational areas. They are poorly suited to farming. The less sloping areas of these soils have few limitations for nonfarm uses.

9. *Detour-Kiva association*

Somewhat poorly drained and well-drained, nearly level to gently sloping loamy and sandy soils that are cobbly or gravelly; on lake plains

This association consists of nearly level to gently undulating, cobbly and gravelly lake plains.

This association makes up about 2 percent of the county. About 50 percent is Detour soils, 20 percent is Kiva soils, and the remaining 30 percent is minor soils.

Detour soils are nearly level to gently sloping on lake terraces and are somewhat poorly drained. Their surface layer is very dark grayish-brown cobbly loam 6 inches thick. Some stones and boulders are present. The subsurface layer is grayish-brown cobbly loam 4 inches thick and has yellowish-brown mottles. The subsoil is dark yellowish-brown, firm cobbly sandy clay loam 10 inches thick and has grayish-brown mottles. Stones and boulders are present. The underlying material is at a depth of 20 inches and is grayish-brown, cobbly sandy loam with yellowish-brown mottles. It has many stones and boulders.

Kiva soils are nearly level to gently sloping and are well drained. Their surface layer is very dark brown gravelly loamy sand 7 inches thick. The subsurface layer is light brownish-gray loamy sand 3 inches thick. The subsoil is dark-brown, friable sandy loam 8 inches thick. The underlying material is at a depth of 18 inches and is light brownish-gray gravelly sand.

The minor soils are Johnswood, Hessel, Alpena, and East Lake soils. The well drained or moderately well drained Johnswood soils are gently sloping to sloping. The poorly drained Hessel soils are nearly level to gently sloping. The Johnswood and Hessel soils are on cobbly lake terraces and plains along the shorelines of Lake Michigan and Lake Charlevoix. The well-drained Alpena and East Lake soils occur with the Kiva soils in scattered areas throughout the association.

The major soils are cobbly and gravelly. The Detour soils are poorly drained, and the Kiva soils are droughty. Most areas of the soils in this association are wooded. They are very poorly suited to farming and poorly suited to woodland. The Detour soils have serious limitations for most nonfarm uses, and the Kiva soils have few limitations.

10. *Roscommon-Charlevoix-Mackinac association*

Poorly drained and somewhat poorly drained, nearly level to gently sloping sandy and loamy soils on lake plains

This association consists of nearly level to gently undulating areas on former glacial lake plains associated with the present Lake Michigan. It is on Beaver, Garden, High, and Hog Islands in Lake Michigan.

This association makes up about 6 percent of the county. About 50 percent is Roscommon soils, 25 percent is Charlevoix and Mackinac soils, and the remaining 25 percent is minor soils.

Roscommon soils are nearly level to gently sloping in depressional areas on lake plains and are poorly drained. Their surface layer is black sand 5 inches thick. The un-

derlying material, at a depth of 5 inches, is brown and grayish-brown sand with yellowish-brown mottles.

Charlevoix and Mackinac soils are nearly level to gently sloping and are somewhat poorly drained. They are in gently undulating areas of the lake plains. The surface layer of Charlevoix soils is very dark brown loam 8 inches thick. The subsurface layer is brown sandy loam 3 inches thick and has yellowish-brown mottles. The subsoil consists of two parts. The upper part is yellowish-brown, friable sandy loam 5 inches thick. The lower part is brown, friable loam 6 inches thick and has strong-brown mottles. The underlying material, at a depth of 22 inches, is light brownish-gray sandy loam with yellowish-brown mottles.

The surface layer of Mackinac soils is very dark-brown loam 8 inches thick. The subsurface layer is yellowish-brown loam 2 inches thick. The subsoil consists of two parts. The upper part is brown, friable loam 6 inches thick and has yellowish-brown mottles. The lower part is light yellowish-brown, friable loam 7 inches thick. The underlying material, at a depth of 23 inches, is brown loam with yellowish-brown mottles.

The minor soils are Brevort, Belding, and Breckenridge soils. The poorly drained to very poorly drained, nearly level to gently sloping Brevort and Breckenridge soils are in depressions on the lake plains. The somewhat poorly drained, nearly level to gently sloping Belding soils are intermingled with Breckenridge soils and are at slightly higher elevations.

The somewhat poorly drained Charlevoix and Mackinac soils are more productive than the poorly drained Roscommon soils. Most areas of the soils of this association are wooded. The Charlevoix and Mackinac soils where they are not cobbly, are well suited to farming if drained. The Roscommon soils are poorly suited to farming. The Charlevoix and Mackinac soils are moderately suited to hardwoods, but the Roscommon soils are poorly suited. The major soils have moderate to severe limitations for many nonfarm uses. They are well suited for use as hunting areas.

11. Carbondale-Lupton-Tawas association

Very poorly drained, nearly level to gently sloping organic soils in depressional areas on till plains, outwash plains, and lake plains

This association consists of low, wet, depressional areas on plains in long, broad valleys.

This association makes up about 10 percent of the county. About 40 percent is Carbondale soils, 20 percent is Lupton soils, 10 percent is Tawas soils, and the remaining 30 percent is minor soils.

Carbondale soils are nearly level to gently sloping in depressional areas and are very poorly drained. Their surface layer is black muck 14 inches thick. The next layer is very dark grayish-brown muck 14 inches thick. Below this, at a depth of 28 inches, is brown mucky peat.

Lupton soils are nearly level to gently sloping in depressional areas and are very poorly drained. Their surface layer is black muck 14 inches thick. The next layer is very dark grayish-brown muck 8 inches thick. The next layer is dark-brown muck 14 inches thick. Below this, at a depth of 36 inches, is dark grayish-brown muck.

Tawas soils are nearly level to gently sloping in depressional areas and natural drainageways and are very poorly drained. Their surface layer is black muck 11 inches thick. The next layer is very dark brown muck 5 inches thick. The next layer is very dark grayish-brown muck 7 inches thick. The underlying material, at a depth of 23 inches, is light brownish-gray sand.

The minor soils are Cathro, Linwood, and Roscommon soils. The very poorly drained Cathro, Linwood, and Roscommon soils are intermingled with the major soils in depressional areas. Roscommon soils are in slightly higher areas.

The major soils are very poorly drained, and many areas are subject to severe frost. Nearly all areas of these soils are wooded. They are very poorly suited to farming and are variably suited to woodland. These soils have severe limitations for most nonfarm uses. They are well suited as a habitat for wetland wildlife.

Descriptions of the Soils

This section describes the soil series and mapping units of Charlevoix County. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

In the pages that follow, a general description of each soil series is given. Each series description has a detailed description of a profile typical of the series and a brief statement of the range in characteristics of the soils in the series, as mapped in this county. Following the series description, each mapping unit in the series is described individually. For full information on any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. Miscellaneous land types, such as Wet alluvial land, are described in alphabetic order along with the soil series.

Two kinds of mapping units are described. In roughly the eastern half of the county, most of the mapping units are of low intensity. In roughly the western half of the county, most of the mapping units are of low intensity. These areas of different survey intensities are shown on the Index To Map Sheets at the back of the survey. The composition of the low-intensity mapping is more variable than that of the medium-intensity units in the county but has been controlled well enough to interpret for the expected use of the soils.

All the mapping units of the low-intensity survey are soil associations, and the word "association" appears in their names. An example of this kind of unit is the Blue Lake-Kalkaska association, undulating.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the soil map and indicates whether it is a medium-intensity or a low-intensity unit. For a soil within the medium-intensity survey, the symbol consists of a combination of capital and lower case letters (BlB). For a soil within the low-intensity survey, the symbol consists of capital letters (BKB).

Descriptions, names, and delineations of soils in this soil survey do not fully agree with soil maps in adjacent counties published at a different date. Differences are the result of better knowledge of soils, modifications in series concepts, intensity of mapping, and the extent of soils within the survey area. In some places it is more feasible to combine small acreages of similar soils that

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent	Soil	Acres	Percent
Alpena gravelly sandy loam, 0 to 6 percent slopes	2, 320	0 9	Emmet-Onaway sandy loams, 6 to 12 percent slopes	4, 074	1 5
Alpena gravelly sandy loam, 6 to 18 percent slopes	498	2	Emmet-Onaway sandy loams, 12 to 18 percent slopes	1, 257	5
Alpena gravelly sandy loam, 18 to 35 percent slopes	166	1	Emmet-Onaway sandy loams, 18 to 25 percent slopes	440	2
Alpena, Kiva and East Lake soils	9, 992	3 7	Emmet-Onaway sandy loams, 25 to 50 percent slopes	606	. 2
Angelica-Ensley loams	2, 451	9	Epoufette sandy loam	1, 546	6
Au Gres sand, 0 to 4 percent slopes	2, 174	8	Gladwin loamy sand, 0 to 6 percent slopes	1, 890	7
Au Gres sand, loamy substratum, 0 to 4 percent slopes	751	3	Greenwood peat	593	2
Barker loam, 2 to 6 percent slopes	204	1	Hessel cobbly loam	472	2
Barker loam, 6 to 12 percent slopes	161	1	Iosco loamy sand, 0 to 6 percent slopes	749	3
Barker loam, 12 to 25 percent slopes	137	1	Johnswood cobbly loam, 2 to 12 percent slopes	118	(1)
Barker loam, shallow variant, 2 to 6 percent slopes	275	1	Kalkaska sand, 0 to 6 percent slopes	6, 410	2. 4
Belding-Breckenridge sandy loams, 0 to 4 percent slopes	4, 810	1 8	Kalkaska sand, 6 to 12 percent slopes	1, 932	. 7
Bergland-Sims silty clay loams	217	1	Kalkaska sand, 12 to 18 percent slopes	1, 155	. 4
Blue Lake loamy sand, 0 to 6 percent slopes	1, 260	5	Kalkaska sand, 18 to 25 percent slopes	1, 490	6
Blue Lake loamy sand, 6 to 12 percent slopes	512	2	Kalkaska sand, 25 to 50 percent slopes	1, 957	7
Blue Lake loamy sand, 12 to 18 percent slopes	185	1	Kalkaska-Leelanau association, undulating	12, 896	4 8
Blue Lake loamy sand, 18 to 50 percent slopes	402	2	Kalkaska-Leelanau association, rolling	7, 986	3 0
Blue Lake-Kalkaska association, undulating	1, 743	7	Kalkaska-Leelanau association, hilly	10, 423	3 8
Blue Lake-Kalkaska association, rolling	600	2	Kawkawlin loam, 0 to 6 percent slopes	316	1
Brevort loamy sand	761	3	Kerston muck	914	3
Brimley soils, 0 to 6 percent slopes	430	2	Lake beaches	2, 733	1 0
Bruce soils	464	2	Leelanau loamy sand, 2 to 6 percent slopes	1, 712	7
Carbondale muck	9, 954	3 7	Leelanau loamy sand, 6 to 12 percent slopes	1, 332	. 5
Cathro muck	1, 167	4	Leelanau loamy sand, 12 to 18 percent slopes	651	. 3
Charlevoix-Kawkawlin association, undulating	400	2	Leelanau loamy sand, 18 to 25 percent slopes	1, 827	7
Charlevoix-Mackinac loams, 0 to 6 percent slopes	3, 794	1 4	Leelanau loamy sand, 25 to 50 percent slopes	887	3
Charlevoix-Mackinac cobbly loams, 0 to 6 percent slopes	310	1	Leelanau-Emmet association, undulating	1, 132	4
Croswell sand, 0 to 4 percent slopes	747	3	Leelanau-Emmet association, rolling	5, 641	2 1
Deer Park-Dune land association, undulating	3, 945	1 5	Leelanau-Emmet association, hilly	7, 792	2 9
Deer Park-Dune land association, rolling	1, 757	7	Leelanau-Rubicon loamy sands, 0 to 6 percent slopes	5, 697	2 2
Deer Park-Dune land association, hilly	946	4	Leelanau-Rubicon loamy sands, 6 to 12 percent slopes	6, 636	2 5
Detour cobbly loam, 0 to 6 percent slopes	2, 698	1 0	Leelanau-Rubicon loamy sands, 12 to 18 percent slopes	4, 000	1 5
East Lake loamy sand, 0 to 6 percent slopes	2, 800	1 1	Leelanau-Rubicon loamy sands, 18 to 25 percent slopes	8, 847	3 3
East Lake loamy sand, 6 to 12 percent slopes	733	3	Leelanau-Rubicon loamy sands, 25 to 50 percent slopes	5, 411	2 0
Eastport sand, 0 to 6 percent slopes	958	4	Linwood muck	1, 926	7
Eastport sand, 6 to 12 percent slopes	505	2	Lupton muck	3, 119	1 2
Edmore sandy loam	200	1	Lupton-Cathro association	3, 501	1 3
Edwards muck	361	1	Made land	111	(1)
Emmet sandy loam, 0 to 2 percent slopes	412	2	Mancelona loamy sand, 0 to 6 percent slopes	5, 616	2 1
Emmet sandy loam, 2 to 6 percent slopes	9, 238	3 5	Mancelona loamy sand, 6 to 12 percent slopes	1, 303	5
Emmet sandy loam, 6 to 12 percent slopes	7, 573	2 9	Mancelona loamy sand, 12 to 18 percent slopes	394	2
Emmet sandy loam, 12 to 18 percent slopes	2, 431	9	Mancelona loamy sand, 18 to 25 percent slopes	430	. 2
Emmet sandy loam, 18 to 25 percent slopes	3, 031	1 1	Mancelona loamy sand, 25 to 50 percent slopes	547	2
Emmet-Leelanau association, undulating	963	4	Mancelona-East Lake association, undulating	2, 613	1 0
Emmet-Leelanau association, rolling	2, 436	9	Mancelona-East Lake association, rolling	846	3
Emmet-Leelanau association, hilly	1, 885	7	Mancelona-East Lake association, hilly	751	3
Emmet-Leelanau complex, 2 to 6 percent slopes	3, 909	1 5	Markey muck	744	3
Emmet-Leelanau complex, 6 to 12 percent slopes	3, 428	1 3	Menominee loamy sand, 0 to 6 percent slopes	665	3
Emmet-Leelanau complex, 12 to 18 percent slopes	1, 429	5	Menominee loamy sand, 6 to 12 percent slopes	243	1
Emmet-Leelanau complex, 18 to 25 percent slopes	2, 203	8	Munuscong fine sandy loam	250	1
Emmet-Leelanau complex, 25 to 50 percent slopes	3, 781	1 4	Nester loam, 2 to 6 percent slopes	539	2
Emmet-Onaway sandy loams, 0 to 2 percent slopes	278	1	Nester loam, 6 to 12 percent slopes	459	2
Emmet-Onaway sandy loams, 2 to 6 percent slopes	1, 704	6	Nester loam, 12 to 18 percent slopes	194	1
			Nester loam, 18 to 35 percent slopes	566	2
			Nester-Emmet association, undulating	119	(1)
			Nester-Emmet association, rolling	251	1
			Nester-Emmet association, hilly	152	1

[1] Less than 0 05 percent

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Acres	Percent	Soil	Acres	Percent
Otisco loamy sand, 0 to 6 percent slopes	296	.1	Summerville stony sandy loam, 0 to 6 percent slopes	929	.4
Roscommon sand	11,083	4.1	Tawas muck	2,730	1.0
Rubicon sand, 0 to 6 percent slopes	327	.1	Tawas-Carbondale association	791	.3
Rubicon sand, 6 to 12 percent slopes	138	.1	Ubly sandy loam, 2 to 6 percent slopes	432	.2
Rubicon sand, 18 to 35 percent slopes	246	.1	Ubly sandy loam, 6 to 12 percent slopes	179	.1
Rubicon sand, loamy substratum, 0 to 6 percent slopes	376	.1	Wallace sand, 0 to 12 percent slopes	835	.3
Rudyard silt loam, 0 to 6 percent slopes	446	.2	Warners loam	553	.2
Ruse soils	579	.2	Wet alluvial land	709	.3
Saugatuck sand, 0 to 6 percent slopes	718	.3			
Stony land	243	.1	Total	264,960	100.0

respond to use and management in much the same way than it is to separate these soils and give them names.

For more general information about the soils, the reader can refer to the section "General Soil Map," in which the broad patterns of soils are described. Many of the terms used in the soil descriptions and other parts of the survey are defined in the Glossary. Unless otherwise specified, the color given in the text refers to a moist soil.

Alpena Series

The Alpena series consists of well-drained, nearly level to very steep soils on beach ridges, lake plains, and lake terraces. These soils formed in gravelly sand. In Charlevoix County the Alpena soils were mapped alone and in an undifferentiated unit with Kiva and East Lake soils.

In a representative profile, the surface layer is very dark brown gravelly sandy loam 8 inches thick. The subsoil is dark yellowish-brown, friable gravelly sandy loam 2 inches thick. The underlying material, at a depth of more than 10 inches, is brown very gravelly sand.

Permeability is rapid. The available water capacity is low. Organic-matter content is moderately low, and natural fertility is low. Surface runoff is slow.

Alpena soils are very poorly suited to farming and are poorly suited to woodland. The less sloping areas of these soils have few limitations for most nonfarm uses. These soils are mainly wooded. They are used mainly for recreation.

Representative profile of Alpena gravelly sandy loam, 0 to 6 percent slopes, in a nonwooded area, SE¼SE¼ sec. 2, T. 33 N., R. 8 W.:

A1—0 to 8 inches, very dark brown (10YR 2/2) gravelly sandy loam; moderate, fine, granular structure; friable; 20 percent coarse fragments; neutral; diffuse, wavy boundary.

B—8 to 10 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam; weak, medium, granular structure; friable; 40 percent coarse fragments; neutral; clear, wavy boundary.

IIC—10 to 60 inches, brown (10YR 5/3) very gravelly sand; single grain; loose; 55 percent coarse fragments; moderately alkaline; slightly effervescent.

The solum ranges from 4 to 10 inches in thickness. Coarse fragments range from 10 to 50 percent by volume throughout the solum. Coarse fragments are gravel, flagstones, cobblestones, and stones but are dominantly gravel. Flaggy and stony fragments are mainly limestone. The IIC horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The Alpena soils in Charlevoix County were mapped with East Lake and Kiva soils. They are similar to the Summerville soils. They have a thinner solum than the East Lake and Kiva soils. They have bedrock at a depth of more than 60 inches, but the Summerville soils have bedrock at a depth of less than 20 inches.

Alpena gravelly sandy loam, 0 to 6 percent slopes (AgB).—This soil is on beach ridges, terraces, and sandy plains. It has the profile described as representative for the series.

Included with this soil in mapping were many seep spots and small areas where the water table is at a depth of less than 3½ feet during most months. These areas are near Lake Michigan. Also included were somewhat poorly drained and poorly drained soils in shallow swales and in some small areas where the surface layer rests directly on alkaline sand and gravel.

Most areas of this soil are wooded. Other areas are in hay crops and pasture. The main concerns of management are conserving soil moisture and maintaining fertility. (Capability unit VIs-2 (Ga); woodland suitability group Y)

Alpena gravelly sandy loam, 6 to 18 percent slopes (AgD).—This soil is on beach ridges, terraces, and along the edges of sandy plains.

Included with this soil in mapping were small, brown, alkaline, eroded areas of very gravelly sand. Also included were small sand deposits in depressions.

This soil is in sparse woodland or is idle. The main concerns of management are conserving soil moisture and maintaining fertility. (Capability unit VIs-2 (Ga); woodland suitability group Y)

Alpena gravelly sandy loam, 18 to 35 percent slopes (AgF).—This soil is on long, narrow escarpments between high and low lake terraces. It has a profile similar to that described as representative for the series, but it is much thinner.

Included with this soil in mapping were small areas that have a loamy sand surface layer. In these areas the depth to alkaline very gravelly sand is less than 8 inches.

This soil is in sparse woodland or is idle. The main concern of management is conserving soil moisture. The main limitation is the steepness of slopes. (Capability unit VIs-2 (Ga); woodland suitability group Y)

Alpena, Kiva and East Lake soils (0 to 50 percent slopes) (Ak).—These soils are on beach ridges, terraces, and sandy plains. The surface layer ranges from gravelly sandy loam to gravelly sand.

Included with these soils in mapping were small eroded areas of soils on the steeper slopes and small areas of Leelanau loamy sand.

Most areas of these soils are wooded. Some of the less sloping areas are in pasture and hay. The main concerns of management are conserving soil moisture and maintaining fertility. The main limitation in a few areas is the steepness of slopes. (Capability unit VIs-2 (Ga, 4a, 5a); woodland suitability group Y)

Angelica Series

The Angelica series consists of poorly drained, nearly level to gently sloping soils on till plains and moraines. These soils formed in loam till. In Charlevoix County the Angelica soils were mapped only in a complex with the Ensley soils.

In a representative profile, the surface layer is black loam 6 inches thick. The subsurface layer is dark grayish-brown loam 2 inches thick and has olive-brown and light brownish-gray mottles. The subsoil consists of two parts. The upper part is light brownish-gray, friable sandy loam 4 inches thick and has strong-brown mottles. The lower part is yellowish-brown, friable sandy loam 7 inches thick. Below the subsoil is yellowish-brown sandy loam 9 inches thick. The underlying material, at a depth of 28 inches, is light brownish-gray loam with yellowish-brown mottles.

Permeability is moderately slow. The available water capacity and the organic-matter content are high. Natural fertility is high. Surface runoff is slow.

If drained, Angelica soils are well suited to farming. They are generally poorly suited to woodland. They have severe limitations for most nonfarm uses. Angelica soils are well suited as habitat for wetland wildlife. These soils are mainly wooded.

Representative profile of an Angelica loam from an area of Angelica-Ensley loams in a nonwooded area, SW¼NW¼ sec. 21, T. 33 N., R. 8 W.:

A1—0 to 6 inches, black (10YR 2/1) loam; weak, coarse, granular structure; friable; less than 5 percent coarse fragments; neutral; clear, smooth boundary.

A2g—6 to 8 inches, dark grayish-brown (2.5Y 4/2) loam; common, medium, distinct, olive-brown (2.5Y 4/4) and light brownish-gray (2.5Y 6/2) mottles; moderate, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

B21g—8 to 12 inches, light brownish-gray (10YR 6/2) sandy loam; common, medium, distinct, strong-brown (7.5YR 5/6) mottles; very weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

B22—12 to 19 inches, yellowish-brown (10YR 5/4) sandy loam; common, medium, faint, yellowish-brown (10YR 5/6) mottles; very weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; mildly alkaline; gradual, wavy boundary.

C1—19 to 28 inches, yellowish-brown (10YR 5/4) sandy loam; common, medium, faint, yellowish-brown (10YR 5/6) mottles; very weak, coarse, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent; diffuse, wavy boundary.

C2g—28 to 60 inches, light brownish-gray (2.5Y 6/2) loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; very weak, coarse, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

Reaction throughout the solum ranges from slightly acid to mildly alkaline. The C horizon is yellowish brown, light brownish gray, or reddish brown. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The texture in the lower part of the B horizon of these soils is coarser and reaction in the solum is more alkaline than the defined range for the series, but these differences do not alter the usefulness or behavior of these soils.

Angelica soils are in a toposequence with the Onaway and Mackinac soils. They are mapped with Ensley soils. Angelica soils are similar to Bruce soils. They have mottles that are lacking in Onaway soils. They differ from Mackinac soils in having one layer or more in the B horizon that is dominantly grayish in color. They contain more clay than the Ensley soils between depths of 10 to 40 inches. Angelica soils differ from Bruce soils in having coarse fragments throughout the profile and in lacking stratification in the C horizon.

Angelica-Ensley loams (0 to 4 percent slopes) (An).—These soils are in swales, in depressions, and on foot slopes of uplands. The Angelica soil makes up about 50 percent of the complex, the Ensley soil, 30 percent, and included soils, about 20 percent.

Included in mapping were small areas of somewhat poorly drained Charlevoix loam in slightly higher positions and a few small areas of thin, sandy overwash material.

These soils are used for common crops where they are drained. Undrained areas are in pasture or woodland. The main concern of management is improving drainage. (Capability unit IIw-4 (2.5c, 3c); woodland suitability group P)

Au Gres Series

The Au Gres series consists of somewhat poorly drained, nearly level to gently sloping soils on till plains, outwash plains, and lake plains. These soils formed in sand.

In a representative profile, the surface layer is very dark grayish-brown sand 4 inches thick. The subsurface layer is light brownish-gray sand 8 inches thick and has dark yellowish-brown mottles. The subsoil is dark yellowish-brown and grayish-brown sand that is slightly cemented in spots and is about 18 inches thick. The underlying material, at a depth of 30 inches, is grayish-brown sand.

Permeability is rapid. The available water capacity is low. The organic-matter content is moderately low, and natural fertility is low. Surface runoff is slow.

Au Gres soils are poorly suited to farming. These soils are poorly suited to hardwoods and pines and moderately suited to aspens. They have moderate to severe limitations for many nonfarm uses. They are used mainly for pasture and woods.

Representative profile of Au Gres sand, 0 to 4 percent slopes, in a nonwooded area, NE¼SW¼ sec. 34., T. 34 N., R. 8 W.:

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) sand; very weak, fine, granular structure; very friable; slightly acid; clear, smooth boundary.

A2—4 to 12 inches, light brownish-gray (10YR 6/2) sand; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; single grain; loose; slightly acid; clear, wavy boundary.

B2ir—12 to 20 inches, dark yellowish-brown (10YR 4/4) sand; single grain; loose; few slightly cemented chunks of ortstein; slightly acid; clear, wavy boundary.

B3g—20 to 30 inches, grayish-brown (10YR 5/2) sand; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; slightly acid; gradual, wavy boundary.

C—30 to 60 inches, grayish-brown (10YR 5/2) sand; single grain; loose; neutral.

Reaction throughout the solum is medium acid or slightly acid. The A2 horizon is gray or light brownish gray. In a few places, a Bhir horizon is present. It is dark-brown or dark reddish-brown sand. The C horizon is grayish brown or brown. It is neutral or mildly alkaline.

The Au Gres soils in Charlevoix County are on most landscapes with the Croswell, Kalkaska, Roscommon, Rubicon, Saugatuck, and Wallace soils. They are similar to Gladwin and Otisco soils. They differ from Croswell soils in having mottles in the A2 horizon or in the upper part of the B horizon. They have mottles that are lacking in Kalkaska, Rubicon, and Wallace soils. Au Gres soils differ from Saugatuck soils in lacking a continuous ortstein layer in the B horizon. They differ from Roscommon soils in having a Bir horizon. Au Gres soils differ from Gladwin and Otisco soils in lacking a loamy B't horizon. Also, they differ from Gladwin soils in lacking effervescent gravelly sand in the C horizon.

Au Gres sand, 0 to 4 percent slopes (ArA).—This soil is on broad, slightly undulating, sandy plains. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of moderately well drained Croswell sand at the slightly higher elevations and small areas of poorly drained Roscommon sand in narrow swales. Also included were areas of Saugatuck sand, generally less than an acre in size.

This soil is generally in pasture or woods, but some areas are in cultivation. The main concerns of management are improving drainage, maintaining fertility, conserving soil moisture where this soil is drained, and controlling soil blowing. (Capability unit IVw-2 (5b); woodland suitability group F)

Au Gres sand, loamy substratum, 0 to 4 percent slopes (AuA).—This soil is on small, sandy plains. It differs from the profile described as representative for the series in having loam underlying material at depths ranging from 42 to 66 inches.

Included with this soil in mapping were small, depressional areas of poorly drained or very poorly drained Roscommon sand and Brevort loamy sand.

Some areas of this soil are in cultivation. Other areas are wooded. A few areas are in hay and pasture. The main concerns of management are improving drainage, maintaining fertility, conserving soil moisture where this soil is drained, and controlling soil blowing. (Capability unit IVw-2 (5/2b); woodland suitability group F)

Barker Series

The Barker series consists of well drained or moderately well drained, gently sloping to steep soils on moraines. These soils formed in silty clay loam till that contained shale fragments. The shallow glacial till deposits are strongly influenced by underlying shale.

In a representative profile, the surface layer is very dark grayish-brown loam 8 inches thick. The subsurface layer is brown silt loam 4 inches thick. The subsoil consists of two parts. The upper part is firm, grayish-brown heavy silt loam. The lower part is very firm, light olive-brown silty clay loam. The underlying material, at a depth of 26 inches, is light olive-brown silty clay loam that contains many shale fragments.

Permeability is moderately slow. The available water capacity is high. Organic-matter content is moderate, and natural fertility is high.

Barker soils are moderately suited to farming. They are well suited to hardwoods. They have severe limitations for most nonfarm uses. These soils occupy small areas and consequently are not generally in cultivation. They are mainly idle or are in pasture.

Representative profile of Barker loam, 2 to 6 percent slopes, in a nonwooded area, SE¼NE¼ sec. 27, T. 32 N., R. 7 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam; moderate, medium, granular structure; friable; 5 percent coarse fragments; slightly acid; clear, smooth boundary.

A2—8 to 12 inches, brown (10YR 5/3) silt loam; moderate, medium, platy structure; friable; 5 percent coarse fragments; slightly acid; clear, smooth boundary.

B21t—12 to 14 inches, grayish-brown (2.5Y 5/2) heavy silt loam; moderate, medium, subangular blocky structure; firm; clay films; 10 percent coarse fragments; neutral; clear, smooth boundary.

B22t—14 to 26 inches, light olive-brown (2.5Y 5/4) silty clay loam; moderate, medium, angular blocky structure; very firm; clay films; 15 percent coarse fragments; neutral; clear, smooth boundary.

C—26 to 48 inches, light olive-brown (2.5Y 5/4) shaly silty clay loam; moderate, medium, angular blocky structure; very firm; 25 percent coarse fragments; mildly alkaline; slightly effervescent.

In a few profiles, shale bedrock ranges from a depth of 40 to 60 inches. Coarse fragments throughout the solum range from 1 to 15 percent by volume. They range from 20 to 35 percent by volume in the C horizon. The A1 horizon is black or very dark grayish brown. The B21t horizon is heavy silt loam or light silty clay loam. The C horizon is shaly silty clay loam or shaly clay loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Barker soils are similar to Barker soils, shallow variant, and Nester soils. They differ from Barker soils, shallow variant, in having bedrock at a depth of more than 40 inches rather than at a depth of 20 to 40 inches. Barker soils have yellower hues in the B and C horizons than the Nester soils. Also, coarse fragments in the Barker soils are dominantly shale.

Barker loam, 2 to 6 percent slopes (BaB).—This soil is on ridgetops and footslopes on uplands. It has the profile described as representative for the series.

Included with this soil in mapping were small, grayish-brown, eroded areas of soils and small areas of Emmet sandy loam and Leelanau loamy sand.

This soil is in cultivation, in pasture, or is idle. Surface runoff is medium. The main concerns of management are controlling water erosion and, in some areas, keeping good soil tilth. (Capability unit IIe-1(1.5a); woodland suitability group B)

Barker loam, 6 to 12 percent slopes (BaC).—This soil is on ridgetops, knolls, and foot slopes on uplands.

Included with this soil in mapping were a few, small, grayish-brown, eroded areas and small areas of Emmet sandy loam.

This soil is in cultivation, in pasture, or is idle. A few areas are wooded. Surface runoff is medium to rapid. The main concerns of management are controlling water erosion and, in some areas, keeping good soil tilth. (Capability unit IIIe-4 (1.5a); woodland suitability group B)

Barker loam, 12 to 25 percent slopes (BaE).—This soil is on hillsides on uplands. It has a profile similar to the one described as representative for the series, but it is thinner because of the steep slopes.

Included with this soil in mapping were many, small, grayish-brown, eroded areas of soils and a few shallow gullies.

This soil is idle or in pasture. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation in some areas is steepness of slopes. (Capability unit IVe-1 (1.5a); woodland suitability group B)

Barker Series, Shallow Variant

The Barker series, shallow variant, consists of somewhat poorly drained and moderately well drained, gently sloping soils on moraines. These soils formed in shaly clay less than 40 inches thick over shale bedrock.

In a representative profile, the surface layer is very dark gray loam 5 inches thick. The subsoil consists of two parts. The upper part is firm, olive-gray clay loam 4 inches thick and has yellowish-brown mottles. The lower part is very firm, olive clay 9 inches thick and has light olive-brown mottles. The underlying material is olive shaly clay 10 inches thick and has light olive-brown mottles. Below this, at a depth of 28 inches, is dark olive-gray shale bedrock.

Permeability is slow above the bedrock. The available water capacity is moderate. Organic-matter content is moderate, and natural fertility is high. Surface runoff is medium.

Barker soils, shallow variant, are poorly suited to farming or to woodland because they are moderately shallow to bedrock. They have severe limitations for many nonfarm uses. These soils are wooded or are used for pasture.

Representative profile of Barker loam, shallow variant, 2 to 6 percent slopes, in a nonwooded area, SE¼NW¼ sec. 9, T. 32 N., R. 7 W.:

Ap—0 to 5 inches, very dark gray (10YR 3/1) loam; moderate, very fine, subangular blocky structure; friable; 5 percent coarse fragments; neutral; abrupt, smooth boundary.

B21tg—5 to 9 inches, olive-gray (5Y 4/2) clay loam; many, fine, prominent, yellowish-brown (10YR 5/6) mottles; strong, fine, angular blocky structure; firm; clay films; 15 percent coarse fragments; medium acid; clear, wavy boundary.

B22t—9 to 18 inches, olive (5Y 4/3) clay; common, medium, distinct, light olive-brown (2.5Y 5/6) mottles; strong, fine, angular blocky structure; very firm; clay films; 15 percent coarse fragments; neutral; clear, wavy boundary.

C—18 to 28 inches, olive (5Y 4/3) shaly clay; common, medium, distinct, light olive-brown (2.5Y 5/6) mottles; strong, fine, angular blocky structure; very firm; 25 percent coarse fragments; mildly alkaline; slightly effervescent.

IIR—28 inches+, dark olive-gray (5Y 3/2) shale bedrock; slightly effervescent.

Depth to bedrock ranges from 20 to 40 inches. Coarse fragments range from 5 to 25 percent by volume in the solum and from 15 to 35 percent in the C horizon. Reaction throughout the solum ranges from medium acid to neutral. In a few profiles, an A2 horizon is present. The B horizon is clay loam or clay. The C horizon is clay loam or clay, or shaly analogs of these textures. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Barker soils, shallow variant, are similar to Barker soils. They differ from Barker soils in having bedrock at a depth of 20 to 40 inches rather than at a depth of more than 40 inches.

Barker loam, shallow variant, 2 to 6 percent slopes (BcB).—This soil is on foot slopes, ridgetops, and hilltops of uplands. The surface layer contains numerous shale fragments.

Included with this soil in mapping were very small areas of well-drained Emmet sandy loam and Leelanau loamy sand. Also included were very small areas of soils that have shale bedrock at a depth of 12 to 20 inches.

This soil is mainly in pasture and woods. A few areas are in cultivation. The main concerns of management are controlling water erosion and, in some areas, improving drainage. (Capability unit IVe-1 (1.5a/Ra); woodland suitability group T)

Belding Series

The Belding series consists of somewhat poorly drained, nearly level to gently sloping soils on lake plains and till plains. These soils formed in sandy loam over loam. In Charlevoix County the Belding soils were mapped only in a complex with the Breckenridge soils.

In a representative profile, the surface layer is dark-brown sandy loam 8 inches thick. The subsurface layer is grayish-brown sandy loam 3 inches thick. The subsoil consists of four parts. The upper part is yellowish-brown, very friable loamy sand 3 inches thick. The next part is brown, very friable sandy loam 2 inches thick. The next part is reddish-brown, friable sandy clay loam 8 inches thick. Below this is brown, friable sandy loam 10 inches thick. The underlying material, at a depth of 34 inches, is light-brown loam.

Permeability is moderately rapid in the subsoil and moderately slow in the underlying material. The available water capacity is moderate. Organic-matter content is moderate, and natural fertility is medium. Surface runoff is slow.

If drained, Belding soils are well suited to farming. They are generally poorly suited to woodland. They have moderate to severe limitations for many nonfarm uses. These soils are mainly in cultivation, but some areas are in woods or pasture.

Representative profile of a Belding sandy loam from an area of Belding-Breckenridge sandy loams, 0 to 4 percent slopes, in an unwooded area, NE¼SE¼ sec. 34, T. 33 N., R. 7 W.:

Ap—0 to 8 inches, dark-brown (10YR 3/3) sandy loam; weak, fine, granular structure; very friable; slightly acid; clear, smooth boundary.

A2—8 to 11 inches, grayish-brown (10YR 5/2) sandy loam; very weak, medium, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

Bir—11 to 14 inches, yellowish-brown (10YR 5/4) loamy sand; common, medium, faint, brown (10YR 4/3) mottles; weak, medium, subangular blocky structure; very friable; slightly acid; gradual, wavy boundary.

A'2—14 to 16 inches, brown (10YR 5/3) sandy loam; common, medium, faint, brown (10YR 4/3) mottles; weak, medium, subangular blocky structure; very friable; slightly acid; clear, smooth boundary.

B'2t—16 to 24 inches, reddish-brown (5YR 4/4) sandy clay loam; very weak, coarse, subangular blocky structure; friable; few thin clay films on surfaces of peds; slightly acid; clear, smooth boundary.

B'3—24 to 34 inches, brown (7.5YR 5/4) sandy loam; massive; friable; neutral; gradual, smooth boundary.
IIC—34 to 60 inches, light-brown (7.5YR 6/4) loam; massive; friable; 15 percent coarse fragments; mildly alkaline; slightly effervescent.

Glacial outwash material ranges from 18 to 42 inches in thickness over a IIC horizon of till or lacustrine material. The A'2 horizon is sandy loam or loamy sand. In a few profiles, the B' horizon formed in till or lacustrine material and is clay loam, loam, or silty clay loam. The C horizon is light brown, light reddish brown, or light yellowish brown. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The texture in the B' horizon is coarser and the color in the lower part of the soil profile is brighter than that of the defined range for the series. These differences, however, do not alter the usefulness and behavior of these soils.

The Belding soils are in toposequence with Breckenridge and Ubly soils. They are similar to Iosco and Charlevoix soils. Belding soils differ from Breckenridge soils in having browner colors or redder hues in the B horizon. They differ from Ubly soils in having mottles in the upper part of the subsoil. Belding soils are dominantly finer textured in the upper part of the profile than the Iosco soils. They are finer textured in the C horizon than the Charlevoix soils.

Belding-Breckenridge sandy loams, 0 to 4 percent slopes (BdA).—These soils are on undulating plains. The Belding soil makes up about 45 percent of the complex; the Breckenridge soil, about 45 percent; and included soils, about 10 percent. Belding sandy loam is on the higher, slightly convex mounds and rises. Intermingled with these areas are Breckenridge sandy loam in lower, slightly concave depressions, drainageways, and flats.

Included in mapping were small areas of Ubly sandy loam on higher crests of the undulating landscape.

These soils are in cultivation or in wood. The main concern of management is improving drainage. The main limitation is a hazard of frost in some years. (Capability unit IIw-8 (3/2b, 3/2c); woodland suitability group G)

Bergland Series

The Bergland series consists of poorly drained, nearly level to gently sloping soils in depressional areas on till plains. These soils formed in silty clay till. In Charlevoix County the Bergland soils were mapped only in a complex with the Sims soils.

In a representative profile, the surface layer is black silty clay loam 8 inches thick. The subsoil consists of two parts. The upper part is firm, brown silty clay loam 4 inches thick. The lower part is very firm, dark grayish-brown silty clay 6 inches thick and has dark yellowish-brown mottles. The underlying material, at a depth of 18 inches, is reddish brown silty clay with reddish-brown mottles.

Permeability is very slow. The available water capacity is moderate. Organic-matter content and natural fertility are high. Surface runoff is very slow.

If drained and not subject to frost, Bergland soils are moderately suited to farming. These soils are poorly suited to woodland. They have severe limitations for most nonfarm uses. Most areas of these soils are wooded.

Representative profile of a Bergland silty clay loam from an area of Bergland-Sims silty clay loams in a cultivated area, NW¼NW¼ sec. 29, T. 33 N., R. 8 W.:

A1—0 to 8 inches, black (10YR 2/1) silty clay loam; moderate, medium, granular structure; firm; slightly acid; clear, wavy boundary.
B1—8 to 12 inches, brown (10YR 5/3) silty clay loam; many, fine, faint, dark-brown (10YR 4/3) mottles; weak, medium, platy structure; firm; slightly acid; clear, wavy boundary.
B2g—12 to 18 inches, dark grayish-brown (10YR 4/2) silty clay; many, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, angular blocky structure; very firm; slightly acid; clear, wavy boundary.
C—18 to 60 inches, reddish-brown (5YR 5/3) silty clay; many, medium, faint, reddish-brown (5YR 4/4) mottles; moderate, medium, angular blocky structure; very firm; mildly alkaline; slightly effervescent.

The solum ranges from 16 to 36 inches in thickness. Reaction throughout the solum ranges from slightly acid to mildly alkaline. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The A1 horizon is thicker and the B and C horizons are lower in clay content than the defined range for the series, but these differences do not alter the usefulness and behavior of these soils.

The Bergland soils are in a toposequence with the Rudyard soils. They were mapped with the Sims soil. Bergland soils have a darker colored surface horizon than the Rudyard soils. They differ from the Sims soils in averaging a higher clay content between depths of 10 and 40 inches.

Bergland-Sims silty clay loams (0 to 4 percent slopes) (Be).—These soils are in narrow swales and flat depressions on clayey plains. The Bergland soil makes up about 50 percent of this complex; the Sims soil, 40 percent; and included soils, about 10 percent.

Included in mapping were small areas of thin, sandy overwash material and small areas of soils that have a thin, mucky surface layer less than 10 inches thick.

These soils are in cultivation where they are drained. Many areas are in woods. A few areas are in pasture or are idle. The main concern of management is improving drainage. The main limitations are restricted permeability and, in the lower areas, frost. (Capability unit IIIw-1 (1c, 1.5c); woodland suitability group P)

Blue Lake Series

The Blue Lake series consists of well-drained, nearly level to very steep soils on till plains and moraines. These soils formed in loamy sand or sand. In Charlevoix County the Blue Lake soils were mapped alone and in associations with Kalkaska soils.

In a representative profile, the surface layer is very dark grayish-brown loamy sand 9 inches thick. The subsurface layer is dark grayish-brown loamy sand 2 inches thick. The subsoil consists of three parts. The upper part is dark-brown, very friable loamy sand 14 inches thick. The middle part consists of thin, interbedded layers of loose, brown sand and dark-brown, very friable heavy loamy sand 25 inches thick. The lower part is reddish-brown, very friable sandy loam 10 inches thick. The underlying material, at a depth of 60 inches, is light brown sand.

Permeability is rapid in the upper 50 inches. The available water capacity is low. Organic-matter content is moderately low, and natural fertility is low.

The less sloping areas of Blue Lake soils are moderately suited to farming. These soils are moderately suited to hardwoods and well suited to pines. The less sloping areas have few limitations for nonfarm uses, and most of these areas are in cultivation. The steeper sloping areas are in woods or pasture.

Representative profile of Blue Lake loamy sand, 0 to 6 percent slopes, in a cultivated area, SE¼SE¼, sec. 33, T. 34 N., R. 6 W.:

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) loamy sand; very weak, fine, granular structure; very friable; medium acid; abrupt, smooth boundary.

A2—9 to 11 inches, dark grayish-brown (10YR 4/2) loamy sand; very weak, medium, platy structure; very friable; medium acid; abrupt, smooth boundary.

B21ir—11 to 18 inches, dark-brown (7.5YR 4/4) loamy sand; weak, medium, subangular blocky structure; very friable; a few weakly cemented chunks of ortstein; medium acid; clear, wavy boundary.

B22ir—18 to 25 inches, dark-brown (7.5YR 4/4) loamy sand; very weak, fine, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

A'&B'—25 to 50 inches, brown (7.5YR 5/4) sand (A'2); single grain; loose; bands of dark-brown (7.5YR 4/4) heavy loamy sand (B'21t); bands are 1 to 2 inches thick and are from 2 to 4 inches apart; clay bridges connect sand grains in bands; massive; very friable; slightly acid; gradual, irregular boundary.

B'22t—50 to 60 inches, reddish-brown (5YR 4/4) sandy loam; weak, medium, subangular blocky structure; very friable; few patchy clay films on ped surfaces; slightly acid; gradual, broken boundary.

C—60 to 66 inches, light-brown (7.5YR 6/4) sand; single grain; loose; slightly acid.

The solum ranges from 50 to 70 inches in thickness. Reaction throughout the solum is medium acid or slightly acid. In cultivated areas the A2 horizon is absent in a few profiles. The B't bands in the A'&B' and B'22t horizons are heavy loamy sand or light sandy loam. The C horizon ranges from slightly acid to mildly alkaline, and, in a few profiles, it is slightly effervescent.

The Blue Lake soils are in a toposequence with the Edmore and Otisco soils. They were mapped with Kalkaska soils. Blue Lake soils are similar to Leelanau and Mancelona soils. Blue Lake soils differ from Edmore and Otisco soils in lacking mottles in the solum. They differ from Kalkaska soils in having a clay-enriched B't horizon. Blue Lake soils differ from Leelanau and Mancelona soils in lacking coarse fragments in the profile.

Blue Lake loamy sand, 0 to 6 percent slopes (BlB).—This soil is on low ridges, knolls, and foot slopes on uplands. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of soils where shale bedrock is at a depth of less than 24 inches. Also included were a few small depressions of sandy overwash deposited on the original surface layer and a few small areas of Emmet sandy loam.

Most areas of this soil are in cultivation, but a few small areas are in woods. Surface runoff is slow. The main concerns of management are controlling soil blowing, conserving soil moisture, and maintaining fertility. (Capability unit IIIs–4 (4a); woodland suitability group C)

Blue Lake loamy sand, 6 to 12 percent slopes (BlC).—This soil is on ridges, knolls, and foot slopes on uplands.

Included with this soil in mapping were small areas where shale bedrock is at a depth of less than 24 inches and small areas of a dark-brown, eroded soil. Also included were small areas of Emmet sandy loam.

This soil is mainly in cultivation, but a few areas are in woods. Surface runoff is slow to medium. The main concerns of management are controlling water erosion, conserving soil moisture, and maintaining fertility. (Capability unit IIIe–9 (4a); woodland suitability group C)

Blue Lake loamy sand, 12 to 18 percent slopes (BlD).—This soil is on ridges and hillsides on uplands.

Included with this soil in mapping were small, dark-brown, eroded areas and small areas of Emmet sandy loam.

This soil is mainly in pasture, is idle, or is in woods. Surface runoff is medium. The main concerns of management are controlling water erosion, conserving soil moisture, and maintaining fertility. (Capability unit IVe–9 (4a); woodland suitability group C)

Blue Lake loamy sand, 18 to 50 percent slopes (BlF).—This soil is on hillsides on uplands.

Included with this soil in mapping were very small areas of soils where shale bedrock is at a depth of less than 24 inches and a few small areas of dark-brown, eroded soils. Also included were a few small areas of Emmet sandy loam.

This soil is mainly in woods, but a few areas are in pasture or are idle. Surface runoff is medium. The main concern of management is controlling water erosion. The main limitation is steepness of slopes. (Capability unit VIe-2 (4a); woodland suitability group C)

Blue Lake-Kalkaska association, undulating (0 to 6 percent slopes) (BkB).—These soils are on undulating sandy plains. Blue Lake and Kalkaska soils make up 80 percent of this association, and the rest is included soils. The Blue Lake soil has a loamy sand surface layer, and the Kalkaska soil has a sand surface layer.

Included in mapping were areas of somewhat poorly drained Au Gres sand along the edges of swamps. Also included were small areas of dark-brown, eroded soils.

These soils are mainly in pasture or are idle, but a few areas are in cultivation. Small areas are in woods. Surface runoff is slow. The main concerns of management are controlling soil blowing, conserving soil moisture, and maintaining fertility. (Capability unit IIIs-4 (4a, 5a); woodland suitability group C)

Blue Lake-Kalkaska association, rolling (6 to 18 percent slopes) (BkC).—These soils are in rolling areas on uplands. The Blue Lake soil has a loamy sand surface layer, and the Kalkaska soil has a sand surface layer.

Included in mapping were small, dark-brown, eroded areas of gravelly East Lake sand.

These soils are mainly in woods. A few areas are in pasture or are idle. Surface runoff is medium. The main concerns of management are controlling water erosion, conserving soil moisture, and maintaining fertility. (Capability unit IVe–9 (4a, 5a); woodland suitability group C)

Breckenridge Series

The Breckenridge series consists of very poorly drained, nearly level to gently sloping soils in depressional areas on lake plains and till plains. These soils formed in sandy loam and in the underlying stratified silt loam and silty clay loam. In Charlevoix County Breckenridge soils were mapped only in a complex with Belding soils.

In a representative profile, the surface layer is black sandy loam 9 inches thick. The subsurface layer is grayish-brown loamy sand 4 inches thick. The subsoil consists of three parts. The upper part is grayish-brown, friable loam 7 inches thick and has yellowish-brown mottles. The middle part is light olive-brown, friable sandy loam 11 inches thick and has dark yellowish-brown mot-

tles. The lower part is firm, light brownish-gray stratified silt loam and silty clay loam 5 inches thick and has dark yellowish-brown mottles. The underlying material, at a depth of 36 inches, is grayish-brown stratified silty loam and silty clay loam.

Permeability is moderately rapid in the upper part of the subsoil and moderately slow in the lower part of the subsoil and in the underlying material. The available water capacity is moderate in the upper part of the subsoil and high in the lower part of the subsoil and in the underlying material. Organic-matter content is high, and natural fertility is medium. Surface runoff is very slow to ponded.

If drained and not subject to frost, the Breckenridge soils are well suited to farming. They are generally poorly suited to woodland. They have severe limitations for most nonfarm uses. Most areas of these soils are cultivated as inclusions in less wet areas of Belding soils.

Representative profile of a Breckenridge sandy loam in an area of Belding-Breckenridge sandy loams, 0 to 4 percent slopes, in a nonwooded area, NW¼SW¼SE¼ sec. 3, T. 38 N., R. 10 W.:

A1—0 to 9 inches, black (10YR 2/1) sandy loam; moderate, fine, granular structure; friable; slightly acid; clear, wavy boundary.

A2g—9 to 13 inches, grayish-brown (2.5Y 5/2) loamy sand; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, thin, platy structure; friable; slightly acid; gradual, wavy boundary.

B2g—13 to 20 inches, grayish-brown (10YR 5/2) loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; moderate, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B31—20 to 31 inches, light olive-brown (2.5Y 5/4) sandy loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIB32g—31 to 36 inches, light brownish-gray (10YR 6/2) stratified silt loam and silty clay loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, medium, subangular blocky structure; firm; neutral; gradual, wavy boundary.

IIC—36 to 60 inches, grayish-brown (10YR 5/2) stratified silt loam and silty clay loam; weak, medium, subangular blocky structure; firm; mildly alkaline; slightly effervescent.

Depth to the IIB or IIC horizons ranges from 18 to 39 inches. In a few profiles, thin strata of sandy material are in the B, IIB, and IIC horizons. Reaction throughout the solum ranges from slightly acid to mildly alkaline. The IIB horizon commonly is absent. The IIC horizon is loam, silt loam, clay loam, or silty clay loam. It is neutral to moderately alkaline and is slightly effervescent.

The color in part of the B horizon is brighter than the defined range for the series, but this difference does not alter the usefulness or behavior of these soils.

Breckenridge soils in Charlevoix County, are near Ubly soils in most areas. They were mapped with Belding soils. Breckenridge soils are similar to Brevort and Munuscong soils. Breckenridge soils differ from Ubly soils in having mottles in the solum. They differ from Belding soils in having grayer, more olive, or yellower hues in the B horizon. Breckenridge soils are dominantly finer textured in the solum than Brevort soils. They contain less total clay separates in the C horizon than Munuscong soils.

Brevort Series

The Brevort series consists of poorly drained or very poorly drained soils in depressional areas on lake plains. These soils formed in sand 18 to 42 inches thick over loam.

In a representative profile, the surface layer is black loamy sand 4 inches thick. The subsoil consists of two parts. The upper part is loose, gray sand 11 inches thick. The lower part is loose, grayish-brown sand 7 inches thick. The underlying material, at a depth of 22 inches, is brown loam.

Permeability is rapid in the sandy layers and moderately slow in the underlying loam. The available water capacity is low in the sandy layers and high in the underlying material. Organic-matter content is high, and natural fertility is low. Surface runoff is very slow to ponded.

Brevort soils are poorly suited to farming and to woodland. They are well suited as habitat for wetland wildlife. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of Brevort loamy sand in a cultivated area, SE¼SE¼ sec. 27, T. 32 N., R. 7 W.:

A1—0 to 4 inches, black (10YR 2/1) loamy sand; very weak, fine, granular structure; very friable; neutral; clear, smooth boundary.

B21g—4 to 15 inches, gray (10YR 6/1) sand; single grain; loose; neutral; gradual, smooth boundary.

B22—15 to 22 inches, grayish-brown (10YR 5/2) sand; single grain; loose; neutral; clear, wavy boundary.

IIC—22 to 60 inches, brown (10YR 5/3) loam; weak, coarse, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The thickness of the solum ranges from 20 to 39 inches and commonly is the same as the depth of the IIC horizon. Coarse fragments throughout the sandy material range from less than 1 percent to 5 percent by volume. The sandy material is neutral or mildly alkaline throughout. The IIC horizon is loam, clay loam, or silty clay loam and is less than 1 percent to about 15 percent coarse fragments by volume. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The A horizon of these soils is thinner, and the color in the lower part of the profile is brighter than the defined range for the series, but these differences do not alter usefulness and behavior of these soils.

The Brevort soils are in a toposequence with the Iosco and Menominee soils. They are similar to Breckenridge and Roscommon soils. Brevort soils are grayer in the B horizon than the Iosco and Menominee soils. They are predominantly coarser textured in the solum than the Breckenridge soils. Brevort soils differ from Roscommon soils in having a finer textured C horizon.

Brevort loamy sand (0 to 4 percent slopes) (Bv).—This nearly level to gently sloping soil is in depressions and small, flat areas of sandy plains.

Included with this soil in mapping were small areas of Iosco loamy sand on low mounds and ridges and small areas of Roscommon sand and Carbondale muck in narrow depressions.

This Brevort soil is mainly wooded, but a few areas are in cultivation. The main concerns of management are improving drainage and maintaining fertility. (Capability unit IIIw-9 (4/2c); woodland suitability group W)

Brimley Series

The Brimley series consists of somewhat poorly drained, nearly level to gently sloping soils on lake plains, outwash plains, and deltas. These soils formed in stratified silt and very fine sand.

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In a representative profile, the surface layer is very dark grayish-brown loam 8 inches thick. The subsurface layer is light brownish-gray loam 3 inches thick and has yellowish-brown mottles. The subsoil consists of three parts. The upper part is light yellowish-brown, friable loam 3 inches thick. The middle part is brown, friable fine sandy loam 4 inches thick. The lower part is firm, brown heavy loam 7 inches thick. The underlying material, at a depth of 25 inches, is light brownish-gray stratified silt and very fine sand with dark yellowish-brown mottles.

Permeability is moderate. The available water capacity is high. Organic-matter content is moderate, and natural fertility is high. Surface runoff is slow.

If drained, Brimley soils are well suited to farming. They are generally poorly suited to woodland. They have moderate to severe limitations for many nonfarm uses. These soils are mainly in pasture or in woods.

Representative profile of a Brimley loam from an area of Brimley soils, 0 to 6 percent slopes, in a cultivated area, NE¼SW¼ sec. 4, T. 33 N., R. 8 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam; moderate, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A2—8 to 11 inches, light brownish-gray (10YR 6/2) loam; common, fine, distinct, yellowish-brown (10YR 5/4) mottles; moderate, medium, platy structure; friable; slightly acid; clear, wavy boundary.

Bir—11 to 14 inches, light yellowish-brown (10YR 6/4) loam; common, fine, faint, brown (10YR 5/3) mottles; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

A'2—14 to 18 inches, brown (10YR 5/3) fine sandy loam; common, medium, faint, brown (10YR 4/3) mottles; weak, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B't—18 to 25 inches, brown (10YR 4/3) heavy loam; common, medium, faint, dark yellowish-brown (10YR 3/4) mottles; moderate, medium, subangular blocky structure; firm; clay films; neutral; clear, smooth boundary.

C—25 to 60 inches, light brownish-gray (10YR 6/2) stratified silt and very fine sand; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; friable; mildly alkaline; slightly effervescent.

The solum ranges from 24 to 36 inches in thickness. In a few profiles, thin strata of sandy or clayey material are in the solum. The A2 and the Bir horizons are silt loam, fine sandy loam, or loam. The A'2 horizon is silt loam or fine sandy loam. The B't horizon is heavy loam, heavy silt loam, or heavy fine sandy loam. The C horizon is silt, very fine sand, or silt loam, but a few profiles have thin strata of other textures. The C horizon is mildly alkaline or moderately alkaline. It is slightly effervescent.

Brimley soils are in a toposequence with the Bruce soils. They are similar to Mackinac and Rudyard soils. Brimley soils are browner or redder in the B horizon than Bruce soils. They differ from Mackinac soils in lacking coarse fragments throughout the profile and in having stratification in the C horizon. Brimley soils are coarser textured in the B and C horizons than the Rudyard soils.

Brimley soils, 0 to 6 percent slopes (BwB).—These soils are on low knolls and ridges on broad plains. They have a profile similar to the one described as representative for the series, but the surface layer is loamy fine sand, silt loam, and fine sandy loam, as well as loam.

Included with these soils in mapping were small areas of well-drained loamy soils. Also included were small areas of poorly drained Bruce soils where the soils in this unit are adjacent to swamps.

These soils are mainly in pasture or woods. They are in cultivation where they are drained. The main concern of management is improving drainage. (Capability unit IIw-4 (2.5b); woodland suitability group Z)

Bruce Series

The Bruce series consists of poorly drained, nearly level to gently sloping soils in depressional areas on outwash plains, lake plains, and deltas. These soils formed in stratified silt loam and very fine sand.

In a representative profile, the surface layer is very dark brown silt loam 9 inches thick. The subsoil consists of three parts. The upper part is light olive-gray, friable silt loam 3 inches thick and has olive mottles. The middle part is olive-gray, friable loam 8 inches thick and has olive mottles. The lower part is very firm olive clay loam 4 inches thick and has olive-gray mottles. The underlying material, at a depth of 24 inches, is light olive-gray stratified silt loam and very fine sand.

Permeability is moderate. The available water capacity is high. Organic-matter content and natural fertility are high. Surface runoff is very slow.

If drained and not subject to frost, the Bruce soils are well suited to farming. They are poorly suited to woodland. They have severe limitations for most nonfarm uses. Most areas of these soils are in woods or pasture.

Representative profile of a Bruce silt loam from an area of Bruce soils in a wooded area, NE¼NE¼ sec. 34, T. 33 N., R. 8 W.:

A1—0 to 9 inches, very dark brown (10YR 2/2) silt loam; moderate, medium, granular structure; friable; slightly acid; clear, smooth boundary.

B1g—9 to 12 inches, light olive-gray (5Y 6/2) silt loam; common, medium, distinct, olive (5Y 4/3) mottles; moderate, medium, platy structure; friable; slightly acid; gradual, smooth boundary.

B21g—12 to 20 inches, olive-gray (5Y 5/2) loam; many, fine, distinct, olive (5Y 4/4) mottles; moderate, medium, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B22—20 to 24 inches, olive (5Y 5/3) clay loam; many, medium, distinct, dark olive-gray (5Y 3/2) mottles; moderate, medium, angular blocky structure; very firm; neutral; gradual, smooth boundary.

C—24 to 60 inches, light olive-gray (5Y 6/2) stratified silt loam and very fine sand; massive; friable; mildly alkaline; slightly effervescent.

An organic layer ranging from 1 to 3 inches in thickness is at the surface in a few profiles. The B horizon is silt loam, loam, silty clay loam, or clay loam. The dominant sand separates for textures in the B horizon are very fine sand and fine sand. In the B horizon of a few profiles, there are thin strata of sandy or clayey material. The C horizon is stratified very fine sand, silt, or silt loam. It is variable in sequence of textures within short distances. In a few profiles, thin strata of finer textured or coarser textured material are in the C horizon. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

In Bruce soils in Charlevoix County, the lower part of the B horizon is brighter colored than the defined range for the series, but this difference does not alter the usefulness or behavior of these soils.

Bruce soils are in a toposequence with Brimley soils. Bruce soils are similar to Angelica and Ensley soils. Bruce soils are grayer, more olive, or yellower in the B horizon than the Brimley soils. They differ from Angelica soils in lacking coarse fragments throughout the profile and in having stratification in the C horizon. Also they average a higher clay content between depths of 10 and 40 inches than the Ensley soils.

Bruce soils (0 to 4 percent slopes) (By).—These soils are in depressional areas on broad plains. They have a profile similar to the one described as representative for the series, but the surface layer is loam, sandy loam, and fine sandy loam, as well as silt loam.

Included with these soils in mapping were small areas of somewhat poorly drained Brimley soils on low knolls and in other, slightly higher positions. Where these soils are adjacent to swamps, a few small areas of Carbondale muck were also included.

These soils are mainly in woods or pasture. A few areas have been drained and are in cultivation. The main concern of management is improving drainage. (Capability unit IIw-4 (2.5c); woodland suitability group P)

Carbondale Series

The Carbondale series consists of very poorly drained, nearly level to gently sloping organic soils in depressional areas on lake plains, till plains, and outwash plains. These soils formed in organic materials more than 42 inches thick. In Charlevoix County the Carbondale soils were mapped alone and in an association with Tawas soils.

In a representative profile, the surface layer is black muck 14 inches thick. The next layer is very dark grayish-brown muck 14 inches thick. Below this, at a depth of 28 inches, is brown mucky peat.

Permeability is moderately rapid. The available water capacity is high. Natural fertility is low. Surface runoff is ponded.

Carbondale soils are very poorly suited to farming. They have variable suitability as woodland. They are well suited as habitat for wetland wildlife. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of Carbondale muck in a wooded area, 700 feet west of Chesapeake and Ohio Railroad, SW¼SW¼ sec. 2, T. 33 N., R. 8 W.:

O1—0 to 14 inches, black (10YR 2/1) muck; moderate, medium, granular structure; friable; slightly acid; gradual, smooth boundary.

O2—14 to 20 inches, very dark grayish-brown (10YR 3/2) muck; weak, medium, granular structure; friable; neutral; clear, smooth boundary.

O3—20 to 28 inches, very dark grayish-brown (10YR 3/2) muck; massive; friable; neutral; clear, smooth boundary.

O4—28 to 42 inches, brown (10YR 4/3) mucky peat; massive; friable; neutral.

The organic material is generally 42 inches thick. Partially decomposed woody fragments range from none to many throughout the profile. The reaction throughout this material ranges from strongly acid to mildly alkaline. The 01 layer is black or very dark brown.

Carbondale soils are similar to Cathro, Edwards, Greenwood, Kerston, Linwood, Lupton, Markey, and Warners soils. They were mapped with Tawas soils. Carbondale soils differ from all of these, except Greenwood and Lupton soils, in lacking mineral material or marl between depths of 12 and 42 inches. Carbondale soils dominantly have more decomposed organic material in most layers between depths of 12 and 42 inches and are less acid throughout than the Greenwood soils. Carbondale soils have less decomposed organic material in a soil layer or in thin soil layers between depths of 12 and 42 inches and are less alkaline throughout the profile than the Lupton soils.

Carbondale muck (0 to 4 percent slopes) (Ca).—This soil is in broad depressions, on plains, on low foot slopes adjacent to the plains, and in small potholes on uplands. This soil is the result of hillside seepage from adjacent uplands.

Included with this soil in mapping were narrow areas of sandy overwash, ranging from 5 to 10 inches in thickness, near the edges of areas of this soil. Also included were small areas of poorly drained Roscommon sand and small areas of Tawas muck and Linwood muck.

This soil is mainly in woods or pasture. The main concerns of management are improving drainage and controlling soil blowing. The main limitation is a hazard of frost. (Capability unit VIwc-1 (Mc); woodland suitability group J)

Cathro Series

The Cathro series consists of very poorly drained, nearly level to gently sloping organic soils in depressional areas on moraines, lake plains, outwash plains, and till plains. These soils formed in organic material 12 to 42 inches thick over loam.

In a representative profile, the surface layer is black muck 8 inches thick. The next layer is dark-brown muck 6 inches thick. Below this is brown muck 12 inches thick. The underlying material, at a depth of 26 inches, is grayish-brown loam.

Permeability is moderately rapid in the muck layers and moderate in the underlying loam. The available water capacity is high. Natural fertility is low. Surface runoff is ponded.

The Cathro soils are very poorly suited to farming. They are variably suited to woodland. They are well suited as habitat for wetland wildlife. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of Cathro muck in a wooded area, SW¼SW¼ sec. 12, T. 33 N., R. 6 W.:

O1—0 to 8 inches, black (10YR 2/1) muck; weak, fine, granular structure; friable; mildly alkaline; gradual, smooth boundary.

O2—8 to 14 inches, dark-brown (7.5YR 3/2) muck; moderate, medium, granular structure; friable; mildly alkaline; gradual, wavy boundary.

O3—14 to 26 inches, brown (7.5YR 4/2) muck; massive; friable; mildly alkaline; clear, smooth boundary.

IIC—26 to 60 inches, grayish-brown (10YR 5/2) loam; massive, separating to very weak, medium, subangular blocky structure; friable; mildly alkaline; slightly effervescent.

Organic material ranges from 12 to 42 inches in thickness and is underlain by loamy material. In a few profiles, thin layers of mucky peat or peat are in the subsurface part of the organic material. Reaction throughout the organic material is neutral or mildly alkaline. The subsurface organic layers are very dark grayish brown, dark reddish brown, dark brown, or brown. The IIC horizon is slightly alkaline or moderately alkaline and is slightly effervescent.

Cathro soils are similar to Carbondale, Edwards, Greenwood, Kerston, Linwood, Lupton, Markey, Tawas, and Warners soils. Cathro soils have thinner organic material, less than 42 inches thick, than the Carbondale, Greenwood, and Lupton soils. They differ from Edwards, Markey, Tawas, and Warners soils in lacking sandy material or marl between a depth of 12 to 42 inches. Cathro soils differ from Kerston soils in lacking two or more strata of mineral material below the surface layer that are separated by organic layers. Cathro soils are more alkaline throughout the organic material than Linwood soils.

Cathro muck (0 to 4 percent slopes) (Cc).—This soil is in broad depressions on plains and in small potholes on uplands. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of soils that have a thin layer of sandy overwash material ranging from 6 to 10 inches in thickness eroded from surrounding uplands. A few small areas of Lupton muck were also included.

This soil is mainly in pasture and woodland. The main concerns of management are improving drainage and controlling soil blowing. The main limitation is a hazard of frost. (Capability unit VIwc-1 (M/3c); woodland suitability group J)

Charlevoix Series

The Charlevoix series consists of somewhat poorly drained, nearly level to gently sloping soils on moraines, till plains, and lake plains. These soils formed in sandy loam till. In Charlevoix County Charlevoix soils were mapped in an association with Kawkawlin soils and in complexes with Mackinac soils.

In a representative profile, the surface layer is very dark brown loam 8 inches thick. The subsurface layer is brown sandy loam 3 inches thick and has yellowish-brown mottles. The subsoil consists of two parts. The upper part is yellowish-brown, friable sandy loam 5 inches thick. The lower part is brown, friable loam 6 inches thick and has strong-brown mottles. The underlying material, at a depth of 22 inches, is light brownish-gray sandy loam and has yellowish-brown mottles.

Permeability is moderate. The available water capacity is moderate. The organic-matter content is moderate, and natural fertility is medium. Surface runoff is slow.

If drained and not cobbly, the Charlevoix soils are well suited to farming. The cobbly areas are poorly suited to farming. They are moderately suited to hardwoods but are poorly suited to pines. They have moderate to severe limitations for many nonfarm uses. The nearly level to gently sloping Charlevoix loams are mainly in cultivation. Most areas of the nearly level to gently sloping Charlevoix cobbly loams and the undulating Charlevoix soils are wooded.

Representative profile of a Charlevoix loam from an area of Charlevoix-Mackinac loams, 0 to 6 percent slopes, in a wooded area, SE. corner, SE¼SW¼ sec. 4, T. 33 N., R. 8 W.:

A1—0 to 8 inches, very dark brown (10YR 2/2) loam; moderate, medium, granular structure; friable; less than 5 percent coarse fragments; mildly alkaline; clear, smooth boundary.

A2—8 to 11 inches, brown (10YR 5/3) sandy loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, thin, platy structure; friable; less than 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

Bir—11 to 16 inches, yellowish-brown (10YR 5/4) sandy loam; many, medium, faint, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

B't—16 to 22 inches, brown (10YR 5/3) loam; common, fine, prominent, strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; friable; clay films; less than 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

Cg—22 to 60 inches, light brownish-gray (2.5Y 6/2) sandy loam; common, fine, distinct, yellowish-brown (10YR 5/4) mottles; weak, coarse, subangular blocky structure; friable; 10 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 20 to 40 inches in thickness. The B't horizon is loam, heavy sandy loam, or sandy clay loam. The solum of these Charlevoix soils is more alkaline than the defined range for the series, but this difference does not alter the usefulness or behavior of these soils.

Charlevoix soils formed in materials similar to those in which Emmet and Ensley soils formed. They were mapped with Kawkawlin soils and with Mackinac soils. Charlevoix soils are similar to Belding soils. Charlevoix soils differ from Emmet soils in having mottles in the solum. They differ from Ensley soils in having a B't horizon and in having redder hues in the A2 horizon and in the upper part of the B horizon. Charlevoix soils contain, on an average, less clay in the B horizon and have a coarser texture in the C horizon than the Kawkawlin soils. They contain, on an average, less clay at a depth of 10 to 40 inches than the Mackinac soils. Also, Charlevoix soils have coarser texture throughout the C horizon than Mackinac soils. Charlevoix soils have a coarser texture in the C horizon than the Belding soils.

Charlevoix-Kawkawlin association, undulating (0 to 6 percent slopes) (CKB).—These soils are on undulating loamy plains on the mainland and on Beaver Island. Charlevoix loam and Kawkawlin loam make up 80 percent of this association, and the rest is included soils.

Included in mapping were small areas of Otisco loamy sand at slightly higher elevations. Also included were areas of poorly drained to very poorly drained Brevort loamy sand in depressions.

These soils are mainly in woods or are idle. A few areas are in cultivation where these soils are drained. The main concern of management is improving drainage. (Capability unit IIw-4 (3b, 1.5b); woodland suitability group Z)

Charlevoix-Mackinac loams, 0 to 6 percent slopes (CmB).—These soils are in swales, in drainageways, on low knolls, and on foot slopes of the uplands. The Charlevoix soil in this complex has the profile described as representative for the Charlevoix series. The Charlevoix soil makes up about 50 percent of the complex; the Mackinac soil, 30 percent; and included soils, about 20 percent.

Included in mapping were small, higher areas of well-drained Emmet sandy loam and small, lower areas of poorly drained Angelica and Ensley loams. Some small areas of soils are covered with 4 to 10 inches of sandy overwash. Also included were small stony areas.

These soils are in cultivation where they are adequately drained. Undrained areas are in pasture or woods. The main concern of management is improving drainage. (Capability unit IIw-4 (3b, 2.5b); woodland suitability group Z)

Charlevoix-Mackinac cobbly loams, 0 to 6 percent slopes (CnB).—These soils are on undulating plains. The Charlevoix soil makes up about 50 percent of the complex; the Mackinac soil, 30 percent; and included soils, about 20 percent.

Included in mapping were small, low areas of Angelica and Ensley loams. Also included were small areas of soils that have a sandy loam surface layer.

These soils are in pasture or woods. The cobblestones interfere greatly with normal tillage operations. The main concern of management is improving drainage. The main limitation is the cobblestones. (Capability unit Vw–1 (3b, 2.5b); woodland suitability group Z)

Croswell Series

The Croswell series consists of moderately well drained, nearly level to gently sloping soils on outwash plains and lake plains. These soils formed in sand.

In a representative profile, the surface layer is very dark grayish-brown sand 5 inches thick. The subsurface layer is light brownish-gray sand 5 inches thick. The subsoil is loose to very friable, yellowish-brown and brown sand 38 inches thick. The lower 20 inches of the subsoil has yellowish-brown mottles. The underlying material, at a depth of 48 inches, is brown sand that has yellowish-brown mottles.

Permeability is rapid. The available water capacity is low. Organic-matter content is moderate, and natural fertility is low. Surface runoff is very slow.

Croswell soils are poorly suited to farming. They are poorly suited to hardwoods but are suited to aspen and pine. They have moderate limitations for many nonfarm uses. They are mainly wooded. Some areas are in pasture.

Representative profile of Croswell sand, 0 to 4 percent slopes, in a nonwooded area, SE¼NE¼ sec. 10, T. 32 N., R. 5 W.:

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) sand; very weak, fine, granular structure; very friable; medium acid; clear, wavy boundary.

A2—5 to 10 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; medium acid; clear, wavy boundary.

B21ir—10 to 14 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; medium acid; gradual, wavy boundary.

B22ir—14 to 28 inches, brown (10YR 5/3) sand; single grain; very friable; slightly acid; gradual, wavy boundary.

B3—28 to 48 inches, brown (10YR 4/3) sand; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; slightly acid; gradual, wavy boundary.

C—48 to 60 inches, brown (10YR 5/3) sand; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; slightly acid.

Depth to mottling ranges from 24 to 40 inches. In cultivated areas the A2 horizon is thin or is absent in many soil profiles. The C horizon is slightly acid or neutral.

Croswell soils on most landscapes are near the Au Gres, Kalkaska, Roscommon, Rubicon, Saugatuck, and Wallace soils. They differ from Au Gres and Saugatuck soils in lacking mottles in the A2 horizon or in the upper part of the B horizon. Croswell soils lack the ortstein that is in the B horizon of the Saugatuck and Wallace soils. They differ from Kalkaska, Rubicon, and Wallace soils in having mottles in the lower part of the B horizon and in the C horizon. They differ from Roscommon soils in having a lighter colored A1 or Ap horizon and in having mottles at greater depths.

Croswell sand, 0 to 4 percent slopes (CrA).—This soil is on broad, sandy plains. It frequently occurs between areas of well-drained Kalkaska sand and somewhat poorly drained Au Gres sand.

Included with this soil in mapping were small areas of Kalkaska sand in slightly higher positions and small areas of Au Gres sand in depressions.

This soil is mainly in pasture, in woods, or is idle. A few small areas are in hay crops. The main concerns of management are conserving soil moisture, maintaining fertility, and controlling soil blowing. (Capability unit IVs-4 (5a); woodland suitability group E)

Deer Park Series

The Deer Park series consists of well-drained, nearly level to very steep soils on dunes and beach ridges. These soils formed in sand. In Charlevoix County the Deer Park soils are mapped only in associations with Dune land.

In a representative profile, the surface layer is very dark grayish-brown fine sand 3 inches thick. The subsurface layer is grayish-brown fine sand 4 inches thick. The subsoil is loose, brown and yellowish-brown sand 13 inches thick. The underlying material, at a depth of 20 inches, is brown sand.

Permeability is rapid. The available water capacity is low. Organic-matter content and natural fertility are low. Surface runoff is slow.

Deer Park soils are very poorly suited to farming. They are poorly suited to hardwoods but are moderately suited to pines. The less sloping areas have few limitations for nonfarm uses. Most areas are wooded or are idle. They are used mainly for recreation.

Representative profile of a Deer Park fine sand from an area of Deer Park-Dune land association, undulating, in a wooded area, NE¼SE¼ sec. 1, T. 33 N., R. 8 W.:

O1—1 inch to 0, very dark brown (10YR 2/2) litter of leaves and leaf mold.

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) fine sand; single grain; loose; medium acid; gradual, wavy boundary.

A2—3 to 7 inches, grayish-brown (10YR 5/2) fine sand; single grain; loose; medium acid; gradual, wavy boundary.

B21—7 to 16 inches, brown (10YR 5/3) sand; single grain; loose; medium acid; gradual, wavy boundary.

B22—16 to 20 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; medium acid; gradual, wavy boundary.

C—20 to 60 inches, brown (10YR 5/3) sand; single grain; loose; slightly acid.

The solum typically ranges from 18 to 36 inches in thickness, but in places it ranges to a depth of 40 inches. Fine sand ranges from 7 to 30 inches in thickness. Reaction throughout the solum is strongly acid or medium acid. The A1 horizon is very dark gray or very dark grayish brown. The A2 horizon is gray, grayish brown, or dark grayish brown.

The texture in the lower part of the profile is coarser and the difference in color between the A2 and B21 horizons is less than the defined range for the series, but these differences do not alter the usefulness and behavior of these soils.

Deer Park soils are similar to Eastport and Rubicon soils. They are mapped with Dune land. Deer Park soils are more acid in the lower part of the B horizon and in the C horizon than Eastport soils. They have more particles of fine sand and very fine sand in soil horizons with the texture class of sand than Rubicon soils.

Deer Park-Dune land association, undulating (0 to 6 percent slopes) (DDB).—This soil and this land type are on undulating beach ridges and dunes near the Lake Michigan shoreline. Deer Park soils and Dune land make up 85 percent of this association, and the rest is included soils. The Deer Park soil has the profile described as representative for the series. Dune land consists of shifting sands.

Included in mapping were small areas of Alpena, Eastport, and East Lake soils. Also included were areas of poorly drained and somewhat poorly drained soils in swales.

This association is wooded or is idle. The main concern of management is controlling soil blowing. (Ca-

pability unit VIIs–1 (5.3a); woodland suitability group H)

Deer Park-Dune land association, rolling (6 to 18 percent slopes) (DDC).—This soil and this land type are on rolling dunes near Lake Michigan. Deer Park soils and Dune land make up 85 percent of this association, and the rest is included soils. The Dune land consists of shifting sands.

Included in mapping were small areas of Alpena, Eastport, and East Lake soils.

This association is wooded or is idle. The main concern of management is controlling soil blowing. (Capability unit VIIs-1 (5.3a); woodland suitability group H)

Deer Park-Dune land association, hilly (18 to 30 percent slopes) (DDE).—This soil and this land type are on hilly dunes near Lake Michigan. The Deer Park soils and Dune land make up 85 percent of this association, and the rest is included soils. Dune land consists of shifting sands.

Included in mapping were small areas of Alpena, East Lake, and Eastport soils and many small, severely eroded areas or blowouts. These blowout areas are shown on the soil map by a special symbol. Also included are a few areas of very steep soils that have slopes ranging from 30 to 50 percent.

This association is wooded or is idle. The main concern of management is controlling soil blowing. The main limitation is the steepness of slopes. (Capability unit VIIs-1 (5.3a); woodland suitability group H)

Detour Series

The Detour series consists of somewhat poorly drained, nearly level to gently sloping soils on lake plains and lake terraces. These soils formed in compact, cobbly sandy loam till.

In a representative profile, the surface layer is very dark grayish-brown cobbly loam 6 inches thick. Some stones and boulders are present in this layer. The subsurface layer is grayish-brown cobbly loam with yellowish-brown mottles and is 4 inches thick. The subsoil is dark yellowish-brown, firm cobbly sandy clay loam with grayish-brown mottles and is 10 inches thick. It is stony and bouldery. The underlying material, at a depth of 20 inches, is grayish-brown cobbly sandy loam with yellowish-brown mottles. It contains many stones and boulders.

Permeability is moderately slow. The available water capacity is moderate. Organic-matter content is moderate, and natural fertility is medium. Surface runoff is slow.

The Detour soils are very poorly suited to farming because of wetness and cobblestones in the surface layer. They are moderately suited to hardwoods but are poorly suited to pines. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of Detour cobbly loam, 0 to 6 percent slopes, in a nonwooded area, NW¼NW¼ sec. 7, T. 33 N., R. 8 W.:

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) cobbly loam, strong, medium, granular structure; friable; 20 percent coarse fragments; neutral; clear, wavy boundary.

A2—6 to 10 inches, grayish-brown (10YR 5/2) cobbly loam; many, medium, distinct, yellowish-brown (10YR 5/6) mottles; moderate, medium, platy structure; friable; 20 percent coarse fragments; clear, wavy boundary.

B2t—10 to 20 inches, dark yellowish-brown (10YR 4/4) cobbly sandy clay loam; many fine, distinct, grayish-brown (10YR 5/2) mottles; moderate, medium, subangular blocky structure; firm; 25 percent coarse fragments; mildly alkaline; clear, wavy boundary.

Cg—20 to 40 inches, grayish-brown (10YR 5/2) cobbly sandy loam; many, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, coarse, subangular blocky structure; firm; 25 percent coarse fragments; moderately alkaline; slightly effervescent.

The solum ranges from 15 to 24 inches in thickness. Bedrock commonly is at a depth of 40 to 60 inches. The B2t horizon is loam, heavy sandy loam, light clay loam, sandy clay loam, or cobbly analogs of these textures.

Detour soils formed in materials similar to those in which the Hessel and Johnswood soils formed. Detour soils are similar to the Mackinac soils. Detour soils are less grayish in the B horizon or are redder in the B and C horizons than the Hessel soils. They differ from the Johnswood soils in having grayish mottles in the B horizon. Detour soils differ from Mackinac soils in being more compact in the B and C horizons and in having more cobblestones throughout the profile.

Detour cobbly loam, 0 to 6 percent slopes (DeB).—This soil is in slightly undulating areas on terraces and norrow plains.

Included with this soil in mapping were small, higher areas of Johnswood cobbly loam and small areas of Hessel cobbly loam in depressions. Also included were small areas of soils that have only a few cobblestones in the surface layer, a few, small, dark yellowish-brown, eroded areas, and a few very cobbly areas.

This soil is mainly in pasture or woods. A few areas are in cultivation. The main concerns of management are improving drainage and tilling the cobbly soil. (Capability unit Vw–1 (Gbc); woodland suitability group Z)

East Lake Series

The East Lake series consists of well-drained, nearly level to very steep soils on beach ridges, lake plains, and lake terraces. These soils formed in gravelly sand. In Charlevoix County the East Lake soils were mapped alone and in an undifferentiated unit with Alpena and Kiva soils. They were also mapped in associations with Mancelona soils.

In a representative profile, the surface layer is very dark grayish-brown loamy sand 7 inches thick. The subsurface layer is grayish-brown sand 4 inches thick. The subsoil is dark-brown to brown, very friable loamy sand 21 inches thick. The underlying material, at a depth of 32 inches, is brown very gravelly sand.

Permeability is rapid. The available water capacity is low. Organic-matter content is moderately low, and natural fertility is low. Surface runoff is slow.

The East Lake soils are poorly suited to farming. They are poorly suited to hardwoods but are well suited to aspen and pine. The less sloping areas have few limitations for most nonfarm uses. Most areas are wooded. They are used for wildlife habitat and recreational areas. A few small areas are in forage crops and pasture.

Representative profile of East Lake loamy sand, 0 to 6 percent slopes, in a nonwooded area, NW¼SE¼ sec. 14, T. 33 N., R. 8 W.:

A1—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, fine, granular structure; friable;

5 percent coarse fragments; slightly acid; clear, smooth boundary.
A2—7 to 11 inches, grayish-brown (10YR 5/2) sand; single grain; loose; 5 percent coarse fragments; slightly acid; clear, wavy boundary.
B21ir—11 to 15 inches, dark-brown (7.5YR 4/4) loamy sand; very weak, medium, subangular blocky structure; very friable; 5 percent coarse fragments; slightly acid; clear, wavy boundary.
B22ir—15 to 32 inches, brown (10YR 4/3) loamy sand; weak, medium, subangular blocky structure; very friable; 5 percent coarse fragments; neutral; clear, wavy boundary.
IIC—32 to 60 inches, brown (10YR 5/3) very gravelly sand; single grain; loose; 40 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 24 to 40 inches in thickness. The A2 horizon is absent in a few profiles. It is grayish brown or light brownish gray.

East Lake soils in most places are near Epoufette, Gladwin, and Kalkaska soils. They were mapped with Alpena and Kiva soils and with Mancelona soils. East Lake soils differ from Epoufette and Gladwin soils in lacking mottles in the A2 and B horizons. They differ from Kalkaska soils in containing coarse fragments. East Lake soils have a thicker solum than Alpena and Kiva soils. They differ from Mancelona soils in lacking a loamy B't horizon.

East Lake loamy sand, 0 to 6 percent slopes (EaB).—This soil is on broad sandy plains, beach ridges, and terraces. In areas that are not in cultivation, this soil has the profile described as representative for the series. In areas that are in cultivation, the plow layer is grayish brown and is a mixture of the surface and subsurface layers.

Included with this soil in mapping were small, flat depressions of somewhat poorly drained Gladwin loamy sand. Also included were a few small, dark-brown, eroded areas of soils.

This soil is in hay and small grain. A few areas are idle, and a few areas are in woods. The main concerns of management are controlling soil blowing, conserving soil moisture, and maintaining fertility. (Capability unit IVs-4 (5a); woodland suitability group E)

East Lake loamy sand, 6 to 12 percent slopes (EaC).—This soil is on the edges of broad, sandy plains and on beach ridges and terraces. It has a profile similar to the one described as representative for the series, but the plow layer or surface layer is grayish brown.

Included with this soil in mapping were small, dark-brown, eroded areas of soils.

A few areas of this soil are in hay and pasture, but generally it is idle. The main concerns of management are conserving moisture and maintaining fertility. (Capability unit VIs–1 (5a); woodland suitability group E)

Eastport Series

The Eastport series consists of well-drained, nearly level to sloping soils on dunes and beach ridges. These soils formed in sand.

In a representative profile, the surface layer is very dark grayish-brown sand 5 inches thick. The subsurface layer is grayish-brown sand 3 inches thick. The subsoil is loose, brown sand 12 inches thick. The underlying material, at a depth of 20 inches, is light brownish-gray sand.

Permeability is rapid. The available water capacity is low. Organic-matter content and natural fertility are low. Surface runoff is slow.

Eastport soils are very poorly suited to farming. They are poorly suited to hardwoods but are moderately suited to pines. They have few limitations for most nonfarm uses. These soils are mainly used for woods, as a habitat for wildlife, and for recreational areas.

Representative profile of Eastport sand, 0 to 6 percent slopes, in a wooded area, NE¼SE¼ sec. 28, T. 34 N., R. 8 W.:

A1—0 to 5 inches, very dark grayish brown (10YR 3/2) sand; very weak, fine, granular structure; loose; neutral; clear, smooth boundary.
A2—5 to 8 inches, grayish-brown (10YR 5/2) sand; single grain; loose; neutral; clear, smooth boundary.
B21—8 to 10 inches, brown (10YR 4/3) sand; single grain; loose; medium acid; gradual, smooth boundary.
B22—10 to 20 inches, brown (10YR 5/3) sand; single grain; loose; neutral,; diffuse, wavy boundary.
C—20 to 60 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; mildly alkaline; slightly effervescent.

The solum ranges from 15 to 25 inches in thickness. Coarse fragments range from less than 1 percent to 15 percent throughout the profile. Reaction throughout the solum is generally slightly acid or neutral, but the A2 and B21 horizons range to medium acid. The C horizon is mildly alkaline or moderately alkaline, and in a few profiles it is slightly effervescent.

Eastport soils are similar to the Deer Park and Rubicon soils but are less acid in the lower part of the B horizon and in the C horizon.

Eastport sand, 0 to 6 percent slopes (EdB).—This soil is on beach ridges and low dunes. It has the profile described as representative for the series. In some areas soil blowing has kept the materials of the surface layer moving, and the surface and subsurface layers are not so uniformly arranged as in the profile described as representative for the series.

Included with this soil in mapping were small areas of recently deposited sand and a few, small, brown, eroded areas of soils. Also included were a few areas of a moderately well drained soil.

Most areas of this soils are sparsely wooded. Some areas are covered by thin stands of grass. The main concern of management is controlling soil blowing. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Eastport sand, 6 to 12 percent slopes (EdC).—This soil is on beach ridges and dunes. In some areas soil blowing has kept the surface materials moving, and the surface and subsurface layers are not so uniformly arranged as in the profile described as representative for the series.

Included with this soil in mapping were small areas of recently deposited sand and small, brown, severely eroded areas.

Most areas of this soil are sparsely wooded. Some areas are covered by thin stands of grass. The main concern of management is controlling soil blowing. (Capability unit VIIs-1 (5.3a); woodland suitability group H)

Edmore Series

The Edmore series consists of poorly drained, nearly level to gently sloping soils in depressional areas on moraines. These soils formed in loamy sand.

In a representative profile, the surface layer is black sandy loam 7 inches thick. The subsoil consists of two parts. The upper part is gray, very friable loamy sand mottled with yellowish brown and is 4 inches thick. The lower part is brown, very friable loamy sand mottled with yellowish brown and is 25 inches thick. The underlying material, at a depth of 36 inches, is grayish-brown loamy sand with yellowish-brown mottles.

Permeability is moderately rapid. In drained areas the available water capacity is low. Organic-matter content is high, and natural fertility is low. Surface runoff is very slow to ponded.

Edmore soils are poorly suited to farming and woodland. These soils are well suited as habitat for wetland wildlife. They have severe limitations for most nonfarm uses. Most areas are in woods or pasture. A few small areas are drained and are in cultivation.

Representative profile of Edmore sandy loam in a nonwooded area, NE¼NW¼ sec. 28, T. 32 N., R. 6 W.:

A1—0 to 7 inches, black (10YR 2/1) sandy loam; moderate, medium, granular structure; friable; slightly acid; clear, smooth boundary.

B21g—7 to 11 inches, gray (10YR 5/1) loamy sand; many, fine, distinct, yellowish-brown (10YR 5/4) mottles; single grain; very friable; slightly acid; clear, smooth boundary.

B22—11 to 36 inches, brown (10YR 5/3) loamy sand; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grain; very friable; neutral; gradual, smooth boundary.

Cg—36 to 60 inches, grayish-brown (10YR 5/2) loamy sand; common, medium, distinct, yellowish-brown (10YR 5/4) mottles; single grain; very friable; less than 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 36 to 48 inches in thickness. Reaction throughout the solum is slightly acid or neutral. The B horizon is dominantly gray and has few or no mottles in the more poorly drained profiles. The C horizon is sand, or it is stratified loamy sand, fine sand, and light sandy loam. It ranges from less than 5 percent to 15 percent coarse fragments. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The annual temperature of these soils is a few degrees cooler, and the color in part of the B horizon is brighter than the defined range for the series. In these soils, a loamy layer is lacking between depths of 10 and 40 inches. These differences do not alter the usefulness or behavior of these soils.

Edmore soils in most places are near Blue Lake, Leelanau, and Otisco soils. They are similar to Epoufette and Roscommon soils. Edmore soils differ from Blue Lake and Leelanau soils in having mottles in the solum. They differ from Otisco soils in lacking a loamy textured B't horizon, and they are less red in the upper part of the B horizon. Edmore soils differ from Epoufette soils in lacking a loamy textured B horizon and in containing fewer fragments in the C horizon. They formed dominantly in finer textured material than Roscommon soils.

Edmore sandy loam (0 to 4 percent slopes) (Ee).—This soil is in swales, in depressions, and on foot slopes of uplands.

Included with this soil in mapping were small areas of Angelica and Ensley loams and a few small areas of a somewhat poorly drained Charlevoix loam at slightly higher elevations. Where this soil occurs adjacent to sloping areas, sandy overwash, 4 to 10 inches thick, is common on the surface.

This soil is in cultivation where it is drained. Undrained areas are in pasture or woods. The main concerns of management are improving drainage and maintaining fertility. (Capability unit IIIw-6 (4c); woodland suitability group W)

Edwards Series

The Edwards series consists of very poorly drained, nearly level to gently sloping organic soils on lake plains and bottom lands. These soils formed in organic materials, 12 to 42 inches thick, over marl.

In a representative profile, the surface layer is black muck 12 inches thick. The next layer is very dark brown muck 12 inches thick. The underlying material, at a depth of 24 inches, is white to light gray marl. The lime content of this material is very high.

Permeability is moderately rapid in the muck and variable in the marl. The available water capacity is moderate. Natural fertility is low. Surface runoff is very slow to ponded.

Edwards soils are poorly suited to farming and woodland. They are well suited as habitat for wetland wildlife. They have severe limitations for most nonfarm uses. Most areas are wooded. Some areas are in marsh grasses and rushes.

Representative profile of Edwards muck in a wooded area, NW¼NW¼ sec. 18, T. 32 N., R. 4 W.:

O1—0 to 12 inches, black (10YR 2/1) muck; moderate, fine, granular structure; friable; mildly alkaline; slightly effervescent.

O2—12 to 24 inches, very dark brown (10YR 2/2) muck; massive; friable; mildly alkaline; slightly effervescent.

IIC—24 to 42 inches, white to light-gray (10YR 7/1) marl; massive; friable; many old root channels; moderately alkaline; violently effervescent.

The organic material ranges from 12 to 42 inches in thickness, over marl. The 01 horizon is neutral or mildly alkaline. The marl ranges from 6 inches to more than 72 inches in thickness.

The annual temperature of these soils is a few degrees cooler than the defined range for the series. This difference does not alter the usefulness or behavior of these soils.

Edwards soils are similar to Carbondale, Cathro, Greenwood, Kerston, Linwood, Lupton, Markey, Tawas, and Warners soils. They differ from all of these, except Warners soils, in having marl between depths of 12 and 42 inches. Edwards soils differ from Warners soils in lacking mineral material immediately above the marl.

Edwards muck (0 to 4 percent slopes) (Ek).—This soil is in depressional areas on plains and bottom lands.

Included with this soil in mapping were narrow areas of sandy overwash, 5 to 10 inches thick, along the edges of areas of this soil. Also included were a few small areas of Cathro muck.

This soil is mainly in woods or pasture. The main concerns of management are improving drainage and controlling soil blowing. The main limitation is a hazard of frost. (Capability unit VIwc-1 (M/mc); woodland suitability group J)

Emmet Series

The Emmet series consists of well-drained, nearly level to very steep soils on moraines, drumlins, and till plains. These soils formed in sandy loam glacial till. In Charlevoix County the Emmet soils were mapped alone and in complexes with the Leelanau soils and with the

Onaway soils. They were also mapped in associations with the Leelanau soils and with the Nester soils.

In a representative profile, the surface layer is very dark grayish-brown sandy loam 8 inches thick. The subsurface layer is brown sandy loam 4 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, friable sandy loam 4 inches thick. The middle part is grayish-brown, friable sandy loam 4 inches thick. The lower part is brown, friable loam 16 inches thick. The underlying material, at a depth of 36 inches, is brown sandy loam.

Permeability is moderate. The available water capacity is moderate. The organic-matter content is moderate, and natural fertility is medium.

Emmet soils are well suited to farming and woodland. The less sloping areas have few limitations for nonfarm uses. Most of the less sloping areas are used for field and forage crops. The steeper areas are in woods and pasture.

Representative profile of Emmet sandy loam, 2 to 6 percent slopes, in a cultivated area, SE¼NE¼ sec. 16, T. 33 N., R. 8 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) sandy loam; moderate, fine, granular structure; friable; less than 5 percent coarse fragments; slightly acid; clear, smooth boundary.

A2—8 to 12 inches, brown (10YR 5/3) sandy loam; weak, medium, platy structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

Bir—12 to 16 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

A'2—16 to 20 inches, grayish-brown (10YR 5/2) sandy loam; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; slightly acid; diffuse, wavy boundary.

B'2t—20 to 36 inches, brown (10YR 4/3) loam; moderate, medium, subangular blocky structure; friable; clay films on surfaces of peds and in pores; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

C—36 to 60 inches, brown (7.5YR 5/4) sandy loam; weak, coarse, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 30 to 48 inches in thickness. In a few profiles, an A1 horizon 2 to 6 inches thick is present. The A2 horizon ranges from 0 to 10 inches in thickness. The Bir horizon ranges from 4 to 12 inches in thickness. The B'2t horizon is sandy loam, loam, or sandy clay loam. In a few profiles, the C horizon contains pockets of loamy sand or sandy clay loam.

Emmet soils are in a toposequence with Charlevoix and Ensley soils. They were mapped with Leelanau, Onoway, and Nester soils. Emmet soils on most lanscapes are near Mackinac soils. They differ from Charlevoix, Ensley, and Mackinac soils in lacking mottles in the solum. Emmet soils are finer textured than Leelanau soils in horizons with the same horizon designation. They are coarser textured than the Onoway soils in the B't and C horizons. Emmet soils are coarser textured in the B and C horizons than the Nester soils.

Emmet sandy loam, 0 to 2 percent slopes (EmA).—This soil is on uplands.

Included with this soil in mapping were small areas of sandy overwash. These materials eroded from surrounding uplands. Also included were small areas of Emmet sandy loam, 2 to 6 percent slopes, and a few, small, depressional areas of somewhat poorly drained Charlevoix soils.

This soil is used mainly for general crops. Small areas are in pasture or woods. Surface runoff is slow. The main concern of management is controlling erosion. (Capability unit IIe-3 (3a); woodland suitability group A)

Emmet sandy loam, 2 to 6 percent slopes (EmB).—This soil is on low knolls, ridges, and foot slopes on uplands. It has the profile described as representative for the series.

Included with this soil in mapping were small depressions where thin, sandy overwash was deposited on the original surface layer. This overwash is generally dark yellowish-brown sandy loam. Also included were a few, small, eroded areas of soils in higher positions, which are the source of the overwash. There are also a few, small, wet areas of soils, particularly in drainageways.

This is one of the most important soils for farming in the county. Most areas are in cultivation. A few areas remain wooded. Surface runoff is slow to medium. The main concern of management is controlling water erosion. (Capability unit IIe-3 (3a); woodland suitability group A)

Emmet sandy loam, 6 to 12 percent slopes (EmC).—This soil is on ridges, knolls, and foot slopes of uplands.

Included with this soil in mapping were some small eroded areas and a few, small, strongly sloping areas of soils. Also included were small stony areas of soils, shown on the soil map by a special symbol, and a few small areas of sandy Leelanau soils.

This soil is mainly in cultivated crops and hay, and some areas are pasture (fig. 4). Small areas are wooded. Surface runoff is medium. The main concern of management is controlling water erosion. (Capability unit IIIe-6 (3a); woodland suitability group A)

Emmet sandy loam, 12 to 18 percent slopes (EmD).—This soil is on ridges and hillsides of uplands.

Included with this soil in mapping were some small, eroded areas and a few steeply sloping areas of soils. Also included were small, stony areas, shown on the soil map by a special symbol, and small areas of sandy Leelanau and loamy Onaway soils.

This soil is mainly in hay and pasture. A few areas are in cultivation, and a few are in woods. Surface runoff is rapid. The main concern of management is controlling water erosion. (Capability unit IVe-4 (3a); woodland suitability group A)

Figure 4.—Hay strips on Emmet sandy loam, 6 to 12 percent slopes, help to control water erosion.

tom lands. These soils were derived from sediments washed from uplands underlain by cherty dolomite and sandstone.

In a typical profile the surface layer of Westerville soils is grayish-brown silt loam about 13 inches thick. The subsoil extends to a depth of more than 48 inches and consists of brown silt loam mottled with dark yellowish brown and yellowish brown. Black concretions are common in the subsoil.

These soils have moderate to moderately slow permeability, high available moisture capacity, and low to moderate natural fertility. They are extremely acid to medium acid. Many areas of these soils are subject to flooding. Most floods occur in winter and early spring.

Westerville soils are used for row crops, pasture, and hay. If management is good, these crops grow well.

Typical profile of Westerville silt loam (NE¼NE¼, section 25, T. 34 N., R. 6 W.):

A1—0 to 13 inches, grayish-brown (10YR 5/2) silt loam with few, fine, distinct, strong-brown (7.5YR 5/6) mottles; weak, fine, subangular blocky structure; very friable; few, fine, black concretions; very strongly acid (pH 4.6); clear, wavy boundary.

B—13 to 48 inches +, brown (10YR 5/3) silt loam with common, medium, faint, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) mottles; very weak, fine, subangular blocky structure; common, medium, black concretions; extremely acid (pH 4.4).

The A horizon ranges from loam to silt loam and in many places is browner in tilled areas than in undisturbed areas. The B horizon is mottled with yellow, red, and gray in some areas. In places the A and B horizons are coarser textured than silt loam. Stratified sediments can be seen in the profile in many areas, though the upper 30 inches is generally silt loam or loam. These soils are extremely acid to medium acid.

Westerville soils commonly occur with the Sharon and Atkins soils. They are not so well drained as the Sharon soils but are better drained than Atkins soils.

Westerville silt loam (We).—This soil is in slight depressions in the bottom lands adjoining uplands or terraces. Slopes are 1 percent or less. This soil generally is separated from soils next to the stream channel by Sharon silt loam, but along some of the slow-moving streams, Westerville silt loam occupies the entire flood plain.

Included with this soil in mapping were spots of Sharon soils on prominent mounds. Below the mounds Westerville silt loam occurs with Atkins soils.

This soil is used for row crops, pasture, and hay. It is well suited to native grasses, a few kinds of trees, and alsike clover, Ladino clover, and other legumes. Excess water on the surface and poor drainage are the main hazards. Because of wetness and frost heaving in winter, this soil is not suited to alfalfa. Additions of green manure are needed where cultivated crops are grown intensively. (Capability unit IIw–1; woodland suitability group 7; wildlife suitability group 1)

Use and Management of Soils

Soils of Dent County are used mainly for cultivated crops, pasture, and trees. This section discusses the uses of the soils for these main purposes, and it gives the estimated yields of the principal crops. Also discussed are the uses of the soils in building highways, farm ponds, and other engineering structures; for growing wildlife habitat; and in developing areas suitable for recreation.

In describing information about the use of soils for crops and pasture, as woodland, and for wildlife habitat, the procedure is to name groups that consist of similar soils and to suggest use and management for those groups. The soils in the subsection on engineering have not been grouped but are placed in tables so that properties significant to engineering can be readily given.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or engineering.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife. (None in Dent County.)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make then unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

makes up about 50 percent. The Emmet soil has a sandy loam surface layer, and the Leelanau soil has a loamy sand surface layer.

Included in mapping were small areas of severely eroded soils that are shown on the soil map by a special symbol. Also included were small areas of less sloping soils.

The soils of this complex are mainly wooded. A few small areas are idle. Surface runoff is rapid. If cleared, these soils are subject to severe erosion. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIIe-2. (3a, 4a); woodland suitability group A)

Emmet-Onaway sandy loams, 0 to 2 percent slopes (EoA).—These soils are in small areas of the western uplands. The Emmet soil makes up about 55 percent of the complex; the Onaway soil, 35 percent; and included soils, about 10 percent.

Included in mapping were small areas of gently sloping soils and a few, small, wet areas of poorly drained Angelica-Ensley loams. Also included were small areas of sandy overwash materials, 6 to 10 inches thick, that eroded from surrounding uplands.

The soils of this complex are used mainly for general crops. Small areas are in pasture or woods. Surface runoff is slow. The main concern of management is controlling erosion. (Capability unit IIe–3 (3a, 2.5a); woodland suitability group A)

Emmet-Onaway sandy loams, 2 to 6 percent slopes (EoB).—These soils are on low knolls, ridges, and foot slopes of the western uplands. The Onaway soil has the profile described as representative for the series. The Emmet soil makes up about 50 percent of the complex; the Onaway soil, about 40 percent; and included soils, about 10 percent.

Included in mapping were a few, small, depressional areas of soils where thin, sandy overwash has been deposited on the original surface layer. Also included were a few, small, eroded areas of soils in higher positions, which are the source of the overwash materials. There are also a few small areas of somewhat poorly drained Charlevoix soils in swales.

The soils of this complex are used mainly for general crops. Small areas are in pasture or woods. Surface runoff is slow to medium. The main concern of management is controlling water erosion. (Capability unit IIe-3 (3a, 2.5a); woodland suitability group A)

Emmet-Onaway sandy loams, 6 to 12 percent slopes (EoC).—These moderately sloping soils are on ridges, knolls, and foot slopes of the western uplands. The Emmet soil makes up about 50 percent of the complex; the Onaway soil, 40 percent; and included soils, about 10 percent.

Included in mapping were small, eroded areas of soils and a few small areas of sandy Leelanau soils. Also included were some small, gently sloping areas and a few strongly sloping areas of soils.

The soils of this complex are mainly in cultivated crops and hay, and some areas are in pasture. Small areas are wooded. Surface runoff is medium. The main concern of management is controlling water erosion. (Capability unit IIIe-6 (3a, 2.5a); woodland suitability group A)

Emmet-Onaway sandy loams, 12 to 18 percent slopes (EoD).—These soils are on ridges and hillsides of the western uplands. The Emmet soil makes up about 50 percent of the complex; the Onaway soil, 35 percent; and included soils, about 15 percent.

Included in mapping were small, eroded areas of soils and a few small areas of sandy Leelanau soils. Also included were a few steeper and a few less sloping areas of Emmet and Onaway soils. There are also small, stony areas of soils that are shown on the soil map by a special symbol.

The soils of this complex are mainly in hay and pasture. A few areas are wooded. Surface runoff is rapid. The main concern of management is controlling water erosion. (Capability unit IVe-4 (3a, 2.5a); woodland suitability group A)

Emmet-Onaway sandy loams, 18 to 25 percent slopes (EoE).—These soils are on hillsides of the western uplands. The Emmet soils makes up about 45 percent of the complex; the Onaway soil, 45 percent; and included soils, about 10 percent. The soil layers are somewhat thinner than those of the profile described as representative for the respective series.

Included in mapping were small, eroded areas of soils. Also included were small, stony areas of soils that are shown on the soil map by special symbols.

The soils of this complex are mainly wooded. A few areas are in hay and pasture (fig. 5). Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIe-2 (3a, 2.5a); woodland suitability group A)

Emmet-Onaway sandy loams, 25 to 50 percent slopes (EoF).—These soils are on hillsides of the western uplands. The Emmet soil makes up about 45 percent of the complex; the Onaway soil, 45 percent; and included soils, about 10 percent. Because of steep slopes, these soils have thinner soil layers than those of the profile described as representative for the respective series.

Included in mapping were small, eroded areas and small areas of less sloping soils. Also included were small areas of sandy Leelanau soils.

The soils of this complex are mainly wooded. A few small areas are idle. Surface runoff is rapid. If cleared, these soils are subject to severe erosion. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIIe-2 (3a, 2.5a); woodland suitability group A)

Ensley Series

The Ensley series consists of poorly drained, nearly level to gently sloping soils on till plains and moraines. These soils formed in sandy loam till. In Charlevoix County the Ensley soils were mapped only in a complex with Angelica soils.

In a representative profile, the surface layer is black loam 7 inches thick. The subsurface layer is dark grayish-brown sandy loam mottled with olive brown and yellowish brown and is 2 inches thick. The subsoil consists of two parts. The upper part is light olive-brown, friable sandy loam mottled with olive yellow and dark yellowish brown and is 5 inches thick. The lower part is yellowish-brown, friable sandy loam 8 inches thick. The underlying

Figure 5.—Hay crops on Emmet-Onaway sandy loams, 18 to 25 percent slopes, reduce runoff and help to control water erosion.

material, at a depth of 22 inches, is light brownish-gray sandy loam mottled with yellowish brown.

Permeability is moderate. The available water capacity is moderate. Organic-matter content is high, and natural fertility is medium. Surface runoff is very slow.

If drained, Ensley soils are well suited to farming. These soils are generally poorly suited to woodland. The Ensley soils are well suited as habitat for wetland wildlife. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile on an Ensley loam from an area of Angelica-Ensley loams, in a wooded area, NE¼NW¼ sec. 18, T. 32 N., R. 7 W.:

A1—0 to 7 inches, black (10YR 2/1) loam; weak, medium, granular structure; friable; neutral; clear, smooth boundary.

A2g—7 to 9 inches, dark grayish-brown (2.5Y 4/2) sandy loam; common, medium, distinct, light olive-brown (2.5Y 5/6) and yellowish-brown (10YR 5/6) mottles; weak, coarse, granular structure; friable; mildly alkaline; clear, wavy boundary.

B21—9 to 14 inches, light olive-brown (2.5Y 5/4) sandy loam; common, medium, distinct, olive-yellow (2.5Y 6/6) and dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable; mildly alkaline; clear, wavy boundary.

B22—14 to 22 inches, yellowish-brown (10YR 5/4) sandy loam; common, medium, faint, dark yellowish-brown (10YR 4/4) mottles; weak, medium subangular blocky structure; friable; mildly alkaline; distinct, wavy boundary.

Cg—22 to 60 inches, light brownish-gray (2.5Y 6/2) sandy loam; many medium, prominent, yellowish-brown (10YR 5/6) mottles; weak, coarse, subangular blocky structure; friable; less than 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 20 to 36 inches in thickness. The A1 horizon ranges from 4 to 9 inches in thickness. The A2 horizon ranges from 0 to 3 inches in thickness. The A horizon ranges from slightly acid to mildly alkaline. The B horizon is dominantly sandy loam, but in a few profiles it is loam or light clay loam. This horizon is neutral or mildly alkaline. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Ensley soils are in a toposequence with Charlevoix and Emmet soils. They were mapped with Angelica soils. Ensley soils are similar to Bruce soils. They differ from Charlevoix soils in lacking the B't horizon and in having yellower hues in the A2 horizon and in the upper part of the B horizon. Ensley soils differ from Emmet soils in having mottles in the solum. They contain less clay than Angelica soils at depths of 10 to 40 inches. Ensley soils differ from Bruce soils in lacking stratification in the C horizon. They contain less clay than Bruce soils at depths between 10 and 40 inches.

Epoufette Series

The Epoufette series consists of poorly drained, nearly level to gently sloping soils in depressional areas on outwash plains, lake plains, and deltas. These soils formed in loamy sand and sandy loam, 18 to 42 inches thick, over gravelly sand.

In a representative profile, the surface layer is black sandy loam 7 inches thick. The subsurface layer is pale-brown loamy sand with dark yellowish-brown mottles and is 4 inches thick. The subsoil is yellowish-red, friable sandy loam with dark yellowish-brown mottles and is 7 inches thick. The underlying material, at a depth of 18 inches, is brown gravelly sand.

Permeability is moderately rapid in the subsoil and rapid in the underlying material. The available water capacity is low. Organic-matter content is high, and natural fertility is low. Surface runoff is very slow to ponded.

If drained, the Epoufette soils are moderately suited to farming. They are poorly suited to woodland. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of Epoufette sandy loam in a wooded area, NE¼NE¼ sec. 26, T. 33 N., R. 7 W.:

A1—0 to 7 inches, black (10YR 2/1) sandy loam; moderate, medium, granular structure; very friable; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

A2—7 to 11 inches, pale-brown (10YR 6/3) loamy sand; few, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; very friable; less than 5 percent coarse fragments; neutral; gradual, wavy boundary.

B2t—11 to 18 inches, yellowish-red (5YR 5/6) sandy loam; few, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; very weak, medium, subangular blocky structure; friable; 10 percent coarse fragments; mildly alkaline; gradual, wavy boundary.

C—18 to 60 inches, brown (7.5YR 5/2) gravelly sand; single grain; loose; 30 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 18 to 40 inches in thickness. The B horizon is sandy loam or light loam and ranges from 2 to 9 inches in thickness. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The color in the subsurface horizons in places is brighter than the defined range for the series, but this difference does not alter the usefulness or behavior of these soils.

Epoufette soils are in a toposequence with Gladwin and Mancelona soils. They are similar to East Lake, Munuscong, and Roscommon soils. Epoufette soils differ from Gladwin soils in lacking a Bir horizon. Excluding the A1, Ap, or A2 horizons, Epoufette soils have a horizon with a matrix color that has a chroma of 2 or less. This horizon is not so deep as it is in Gladwin soils. Epoufette soils differ from Mancelona soils in having mottles in the solum and in lacking a Bir horizon. The texture of Epoufette soils is coarser than that of Munuscong soils in horizons with the same horizon designation. Their texture is finer in the upper part of the profile than that of Roscommon soils. Also, Epoufette soils differ from Roscommon soils in containing gravelly sand in the lower part of the profile.

Epoufette sandy loam (0 to 4 percent slopes) (Ep).—This soil is in swales and depressions on sandy plains in some of the large valleys.

Included with this soil in mapping were small areas of Gladwin loamy sand at slightly higher elevations and a few depressional areas of Tawas muck and Roscommon sand. Also included were small areas of soils that have a loamy sand surface layer.

This soil is mainly wooded. Other small areas are in pasture or cultivation. The main concerns of management are improving drainage and maintaining fertility. (Capability unit IIIw-6 (4c); woodland suitability group W)

Gladwin Series

The Gladwin series consists of somewhat poorly drained, nearly level to gently sloping soils on beach ridges and outwash plains. These soils formed in loamy sand.

In a representative profile, the surface layer is very dark brown loamy sand 8 inches thick. The subsurface layer is light brownish-gray loamy sand with dark yellowish-brown mottles and is 2 inches thick. The subsoil consists of three parts. The upper part is yellowish-brown, very friable loamy sand 3 inches thick. The middle part is brown, friable loamy sand with dark yellowish-brown mottles and is 4 inches thick. The lower part is brown, friable loam with yellowish-brown mottles and is 8 inches thick. The underlying material is grayish-brown gravelly sand.

Permeability is moderately rapid. The available water capacity is low. Organic-matter content is moderately low, and natural fertility is low. Surface runoff is slow.

The Gladwin soils are moderately well suited to farming. They are generally poorly suited to woodland. They have moderate to severe limitations for many nonfarm uses. Many areas of these soils are farmed. The remaining areas are wooded.

Representative profile of Gladwin loamy sand, 0 to 6 percent slopes, in a nonwooded area, SW¼SW¼ sec. 2, T. 33 N., R. 8 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) loamy sand; weak, fine, granular structure; very friable; less than 1 percent coarse fragments; slightly acid; clear, wavy boundary.

A2—8 to 10 inches, light brownish-gray (10YR 6/2) loamy sand; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, platy structure; very friable; less than 1 percent coarse fragments; slightly acid; clear, wavy boundary.

Bir—10 to 13 inches, yellowish-brown (10YR 5/4) loamy sand; common, fine, faint, brown (10YR 5/3) mottles; weak, medium, subangular blocky structure; very friable; less than 1 percent coarse fragments; slightly acid; clear, wavy boundary.

A'2—13 to 17 inches, brown (10YR 5/3) loamy sand; many, fine, faint, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable; less than 1 percent coarse fragments; neutral; clear, wavy boundary.

B't—17 to 25 inches, brown (10YR 4/3) loam; many, fine, distinct, light yellowish-brown (10YR 6/4) mottles; moderate, medium, subangular blocky structure; friable; clay films on surfaces of peds; 5 percent coarse fragments; neutral; gradual, wavy boundary.

C—25 to 60 inches, grayish-brown (10YR 5/2) gravelly sand; single grain; loose; 25 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 20 to 40 inches in thickness. Coarse fragments throughout the solum range from less than 1 percent to about 20 percent. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Gladwin soils are in a toposequence with Epoufette and Mancelona soils. They are similar to Au Gres and East Lake soils. They differ from Epoufette soils in having a Bir horizon. Excluding the A1, Ap, or A2 horizons, Gladwin soils have a horizon with a matrix color that has a chroma of 2 or less. This horizon is further from the surface than it is in Epoufette soils. Gladwin soils differ from Mancelona soils in

having mottles in the A2 and B horizons. They differ from Au Gres soils in having a loamy textured B't horizon and in having effervescent gravelly sand in the C horizon. Gladwin soils differ from East Lake soils in having mottles in the A2 and B horizons.

Gladwin loamy sand, 0 to 6 percent slopes (GlB).—This soil is in shallow swales and on low foot slopes of sandy plains. It is also on low beach ridges.

Included with this soil in mapping were small areas of well-drained Mancelona loamy sand in slightly higher positions and small stony areas of soils that are shown on the soil map by a special symbol. Also included were a few, small, low areas of Epoufette sandy loam.

This soil is mainly in pasture and hay. Many areas have suitable drainage and are in cultivation. Other areas are wooded. The main concerns of management are improving drainage, maintaining fertility, and conserving soil moisture throughout the growing season. (Capability unit IIIw-5 (4b); woodland suitability group G)

Greenwood Series

The Greenwood series consists of very poorly drained, nearly level to gently sloping organic soils in depressional areas on moraines, till plains, and outwash plains. These soils formed in acid organic material. A large area of Greenwood soils is on Beaver Island.

In a representative profile, the surface layer is very dark brown peat 12 inches thick. The next layer is dark reddish-brown mucky peat 12 inches thick. Below this, at a depth of 24 inches, is reddish-brown mucky peat.

Permeability is moderately rapid. The available water capacity is very high. Natural fertility is low. Surface runoff is very slow.

Greenwood soils are not suited to farming or woodland. They are well suited as habitat for wetland wildlife. They have severe limitations for most nonfarm uses. These soils are not used for any specific purpose, and they remain in their natural state of marsh vegetation.

Representative profile of Greenwood peat in a marsh area, SW¼SW¼ sec. 28, T. 38 N., R. 10 W.:

O1—0 to 12 inches, very dark brown (10YR 2/2) peat (sphagnum moss): massive; friable; very strongly acid; clear, wavy boundary.

O2—12 to 16 inches, dark reddish-brown (5YR 3/4) mucky peat; massive; friable; very strongly acid; clear, wavy boundary.

O3—16 to 24 inches, dark reddish-brown (5YR 2/2) mucky peat; massive; friable; very strongly acid; gradual, wavy boundary.

O4—24 to 42 inches, reddish-brown (5YR 4/4) mucky peat; massive, separating to weak, thick, platy structure; friable; very strongly acid.

The organic material is 42 inches or more in thickness. The soil formed in sphagnum moss and sedges. The 01 horizon is very dark brown, dark grayish brown, or brown. Below this the layers are dark reddish brown, reddish brown, yellowish brown, very dark brown, dark brown, very dark grayish brown, dark grayish brown, or dark yellowish brown. The amount of moss materials in these layers is small.

Greenwood soils are similar to Carbondale, Cathro, Edwards, Kerston, Linwood, Lupton, Markey, Tawas, and Warners soils. They differ from all these, except Carbondale and Lupton soils, in lacking mineral material and marl at depths of less than 42 inches. Greenwood soils dominantly have less decomposed organic material in most layers between depths of 12 and 42 inches than Carbondale soils, and they are more acid throughout the profile. Greenwood soils are less decomposed and are more acid throughout the profile than the Lupton soils.

Greenwood peat (0 to 4 percent slopes) (Gr).—This soil is in broad, depressional, boggy basins on plains and in smaller depressional areas on uplands.

This soil is idle. It is covered with marsh vegetation and is not in cultivation. The main concerns of management are improving drainage, reducing acidity, and maintaining fertility. The main limitation is a hazard of frost. (Capability unit VIIIwc-1 (Mc-a); woodland suitability group not assigned)

Hessel Series

The Hessel series consists of poorly drained, nearly level to gently sloping soils on lake plains and lake terraces. These soils formed in compact, cobbly loam till. Most areas of these soils are on a lake plain north of the city of Charlevoix.

In a representative profile, the surface is very dark brown cobbly loam 8 inches thick. The subsoil is firm, grayish-brown cobbly loam with light olive-brown mottles and is 5 inches thick. The underlying material, at a depth of 13 inches, is light brownish-gray cobbly loam with dark yellowish-brown mottles.

Permeability is moderately slow. The available water capacity is high. Organic-matter content and natural fertility are high. Surface runoff is slow.

The Hessel soils are poorly suited to farming because of wetness and cobblestones in the surface layer. They are poorly suited to woodland. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of Hessel cobbly loam in a wooded area, SW¼SW¼ sec. 8, T. 34 N., R. 7 W.:

A1—0 to 8 inches, very dark brown (10YR 2/2) cobbly loam; moderate, medium, granular structure; friable; 25 percent coarse fragments; mildly alkaline; clear, wavy boundary.

Bg—8 to 13 inches, grayish-brown (2.5Y 5/2) cobbly loam; common, medium, distinct, light olive-brown (2.5Y 5/6) mottles; weak, medium, subangular blocky structure; firm; 25 percent coarse fragments; mildly alkaline; slightly effervescent; gradual, wavy boundary.

Cg—13 to 40 inches, light brownish-gray (2.5Y 6/2) cobbly loam; many, medium, prominent, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; firm; 30 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 10 to 15 inches in thickness. Coarse fragments throughout the solum range from about 2 percent to 25 percent. The Bg horizon is loam, clay loam, or gravelly or cobbly analogs of these textures. The C horizon is gravelly or cobbly loam or sandy loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Hessel soils are in a toposequence with Detour and Johnswood soils. They are similar to Ruse soils. Hessel soils are more grayish in the B horizon or are yellower in the B and C horizons than Detour soils. Hessel soils differ from Johnswood soils in having mottles in the B and C horizons. They are yellower in the B and C horizons than are Johnswood soils. Hessel soils differ from Ruse soils in having bedrock at a depth of more than 40 inches.

Hessel cobbly loam (0 to 4 percent slopes) (Hs).—This soil is in small depressions on terraces and narrow plains.

Included with this soil in mapping were small areas of soils that have only a few cobblestones in the surface layer and small areas of somewhat poorly drained Detour cobbly loam in slightly higher positions.

This soil is mainly wooded. The main concerns of management are improving drainage and tilling this cobbly

soil. (Capability unit Vw-1 (Gbc); woodland suitability group P)

Iosco Series

The Iosco series consists of somewhat poorly drained, nearly level to gently sloping soils on lake plains. These soils formed in loamy sand, ranging from 18 to 42 inches in thickness, over loam.

In a representative profile, the surface layer is very dark grayish-brown loamy sand 8 inches thick. The subsurface layer is light brownish gray loamy sand 4 inches thick. The subsoil consists of three parts. The upper part is loose, dark-brown loamy sand 4 inches thick. The middle part is grayish-brown, very friable loamy sand with dark yellowish-brown mottles and is 6 inches thick. The lower part is brown, very friable heavy loamy sand with yellowish-brown mottles and is 8 inches thick. The underlying material, at a depth of 30 inches, is brown loam.

Permeability is rapid in the subsoil and moderately slow in the underlying material. The available water capacity is low in the subsoil and high in the underlying material. Organic-matter content is moderately low, and natural fertility is low. Surface runoff is slow.

Iosco soils are moderately suited to farming. They are generally poorly suited to woodland. They have moderate to severe limitations for many nonfarm uses. These soils are mainly farmed.

Representative profile of Iosco loamy sand, 0 to 6 percent slopes, in a cultivated area, NW¼NW¼ sec. 35, T. 32 N., R. 7 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, fine, granular structure; very friable; slightly acid; clear, smooth boundary.

A2—8 to 12 inches, light brownish-gray (10YR 6/2) loamy sand; many, fine, faint, brown (10YR 5/3) mottles; weak, thin, platy structure; very friable; slightly acid; clear, wavy boundary.

Bir—12 to 16 inches; dark-brown (7.5YR 4/4) loamy sand; common, medium, faint, dark yellowish-brown (10YR 4/4) mottles; very weak, medium, subangular blocky structure; very friable; slightly acid; gradual, wavy boundary.

A'2—16 to 22 inches, grayish-brown (10YR 5/2) loamy sand; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; very friable, slightly acid; abrupt, irregular boundary.

B't—22 to 30 inches, brown (10YR 4/3) heavy loamy sand; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; very friable; clay films on surface of peds; neutral; abrupt, wavy boundary.

IIC—30 to 60 inches, brown (10YR 5/3) loam; weak, coarse, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

Depth to the loamy material in the IIB or IIC horizon ranges from 20 to 40 inches. The sandy A and B horizons are dominantly loamy sand, but in a few profiles there are thin strata of sandy loam. Content of coarse fragments throughout the sandy material ranges from 0 to about 5 percent. It ranges from less than 1 percent to about 15 percent throughout the loamy material. The Bir horizon is dark brown or yellowish brown. In many profiles, a IIB't horizon is present and is silty clay loam, clay loam, sandy clay loam, or heavy loam. It is neutral or mildly alkaline. The IIC horizon is loam or silty clay loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The mottles are closer to the surface, and the texture in the B't horizon is coarser than the defined range for the series, but these differences do not alter the usefulness or behavior of these soils.

Iosco soils are in a toposequence with Brevort and Menominee soils. They are similar to Belding soils. Iosco soils are browner in the B horizon than Brevort soils. They differ from Menominee soils in having mottles in the solum. Iosco soils are dominantly coarser textured in the upper part of the profile than Belding soils.

Iosco loamy sand, 0 to 6 percent slopes (IIB).—This soil is on broad, slightly undulating, sandy plains.

Included with this soil in mapping were small areas of well drained or moderately well drained Menominee loamy sand on low mounds and ridges. Also included were small areas of poorly drained or very poorly drained Brevort loamy sand in swales and other small depressions.

This soil is mainly in cultivation. Small areas are wooded. The main concerns of management are improving drainage and maintaining fertility. (Capability unit IIIw-9 (4/2b); woodland suitability group G)

Johnswood Series

The Johnswood series consists of well drained or moderately well drained, gently sloping to sloping soils on lake plains and lake terraces. These soils formed in compact cobbly loam. Johnswood soils are along the shores of Lake Michigan and Lake Charlevoix.

In a representative profile, the surface layer is very dark grayish-brown cobbly loam 9 inches thick. The subsoil is yellowish brown, friable cobbly heavy loam 2 inches thick. The underlying material, at a depth of 11 inches, is light brownish-gray cobbly loam.

Permeability is moderate. The available water capacity is high. Organic-matter content is moderate, and natural fertility is medium. Surface runoff is medium.

The Johnswood soils are poorly suited to farming because of cobblestones in the surface layer. They are poorly suited to woodland. They have moderate to severe limitations for many nonfarm uses. These soils are mainly wooded.

Representative profile of Johnswood cobbly loam, 2 to 12 percent slopes, in a nonwooded area, NW¼NW¼ sec. 16, T. 33 N., R. 7 W.:

A1—0 to 9 inches, very dark grayish-brown (10YR 3/2) cobbly loam; moderate, fine, subangular blocky structure; friable; 30 percent coarse fragments; mildly alkaline; abrupt, smooth boundary.

B—9 to 11 inches, yellowish-brown (10YR 5/6) cobbly heavy loam; moderate, fine, subangular blocky structure; friable; 40 percent coarse fragments; mildly alkaline; abrupt, smooth boundary.

C—11 to 40 inches, light brownish-gray (10YR 6/2) cobbly loam; moderate, fine, subangular blocky structure; firm; 40 percent coarse fragments; moderately alkaline; slightly effervescent.

The solum ranges from 10 to 18 inches in thickness. Depth to bedrock ranges from 42 to 60 inches in many profiles. An A2 horizon is present in a few profiles. It is grayish brown and ranges from less than 1 inch to 2 inches in thickness. The B horizon ranges from cobbly or gravelly loam to cobbly or gravelly sandy clay loam. It ranges from less than 1 inch to more than 3 inches in thickness. The C horizon is cobbly silt loam or cobbly loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Johnswood soils are in a toposequence with Detour and Hessel soils. They are similar to Summerville soils. Johnswood soils differ from Detour soils in lacking grayish mottles in the B horizon. They differ from Hessel soils in lacking mottles in the B and C horizons and in having browner hues

in these horizons. Johnswood soils have bedrock at a depth of more than 40 inches, but Summerville soils have bedrock at a depth of less than 20 inches.

Johnswood cobbly loam, 2 to 12 percent slopes (JoC).—This soil is on low knolls and narrow ridges on terraces and narrow plains.

Included with this soil in mapping were a few, small areas of yellowish-brown, eroded soils and a few small areas of Emmet sandy loam.

This soil is in pasture or woods. The main concerns of management are controlling water erosion and tilling this cobbly soil. (Capability unit IVe-4 (3a); woodland suitability group B)

Kalkaska Series

The Kalkaska series consists of well-drained, nearly level to very steep soils on moraines, lake plains, and valley trains. These soils formed in sand. In Charlevoix County the Kalkaska soils were mapped alone and in associations with Blue Lake soils and with Leelanau soils.

In a representative profile, the surface layer is very dark brown sand 4 inches thick. The subsurface layer is light brownish-gray sand 6 inches thick. The subsoil consists of three parts. The upper part is loose, dark-brown, slightly cemented sand 6 inches thick. The middle part is loose, dark yellowish-brown sand 6 inches thick. The lower part is loose, yellowish-brown sand 11 inches thick. The underlying material, at a depth of 33 inches, is light yellowish-brown sand (fig. 6).

Permeability is rapid. The available water capacity is low. Organic-matter content and natural fertility are low. Surface runoff is slow.

Kalkaska soils are poorly to very poorly suited to farming because of droughtiness. They are poorly suited to hardwoods but are well suited to pines. The less sloping areas of these soils have few limitations for nonfarm uses, and they have been cleared and are in limited cultivation. The steeper areas are wooded or are in native pasture.

Representative profile of Kalkaska sand, 0 to 6 percent slopes, in a wooded area, NE¼NW¼ sec. 2, T. 33 N., R. 8 W.:

A1—0 to 4 inches, very dark brown (10YR 2/2) sand; very weak, fine, granular structure; friable; medium acid; gradual, smooth boundary.

A2—4 to 10 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; medium acid; clear, irregular boundary.

B21hir—10 to 16 inches, dark-brown (7.5YR 3/2) sand; single grain; loose; few chunks of weakly cemented ortstein; medium acid; gradual, smooth boundary.

B22ir—16 to 22 inches, dark yellowish-brown (10YR 4/4) sand; single grain; loose; medium acid; diffuse, smooth boundary.

B3—22 to 33 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; slightly acid; diffuse, smooth boundary.

C2—33 to 60 inches, light yellowish-brown (10YR 6/4) sand; loose; slightly acid.

The A2 horizon ranges from less than 1 inch to 36 inches or more in thickness. The A2 horizon commonly tongues into the B3 horizon or C horizon. The Bir horizon is dark yellowish brown or yellowish brown. The B horizon ranges from 4 to 30 inches in thickness.

Kalkaska soils in most areas are near the Au Gres, Croswell, Roscommon, Rubicon, and Saugatuck soils. They are mapped with Blue Lake and Leelanau soils. Kalkaska soils are similar to East Lake, Mancelona, and Wallace soils. They lack the mottles that are present in the Au Gres, Roscommon, and Saugatuck soils. Also, they lack the continuous ortstein that is in the B horizon of the Saugatuck soils. Kalkaska soils differ from Croswell soils in lacking mottles in the lower part of the B horizon. They have a dark-brown Bhir horizon that is lacking in Rubicon soils. They differ from Blue Lake and Leelanau soils in lacking a clay-enriched B't horizon. Also, Kalkaska soils lack the coarse fragments that are present in Leelanau soils. They are dominantly coarser textured throughout than the Leelanau soils. Kalkaska soils lack the coarse fragments that are present throughout East Lake and Mancelona soils. Also, they differ from Mancelona soils in lacking the sandy loam B't horizon. Kalkaska soils differ from Wallace soils in having a lighter colored Bhir horizon and in lacking a continuous ortstein.

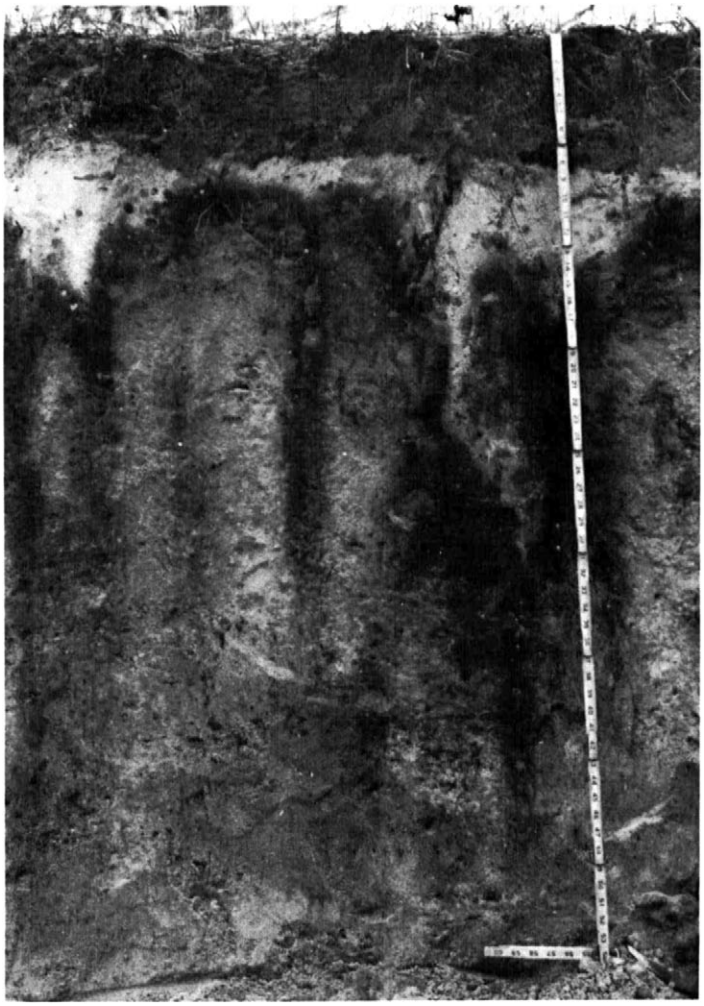

Figure 6.—Profile of Kalkaska sand showing the light brownish-gray subsurface layer over the dark-brown upper part of the subsoil.

Kalkaska sand, 0 to 6 percent slopes (KaB).—This soil is in valleys and on broad, sandy plains. In areas that are not in cultivation, this soil has the profile described as representative for the series. In cultivated areas there is a dark grayish-brown plow layer that is a mixture of the original very dark brown surface layer and the light brownish-gray subsurface layer.

Included with this soil in mapping were small areas of dark-brown, eroded soils. Also included were a few

small areas of gravelly East Lake loamy sand and Blue Lake loamy sand.

Most areas of this soil have been cleared and are in limited cultivation or are in pasture. The rest is wooded or is idle. Many areas are being reforested by pine plantings. The main concerns of management are conserving soil moisture, maintaining fertility, and controlling soil blowing. (Capability unit IVs-4 (5a); woodland suitability group E)

Kalkaska sand, 6 to 12 percent slopes (KaC).—This soil is on foot slopes between hilly uplands, along the edges of level sand plains, and on uplands. In areas that are in cultivation, the light brownish-gray subsurface layer is mixed with the original surface layer.

Included with this soil in mapping were a few, small, dark-brown, eroded areas of Kalkaska sand. Also included were small areas of Blue Lake loamy sand and Leelanau loamy sand.

This soil is in limited cultivation or in pasture. About half of it remains wooded. The main concerns of management are conserving soil moisture and maintaining fertility. (Capability unit VIs-1 (5a); woodland suitability group E)

Kalkaska sand, 12 to 18 percent slopes (KaD).—This soil is on foot slopes, in hilly areas, along the edges of level sand plains, and on uplands. The soil layers are thinner than those of the profile described as representative for the series.

Included with this soil in mapping were small, dark-brown, eroded areas of Kalkaska sand and small areas of Blue Lake loamy sand and Leelanau loamy sand.

Some areas of this soil are in pasture and hay. Some areas are being reforested by pine plantings. The main concerns of management are conserving soil moisture and controlling erosion. The main limitation is the steepness of slopes. (Capability unit VIIs-1 (5a); woodland suitability group E)

Kalkaska sand, 18 to 25 percent slopes (KaE).—This soil is on hillsides on uplands. It has thinner soil layers than those of the profile described as representative for the series.

Included with this soil in mapping were a few, dark-brown, eroded areas of Kalkaska sand and small areas of Blue Lake loamy sand and Leelanau loamy sand. Also included were many small blown-out areas that are a result of soil blowing. These areas are shown on the soil map by a special symbol.

This soil is mainly wooded, or it is being reforested by pine plantings. The main concerns of management are conserving soil moisture and controlling erosion. The main limitation is the steepness of slopes. (Capability unit VIIs-1 (5a); woodland suitability group E)

Kalkaska sand, 25 to 50 percent slopes (KaF).—This soil is on hillsides on uplands. It has thinner soil layers than those of the profile described as representative for the series.

Included with this soil in mapping were some small, dark-brown, eroded areas of Kalkaska sand and small areas of Leelanau loamy sand.

This soil is mainly wooded. The main concerns of management are controlling erosion and conserving soil moisture. The main limitation is the steepness of slopes. (Capability unit VIIs-1 (5a); woodland suitability group E)

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Kalkaska-Leelanau association, undulating (0 to 6 percent slopes) (KLB).—These undulating soils are on sand plains on uplands and in valleys. Kalkaska and Leelanau soils together make up 85 percent of this association, and the rest is included soils. The Kalkaska soil has a surface layer of sand, and the Leelanau soil has a surface layer of loamy sand.

Included in mapping were small areas of Blue Lake loamy sand and Emmet sandy loam. Also included were small eroded areas and wet depressions.

The soils of this association are in pasture, in woods, or are idle. The main concerns of management are conserving soil moisture, maintaining fertility, and controlling soil blowing. (Capability unit IVs-4 (5a, 4a); woodland suitability group E)

Kalkaska-Leelanau association, rolling (6 to 18 percent slopes) (KLC).—These soils are in rolling areas on uplands. Kalkaska and Leelanau soils together make up 85 percent of this association, and the rest is included soils. The Kalkaska soil has a surface layer of sand, and the Leelanau soil has a surface layer of loamy sand.

Included in mapping were small areas of Blue Lake loamy sand and Emmet sandy loam. Also included were small eroded areas.

The soils of this association are idle or are in pasture. Some areas are wooded. The main concerns of management are conserving soil moisture and maintaining fertility. (Capability unit VIs-1 (5a, 4a); woodland suitability group E)

Kalkaska-Leelanau association, hilly (18 to 30 percent slopes) (KLE).—These soils are in hilly areas on uplands. Kalkaska and Leelanau soils together make up 85 percent of this association, and the rest is included soils. The Kalkaska soil has a surface layer of sand, and the Leelanau soil has a surface layer of loamy sand.

Included in mapping were small areas of Blue Lake loamy sand and Emmet sandy loam. Also included were small, yellowish-brown, severely eroded areas of soils that have a few gullies, and a few areas of very steep soils that have slopes ranging from 30 to 50 percent.

These soils are wooded or are idle. The main concerns of management are controlling soil blowing and water erosion and conserving soil moisture. The main limitation is the steepness of slopes. (Capability unit VIIs-1 (5a, 4a); woodland suitability group E)

Kawkawlin Series

The Kawkawlin series consists of somewhat poorly drained, nearly level to gently sloping soils on till plains and moraines. These soils formed in silty clay loam till. In Charlevoix County the Kawkawlin soils were mapped alone and in an association with Charlevoix soils.

In a representative profile, the surface layer is very dark grayish-brown loam 9 inches thick. The subsoil consists of two parts. The upper part is grayish-brown, friable heavy loam with dark yellowish-brown mottles and is 3 inches thick. The lower part is brown, very firm heavy silty clay loam with light yellowish-brown mottles and is 10 inches thick. The underlying material, at a depth of 25 inches, is grayish-brown silty clay loam.

Permeability is moderately slow. The available water capacity is high. Organic-matter content is moderate, and natural fertility is high. Surface runoff is slow.

If drained, the Kawkawlin soils are suited to farming. They are moderately suited to hardwoods but are poorly suited to pines. They have moderate to severe limitations for many nonfarm uses. If drained, most areas of these soils are in cultivation.

Representative profile of Kawkawlin loam, 0 to 6 percent slopes, in a cultivated area, NE¼NE¼ sec. 8, T. 32 N., R. 7 W.:

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, granular structure; friable; less than 5 percent coarse fragments; slightly acid; clear, smooth boundary.

A2—9 to 12 inches, grayish-brown (10YR 5/2) loam; weak, medium, platy structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B21t—12 to 15 inches, grayish-brown (10YR 5/2) heavy loam; many fine, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

B22t—15 to 25 inches, brown (10YR 4/3) heavy silty clay loam; common, fine, distinct, light yellowish-brown (10YR 6/4) mottles; moderate, medium, angular blocky structure; very firm; clay films on surfaces of peds; less than 5 percent coarse fragments; neutral; gradual, smooth boundary.

C—25 to 60 inches, grayish-brown (10YR 5/2) silty clay loam; weak, coarse, angular blocky structure; very firm; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 15 to 36 inches in thickness. The A2 horizon is light gray or grayish brown. The C horizon is grayish brown or light brownish gray. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Where these soils have a solum ranging from 15 to 20 inches in thickness, they are thinner than the defined range for the series. This difference, however, does not alter their usefulness or behavior.

Kawkawlin soils are in a toposequence with Nester and Sims soils. They are mapped with Charlevoix soils. Kawkawlin soils are similar to Rudyard soils. They have mottles that are lacking in the B horizon of Nester soils. They lack the mottles that are immediately beneath the A1 or Ap horizon in Sims soils. Kawkawlin soils contain more clay in the B horizon and have a finer texture in the C horizon than Charlevoix soils. Kawkawlin soils have a coarser texture in the B and C horizons than Rudyard soils. Also, they have coarse fragments that are lacking in the profile of Rudyard soils.

Kawkawlin loam, 0 to 6 percent slopes (KnC).—This soil is in swales, in depressions, and on foot slopes on uplands. It has the profile described as representative for the series.

Included with this soil in mapping were a few, small, lower areas of Angelica and Ensley loams and some small areas of somewhat poorly drained Charlevoix and Mackinac loams. Also included were small areas of soils that have a sandy loam surface layer.

These soils are in cultivation when they have been drained. Undrained areas are wooded. The main concern of management is improving drainage. (Capability unit IIw-4 (1.5b); woodland suitability group Z)

Kerston Series

The Kerston series consists of very poorly drained, nearly level to gently sloping soils on bottom lands. These soils formed in organic and mineral materials in alternate layers.

In a representative profile, the surface layer is black muck 13 inches thick. The next layer is gray sandy loam 4 inches thick. The next layer is black muck 11 inches thick. Below this layer, at a depth of 28 inches, is grayish-brown sandy loam.

Permeability is moderately rapid. The available water capacity is high. Natural fertility is low. Surface runoff is very slow.

Kerston soils are very poorly suited to farming. They are poorly suited to woodlands. They have severe limitations for most nonfarm uses. These soils are mainly wooded or are in native pasture.

Representative profile of Kerston muck in a nonwooded area, NE¼NW¼ sec. 26, T. 32 N., R. 7 W.:

O1—0 to 13 inches, black (10YR 2/1) muck; moderate, fine, granular structure; friable; neutral; abrupt; smooth boundary.

IIC1—13 to 17 inches, gray (10YR 5/1) sandy loam; massive; friable; neutral; abrupt, smooth boundary.

O2—17 to 28 inches, black (10YR 2/1) muck; weak, medium, granular structure; friable; neutral; abrupt, smooth boundary.

IIC2—28 to 42 inches, grayish-brown (10YR 5/2) sandy loam; massive; friable; mildly alkaline; slightly effervescent.

Reaction of the organic material ranges from neutral to mildly alkaline. In places the organic layers are slightly effervescent. Reaction of the mineral material is neutral or mildly alkaline. Many mineral horizons are slightly effervescent. The thickness and sequence of organic and mineral materials are variable within a short distance.

The annual temperature of these soils is a few degrees cooler and the mineral material is thicker than the defined range for the series. These differences, however, do not alter the usefulness or behavior of these soils.

The Kerston soils are similar to Carbondale, Cathro, Edwards, Greenwood, Linwood, Lupton, Markey, Tawas, and Warners soils. Kerston soils differ from Carbondale, Greenwood, and Lupton soils in containing mineral material within a depth of 42 inches. They lack the marl that is within a depth of 42 inches in the Edwards and Warners soils. Kerston soils differ from Cathro, Linwood, Markey, and Tawas soils in having two or more strata of mineral material below the surface layer that are separated by organic layers.

Kerston muck (0 to 4 percent slopes) (Kr).—This soil is in narrow depressions and drainageways on bottom lands.

Included with this soil in mapping were small areas of Lupton and Tawas mucks. Also included were small areas of soils that have a sandy loam or silt loam surface layer.

This soil is mainly in pasture or woods. The main concerns of management are improving drainage, reducing the hazard of flooding, and controlling soil blowing. In many areas there is a hazard of frost. (Capability unit VIwc-2 (L-Mc); woodland suitability group J)

Kiva Series

The Kiva series consists of well-drained, nearly level to very steep soils on beach ridges, lake plains, and lake terraces. These soils formed in gravelly sand. In Charlevoix County the Kiva soils were mapped only in an undifferentiated unit with Alpena and East Lake soils.

In a representative profile, the surface layer is very dark brown gravelly loamy sand 7 inches thick. The subsurface layer is light brownish-gray loamy sand 3 inches thick. The subsoil is dark-brown, friable sandy loam 8 inches thick. The underlying material, at a depth of 18 inches, is light brownish-gray gravelly sand.

Permeability is moderately rapid. The available water capacity is low. Organic-matter content is moderately

low, and natural fertility is low. Surface runoff is slow.

The Kiva soils are very poorly suited to farming and are poorly suited to woodland. Less sloping areas have few limitations for most nonfarm uses. The soils are mostly wooded. They are used mainly for recreation.

Representative profile of Kiva gravelly loamy sand from an area of Alpena, Kiva and East Lake soils, in a wooded area, NE¼NE¼ sec. 4, T. 32 N., R. 7 W.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) gravelly loamy sand; weak, fine, granular structure; friable; 25 percent coarse fragments; slightly acid; abrupt, wavy boundary.

A2—7 to 10 inches, light brownish-gray (10YR 6/2) loamy sand; weak, thin, platy structure; friable; 15 percent coarse fragments; slightly acid; clear, wavy boundary.

Bir—10 to 18 inches, dark-brown (7.5YR 4/4) sandy loam; weak, medium, subangular blocky structure; friable; 15 percent coarse fragments; slightly acid; clear, wavy boundary.

IIC—18 to 60 inches, light brownish-gray (10YR 5/3) gravelly sand; single grain; loose; 30 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 10 to 24 inches in thickness. In a few profiles, the A2 horizon is absent.

Kiva soils were mapped with Alpena and East Lake soils. They have a thicker solum than the Alpena soils. They have a thinner solum than the East Lake soils.

Lake Beaches

Lake beaches (Lb) is in narrow strips along the shores of Lake Michigan and the large inland lakes. These beaches are composed mostly of sand and gravel that are subject to wave action, which is severe during storms. No consistent sequence of soil horizons has formed, because these soil materials are moved periodically.

In addition to sand and gravel, Lake beaches includes stones and boulders. Some beaches are rocky, and bedrock is exposed. In many places this land type is underlain by glacial drift consisting of silt, silt loam, loam, or sandy loam, or by lacustrine silt and clay. These underlying materials generally are in areas where waves have cut into bluffs or escarpments of similar material.

Along areas of Lake beaches, the level of the lakes fluctuates as much as 12 inches annually. When the lakes are low, many areas are stable enough to have a cover of beachgrass, willow, elm, basswood, paper birch, white-cedar, and shrubs. These plants are commonly washed away during periods of high water. In many places areas of Lake beaches are very narrow and are included in mapped areas of adjoining soils.

Lake beaches generally is idle or is used for recreation. Some areas are used for resorts. (Capability unit VIIIs-1; woodland suitability group not assigned)

Leelanau Series

The Leelanau series consists of well-drained, nearly level to very steep soils on moraines and till plains. These soils formed in loamy sand till. In Charlevoix County the Leelanau soils were mapped alone and in complexes with the Rubicon soils and with the Emmet soils. The Leelanau soils were also mapped in associations with the Emmet soils and with the Kalkaska soils.

In a representative profile, the surface layer is very dark brown loamy sand 4 inches thick. The subsurface layer is grayish-brown loamy sand 4 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, very friable loamy sand 7 inches thick. The middle part is pale-brown, loose loamy sand 5 inches thick. The lower part consists of thin, interbedded layers of dark yellowish-brown, friable sandy loam and pale-brown, loose loamy sand. These interbedded layers have a total thickness of 22 inches. The underlying material, at a depth of 42 inches, is grayish-brown loamy sand.

Permeability is moderately rapid. The available water capacity is low. Organic-matter content is moderately low, and natural fertility is low.

The Leelanau soils are moderately suited to farming. They are moderately suited to hardwoods and are well suited to pines. The less sloping areas of these soils have few limitations for nonfarm use. Most of the less sloping areas are used for field and forage crops. The more sloping areas are in woods and pasture.

Representative profile of Leelanau loamy sand, 2 to 6 percent slopes, in a nonwooded area, NW¼SW¼ sec. 35, T. 34 N., R. 8 W.:

A1—0 to 4 inches, very dark brown (10YR 2/2) loamy sand; weak, medium, granular structure; very friable; slightly acid; clear, wavy boundary.

A2—4 to 8 inches, grayish-brown (10YR 5/2) loamy sand; weak, thin, platy structure; very friable; slightly acid; clear, wavy boundary.

Bhir—8 to 15 inches, dark yellowish-brown (10YR 3/4) loamy sand; very weak, medium, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

A'2—15 to 20 inches, pale-brown (10YR 6/3) loamy sand; single grain; loose; slightly acid; abrupt, wavy boundary.

A'2&B'2t—20 to 42 inches, pale-brown (10YR 6/3) loamy sand (A'2); single grain; loose; bands of dark yellowish-brown (10YR 4/4) sandy loam (B'2t); weak, medium, subangular blocky structure; friable; bands are 1 to 3 inches thick; clay bridges connect sand grains in bands; less than 5 percent coarse fragments; slightly acid; abrupt, irregular boundary.

C—42 to 60 inches, grayish-brown (10YR 5/2) loamy sand; single grain; loose; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 30 to 60 inches in thickness. In cultivated areas the A1 and A2 horizons are mixed to form an Ap horizon. The A2 horizon is gray or grayish brown. The Bhir horizon is dark yellowish brown or yellowish brown and ranges from 4 to 10 inches in thickness. The B'2t bands in the A'2&B'2t horizon are heavy loamy sand or sandy loam and are one to six in number. In a few profiles, the C horizon has pockets of sand or gravelly sand. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

In places the solum of Leelanau soils in Charlevoix County is 48 to 60 inches thick. This thickness is greater than the defined range for the series, but this difference does not alter the usefulness or behavior of these soils.

Leelanau soils were mapped with Rubicon, Emmet, and Kalkaska soils. The Leelanau soils are similar to the Blue Lake, Edmore, Mancelona, and Otisco soils. Leelanau soils are coarser textured than the Emmet soils in horizons that have the same horizon designation. They are dominantly finer textured throughout the profile than Rubicon and Kalkaska soils. Also, Leelanau soils differ from Kalkaska and Rubicon soils in having a loamy B't horizon and in containing coarse fragments. Leelanau soils differ from Blue Lake soils in having coarse fragments. Leelanau soils lack the mottles that are in the solum of Edmore soils. They are mainly finer textured in the C horizon than Mancelona soils. Leelanau soils lack the mottles that are in the solum of Otisco soils.

Leelanau loamy sand, 2 to 6 percent slopes (LdB).—This soil is in medium-sized to large areas on low knolls, ridges, and foot slopes of uplands. It has the profile de-

scribed as representative for the series. In cultivated areas there is a grayish-brown plow layer that is a mixture of the original very dark brown loamy sand surface layer and the grayish-brown loamy sand subsurface layer.

Included with this soil in mapping were some small depressions where sandy overwash covers the original surface layer, and a few, small, eroded areas in higher positions that were the source of the overwash materials. Also included were some wetter areas in depressions or in drainageways. A few, small, loamy or clayey deposits are in the underlying material in some areas.

Most areas of this soil are in cultivation. Some areas are in woodland, and a few areas are in hay crops, in pasture, or are idle. Surface runoff is slow. The main concerns of management are controlling soil blowing, conserving soil moisture, and maintaining fertility. (Capability unit IIIs-4 (4a); woodland suitability group C)

Leelanau loamy sand, 6 to 12 percent slopes (LdC).—This soil is in medium-sized to large areas on ridges, knolls, and foot slopes of uplands. In cultivated areas the grayish-brown plow layer is a mixture of the original surface layer and the subsurface layer.

Included with this soil in mapping were a few, small, dark-brown, eroded areas of soils, and small areas of Emmet sandy loam. A few, small, loamy or clayey deposits are in the underlying material in some areas.

Many areas of this soil are in cultivation or in hay crops and pasture. Other areas are wooded. Surface runoff is medium. The main management concerns are controlling water erosion, conserving moisture, and maintaining fertility. (Capability unit IIIe-9 (4a); woodland suitability group C)

Leelanau loamy sand, 12 to 18 percent slopes (LdD).—This soil is on ridges and hillsides of uplands. It has thinner surface and subsurface layers and a thinner subsoil than the profile of the soil described as representative for the series.

Included with this soil in mapping were small areas of Emmet sandy loam and Blue Lake loamy sand. Also included were small areas of soils in which a few loamy or clayey pockets are in the underlying material.

This soil is mainly wooded. A few areas are in pasture or hay crops. Surface runoff is rapid. The main concerns of management are controlling water erosion, conserving moisture, and maintaining fertility. (Capability unit IVe-9 (4a); woodland suitability group C)

Leelanau loamy sand, 18 to 25 percent slopes (LdE).—This soil is on hillsides of uplands. It has much thinner layers than those in the profile described as representative for the series.

Included with this soil in mapping were small areas of Emmet sandy loam, Blue Lake loamy sand, and small, severely eroded areas. These dark yellowish-brown, eroded areas are shown on the soil map by a special symbol.

This soil is mainly wooded. A few small areas are in hay crops and pasture. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIe-2 (4a); woodland suitability group C)

Leelanau loamy sand, 25 to 50 percent slopes (LdF).—This soil is on hillsides of uplands. It has layers that are much thinner than those in the profile descibed as representative for the series.

Included with this soil in mapping were some small areas of Emmet sandy loam; a few, small, less sloping areas; and some, small, eroded areas.

This soil is almost all wooded. A few small areas are in pasture or are idle. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the very steep slopes. (Capability unit VIIe-2 (4a); woodland suitability group C)

Leelanau-Emmet association, undulating (0 to 6 percent slopes) (LEB).—These soils are in undulating areas of the central and eastern uplands. Leelanau and Emmet soils together make up 95 percent of this association, and the rest is included soils. The Leelanau soil has a loamy sand surface layer, and the Emmet soil has a sandy loam surface layer.

Included in mapping were small areas of Kalkaska sand and some wetter soils in lower areas. Also included were a few, small, eroded areas.

The soils of this association are mainly in cultivation or in hay crops and pasture. Some areas are wooded. Surface runoff is slow. The main concerns of management are controlling soil blowing, conserving soil moisture, and maintaining fertility. (Capability unit IIIs-4 (4a, 3a); woodland suitability group C)

Leelanau-Emmet association, rolling (6 to 18 percent slopes) (LEC).—These soils are in rolling areas of the central and eastern uplands. Leelanau and Emmet soils together make up 95 percent of this mapping unit, and the rest is included soils. The Leelanau soil has a loamy sand surface layer, and the Emmet soil has a sandy loam surface layer.

Included in mapping were small areas of Kalkaska sand and small, eroded areas.

Some areas of these soils are in hay crops and pasture. Other areas are wooded. Surface runoff is medium to rapid. The main concerns of management are controlling water erosion, conserving moisture, and maintaining fertility. (Capability unit IVe-9 (4a, 3a); woodland suitability group C)

Leelanau-Emmet association, hilly (18 to 30 percent slopes) (LEE).—These soils are in hilly areas of the central and eastern uplands. Leelanau and Emmet soils together make up 95 percent of this mapping unit, and the rest is included soils. The Leelanau soil has a loamy sand surface layer, and the Emmet soil has a sandy loam surface layer.

Included in mapping were small areas of Kalkaska sand and small, eroded areas. Also included were a few very steep soils that have slopes ranging from 30 to 50 percent.

The soils of this association are mainly wooded. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIe-2 (4a, 3a); woodland suitability group C)

Leelanau-Rubicon loamy sands, 0 to 6 percent slopes (LrB).—These soils are in medium-sized to large areas on low knolls, ridges, and foot slopes of the uplands. The Leelanau soil makes up about 65 percent of the complex; the Rubicon soil, 25 percent; and included soils, about 10 percent.

Included in mapping were small depressions in which sandy overwash covers the original surface layer, and a

few eroded areas in higher positions that were the source of the overwash materials. Also included were a few small areas of Emmet sandy loam and small, wet depressions and drainageways.

This soil is mainly in cultivation or is in hay crops or pasture. Other areas are wooded. Surface runoff is slow. The main concerns of management are controlling soil blowing, conserving soil moisture, and maintaining fertility. (Capability unit IIIs-4 (4a, 5.3a); woodland suitability group C)

Leelanau-Rubicon loamy sands, 6 to 12 percent slopes (LrC).—These soils are on knolls, ridges, and foot slopes in the uplands. The Leelanau soil makes up about 70 percent of the complex; the Rubicon soil, 20 percent; and included soils, about 10 percent.

Included in mapping were small, eroded areas and a few small areas of Emmet sandy loam.

The soils of this complex are mainly in hay crops and pasture. A few are in small grain, but many areas are wooded. Surface runoff is slow to medium. The main concerns of management are controlling water erosion, conserving moisture, and maintaining fertility. (Capability unit IIIe-9 (4a, 5.3a); woodland suitability group C)

Leelanau-Rubicon loamy sands, 12 to 18 percent slopes (LrD).—These soils are on ridges and hillsides of the uplands. The Leelanau soil makes up about 70 percent of the complex; the Rubicon soil, 20 percent; and included soils, about 10 percent.

Included in mapping were small, eroded areas and small areas of Emmet sandy loam.

The soils of this complex are mainly wooded. A few areas are in pasture or hay crops. Surface runoff is medium to rapid. The main concerns of managment are controlling water erosion, conserving moisture, and maintaining fertility. (Capability unit IVe-9 (4a, 5.3a); woodland suitability group C)

Leelanau-Rubicon loamy sands, 18 to 25 percent slopes (LrE).—These soils are on hillsides in the uplands. The Leelanau soil makes up about 65 percent of the complex; the Rubicon soil, 20 percent; and included soils, about 15 percent.

Included in mapping were small, eroded areas and some moderately sloping and very steep areas. Also included were small areas of Emmet sandy loam.

The soils of this complex are mainly wooded. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIe–2 (4a, 5.3a); woodland suitability group C)

Leelanau-Rubicon loamy sands, 25 to 50 percent slopes (LrF).—These soils are on hillsides in the uplands. The Leelanau soil makes up about 65 percent of the complex; the Rubicon soil, 20 percent; and included soils, about 15 percent.

Included in mapping were small, severely eroded areas or blowouts, shown on the soil map by a special symbol. Also included were small areas of less sloping soils and small areas of Emmet sandy loam.

The soils of this complex are mainly wooded. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the very steep slopes. (Capability unit VIIe–2 (4a, 5.3a); woodland suitability group C)

Linwood Series

The Linwood series consists of very poorly drained organic soils in depressional areas on lake plains, till plains, and moraines. These soils formed in organic material 12 to 42 inches thick over loam.

In a representative profile, the surface layer is black muck 10 inches thick. The next layer is very dark brown muck 10 inches thick. The underlying material, at a depth of 20 inches, is grayish-brown loam.

Permeability is moderately rapid in the muck layers and moderate in the underlying loam. The available water capacity is high. Natural fertility is low. Surface runoff is very slow.

Linwood soils are very poorly suited to farming. They have variable suitability for woodland. They are well suited as habitat for wetland wildlife. These soils have severe limitations for most nonfarm uses. They are mainly wooded or are in native pasture.

Representative profile of Linwood muck in a nonwooded area, NE¼SE¼ sec. 27, T. 32 N., R. 7 W.:

O1—0 to 10 inches, black (10YR 2/1) muck; strong, fine, granular structure; friable; neutral; diffuse, smooth boundary.

O2—10 to 20 inches, very dark brown (10YR 2/2) muck; moderate, medium, granular structure; friable; neutral; abrupt, smooth boundary.

IIC—20 to 60 inches, grayish-brown (10YR 5/2) loam; weak, coarse, subangular blocky structure; slightly sticky, slightly plastic; mildly alkaline; slightly effervescent.

The organic material ranges from 12 to 42 inches in thickness over loamy material. Reaction throughout this material ranges from strongly acid to neutral. The IIC horizon is sandy loam, loam, or sandy clay loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The annual temperature of these soils is a few degrees cooler than the defined range for the series. This difference, however, does not alter the usefulness or behavior of these soils.

Linwood soils are similar to Carbondale, Cathro, Edwards, Greenwood, Kerston, Lupton, Markey, Tawas, and Warners soils. They differ from Carbondale, Greenwood, and Lupton soils in lacking more than 42 inches of organic material. Linwood soils lack the marl that is between depths of 12 and 42 inches in the Edwards and Warners soils. They have finer textured mineral material than the Markey and Tawas soils. These soils differ from Kerston soils in lacking two or more strata of mineral material below the surface layer that are separated by organic layers. The organic material in Linwood soils is less alkaline than in Cathro soils.

Linwood muck (0 to 4 percent slopes) (Ls).—This soil is in broad depressions on plains and in small potholes on uplands.

Included with this soil in mapping were small areas of thin, sandy overwash material, 6 to 10 inches thick, that eroded from surrounding uplands. Also included were small areas of Tawas muck and Carbondale muck.

This soil is mainly in pasture and woods. The main concerns of management are improving drainage and controlling soil blowing. The main limitation is a hazard of frost. (Capability unit VIwc–1 (M/3c); woodland suitability group J)

Lupton Series

The Lupton series consists of very poorly drained, nearly level to gently sloping organic soils in depressional areas on moraines, lake plains, outwash plains, and till

plains. These soils formed in organic material more than 42 inches thick. In Charlevoix County the Lupton soils were mapped alone and in an association with Cathro soils.

In a representative profile, the surface layer is black muck 14 inches thick. The next layer is very dark grayish-brown muck 8 inches thick. The next layer is dark-brown muck 14 inches thick. Below this layer, at a depth of 36 inches, is very dark grayish-brown muck.

Permeability is moderately rapid. The available water capacity is very high. Natural fertility is low. Surface runoff is very slow.

The Lupton soils are very poorly suited to farming. They have variable suitability for woodland. They are well suited as a habitat for wetland wildlife. The Lupton soils have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of Lupton muck in a wooded area, SW¼NW¼ sec. 25, T. 33 N., R. 7 W.:

O1—0 to 14 inches, black (10YR 2/1) muck; moderate, medium, granular structure; friable; mildly alkaline; gradual, wavy boundary.

O2—14 to 22 inches, very dark grayish-brown (10YR 3/2) muck; moderate, medium, granular structure; friable; mildly alkaline; gradual, wavy boundary.

O3—22 to 36 inches, dark-brown (10YR 3/3) muck; massive; friable; mildly alkaline; gradual, wavy boundary.

O4—36 to 42 inches, very dark grayish-brown (10YR 3/2) muck; massive; friable; small amount of woody material; mildly alkaline.

Organic material is generally more than 42 inches thick. Reaction throughout the profile ranges from neutral to mildly alkaline but is dominantly mildly alkaline. The 01 horizon is very dark brown or black. The layers below the surface layers are very dark grayish brown, very dark brown, dark brown, or black.

Lupton soils are similar to Carbondale, Edwards, Greenwood, Kerston, Linwood, Markey, Tawas, and Warners soils. They were mapped with Cathro soils. Lupton soils differ from all these soils, except Carbondale and Greenwood soils, in lacking mineral material or marl between depths of 12 and 42 inches. Lupton soils are dominantly more decomposed in most layers between depths of 12 and 42 inches than Carbondale soils. They are more alkaline throughout the profile than Carbondale soils. These soils are dominantly more decomposed and less acid throughout the profile than the Greenwood soils.

Lupton muck (0 to 4 percent slopes) (Lt).—This soil is on broad, depressional flats on plains and in small potholes on uplands. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Markey muck or Cathro muck. These areas are near the edges of areas of the soil in this unit. Also included near the edges were small deposits of sandy overwash material ranging from 5 to 10 inches in thickness.

These soils are mainly in woods or pasture. The main concerns of management are improving drainage and controlling soil blowing. The main limitation is a hazard of frost. (Capability unit VIwc–1 (Mc); woodland suitability group J)

Lupton-Cathro association (0 to 4 percent slopes) (LU).—These soils are in broad, depressional areas on plains and in small potholes on uplands. The Lupton muck and Cathro muck together make up 90 to 95 percent of this association, and the rest is included soils.

Included in mapping were small, narrow areas of sandy overwash material ranging from 5 to 10 inches in thickness. These areas are near the edges of areas of the soils in this association.

The soils of this association are mainly wooded. The main concerns of management are improving drainage and controlling soil blowing. The main limitation is a hazard of frost. (Capability unit VIwc–1 (Mc, M/3c); woodland suitability group J)

Mackinac Series

The Mackinac series consists of somewhat poorly drained, nearly level to gently sloping soils on moraines, till plains, and lake plains. These soils formed in loam till. In Charlevoix County the Mackinac soils were mapped only in complexes with the Charlevoix soils.

In a representative profile, the surface layer is very dark brown loam 8 inches thick. The subsurface layer is yellowish-brown loam 2 inches thick. The subsoil consists of two parts. The upper part is brown, friable loam with yellowish-brown mottles and is 6 inches thick. The lower part is light yellowish-brown, friable loam 7 inches thick. The underlying material, at a depth of 23 inches, is brown loam that has yellowish-brown mottles.

Permeability is moderate. The available water capacity is high. Organic-matter content is moderate, and natural fertility is high. Surface runoff is slow.

If drained and where not cobbly, the Mackinac soils are well suited to farming and are used mainly for this purpose. The areas containing cobblestones are poorly suited to farming and are mainly wooded. They are moderately suited to hardwoods but are poorly suited to pines. The Mackinac soils have moderate to severe limitations for many nonfarm uses.

Representative profile of a Mackinac loam from an area of Charlevoix-Mackinac loams, 0 to 6 percent slopes, in a nonwooded area, SE¼NW¼ sec. 24, T. 33 N., R. 7 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) loam; weak, fine, granular structure; friable; less than 5 percent coarse fragments; mildly alkaline; clear, smooth boundary.

A2—8 to 10 inches, yellowish-brown (10YR 5/4) loam; common, medium, faint, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

Bir—10 to 16 inches, brown (10YR 5/3) loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; mildly alkaline; gradual, wavy boundary.

B't—16 to 23 inches, light yellowish-brown (10YR 6/4) loam; common, medium, faint, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable; few very thin clay films on surfaces of peds; less than 5 percent coarse fragments; mildly alkaline; gradual, wavy boundary.

C—23 to 60 inches, brown (10YR 5/3) loam; few, medium, faint, dark yellowish-brown (10YR 4/4) mottles and few, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, coarse, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is dominantly 24 to 40 inches thick but ranges from 18 to 40 inches in thickness. The A2 horizon is loam or sandy loam. The Bir horizon is sandy loam or loam. The B't horizon is loam or clay loam. The C horizon is brown or reddish brown, and it is loam or sandy loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The solum is more alkaline than the defined range for the series, but this difference does not alter the usefulness or behavior of these soils.

Mackinac soils are in a toposequence with Angelica and Onaway soils. They were mapped with Charlevoix soils. Mackinac soils are similar to Brimley and Detour soils. Mackinac soils in most areas are near Emmet soils. They lack the grayish-colored matrix that is in the B horizon of Angelica soils. They differ from Onaway soils in having mottles in the solum. They contain more clay between depths of 10 and 40 inches than Charlevoix soils. Also, they have a finer texture throughout the C horizon than Charlevoix soils. Mackinac soils differ from Brimley soils in containing coarse fragments throughout the profile and in lacking stratification in the C horizon. They differ from Detour soils in being less compact in the B and C horizons and in having fewer cobblestones throughout the profile. They differ from Emmet soils in having mottles in the solum.

Made Land

Made land (Ma) consists mainly of areas that have been filled with soil materials that were hauled in and leveled to provide building sites on poorly drained soils.

Included with this land type in mapping were areas that were leveled to make building sites in sloping areas. Also included were areas that had been dumping grounds or gravel pits.

These areas have a thin soil cover over solid waste material. (Capability unit not assigned; woodland suitability group not assigned)

Mancelona Series

The Mancelona series consists of well drained or moderately well drained, nearly level to very steep soils on lake plains and in valley trains. These soils formed in loamy sand. In Charlevoix County the Mancelona soils were mapped alone and in an association with the East Lake soils.

In a representative profile, the surface layer is very dark grayish-brown loamy sand 8 inches thick. The subsurface layer is pale-brown loamy sand 3 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown, very friable loamy sand that contains some cemented chunks and is 3 inches thick. The middle part is loose, brown loamy sand 4 inches thick. The lower part is brown, friable sandy loam 8 inches thick. The underlying material, at a depth of 26 inches, is pale-brown very gravelly sand.

Permeability is moderately rapid. The available water capacity is low. The organic-matter content is moderately low, and natural fertility is low.

The less sloping areas of these soils are moderately suited to farming. They are moderately suited to hardwoods and are well suited to pines. The less sloping areas have few limitations for nonfarm uses. These areas are mainly farmed. The steeper areas are in woods or pasture.

Representative profile of Mancelona loamy sand, 0 to 6 percent slopes, in a nonwooded area, NE¼SW¼ sec. 7, T. 33 N., R. 7 W.:

A1—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, fine, granular structure; very friable; less than 5 percent coarse fragments; slightly acid; clear, smooth boundary.

A2—8 to 11 inches, pale-brown (10YR 6/3) loamy sand; very weak, thin, platy structure; very friable; less than 5 percent coarse fragments; medium acid; clear, wavy boundary.

Bir—11 to 14 inches, dark yellowish-brown (10YR 4/4) loamy sand; very weak, medium, subangular blocky structure; very friable; a few cemented chunks of ortstein; 5 percent coarse fragments; medium acid; clear, wavy boundary.

A'2—14 to 18 inches, brown (10YR 5/3) loamy sand; single grain; loose; 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B't—18 to 26 inches, brown (7.5YR 4/4) sandy loam; weak, medium, subangular blocky structure; friable; clay films and bridging; 10 percent coarse fragments; slightly acid; abrupt, irregular boundary.

IIC—26 to 60 inches, pale-brown (10YR 6/3) very gravelly sand; single grain; loose; 40 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 24 to 40 inches in thickness. The Ap horizon is very dark grayish brown, very dark brown, or dark brown. The Bir horizon is dark yellowish brown, yellowish brown, or reddish brown. In a few profiles an A'2 horizon is absent. It is brown loamy sand about 4 inches thick. The B't horizon is sandy loam, light sandy clay loam, or a gravelly analog of these textures. It ranges from 2 to 10 inches in thickness. The IIC horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Mancelona soils are in a toposequence with Epoufette and Gladwin soils. They were mapped with East Lake soils. The Mancelona soils are similar to Blue Lake, Kalkaska, and Leelanau soils. They differ from Epoufette soils in lacking mottles in the solum and in having a Bir horizon. They differ from Gladwin soils in lacking mottles in the A2 and B horizons. They differ from East Lake and Kalkaska soils in having a loamy B't horizon. They have coarse fragments throughout the profile that are lacking in Kalkaska and Blue Lake soils. Mancelona soils are dominantly coarser in texture in the C horizon than Leelanau soils.

Mancelona loamy sand, 0 to 6 percent slopes (McB).—This soil is on sandy plains and in valleys. In areas that are not in cultivation, this soil has the profile described as representative for the series. In cultivated areas, there is a grayish-brown plow layer that is a mixture of the original surface layer and the subsurface layer. Most areas are well drained, but some are moderately well drained.

Included with this soil in mapping were small areas of Kalkaska sand in slightly higher positions. Also included were areas of somewhat poorly drained Gladwin loamy sand in slight depressions; small depressions where sandy overwash covers the original surface layer; and a few, dark yellowish-brown, eroded areas that were the source of the overwash materials. There are also small cobbly and stony areas.

This soil is mainly in cultivation. A few areas are in pasture or woods. Surface runoff is slow. The main concerns of management are controlling soil blowing, conserving soil moisture, and maintaining fertility. (Capability unit IIIs–4 (4a); woodland suitability group C)

Mancelona loamy sand, 6 to 12 percent slopes (McC).—This soil is on sandy plains and valley foot slopes.

Included with this soil in mapping were small areas of Kalkaska sands that are more droughty than the soil in this unit. Also included were a few, dark yellowish-brown, eroded areas and small areas of gently sloping and strongly sloping soils.

Many areas of this soil are in cultivation or are in hay and pasture. Some areas are wooded. Surface runoff is medium. The main concerns of management are controlling water erosion and maintaining fertility. (Capability unit IIIe–9 (4a); woodland suitability group C)

Mancelona loamy sand, 12 to 18 percent slopes (McD).—This soil is along the edges of sandy plains and in valleys.

Included with this soil in mapping were a few areas of dark yellowish-brown, eroded soils and small areas of moderately sloping and steep soils.

This soil is mainly in woods. A few areas are in hay and pasture or are idle. Surface runoff is medium to rapid. The main concerns of management are controlling water erosion, conserving moisture, and maintaining fertility. (Capability unit IVe–9 (4a); woodland suitability group C)

Mancelona loamy sand, 18 to 25 percent slopes (McE).—This soil is on narrow, knoblike slopes adjacent to deep, wet depressions on sand plains and in valleys.

Included with this soil in mapping were small areas of a dark yellowish-brown, eroded soil and a few areas of very steep soils.

This soil is mainly in woods. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIe–2 (4a); woodland suitability group C)

Mancelona loamy sand, 25 to 50 percent slopes (McF).—This soil is on narrow, knoblike slopes adjacent to deep, wet depressions on sand plains and in valleys. Because this soil is very steep, the soil layers are thinner than those of the profile described as representative for the series.

Included with this soil in mapping were some small areas of dark yellowish-brown and brown, eroded soils.

Almost all of this soil is in woods. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIIe–2 (4a); woodland suitability group C)

Mancelona-East Lake association, undulating (0 to 6 percent slopes) (MEB).—These soils are on undulating plains. The Mancelona and East Lake loamy sands together make up 85 percent of this association, and the rest is included soils.

Included in mapping were small areas of soils that have a cobbly or stony surface layer and small, depressional areas of Gladwin loamy sand and Epoufette sandy loam. Also included were small eroded areas of soils that have a dark-brown or dark yellowish-brown surface layer.

These soils are mainly in cultivation or are in hay and pasture. A few areas are in woods. Surface runoff is slow. The main concerns of management are controlling soil blowing, conserving soil moisture, and maintaining fertility. (Capability unit IIIs–4 (4a, 5a); woodland suitability group C)

Mancelona-East Lake association, rolling (6 to 18 percent slopes) (MEC).—These soils are on rolling plains. Mancelona and East Lake loamy sands together make up 85 percent of this association, and the rest is included soils.

Included in mapping were small, eroded areas of soils that have a dark-brown or dark yellowish-brown surface layer.

This soil is mainly in hay, pasture, and woods. Surface runoff is medium to rapid. The main concerns of management are controlling water erosion, conserving soil moisture, and maintaining fertility. (Capability unit IVe–9 (4a, 5a); woodland suitability group C)

Mancelona-East Lake association, hilly (18 to 30 percent slopes) (MEE).—These soils are in hilly areas along the narrow edges of sand plains. The Mancelona and East Lake loamy sands together make up 85 percent of this association, and the rest is included soils.

Included in mapping were small, eroded areas of soils that have a dark-brown or dark yellowish-brown surface layer. Also included were a few areas of very steep soils that have slopes ranging from 30 to 50 percent.

This soil is mainly in woods or pasture. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIe–2 (4a, 5a); woodland suitability group C)

Markey Series

The Markey series consists of very poorly drained, nearly level to gently sloping organic soils in depressional areas on till plains, lake plains, and moraines. These soils formed in organic material 12 to 42 inches thick over loamy sand.

In a representative profile, the surface layer is black muck 9 inches thick. The next layer is dark-brown muck 13 inches thick. The underlying material, at a depth of 22 inches, is grayish-brown loamy sand.

Permeability is moderately rapid in the muck layers and rapid in the underlying loamy sand. The available water capacity is high. Natural fertility is low. Surface runoff is very slow.

Markey soils are very poorly suited to farming. They have variable suitability for woodland. They are well suited as habitat for wetland wildlife. These soils have severe limitations for most nonfarm uses. They are mainly wooded.

Representative profile of Markey muck in a nonwooded area, SW¼SW¼ sec. 7, T. 32 N., R. 4 W.:

O1—0 to 9 inches, black (10YR 2/1) muck; moderate, fine, granular structure; friable; mildly alkaline; gradual, wavy boundary.

O2—9 to 18 inches, dark-brown (7.5YR 3/2) muck; weak, medium, granular structure; friable; mildly alkaline; gradual, wavy boundary.

O3—18 to 22 inches, dark-brown (7.5YR 4/2) muck; massive; friable; mildly alkaline; abrupt, smooth boundary.

IIC—22 to 60 inches, grayish-brown (10YR 5/2) loamy sand; single grain; loose; mildly alkaline; slightly effervescent.

The organic material ranges from 12 to 42 inches in thickness over sandy material. Reaction throughout the organic material ranges from neutral to mildly alkaline, but it is dominantly mildly alkaline. The organic subsurface layer is very dark grayish brown, dark reddish brown, or dark brown. The IIC horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Markey soils are similar to Carbondale, Cathro, Edwards, Greenwood, Kerston, Linwood, Lupton, Tawas, and Warners soils. They differ from Carbondale, Greenwood, and Lupton soils in lacking organic material more than 42 inches thick. They lack the marl that is between depths of 12 and 42 inches in Edwards and Warners soils. They differ from Kerston soils in lacking two or more strata of mineral material below the surface layer that are separated by organic layers. These soils lack the loamy material that underlies Cathro and Linwood soils. They are more alkaline throughout the organic material than Tawas soils.

Markey muck (0 to 4 percent slopes) (Mk).—This soil is in broad, depressional areas on plains and in small potholes on uplands.

Included with this soil in mapping were small, narrow areas of Roscommon sand and thin deposits of sandy overwash material, 5 to 10 inches thick, near the edges of areas of this soil. Also included were small areas of deeper Lupton muck.

This soil is mainly in pasture or woods. The main concerns of management are improving drainage and controlling soil blowing. The main limitation is a hazard of frost. (Capability unit VIwc–1 (M/4c); woodland suitability group J)

Menominee Series

The Menominee series consists of well drained or moderately well drained, nearly level to sloping soils on lake plains and moraines. These soils formed in loamy sand 18 to 42 inches thick over loam.

In a representative profile, the surface layer is very dark grayish-brown loamy sand 7 inches thick. The subsurface layer is grayish-brown loamy sand 3 inches thick. The subsoil consists of two parts. The upper part is strong-brown, very friable sand 5 inches thick. The lower part is brown, friable loamy sand 13 inches thick. The underlying material, at a depth of 28 inches, is brown loam.

Permeability is rapid in the subsoil and moderately slow in the underlying material. The available water capacity is low in the subsoil and moderate in the underlying material. Organic-matter content is moderately low, and natural fertility is low.

Menominee soils are moderately suited to farming. They are moderately suited to hardwoods and are well suited to pines. They have moderate to severe limitations for many nonfarm uses. These soils are mainly in cultivation.

Representative profile of Menominee loamy sand, 0 to 6 percent slopes, in a nonwooded area, NW¼SE¼ sec. 14, T. 33 N., R. 8 W.:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, fine, granular structure; very friable; slightly acid; clear, smooth boundary.

A2—7 to 10 inches, grayish-brown (10YR 5/2) loamy sand; weak, thin, platy structure; friable; medium acid; clear, wavy boundary.

Bir—10 to 15 inches, strong-brown (7.5YR 5/6) sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B't—15 to 28 inches, brown (10YR 4/3) loamy sand; weak, medium, subangular blocky structure; friable; clay bridging of sand grains; slightly acid; clear, wavy boundary.

IIC—23 to 60 inches, brown (7.5 YR 5/4) loam; weak, coarse, angular blocky structure; firm; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The sandy upper part of the profile is dominantly 20 to 40 inches in thickness, but in some areas it ranges from 18 to 42 inches in thickness. Since the Ap horizon was formed by the mixing of the A1 horizon and all or part of the A2 horizon, the A2 horizon, after tillage operations, is thin or discontinuous in many profiles. The Bir horizon is dark brown, strong brown, or yellowish brown. In a few profiles, the Bir horizon contains weakly cemented chunks of ortstein. The IIC horizon is loam, clay loam, or silty clay loam. It is moderately alkaline or mildly alkaline and is slightly effervescent.

The B't horizon is coarser in texture than the defined range for the series, but this difference does not alter the usefulness or behavior of these soils.

Menominee soils are in a toposequence with Brevort and Iosco soils. They are similar to Ubly soils. They are browner in the B horizon than Brevort soils. These soils lack the mottles that are in the solum of Iosco soils. They are dominantly coarser in texture in the upper part of the profile than Ubly soils.

Menominee loamy sand, 0 to 6 percent slopes (MnB).—This soil is on sandy plains and on low ridges, knolls, and foot slopes on uplands. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of somewhat poorly drained Iosco loamy sand in narrow swales. Also included were small areas of Rubicon sand, loamy substratum, on low ridges and a few small areas of soils that have a dense loamy sand subsoil and clay underlying material.

This soil is mainly in hay and pasture. Small areas are in small grain. Some areas are in woods. Surface runoff is slow. The main concerns of management are controlling soil blowing, conserving soil moisture, and maintaining fertility. (Capability unit IIIs–4 (4/2a); woodland suitability group C)

Menominee loamy sand, 6 to 12 percent slopes (MnC).—This soil is on sandy plains and on knolls, ridges, and foot slopes on uplands.

Included with this soil in mapping were small areas of Rubicon sand, loamy substratum, and Leelanau loamy sand at slightly higher elevations. Also included were small areas of brown, eroded soils.

This soil is mainly in hay and pasture. Some areas are in woods. Surface runoff is medium. The main concerns of management are controlling water erosion and maintaining fertility. (Capability unit IIIe–9 (4/2a); woodland suitability group C)

Munuscong Series

The Munuscong series consists of poorly drained or very poorly drained, nearly level to gently sloping soils in depressional areas on lake plains and till plains. These soils formed in sandy loam and loam deposits 18 to 42 inches thick over silty clay.

In a representative profile, the surface layer is very dark gray fine sandy loam 10 inches thick. The subsurface layer is grayish-brown fine sandy loam with dark yellowish-brown mottles and is 5 inches thick. The subsoil is firm, light brownish-gray loam with dark yellowish-brown mottles and is 9 inches thick. The underlying material, at a depth of 24 inches, is dark grayish-brown silty clay that has dark yellowish-brown mottles.

Permeability is moderately rapid in the subsoil and slow in the underlying material. The available water capacity is moderate. Organic-matter content is high, and natural fertility is medium. Surface runoff is very slow to ponded.

If drained and not subject to frost, the Munuscong soils are moderately suited to farming. They are poorly suited to woodland. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of Munuscong fine sandy loam in a nonwooded area, NE¼NE¼ sec. 36, T. 33 N., R. 7 W.:

A1—0 to 10 inches, very dark gray (10YR 3/1) fine sandy loam; moderate, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A2g—10 to 15 inches, grayish-brown (10YR 5/2) fine sandy loam; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, medium, platy structure; friable; slightly acid; clear, smooth boundary.

B2tg—15 to 24 inches, light brownish-gray (10YR 6/2) loam; common, medium, distinct, dark yellowish-brown (10YR 3/4) mottles; weak, medium, subangular blocky structure; firm; slightly acid; gradual, wavy boundary.

IICg—24 to 60 inches, dark grayish-brown (10YR 4/2) silty clay; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; very firm; mildly alkaline; slightly effervescent.

The loamy upper part of the profile is dominantly 20 to 40 inches thick but ranges from 18 to 42 inches. In a few profiles, thin strata of materials that have coarser texture or finer texture are in the loamy part of the profile. The A1 and A2 horizons are medium acid or slightly acid. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The A1 horizon is thicker than the defined range for the series, but this difference does not alter the usefulness or behavior of these soils.

Munuscong soils are similar to Breckenridge and Epoufette soils. They contain more total clay separates in the C horizon than Breckenridge soils. They have finer texture than Epoufette soils in horizons that have the same horizon designation.

Munuscong fine sandy loam (0 to 4 percent slopes) (Mu).—This soil is in depressions and swales on a few plains.

Included with this soil in mapping were small areas of somewhat poorly drained Belding sandy loam and Iosco loamy sand and a few areas of well drained or moderately well drained Menominee loamy sand. These included soils are in slightly higher positions. Also included were small areas of soils that have a muck surface layer.

This soil is mainly in woods. Some areas are in pasture. A few drained areas are in cultivation. The main concern of management is improving drainage. The main limitation is a hazard of frost. (Capability unit IIIw–9 (3/1c); woodland suitability group P)

Nester Series

The Nester series consists of well drained or moderately well drained, nearly level to very steep soils on till plains and moraines. These soils formed in silty clay loam till. In Charlevoix County the Nester soils were mapped alone and in an association with the Emmet soils.

In a representative profile, the surface layer is very dark brown loam 4 inches thick. The subsurface layer is brown loam 3 inches thick. The subsoil consists of two parts. The upper part is dark yellowish-brown, friable loam 6 inches thick. The lower part is very firm, brown heavy silty clay loam with pinkish-gray splotches of color and is 11 inches thick. The underlying material, at a depth of 24 inches, is brown silty clay loam.

Permeability is moderately slow. The available water capacity is high. The organic-matter content is moderate, and natural fertility is high.

The less sloping areas of Nester soils are well suited to farming. They are well suited to hardwoods but are poorly suited to pines. They have moderate to severe limitations for many nonfarm uses. The less sloping areas are in cultivation. The steeper sloping areas are wooded.

Representative profile of Nester loam, 2 to 6 percent slopes, in a wooded area, SE¼SW¼ sec. 26, T. 33 N., R. 4 W.:

A1—0 to 4 inches, very dark brown (10YR 2/2) loam; moderate, medium, granular structure; friable; neutral; clear, wavy boundary.

A2—4 to 7 inches, brown (7.5YR 4/2) loam; weak, medium, platy structure; friable; neutral; clear, wavy boundary.

B1—7 to 13 inches, dark yellowish-brown (10YR 4/4) loam; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B2t—13 to 24 inches, brown (7.5YR 4/4) heavy silty clay loam; common, coarse, distinct, pinkish-gray (7.5YR 6/2) splotches of color; strong, medium, angular blocky structure; very firm; clay films on surfaces of peds; less than 5 percent coarse fragments; neutral; gradual, wavy boundary.

C—24 to 60 inches, brown (7.5YR 4/4) silty clay loam; moderate, medium, angular blocky structure; very firm; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 24 to 40 inches in thickness. Small pockets or thin strata of materials that have coarser textures are in the B and C horizons of a few profiles. Partially decomposed forest litter about 1 inch thick is on profiles where the soils are not mixed with mineral material. The A1 horizon is very dark brown or very dark gray. This horizon and all or part of the A2 horizon are mixed during tillage operations to form a very dark grayish-brown or dark grayish-brown Ap horizon. The lower part of the B horizon is mottled in many profiles. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Nester soils are in a toposequence with Kawkawlin and Sims soils. They were mapped with Emmet soils. Nester soils are similar to Barker soils. They lack the mottles that are in the B horizon of Kawkawlin soils. They lack the mottles that are in the solum of Sims soils. Nester soils have finer texture in the B and C horizons than Emmet soils. They have redder hues in the B and C horizons than Barker soils. They also differ from Barker soils in lacking coarse fragments that are dominantly shale.

Nester loam, 2 to 6 percent slopes (NsB).—This soil is on low knolls, ridges, and foot slopes on uplands. The slopes are generally less than 100 feet in length. In wooded areas this soil has the profile described as representative for the series. In cultivated areas the surface layer is dark grayish-brown loam.

Included with this soil in mapping were a few, small, wet depressions, other depressions of sandy overwash that was deposited on the original surface layer, and a few, small, eroded areas in higher positions that were the source of the overwash materials. Also included were small areas of Ubly and Emmet sandy loams.

This soil is mainly in cultivation, in hay, or in pasture. Some areas are in woods. Surface runoff is slow to medium. The main concerns of management are controlling water erosion and, in some areas, keeping good soil tilth. (Capability unit IIe–1 (1.5a); woodland suitability group B)

Nester loam, 6 to 12 percent slopes (NsC).—This soil is on knolls, ridges, and foot slopes on uplands. The slopes are generally less than 100 feet in length.

Included with this soil in mapping were a few eroded areas of soils that have a brown surface layer. Also included were small areas of Ubly and Emmet sandy loams.

This soil is mainly in hay and pasture. A few areas are in cultivation. Some areas are in woods. Surface runoff is medium to rapid. The main concerns of management are

controlling water erosion and, in some areas, keeping good soil tilth. (Capability unit IIIe–4 (1.5a); woodland suitability group B)

Nester loam, 12 to 18 percent slopes (NsD).—This soil is on ridges and hillsides on uplands.

Included with this soil in mapping were a few areas of eroded soils that have a brown surface layer and a few small areas of moderately sloping and steeply sloping soils. Also included were small areas of Emmet and Ubly sandy loams.

This soil is mainly in pasture or woods. Surface runoff is rapid. The main concerns of management are controlling water erosion and, in some areas, keeping good soil tilth. (Capability unit IVe–1 (1.5a); woodland suitability group B)

Nester loam, 18 to 35 percent slopes (NsE).—This soil is on short hillsides on uplands. The steep slopes cause the soil layers to be thinner than those of the profile described as representative for the series.

Included with this soil in mapping were a few small areas of eroded soils that have a brown surface layer and small areas of Emmet sandy loam.

This soil is mainly in woods. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIe–1 (1.5a); woodland suitability group B)

Nester-Emmet association, undulating (2 to 6 percent slopes) (NEB).—These soils are in undulating areas of the eastern uplands. Nester and Emmet soils together make up 85 percent of this association, and the rest is included soils. The Nester soil has a loam surface layer, and the Emmet soil has a sandy loam surface layer.

Included in mapping were small areas of somewhat poorly drained Charlevoix and Kawkawlin soils in the low areas. Also included were small areas of well-drained Leelanau and Ubly soils in higher positions and small areas of eroded soils that have a brown surface layer.

These soils are mainly in woods. Small areas are in pasture. Surface runoff is slow to medium. The main concern of management is controlling water erosion. (Capability unit IIe–1 (1.5a, 3a); woodland suitability group B)

Nester-Emmet association, rolling (6 to 18 percent slopes) (NEC).—These soils are in rolling areas of the eastern uplands. Nester and Emmet soils together make up 85 percent of this association, and the rest is included soils. The Nester soil has a loam surface layer, and the Emmet soil has a sandy loam surface layer.

Included in mapping were small areas of well-drained Leelanau and Ubly soils in slightly higher positions. Also included were small areas of eroded soils that have a brown surface layer.

These soils are mainly in woods. Small areas are in pasture. Surface runoff is medium to rapid. The main concern of management is controlling water erosion. (Capability unit IVe–1 (1.5a, 3a); woodland suitability group B)

Nester-Emmet association, hilly (18 to 30 percent slopes) (NEE).—These soils are in hilly areas of the eastern uplands. Nester and Emmet soils together make up 85 percent of this association, and the rest is included soils. The Nester soil has a loam surface layer, and the Emmet soil has a sandy loam surface layer.

Included in mapping were small areas of sandy Leelanau soils. Also included were small areas of eroded soils that have a brown surface layer.

These soils are mainly in woods. Surface runoff is rapid. The main concern of management is controlling water erosion. The main limitation is the steepness of slopes. (Capability unit VIe–1 (1.5a, 3a); woodland suitability group B)

Onaway Series

The Onaway series consists of well-drained, nearly level to very steep soils on drumlins and moraines. These soils formed in loam till. In Charlevoix County the Onaway soils were mapped only in a complex with Emmet soils.

In a representative profile, the surface layer is very dark grayish-brown sandy loam 8 inches thick. The subsurface layer is brown sandy loam 2 inches thick. The subsoil consists of three parts. The upper part is brown, friable sandy loam 3 inches thick. The middle part is grayish-brown, friable sandy loam 4 inches thick. The lower part is firm, brown clay loam 9 inches thick. The underlying material, at a depth of 26 inches, is brown loam.

Permeability is moderate. The available water capacity is high. Organic-matter content is moderate, and natural fertility is high.

Onaway soils are well suited to farming and woodland. The less sloping areas have few limitations for nonfarm uses. Most of the less sloping areas are used for field and forage crops. The steeper sloping areas are in woods and pasture.

Representative profile of an Onaway sandy loam from an area of Emmet-Onaway sandy loams, 2 to 6 percent slopes, in a cultivated area, NE¼NW¼ sec. 29, T. 33 N., R. 7 W.:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) sandy loam, moderate, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A2—8 to 10 inches, brown (10YR 5/3) sandy loam; moderate, thin, platy structure; friable; slightly acid; clear, smooth boundary.

Bir—10 to 13 inches, brown (10YR 4/3) sandy loam; weak, medium, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A'2—13 to 17 inches, grayish-brown (10YR 5/2) sandy loam; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; slightly acid; clear, smooth boundary.

B't—17 to 26 inches, brown (7.5YR 4/4) clay loam; moderate, medium, subangular blocky structure; firm; clay films on surfaces of peds; less than 5 percent coarse fragments; neutral; clear, smooth boundary.

C—26 to 60 inches, brown (7.5YR 5/4) loam; weak, coarse, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 20 to 30 inches in thickness. A few profiles have an A1 horizon that is very dark gray or black and that ranges from 3 to 6 inches in thickness. The B't horizon is heavy loam or clay loam. The C horizon is loam or clay loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Onaway soils are in a toposequence with Angelica and Mackinac soils. They were mapped with Emmet soils. Onaway soils lack the mottles that are present in the solum of Angelica and Mackinac soils. They have a finer texture in the B't and C horizons than Emmet soils.

Otisco Series

The Otisco series consists of somewhat poorly drained, nearly level to gently sloping soils on till plains and moraines. These soils formed in loamy sand.

In a representative profile, the surface layer is dark-brown loamy sand 7 inches thick. The subsurface layer is yellowish-brown loamy sand 5 inches thick. The subsoil consists of three parts. The upper part is dark-brown, friable loamy sand 4 inches thick. The middle part is yellowish-brown, friable loamy sand 4 inches thick. The lower part consists of thin, interbedded layers of loose, light yellowish-brown loamy sand and strong-brown, friable sandy loam. These interbedded layers have a total thickness of 16 inches. The underlying material, at a depth of 36 inches, is yellowish-brown loamy sand.

Permeability is moderately rapid. The available water capacity is low. Organic-matter content and natural fertility are low. Surface runoff is slow.

Otisco soils are moderately suited to farming. They are generally poorly suited to woodland. They have moderate to severe limitations for many nonfarm uses. Most areas of these soils are in cultivation.

Representative profile of Otisco loamy sand, 0 to 6 percent slopes, in a cultivated area, NE¼SW¼ sec. 16, T. 32 N., R. 7 W.:

Ap—0 to 7 inches, dark-brown (7.5YR 3/2) loamy sand; very weak, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A2—7 to 12 inches, yellowish-brown (10YR 5/4) loamy sand; common, medium, faint, dark yellowish-brown (10YR 4/4) mottles; weak, medium, platy structure; friable; slightly acid; gradual, wavy boundary.

Bir—12 to 16 inches, dark-brown (7.5YR 4/4) loamy sand; common, fine, faint, dark reddish-brown (5YR 3/4) mottles; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

A'2—16 to 20 inches, yellowish-brown (10YR 5/4) loamy sand; common, medium, faint, brown (7.5YR 4/4) mottles; very weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.

A'&B'—20 to 36 inches, light yellowish-brown (10YR 6/4) loamy sand (A'2); single grain; loose; bands of strong-brown (7.5YR 5/6) sandy loam (B'2t); weak, medium, subangular blocky structure; friable; bands are 1 to 3 inches thick; slightly acid; gradual, smooth boundary.

C—36 to 60 inches, yellowish-brown (10YR 5/6) loamy sand; common, fine, faint, yellowish-brown (10YR 5/4) mottles; massive; very friable; neutral.

The A2 horizon ranges from 2 to 8 inches in thickness. The Bir horizon is dark brown or reddish brown. The B't horizon of the A'&B' horizon is strong brown or reddish brown. In a few profiles, the C horizon is sand or loamy sand or a stratification of these textures. The C horizon is neutral or mildly alkaline and commonly is slightly effervescent.

Otisco soils are in a toposequence with Edmore soils. They are similar to Au Gres, Blue Lake, and Leelanau soils. They differ from Edmore soils in having a loamy B't horizon and in having hues that are redder in the upper part of the horizon. They differ from Au Gres soils in having a loamy textured B't horizon. Otisco soils have mottles that are lacking in the solum of Blue Lake and Leelanau soils.

Otisco loamy sand, 0 to 6 percent slopes (OtB).—This soil is in small, undulating areas on sandy plains and on low foot slopes on uplands.

Included with this soil in mapping were small areas of well-drained Leelanau loamy sand in slightly higher positions. Also included were small depressions of sandy overwash materials that eroded from surrounding uplands. This overwash material ranges from 6 to 10 inches in thickness.

This soil is mainly in cultivation or pasture. The main concerns of management are improving drainage, maintaining fertility, and conserving soil moisture throughout the growing season. (Capability unit IIIw–5 (4b); woodland suitability group G)

Roscommon Series

The Roscommon series consists of poorly drained, nearly level to gently sloping soils on lake plains and in glacial drainageways. These soils formed in sand.

In a representative profile, the surface layer is black sand 5 inches thick. The underlying material, at a depth of 5 inches, is brown and grayish-brown sand with yellowish-brown mottles.

Permeability is rapid. If drained, the available water capacity is low. The organic-matter content is high, and natural fertility is low. Surface runoff is very slow to ponded.

Roscommon soils are very poorly suited to farming and to woodland. They are well suited as habitat for wetland wildlife. They have severe limitations for most nonfarm uses. Most areas of these soils are wooded.

Representative profile of Roscommon sand in a nonwooded area, NW¼SE¼ sec. 34, T. 34 N., R. 8 W.:

A1—0 to 5 inches, black (10YR 2/1) sand; very weak, fine, granular structure; friable; slightly acid; clear, wavy boundary.

C1—5 to 12 inches, brown (10YR 5/3) sand; single grain; loose; slightly acid; gradual, wavy boundary.

C2—12 to 15 inches, grayish-brown (10YR 5/2) sand; single grain; loose; slightly acid; gradual, wavy boundary.

C3—15 to 22 inches, brown (10YR 5/3) sand; common, medium, distinct, yellowish-brown (10YR 5/6) mottles single grain; loose; neutral; diffuse, wavy boundary.

C4—22 to 60 inches, brown (10YR 5/3) sand; single grain loose; neutral.

A muck layer, ranging from 1 to 12 inches in thickness, is on the surface of a few profiles.

The A1 horizon is thinner and the color of the substratum is brighter than the defined range for the series, but these differences do not alter the usefulness or behavior of these soils.

Roscommon soils in most landscapes are near Au Gres, Croswell, Kalkaska, Rubicon, Saugatuck, and Wallace soils. These soils are similar to Brevort, Edmore, and Epoufette soils. They differ from Au Gres soils in lacking a Bir horizon. They differ from Croswell soils in having an Al or Ap horizon of darker color. Also, they have mottles that are nearer the surface than in Croswell soils. Roscommon soils differ from Kalkaska, Rubicon, and Wallace soils in having mottles in the profile. They lack the ortstein that is present in the B horizon of Saugatuck and Wallace soils. They have a coarser texture in the C horizon than Brevort soils. They formed dominantly in material having a coarser texture than the Edmore soils. Roscommon soils are coarser in texture in the upper part of the profile than the Epoufette soils. They also lack the gravelly sand in the lower part of the profile that is present in Epoufette soils.

Roscommon sand (0 to 4 percent slopes) (Rc).—This soil is in broad, flat, depressional areas on sandy plains and in large drainageways throughout the county.

Included with this soil in mapping were small areas of somewhat poorly drained Au Gres sand at slightly higher elevations and many small areas of Tawas muck and Carbondale muck. Also included were a few small areas of soils that have loamy underlying material at depths between 42 and 66 inches.

This soil is mainly in woods. A few areas are in pasture or are idle. The main concerns of management are improving drainage and maintaining fertility. The main limitation is a hazard of frost. (Capability unit VIwc–2 (5c); woodland suitability group W)

Rubicon Series

The Rubicon series consists of well-drained, nearly level to very steep soils on moraines, outwash plains, and lake plains. These soils formed in sand. In Charlevoix County the Rubicon soils were mapped alone and in complexes with Leelanau soils.

In a representative profile, the surface layer is very dark grayish-brown sand 2 inches thick. The subsurface layer is light brownish-gray sand 7 inches thick. The subsoil consists of two parts. The upper part is yellowish-brown, loose sand 9 inches thick. The lower part is brown, loose sand 17 inches thick. The underlying material, at a depth of 35 inches, is light brownish-gray sand.

Permeability is rapid. The available water capacity is low. Organic-matter content and natural fertility are low. Surface runoff is slow.

The Rubicon soils are very poorly suited to farming. They are poorly suited to hardwoods but are moderately suited to pines. They have slight limitations for many nonfarm uses. These soils are mainly wooded.

Representative profile of Rubicon sand, 0 to 6 percent slopes, in a nonwooded area, SW¼SW¼ sec. 4, T. 32 N., R. 5 W.:

A1—0 to 2 inches, very dark grayish-brown (10YR 3/2) sand; very weak, fine, granular structure; very friable; strongly acid; clear, wavy boundary.

A2—2 to 9 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; very strongly acid; clear, wavy boundary.

B2ir—9 to 18 inches, yellowish-brown (10YR 5/8) sand; single grain; loose; medium acid; gradual, wavy boundary.

B3—18 to 35 inches, brown (10YR 5/3) sand; single grain; loose; medium acid; diffuse, wavy boundary.

C—35 to 60 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; slightly acid.

The solum ranges from 20 to 40 inches in thickness. Reaction throughout the solum ranges from very strongly acid to medium acid. In places the A1 horizon and all or part of the A2 horizon have been mixed during tillage operations to form an Ap horizon; therefore, the A2 horizon is thinner in profiles that have been tilled. The B2ir horizon is yellowish brown or dark brown. In a few profiles, the B2ir horizon has weakly cemented chunks of ortstein. Thin strata of fine sand or gravelly sand are in the C horizon of a few profiles.

The Rubicon soils in most landscapes are near the Au Gres, Croswell, Kalkaska, Roscommon, and Wallace soils. They were mapped with Leelanau soils. Rubicon soils are similar to Deer Park, Eastport, and Saugatuck soils. Rubicon soils lack the mottles that are in the profile of Au Gres and Roscommon soils. They differ from Croswell soils in lacking mottles throughout the profile. Rubicon soils differ from Kalkaska soils in lacking a dark-brown Bhir horizon. They lack the ortstein that is in the B horizon of Saugatuck and Wallace soils. Also, they lack the mottles that are in the solum of Saugatuck soils. Rubicon soils dominantly are coarser textured throughout the profile than Leelanau soils. Also, they differ from Leelanau soils in lacking a loamy B't horizon and in lacking coarse fragments in the profile. Rubicon soils have fewer particles of fine sand and very fine sand in horizons with the texture class of sand than Deer Park soils. They are more acid in the lower part of the B horizon and in the C horizon than the Eastport soils.

Rubicon sand, 0 to 6 percent slopes (RdB).—This nearly level to gently sloping soil is on broad, sandy plains and in small areas on uplands. In uncultivated areas this soil has the profile described as representative for the series. In the few cultivated areas, there is a grayish-brown plow layer that is a mixture of the original surface layer and the subsurface layer.

Included with this soil in mapping were small depressions where thin, very sandy overwash covers the original surface layer, and a few yellowish-brown, eroded areas that were the source of the overwash materials. Also included were a few, small, lower areas of moderately well-drained Croswell sand.

This Rubicon soil is mainly wooded, but a few areas are in hay, in pasture, or are idle. The main concerns of management are controlling soil blowing, conserving moisture, and maintaining fertility. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Rubicon sand, 6 to 12 percent slopes (RdC).—This moderately sloping soil is in short, choppy areas along the edge of sand plains and on knolls and foot slopes on uplands. In cultivated areas the surface layer is grayish-brown sand and is a mixture of the original surface layer and the subsurface layer.

Included with this soil in mapping were a few small areas of Leelanau loamy sand and a few, small, brown, severely eroded areas or blowouts. These blown-out areas are shown by a special symbol on the soil map.

Most areas of this soil remain in woods, but a few small areas are idle and a few areas are in pasture. The main concerns of management are controlling soil blowing, conserving moisture, and maintaining fertility. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Rubicon sand, 18 to 35 percent slopes (RdE).—This soil is in short, choppy areas along the edge of sandy plains and on hillsides on uplands. Its profile has thinner soil layers than those in the profile described as representative for the series.

Included with this soil in mapping were small areas of Leelanau loamy sand and small areas of brown, eroded soils.

This soil is mainly wooded, but a few small areas are idle or are in pasture. The main concern of management is controlling erosion. The main limitation is the steepness of slopes. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Rubicon sand, loamy substratum, 0 to 6 percent slopes (RoB).—This nearly level to gently sloping soil is on broad, sandy plains. It is underlain by loam or clay loam materials at a depth of 42 to 60 inches.

Included with this soil in mapping were small areas of well drained or moderately well drained Menominee loamy sand and small depressions in which thin, sandy overwash covers the original surface layer. Also included were small depressions of somewhat poorly drained Au Gres sand.

Areas of this soil are in cultivation, are used for pasture or for hay, or are idle. Some areas are wooded. The main concerns of management are controlling soil blowing, conserving moisture, and maintaining fertility. (Capability unit IVs–4 (5/2a); woodland suitability group C)

Rudyard Series

The Rudyard series consists of somewhat poorly drained, nearly level to gently sloping soils on lake plains along Lake Michigan and Lake Charlevoix. These soils formed in silty clay.

In a representative profile, the surface layer is very dark grayish-brown silt loam 9 inches thick. The subsurface layer is pale-brown silt loam with dark yellowish-brown and light olive-brown mottles and is 4 inches thick. The subsoil is grayish-brown, firm silty clay 7 inches thick. The underlying material, at a depth of 20 inches, is olive-brown silty clay with brown mottles.

Permeability is very slow. The available water capacity is moderate. Organic-matter content is moderate, and natural fertility is high. Surface runoff is slow.

The Rudyard soils are moderately suited to farming if drained. They are moderately suited to hardwoods but are poorly suited to pines. They have severe limitations for most nonfarm uses. These soils are mainly used for pasture or are wooded.

Representative profile of Rudyard silt loam, 0 to 6 percent slopes, in a cultivated area, NE¼SW¼ sec. 36, T. 32 N., R. 7 W.:

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam; moderate, fine, granular structure; firm; neutral; clear, smooth boundary.

A2—9 to 13 inches, pale-brown (10YR 6/3) silt loam; common, fine, distinct, dark yellowish-brown (10YR 4/4) and light olive-brown (2.5Y 5/4) mottles; moderate, medium, platy structure; firm; neutral; clear, wavy boundary.

B2tg—13 to 20 inches, grayish-brown (2.5Y 5/2) silty clay; many, fine, faint, brown (10YR 5/3) mottles; moderate, medium, subangular blocky structure; firm; clay films on surfaces of a few peds; neutral; clear, wavy boundary.

C—20 to 60 inches, olive-brown (2.5Y 4/4) silty clay; many, medium, distinct, brown (7.5YR 4/4) mottles; moderate, medium, angular blocky structure; very firm; mildly alkaline; slightly effervescent.

The solum ranges from 18 to 40 inches in thickness. Reaction throughout the solum ranges from medium acid to neutral. The B and C horizons are silty clay or clay. The C horizon is dark yellowish brown, olive brown, or reddish brown. It is mildly aklaline or moderately alkaline and is slightly effervescent.

The B2tg horizon of these soils is lower in clay content and grayer in color than the defined range for the series, but these differences do not alter the usefulness or behavior of the soils.

Rudyard soils are in a toposequence with the Bergland soils. They are similar to the Brimley and Kawkawlin soils. Rudyard soils differ from Bergland soils in having a lighter colored A horizon. Rudyard soils are finer textured in the B and C horizons than the Brimley soils. They are finer textured in the B and C horizons than Kawkawlin soils. Also, they lack the coarse fragments that are in the profile of the Kawkawlin soils.

Rudyard silt loam, 0 to 6 percent slopes (RrB).—This nearly level to gently sloping soil is on small, undulating plains.

Included with this soil in mapping were small areas of poorly drained Bergland silty clay loam where this soil is adjacent to swamps or to other low areas.

This soil is mainly used for pasture or is wooded. Areas that have been drained are in cultivation. The main concerns of management are improving drainage and keeping good soil tilth. The main limitation is a hazard of frost, but very slow permeability is also a limitation. (Capability unit IIIw–1 (1b); woodland suitability group Z)

Ruse Series

The Ruse series consists of poorly drained, nearly level to gently sloping, shallow soils in depressional areas on lake terraces and lake plains. These soils formed in sandy loam less than 20 inches thick over limestone bedrock.

In a representative profile, the surface layer is black mucky sand 4 inches thick. The subsoil consists of two parts. The upper part is dark grayish-brown, friable sandy loam 3 inches thick. The lower part is light brownish-gray, friable sandy loam with olive-brown mottles and is 9 inches thick. The underlying material, at a depth of 16 inches, is light-gray limestone bedrock.

Permeability is moderately rapid above the bedrock. The available water capacity is moderate. Organic-matter content is very high, and natural fertility is medium. Surface runoff is very slow.

Because of the shallow depth to bedrock, Ruse soils are very poorly suited to farming or to woodland. They are suitable as habitat for wetland wildlife. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of a Ruse mucky sand from an area of Ruse soils, in a wooded area, SW¼SE¼ sec. 28, T. 34 N., R. 8 W.:

A1—0 to 4 inches, black (10YR 2/1) mucky sand; moderate, fine, granular structure; friable; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

B1g—4 to 7 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, fine, granular structure; friable; 10 percent coarse fragments; mildly alkaline; clear, wavy boundary.

B2g—7 to 16 inches, light brownish-gray (2.5YR 6/2) sandy loam; common, medium, distinct, olive-brown (2.5Y 4/4) mottles; massive; friable; 15 percent coarse fragments; neutral; abrupt, wavy boundary.

IIR—16 inches+, light-gray (2.5Y 7.2) limestone bedrock.

The solum ranges from 10 to 20 inches in thickness and dominantly coincides with depth to bedrock. In some profiles depth to bedrock ranges to 40 inches and the solum is more than 20 inches thick. Reaction throughout the solum ranges from slightly acid to mildly alkaline. In a few profiles, a IIB horizon 1 to 3 inches thick has formed in the upper part of the weathered limestone bedrock.

The Ruse soils that are 20 to 40 inches deep to bedrock are deeper than the defined range for the series. This difference alters the usefulness and behavior of these soils for many farm and nonfarm uses.

Ruse soils are in a toposequence with Summerville soils. They are similar to Hessel soils. Ruse soils differ from Summerville soils in having mottles in the solum. They differ from Hessel soils in having bedrock between depths of 10 and 20 inches rather than at a depth of more than 40 inches.

Ruse soils (0 to 4 percent slopes) (Ru).—This soil is in small depressions on terraces and narrow plains. The surface layer ranges from loam to mucky sand.

Included with this soil in mapping were a few, small, higher areas of well-drained Summerville soils and small areas of limestone bedrock. Also included were a few small depressions containing soils that have a thin, mucky surface layer.

This soil is mainly wooded. The main limitations are wetness and the shallow root zone. (Capability unit VIIwc–2 (Rbc); woodland suitability group W)

Saugatuck Series

The Saugatuck series consists of somewhat poorly drained, nearly level to gently sloping soils in depressional areas on lake plains. These soils formed in sand.

In a representative profile, the surface layer is very dark grayish-brown sand 5 inches thick. The subsurface layer is grayish-brown sand 6 inches thick. The subsoil consists of two parts. The upper part is very dark brown, strongly cemented sand 9 inches thick. The lower part is brown, loose sand 20 inches thick. The underlying material, at a depth of 40 inches, is yellowish-brown sand.

Permeability is slow because of the cemented subsoil layer. Available water capacity is low. Organic-matter content is moderately low, and natural fertility is low. Surface runoff is slow.

Because of the cemented subsoil layer, Saugatuck soils are poorly suited to farming and woodland. They have severe limitations for many nonfarm uses. These soils are mainly in woods or pasture.

Representative profile of Saugatuck sand, 0 to 6 percent slopes, in a wooded area, NW¼NE¼ sec. 7, T. 33 N., R. 7 W.:

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) sand; single grain; loose; medium acid; clear, wavy boundary.

A2—5 to 11 inches, grayish-brown (10YR 5/2) sand; few, fine, faint, brown (10YR 5/3) mottles; single grain; loose; medium acid; clear, wavy boundary.

B21hirm—11 to 21 inches, very dark brown (10YR 2/2) sand; massive; weakly and strongly cemented ortstein; strongly acid; clear, wavy boundary.

B22ir—20 to 40 inches, brown (7.5YR 4/4) sand; few, fine, distinct, strong-brown (7.5YR 5/6) mottles; single grain; loose; medium acid; gradual, wavy boundary.

C—40 to 60 inches, yellowish-brown (10YR 5/6) sand; single single grain; loose; slightly acid.

The A2 horizon ranges from 1 to 15 inches in thickness. The Bhirm horizon ranges from 5 to 25 inches in thickness. In a few profiles, it has a clear, irregular boundary and tongues into the C horizon. The B22ir horizon is brown or strong brown.

The annual temperature of these soils is a few degrees cooler than the defined range for the series, but this difference does not alter their usefulness or behavior.

Saugatuck soils in most areas are near the Au Gres, Croswell, Kalkaska, Roscommon, Rubicon, and Wallace soils. Saugatuck soils differ from all these soils, except the Wallace soils, in having a continuous ortstein in the B horizon. They have mottles that are lacking in the A2 horizon or in the upper part of the B horizon of Croswell soils. They differ from Kalkaska, Rubicon, and Wallace soils in having mottles.

Saugatuck sand, 0 to 6 percent slopes (SaB).—This soil is on small, slightly undulating, sandy plains.

Included with this soil in mapping were a few areas of Au Gres sand and Au Gres sand, loamy substratum.

This soil is mainly in woods or in pasture. The main concerns of management are improving drainage and controlling soil blowing. The main limitation is the cemented subsoil layer. (Capability unit IVw–2 (5b–h); woodland suitability group F)

Sims Series

The Sims series consists of poorly drained, nearly level to gently sloping soils in depressional areas on till plains. They formed in silty clay loam till. In Charlevoix County the Sims soils were mapped only in a complex with Bergland soils.

In a representative profile, the surface layer is very dark gray silty clay loam 6 inches thick. The subsoil consists of two parts. The upper part is brown, firm silty clay loam 3 inches thick. The lower part is dark-brown, very firm silty clay 11 inches thick. The underlying material, at a depth of 20 inches, is reddish-brown silty clay loam.

Permeability is slow. The available water capacity is high. Organic-matter content and natural fertility are high. Surface runoff is very slow.

If drained and not subject to frost, Sims soils are moderately suited to farming. They are poorly suited to woodland. They have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of a Sims silty clay loam from an area of Bergland-Sims silty clay loams in a wooded area, SW¼NE¼ sec. 29, T. 33 N., R. 5 W.:

A1—0 to 6 inches, very dark gray (10YR 3/1) silty clay loam moderate, fine, granular structure; firm; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

B21g—6 to 9 inches, brown (7.5YR 5/2) silty clay loam; common, fine, faint, dark-brown (7.5YR 4/4) mottles; moderate, medium platy structure; firm; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B22—9 to 20 inches, dark-brown (7.5YR 4/4) silty clay; many, fine, faint, strong-brown (7.5YR 5/6) mottles; moderate, medium, angular blocky structure; very firm; 5 percent coarse fragments; neutral; clear, wavy boundary.

C—20 to 60 inches, reddish-brown (5YR 5/3) silty clay loam; many, fine, faint. dark reddish-brown (5YR 4/2) mottles; moderate, medium, angular blocky structure; very firm; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 20 to 40 inches in thickness. On the surface of a few profiles is a muck or mucky peat layer ranging from 1 to 4 inches in thickness. The A1 horizon is very dark gray or black and ranges from 6 to 9 inches in thickness. The distinctness of the boundary is abrupt or clear for the A horizon. The A1 and B21g horizon is slightly acid or neutral. The B22 horizon is neutral or mildly alkaline. The C horizon is brown or reddish brown. It is mildly alkaline or moderately alakaline and is slightly effervescent.

The color of the subsurface horizon in places is brighter than the defined range for the series, but this difference does not alter the usefulness or behavior of these soils.

Sims soils are in a toposequence with the Kawkawlin and Nester soils. They were mapped in a complex with the Bergland soils. Sims soils differ from Kawkawlin soils in having mottles immediately beneath the A1 or Ap horizon. They have mottles that are lacking in the solum of Nester soils. Sims soils differ from the Bergland soils in having a lower content of clay at depths between 10 and 40 inches.

Stony Land

Stony land (St) consists of recent deposits of limestone beach fragments. The surface layer is very dark gray loamy soil material mixed with large quantities of limestone fragments 2 to 6 inches long and ½ to 1 inch thick. These limestone fragments make up 75 to 90 percent of the deposits. Limestone bedrock crops out on about 30 percent of this land type.

This land type is in sparse woods. The main limitations are the limestone outcrops and the lack of soil moisture. (Capability unit VIIs–1 (Ra); woodland suitability group not assigned)

Summerville Series

The Summerville series consists of well-drained, nearly level to gently sloping, shallow soils on lake terraces and lake plains. These soils formed in sandy loam less than 20 inches thick over limestone bedrock. The Summerville soils are mainly south of the town of Charlevoix along Lake Michigan.

In a representative profile, the surface layer is very dark grayish-brown stony sandy loam 6 inches thick. The subsurface layer is brown sandy loam 6 inches thick. The subsoil is dark-brown, friable sandy loam 4 inches thick. The underlying material, at a depth of 16 inches, is limestone bedrock.

Permeability is moderate above the bedrock. The available water capacity is moderate. Organic-matter content is moderate, and natural fertility is medium. Surface runoff is medium.

Summerville soils are very poorly suited to farming and to woodland because of the shallow depth to bedrock. They have severe limitations for most nonfarm uses. These soils are mainly wooded. A few areas are in pasture.

Representative profile of Summerville stony sandy loam, 0 to 6 percent slopes, in a wooded area, SE¼SE¼ sec. 28, T. 34 N., R. 8 W.:

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) stony sandy loam; moderate, medium, granular structure; friable; 5 percent coarse fragments; neutral; gradual, smooth boundary.

A2—6 to 12 inches, brown (10YR 5/3) sandy loam; moderate, medium, granular structure; friable; 5 percent coarse fragments; neutral; gradual, smooth boundary.

Bhir—12 to 16 inches, dark-brown (10YR 3/3) sandy loam; moderate, medium, granular structure; friable; 5 percent coarse fragments; neutral; abrupt, smooth boundary.

IIR—16 inches +, limestone bedrock.

The solum ranges from 10 to 18 inches in thickness. Depth to bedrock ranges from 10 to 20 inches. In many profiles, the content of coarse fragments of limestone throughout the profile ranges from 5 to 25 percent. In a few profiles, the horizon immediately above the IIR horizon is dark reddish-brown clay ranging from 1 to 2 inches in thickness. This clay horizon formed in the limestone bedrock.

Summerville soils are in a toposequence with the Ruse soils. They are similar to the Alpena and Johnswood soils. Summerville soils lack the mottles that are in the solum of the Ruse soils. They differ from Alpena soils in having bedrock at a depth of less than 20 inches, rather than at a depth of more than 60 inches. Summerville soils differ from Johnswood soils in having bedrock at a depth of less than 20 inches, rather than at a depth of more than 40 inches.

Summerville stony sandy loam, 0 to 6 percent slopes (SuB).—This soil is in small areas on terraces and narrow plains.

Included with this soil in mapping were small areas of poorly drained Ruse soils in swales and many small areas of limestone outcrop. Also included were small areas of soils that have many stones on the surface and a loam surface layer.

This soil is mainly wooded. A few small areas are idle. The main limitations are stoniness and the shallow root zone. (Capability unit VIIs–1 (Ra); woodland suitability group T)

Tawas Series

The Tawas series consists of very poorly drained, nearly level to gently sloping organic soils in depressional areas on lake plains, outwash plains, and till plains. They formed in organic material 12 to 42 inches thick over sand. In Charlevoix County the Tawas soils were mapped alone and in a complex with the Carbondale soils.

In a representative profile, the surface layer is black muck 11 inches thick. The next layer is very dark brown muck 5 inches thick. The next layer is very dark grayish-brown muck 7 inches thick. The underlying material, at a depth of 23 inches, is light brownish-gray sand.

Permeability is moderately rapid in the muck and rapid in the underlying sand. The available water capacity is high. Natural fertility is low. Surface runoff is very slow.

The Tawas soils are very poorly suited to farming. They have variable suitability for woodland. They are well suited as a habitat for wetland wildlife. The Tawas soils have severe limitations for most nonfarm uses. These soils are mainly wooded.

Representative profile of Tawas muck in a wooded area, SE¼SE¼ sec. 16, T. 33 N., R. 5 W.:

O1—0 to 11 inches, black (10YR 2/1) muck; moderate, medium, granular structure; friable; many woody fragments; slightly acid; gradual, smooth boundary.

O2—11 to 16 inches, very dark brown (10YR 2/2) muck; weak, medium, granular structure; friable; many woody fragments; slightly acid; clear, wavy boundary.

O3—16 to 23 inches, very dark grayish-brown (10YR 3/2) muck; massive; friable; many woody fragments; slightly acid; abrupt, wavy boundary.

IIC—23 to 60 inches, light brownish-gray (10YR 6/2) sand; single grain; loose, mildly alkaline.

The organic material ranges from 12 to 42 inches in thickness over sandy material. Partially decomposed woody fragments throughout the organic material range from few to many. Reaction throughout the organic material ranges from medium acid to neutral. The 01 horizon is very dark brown or black. In a few profiles, the organic material, ranging from 2 to 3 inches in thickness, is immediately above the mineral material and contains a considerable amount of sand. The C horizon is sand or loamy sand. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Tawas soils were mapped with the Carbondale soils. They are similar to the Cathro, Edwards, Greenwood, Kerston, Linwood, Lupton, Markey, and Warners soils. They differ from Carbondale, Greenwood, and Lupton soils in having organic material less than 42 inches thick. Tawas soils lack the marl that is at depths between 12 and 42 inches in Edwards and Warners soils. They differ from Kerston soils in lacking two or more strata of mineral material below the surface layer separated by organic layers. Tawas soils lack the loamy material that is at depths between 12 and 42 inches in Cathro and Linwood soils. Tawas soils are less alkaline throughout the organic material than Markey soils.

Tawas muck (0 to 4 percent slopes) (Ta).—This soil is in small, narrow depressions, in broad depressional basins on plains, and in narrow areas bordering the edges of large swamps. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of deeper Carbondale muck and small, sandy areas of Roscommon sand.

This soil is mainly wooded, but a few areas are in pasture. The main concerns of management are improving drainage and controlling soil blowing. The main limi-

tation is a hazard of frost. (Capability unit VIwc–1 (M/4c) ; woodland suitability group J)

Tawas-Carbondale association (0 to 4 percent slopes) (TC).—These soils are in broad, depressional areas on plains. The Tawas and Carbondale mucks together make up 95 percent of this association, and the rest is included soils.

Included in mapping were small areas of Roscommon sand and Epoufette sandy loam.

These soils are mainly in woods, but a few areas are in pasture. The main concerns of management are improving drainage and controlling soil blowing. The main limitation is a hazard of frost. (Capability unit VIwc–1 (M/4c, Mc) ; woodland suitability group J)

Ubly Series

The Ubly series consists of well drained to moderately well drained, gently sloping to sloping soils on till plains and moraines. These soils formed in loamy sand and the underlying loam.

In a representative profile, the surface layer is very dark grayish-brown sandy loam 7 inches thick. The subsurface layer is grayish-brown loamy sand 3 inches thick. The subsoil consists of three parts. The upper part is yellowish-brown, friable loamy sand 3 inches thick. The middle part is brown, friable loamy sand 2 inches thick. The lower part is yellowish-brown, friable sandy loam 9 inches thick. The underlying material, at a depth of 24 inches, is brown loam.

Permeability is moderate in the upper part of the subsoil and moderately slow in the lower part of the subsoil and in the underlying material The available water capacity is moderate. Organic-matter content is moderately low, and natural fertility is medium. Surface runoff is medium.

The Ubly soils are moderately well suited to well suited to farming. These soils are well suited to woodland. The Ubly soils have moderate to severe limitations for a few nonfarm uses. These soils are mainly farmed.

Representative profile of Ubly sandy loam, 2 to 6 percent slopes, in a nonwooded area, SE¼SW¼ sec. 16, T. 33 N., R. 7 W.:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) sandy loam; moderate, fine, granular structure; friable, slightly acid ; clear, smooth boundary.

A2—7 to 10 inches, grayish-brown (10YR 5/2) loamy sand; weak, thin, platy structure; friable; slightly acid; clear, wavy boundary.

Bir—10 to 13 inches, yellowish-brown (10YR 5/6) loamy sand; very weak, medium, subangular blocky structure ; very friable ; slightly acid ; clear, wavy boundary.

A'2—13 to 15 inches, brown (10YR 5/3) loamy sand; massive; very friable; slightly acid; gradual, smooth boundary.

B't—15 to 24 inches, yellowish-brown (10YR 5/4) sandy loam; weak, medium, subangular blocky structure; friable; clay films on surfaces of peds; 5 percent coarse fragments; neutral; clear, smooth boundary.

IIC—24 to 60 inches, brown (10YR 5/3) loam; weak, coarse, subangular blocky structure ; friable ; 10 percent coarse fragments ; mildly alkaline ; slightly effervescent.

The solum ranges from 20 to 42 inches in thickness, which commonly coincides with depth to the IIC horizon. The Ap horizon is very dark grayish brown or very dark brown. The A2, Bir, and A'2 horizons are loamy sand or sandy loam. The B't horizon is sandy loam or loam. In many profiles, a IIB't horizon is present. It is loam, clay loam, or silty clay loam, and is neutral or mildly alkaline. The combined thickness of the B't and IIB't horizons ranges from 5 to 10 inches. The IIC horizon is loam, clay loam, or silty clay loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Ubly soils are in a toposequence with Belding and Breckenridge soils. They are similar to Menominee soils. Ubly soils lack the mottles that are in the solum of Belding and Breckenridge soils. Ubly soils dominantly are finer textured in the upper part of the profile than Menominee soils.

Ubly sandy loam, 2 to 6 percent slopes (UbB).—This soil is on foot slopes and low ridges on uplands. It has the profile described as representative for the series.

Included with this soil in mapping were areas of somewhat poorly drained or poorly drained soils in swales and small areas of Emmet sandy loam and Leelanau loamy sand in slightly higher positions. Also included were a few small areas of yellowish-brown, eroded soils.

Most areas of this soil are in cultivation. Other areas are in pasture or are idle. A few acres are wooded. Surface runoff is slow to medium. The main concern of management is controlling water erosion. (Capability unit IIe–3 (3/2a) ; woodland suitability group A)

Ubly sandy loam, 6 to 12 percent slopes (UbC).—This soil is on foot slopes and low ridges on uplands.

Included with this soil in mapping were small areas of Emmet sandy loam and Leelanau loamy sand in slightly higher positions. Also included were small areas of yellowish-brown, eroded soils.

Most areas of this soil are in cultivation, in pasture, or are idle. A few small areas are wooded. Surface runoff is medium. The main concern of management is controlling water erosion. (Capability unit IIIe–6 (3/2a) ; woodland suitability group A)

Wallace Series

The Wallace series consists of well drained or moderately well drained, nearly level to sloping soils on beach ridges and outwash plains. These soils formed in sand.

In a representative profile, the surface layer is very dark gray sand 7 inches thick. The subsurface layer is light brownish-gray sand 4 inches thick. The subsoil consists of two parts. The upper part is very dark brown or yellowish-red, strongly cemented sand 19 inches thick. The lower part is yellowish-brown, loose sand 18 inches thick. The underlying material, at a depth of 48 inches, is light yellowish-brown sand.

Permeability is moderately slow in the cemented layers and rapid in the underlying sand. The available moisture capacity is low. Organic-matter content and natural fertility are low. Surface runoff is slow.

The Wallace soils are very poorly suited to farming. They are very poorly suited to hardwoods but are moderately suited to pines. The Wallace soils have severe limitations for many nonfarm uses. These soils are mainly sparsely wooded or are idle.

Representative profile of Wallace sand, 0 to 12 percent slopes, in a nonwooded area, SE¼SW¼ sec. 25, T. 32 N., R. 7 W.:

A1—0 to 7 inches, very dark gray (10YR 3/1) sand; single grain ; loose ; strongly acid ; abrupt, smooth boundary.

A2—7 to 11 inches, light brownish-gray (10 YR 6/2) sand; single grain ; loose ; strongly acid ; abrupt, smooth boundary.

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B21hirm—11 to 16 inches, very dark brown (10YR 2/2) sand; massive; strongly cemented ortstein; very strongly acid; gradual, wavy boundary.
B22irm—16 to 30 inches, yellowish-red (5YR 4/8) sand; massive; strongly cemented ortstein; strongly acid; gradual, irregular boundary.
B3—30 to 48 inches, yellowish-brown (10YR 5/6) sand; single grain; loose; medium acid; gradual, wavy boundary.
C—48 to 60 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; slightly acid.

The Bhirm and Birm horizons range from weakly cemented to strongly cemented. They have a clear or gradual, wavy boundary or a clear or gradual, irregular boundary.

Wallace soils in most areas are near the Au Gres, Croswell, Kalkaska, Roscommon, Rubicon, and Saugatuck soils. Wallace soils differ from all these soils, except Saugatuck soils, in having a continuous ortstein in the B horizon. They differ from Au Gres, Croswell, Roscommon, and Saugatuck soils in lacking mottles in the profile.

Wallace sand, 0 to 12 percent slopes (WaC).—This soil is on sandy plains and narrow beach ridges. It has a cemented hardpan layer in the subsoil that prevents root penetration.

Included with this soil in mapping were a few, small, eroded areas of soils that have an exposed, very dark brown, cemented subsoil, and a few small areas of Kalkaska sand that lacks the thick, cemented subsoil layer.

Most areas of this soil are in pasture or sparse woods, but a few areas are idle. The main concerns of management are conserving moisture and controlling soil blowing. The main limitation is the shallow root zone. (Capability unit VIIs–1 (5a–h); woodland suitability group H)

Warners Series

The Warners series consists of very poorly drained, nearly level to gently sloping soils in depressional areas on lake plains and bottom lands. They formed in less than 12 inches of loam over marl.

The surface layer is black loam 8 inches thick. The next layer is white marl 12 inches thick. Below this layer, at a depth of 20 inches, is black mucky peat.

Permeability is moderately slow. The available water capacity is variable. Organic-matter content is high, and natural fertility is low. Surface runoff is slow to ponded.

Warners soils are very poorly suited to farming and to woodland. They have severe limitations for most nonfarm uses. These soils are mainly wooded or are in native pasture.

Representative profile of Warners loam in a nonwooded area, SE¼NW¼ sec. 35, T. 32 N., R. 7 W.:

A1—0 to 8 inches, black (10YR 2/1) loam; moderate, fine, granular structure; friable; moderately alkaline; strongly effervescent; clear, smooth boundary.
IIC1—8 to 20 inches, white (10YR 8/1) marl; massive; friable; moderately alkaline; violently effervescent; clear, wavy boundary.
IIIO2—20 to 42 inches, black (10WR 2/1) mucky peat; massive; friable; moderately alkaline; slightly effervescent.

The marl is generally at a depth of less than 12 inches. It ranges from 6 inches to 72 inches or more in thickness. The A1 horizon is very dark grayish brown, very dark gray, very dark brown, or black. In many profiles the marl is underlain by muck, mucky peat, peat, clay loam, or silty clay loam at a depth of less than 42 inches. The clay loam and silty clay loam commonly are light olive brown.

The annual temperature of these soils is a few degrees cooler and the mineral material is thinner than the defined range for the series. Also, the organic material in the lower part of the profile is not in the defined range for the series. These differences alter the usefulness and behavior of these soils.

Warners soils are similar to Carbondale, Cathro, Edwards, Greenwood, Kerston, Linwood, Lupton, Markey, and Tawas soils. They differ from all these soils, except Edwards soils, in having marl within a depth of 42 inches. Warners soils differ from Edwards soils in having marl at a depth of less than 12 inches, rather than at a depth of 12 to 42 inches.

Warners loam (0 to 4 percent slopes) (Wr).—This soil is in depressional areas on plains and bottom lands. Some delineations of this unit are shown by a special symbol on the soil map. The majority of these delineations lack marl.

Included with this soil in mapping were many small areas of soils in which the marl is at or near the surface. Also included were small areas of soils that have a silt loam surface layer and small areas of deeper Edwards muck. A few areas of this soil have loamy or clayey deposits under the mucky peat.

Most areas of this soil are in pasture or woods. A few small areas are in cultivation. The main concern of management is improving drainage. The main limitations are a shallow root zone, caused by the shallow depth to marl, and a hazard of frost. (Capability unit VIwc–2 (M/mc); woodland suitability group not assigned)

Wet Alluvial Land

Wet alluvial land (Wt) is on narrow bottom lands. It consists of soil material that ranges in texture from coarse sand to fine clay and includes some organic material. The dominant texture, however, is sandy loam to loam. There are a few, small, well-drained areas and many poorly drained areas.

Most areas of this land type are in pasture and woods. A few areas are idle. The main concerns of management are improving drainage and reducing the hazard of flooding. The main limitation is a hazard of frost in many areas. (Capability unit VIwc–2 (L–2c); woodland suitability group not assigned)

Use and Management of the Soils

In this section the capability classification used by the Soil Conservation Service is explained. Then the capability units are discussed in detail, and suggestions about use and management of the soils are given. Next, predicted yields of the principal crops are listed. Finally, information about the use of the soils for woodland, wildlife, and engineering purposes is given.

Capability Grouping [2]

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or

[2] RICHARD H. DRULLINGER, agronomist, Soil Conservation Service, assisted in the preparation of this subsection.

other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or engineering.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. (None in Charlevoix County.)

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–3 or IIIe–4. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

The capability classification of the soils in Charlevoix County is given in the "Guide to Mapping Units" at the back of this survey. For a complete explanation of the capability classification, see Agriculture Handbook No. 210, Land Capability Classification (*7*).

Management by capability units

In the following pages, the capability units in Charlevoix County are described and suggestions for the use and management of the soils in each unit are given. The Arabic numerals used in this survey are not consecutive, because not all the capability units used in Michigan are represented in Charlevoix County.

In this soil survey, symbols made up of Arabic numerals and small or capital letters follow the symbol of each capability unit. These symbols in parentheses identify the management group or groups, all or part of which are represented by the soils in the capability unit. The management groups are part of a statewide system used in Michigan for making recommendations about applications of lime and fertilizer, about drainage, and about other practices. For an explanation of this classification, refer to "Fertilizer Recommendations for Michigan Vegetables and Field Crops" (*3*).

The names of soil series represented are mentioned in the description of each capability unit, but this does not mean that all the soils of a given series appear in that unit. To find the names of all the soils and the capability unit in which each one has been grouped, refer to the "Guide to Mapping Units" at the back of this survey.

Certain practices basic to good soil management should be mentioned before discussing the individual capability units. Management practices needed to improve yields include drainage, control of erosion, rotation of crops, use of suitable crop varieties, and the use of adequate lime and fertilizer. Lime and fertilizer should be applied according to soil tests and the needs of the crops.

Many of the soils in Charlevoix County need artificial drainage. Drainage of cropland improves the air-water relationship in the root zone. Tile drains or surface drainageways, or both, can be used to remove excess water, but they should be designed to function properly. Suitable outlets are difficult to obtain. Good soil structure and an ample supply of organic matter also benefit soil drainage. Low-lying areas are subject to a shortened growing season because of frost late in spring and early in fall.

The loss of surface soil through erosion reduces soil productivity. Erosion generally can be controlled by reducing the rate and volume of runoff and by increasing the rate of water absorption by the soil. Growing meadow

crops, cover crops, green-manure crops, and the proper use of crop residue help to reduce surface runoff. Use of contour cultivation, stripcropping, grassed waterways, windbreaks, minimum tillage, diversions and terraces, and other measures is effective in controlling erosion (fig. 7).

Practices to maintain and improve organic-matter content and soil tilth include the growing of cover crops and green-manure crops, the use of stubble mulching and minimum tillage, and the application of barnyard manure. Grazing loamy and clayey soils when wet should be avoided because it results in compaction of the soils and poor tilth. These practices are needed most if the rotation is intensive or if cultivation is continuous.

Orchard crops are important in the county. Care should be taken in choosing sites that have proper air drainage. Many of the orchards are grown in sod. When the orchards are fertilized, adequate fertilizer should be applied for both the sod and the fruit trees. Also, the competition for moisture, particularly in the sandy soils, should be considered. Land shaping is a practice that has been used to some extent in the county. Practices to improve organic-matter content, soil tilth, and soil fertility are needed on these sites. Control of erosion on these sites is critical.

Additional help in managing the soils can be obtained by consulting the local representative of the Soil Conservation Service or the Cooperative Extension Service.

CAPABILITY UNIT IIe–1 (1.5a, 3a)

This unit consists of well drained and moderately well drained, dominantly nearly level to gently sloping soils of the Barker, Emmet, and Nester series. These soils generally have a surface layer of loam and a subsoil of silt loam, loam, or silty clay loam.

In the Barker and Nester soils, permeability is moderately slow, available water capacity is high, and fertility is high. In the Emmet soils, permeability is moderate, available water capacity is moderate, and fertility is medium. In all the soils, organic-matter content is moderate and runoff is medium.

The main limitation of these soils for farming is their susceptibility to water erosion. A concern of management in some areas is keeping good tilth. These soils are well suited to row crops, small grain, hay, and pasture plants. They warm up more slowly in spring than the more sandy soils, and they generally contain a few, small, wet

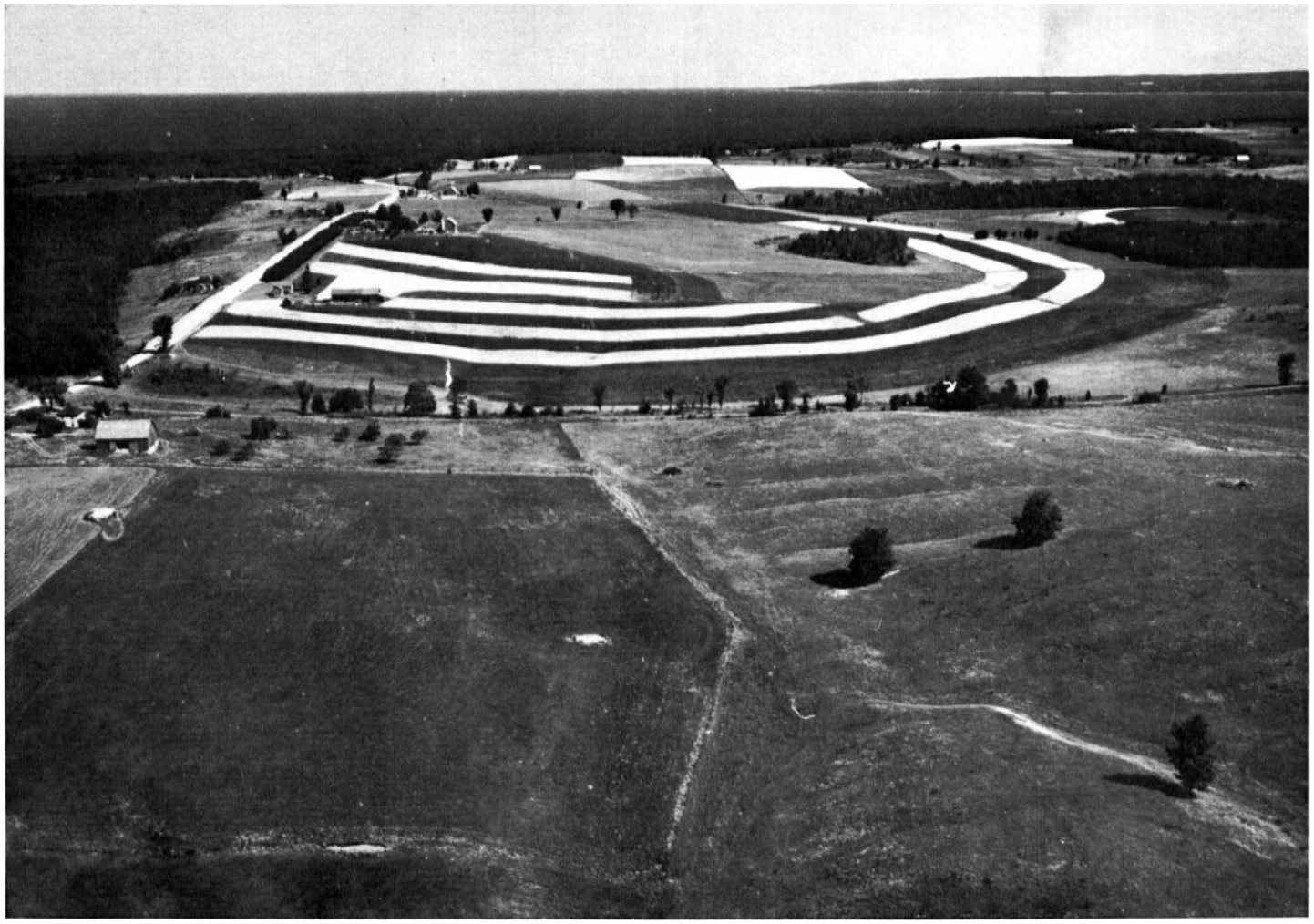

Figure 7.—**Stripcropping, grassed waterways, and windbreaks for controlling erosion on Emmet-Onaway soils. Lake Michigan is in background.**

depressions that delay planting and harvesting during wet periods. Fall plowing permits earlier planting in the following spring. If these soils are tilled when wet, they compact and runoff increases.

CAPABILITY UNIT IIe–3 (2.5a, 3a, 3/2a, 4a)

This unit consists mainly of well drained or moderately well drained, dominantly nearly level to gently sloping soils of the Emmet, Leelanau, Onaway, and Ubly series. These soils generally have a surface layer of sandy loam and a subsoil of loamy sand to clay loam.

In the Emmet, Onaway, and Ubly soils, permeability generally is moderate; in the Ubly soils, however, permeability is moderately slow in the loam underlying material. Available water capacity of these soils is moderate to high, and fertility is medium to high. In the Leelanau soils permeability is moderately rapid, available water capacity is low, and fertility is low. In all the soils of this unit, organic-matter content is moderate or moderately low and runoff is slow.

The main limitation of these soils for farming is susceptibility to water erosion. They are well suited to row crops, small grain, hay, and pasture plants. In frost-free areas, these soils are well suited to orchards. They are easy to till over a wide range of moisture conditions. They warm up early in spring and dry out quickly after rain.

CAPABILITY UNIT IIw–4 (1.5b, 2.5b, 2.5c, 3b, 3c)

This unit consists of somewhat poorly drained or poorly drained, nearly level to gently sloping soils of the Angelica, Brimley, Bruce, Charlevoix, Ensley, Kawkawlin, and Mackinac series. These soils have a surface layer of loam or sandy loam and a subsoil of sandy loam to clay loam.

Permeability is moderate to moderately slow. Available water capacity is moderate to high. Organic-matter content is moderate to high, and fertility is medium to high. Runoff is slow to very slow.

The main limitation of these soils for farming is wetness. Once drained, these soils are well suited to row crops, small grain, hay, and pasture plants. If not drained, these soils are excessively wet during spring and after rain because of a fluctuating high water table and moderately slow permeability in some of the soils. In a few areas, the undulating relief makes the installation of a complete drainage system difficult. In these areas, random tile drains and surface drains provide drainage if adequate outlets are available. Installing tile drains in the Brimley and Bruce soils is more difficult than in the other soils because of unstable underlying material. If the Kawkawlin soils are tilled when wet, they compact and lose their good tilth.

CAPABILITY UNIT IIw–8 (3/2b, 3/2c)

This unit consists of somewhat poorly drained or very poorly drained, nearly level to gently sloping soils of the Belding and Breckenridge series. These soils have a surface layer of sandy loam and a subsoil of loamy sand to silty clay loam.

Permeability is generally moderately rapid in the subsoil and moderately slow in the underlying material. Available water capacity is moderate to high. Organic-matter content is moderate to high, and fertility is medium. Runoff is slow to ponded.

The main limitation of these soils for farming is wetness. Frost damages crops in low-lying areas during some years. If drained, these soils are well suited to corn, small grain, hay, and pasture plants. Once drained, they dry out rapidly after rain and are easily worked. Tilth is not a serious concern of management. If not drained, these soils are excessively wet during spring and after rain because of a fluctuating high water table and moderately slow permeability in the underlying material. In a few areas, the undulating relief makes the installation of a complete drainage system difficult. In these areas, random tile drains and surface drains provide drainage if adequate outlets are available.

CAPABILITY UNIT IIIe–4 (1.5a)

This unit consists of well drained or moderately well drained, sloping soils of the Barker and Nester series. They have a surface layer of loam and a subsoil of silt loam, loam, or silty clay loam.

Permeability is moderately slow. Available water capacity is high. Organic-matter content is moderate, and fertility is high. Runoff is medium to rapid.

The main limitation of these soils for farming is susceptibility to water erosion. A concern of management is keeping good soil tilth in some areas, particularly on the small, eroded spots. These soils are moderately suited to row crops and small grain and well suited to hay and pasture plants. They warm up more slowly in spring than more sandy soils, and they generally contain a few, small, wet depressions that delay planting and harvesting during wet periods. Fall plowing permits earlier planting in the following spring. If tilled when wet, these soils compact and runoff increases.

CAPABILITY UNIT IIIe–6 (2.5a, 3a, 3/2a, 4a)

This unit consists of well drained or moderately well drained, sloping soils of the Emmet, Leelanau, Onaway, and Ubly series. These soils generally have a surface layer of sandy loam and a subsoil of loamy sand to clay loam.

In the Emmet, Onaway, and Ubly soils, permeability is generally moderate; in the Ubly soils, however, permeability is moderately slow in the loam underlying material. Available water capacity of these soils is moderate to high, and fertility is medium to high. In the Leelanau soils, permeability is moderately rapid, available water capacity is low, and fertility is low. In all the soils of this unit, organic-matter content is moderate or moderately low and runoff is medium.

The main limitation of these soils for farming is susceptibility to water erosion. They are moderately suited to row crops and small grain and well suited to hay and pasture plants. In frost-free areas, these soils are well suited to orchards. They are easy to till over a wide range of moisture conditions. They warm up early in spring and dry out quickly after rain.

CAPABILITY UNIT IIIe–9 (4a, 4/2a, 5.3a)

This unit consists of well drained or moderately well drained, sloping soils of the Blue Lake, Leelanau, Mancelona, Menominee, and Rubicon series. These soils generally have a surface layer of loamy sand and a subsoil of loamy sand or sandy loam. The subsoil of the Rubicon soils is sand.

Permeability generally is moderately rapid or rapid; in the Menominee soils, however, permeability is moderately slow in the loam underlying material. Available water capacity is low. Organic-matter content is low or moderately low, and fertility is low. Runoff is medium.

The main limitations of these soils for farming are susceptibility to water erosion, low soil moisture, and low fertility. Soil blowing is a concern of management in large, cultivated areas. These soils generally are moderately suited to row crops, small grain, hay, and pasture plants, but the sandy Rubicon soils are poorly to very poorly suited to crops. In frost-free areas, the soils of this unit are moderately suited to orchards. Low soil moisture prevents shallow-rooted crops from attaining their optimum growth. Small grains normally mature before these soils become too dry. These soils warm up early in spring and are ready for planting sooner than more loamy and clayey soils.

CAPABILITY UNIT IIIw–1 (1b, 1c, 1.5c)

This unit consists of somewhat poorly drained or poorly drained, nearly level to gently sloping soils of the Bergland, Rudyard, and Sims series. These soils have a surface layer of silt loam or silty clay loam and a subsoil of silty clay loam or silty clay.

Permeability is slow or very slow. Available water capacity is moderate to high. Organic-matter content and fertility are high. Runoff is slow to very slow.

The main limitations of these soils for farming are wetness and restricted permeability. Frost damage to crops in the lowest areas also limits crop growth. If drained and in frost-free areas, these soils are moderately suited to row crops, small grain, hay, and pasture plants. Undrained areas are very poorly suited to row crops and small grain but are moderately suited to hay and pasture plants. Because of the slow to very slow permeability, surface drains and bedding systems are more effective than tile drains in removing excess water. If these soils are tilled during wet periods, the structure is destroyed and this results in poor tilth. Fall plowing allows earlier tillage the following spring.

CAPABILITY UNIT IIIw–5 (4b)

This unit consists of somewhat poorly drained, nearly level to gently sloping soils of the Gladwin and Otisco series. These soils have a surface layer of loamy sand and a subsoil of loamy sand to loam.

Permeability is moderately rapid. Available water capacity is low. Organic-matter content is moderately low to low, and fertility is low. Runoff is slow.

The main limitations of these soils for farming are wetness, low fertility, and low soil moisture during the latter part of the growing season, especially after drainage. These soils are moderately suited to row crops, small grain, hay, and pasture plants. Installation of drainage allows earlier tillage of the soils in spring and after rains and permits crops to reach maturity. Drainage in some areas is impractical because of a lack of outlets or because of uneven relief. Loss of nutrients through leaching is high. Small grain normally matures before these soils become too dry. Hay and pasture plants grow well early in the growing season, but their growth is reduced by lack of soil moisture late in summer.

CAPABILITY UNIT IIIw–6 (4c)

This unit consists of poorly drained, nearly level to gently sloping soils of the Edmore and Epoufette series. These soils have a surface layer of sandy loam and a subsoil of loamy sand to sandy loam.

Permeability is generally moderately rapid. Available water capacity is low. Organic-matter content is high, but fertility is low. Runoff is very slow to ponded.

The main limitations of these soils for farming are wetness and low fertility. Frost is a hazard in some low areas. These soils are saturated during spring because of a high water table. Undrained areas are moderately suited to water-tolerant hay and pasture plants. If drained, these soils are moderately suited to row crops and small grain; however, they are droughty late in summer.

CAPABILITY UNIT IIIw–9 (3/1c, 4/2b, 4/2c)

This unit consists of somewhat poorly drained to very poorly drained, nearly level to gently sloping soils of the Brevort, Iosco, and Munuscong series. The Brevort and Iosco soils have a surface layer of loamy sand and a subsoil of sand or loamy sand underlain by loam at a depth of 18 to 42 inches. The Munuscong soil has a surface layer of fine sandy loam and a subsoil of loam underlain by silty clay at a depth of 18 to 42 inches.

In the Brevort and Iosco soils, permeability is rapid in the subsoil but is moderately slow in the underlying loam; available water capacity is low in the subsoil and high in the underlying loam; fertility is low; and runoff is slow to ponded. Organic-matter content is moderately low in the Iosco soils and high in the Brevort soils. In the Munuscong soil, permeability is moderately rapid in the subsoil and slow in the underlying silty clay; available water capacity is moderate, organic-matter content is high, and fertility is medium.

The main limitation of these soils for farming is wetness. Frost is a hazard in some low areas. Undrained areas of these soils generally are moderately suited to hay and pasture plants, and drained areas generally are moderately suited to row crops and small grain. These soils are saturated during spring because of a high water table. Tile drains are difficult to install in many areas because of the variable depth to the loam or silty clay underlying material and the lack of outlets. The low fertility of the Iosco and Brevort soils limits them for crop production. If these soils are drained, they are droughty late in summer. The Munuscong soil is more productive than the other soils in this unit. The underlying, slowly permeable silty clay of this soil limits the effectiveness of tile drains.

CAPABILITY UNIT IIIs–4 (3a, 4a, 4/2a, 5a, 5.3a)

This unit consists of well drained or moderately well drained, nearly level to gently sloping soils of the Blue Lake, East Lake, Emmet, Kalkaska, Leelanau, Mancelona, Menominee, and Rubicon series. These soils generally have a surface layer of loamy sand or sand and a subsoil of sand to sandy loam, but the Emmet soil has a surface layer of sandy loam and a subsoil of sandy loam and loam.

Permeability generally is moderately rapid or rapid; in the Menominee soils, however, permeability is moderately slow in the loam underlying material. In the Emmet soils, permeability is moderate, available water capacity is moderate, and organic-matter content and fertility are me-

dium. In all but the Emmet soils, available water capacity is low, organic-matter content is low or moderately low, and fertility is low. Runoff is slow on all the soils in this unit.

The main limitations of these soils for farming are low soil moisture, low fertility, and susceptibility to soil blowing. Most of these soils are moderately suited to row crops, small grain, hay, and pasture plants. The sandy Kalkaska and Rubicon soils, however, are poorly or very poorly suited to crops. In frost-free areas, the soils in this unit are moderately suited to orchards. Low soil moisture prevents shallow-rooted crops from attaining their optimum growth. Small grain normally matures before these soils become too dry. These soils warm up early in spring and are ready for planting sooner than more loamy and clayey soils.

CAPABILITY UNIT IVe–1 (1.5a, 1.5a/Ra, 3a)

This unit consists mainly of well drained or moderately well drained, strongly sloping to steep soils of the Barker, Emmet, and Nester series, and of the Barker series, shallow variant. These soils have a surface layer of loam and a subsoil of silt loam, loam, or silty clay loam. The moderately well drained or somewhat poorly drained Barker soil, shallow variant, is underlain by shale bedrock at a depth of less than 40 inches.

In the Barker and Nester soils, permeability is moderately slow, available water capacity is high, organic-matter content is moderate, and fertility is high. In the Emmet soils, permeability and available water capacity are moderate and fertility is medium. In the Barker soil, shallow variant, permeability is slow and available water capacity is moderate. Runoff is rapid on all of the soils in this unit.

The main limitation of these soils for farming is susceptibility to water erosion. Keeping good tilth is a concern of management in some areas, particularly on the eroded spots. Wetness is a limitation of the Barker soil, shallow variant, in some areas. The soils in this unit are poorly suited to row crops and small grain and are moderately suited to hay and pasture plants. Because of the underlying shale bedrock, intensive erosion control practices are needed in areas of the Barker soil, shallow variant. The slopes in many areas of these soils are too complex and short for stripcropping. In these areas, use of a cropping system that includes mostly close-growing crops reduces runoff and erosion.

CAPABILITY UNIT IVe–4 (2.5a, 3a, 4a)

This unit consists mainly of well-drained, strongly sloping soils of the Emmet, Johnswood, Leelanau, and Onaway series. The Johnswood soils have a cobbly loam surface layer, and the Leelanau soil has a loamy surface layer. The Emmet and Onaway soils have a surface layer of sandy loam and a subsoil of sandy loam to clay loam.

In most of these soils, permeability is moderate, available water capacity is moderate to high, organic-matter content is moderate to high, and fertility is medium to high. In the Leelanau soils, however, permeability is moderately rapid, available water capacity is low, organic-matter content is moderate, and fertility is low. Runoff is medium to rapid on all of the soils in this unit.

The main limitation of these soils for farming is susceptibility to water erosion. These soils are poorly suited to row crops but are moderately suited to small grain, hay, and pasture plants. The cobbly loam surface layer of the Johnswood soil severely limits its use for cultivated crops. In many areas of the soils in this unit, the slopes are too complex and short for stripcropping. In these areas a cropping system that includes mostly close-growing crops reduces runoff and erosion.

CAPABILITY UNIT IVe–9 (3a, 4a, 5a, 5.3a)

This unit consists of well drained or moderately well drained, dominantly strongly sloping soils of the Blue Lake, East Lake, Emmet, Kalkaska, Leelanau, Mancelona, and Rubicon series. These soils generally have a surface layer of loamy sand or sand and a subsoil of sand to sandy loam, but the Emmet soils have a surface layer of sandy loam and a subsoil of sandy loam and loam.

In most of these soils, permeability is moderately rapid or rapid, available water capacity is low, organic-matter content is moderately low or low, and fertility is low. In the Emmet soils, however, permeability is moderate, available water capacity is moderate, organic-matter content is moderate, and fertility is medium. Runoff is medium on all of the soils in this unit.

The main limitations of these soils for farming are susceptibility to water erosion, low soil moisture, and low fertility. They are poorly suited to row crops but are moderately suited to small grain, hay, and pasture plants. The sandy Kalkaska and Rubicon soils are poorly to very poorly suited to crops. Small grain normally matures before these soils become too dry. These soils warm up early in spring and are ready for planting sooner than the more loamy and clayey soils.

CAPABILITY UNIT IVw–2 (5b, 5b–h, 5/2b)

This unit consists of somewhat poorly drained, nearly level to gently sloping soils of the Au Gres and Saugatuck series. One of the Au Gres soils has a surface layer and subsoil of sand, and the other has loam underlying material at depths between 42 and 66 inches. The Saugatuck soil has a cemented subsoil.

Permeability generally is rapid, but it is slow in the cemented subsoil of the Saugatuck soil and moderately slow in the loamy substratum of one of the Au Gres soils. In all of the soils in this unit, available water capacity is low, organic-matter content is moderately low, fertility is low, and runoff is slow.

The main limitations of these soils for farming are wetness, low fertility, low soil moisture during the summer months where these soils are drained, and susceptibility to soil blowing. The cemented subsoil layer of the Saugatuck soil restricts root growth. The soils in this unit are poorly suited to row crops and small grain and are moderately suited to hay and pasture plants. They are excessively wet during spring but become somewhat droughty during summer. Drainage is difficult to install, because the sandy material caves into the trenches and open ditches. Ditchbanks are difficult to maintain and vegetate. Once installed, tile drains tend to fill with sandy material. Organic-matter content and fertility are difficult to maintain in these sandy soils. If these soils are used for crops, erosion control measures are necessary to reduce soil blowing.

CAPABILITY UNIT IVs–4 (4a, 5a, 5/2a)

This unit consists of well drained or moderately well drained, nearly level to gently sloping soils of the Croswell, East Lake, Kalkaska, Leelanau, and Rubicon series. These soils have a surface layer of loamy sand or sand and a subsoil of dominantly loamy sand or sand. Rubicon sand, loamy substratum, is underlain by loam or clay loam between depths of 42 and 60 inches.

Permeability is dominantly rapid. Available water capacity is low. Organic-matter content is generally low to moderately low, and fertility is low. Runoff is very slow to slow.

The main limitations of these soils for farming are low soil moisture, low fertility, and susceptibility to soil blowing. Most of these soils are poorly suited to row crops and small grain, but they are moderately suited to hay and pasture plants. The Leelanau soils, however, are moderately suited to row crops and small grain. Soil moisture is rarely adequate for good crop growth. Crops on these soils reflect the effects of drought sooner than crops on most other soils in the county. During dry years, shallow-rooted crops such as corn do not mature because of low soil moisture. These soils also have a low capacity to hold plant nutrients. Nutrients are readily leached from the soils by rainfall. These sandy soils blow readily when exposed by tillage, and erosion control practices are essential to prevent damage to crops and soils.

CAPABILITY UNIT Vw–1 (2.5b, 3b, Gbc)

This unit consists of somewhat poorly drained or poorly drained, nearly level to gently sloping soils of the Charlevoix, Detour, Hessel, and Mackinac series. These soils have a surface layer of cobbly loam and a subsoil of sandy loam, loam, cobbly loam, and cobbly sandy clay loam.

Permeability is moderate or moderately slow. Available water capacity is high. Organic-matter content is moderate to high, and fertility is medium to high. Runoff is slow.

The main limitations of these soils for farming are wetness and a cobbly surface layer. They are poorly suited to row crops and small grain but are moderately well suited to hay and pasture plants. Most areas of these soils are too wet and too cobbly to be cultivated. These soils are also too cobbly to install tile drains for removal of excess water. Where farmed, these soils are generally in permanent pasture.

CAPABILITY UNIT VIe–1 (1.5a, 3a)

This unit consists of well drained or moderately well drained, dominantly steep or very steep soils of the Nester and Emmet series. These soils have a surface layer of loam and a subsoil of loam and silty clay loam.

In the Nester soils, permeability is moderately slow, available water capacity is high, organic-matter content is moderate, fertility is high, and runoff is rapid. In the Emmet soils, permeability and available water capacity are moderate, fertility is medium, organic-matter content is moderate, and runoff is rapid.

The main limitations of these soils for farming are susceptibility to water erosion and steepness of slopes. They are suited to hay and pasture plants. These soils erode easily if they are intensively cultivated (fig. 8). Maintaining a vegetative cover helps to reduce runoff and to control erosion.

Figure 8.—**Eroded pasture on Nester-Emmet association. These soils erode easily if they are intensively cultivated.**

CAPABILITY UNIT VIe–2 (2.5a, 3a, 4a, 5a, 5.3a)

This unit consists of well drained or moderately well drained, steep or very steep soils of the Blue Lake, East Lake, Emmet, Leelanau, Mancelona, Onaway, and Rubicon series. These soils generally have a surface layer of loamy sand or sandy loam and a subsoil of sand to loam, but the Onaway soils have a subsoil of sandy loam and clay loam.

Permeability is moderate to rapid. Available water capacity generally is low to moderate, but in the Onaway soil it is high. Organic-matter content is low to moderate. Fertility generally is low to medium, but in the Onaway soil it is high. Runoff is generally rapid.

The main limitations of these soils for farming are susceptibility to water erosion and steepness of slopes. These soils are better suited to hay and pasture plants than to cultivated crops. They erode easily if they are intensively cultivated. Maintaining a vegetative cover helps to control erosion.

CAPABILITY UNIT VIwc–1 (Mc, M/mc, M/3c, M/4c)

This unit consists of very poorly drained, nearly level to gently sloping organic soils of the Carbondale, Cathro, Edwards, Linwood, Lupton, Markey, and Tawas series. These soils have a surface layer of muck. The Carbondale and Lupton soils are deep and have more than 42 inches of muck or mucky peat. The Cathro and Linwood soils are underlain by loam, the Edwards soil by marl, the Markey soil by loamy sand, and the Tawas soil by sand between depths of 12 and 42 inches.

Permeability is moderately rapid in the organic layers and is variable in the underlying mineral and marl material. Available water capacity is moderate to very high. Fertility is low. Runoff is very slow to ponded.

The main limitations of these soils for farming are wetness, susceptibility to frost, and soil blowing. They are very poorly suited to crops. Because of these limitations, most areas of these soils are not farmed. A few areas are in hay or native pasture. Because of their low-lying posi-

tion, these soils remain cold and dry out slowly even after drainage. In many areas drainage is impractical because of a lack of outlets.

CAPABILITY UNIT VIwc–2 (5c, L–Mc, L–2c, M/mc)

This unit consists of poorly drained or very poorly drained, nearly level to gently sloping soils of the Kerston, Roscommon, and Warners series and of Wet alluvial land. The Kerston soil has a surface layer of muck over alternate layers of muck and sandy loam. The Roscommon soil has a surface layer of sand over layers of sand. The Warners soil is underlain by marl at a depth of less than 12 inches. Wet alluvial land has variable texture within short distances, but it is mostly sandy loam, silt loam, or loam.

Permeability generally is moderately rapid to rapid, fertility is low, and runoff is slow to ponded. Available water capacity is high in the Kerston soil and low in the Roscommon soil. Organic-matter content is high in the Roscommon and Kerston soils. In the Warners soil, permeability is moderately slow, available water capacity is variable, and organic-matter content is high.

The main limitations of these soils for farming are wetness, low fertility, and susceptibility to frost. The Kerston soil and Wet alluvial land are also subject to flooding. The shallow rooting depth to marl is an additional limitation of the Warners soil. All of the soils of this unit are very poorly suited to crops, but a few areas of the Roscommon soil are moderately suited to hay and pasture plants. Because of these severe limitations, these soils are seldom planted to crops. In many areas outlets for drainage are lacking and ditches must be dug to provide outlets. The sandy material of the Roscommon soil fills tile drains, and ditchbanks are unstable and difficult to vegetate. Organic-matter content and fertility are difficult to maintain in the Roscommon soil if it is cultivated. Crops on all of these soils are subject to frost because of their low-lying position. Frost prevents crops from maturing during most seasons.

CAPABILITY UNIT VIs–1 (4a, 5a)

This unit consists of well-drained, sloping to strongly sloping soils of the East Lake, Kalkaska, and Leelanau series. These soils have a surface layer of loamy sand or sand and a subsoil of dominantly loamy sand or sand.

Permeability is dominantly rapid. Available water capacity is low. Organic-matter content is low to moderately low, and fertility is low. Runoff is generally slow.

The main limitations of these soils for farming are low soil moisture and low fertility. Most areas of these soils are very poorly suited to cultivated crops and are poorly to moderately suited to hay and pasture plants. The Leelanau soils are better suited to hay and pasture plants than the other soils of this unit. Soil moisture and fertility are rarely adequate for good crop growth. Hay and pasture plants grow fairly well during the early part of the growing season, but as soil moisture is depleted late in summer, plant growth is severely reduced.

CAPABILITY UNIT VIs–2 (4a, 5a, Ga)

This unit consists of well-drained, nearly level to very steep soils of the Alpena, Kiva, and East Lake series. These soils have a surface layer of gravelly sandy loam or gravelly loamy sand and a subsoil of gravelly sandy loam or gravelly loamy sand.

Permeability is moderately rapid to rapid. Available water capacity is low. Organic-matter content is moderately low, and fertility is low. Runoff is slow.

The main limitations of these soils for farming are low soil moisture, low fertility, and the steepness of slope in a few areas. They are very poorly suited to cultivated crops but are moderately suited to hay and pasture plants. These plants grow well during the early part of the growing season, but plant growth is seriously limited during the latter part of the season as soil moisture is depleted. Maintaining a cover of vegetation reduces the hazard of soil blowing in the larger areas of these soils.

CAPABILITY UNIT VIIe–2 (2.5a, 3a, 4a, 5.3a)

This unit consists of well drained or moderately well drained, very steep soils of the Emmet, Leelanau, Mancelona, Onaway, and Rubicon series. These soils generally have a surface layer of loamy sand or sandy loam and a subsoil of sand to loam. The subsoil of Onaway soils is sandy loam and clay loam.

In most of the soils in this unit, permeability is moderate to rapid, available water capacity is low to moderate, organic-matter content is low to moderate, and fertility is low to medium. The Onaway soil, however, has high available water capacity and fertility. Runoff is generally rapid on all the soils in this unit.

The main limitations of these soils for farming are susceptibility to water erosion and the very steep slopes. These soils are suited to pasture or woods. Maintaining a vegetative cover is essential to prevent erosion.

CAPABILITY UNIT VIIwc–2 (Rbc)

This unit consists of the poorly drained, nearly level to gently sloping Ruse soils. These soils have a surface layer of mucky sand to loam and a subsoil of sandy loam. They are underlain by limestone bedrock at a depth of less than 20 inches.

Permeability above the bedrock is moderately rapid. Available water capacity is moderate. Organic-matter content is very high, and fertility is medium. Runoff is very slow.

The main limitations of these soils for farming are wetness and their shallow depth over bedrock. Because of these severe limitations, these soils are very poorly suited to crops and are seldom farmed. A few small areas can be used for pasture.

CAPABILITY UNIT VIIs–1 (4a, 5a, 5a–h, 5.3a, Ra)

This unit consists mainly of well-drained, nearly level to very steep soils of the Deer Park, Eastport, Kalkaska, Leelanau, Rubicon, Summerville, and Wallace series and of Dune land and Stony land. All of these soils, except the Summerville and Wallace soils, have a surface layer of sand or fine sand and a subsoil of sand. The Summerville soil is less than 20 inches thick over limestone bedrock. The Wallace soil has a cemented sand subsoil.

Permeability generally is rapid. In the cemented subsoil of the Wallace soil, however, permeability is moderately slow. In most of these soils, available water capacity, organic-matter content, and fertility are low, and runoff is generally slow. In the Summerville soil, perme-

ability, available water capacity, and organic-matter content are moderate, fertility is medium, and runoff is medium. In the Leelanau soil, permeability is moderately rapid and organic-matter content is moderately low.

The main limitations of these soils for farming are low soil moisture, low fertility, soil blowing, water erosion, and the steepness of slopes in many areas. The cemented subsoil of the Wallace soil and the shallow depth and stoniness of the Summerville soil severely restrict the rooting zone of plants. The soils of this unit are suited to pasture or woodland. Maintaining a vegetative cover is essential to prevent erosion.

CAPABILITY UNIT VIIIwc–1 (Mc–a)

The only soil in this unit is the very poorly drained, nearly level to gently sloping Greenwood peat. The surface layer is peat, and the underlying layers are mucky peat.

Permeability is moderately rapid. Available water capacity is very high. Fertility is low. Runoff is very slow. Soil reaction is very strongly acid.

The main limitations of this soil for farming are wetness, acidity, low fertility, and susceptibility to frost. Because of these severe limitations, this soil is not suitable for farming. This soil is well suited as a habitat for wetland wildlife. Marsh vegetation is common.

CAPABILITY UNIT VIIIs–1

This unit consists only of Lake beaches. This land type consists of gently sloping sandy beaches along lake shores. It is poorly drained near the edge of the water and well drained inland.

This land type is not suited to farming. Soil blowing and wave action generally prevent vegetation from growing. Groins, jetties, and other breakwater structures are needed to protect beach areas. Ice damage to structures can be severe. Dependable methods of controlling soil blowing have not been developed for these areas.

This land type is well suited to recreation. It also provides habitat for some species of wildlife.

Predicted Yields

The soils of Charlevoix County have a wide range in productivity. Some consistently produce higher yields of cultivated crops, while others are better suited to less intensive uses because of soil limitations or erosion hazards.

The average acre yield of the principal crops for the soils of the county are given in table 2. These yields are obtained under two levels of management—prevailing management and improved management.

In columns A is the range of recorded yields for crops grown under prevailing management. Under prevailing management, legume-grass crops are grown in the crop rotations. Generally, little consideration is given to the suitability of the rotation for the soil. Barnyard manure that is produced is returned to the soil. Lime is applied, although in many places in insufficient amounts and not according to soil test recommendations. Some fertilizer is applied. Poorly drained areas are worked when wet, and often only a partial crop is harvested because of excess water. Erosion control and proper soil management practices are not used to the fullest advantage.

In columns B is the range in yields for crops obtained under improved management. Under improved management, the crop rotation is adapted to the soil and the proper proportion of row crops to legume-grass crops is used. The rotation is supplemented by the necessary conservation measures needed to control soil blowing and water erosion. Such measures may include contour tillage, stripcropping, minimum tillage, and return of crop residue. The quantity of lime applied is determined by soil tests. The quantity of fertilizer applied is also determined by soil tests and is based on the amounts and kinds of plant food needed by the crop. If needed, an adequate system of artificial drainage is installed. Improved varieties of plants and high-quality seeds are used. Weed, disease, and insect control is practiced. Suitable methods and proper timing of tillage and harvesting are used. Cover crops, crop residue, and manure are returned to improve soil structure, supply organic matter, and control erosion.

The crop yields listed are those that are expected over a period of several years under the two defined levels of management. The yields under improved management are not presumed to be the maximum obtainable. Potential yields per acre are somewhat higher, especially if there is a favorable combination of soil, plant, and weather conditions. Irrigation is not considered a part of improved management, because this practice is limited mainly to the production of truck and fruit crops.

Woodland [3]

Charlevoix County originally was covered almost entirely by forest. Northern hardwoods and pines grew on the uplands, and swamp hardwoods and conifers grew on the lowlands and bottom lands. Cutting of pines began about 1860 and continued until about 1900, and then the hardwoods were cut. Most of the cuttings were made for lumber.

About half of the land area of the county is now wooded. Farmers and other individuals own about three-fourths of the woodland. State and Federal holdings make up the balance.

There are four general types of woodland in the county: (1) northern hardwoods, (2) aspen and white birch, (3) pines, and (4) conifer swamp. The conifer swamp type of woodland is the least extensive type in the county and occurs in small to large tracts throughout areas of other types of woodland. The type of woodland that develops depends largely on soil texture, drainage, use, and past management.

Northern hardwoods.—This type of woodland consists chiefly of sugar maple. Varying quantities of beech, elm, and basswood are also present. Some red oak, white ash, and scattered yellow birch also occur. Northern hardwoods are dominant on the well-drained, moderately coarse textured to fine-textured soils. In some places they are on the well-drained, coarse-textured soils. The northern hardwoods are important commercially. For example, sugar maple, one of the most common hardwoods, is not only valuable for saw logs but also for making maple sugar.

[3] JACQUES J. PINKARD, woodland conservationist, Soil Conservation Service, assisted in the preparation of this subsection.

TABLE 2.—*Predicted average acre yields for crops under two levels of management*

[Yields in columns A are those expected for management common to the county; those in columns B are for improved management. Dashes indicate soil is not suited to the crop; that the crop ordinarily is not grown, or, in the case of soils mapped in associations, that yields are variable and depend on the extent of component soils in the particular area]

Mapping unit	Corn (grain)		Corn (silage)		Oats		Wheat		Clover-grass hay		Alfalfa or alfalfa-brome hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Alpena gravelly sandy loam, 0 to 6 percent slopes									1.0	1.6	1.5	2.5
Alpena gravelly sandy loam, 6 to 18 percent slopes									0.9	1.4	1.4	2.2
Alpena gravelly sandy loam, 18 to 35 percent slopes												
Alpena, Kiva and East Lake soils												
Angelica-Ensley loams		75		14	35	60	15	43	1.5	2.3		3.0
Au Gres sand, 0 to 4 percent slopes	25	45	5	8	20	35	15	25	0.8	1.5	1.2	2.0
Au Gres sand, loamy substratum, 0 to 4 percent slopes	25	45	5	8	20	35	15	25	0.8	1.5	1.2	2.0
Barker loam, 2 to 6 percent slopes	50	75	9	13	20	35	15	25	1.0	1.6	1.5	2.5
Barker loam, 6 to 12 percent slopes	35	55	6	9	18	30	15	25	1.0	1.6	1.5	2.5
Barker loam, 12 to 25 percent slopes									0.8	1.5	1.0	2.0
Barker loam, shallow variant, 2 to 6 percent slopes									0.8	1.5	1.5	2.0
Belding-Breckenridge sandy loams, 0 to 4 percent slopes	50	85	9	14	40	70	28	50	1.8	3.2	2.2	4.0
Bergland-Sims silty clay loams		65		10	30	55	25	45	1.8	2.5		3.5
Blue Lake loamy sand, 0 to 6 percent slopes	30	55	5	9	30	50	15	25	1.4	2.0	1.6	2.7
Blue Lake loamy sand, 6 to 12 percent slopes	25	45	5	8	27	50	12	22	1.2	2.0	1.5	2.5
Blue Lake loamy sand, 12 to 18 percent slopes					25	50	10	20	1.1	1.9	1.3	2.3
Blue Lake loamy sand, 18 to 50 percent slopes												
Blue Lake-Kalkaska association, undulating												
Blue Lake-Kalkaska association, rolling												
Brevort loamy sand		50		8	25	45	15	30	1.0	1.8		2.2
Brimley soils, 0 to 6 percent slopes	50	85	9	14	40	70	27	42	1.6	2.4	2.0	3.0
Bruce soils		65		11	40	75	27	45	1.7	2.7		3.3
Carbondale muck									1.0	2.2		
Cathro muck									1.0	2.2		
Charlevoix-Kawkawlin association, undulating												
Charlevoix-Mackinac loams, 0 to 6 percent slopes	55	85	10	14	45	70	30	50	1.8	2.8	2.3	3.5
Charlevoix-Mackinac cobbly loams, 0 to 6 percent slopes									1.4	2.4	2.0	3.0
Croswell sand, 0 to 4 percent slopes	25	55	4	9	25	45	15	25	1.0	1.8	1.2	2.3
Deer Park-Dune land association, undulating												
Deer Park-Dune land association, rolling												
Deer Park-Dune land association, hilly												
Detour cobbly loam, 0 to 6 percent slopes									1.4	2.4	2.0	3.0
East Lake loamy sand, 0 to 6 percent slopes	25	50	4	8	25	45	15	25	1.5	2.0	1.5	2.4
East Lake loamy sand, 6 to 12 percent slopes									1.5	2.0	1.5	2.4
Eastport sand, 0 to 6 percent slopes												
Eastport sand, 6 to 12 percent slopes												
Edmore sandy loam		50		8	25	45	15	30	1.0	1.8		2.2
Edwards muck												
Emmet sandy loam, 0 to 2 percent slopes	50	75	9	13	40	70	25	40	1.8	2.8	2.0	3.6
Emmet sandy loam, 2 to 6 percent slopes	50	75	9	13	40	65	25	40	1.8	2.8	2.0	3.6
Emmet sandy loam, 6 to 12 percent slopes	45	60	7	10	35	55	20	35	1.8	2.8	2.0	3.6
Emmet sandy loam, 12 to 18 percent slopes					30	50	18	30	1.5	2.4	1.8	3.0
Emmet sandy loam, 18 to 25 percent slopes									1.3	2.2	1.6	2.8
Emmet-Leelanau association, undulating												
Emmet-Leelanau association, rolling												
Emmet-Leelanau association, hilly												
Emmet-Leelanau complex, 2 to 6 percent slopes	45	70	8	12	35	60	20	35	1.4	2.4	1.6	2.8
Emmet-Leelanau complex, 6 to 12 percent slopes	40	55	7	9	30	50	18	30	1.4	2.4	1.6	2.8
Emmet-Leelanau complex, 12 to 18 percent slopes					25	40	16	20	1.1	2.0	1.4	2.2
Emmet-Leelanau complex, 18 to 25 percent slopes									1.0	1.8	1.2	2.0
Emmet-Leelanau complex, 25 to 50 percent slopes												
Emmet-Onaway sandy loams, 0 to 2 percent slopes	55	80	10	13	45	70	27	45	2.0	3.0	2.2	3.8
Emmet-Onaway sandy loams, 2 to 6 percent slopes	55	80	10	13	45	70	27	45	2.0	3.0	2.2	3.8
Emmet-Onaway sandy loams, 6 to 12 percent slopes	50	70	9	12	40	60	22	40	2.0	3.0	2.2	3.8
Emmet-Onaway sandy loams, 12 to 18 percent slopes					35	55	15	32	1.7	2.6	2.0	3.2
Emmet-Onaway sandy loams, 18 to 25 percent slopes									1.5	2.4	1.8	3.0
Emmet-Onaway sandy loams, 25 to 50 percent slopes												
Epoufette sandy loam		55		9	25	45	15	30	1.4	2.4		2.8
Gladwin loamy sand, 0 to 6 percent slopes	35	65	6	11	32	52	22	35	1.2	2.1	1.4	2.4
Greenwood peat												
Hessel cobbly loam												
Iosco loamy sand, 0 to 6 percent slopes	35	65	6	11	35	55	22	38	1.6	2.8	2.0	3.0

TABLE 2.—*Predicted average acre yields for crops under two levels of management*—Continued

Mapping unit	Corn (grain)		Corn (silage)		Oats		Wheat		Clover-grass hay		Alfalfa or alfalfa-brome hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Johnswood cobbly loam, 2 to 12 percent slopes												
Kalkaska sand, 0 to 6 percent slopes	25	50	4	8	25	45	15	25	1.5	2.0	1.5	2.4
Kalkaska sand, 6 to 12 percent slopes									1.2	1.8	1.2	2.0
Kalkaska sand, 12 to 18 percent slopes									1.0	1.6	1.1	1.8
Kalkaska sand, 18 to 25 percent slopes												
Kalkaska sand, 25 to 50 percent slopes												
Kalkaska-Leelanau association, undulating												
Kalkaska-Leelanau association, rolling												
Kalkaska-Leelanau association, hilly												
Kawkawlin loam, 0 to 6 percent slopes	45	80	8	13	50	70	30	45	2.0	3.2	2.5	4.0
Kerston muck												
Lake beaches												
Leelanau loamy sand, 2 to 6 percent slopes	40	65	7	11	30	55	18	30	1.4	2.4	1.6	2.8
Leelanau loamy sand, 6 to 12 percent slopes	35	50	6	8	25	45	16	25	1.4	2.4	1.6	2.8
Leelanau loamy sand, 12 to 18 percent slopes					20	30	15	20	1.1	2.0	1.4	2.2
Leelanau loamy sand, 18 to 25 percent slopes									1.0	1.8	1.2	2.0
Leelanau loamy sand, 25 to 50 percent slopes												
Leelanau-Emmet association, undulating												
Leelanau-Emmet association, rolling												
Leelanau-Emmet association, hilly												
Leelanau-Rubicon loamy sands, 0 to 6 percent slopes	30	50	5	8	28	45	17	28	1.2	1.8	1.5	2.0
Leelanau-Rubicon loamy sands, 6 to 12 percent slopes	25	40	4	7	25	40	15	25	1.2	1.8	1.5	2.0
Leelanau-Rubicon loamy sands, 12 to 18 percent slopes					20	35	12	22	1.0	1.6	1.3	1.8
Leelanau-Rubicon loamy sands, 18 to 25 percent slopes									0.8	1.2	1.0	1.5
Leelanau-Rubicon loamy sands, 25 to 50 percent slopes												
Linwood muck									1.0	2.2		
Lupton muck									1.0	2.2		
Lupton-Cathro association												
Made land												
Mancelona loamy sand, 0 to 6 percent slopes	35	65	6	11	30	50	25	40	1.6	2.4	1.8	3.2
Mancelona loamy sand, 6 to 12 percent slopes	30	60	5	10	25	45	20	35	1.6	2.4	1.8	3.2
Mancelona loamy sand, 12 to 18 percent slopes					25	40	10	20	1.3	2.2	1.6	2.6
Mancelona loamy sand, 18 to 25 percent slopes									1.1	2.0	1.4	2.4
Mancelona loamy sand, 25 to 50 percent slopes												
Mancelona-East Lake association, undulating												
Mancelona-East Lake association, rolling												
Mancelona-East Lake association, hilly												
Markey muck									1.0	2.2		
Menominee loamy sand, 0 to 6 percent slopes	35	60	6	10	30	55	18	30	1.4	2.4	1.6	2.8
Menominee loamy sand, 6 to 12 percent slopes	30	50	5	8	25	45	16	25	1.4	2.4	1.6	2.8
Munuscong fine sandy loam		70		12	35	50	25	35	1.2	2.4		3.0
Nester loam, 2 to 6 percent slopes	50	80	9	13	50	70	30	45	1.4	3.0	2.3	4.0
Nester loam, 6 to 12 percent slopes	35	60	6	10	45	65	25	35	1.2	2.5	2.0	3.5
Nester loam, 12 to 18 percent slopes					30	50	18	25	1.0	2.5	2.0	3.5
Nester loam, 18 to 35 percent slopes									1.0	2.3	1.7	3.0
Nester-Emmet association, undulating												
Nester-Emmet association, rolling												
Nester-Emmet association, hilly												
Otisco loamy sand, 0 to 6 percent slopes	30	70	5	12	40	65	25	45	1.6	3.0	2.2	3.5
Roscommon sand					22	45	12	22	1.0	1.8		2.0
Rubicon sand, 0 to 6 percent slopes									0.8	1.4	0.9	1.6
Rubicon sand, 6 to 12 percent slopes												
Rubicon sand, 18 to 35 percent slopes												
Rubicon sand, loamy substratum, 0 to 6 percent slopes	25	40	4	7	24	40	17	28	1.4	2.0	1.5	2.5
Rudyard silt loam, 0 to 6 percent slopes	35	70	6	12	40	65	25	35	1.8	2.3	2.2	3.1
Ruse soils												
Saugatuck sand, 0 to 6 percent slopes									0.8	1.5		
Stony land												
Summerville stony sandy loam, 0 to 6 percent slopes												
Tawas muck									1.0	2.2		
Tawas-Carbondale association												
Ubly sandy loam, 2 to 6 percent slopes	45	75	8	13	40	65	25	40	1.8	2.8	2.2	3.5
Ubly sandy loam, 6 to 12 percent slopes	40	70	7	12	35	60	22	35	1.8	2.8	2.2	3.5
Wallace sand, 0 to 12 percent slopes												
Warners loam												
Wet alluvial land												

Aspen and white birch.—Dominant species in the aspen and white birch type of woodland are quaking aspen and largetooth aspen. Aspen occurs naturally in pure stands or in a mixture with most of the native pines and hardwoods. It is one of the most widespread of all types of woodland in Charlevoix County and is found in areas that have a wide range of soil conditions. Aspen stands are even-aged and originated following extensive logging and severe fires. Although white birch is mostly mixed with aspen, small, pure stands of white birch are in some areas. Eventually, these stands of aspen and white birch will naturally convert to pine or a mixture of pine and hardwoods. Aspen for pulp is important commercially.

Pines.—This type of woodland consists of jack pine, red pine, or white pine in pure or mixed stands. The majority of these stands are in plantations. Originally, natural jack pine and red pine stands were dominant on some of the well-drained, sand and loamy sand soils. White pine occurred in a mixture with hardwoods on the well-drained, sandy loam to clay loam soils. The use of pines for Christmas trees, posts, poles, saw timber, and pulp makes them the most valuable trees for plantations.

Conifer swamp.—The dominant species in the conifer swamp type of woodland are black spruce, white-cedar, tamarack, balsam fir, hemlock, and white pine. There are variable mixtures of aspen, white birch, elm, willow, red maple, and various shrubs. In some areas pure stands of black spruce, white-cedar, or tamarack occur. The pure stands of white-cedar are especially important as a source of fenceposts and logs for cabins.

Woodland suitability groups

The soils of Charlevoix County have been placed in 13 woodland suitability groups to assist owners in planning the use of their soils for wood crops. Since the woodland groups are established on a statewide basis, not all groups are present or described in Charlevoix County. Not placed in a woodland suitability group are Lake beaches, Made land, Stony land, Wet alluvial land, and soils of the Greenwood and Warners series. Woodland management of these areas requires specific recommendations from local soil conservationists or forestry technicians. The names of soil series represented are mentioned in the description of each woodland group, but this does not mean that all soils of a given series are in the group. The names of all soils in any given woodland group can be found by referring to the "Guide to Mapping Units" at the back of this survey.

Each woodland suitability group consists of kinds of soil that are capable of producing similar kinds of wood crops, that need similar management to produce these crops if existing vegetation is similar, and that have about the same potential productivity. The factors considered in placing each soil in a woodland group include productivity; species priority, or trees to favor in management of existing stands and for planting; and soil-related hazards and major limitations to be considered in management. These factors are explained in the paragraphs that follow.

Productivity.—The productivity for a given species of tree on a particular group of soils is based on an average annual growth rate of fully stocked, well-managed stands that have not been affected by special practices, such as artificial drainage or fertilization. Fully stocked stands have the required amount of good growing stock to produce maximum growth per acre. The number of trees in a fully stocked stand is dependent on the size, age, and species of the trees present in the stand. Well-managed stands sustain production and maintain fully stocked stands. They are improved and harvested by timely and orderly cuttings and are protected from fire and livestock. Many of the stands in Charlevoix County are overstocked with undesirable species, but generally sufficient quantities of desirable species are present to make management of the stands feasible.

In table 3 is given potential productivity ratings per acre per year for types of woodland. The ratings used are expressed as averages and ranges of annual growth in board feet and cords per acre. These productivity ratings reflect, in part, the effects of soil, climate, particularly drought, insects, or disease that are associated with particular soils or are common to the area. They also reflect genetic influences and other common factors that affect the development of a stand of trees even under good management.

The estimates of production in table 3 were prepared by a committee of foresters and soil scientists representing the U.S. Forest Service, Michigan Conservation Department, University of Michigan, Michigan State University, Michigan College of Mining and Technology, Michigan Cooperative Extension Service, and the U.S. Soil Conservation Service. Estimates were based on available research and field experience and observations. As additional research and knowledge becomes available, these production estimates may be altered to some degree.

Species priority.—Trees species listed under species priority for the different woodland suitability groups show the kinds of trees to favor in existing stands and those suitable for planting. They are listed in order of preference, most desirable first. Priorities are based on adaptibility or tolerance and the productivity and commercial value of the dominant trees that grow on the soils in a particular group. As listed, these species priorities do not take into consideration disease or insect infestations that plague certain localities.

Seedling mortality.—This term refers to the expected loss of seedlings that is caused by unfavorable features of the soils, such as high water table, extreme acidity, extreme alkalinity, droughtiness, and high soil temperature. A rating of *slight* indicates that ordinary losses from these causes are not more than 25 percent of the planted

TABLE 3.—*Potential productivity ratings per acre per year for types of woodland*

[International rule, ¼ inch; >=more than, and <=less than]

Productivity rating	Board feet		Cords	
	Average	*Range*	*Average*	*Range*
Very high	>325	325–350	1. 5	1. 5–1. 7
High	300	270–325	1. 3	1. 0–1. 5
Medium	240	200–270	. 8	0. 6–1. 0
Low	160	125–200	. 3	0. 1–0. 6
Very low	<125	<125	. 07	<0. 1

stock. A rating of *moderate* indicates that losses are between 25 and 50 percent of the planted stock. A rating of *severe* indicates that more than 50 percent of the planting is likely to die.

Plant competition.—When a site has been disturbed by fire, by cutting, or by other factors, and if the soil is fertile and moist, the invasion of undesirable brush, trees, or other plants may delay or prevent the establishment and growth of desirable trees. A rating of *slight* indicates that competition from other plants is not a concern of management. A rating of *moderate* indicates that competing plants do not ordinarily prevent the establishment of adequate stands of desirable tree species. Development of fully stocked stands may take longer. Establishment of seedlings is delayed and early growth is slow. Management practices that eliminate or retard competition will speed up establishment and growth of seedlings. A rating of *severe* indicates that competing plants prevent natural reestablishment of desirable trees and that careful management is needed to control these plants in areas where seedlings are planted.

Equipment limitations.—The use of equipment commonly used in tending or harvesting trees may be limited or prevented by some soil characteristics and topographic features, such as drainage, slope, number or size of stones, or soil texture. Some soils may require special equipment, methods of operation, or seasons during which equipment can be used. A rating of *slight* indicates that there is no special problem in use of equipment. *Moderate* indicates that not all types of equipment can be used and that there is a seasonal restriction of less than 3 months when equipment cannot be used because of wetness or steep slopes and loose soil, requiring hand planting or special logging techniques. Equipment limitation is *severe* if the type of equipment that can be used without damage to the trees is very limited and if there is a seasonal restriction of more than 3 months during which equipment cannot be used.

Erosion hazard.—A soil is well protected from erosion if adapted species of trees are grown, the rotation age and cutting cycles are adjusted, new plantings are laid out on the contour, and roads, trails, and landings are carefully constructed and maintained. When diverting runoff from cultivated fields and into wooded areas, the soil erodibility, slope gradient, and ground cover in the woods should be such as to prevent gully formation. A rating of *slight* indicates that little or no erosion has taken place and that it is not likely if ordinary methods of clear cutting are used. A rating of *moderate* indicates that in clear-cut areas some protective cover must be maintained to prevent water erosion, soil blowing, or both. Excessive disturbance or removal of the forest litter should be avoided. A rating of *severe* means that gullies form readily and cut rapidly and deeply into the soil, that wind causes blowouts in areas without a protective cover, and that clear cutting can be done only where the areas have a dense ground cover. Also, roads and trails wash out frequently unless they are properly laid out, are stabilized with compacted soil material, or are maintained in other ways.

Windthrow hazard.—The hazard of windthrow depends on the development of roots and the ability of the soil to anchor trees firmly against the force of the wind. Soil characteristics, such as the presence of a high water table or a cemented subsoil layer, affect the development of tree roots, and this in turn determines the resistance of the tree to the force of the wind. It is important to know the degree of this hazard when choosing tree species for planting or when planning release or harvest cuttings. A rating of *slight* indicates that the roots of the adapted species of trees develop normally and windthrow is not common. A rating of *moderate* indicates that in protected areas the trees remain standing during windstorms of medium intensity, that scattered trees blow over in unprotected areas, and that protective measures must be taken, especially in harvesting and release cutting. A rating of *severe* indicates that a high water table or a hardpan or other restrictive layer limits the depth of rooting so that stability is not adequate.

WOODLAND SUITABILITY GROUP A

This group consists of well drained or moderately well drained soils of the Emmet, Leelanau, Onaway, and Ubly series. The Emmet, Onaway, and Ubly soils have a sandy loam surface layer and a sandy loam to clay loam subsoil. The Leelanau soils have a loamy sand surface layer and a loamy sand to sandy loam subsoil. Most of the soils in this group have moderate permeability, moderate to high available water capacity, and medium to high fertility. The Ubly soils have moderately slow permeability in the underlying loam material. Slopes range from 0 to 50 percent.

Northern hardwoods are better suited to these soils than pines, but pines are also suited. Fully stocked, well-managed stands of northern hardwoods normally grow more than 325 board feet per acre annually. Red pine is an excellent producer, but white pine is a more common component of the native vegetation on these soils. Aspen is well suited to these soils and responds to management in well-stocked natural stands. Harvesting the aspen and converting the stand to hardwoods or pines is generally the most profitable plan of management in the long run.

The preferred species in natural stands are sugar maple, basswood, red pine, and white pine. White pine, red pine, and white spruce are the preferred species for planting.

Seedling mortality is slight, plant competition is moderate, and the windthrow hazard is slight.

The equipment limitations are generally slight, but use of equipment is limited in steep, stony, or gullied areas. In these areas, use of tree planters is not feasible. Hand planting is a means of establishing trees in these areas.

The erosion hazard is slight or moderate in most areas of these soils, but it is moderate or severe where these soils are steep. Planting trees on the contour and locating logging and skid trails on the contour help to prevent erosion.

WOODLAND SUITABILITY GROUP B

This group consists of well drained or moderately well drained soils of the Barker, Emmet, Johnswood, and Nester series. These soils dominantly have a loam surface layer and a silty clay loam subsoil. The Emmet soils have a sandy loam surface layer and a sandy loam to loam subsoil. The Johnswood soil has a cobbly loam surface layer and a compact cobbly loam subsoil. Most of the soils in this group have moderately slow permeability, high available water capacity, and high fertility. Slopes range from 0 to 50 percent.

Northern hardwoods generally give the greatest yields compared to other tree species. Fully stocked, well-managed stands of hardwoods normally have high productivity. Pines are not generally suited to these soils and have low productivity. Productivity of aspen and white birch is high or very high. Spruce and fir do not occur naturally.

The preferred species in natural stands are sugar maple, basswood, white spruce, and yellow birch. Conifers are the preferred species for planting in open fields and for reestablishing forest cover. Preferred species for planting are white spruce, Norway spruce, white pine, white-cedar, and Austrian pine.

Seedling mortality is slight in native stands and moderate in planted stands. If seedlings or transplants are planted, extra care is needed to pack the soil around roots, especially if the seedlings are planted by machine, because air pockets remain.

Plant competition is moderate. Plant competition generally does not prevent reestablishment of good hardwood stands, but competition may delay and retard early growth.

Windthrow hazard is slight.

The equipment limitations are generally slight, but logging is difficult and hand planting is necessary on steep areas. Gullied areas are difficult to plant unless the gullies are filled and the slopes are stabilized.

The erosion hazard is slight. Contour planting helps to prevent erosion if trees are planted by machine. Locating roads and skid trails on the contour in sloping areas prevents excessive erosion. Excessive disturbance or removal of ground cover in sloping to steep areas increases the erosion hazard.

WOODLAND SUITABILITY GROUP C

This group consists of well drained or moderately well drained soils of the Blue Lake, Emmet, East Lake, Kalkaska, Leelanau, Mancelona, Menominee, and Rubicon series. Most of these soils have a loamy sand or sand surface layer and a sand to sandy loam subsoil. The Emmet soils have a sandy loam surface layer and a sandy loam to loam subsoil. Most of the soils in this group have moderately rapid to rapid permeability, low available water capacity, and low fertility. The Menominee soils have moderately slow permeability in the underlying loam material. Slopes range from 0 to 50 percent.

Productivity of northern hardwoods is medium. Productivity of pines and aspen is high or very high. An annual growth of approximately 300 board feet per acre can be expected in fully stocked, well-managed stands of red pine. Aspen is less valuable than pines or hardwoods. Spruce and fir do not occur naturally.

Red pine has the highest priority for these soils. The preferred species in natural stands are red pine, sugar maple, and white pine. Preferred species for planting are red pine, white pine, and white spruce. Jack pine is preferred in areas that are severely eroded, gullied, or exposed.

Seedling mortality is slight, plant competition is slight or moderate, and the windthrow hazard is slight.

The equipment limitations generally are slight, but use of equipment is limited in steep, stony, or gullied areas. In these areas the use of tree planters is not feasible. Hand planting is a means of establishing trees in these areas.

The erosion hazard is moderate to severe. Planting trees on the contour and locating logging and skid trails on the contour help to prevent erosion.

WOODLAND SUITABILITY GROUP E

This group consists of well drained or moderately well drained soils of the Croswell, East Lake, Kalkaska, and Leelanau series. These soils have a loamy sand or sand surface layer and a dominantly loamy sand or sand subsoil. Most of these soils have rapid permeability. Available water capacity and fertility are low. Slopes range from 0 to 50 percent.

Productivity of hardwoods is low. Productivity of pine, aspen, and white birch is high. Spruce and fir do not occur naturally.

The preferred species in natural stands are white pine, red pine, and aspen. Preferred species for planting are red pine, white pine, and jack pine.

Seedling mortality is slight in native and planted stands, plant competition is slight, and the windthrow hazard is slight.

The equipment limitations generally are slight, but use of equipment is limited in some areas by the steep slopes and the loose, sandy condition of the soils. Building roads and trails on the contour helps to reduce the equipment limitations and prevents excessive erosion. Although the hazard of erosion is slight to moderate, it is severe on slopes exceeding 18 percent in some areas.

WOODLAND SUITABILITY GROUP F

This group consists of somewhat poorly drained soils of the Au Gres and Saugatuck series. These soils have a sandy surface layer and a sand subsoil. The subsoil of the Saugatuck soil is cemented sand. The Au Gres soils have rapid permeability, low available water capacity, and low fertility. The Saugatuck soils have slow permeability because of the cemented sand subsoil. They have low available water capacity and low fertility. Slopes range from 0 to 6 percent.

Productivity of fully stocked, well-managed stands of hardwoods and pines is low or very low. Productivity of aspen, white birch, spruce, and fir is medium or low.

The preferred species in natural stands are aspen and spruce. Tree plantings are not generally made. Planting requires special techniques, and considerable replanting is necessary.

Erosion hazard is slight. Windthrow hazard is slight to moderate on the Au Gres soils. It is severe on the Saugatuck soil, especially if openings are left by the removal of trees.

Seedling mortality is severe because of plant competition in wet periods. Natural regeneration does not always give adequate restocking.

Plant competition is so severe that natural regeneration does not always provide adequate restocking if chemicals are not used or undesired trees and brush are not girdled. Plant competition delays and slows initial growth of desired species. Aspen is severely affected by hypoxylon canker on the Au Gres soils.

The equipment limitations are moderate, and use of equipment is limited by excessive wetness during spring and other wet periods. This limitation generally is for

periods of less than 3 months. Tree roots are damaged in some areas by heavy equipment.

WOODLAND SUITABILITY GROUP G

This group consists of somewhat poorly drained to very poorly drained soils of the Belding, Breckenridge, Gladwin, Iosco, and Otisco series. These soils have a sandy loam or loamy sand surface layer and a loamy sand to silty clay loam subsoil. They generally have moderately rapid to rapid permeability, low to high available water capacity, and low to medium fertility. Slopes range from 0 to 6 percent.

Productivity of fully stocked, well-managed stands of hardwoods and pines is low. Productivity of aspen and white birch ranges from low to high, and productivity of spruce and fir is medium to high.

The preferred species in natural stands are white spruce, white pine, and yellow birch. If these soils are drained, the preferred species for planting are white spruce, Norway spruce, white-cedar, and white pine.

Seedling mortality is slight to moderate in native stands and moderate to severe in planted stands. The erosion hazard is slight.

Plant competition from brush and other plants following the removal of the overstory is moderate to severe and prevents adequate stand establishment in some areas. On some soils the competition is so severe that natural regeneration does not provide adequate restocking. Maintenance planting is required because of moderate to severe seedling mortality.

The equipment limitations are slight to moderate, restricting or preventing the use of heavy equipment during wet periods.

The windthrow hazard generally is slight to moderate, but it is moderate if large openings are left by harvesting. Controlled thinning during harvesting helps to prevent large openings and to decrease the windthrow hazard.

WOODLAND SUITABILITY GROUP H

This group consists of well drained or moderately well drained soils of the Deer Park, Eastport, Rubicon, and Wallace series and of Dune land. These soils and land type generally have a fine sand or sand surface layer and a sand subsoil, but the Wallace soil has a cemented sand subsoil. Most of these soils have rapid permeability, low available water capacity, and low fertility. The Wallace soils have moderately slow permeability in the cemented sand subsoil. Slopes range from 0 to 50 percent.

Productivity of hardwoods is very low, productivity of pines is medium, and productivity of aspen is low. Spruce and fir do not occur naturally. Hardwoods are not so well suited to these soils as other species, their quality is very low, and annual growth is commonly less than 125 board feet per acre. Pines are better suited to these soils than are other species. An annual growth of approximately 240 board feet per acre can be expected in fully stocked, well-managed stands of red pine. Aspen is suited to these soils, but annual growth is only about 0.3 cord per acre. If these soils are used for woodland production, converting the stands from hardwoods to pines is generally the most profitable plan of management.

Preferred species in natural stands and for planting are red pine, white pine, and jack pine. Hardwoods and aspen have the lowest priority for the soils in this group.

Seedling mortality, plant competition, and windthrow hazard are slight.

High soil temperatures, droughtiness, and the cutting action of wind affect the establishment of planted seedlings. Seedling mortality is less than 25 percent, and establishment is successful in most areas.

Equipment limitations are slight, and use of equipment is not restricted except where the slope exceeds 18 percent. Placing roads and skid roads on the contour helps to prevent erosion.

Soil blowing is a potential hazard if surface cover is removed from large areas.

WOODLAND SUITABILITY GROUP J

This group consists of very poorly drained soils of the Carbondale, Cathro, Edwards, Kerston, Linwood, Lupton, Markey, and Tawas series. These soils have a muck surface layer. The Carbondale and Lupton soils have a deep muck or mucky peat layer more than 42 inches thick. The Cathro and Linwood soils are underlain by loam, the Edwards soil by marl, the Markey soil by loamy sand, and the Tawas soil by sand, at depths between 12 and 42 inches. The Kerston soil has alternating layers of muck and sandy loam. These soils have moderately rapid permeability in the organic layers and variable permeability in the mineral and marl underlying material, moderate to very high available water capacity, and low fertility. Slopes range from 0 to 4 percent.

Timber production is variable, and little information is available on potential productivity. Existing woodlands are lowland hardwoods and swamp conifers. Growth and species priority are governed mainly by depth to the water table and degree of saturation of the soils.

Seedling mortality is moderate in native stands and severe in planted stands, plant competition is severe, and erosion hazard is slight.

Equipment limitations are severe because of the high water table and the unstable condition of the soils. Harvesting is limited to the winter months when the soils are frozen.

The windthrow hazard is severe because of the unstable condition of the soils and the shallow root zone.

WOODLAND SUITABILITY GROUP P

This group consists of poorly drained or very poorly drained soils of the Angelica, Bergland, Bruce, Ensley, Hessel, Munuscong, and Sims series. These soils have a sandy loam to silty clay loam surface layer and a sandy loam to silty clay subsoil. The Hessel soil is cobbly throughout. Most of these soils have moderately slow to very slow permeability, moderate to high available water capacity, and high fertility. Slopes range from 0 to 4 percent.

Productivity of fully-stocked stands of hardwood is low or very low. The annual growth rate is only 160 board feet or less per acre. Pines generally do not occur naturally. Productivity of aspen, white birch, spruce, and fir is low to medium. The annual growth of aspen and spruce is only about 0.3 to 0.8 cord per acre.

The preferred species in natural stands are spruce, white-cedar, and balsam fir. Trees generally are not planted on these soils.

Plant competition is severe and prevents adequate immediate restocking of desired species by natural regeneration. Mortality of natural seedlings is severe, but they are produced in large enough numbers to assure ultimate restocking. Because of a high water table, tree roots are restricted to the upper part of these soils, resulting in a severe windthrow hazard.

Equipment limitations are severe, and use of equipment is restricted because of wetness during most of the year. Logging is best accomplished during dry seasons or when the soil is firmly frozen.

WOODLAND SUITABILITY GROUP T

This group consists of well drained to somewhat poorly drained soils of the Barker series, shallow variant, and of the Summerville series. The Barker soil, shallow variant, has a loamy surface layer and a clay loam to clay subsoil. It is underlain by shale bedrock at a depth of less than 40 inches. The Summerville soil has a stony sandy loam surface layer and a sandy loam subsoil. It is underlain by limestone bedrock at a depth of less than 20 inches. The soils in this group have moderate to slow permeability, moderate available water capacity, and medium to high fertility. Slopes range from 0 to 6 percent.

Northern hardwoods, white-cedar, and balsam fir grow naturally on these soils. Northern hardwoods are better suited to these soils than white-cedar and balsam fir. Productivity of hardwoods is low to medium. Productivity of pines, aspen, spruce, and fir is low to medium, depending on the depth to bedrock.

The preferred species in natural stands are sugar maple, basswood, and white pine. The preferred species for planting is white pine.

Seedling mortality is moderate, plant competition is slight, equipment limitations are slight, and erosion hazard is slight to moderate. Windthrow hazard is moderate for the Barker soil, shallow variant, and severe for the Summerville soil.

Because of stoniness, the Summerville soil cannot be planted by mechanical methods. Natural stands should be preserved by controlled thinning and harvesting.

WOODLAND SUITABILITY GROUP W

This group consists of poorly drained or very poorly drained soils of the Brevort, Edmore, Epoufette, Roscommon, and Ruse series. These soils have a sandy loam to sand surface layer and a sandy loam to sand subsoil. The Brevort soil is underlain by loam at depths between 18 and 42 inches. The Ruse soils are underlain by limestone bedrock at a depth of less than 20 inches. Most of the soils of this group have moderately rapid to rapid permeability. The Brevort soil has moderately slow permeability in the loam underlying material. If drained, these soils have low available water capacity. Fertility is low. Slopes range from 0 to 4 percent.

Productivity of hardwoods and aspen is very low or low. The annual growth is less than 125 board feet per acre. The annual growth of aspen averages 0.1 cord per acre. Swamp conifers, spruce, and white-cedar have low productivity ratings. Pines are not suited to these soils, and productivity ratings are not available.

The preferred species in natural stands are white-cedar and spruce. The priority of all species is very low if based on productivity. Trees are seldom planted on these soils. Extensive site preparation, such as lowering the water table, and control of plant competition are required before trees are planted on these soils.

Seedling mortality and plant competition are severe, and erosion hazard is slight.

Equipment limitations are severe because of a high water table in most areas. A high water table and the shallow depth to limestone bedrock in the Ruse soils also restricts root penetration, which results in a severe windthrow hazard.

WOODLAND SUITABILITY GROUP Y

This group consists of well-drained soils of the Alpena, Kiva, and East Lake series. These soils have a gravelly sand to gravelly sandy loam surface layer and a gravelly sandy loam, sandy loam, or loamy sand subsoil. They have moderately rapid to rapid permeability, low available water capacity, and low fertility. Slopes range from 0 to 50 percent.

Productivity of all species is low. Existing trees are mainly northern hardwoods. A scattering of white-cedar, balsam fir, and white pine is also present.

The preferred species in natural stands are sugar maple, white pine, and basswood. Preferred species for planting are white pine and red pine.

Seedling mortality, plant competition, equipment limitation, and the windthrow hazard are all slight. Erosion hazard is moderate.

The most important concern of management of woodland on these soils is preservation of the natural stands by controlled thinning and harvesting.

WOODLAND SUITABILITY GROUP Z

This group consists of somewhat poorly drained soils of the Brimley, Charlevoix, Detour, Kawkawlin, Mackinac, and Rudyard series. These soils generally have a surface layer of fine sandy loam, loam, cobbly loam, or silt loam and a subsoil of sandy loam to silty clay. The Detour soil is cobbly throughout. Most of the soils of this group have moderate to moderately slow permeability, moderate to high available water capacity, and medium to high fertility. The Rudyard soil has very slow permeability. Slopes range from 0 to 6 percent.

Productivity of hardwoods and aspens is medium. Fully stocked, well-managed stands of northern hardwoods have an annual growth of approximately 240 board feet. Productivity of pines is very low, and productivity of spruce is medium to high.

The preferred species in natural stands are spruce and sugar maple. Trees are seldom planted. If planting is desired, white spruce or Norway spruce have first priority.

Because of a fluctuating high water table, seedling mortality is moderate and special site preparation is needed to insure full stands. Plant competition is severe and chemical and mechanical control of undesired plants is needed to insure adequate stands of trees.

Equipment limitations are moderate. Use of heavy equipment is restricted during wet seasons because these soils are unstable. In winter these soils seldom freeze under thick blankets of snow.

Windthrow is a hazard if large areas are opened by logging operations. The erosion hazard is slight.

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Wildlife [4]

Table 4 rates the soils according to their suitability for elements of wildlife habitat and for general kinds of wildlife. A rating of *well suited* means that the soil is relatively free of limitations or that the limitations are easily overcome. *Suited* means that the limitations need to be recognized, but that they can be overcome by good management and careful design. *Poorly suited* means that limitations are severe enough to make use of the soil questionable for wildlife habitat. *Not suited* means that extreme measures are needed to overcome the limitations and that usage generally is not practical. The eight ele-

[4] By CHARLES M. SMITH, biologist, Soil Conservation Service.

TABLE 4.—*Suitability of soils for elements of*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in such to other series as

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood woody plants
*Alpena: AgB, AgD, AgF, Ak For Kiva and East Lake parts of Ak, see the respective series.	Not suited	Not suited	Not suited	Poorly suited
*Angelica: An For Ensley part of An, see Ensley series.	Not suited	Not suited	Not suited	Suited
Au Gres: ArA, AuA	Not suited	Poorly suited	Poorly suited	Poorly suited
Barker: BaB BaC BaE	Well suited Suited Poorly suited	Well suited Suited Suited	Well suited Well suited Well suited	Well suited Well suited Well suited
Barker, shallow variant: BcB	Well suited	Well suited	Well suited	Well suited
*Belding: BdA For Breckenridge part of BdA, see Breckenridge series.	Suited	Suited	Well suited	Suited
*Bergland: Be For Sims part of Be, see Sims series.	Not suited	Not suited	Poorly suited	Suited
*Blue Lake: BKB, BKC, BlB, BlC BlD BlF For Kalkaska part of BKB and BKC, see Kalkaska series.	Suited Poorly suited Not suited	Well suited Suited Poorly suited	Well suited Well suited Well suited	Well suited Well suited Well suited
Breckenridge Mapped only in a complex with a Belding soil.	Not suited	Poorly suited	Poorly suited	Well suited
Brevort: Bv	Not suited	Poorly suited	Poorly suited	Not suited
Brimley: BwB	Suited	Suited	Well suited	Suited
Bruce: By	Not suited	Poorly suited	Poorly suited	Suited
Carbondale: Ca	Not suited	Poorly suited	Not suited	Not suited
Cathro: Cc	Not suited	Poorly suited	Not suited	Not suited
*Charlevoix: CmB, CnB, CKB For Mackinac part of CmB and CnB, see Mackinac series; for Kawkawlin part of CKB, see Kawkawlin series.	Suited	Suited	Well suited	Suited
Crosswell: CrA	Not suited	Poorly suited	Poorly suited	Poorly suited
*Deer Park: DDB, DDC, DDE For Dune land part, see Dune land.	Not suited	Poorly suited	Poorly suited	Poorly suited
Detour: DeB	Suited	Suited	Well suited	Suited

ments of wildlife habitat are discussed briefly in the following paragraphs.

Grain and seed crops.—Among these crops are corn, wheat, oats, barley, rye, buckwheat, millet, sorghum, soybeans, and sunflowers.

Grasses and legumes.—These are planted grasses and legumes commonly used for forage. Examples are bromegrass, fescue, timothy, redtop, trefoil, orchardgrass, reed canarygrass, clover, alfalfa, and sudangrass.

Wild herbaceous upland plants.—In this group are native annuals or other herbaceous plants that commonly grow in upland areas. Among them are strawberries, dandelion, goldenrod, wild oat, nightshade, ragweed, lambsquarters, and native grasses.

wildlife habitat and kinds of wildlife

mapping units may have different properties and limitations, and it is necessary to follow carefully the instructions for referring indicated]

Elements of wildlife habitat—Continued				Kinds of wildlife		
Coniferous woody plants	Wetland food and cover plants	Shallow-water developments	Excavated ponds	Open-land wildlife	Woodland wildlife	Wetland wildlife
Poorly suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Suited	Well suited.
Well suited	Poorly suited	Suited	Suited	Poorly suited	Poorly suited	Poorly suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Poorly suited	Well suited	Well suited	Poorly suited	Suited	Suited.
Suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Suited	Well suited	Well suited	Well suited	Poorly suited	Well suited	Well suited.
Suited	Not suited	Well suited	Well suited	Poorly suited	Well suited	Poorly suited.
Suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Suited	Well suited.
Poorly suited	Suited	Well suited	Well suited	Not suited	Not suited	Well suited.
Poorly suited	Suited	Well suited	Well suited	Not suited	Not suited	Well suited.
Suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Suited	Suited	Suited	Well suited	Suited	Suited.

TABLE 4.—*Suitability of soils for elements of*

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood woody plants
Dune land Mapped only in complexes with Deer Park soils.	Not suited	Not suited	Not suited	Not suited
East Lake: EaB, EaC	Not suited	Poorly suited	Poorly suited	Poorly suited
Eastport: EdB, EdC	Not suited	Not suited	Poorly suited	Poorly suited
Edmore: Ee	Not suited	Poorly suited	Poorly suited	Well suited
Edwards: Ek	Not suited	Poorly suited	Not suited	Not suited
*Emmet: EmA, EmB, EnB, EoA, EoB, ELB EmC, EnC, EoC, ELC EmD, EmE, EnD, EnE, EoD, EoE, ELE EnF, EoF For Leelanau part of EnB, EnC, EnD, EnE, EnF, ELB, ELC, and ELE, see Leelanau series; for Onaway part of EoA, EoB, EoC, EoD, EoE, and EoF, see Onaway series.	Well suited Suited Poorly suited Not suited	Well suited Well suited Suited Poorly suited	Well suited Well suited Well suited Well suited	Well suited Well suited Well suited Well suited
Ensley Mapped only in a complex with an Angelica soil.	Not suited	Poorly suited	Poorly suited	Well suited
Epoufette: Ep	Not suited	Poorly suited	Poorly suited	Well suited
Gladwin: GlB	Suited	Suited	Well suited	Suited
Greenwood: Gr	Not suited	Poorly suited	Not suited	Not suited
Hessel: Hs	Not suited	Poorly suited	Poorly suited	Suited
Iosco: IIB	Not suited	Poorly suited	Poorly suited	Poorly suited
Johnswood: JoC	Suited	Well suited	Well suited	Well suited
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KLB, KLC, KLE. For Leelanau part of KLB, KLC, and KLE, see Leelanau series.	Not suited	Poorly suited	Poorly suited	Poorly suited
Kawkawlin: KnC	Suited	Suited	Well suited	Well suited
Kerston: Kr	Not suited	Not suited	Not suited	Not suited
Kiva Mapped only in a complex with Alpena and East Lake soils.	Not suited	Poorly suited	Poorly suited	Poorly suited
Lake beaches: Lb	Not suited	Not suited	Not suited	Not suited
*Leelanau: LdB, LrB, LEB LdC, LrC, LEC LdD, LdE, LrD, LrE, LEE LdF, LrF For Rubicon part of LrB, LrC, LrD, LrE, and LrF, see Rubicon series; for Emmet part of LEB, LEC, and LEE, see Emmet series.	Well suited Suited Poorly suited Not suited	Well suited Well suited Suited Poorly suited	Well suited Well suited Well suited Well suited	Well suited Well suited Well suited Well suited
Linwood: Ls	Not suited	Not suited	Not suited	Not suited
*Lupton: Lt, LU For Cathro part of LU, see Cathro series.	Not suited	Poorly suited	Not suited	Not suited

wildlife habitat and kinds of wildlife—Continued

Elements of wildlife habitat—Continued				Kinds of wildlife		
Coniferous woody plants	Wetland food and cover plants	Shallow-water developments	Excavated ponds	Open-land wildlife	Woodland wildlife	Wetland wildlife
Suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Well suited	Well suited.
Poorly suited	Suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Not suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Suited	Well suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Not suited	Well suited	Well suited	Well suited	Not suited	Not suited	Well suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Suited	Suited.
Suited	Poorly suited	Suited	Suited	Poorly suited	Not suited	Poorly suited.
Well suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Not suited	Well suited	Well suited	Well suited	Not suited	Not suited	Well suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Not suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Well suited	Well suited	Not suited	Poorly suited	Well suited.
Poorly suited	Suited	Well suited	Well suited	Not suited	Not suited	Well suited.

TABLE 4.—*Suitability of soils for elements of*

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood woody plants
Mackinac Mapped only in complexes with Charlevoix series.	Suited	Suited	Well suited	Suited
Made land: Ma. Individual areas require onsite investigation.				
*Mancelona: McB, McC, MEB, MEC McD, McE, MEE McF For East Lake part of MEB, MEC, and MEE, see East Lake series.	Suited Poorly suited Not suited	Well suited Suited Poorly suited	Well suited Well suited Well suited	Well suited Well suited Well suited
Markey: Mk	Not suited	Poorly suited	Not suited	Not suited
Menominee: MnB, MnC	Suited	Suited	Well suited	Suited
Munuscong: Mu	Not suited	Poorly suited	Poorly suited	Suited
*Nester: NsB, NEB NsC, NEC NsD NsE, NEE For Emmet part of NEB, NEC, and NEE, see Emmet series.	Well suited Suited Poorly suited Not suited	Well suited Well suited Suited Poorly suited	Well suited Well suited Well suited Well suited	Well suited Well suited Well suited Well suited
Onaway Mapped only in complexes with Emmet soils.	EoA and EoB, well suited; EoC, suited; EoD and EoE, poorly suited; EoF, not suited.	EoA, EoB and EoC, well suited; EoD and EoE, suited; EoF, poorly suited.	Well suited	Well suited
Otisco: OtB	Not suited	Poorly suited	Poorly suited	Poorly suited
Roscommon: Rc	Not suited	Poorly suited	Poorly suited	Not suited
Rubicon: RdB, RdC, RdE, RoB	Not suited	Not suited	Poorly suited	Poorly suited
Rudyard: RrB	Suited	Suited	Suited	Suited
Ruse: Ru	Not suited	Poorly suited	Poorly suited	Suited
Saugatuck: SaB	Not suited	Poorly suited	Poorly suited	Poorly suited
Sims Mapped only in a complex with a Bergland soil.	Not suited	Poorly suited	Poorly suited	Well suited
Stony land: St	Not suited	Poorly suited	Suited	Suited
Summerville: SuB	Not suited	Not suited	Poorly suited	Suited
*Tawas: Ta, TC For Carbondale part of TC, see Carbondale series.	Not suited	Poorly suited	Not suited	Not suited
Ubly: UbB UbC	Well suited Suited	Well suited Well suited	Well suited Well suited	Well suited Well suited
Wallace: WaC	Not suited	Poorly suited	Poorly suited	Poorly suited
Warners: Wr	Not suited	Poorly suited	Not suited	Not suited
Wet alluvial land: Wt	Poorly suited	Poorly suited	Suited	Suited

wildlife habitat and kinds of wildlife—Continued

Elements of wildlife habitat—Continued				Kinds of wildlife		
Coniferous woody plants	Wetland food and cover plants	Shallow-water developments	Excavated ponds	Open-land wildlife	Woodland wildlife	Wetland wildlife
Suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Not suited	Well suited	Well suited	Well suited	Not suited	Not suited	Well suited.
Suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Suited	Suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	EoA and EoC, well suited; EoD and EoE, suited.	EoA, EoC, and EoD, well suited; EoE, suited.	Not suited.
Suited	Poorly suited	Suited	Suited	Poorly suited	Not suited	Poorly suited.
Well suited	Not suited	Well suited	Well suited	Poorly suited	Well suited	Poorly suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Suited	Suited	Suited	Suited	Poorly suited	Poorly suited.
Well suited	Well suited	Suited	Not suited	Not suited	Suited	Suited.
Well suited	Poorly suited	Suited	Suited	Poorly suited	Not suited	Poorly suited.
Well suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Poorly suited	Suited	Well suited	Well suited	Not suited	Not suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Not suited	Not suited	Well suited	Well suited	Not suited	Poorly suited	Well suited.
Suited	Well suited	Poorly suited	Not suited	Suited	Suited	Suited.

Hardwood woody plants.—These plants are hardwood trees and shrubs that grow vigorously and produce sprouts, fruits, or seeds that wildlife browse on. These woody plants either grow naturally or are planted. Examples are maple, beech, oak, poplar, birch, dogwood, willow, hawthorn, viburnum, wintergreen, raspberries, blackberries, cherries, grapes, and blueberries.

Coniferous woody plants.—Examples of native or planted coniferous trees and shrubs are pine, spruce, white-cedar, hemlock, balsam fir, yew, larch, and juniper.

Wetland food and cover plants.—These are plants that grow in moist or wet sites and that provide food and cover for waterfowl and fur-bearing animals. Examples are cattails, sedges, bulrushes, smartweed, wild millet, water plantain, wildrice, arrowhead, pondweed, pickerelweed, wild celery, duckweed, and burreed.

Shallow-water developments.—These are impoundments of shallow water in marshy areas and stream channels. They consist of low dikes, nearly level ditches, dugouts, and devices to maintain water at a depth suitable for wetland wildlife.

Excavated ponds.—Migrating waterfowl are especially attracted to excavated ponds or dugout ponds. Such ponds should have an independent source of water. They should not depend on runoff from surrounding areas, though they benefit from runoff that is not excessive.

The ratings shown in table 4 under the heading "Kinds of wildlife" apply to wildlife in general and not to a specific species. Not considered, therefore, are present land use, existing vegetation, and the extent of artificial drainage provided, because these factors are subject to change. Nor is consideration given to the ability of wildlife to move from place to place.

A rating of *well suited* or *suited* means that the soil can be managed most practically and has the best chance of success. A rating of *poorly suited* does not necessarily mean that a soil cannot be managed for wildlife, but it does indicate that a high level of management is required to improve the soil. Following are discussions of the kinds of wildlife.

Open-land wildlife.—This kind of wildlife is made up of birds and mammals that normally frequent cropland, pasture, meadow, and areas overgrown with grasses, herbs, and shrubs. Examples are meadowlark, field sparrow, red fox, snowshoe rabbit, woodchuck, and hawk.

Woodland wildlife.—These birds and mammals normally frequent wooded areas consisting of hardwood trees, coniferous trees, shrubs, or mixed stands of such plants. Among them are squirrel, raccoon, ruffed grouse, woodcock, woodpecker, warbler, nuthatch, deer, gray fox, and owl.

Wetland wildlife.—In this group are birds and mammals that normally frequent such wet areas as ponds, marshes, and swamps. Examples are muskrat, duck, geese, heron, rail, kingfisher, mink, crane, and bittern.

Engineering Uses of the Soils [5]

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for storing water, structures for controlling erosion, drainage systems, and systems for disposing of sewage. Among the soil properties most important to engineers are permeability, shear strength, compaction characteristics, drainage, shrink-swell characteristics, grain size, plasticity, and reaction. Also important are depth to water table, flooding hazard, depth to bedrock, and relief. Such information is made available in this subsection. Engineers can use it to—

1. Make studies of soil and land use that aid in selecting and developing sites for industries, businesses, residences, and recreational facilities.
2. Make estimates of engineering properties for use in planning agricultural drainage structures, dams, and other structures for conserving soil and water; in locating suitable routes for underground conduits and cables; and in locating sites for sewage disposal fields.
3. Make preliminary evaluations of soil conditions that will aid in selecting locations for highways, airports, pipelines, and sewage disposal fields, and in planning detailed surveys of the soils at the selected locations.
4. Locate sources of sand, gravel, and other material for use in construction.
5. Correlate pavement performance with the soil mapping units and thus develop information that will be useful in designing and maintaining the pavements.
6. Supplement information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
7. Determine suitability of soils for movement of vehicles and construction equipment.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

It should be emphasized that the interpretations made in this survey are not a substitute for the sampling and testing needed at a site chosen for a specific engineering work that involves heavy loads or at a site where excavations are to be deeper than the depths of the layers here reported. The estimates reported are generally to a depth of about 5 feet, and they normally do not apply to greater depths. Nevertheless, by using this survey, an engineer can select and concentrate on those soil units most important for his proposed kind of construction. In this manner the engineer can reduce the number of soil samples taken for laboratory testing and complete an adequate soil investigation at minimum cost.

The mapping units shown on the maps at the back of this survey may include small areas of different soils. These included soils may be as much as 2 acres in size. They are too small to be mapped separately and generally are not significant to farming in the area but may be important in engineering planning.

Information of value in planning engineering work is given throughout the text, particularly in the sections "Descriptions of the Soils" and "Formation, Morphology, and Classification of Soils."

Some of the terms used by the scientist may be unfamiliar to the engineer, and some words, for example, soil,

[5] KEITH I. BAKEMAN, civil engineer, Soil Conservation Service, assisted in the preparation of this subsection.

clay, silt, and sand, may have special meaning in soil science. These and other special terms used in the soil survey are defined in the Glossary at the back of this survey. Most of the information about engineering is given in tables 5, 6, 7, and 8.

Engineering classification systems

Agricultural scientists of the United States Department of Agriculture classify soils according to texture. In some ways this system of naming textural classes is comparable to the systems most commonly used by engineers for classifying soils; that is, the system of the American Association of State Highway Officials (AASHO) and the Unified system. Both classification systems are used in tables 5 and 6 and are briefly described here.

Most highway engineers classify soil material in accordance with the system approved by the American Association of State Highway Officials (*1*). In this system soil materials are classified in seven principal groups. The groups range from A–1 (gravelly soils having high bearing capacity, the best soils for subgrade), to A–7 (clayey soils having low strength when wet, the poorest soils for subgrade). Within each group the relative engineering value of the soil material is indicated by a group index number. Group index numbers range from 0 for the best material to 20 for the poorest.

Some engineers prefer to use the Unified soil classification system (*9*). In this system soil materials are identified according to their texture, plasticity, and performance as construction material. Soil materials are identified as coarse grained (GW, GP, GM, GC, SW, SP, SM, and SC), fine grained (ML, CL, OL, MH, CH, and OH), and highly organic (Pt).

Engineering test data

Engineering test data for two series sampled from four locations in Charlevoix County are given in table 5. These data were obtained from tests performed in the laboratories of the Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials.

The soil samples were taken from selected horizons of the soils at representative sites. They do not represent the entire range of soil properties in the county, or even those properties within the two series sampled.

Both the AASHO and Unified classifications are listed in table 5. These classifications are based on data obtained by mechanical analyses and by tests to determine the liquid limit and the plastic limit. The mechanical analyses were made by the combined sieve and hydrometer method. Percentages of silt and clay determined by the hydrometer method should not be used in naming textural classes for soil classification. The information is useful, however, in determining general engineering properties of the soils.

The terms for texture used by soil scientists have different meanings to engineers. For example, clay, to soil scientists, refers to mineral grains less than 0.002 millimeter in diameter, but engineers frequently define clay as less than 0.005 millimeter in diameter. These and other terms used by soil scientists are defined in the "Soil Survey Manual" (*5*) and in the Glossary at the back of this survey.

The tests for liquid limit and for plastic limit measure the effect of water on the consistency of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a semisolid state to a plastic state. As the moisture content is further increased, the material changes from the plastic state to a liquid state. The *plastic limit* is the moisture content at which the soil material passes from a semisolid to a plastic state. The *liquid limit* is the moisture content at which the material passes from a plastic to a liquid state. The *plasticity index* is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which the soil material is in a plastic condition.

Engineering properties

Table 6 gives estimates of properties of soils significant in engineering. The estimated properties are those of the representative soil. If test data are available, that information is used. If test data are not available, the estimates shown are based on comparisons with the soils that were tested in Charlevoix County and with similar soils tested in other counties.

Depth to the seasonal high water table is the maximum height to which the water table rises during the year. The estimates are for soil material that has not been artificially drained. In general, the information in the table applies to a depth of less than 5 feet. Depth from the surface normally is given only for the major horizons. Other horizons are listed if they have engineering properties significantly different from adjacent horizons. Depth to bedrock is given in footnotes in table 6 for soils of the Barker series, shallow variant, and of the Detour, Johnswood, Ruse, and Summerville series. Inclusions of bedrock in other soils are described in the mapping units in the section "Descriptions of the Soils."

The estimated classification according to the textural classification of the U.S. Department of Agriculture and according to the AASHO and Unified classification systems is given for each important layer. The figures showing the percentage of material passing through sieves Nos. 4, 10, and 200 are rounded off to the nearest 5 percent. The percentage passing the No. 200 sieve approximates the combined amount of silt and clay in the soil.

In the column showing permeability are estimates of the rate at which water moves downward through undisturbed soil material. The estimates are based mainly on texture, structure, and consistence of the soils.

Available water capacity, expressed in inches per inch of soil depth, refers to the capacity of soils to a depth of 60 inches or to the depth of bedrock to store water available for use by most plants. It is commonly defined as the difference between the percentage of soil water at field capacity and the percentage at wilting point.

Reaction, as shown in table 6, is the measured range in pH values for each major horizon of the described representative soils as determined in the field. It indicates the acidity or alkalinity of the soils. A pH of 7.0, for example, indicates a neutral soil; a lower pH value indicates acidity; and a higher value indicates alkalinity.

Shrink-swell potential refers to the change in volume of the soil that results from a change in moisture content. The estimates are based mainly on the amount and kind of clay in the soil.

TABLE 5.—*Engineering*

[Tests performed by the Bureau of Public Roads in accordance with standard

Soil name and location	Parent material	Bureau of Public Roads report No.	Depth	Mechanical analysis [1]		
				Percentage passing sieve—		
				3-in.	¾-in.	No. 4 (4.7 mm.)
			Inches			
Emmet sandy loam:						
100 feet west of northeast corner of SE¼ sec. 14, T. 34 N., R. 7 W. (Modal).	Sandy loam.	S-39598	0-3	----------	100	99
		S-39599	5-18	----------	100	98
		S-39600	28-37	----------	100	98
		S-39601	37	100	90	82
285 feet north and 171 feet east of southwest corner of sec. 23, T. 34 N., R. 7 W. (Coarser textured than modal profile).	Sandy loam.	S-39602	0-6	----------	100	99
		S-39603	8-12	----------	100	98
		S-39604	20-38	100	96	94
		S-39605	38-45	100	95	90
Leelanau loamy sand:						
684 feet west and 120 feet south of northeast corner of NW¼ sec. 32, T. 32 N., R. 6 W. (Modal).	Loamy sand.	S-39614	0-3	----------	100	99
		S-39615	6-17	----------	----------	----------
		S-39616	17-34	----------	100	98
		S-39617	34-42	----------	100	99
		S-39618	50-72	100	97	95
NW¼SW¼ sec. 23, T. 34 N., R. 7 W. (Coarser textured than modal profile).	Loamy sand.	S-39610	0-4	----------	----------	----------
		S-39611	8-16	----------	100	99
		S-39612	20-46	100	99	97
		S-39613	46-60	100	99	97

[1] Mechanical analyses according to AASHO Designation T 88 (*1*). Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in

TABLE 6.—*Estimated engineering*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in such mapping as indicated. The symbol < means less

Soil series and map symbols	Depth to seasonal high water table	Depth from surface [1]	Classification
			USDA texture
	Feet	*Inches*	
*Alpena: AgB, AgD, AgF, Ak	>3	0-10	Gravelly sandy loam
For Kiva and East Lake parts of Ak, see their respective series.		10-60	Very gravelly sand
*Angelica: An	<1	0-8	Loam
For Ensley part of An, see Ensley series.		8-28	Sandy loam
		28-60	Loam
Au Gres: ArA	1-2	0-12	Sand
		12-30	Loamy sand and sand
		30-60	Sand
Au Gres, loamy substratum: AuA	1-2	0-10	Sand
		10-25	Loamy sand
		25-48	Sand
		48-60	Loam
Barker: BaB, BaC, BaE	2-3	0-12	Loam and silt loam
		12-26	Heavy silt loam and silty clay loam
		26-48	Shaly silty clay loam

test data

procedures of the American Association of State Highway Officials (AASHO) (*1*)]

Mechanical analysis[1]—Continued							Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued			Percentage smaller than—							
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.			AASHO[2]	Unified[3]
							Percent			
98	81	26	25	17	7	6	[4] NP	[4] NP	A-2-4(0)	SM
97	80	23	21	16	10	7	NP	NP	A-2-4(0)	SM
97	82	22	20	18	17	15	17	3	A-2-4(0)	SM
80	65	17	15	14	11	10	NP	NP	A-2-4(0)	SM
99	85	24	22	15	7	4	NP	NP	A-2-4(0)	SM
97	82	16	16	11	5	2	NP	NP	A-2-4(0)	SM
93	79	20	19	18	15	12	17	2	A-2-4(0)	SM
87	73	18	17	16	12	10	NP	NP	A-2-4(0)	SM
100	84	21	20	16	7	5	NP	NP	A-2-4(0)	SM
98	82	11	10	8	6	4	NP	NP	A-2-4(0)	SP-SM
97	82	7	16	5	5	4	NP	NP	A-3(0)	SP-SM
98	80	16	15	15	14	13	NP	NP	A-2-4(0)	SM
93	77	12	11	10	9	8	NP	NP	A-2-4(0)	SP-SM
100	87	17	16	13	6	5	NP	NP	A-2-4(0)	SM
99	84	9	8	6	4	4	NP	NP	A-3(0)	SP-SM
95	73	6	5	4	4	4	NP	NP	A-3(0)	SP-SM
96	72	8	7	6	6	5	NP	NP	A-3(0)	SP-SM

this table are not suitable for use in naming textual classes for soil.
[2] Based on AASHO Designation M 145-49 (*1*).
[3] Based on the Unified soil classification system (*9*).
[4] Nonplastic.

properties of soils

units may have different properties and limitations, and it is necessary to follow carefully the instructions for referring to other series than; the symbol > means more than]

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
SM	A-2	70-85	55-80	15-30	6. 3-20. 0	0. 14	6. 6-7. 3	Low.
GP or SP	A-1	25-60	20-60	0-5	6. 3-20. 0	. 04	[5] 7. 9-8. 1	Low.
ML or CL	A-4	100	90-100	60-75	0. 63-2. 0	. 20	6. 6-7. 8	Low.
SM or ML	A-2 or A-4	100	85-100	25-55	0. 63-2. 0	. 14	7. 4-7. 8	Low.
ML or CL	A-4 or A-6	100	80-95	60-80	0. 20-0. 63	. 16	[5] 7. 4-7. 8	Low to moderate.
SP or SP-SM	A-3	100	95-100	0-10	6. 3-20. 0	. 06	6. 1-6. 5	Low.
SP or SP-SM	A-3	100	95-100	0-10	6. 3-20. 0	. 08	6. 1-6. 5	Low.
SP or SP-SM	A-3	100	95-100	0-10	6. 3-20. 0	. 06	6. 6-7. 3	Low.
SP or SP-SM	A-3	100	100	0-10	6. 3-20. 0	. 06	6. 1-6. 5	Low.
SM	A-2	100	100	15-20	6. 3-20. 0	. 08	6. 1-7. 3	Low.
SP or SP-SM	A-3	100	100	0-10	6. 3-20. 0	. 06	6. 6-7. 3	Low.
ML or CL	A-4 to A-6	95-100	90-100	60-80	0. 20-0. 63	. 16	[5] 7. 4-8. 1	Low to moderate.
ML	A-4	95-100	95-100	55-75	0. 63-2. 0	. 22	6. 1-6. 5	Low.
CL	A-6	95-100	80-90	75-85	0. 20-0. 63	. 20	6. 6-7. 3	Moderate.
CL	A-6	90-95	65-90	60-85	0. 20-0. 63	. 18	[5] 7. 4-7. 8	Moderate.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface [1]	Classification: USDA texture
	Feet	*Inches*	
Barker, shallow variant: [3] BcB	1–2	0–5	Loam
		5–18	Clay loam and clay
		18–28	Shaly clay
		28	Shale bedrock.
*Belding: BdA	1–2	0–16	Sandy loam and loamy sand
		16–24	Sandy clay loam
		24–34	Sandy loam
		34–60	Loam
*Bergland: Be	<1	0–12	Silty clay loam
		12–18	Silty clay
		18–60	Silty clay
*Blue Lake: BlB, BlC, BlD, BlF, BKB, BKC	>4	0–25	Loamy sand
		25–50	Layers of sand and loamy fine sand
		50–60	Sandy loam
		60–66	Sand
Breckenridge	<1	0–13	Sandy loam and loamy sand
		13–20	Loam
		20–31	Sandy loam
		31–60	Silt loam and silty clay loam
Brevort: Bv	<1	0–4	Loamy sand
		4–22	Sand
		22–60	Loam
Brimley: BwB	1–2	0–14	Loam
		14–25	Fine sandy loam and heavy loam
		25–60	Stratified silt and very fine sand
Bruce: By	<1	0–12	Silt loam
		12–24	Loam and clay loam
		24–60	Stratified silt loam and very fine sand
Carbondale: Ca	0	0–28	Muck
		28–42	Mucky Peat
Cathro: Cc	0	0–26	Muck
		26–60	Loam
*Charlevoix: CmB, CnB, CKB	1–2	0–8	Loam
		8–16	Sandy loam
		16–22	Loam
		22–60	Sandy loam
Croswell: CrA	2–3	0–10	Sand
		10–60	Sand
*Deer Park: DDB, DDC, DDE	>4	0–7	Fine Sand
		7–60	Sand
Detour: [4] DeB	1–2	0–10	Cobbly loam [5]
		10–20	Cobbly sandy clay loam [5]
		20–40	Cobbly sandy loam [5]
Dune land	>4	0–60	Sand

properties of soils—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
ML	A-4	95–100	95–100	55–65	0. 63–2. 0	. 20	6. 6–7. 3	Low.
CL	A-6	95–100	80–90	75–85	0. 20–0. 63	. 14	5. 6–7. 3	Moderate to high.
CL	A-6 or A-7	90–95	65–90	60–85	0. 06–0. 20	. 10	[2] 7. 4–7. 8	High.
SM	A-2	95–100	95–100	15–35	2. 0–6. 3	. 12	6. 1–6. 5	Low.
SC or SM–SC or CL	A-6	85–95	80–100	40–55	2. 0–6. 3	. 16	6. 1–6. 5	Moderate.
SM	A-2	95–100	95–100	15–35	2. 0–6. 3	. 12	6. 6–7. 3	Low.
ML–CL or CL	A-4 or A-6	85–95	80–95	60–75	0. 2–0. 63	. 16	[2] 7. 4–7. 8	Moderate.
CL	A-6	100	100	80–90	0. 2–0. 63	. 22	6. 1–6. 5	Moderate.
CH	A-7	100	100	80–95	<0. 06	. 12	6. 1–6. 5	High.
CH	A-7	100	95–100	75–95	<0. 06	. 10	[2] 7. 4–7. 8	High.
SM	A-2	100	100	10–20	6. 3–20. 0	. 10	5. 6–6. 5	Low.
Layers of SM and SP–SM	A-2	100	100	15–25	6. 3–20. 0	. 08	6. 1–6. 5	Low.
SM	A-2 or A-4	100	95–100	25–45	2. 0–6. 3	. 10	7. 4–7. 8	Low.
SP	A-3	100	95–100	0–5	6. 3–20. 0	. 06	6. 1–6. 5	Low.
SM	A-2 or A-4	100	95–100	25–50	2. 0–6. 3	. 12	6. 1–6. 5	Low.
ML	A-4	95–100	95–100	55–75	2. 0–6. 3	. 18	6. 6–7. 3	Low.
SM	A-2 or A-4	95–100	90–100	25–50	2. 0–6. 3	. 12	6. 6–7. 3	Low.
ML or CL	A-4 or A-6	95–100	90–100	70–85	0. 2–0. 63	. 20	[2] 6. 6–7. 8	Low to moderate.
SM	A-2	100	100	15–35	6. 3–20. 0	. 12	6. 6–7. 3	Low.
SP–SM or SP	A-3	95–100	95–100	0–10	6. 3–20. 0	. 06	6. 6–7. 3	Low.
ML or CL	A-4 or A-6	85–95	80–95	70–90	0. 2–0. 63	. 18	[2] 7. 4–7. 8	Moderate.
ML–CL	A-4	100	100	60–70	0. 63–2. 0	. 20	6. 1–6. 5	Low.
ML or CL	A-4 or A-6	100	100	60–85	0. 63–2. 0	. 18	6. 1–7. 3	Low.
Layers of ML and SM	Layers of A-4 and A-2	100	95–100	45–70	0. 63–2. 0	. 16	[2] 7. 4–7. 8	Low.
ML	A-4	100	100	70–80	0. 63–2. 0	. 22	6. 1–6. 6	Low.
ML–CL	A-4 or A-6	100	100	70–95	0. 63–2. 0	. 18	6. 6–7. 3	Low to moderate.
Layers of ML	Layers of A-4	100	95–100	45–70	0. 63–2. 0	. 16	[2] 7. 4–7. 8	Low.
Pt					2. 0–6. 3	. 50	6. 6–7. 3	Variable.
Pt					2. 0–6. 3	. 50	6. 6–7. 3	Variable.
Pt					2. 0–6. 3	. 50	7. 4–8. 1	Variable.
ML–CL	A-4 or A-6	95–100	90–100	60–90	0. 63–2. 0	. 16	[2] 7. 4–7. 8	Low to moderate.
ML	A-4	95–100	95–100	55–80	2. 0–6. 3	. 20	7. 4–7. 8	Low.
SM or ML	A-2 or A-4	95–100	85–95	30–55	2. 0–6. 3	. 14	7. 4–7. 8	Low.
ML	A-6 or A-4	95–100	85–100	50–65	0. 63–2. 0	. 16	7. 4–7. 8	Low to moderate.
SM or ML	A-2 or A-4	90–100	85–95	30–55	2. 0–6. 3	. 12	[2] 7. 4–7. 8	Low.
SP–SM or SM	A-2 or A-3	100	95–100	5–20	6. 3–20. 0	. 08	5. 6–6. 0	Low.
SP	A-3	100	95–100	0–5	6. 3–20. 0	. 06	5. 6–6. 5	Low.
SP–SM or SM	A-2 or A-3	100	95–100	5–20	6. 3–20. 0	. 10	5. 6–6. 0	Low.
SP or SP–SM	A-3	100	95–100	0–10	6. 3–20. 0	. 06	5. 6–6. 5	Low.
ML–CL	A-4	65–85	60–80	60–70	0. 63–2. 0	. 20	6. 6–7. 3	Low.
CL or ML	A-6 or A-4	85–95	70–95	50–70	0. 2–0. 63	. 18	7. 4–7. 8	Low to moderate.
ML or SM	A-4	85–95	70–95	35–65	0. 63–2. 0	. 12	[2] 7. 9–8. 1	Low.
SP	A-3	100	100	0–5	6. 3–20. 0	. 04	6. 1–7. 3	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface[1]	Classification: USDA texture
	Feet	*Inches*	
East Lake: EaB, EaC	>3	0–11	Loamy sand and sand
		11–32	Loamy sand
		32–60	Very gravelly sand
Eastport: EdB, EdC	>4	0–8	Sand
		8–20	Sand
		20–60	Sand
Edmore: Ee	<1	0–7	Sandy loam
		7–36	Loamy sand
		36–60	Loamy sand
Edwards: Ek	0	0–24	Muck
		24–42	Marl
*Emmet: EmA, EmB, EmC, EmD, EmE, EnB, EnC, EnD, EnE, EnF, EoA, EoB, EoC, EoD, EoE, EoF, ELB, ELC, ELE. For Leelanau part of EnB, EnC, EnD, EnE, EnF, ELB, ELC, and ELE, see Leelanau series; for the Onaway part of EoA, EoB, EoC, EoD, EoE, and EoF, see the Onaway series.	>4	0–20	Sandy loam
		20–36	Loam
		36–60	Sandy loam
Ensley	<1	0–7	Loam
Mapped only in a complex with an Angelica soil.		7–22	Sandy loam
		22–60	Sandy loam
Epoufette: Ep	<1	0–11	Sandy loam and loamy sand
		11–18	Sandy loam
		18–60	Gravelly sand
Gladwin: GlB	1–2	0–17	Loamy sand
		17–25	Loam
		25–60	Gravelly sand
Greenwood: Gr	0	0–12	Peat
		12–42	Mucky peat
Hessel: Hs	<1	0–8	Cobbly loam [5]
		8–40	Cobbly loam [5]
Iosco: IlB	1–2	0–12	Loamy sand
		12–30	Loamy sand and heavy loamy sand
		30–60	Loam
Johnswood:[6] JoC	>2	0–11	Cobbly loam [5]
		11–40	Cobbly loam [5]
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KLB, KLC, KLE. For Leelanau part of KLB, KLC, and KLE, see Leelanau series.	>4	0–10	Sand
		10–22	Sand
		22–60	Sand
Kawkawlin: KnC	1–2	0–15	Loam
		15–25	Heavy silty clay loam
		25–60	Silty clay loam
Kerston: Kr	0	0–13	Muck
		13–17	Sandy loam
		17–28	Muck
		28–42	Sandy loam
Kiva	>4	0–10	Gravelly loamy sand
Mapped only in an undifferentiated unit with Alpena and East Lake soils.		10–18	Sandy loam
		18–60	Gravelly sand

properties of soils—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
SM	A-2	95-100	80-90	10-25	6. 3-20. 0	. 08	6. 1-6. 5	Low.
SM	A-2	75-95	70-90	15-30	6. 3-20. 0	. 10	6. 1-7. 3	Low.
GP or SP	A-1	25-60	20-60	0-5	>20. 0	. 02	[2] 7. 4-7. 8	Low.
SP-SM or SM	A-2 or A-3	100	95-100	5-15	6. 3-20. 0	. 08	6. 6-7. 3	Low.
SP-SM or SM	A-3 or A-2	100	95-100	5-15	6. 3-20. 0	. 08	5. 6-7. 3	Low.
SP	A-3	90-100	85-100	0-5	6. 3-20. 0	. 06	[2] 7. 4-7. 8	Low.
SM	A-2 or A-4	95-100	90-100	25-45	2. 0-6. 3	. 14	6. 1-6. 5	Low.
SM	A-2	95-100	90-100	20-35	2. 0-6. 3	. 10	6. 1-7. 3	Low.
SM	A-2	85-95	80-95	15-35	2. 0-6. 3	. 10	[2] 7. 4-7. 8	Low.
Pt					2. 0-6. 3	. 50	[2] 7. 4-7. 8	Variable.
					(6)	(6)	[7] 7. 9-8. 1	Variable.
SM	A-2 or A-4	95-100	90-100	25-45	2. 0-6. 3	. 14	6. 1-6. 5	Low.
ML or ML-CL	A-4	95-100	90-100	55-80	0. 63-2. 0	. 16	6. 1-6. 5	Low.
SM	A-2 or A-4	80-95	75-90	20-45	2. 0-6. 3	. 12	[2] 7. 4-7. 8	Low.
ML or ML-CL	A-4	95-100	90-100	55-70	0. 63-2. 0	. 20	6. 6-7. 3	Low.
SM or ML	A-4	95-100	90-100	40-60	0. 63-2. 0	. 14	7. 4-7. 8	Low.
SM	A-2 or A-4	85-95	80-95	20-45	2. 0-6. 3	. 12	[2] 7. 4-7. 8	Low.
SM	A-2	95-100	95-100	15-30	2. 0-6. 3	. 12	6. 6-7. 3	Low.
SM	A-2 or A-4	95-100	85-95	20-40	2. 0-6. 3	. 12	7. 4-7. 8	Low.
GP or SP	A-1	40-80	30-70	0-5	6. 3-20. 0	. 04	[2] 7. 4-7. 8	Low.
SM	A-2	95-100	95-100	15-30	6. 3-20. 0	. 12	6. 1-7. 3	Low.
ML or CL	A-4 or A-6	70-100	90-100	50-70	2. 0-6. 3	. 16	6. 6-7. 3	Low.
SP or SP-SM	A-3	55-80	50-70	0-10	6. 3-20. 0	. 04	[2] 7. 4-7. 8	Low.
Pt					2. 0-6. 3	. 50	4. 5-5. 0	Variable.
Pt					2. 0-6. 3	. 50	4. 5-5. 0	Variable.
ML or ML-CL	A-4	100	70-95	50-70	0. 63-2. 0	. 20	7. 4-7. 8	Low.
ML or CL	A-4 or A-6	95-100	65-70	55-65	0. 2-0. 63	. 18	[2] 7. 4-7. 8	Low to moderate.
SM	A-2	95-100	95-100	15-30	6. 3-20. 0	. 10	6. 1 6. 5	Low.
SM or SM-SC	A-2	95-100	95-100	15-30	6. 3-20. 0	. 10	6. 1-7. 3	Low.
ML or CL	A-4 or A-6	85-95	80-95	60-70	0. 20-0. 63	. 18	7. 4-7. 8	Low to moderate.
SC	A-4	100	50-65	35-45	0. 63-2. 0	. 20	7. 4-7. 8	Low.
ML or CL or SC	A-4 or A-6	90-95	45-85	35-60	0. 63-2. 0	. 18	[2] 7. 9-8. 1	Low.
SP-SM or SM	A-2 or A-3	100	95-100	5-20	6. 3-20. 0	. 08	5. 6-6. 0	Low.
SP or SP-SM	A-3	100	95-100	0-10	6. 3-20. 0	. 08	5. 6-6. 0	Low.
SP	A-3	100	95-100	0-5	6. 3-20. 0	. 06	6. 1-6. 5	Low.
ML	A-4	95-100	95-100	55-70	0. 63-2. 0	. 20	6. 1-7. 3	Low.
CL or CH	A-6 or A-7	95-100	95-100	70-85	0. 2-0. 63	. 16	6. 6-7. 3	Moderate to high.
CL	A-6	90-95	85-95	70-80	0. 2-0. 63	. 18	[2] 7. 4-7. 8	Moderate.
Pt					6. 3-20. 0	. 5[illegible]	6. 6-7. 3	Variable.
SM or ML	A-4	100	95-100	35-65	2. 0-6. 3	. 1[illegible]	6. 6-7. 3	Low.
Pt					2. 0-6. 3	. 5[illegible]	6. 6-7. 3	Variable.
SM or ML	A-4	100	95-100	35-65	2. 0-6. 3	. 1[illegible]	[2] 7. 4-7. 8	Low.
SM	A-2	90-95	70-80	15-35	6. 3-20. 0	. 1[illegible]	6. 1-6. 5	Low.
SM	A-2 or A-4	85-95	75-[illegible]	25-55	2. 0-6. 3	. 1[illegible]	6. 1-6. 5	Low.
SP or SP-SM	A-1	70-90	60-80	0-10	6. 3-20. 0	. 0[illegible]	[2] 7. 4-7. 8	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface[1]	Classification: USDA texture
	Feet	*Inches*	
Lake beaches: Lb. Too variable to be rated. Onsite investigation required.			
*Leelanau: LdB, LdC, LdD, LdE, LdF, LrB, LrC, LrD, LrE, LrF, LEB, LEC, LEE. For Rubicon part of LrB, LrC, LrD, LrE, and LrF, see Rubicon series; for Emmet part of LEB, LEC, and LEE, see Emmet series.	>4	0–20 20–42 42–60	Loamy sand Layers of loamy sand and sandy loam Loamy sand
Linwood: Ls	0	0–20 20–60	Muck Loam
*Lupton: Lt, LU For Cathro part of LU, see Cathro series.	0	0–42	Muck
Mackinac Mapped only in complexes with Charlevoix soils.	1–2	0–10 10–23 23–60	Loam Loam Loam
Made land: Ma. Too variable to be rated. Onsite investigation required.			
*Mancelona: McB, McC, McD, McE, McF, MEB, MEC, MEE. For East Lake part of MEB, MEC, and MEE, see East Lake series.	>3	0–18 18–26 26–60	Loamy sand Sandy loam Very gravelly sand
Markey: Mk	0	0–22 22–60	Muck Loamy sand
Menominee: MnB, MnC	>3	0–28 28–60	Loamy sand and sand Loam
Munuscong: Mu	<1	0–15 15–24 24–60	Fine sandy loam Loam Silty clay
*Nester: NsB, NsC, NsD, NsE, NEB, NEC, NEE For Emmet part of NEB, NEC, and NEE, see Emmet series.	>3	0–13 13–24 24–60	Loam Heavy silty clay loam Silty clay loam
Onaway Mapped only in complexes with Emmet soils.	>3	0–17 17–26 26–60	Sandy loam Clay loam Loam
Otisco: OtB	1–2	0–20 20–36 36–60	Loamy sand Layers of loamy sand and sandy loam Loamy sand
Roscommon: Rc	<1	0–5 5–60	Sand Sand
Rubicon: RdB, RdC, RdE	>4	0–18 18–60	Sand Sand
Rubicon, loamy substratum: RoB	>3	0–9 9–44 44–60	Sand Sand Loam or clay loam
Rudyard: RrB	1–2	0–13 13–60	Silt loam Silty clay

properties of soils—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
SM	A-2	100	100	15–30	6. 3–20. 0	. 10	6. 1–6. 5	Low.
SM	A-2	100	95–100	5–25	2. 0–6. 3	. 10	6. 1–6. 5	Low.
SM	A-2	90–100	85–95	5–20	6. 3–20. 0	. 08	[2] 7. 4–7. 8	Low.
Pt					2. 0–6. 3	. 50	6. 1–7. 3	Variable.
CL or ML–CL	A-4 or A-6	95–100	95–100	60–85	0. 63–2. 0	. 15	[2] 7. 4–7. 8	Low to moderate.
Pt					2. 0–6. 3	. 50	[2] 7. 4–7. 8	Variable.
ML	A-4	100	95–100	60–70	0. 63–2. 0	. 20	7. 4–7. 8	Low.
CL	A-4 or A-6	95–100	95–100	65–90	0. 63–2. 0	. 18	7. 4–7. 8	Low.
ML–CL	A-4	90–95	85–95	60–80	0. 63–2. 0	. 16	[2] 7. 4–7. 8	Low.
SM	A-2	95–100	70–100	15–30	6. 3–20. 0	. 10	5. 6–6. 5	Low.
SM or SC	A-2 or A-6	95–100	60–85	30–45	2. 0–6. 3	. 12	6. 1–6. 5	Low.
GP or SP	A-1	25–60	20–60	0–5	6. 3–20. 0	. 04	[2] 7. 4–7. 8	Low.
Pt					2. 0–6. 3	. 50	7. 4–7. 8	Variable.
SM	A-2	100	95–100	10–30	6. 3–20. 0	. 02	[2] 7. 4–7. 8	Low.
SM	A-2	95–100	95–100	15–30	6. 3–20. 0	. 10	5. 6–6. 5	Low.
ML or CL	A-4 or A-6	85–95	80–90	60–70	0. 2–0. 63	. 18	[2] 7. 4–7. 8	Low to moderate.
SM	A-2 or A-4	100	95–100	25–45	2. 0–6. 3	. 16	6. 1–6. 5	Low.
ML or CL	A-4 or A-6	100	95–100	50–65	2. 0–6. 3	. 18	6. 1–6. 5	Low.
CH	A-7	100	95–100	85–95	0. 06–0. 2	. 12	[2] 7. 4–7. 8	High.
ML	A-4	95–100	95–100	55–65	0. 63–2. 0	. 20	6. 1–7. 3	Low.
CL or CH	A-6 or A-7	95–100	95–100	80–95	0. 2–0. 63	. 18	6. 6–7. 3	Moderate to high.
CL	A-6	90–95	85–95	80–90	0. 2–0. 63	. 18	[2] 7. 4–7. 8	Moderate.
SM	A-4	100	95–100	40–50	2. 0–6. 3	. 14	6. 1–6. 5	Low.
CL	A-6	95–100	95–100	65–80	0. 63–2. 0	. 18	6. 6–7. 3	Low to moderate.
CL or ML	A-4 or A-6	90–95	85–95	60–75	0. 63–2. 0	. 16	[2] 7. 4–7. 8	Low.
SM	A-2	100	100	15–30	6. 3–20. 0	. 10	6. 1–6. 5	Low.
SM	A-2	100	100	10–35	2. 0–6. 3	. 10	6. 1–6. 5	Low.
SM or SP–SM	A-2 or A-3	100	95–100	5–20	6. 3–20. 0	. 08	6. 6–7. 3	Low.
SP–SM	A-3	100	100	5–10	6. 3–20. 0	. 08	6. 1–6. 5	Low.
SP	A-3	100	95–100	0–5	6. 3–20. 0	. 06	6. 1–7. 3	Low.
SP–SM or SM	A-2 or A-3	100	95–100	5–15	6. 3–20. 0	. 08	4. 5–6. 0	Low.
SP	A-3	100	95–100	0–5	6. 3–20. 0	. 06	5. 6–6. 5	Low.
SP–SM or SM	A-2 or A-3	100	95–100	5–15	6. 3–20. 0	. 08	4. 5–5. 5	Low.
SP	A-3	100	95–100	0–5	6. 3–20. 0	. 06	5. 6–6. 0	Low.
ML or CL	A-4 or A-6	85–95	80–95	60–70	0. 2–0. 63	. 16	[2] 7. 4–7. 8	Low to moderate.
ML	A-4	001	100	70–95	0. 63–2. 0	. 22	6. 6–7. 3	Low.
CH	A-7	100	100	80–95	<0. 06	. 12	[2] 6. 6–7. 8	High.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface[1]	Classification: USDA texture
	Feet	*Inches*	
Ruse:[3] Ru	<1	0–4	Mucky sand
		4–16	Sandy loam
		16	Limestone bedrock.
Saugatuck: SaB	1–2	0–11	Sand
		11–20	Cemented sand
		20–60	Sand
Sims	<1	0–9	Silty clay loam
Mapped only in a complex with a Bergland soil.		9–20	Silty clay
		20–60	Silty clay loam
Stony land: St. Too variable to be rated. Onsite investigation required.			
Summerville:[3] SuB	(4)	0–6	Stony sandy loam[5]
		6–16	Sandy loam[5]
		16	Limestone bedrock.
*Tawas: Ta, TC	0	0–23	Muck
For Carbondale part of TC, see Carbondale series.		23–60	Sand
Ubly: UbB, UbC	>3	0–7	Sandy loam
		7–15	Loamy sand
		15–24	Sandy loam
		24–60	Loam
Wallace: WaC	>4	0–11	Sand
		11–30	Cemented sand
		30–60	Sand
Warners: Wr	0	0–8	Loam
		8–20	Marl
		20–42	Mucky peat
Wet alluvial land: Wt. Too variable to be rated. Onsite investigation required.			

[1] The depth given is for the representative profile of the soils in Charlevoix County. Variations in the thickness and in the depth to a layer are common for most of the soils.
[2] Slightly effervescent.
[3] Bedrock within 2 feet of surface.
[4] Bedrock within 10 feet of surface in many areas.

properties of soils—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
SM	A-2	95-100	85-100	15-30	6. 3-20. 0	. 10	6. 6-7. 3	Low.
SM or ML	A-2 or A-4	90-95	70-95	30-55	2. 0-6. 3	. 12	6. 6-7. 8	Low.
SP-SM or SM	A-3 or A-2	100	95-100	5-15	6. 3-20. 0	. 08	5. 6-6. 0	Low.
SP or SP-SM	A-3	100	95-100	0-10	0. 06-0. 2	. 02	5. 1-5. 5	Low.
SP or SP-SM	A-3	100	95-100	0-10	6. 3-20. 0	. 06	5. 6-6. 5	Low.
CL	A-6	100	90-100	60-70	0. 63-2. 0	. 20	6. 1-7. 3	Moderate.
CL or CH	A-6 or A-7	100	85-95	80-90	0. 06-0. 2	. 12	6. 6-7. 3	Moderate to high.
CL	A-6	100	80-95	80-90	0. 2-0. 63	. 18	[2] 7. 4-7. 8	Moderate.
SM	A-2 or A-4	90-95	75-95	30-50	2. 0-6. 3	. 14	6. 6-7. 3	Low.
SM	A-4 or A-2	90-95	75-90	30-40	0. 63-2. 0	. 12	6. 6-7. 3	Low.
Pt					2. 0-6. 3	. 50	6. 1-6. 5	Variable.
SM or SP	A-3 or A-2	100	95-100	0-20	6. 3-20. 0	. 02	[2] 7. 4-8. 1	Low.
SM	A-2	95-100	95-100	15-35	2. 0-6. 3	. 12	6. 1-6. 5	Low.
SM	A-2	95-100	95-100	15-35	2. 0-6. 3	. 08	6. 1-7. 3	Low.
ML or SM	A-4	85-95	80-95	40-55	0. 63-2. 0	. 16	6. 6-7. 3	Low.
CL	A-4 or A-6	85-95	80-95	70-90	0. 2-0. 63	. 16	[2] 7. 4-7. 8	Low to moderate.
SP-SM or SM	A-2 or A-3	100	95-100	5-15	6. 3-20. 0	. 08	5. 1-5. 5	Low.
SP-SM	A-3	100	95-100	5-10	0. 2-6. 3	. 02	4. 5-5. 5	Low.
SP	A-3	100	95-100	0-5	6. 3-20. 0	. 06	5. 6-6. 5	Low.
ML	A-4	100	95-100	60-70	0. 63-2. 0	. 20	[7] 7. 9-8. 1	Low.
					0. 2-0. 63	([6])	[7] 7. 9-8. 1	Variable.
Pt					2. 0-6. 3	. 50	[7] 7. 9-8. 1	Variable.

[5] Coarse fraction greater than 3 inches is 1 to 25 percent.
[6] Variable.
[7] Strongly effervescent.
[8] Broken limestone bedrock within 3½ to 5 feet of surface in a few areas.
[9] In bedrock.

TABLE 7.—*Engineering interpretations*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in such
referring to other

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
*Alpena: AgB, AgD, AgF, Ak For Kiva and East Lake parts of Ak, see their respective series.	Poor: 6 to 8 inches thick; gravelly; low organic-matter content; droughty.	Good: sandy and gravelly material to a depth of 60 inches or more.	Fair to good: over 50 percent sands.	Fair: good if soil binder is added; fair stability and workability; cobbly and stony in some areas.
*Angelica: An For Ensley part of An, see Ensley series.	Good: 6 to 8 inches thick; loamy; high organic-matter content; high water table.	Not suitable	Not suitable	Fair: fair to poor stability; fair workability; high water table.
Au Gres: ArA	Poor: sandy; low organic-matter content; seasonal high water table; droughty.	Good: sandy material to a depth of 60 inches; high water table hinders excavation during wet seasons.	Not suitable	Fair: fair stability and workability; seasonal high water table.
Au Gres, loamy substratum: AuA	Poor: sandy; low organic-matter content; seasonal high water table; droughty.	Fair: 42 to 66 inches of sandy material; some fines; high water table hinders excavation during wet seasons.	Not suitable	Fair: 42 to 66 inches of sandy material; fair stability and workability; fair to poor stability; fair workability for loamy underlying material; moderate shrink-swell potential; seasonal high water table.
Barker: BaB, BaC, BaE	Fair: 7 to 9 inches thick; loamy; moderate organic-matter content; few cobblestones on surface.	Not suitable	Not suitable	Fair: fair stability and workability; difficult to work and compact when wet; moderate shrink-swell potential; many shale fragments; shale bedrock at a depth of 40 inches or more in some areas.

for nonfarm uses

mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for series as indicated]

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Cuts and fills needed in many areas; cobblestones and stones hinder grading in some areas.	Well drained; slight compressibility; good shear strength.	Sandy and gravelly; low moisture content; good stability on thawing.	Slight where slopes are 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low	Low.
High water table; fair to poor stability; moderate potential for frost action.	Poorly drained; high water table; medium to high compressibility; poor to fair shear strength; moderate potential for frost action.	Loamy; high water table; wet conditions hinder operations; poor stability on thawing.	Severe: poorly drained; high water table; moderately slow permeability.	High	Low.
Seasonal high water table; poor stability when wet.	Somewhat poorly drained; seasonal high water table; slight compressibility; good shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; rapid permeability.	Low	Low.
Seasonal high water table; poor stability when wet; moderate potential for frost action; moderate shrink-swell potential in loamy underlying material.	Somewhat poorly drained; seasonal high water table; moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; rapid permeability in sandy material; moderately slow permeability in loamy underlying material.	Low in sandy material; high in underlying loamy material.	Low.
Moderate shrink-swell potential; shale bedrock at a depth of 40 inches or more in some areas; cuts and fills needed in some areas.	Well drained and moderately well drained; moderate shrink-swell potential; medium to high compressibility; fair shear strength; shale bedrock at a depth of 40 inches or more in some areas.	Loamy; moisture content often too high for good compaction; poor stability on thawing; shale bedrock at a depth of 40 inches or more in some areas.	Severe: moderately slow permeability; sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Moderate	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
Barker, shallow variant: BcB	Fair: 7 to 9 inches thick; loamy; moderate organic-matter content; few cobblestones on surface.	Not suitable	Not suitable	Poor: fair stability and workability; difficult to work and compact when wet; moderate to high shrink-swell potential; shale bedbedrock at a depth of less than 40 inches; seasonal high water table in some areas.
***Belding:** BdA For Breckenridge part of BdA, see Breckenridge series.	Fair: 8 to 10 inches thick; loamy; moderate organic-matter content; seasonal high water table.	Not suitable	Not suitable	Fair: fair stability; fair to good workability; low to moderate shrink-swell potential; seasonal high water table.
***Bergland:** Be For Sims part of Be, see Sims series.	Poor: 6 to 8 inches thick; clayey; high organic-matter content; high water table; poor workability.	Not suitable	Not suitable	Poor: poor suitability and workability; difficult to work and compact when wet; high shrink-swell potential; high water table.
***Blue Lake:** BIB, BIC, BID, BIF, BKB, BKC. For Kalkaska part of BKB and BKC, see Kalkaska series.	Poor: 6 to 8 inches thick; sandy; low organic-matter content; droughty.	Good to a depth of 60 inches or more: some fines.	Not suitable	Fair to good: fair stability and workability.
Breckenridge Mapped only in a complex with a Belding soil.	Good: 6 to 8 inches thick; loamy; high organic-matter content.	Not suitable	Not suitable	Fair: poor to fair stability; fair workability; low to moderate shrink-swell potential for underlying loamy material; high water table.
Brevort: Bv	Poor: 7 to 9 inches thick; sandy; high organic-matter content; high water table; droughty.	Fair: limited source of sandy material to a depth between 18 and 42 inches; high water table hinders excavation.	Not suitable	Fair: 18 to 42 inches of sandy material; fair stability and workability; poor to fair stability; fair workability for the underlying loamy material; high water table.

for nonfarm uses—Continued

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Seasonal high water table in some areas; moderate to high shrink-swell potential; shale bedrock at a depth of less than 40 inches.	Moderately well drained and somewhat poorly drained; seasonal high water table in some areas; high shrink-swell potential; high compressibility; poor to fair shear strength; shale bedrock at a depth of less than 40 inches.	Loamy and clayey; seasonal high water table in some areas; moisture content often too high for good compaction; poor stability on thawing; shale bedrock at a depth of less than 40 inches.	Severe: somewhat poorly drained; seasonal high water table in some areas; slow permeability; shale bedrock at a depth of less than 40 inches.	High	Low.
Seasonal high water table; low to moderate shrink-swell potential.	Somewhat poorly drained; seasonal high water table; moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Loamy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderately slow permeability in underlying loamy material.	High	Low.
High water table; poor stability; clayey; plastic; slippery when wet; high shrink-swell potential.	Poorly drained; high water table; high shrink-swell potential and compressibility; poor shear strength.	Clayey; high water table; moisture content often too high for good compaction; poor stability on thawing.	Severe: poorly drained; high water table; very slow permeability.	High	Low.
Cuts and fills needed in many areas.	Well drained; slight compressibility; fair shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slopes are 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: side-hill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low	Low.
High water table; low to moderate shrink-swell potential.	Very poorly drained; high water table; low to moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Loamy; high water table; wet conditions hinder operations; poor to fair stability on thawing.	Severe: very poorly drained; high water table; moderately slow permeability in underlying loamy material.	High	Low.
High water table; poor stability when wet.	Poorly drained or very poorly drained; high water table; moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: very poorly drained or poorly drained; high water table; moderately slow permeability in underlying loamy material.	High	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
Brimley: BwB	Good: 6 to 8 inches thick; loamy; moderate organic-matter content; seasonal high water table.	Not suitable	Not suitable	Poor: poor stability; fair workability; material flows when wet; high potential for frost action; seasonal high water table.
Bruce: By	Good: 8 to 10 inches thick; high organic-matter content; loamy; high water table.	Not suitable	Not suitable	Poor: poor stability; fair workability; material flows when wet; high potential for frost action; high water table.
Carbondale: Ca	Poor: organic material; erodible; oxidizes readily; high water table; fair to good if mixed with mineral materials.	Not suitable	Not suitable	Not suitable: organic material; poor stability; high compressibility; high water table.
Cathro: Cc	Poor: organic material; erodible; oxidizes readily; high water table; fair to good if mixed with mineral materials.	Not suitable	Not suitable	Not suitable in upper organic layers: poor stability; high compressibility; fair in underlaying loamy material; poor to fair stability; fair workability; low to moderate shrink-swell potential; high water table.
*Charlevoix: CmB, CnB, CKB For Mackinac part of CmB and CnB, see Mackinac series; for Kawkawlin part of CKB, see Kawkawlin series.	Fair: 8 to 10 inches thick; loamy; moderate organic-matter content; seasonal high water table; cobblestones on surface in some areas.	Not suitable	Not suitable	Fair: poor to fair stability; fair workability; low to moderate shrink-swell potential; seasonal high water table; cobbly in some areas.
Croswell: CrA	Poor: 6 to 8 inches thick; sandy; low organic-matter content; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability.
*Deer Park: DDB, DDC, DDE For Dune land part, see Dune land.	Poor: 6 to 8 inches thick; sandy; low organic-matter content; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability.

for nonfarm uses—Continued

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Seasonal high water table; poor stability; high potential for frost action.	Somewhat poorly drained seasonal high water table; slight to medium compressibility; poor to fair shear strength; high potential for frost action.	Loamy; seasonal high water table; wet conditions hinder operations on some areas; poor stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderate permeability; soil material flows when wet; may fill tile and filter bed.	High	Low.
High water table; poor stability; high potential for frost action.	Poorly drained; high water table; slight to medium compressibility; poor to fair shear strength; high potential for frost action.	Loamy; high water table; wet conditions hinder operations; poor stability on thawing.	Severe: poorly drained; high water table; moderate permeability; soil material flows when wet; may fill tile and filter bed.	High	Low.
High water table; poor stability; organic material must be removed.	Very poorly drained; high water table; high compressibility; poor shear strength; poor stability.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability; unstable organic material.	High	Low.
High water table; poor stability; organic material must be removed; low to moderate shrink-swell potential in underlying loamy material.	Very poorly drained; high water table; medium to high compressibility; poor to fair shear strength.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability in unstable organic material; moderate permeability in the underlying loamy material.	High	Low.
Seasonal high water table; low to moderate shrink-swell potential; cobblestones hinder grading in some areas.	Somewhat poorly drained; seasonal high water table; slight to medium compressibility; poor to fair shear strength; cobbly in some areas.	Loamy; seasonal high water table; wet conditions hinder operations in some areas; poor to fair stability on thawing; cobblestones hinder grading in some areas.	Severe: somewhat poorly drained; seasonal high water table; moderate permeability; cobbly in some areas.	High	Low.
Loose sand hinders operations in some areas.	Moderately well drained; slight compressibility; good shear strength.	Sandy; fair stability on thawing.	Moderate: moderately well drained; rapid permeability; possible contamination of shallow water supplies by effluent.	Low	Low.
Cuts and fills needed in many areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slopes are 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
Detour: DeB	Poor: 6 to 8 inches thick; loamy; moderate organic-matter content; seasonal high water table; cobblestones on surface.	Not suitable	Not suitable	Poor: poor to fair stability; poor workability; difficult to work and compact when wet; low to moderate shrink-swell potential seasonal high water table; cobbly throughout.
Dune land Mapped only in associations with Deer Park soils.	Poor: sandy; low organic-matter content; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability.
East Lake: EaB, EaC	Poor: 6 to 8 inches thick; candy; low organci-matter content; doughty.	Good: sandy material to a depth of 60 inches or more.	Good: 40 to 80 percent gravel.	Fair to good: fair stability; good workability.
Eastport: EdB, EdC	Poor: 6 to 8 inches thick; sandy; low organic-matter content; droughty.	Good: sandy material to a depth of 60 inches or more.	Poor to not suitable: thin gravelly layers in some areas.	Fair: good if soil binder is added; fair stability and workability.
Edmore: Ee	Good: 6 to 9 inches thick; loamy; high organic-matter content; high water table.	Not suitable	Not suitable	Fair: fair stability and workability; high water table hinders excavation.
Edwards. Ek	Poor: organic material; oxidizes readily; high water table; erodible; fair to good if mixed with mineral material.	Not suitable	Not suitable	Not suitable: organic material over marl; poor stability; high compressibility; high water table.
*Emmet: EmA, EmB, EmC, EmD, EmE, EnB, EnC, EnD, EnE, EnF, EoA, EoB, EoC, EoD, EoE, EoF, ELB, ELC, ELE. For Leelanau parts of EnB, EnC, EnD, EnE, EnF, ELB, ELC, and ELE, see Leelanau series; for Onaway part of EoA, EoB, EoC, EoD, EoE, and EoF, see Onaway series.	Fair: 6 to 8 inches thick; loamy; moderate organic-matter content; cobblestones and stones on surface in some areas.	Not suitable	Not suitable	Good: fair stability; fair to good workability.

for nonfarm uses—Continued

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Seasonal high water table; numerous cobblestones and stones hinder grading operations.	Somewhat poorly drained; seasonal high water table; slight to medium compressibility; poor to fair shear strength; cobbly.	Loamy; seasonal high water table; wet conditions and cobblestones and stones hinder operations; poor to fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderately slow permeability; numerous cobblestones and stones.	High	Low.
Cuts and fills needed in many areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slopes are 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low	Low.
Cuts and fills needed in many areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slopes are 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low	Low.
Cuts and fills needed in a few areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight: rapid permeability; possible contamination of shallow water supplies.	Low	Low.
High water table	Poorly drained; high water table; slight compressibility; fair shear strength.	Sandy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: poorly drained; high water table; moderately rapid permeability.	High	Low.
High water table; poor stability; organic material and marl must be removed.	Very poorly drained; high water table; high compressibility; poor shear strength; poor stability.	Organic material over marl; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability in organic material; variable permeability in marl; unstable organic material over marl.	High	Low.
Cuts and fills needed in many areas; stones hinder grading operations in some areas.	Well drained; slight compressibility; fair shear strength.	Loamy; fair stability on thawing; stones hinder grading operations in some areas.	Slight where slopes are 0 to 12 percent: moderate permeability. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
Ensley Mapped only in a complex with an Angelica soil.	Good: 6 to 9 inches thick; loamy; high organic-matter content; high water table.	Not suitable	Not suitable	Fair: fair stability and workability; high water table hinders excavation.
Epoufette: Ep	Fair: 6 to 8 inches thick; loamy; high organic-matter content; high water table.	Good: gravelly sand; wetness hinders excavation in many areas.	Good: 30 to 70 percent gravel; wetness hinders excavation in many areas.	Fair: fair stability and workability; high water table hinders excavation.
Gladwin: GlB	Poor: 8 to 10 inches thick; sandy; moderately low organic-matter content; seasonal high water table.	Good: sandy with some fines and gravel.	Fair: less than 50 percent gravel.	Fair: fair stability; fair to good workability; seasonal high water table.
Greenwood: Gr	Poor: organic material; erodible; oxidizes readily; high water table; very strongly acid.	Not suitable	Not suitable	Not suitable: organic material; poor stability; high compressibility; high water table.
Hessel: Hs	Poor: 6 to 10 inches thick; loamy; high organic-matter content; high water table; cobbly.	Not suitable	Not suitable	Poor: poor to fair stability; poor workability; low to moderate shrink-swell potential; high water table; cobbly.
Iosco: IIB	Poor: 7 to 9 inches thick; sandy; moderately low organic-matter content; seasonal high water table.	Fair: limited source of sandy material to a depth between 18 and 42 inches.	Not suitable	Fair: 18 to 42 inches of sandy material; fair stability and workability; poor to fair stability; fair workability for underlying loamy material; low to moderate shrink-swell potential; seasonal high water table.
Johnswood: JoC	Poor: 6 to 9 inches thick; loamy; moderate organic-matter content; cobbly.	Not suitable	Not suitable	Poor: poor to fair stability; poor workability; difficult to work and compact when wet; cobbly throughout.

for nonfarm uses—Continued

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
High water table----	Poorly drained; high water table; slight compressibility; fair shear strength.	Loamy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: poorly drained; high water table; moderate permeability.	High----------	Low.
High water table----	Poorly drained; high water table; slight compressibility; good shear strength.	Sandy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: poorly drained; high water table; moderately rapid to rapid permeability.	High----------	Low.
Seasonal high water table.	Somewhat poorly drained; seasonal high water table; slight compressibility; good shear strength.	Sandy; seasonal high water table; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderately rapid permeability.	Moderate-----	Low.
High water table; poor stability; organic material must be removed.	Very poorly drained; high water table; high compressibility; poor shear strength; poor stability.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability; unstable organic material.	High----------	High.
High water table; poor to fair stability; low to moderate shrink-swell potential; cobblestones hinder grading operations.	Poorly drained; high water table; low to moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength; cobbly.	Loamy; high water table; wet conditions and cobblestones hinder operations; poor to fair stability on thawing.	Severe: poorly drained; high water table; moderately slow permeability; cobbly.	High----------	Low.
Seasonal high water table; poor stability when wet; moderate potential for frost action; low to moderate shrink-swell potential for underlying loamy material.	Somewhat poorly drained; seasonal high water table; low to moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; rapid permeability in sandy material; moderately slow permeability in underlying loamy material.	High----------	Low.
Cuts and fills needed in a few areas; numerous cobblestones and stones hinder grading operations; shallow depth to bedrock in a few areas.	Slight to medium compressibility; poor to fair shear strength; cobbly; shallow depth to bedrock in a few areas.	Loamy; cobblestones and stones hinder operations; poor to fair stability on thawing.	Slight: moderate permeability; numerous cobblestones and stones.	Moderate-----	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KLB, KLC, KLE. For Leelanau part of KLB, KLC, and KLE, see Leelanau series.	Poor: 4 to 10 inches thick; sandy; low organic-matter content; droughty.	Good: sandy materials to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability.
Kawkawlin: KnC	Fair: 8 to 10 inches thick; loamy; moderate organic-matter content; seasonal high water table; crusts slightly when dry.	Not suitable	Not suitable	Poor: poor to fair stability and workability; difficult to work; compact when wet; moderate to high shrink-swell potential; seasonal high water table.
Kerston: Kr	Poor: organic material; erodible, oxidizes readily; high water table; fair to good if mixed with mineral material.	Not suitable	Not suitable	Poor: poor stability; fair workability; material flows when wet; high water table.
Kiva. Mapped only in an undifferentiated unit with Alpena and East Lake soils.	Poor: 4 to 8 inches thick; gravelly and sandy; moderately low organic-matter content; droughty; cobblestones on surface in some areas.	Good: sands with some fines and gravel.	Fair: 20 to 40 percent gravel with some fines.	Fair: good if soil binder is added; fair stability and workability; cobbly and stony in some areas.
Lake beaches: Lb. Too variable to be rated. Onsite investigation required.				
*Leelanau: LdB, LdC, LdD, LdE, LdF, LrB, LrC, LrD, LrE, LrF, LEB, LEC, LEE. For Rubicon part of LrB, LrC, LrD, LrE, and LrF, see Rubicon series; for Emmet part of LEB, LEC, and LEE, see Emmet series.	Poor: 6 to 8 inches thick; sandy; moderately low organic-matter content; droughty.	Fair: sandy with thin layers of fines.	Not suitable	Fair to good: fair stability and workability.

for nonfarm uses—Continued

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Cuts and fills needed in many areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slopes are 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low	Low.
Seasonal high water table; poor to fair stability; slippery when wet; moderate to high shrink-swell potential.	Somewhat poorly drained; seasonal high water table; moderate shrink-swell potential; medium to high compressibility; fair shear strength.	Loamy; seasonal high water table; moisture often too high for good compaction; poor to fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderately slow permeability.	High	Low.
High water table; subject to flooding; poor stability; layers of organic material must be removed.	Very poorly drained; high water table; subject to flooding; high compressibility and poor shear strength in organic layers; slight compressibility and fair shear strength for sandy loam layers.	Organic material and loamy; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability.	High	High.
Cuts and fills needed in many areas; cobblestones hinder grading in some areas.	Well drained; slight compressibility; good shear strength.	Sandy and gravelly; cobblestones hinder operations in some areas; low moisture content, good stability on thawing.	Slight where slopes are 0 to 12 percent: moderately rapid permeability; possible contamination of shallow water supplies. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low to moderate.	Low.
Cuts and fills needed in many areas.	Well drained; slight compressibility; fair shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slopes are 0 to 12 percent: moderately rapid permeability; possible contamination of shallow water supplies. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
Linwood: Ls	Poor: organic material; oxidizes readily; erodible; high water table; fair to good if mixed with mineral material.	Not suitable	Not suitable	Not suitable for upper organic layers: poor stability; high compressibility; fair for underlying loamy material; poor to fair stability; fair workability; low to moderate shrink-swell potential; high water table.
*Lupton: Lt, LU For Cathro part of LU, see Cathro series.	Poor: organic material; oxidizes readily; erodible; high water table; fair to good if mixed with mineral material.	Not suitable	Not suitable	Not suitable: organic material; poor stability; high compressibility; high water table.
Mackinac Mapped only in complexes with Charlevoix soils.	Good: 7 to 9 inches thick; loamy; moderate organic-matter content; seasonal high water table; cobbly in some areas.	Not suitable	Not suitable	Fair: poor to fair stability; fair to good workability; seasonal high water table; cobbly in some areas.
Made land: Ma. Too variable to be rated. Onsite investigation required.				
*Mancelona: McB, McC, McD, McE, McF, MEB, MEC, MEE. For East Lake part of MEB, MEC, and MEE, see East Lake series.	Poor: 6 to 8 inches thick; sandy; droughty; moderately low organic-matter content; gravel and cobblestones on surface in some areas.	Good: sands with some fines and gravel.	Good: 40 percent or more gravel with some fines.	Good: fair stability; fair to good workability; cobbly in some areas.
Markey: Mk	Poor: organic material; erodible; oxidizes readily; high water table; fair to good if mixed with mineral material.	Fair: sandy material at a depth between 12 and 42 inches; excess water hinders excavation.	Not suitable	Not suitable for upper organic layers: poor stability; high compressibility; fair in underlying sandy material; fair stability and workability; high water table hinders excavation.
Menominee: MnB, MnC	Poor: 7 to 9 inches thick; sandy; moderately low organic-matter content; droughty.	Fair: limited source of sandy material to a depth between 18 and 42 inches.	Not suitable	Fair: 18 to 42 inches of sandy material; fair stability and workability; poor to fair stability; fair workability in loamy underlying material; low to moderate shrink-swell potential.

for nonfarm uses—Continued

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
High water table; poor stability; organic material must be removed; low to moderate shrink-swell potential for underlying loamy material.	Very poorly drained; high water table; medium to high compressibility; poor to fair shear strength.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability in unstable organic material; moderate permeability in the loamy underlying material.	High	Low.
High water table; poor stability; organic material must be removed.	Very poorly drained; high water table; high compressibility; poor shear strength; poor stability.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability; unstable organic material.	High	Low.
Seasonal high water table; cobblestones hinder grading in some areas.	Somewhat poorly drained; seasonal high water table; medium to high compressibility; poor to fair shear strength; cobbly in some areas.	Loamy; seasonal high water table; wet conditions and cobblestones hinder operations in some areas; poor to fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderate permeability; cobbly in some areas.	Moderate	Low.
Cuts and fills needed in many areas; cobblestones hinder grading operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slopes are 12 percent: moderately rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low to moderate.	Low.
High water table; poor stability; organic material must be removed.	Very poorly drained; high water table; slight compressibility; fair shear strength.	Organic material; high water table; wet conditions hinder operations; very poor stability in thawing.	Severe: very poorly drained; high water table; moderately rapid to rapid permeability.	High	Low.
Low to moderate shrink-swell potential; cuts and fills needed in a few areas.	Well drained or moderately well drained; low to moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; moisture content often too high for good compaction; poor stability on thawing.	Severe: moderately slow permeability in loamy underlying material.	Moderate	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
Munuscong: Mu	Good: 8 to 10 inches thick; loamy; high organic-matter content; high water table.	Not suitable to very poor: variable content of fines.	Not suitable	Fair: 18 to 42 inches of loamy material; good workability; poor stability and workability in underlying clayey material; high shrink-swell potential in clayey material; high water table.
*Nester: NsB, NsC, NsD, NsE, NEB, NEC, NEE. For Emmet part of NEB, NEC, and NEE, see Emmet series.	Fair: 5 to 9 inches thick; loamy; moderate organic-matter content; cobbly and stony in a few areas.	Not suitable	Not suitable	Poor: poor to fair stability and workability; difficult to work and compact when wet; moderate to high shrink-swell potential; cobbly and stony in a few areas.
Onaway Mapped only in complexes with Emmet soils.	Fair: 6 to 10 inches thick; loamy; moderate organic-matter content; cobblestones and stones on surface in some areas.	Not suitable	Not suitable	Fair: poor to fair stability; fair to good workability; low to moderate shrink-swell potential.
Otisco: OtB	Poor: 6 to 8 inches thick; sandy; low organic-matter content; seasonal high water table; droughty.	Good: sandy material to a depth of 60 inches or more; high water table hinders excavation during wet seasons.	Not suitable	Fair: fair stability and workability; seasonal high water table hinders excavation during wet seasons.
Roscommon: Rc	Poor: 4 to 6 inches thick; sandy; high organic-matter content; high water table; droughty.	Good: sandy material; excess wetness hinders excavation in many areas.	Not suitable	Fair: fair stability and workability; high water table hinders excavation during wet seasons.
Rubicon: RdB, RdC, RdE	Poor: 3 to 9 inches thick; sandy; low organic-matter content; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability.

for nonfarm uses—Continued

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
High water table; high shrink-swell potential in underlying clayey material.	Poorly drained or very poorly drained; high water table; high shrink-swell potential; high compressibility; poor shear strength.	Loamy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: poorly drained or very poorly drained; high water table; slow permeability in underlying clayey material.	High	Low.
Seepage areas; clayey, plastic, and slippery when wet; moderate to high shrink-swell potential; cuts and fills needed in many areas; cobbly and stony in a few areas.	Well drained or moderately well drained; seepage areas; moderate shrink-swell potential; medium to high compressibility; fair shear strength.	Loamy; moisture content often too high for good compaction; poor stability on thawing; cobbly and stony in a few areas.	Severe: moderately slow permeability; sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Moderate	Low.
Low to moderate shrink-swell potential; cuts and fills needed in many areas; stones hinder grading operations in some areas.	Well drained; medium to high compressibility; poor to fair shear strength.	Loamy; poor to fair stability on thawing; stones hinder grading operations in some areas.	Slight where slopes are 0 to 12 percent: moderate permeability. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Moderate	Low.
Seasonal high water table; poor stability when wet.	Somewhat poorly drained; seasonal high water table; slight compressibility; fair shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderately rapid permeability.	Low	Low.
High water table; poor stability when wet.	Poorly drained; high water table; slight compressibility; good shear strength.	Sandy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: poorly drained; high water table; rapid permeability.	High	Low to moderate.
Cuts and fills needed in many areas; loose sand hinders hauling in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slopes are 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slopes are 12 to 18 percent. Severe where slopes are 18 to 50 percent: sidehill seepage may occur; installation and operation of disposal fields are difficult where slopes are more than 12 percent.	Low	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
Rubicon, loamy substratum: RoB	Poor: 4 to 8 inches thick; sandy; low organic-matter content; droughty.	Fair: limited source to a depth between 42 and 60 inches; some fines.	Not suitable	Fair: 42 to 60 inches of sandy material; fair stability and workability; poor to fair stability and fair workability in underlying loamy material; moderate shrink-swell potential.
Rudyard: RrB	Fair to poor: 6 to 13 inches thick; loamy; moderate organic-matter content; seasonal high water table; erodible.	Not suitable	Not suitable	Poor: poor stability and workability; difficult to work and compact when wet; high shrink-swell potential; seasonal high water table.
Ruse: Ru	Poor: 3 to 6 inches thick; loamy and sandy; very high organic-matter content; high water table; bedrock in some areas.	Not suitable	Not suitable	Not suitable: bedrock at a depth of less than 2 feet; high water table.
Saugatuck: SaB	Poor: 4 to 11 inches thick; sandy; moderately low organic-matter content; seasonal high water table; droughty.	Good: sandy material to a depth of 60 inches or more; high water table hinders excavation during wet seasons.	Not suitable	Fair: fair stability and workability; seasonal high water table; cemented layers.
Sims Mapped only in a complex with a Bergland soil.	Fair: 4 to 10 inches thick; loamy; high organic-matter content; high water table; crusts when dry.	Not suitable	Not suitable	Poor: poor to fair stability and workability; difficult to work and compact when wet; moderate to high shrink-swell potential; high water hinders excavation.
Stony land: St. Too variable to be rated. Onsite investigation required.				
Summerville: SuB	Poor: 6 to 12 inches thick; loamy; moderate organic-matter content; stony.	Not suitable	Not suitable unless bedrock is crushed.	Not suitable: bedrock at a depth of more than 2 feet; numerous stones.
*Tawas: Ta, TC For Carbondale part of TC, see Carbondale series.	Poor: organic material; erodible; oxidizes readily; high water table; fair to good if mixed with mineral material.	Fair: sandy material at a depth between 18 and 42 inches; excess water; organic material hinders excavation.	Not suitable	Not suitable in upper organic layers: poor stability; high compressibility. Fair in underlying-sandy material; fair stability and workability; high water table hinders excavation.

for nonfarm uses—Continued

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Low to moderate shrink-swell potential in underlying loamy material; loose sands hinder operations in some areas.	Well drained; low to moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; low moisture content; good stability on thawing.	Moderate: rapid permeability in sandy material, moderately slow permeability in underlying loamy material; possible contamination of shallow water supplies by effluent.	High	Low.
Seasonal high water table; poor stability; clayey, plastic, and slippery when wet; high shrink-swell potential.	Somewhat poorly drained; seasonal high water table; high shrink-swell potential and compressibility; poor shear strength.	Clayey; seasonal high water table; moisture content often too high for good compaction; poor stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; very slow permeability.	High	Low.
High water table; bedrock at a depth of less than 2 feet.	Poorly drained; high water table; bedrock at a depth of less than 2 feet.	Sandy; high water table; bedrock at a depth of less than 2 feet; poor stability on thawing.	Severe: poorly drained; high water table; moderately rapid permeability; bedrock at a depth of less than 2 feet.	High	Low.
Seasonal high water table; poor stability when wet.	Somewhat poorly drained; seasonal high water table; slight compressibility; good shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; with slow permeability; seasonal high water table; cemented layer between depths of 11 and 20 inches; rapid permeability below.	Low	Moderate to high.
High water table; poor to fair stability; slippery when wet; moderate to high shrink-swell potential.	Poorly drained; high water table; moderate shrink-swell potential; medium to high compressibility; fair shear strength.	Loamy; high water table; moisture content often too high for good compaction; poor stability on thawing.	Severe: poorly drained; high water table; slow permeability.	High	Low.
Bedrock at a depth of less than 2 feet; stony.	Well drained; bedrock at a depth of less than 2 feet.	Loamy; bedrock at a depth of less than 2 feet; fair stability on thawing; stony.	Severe: Moderate permeability; bedrock at a depth of less than 2 feet; stony.	Low	Low.
High water table; poor stability; organic material must be removed.	Very poorly drained; high water table; slight compressibility; fair to good shear strength.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid to rapid permeability.	High	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil [1]	Sand	Gravel	Road fill
Ubly: UbB, UbC	Fair: 6 to 10 inches thick; loamy; moderately low organic-matter content.	Not suitable	Not suitable	Fair: fair stability; fair to good workability; low to moderate shrink-swell potential.
Wallace: WaC	Poor: 6 to 11 inches thick; sandy; low organic-matter content; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability; cemented layers.
Warners: Wr	Fair: 6 to 10 inches thick; high organic-matter content; high water table; alkaline.	Not suitable	Not suitable	Not suitable: marl over organic material; poor stability and workability; high water table.
Wet alluvial land: Wt. Too variable to be rated. Onsite investigation required.				

[1] Thickness given is that of the surface layer.

TABLE 8.—*Engineering interpretations*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in such mapping to other series

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
*Alpena: AgB, AgD, AgF, Ak. For Kiva and East Lake parts of Ak, see the respective series.	Well drained	Low available water capacity; rapid intake rate; hazard of soil blowing.
*Angelica: An. For Ensley part of An, see Ensley series.	Poorly drained; moderately slow permeability; high water table.	High available water capacity; medium intake rate; drainage needed.
Au Gres: ArA	Somewhat poorly drained; rapid permeability; seasonal high water table; wet depressions; ditchbanks unstable; blinding of tile required.	Low available water capacity; rapid intake rate; drainage needed.

for nonfarm uses—Continued

Soil features affecting—			Limitations for septic tank disposal fields	Corrosion potential for conduits	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Low to moderate shrink-swell potential; cuts and fills needed in a few areas.	Well drained and moderately well drained; low to moderate shrink-swell potential; medium to high compressibility; fair shear strength.	Loamy; good stability on thawing.	Moderate: moderate permeability; 18 to 42 inches in loamy and sandy material; moderately slow permeability in the underlying loamy material.	Moderate	Low.
Cuts and fills needed in a few areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Moderate: cemented layer at a depth between 11 and 30 inches with moderately slow permeability; rapid permeability below; possible contamination of shallow water supplies by effluent.	Low	Low.
High water table; poor stability; marl and organic material must be removed.	Very poorly drained; high water table; high compressibility; poor shear strength; poor stability.	Loam over marl and organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately slow permeability in marl; moderately rapid permeability in organic material.	High	Low.

for farm uses

units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring as indicated]

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir area	Embankment
0 to 50 percent slopes; slopes too short and irregular in many areas; sandy; difficult to vegetate; wind may deposit soil material in channels; shallow to very gravelly sand.	Not needed; sandy; little runoff.	Rapid seepage rate; too sandy and porous to hold water unless a seal blanket is used.	Fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.
Not needed	Not needed	High water table; medium to slow seepage rate; suited to pit-type ponds.	Poor to fair stability and fair to good compaction properties; poor resistance to piping; slow seepage rate.
Not needed; sandy; gentle slopes; little runoff.	Not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage rate; material too sandy and porous to hold water unless seal blanket is used.	Fair to good stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
Au Gres, loamy substratum: AuA	Somewhat poorly drained; rapid permeability above depth of 42 to 66 inches and moderately slow permeability below; seasonal high water table: blinding of tile required.	Low available water capacity; rapid intake rate; drainage needed.
Barker: BaB, BaC, BaE	Well drained or moderately well drained; moderately slow permeability; small wet areas may need random tile.	High available water capacity; medium intake rate; medium to rapid runoff; hazard of water erosion.
Barker, shallow variant: BcB	Moderately well drained or somewhat poorly drained; slow permeability; seasonal high water table in some areas; drainage impractical because of shallow depth to bedrock.	Moderate available water capacity; medium intake rate; medium runoff; hazard of water erosion; shallow depth to bedrock.
*Belding: BdA For Breckenridge part of BdA, see Breckenridge series.	Somewhat poorly drained; moderately rapid permeability at a depth between 18 and 42 inches; moderately slow permeability below; seasonal high water table; wet depressions need random tile or surface drains.	Moderate available water capacity; moderately rapid intake rate; drainage needed.
*Bergland: Be For Sims part of Be, see Sims series.	Poorly drained; very slow permeability; high water table; special blinding and close spacing of tile required.	Moderate available water capacity; slow intake rate; drainage needed.
*Blue Lake: BlB, BlC, BlD, BlF, BKB, BKC. For Kalkaska part of BKB and BKC, see Kalkaska series.	Well drained; rapid permeability	Low available water capacity; rapid intake rate.
Breckenridge Mapped only in a complex with a Belding soil.	Very poorly drained; moderately rapid permeability in sandy and loamy material above depth of 18 to 42 inches; moderately slow permeability below; high water table; wet depressions need surface drains.	Moderate to high available water capacity; rapid intake rate; drainage needed.
Brevort: Bv	Poorly drained or very poorly drained; rapid permeability for sandy material above depth of 18 to 42 inches, moderately slow permeability below; high water table; wet depressions need surface drains.	Low to high available water capacity; rapid intake rate; drainage needed.
Brimley: BwB	Somewhat poorly drained; moderate permeability; seasonal high water table; fine soil material may fill tile; ditchbanks unstable.	High available water capacity; medium intake rate; drainage needed.
Bruce: By	Poorly drained; moderate permeability; high water table; fine soil material may fill tile; ditchbanks unstable.	High available water capacity; medium intake rate; drainage needed.

for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir area	Embankment
Not needed; sandy; gentle slopes; little runoff.	Not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage rate in sandy material; slow seepage rate in underlying loamy material; material too sandy and porous to hold water unless seal blanket is used.	Sandy material has fair to good stability and compaction properties, poor to fair resistance to piping, and rapid seepage rate; the underlying loamy material has poor to fair stability and compaction properties, poor to fair resistance to piping, and slow seepage rate.
2 to 25 percent slopes; slopes too steep and irregular in some areas; medium to rapid runoff; moderately erodible.	Steep and irregular slopes in some areas; medium to rapid runoff; moderately erodible.	Slow seepage rate	Fair to good stability and compaction properties; moderate shrink-swell potential; numerous shale fragments; slow seepage rate.
2 to 6 percent slopes; medium runoff; moderately erodible; shallow depth to bedrock hinders construction.	No unfavorable features other than a seasonal high water table in some areas.	Seasonal high water table in some areas; slow seepage rate; shallow depth to bedrock may hinder construction.	Fair stability and compaction properties; moderate to high shrink-swell potential; slow seepage rate; shallow depth to bedrock.
Not needed; gentle slopes; little runoff.	No unfavorable features other than a seasonal high water table.	Seasonal high water table; medium to slow seepage rate.	Fair to good stability and compaction properties; poor to fair resistance to piping; slow seepage rate.
Not needed	Not needed	High water table; slow seepage rate; suited to pit-type ponds.	Fair stability; poor to fair compaction properties; moderate to high shrink-swell potential; slow seepage rate.
0 to 50 percent slopes; slopes too steep and irregular in some areas; sandy; difficult to vegetate.	0 to 50 percent slopes; medium runoff; moderately erodible on the steeper slopes; droughty; difficult to vegetate.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability and compaction properties; poor resistance to piping; rapid to medium seepage rate.
Not needed	Not needed	High water table; medium seepage rate; suited to pit-type ponds.	Poor to fair stability and compaction properties; poor to fair resistance to piping; low to moderate shrink-swell potential; slow seepage rate.
Not needed	Not needed	High water table; rapid seepage rate above depth of 18 to 42 inches, medium to slow rate below; sides of ponds unstable when wet.	Fair stability and compaction properties; poor to fair resistance to piping; low to moderate shrink-swell potential; medium to slow seepage rate.
0 to 6 percent slopes; not needed; little runoff.	No unfavorable features other than a seasonal high water table.	Seasonal high water table; medium seepage rate; sides of ponds unstable when wet.	Poor to fair stability; fair compaction properties; poor resistance to piping; medium seepage rate; erodible.
Not needed	Not needed	High water table; medium seepage rate; suited to pit-type ponds; sides of ponds unstable when wet.	Poor to fair stability; fair compaction properties; poor resistance to piping; medium seepage rate; erodible.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
Carbondale: Ca	Very poorly drained; moderately rapid permeability; high water table; impractical to drain in many areas because of frost hazard.	Very high available water capacity; rapid intake rate; drainage needed; hazard of soil blowing.
Cathro: Cc	Very poorly drained; moderately rapid permeability in organic material; moderate permeability in underlying loamy material; high water table; impractical to drain in many areas because of frost hazard.	High available water capacity; rapid intake rate; drainage needed; hazard of soil blowing.
*Charlevoix: CmB, CnB, CKB For Mackinac part of CmB and CnB, see Mackinac series; for Kawkawlin part of CKB, see Kawkawlin series.	Somewhat poorly drained; moderate permeability; seasonal high water table; impractical to drain in some areas because of cobblestones.	Moderate available water capacity; medium intake rate; drainage needed; cobblestones and stones in some areas.
Croswell: CrA	Moderately well drained; rapid permeability; ditchbanks unstable.	Low available water capacity; rapid intake rate; hazard of soil blowing.
*Deer Park: DDB, DDC, DDE For Dune land part, see Dune land.	Well drained; rapid permeability	Low available water capacity; rapid intake rate; hazard of soil blowing.
Detour: DeB	Somewhat poorly drained; moderately slow permeability; seasonal high water table; impractical to drain because of cobblestones.	Moderate available water capacity; medium to slow intake rate; cobbly surface.
Dune land Mapped only in associations with Deer Park soils.	Well drained; rapid permeability	Low available water capacity; rapid intake rate; hazard of soil blowing.
East Lake: EaB, EaC	Well drained; rapid permeability	Low available water capacity; rapid intake rate; subject to soil blowing.
Eastport: EdB, EdC	Well drained; rapid permeability	Low available water capacity; rapid intake rate; subject to soil blowing.
Edmore: Ee	Poorly drained; moderately rapid permeability; high water table.	Low available water capacity; rapid intake rate; drainage needed.
Edwards: Ek	Very poorly drained; moderately rapid permeability; high water table; impractical to drain because of frost hazard.	Very high available water capacity; rapid intake rate; subject to soil blowing.

for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir area	Embankment
Not needed	Not needed	High water table; rapid seepage rate; suited to pit-type ponds; flotation of organic material likely.	Not suitable; organic material.
Not needed	Not needed	High water table; rapid seepage rate above depth of 18 to 42 inches, slow below; suited to pit-type ponds; flotation of organic material likely.	Not suitable; 12 to 42 inches of organic material; poor to fair stability and compaction properties; poor to fair resistance to piping; low to moderate shrink-swell potential; slow seepage rate in underlying loamy material.
Generally not needed; gentle slopes; little runoff; cobbly in some areas.	No unfavorable features other than seasonal high water table and cobblestones in some areas.	Seasonal high water table; medium seepage rate.	Poor to fair stability and compaction properties; poor to fair resistance to piping; medium seepage rate; cobblestones in some areas.
Not needed; sandy; gentle slopes; little runoff.	Not needed; sandy; gentle slopes; little runoff.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.
0 to 50 percent slopes; slopes too steep and irregular in many areas; sandy; low runoff; difficult to vegetate.	0 to 50 percent slopes; little runoff; droughty; difficult to vegetate.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.
0 to 6 percent slopes; numerous cobblestones hinder construction.	0 to 6 percent slopes; numerous cobblestones; seasonal high water table.	Seasonal high water table; medium to slow seepage rate; cobbly.	Poor to fair stability; poor compaction properties; poor resistance to piping; low to moderate shrink-swell potential; medium seepage rate; cobbly.
0 to 50 percent slopes; slopes too steep and irregular in many areas; sandy; low runoff; difficult to vegetate.	0 to 50 percent slopes; little runoff; droughty; difficult to vegetate.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.
0 to 50 percent slopes; slopes too steep and irregular in many areas; sandy; difficult to vegetate; wind may deposit soil material in channels; shallow to very gravelly sand.	0 to 50 percent slopes; little runoff; droughty; difficult to vegetate.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability; fair to good compaction properties; rapid seepage rate.
0 to 12 percent slopes; sandy; difficult to vegetate; wind may deposit soil material in in channels.	0 to 12 percent slopes; little runoff; difficult to vegetate.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.
Not needed	Not needed	High water table; rapid seepage rate; suited to pit-type ponds.	Fair stability; fair to good compaction properties; poor resistance to piping; medium seepage rate.
Not needed	Not needed	High water table; rapid seepage rate at depth of 12 to 42 inches, slow below; suited to pit-type ponds; flotation of organic material possible.	12 to 42 inches of organic material over marl; not suitable.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
*Emmet: EmA, EmB, EmC, EmD, EmE, EnB, EnC, EnD, EnE, EnF, EoA, EoB, EoC, EoD, EoE, EoF, ELB, ELC, ELE. For Leelanau part of EnB, EnC, EnD, EnE, EnF, ELB, ELC, and ELE, see Leelanau series; for Onaway part of EoA, EoB, EoC, EoD, EoE, and EoF, see Onaway series.	Well drained; moderate permeability; small, wet areas need random tile.	Moderate available water capacity; moderately rapid intake rate; hazard of water erosion in sloping areas.
Ensley. Mapped only in a complex with an Angelica soil.	Poorly drained; moderate permeability; high water table.	Moderate available water capacity; rapid intake rate; drainage needed.
Epoufette: Ep	Poorly drained; moderately rapid to rapid permeability; high water table; blinding of tile required.	Low available water capacity; rapid intake rate; drainage needed.
Gladwin: GlB	Somewhat poorly drained; moderately rapid permeability; seasonal high water table; blinding of tile required.	Low available water capacity; rapid intake rate; drainage needed.
Greenwood: Gr	Very poorly drained; moderately rapid permeability; high water table; impractical to drain because of frost hazard.	Very high available water capacity; rapid intake rate.
Hessel: Hs	Poorly drained; moderately slow permeability; high water table; impractical to drain because of numerous cobblestones.	High available water capacity; medium intake rate; drainage needed; numerous cobblestones.
Iosco: IlB	Somewhat poorly drained; moderately rapid permeability above depth of 18 to 42 inches; moderately slow permeability below; seasonal high water table; wet depressions need random tile or surface drains.	Low available water capacity above depth of 18 to 42 inches, high below; rapid intake rate; drainage needed.
Johnswood: JoC	Well drained or moderately well drained; moderate permeability.	High available water capacity; medium intake rate; hazard of water erosion in sloping areas; numerous cobblestones.
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KLB, KLC, KLE. For Leelanau part of KLB, KLC, and KLE, see Leelanau series.	Well drained; rapid permeability	Low available water capacity; rapid intake rate; hazard of soil blowing.
Kawkawlin: KnC	Somewhat poorly drained; moderately slow permeability; seasonal high water table; wet depressions need surface drains.	High available water capacity; medium intake rate; drainage needed.
Kerston: Kr	Very poorly drained; moderately rapid permeability; impractical to drain because of flooding and frost hazard.	High available water capacity; rapid intake rate; protection from flooding required.

for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir area	Embankment
0 to 50 percent slopes; slopes too steep and irregular in many areas; slow to rapid runoff; moderately erodible; stony in some areas.	0 to 50 percent slopes; slow to rapid runoff; moderately erodible.	Medium seepage rate in subsoil, medium to rapid in underlying loamy material; stony in some areas.	Fair stability; fair to good compaction properties; poor resistance to piping; slow to medium seepage rate; stony in some areas.
Not needed	Not needed	High water table; medium seepage rate; suited to pit-type ponds.	Fair stability; fair to good compaction properties; poor resistance to piping; medium seepage rate.
Not needed	Not needed	High water table; rapid seep-rate; suited to pit-type ponds.	Fair stability; fair to good compaction properties; poor to fair resistance to piping; medium to rapid seepage rate.
0 to 6 percent slopes; not needed; sandy; gentle slopes; little runoff.	Not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; medium seepage rate in subsoil, rapid seepage rate in underlying material; seal blanket required when porous gravelly sand is exposed.	Fair stability and compaction properties; poor to fair resistance to piping; medium to rapid seepage rate.
Not needed	Not needed	High water table; rapid seepage rate; suited to pit-type ponds; flotation of organic material likely.	Organic material; not suitable.
Not needed	Not needed	High water table; medium to slow seepage rate; suited to pit-type ponds.	Poor to fair stability; poor compaction properties; slow seepage rate; numerous cobblestones.
Not needed; sandy; gentle slopes; little runoff.	Not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage rate above depth of 18 to 42 inches; medium to slow rate below; sides of ponds unstable when wet.	Fair stability; fair to good compaction properties; poor resistance to piping; low to moderate shrink-swell potential; medium to slow seepage rate.
2 to 12 percent slopes; medium runoff; moderately erodible; numerous cobblestones hinder construction.	2 to 12 percent slopes; medium runoff; moderately erodible; numerous cobblestones.	Medium to slow seepage rate; numerous cobblestones.	Poor to fair stability; poor compaction properties; slow seepage rate; numerous cobblestones.
0 to 50 percent slopes; slopes too steep and irregular in many areas; sandy; difficult to vegetate; wind may deposist soil material in channels.	0 to 50 percent slopes; sandy; little runoff; droughty; difficult to vegetate.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.
Generally not needed; 0 to 6 percent slopes.	No unfavorable features other than a seasonal high water table.	Seasonal high water table; slow seepage rate.	Poor to fair stability and compaction properties; moderate to high shrink-swell potential; slow seepage rate.
Not needed	Not needed	High water table; rapid seepage rate; suited to pit-type ponds; flotation of organic material likely.	Poor stability and compaction properties; poor resistance to piping; rapid seepage rate; interbedded layers of organic material.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
*Kiva Mapped only in an undiffentiated unit with Alpena and East Lake soils.	Well drained; moderately rapid permeability.	Low available water capacity; rapid intake rate.
Lake beaches: Lb. Too variable to be rated. Onsite investigation required.		
*Leelanau: LdB, LdC, LdD, LdE, LdF, LrB, LrC, LrD, LrE, LrF, LEB, LEC, LEE. For Rubicon part of LrB, LrC, LrD, LrE, and LrF, see Rubicon series; for Emmet part of LEB, LEC, and LEE, see Emmet series.	Well drained; moderately rapid permeability.	Low available water capacity; rapid intake rate; hazard of water erosion in sloping areas.
Linwood: Ls	Very poorly drained; moderately rapid permeability in organic material; moderate permeability in underlying loamy material; high water table; impractical to drain in many areas because of frost hazard.	High available water capacity; rapid intake rate; hazard of soil blowing.
*Lupton: Lt, LU For Cathro part of LU, see Cathro series.	Very poorly drained; moderately rapid permeability; high water table; impractical to drain in many areas because of frost hazard.	Very high available water capacity; rapid intake rate; hazard of soil blowing.
Mackinac Mapped only in complexes with Charlevoix soils.	Somewhat poorly drained; moderate permeability; seasonal high water table; wet depressions need surface drains; cobblestones in some areas.	High available water capacity; medium intake rate; cobblestones in some areas.
Made land: Ma. Too variable to be rated. Onsite investigation required.		
*Mancelona: McB, McC, McD, McE, McF, MEB, MEC, MEE. For East Lake part of MEB, MEC, and MEE, see East Lake series.	Well drained or moderately well drained; moderately rapid permeability.	Low available water capacity; rapid intake rate; hazard of water erosion in sloping areas.
Markey: Mk	Very poorly drained; moderately rapid to rapid permeability; high water table; impractical to drain in many areas because of frost hazard.	High available water capacity; rapid intake rate; hazard of soil blowing.
Menominee: MnB, MnC	Well drained or moderately well drained; rapid permeability in sandy material; moderately slow permeability in underlying loamy material.	Low to moderate available water capacity; rapid intake rate; hazard of water erosion in sloping areas.
Munuscong: Mu	Poorly drained or very poorly drained; moderately rapid permeability in sandy material; moderately slow permeability in underlying loamy material.	Moderate available water capacity; rapid intake rate drainage needed.

for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir area	Embankment
0 to 50 percent slopes; slopes too steep and irregular in many areas; sandy; difficult to vegetate; wind may deposit soil material in channels.	0 to 50 percent slopes; sandy; little runoff; droughty; difficult to vegetate.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability; fair to good compaction properties; poor to fair resistance to piping; rapid seepage rate.
0 to 50 percent slopes; slopes too steep and irregular in many areas; slow to rapid runoff; moderately erodible; difficult to vegetate.	0 to 50 percent slopes; slow to rapid runoff; moderately erodible; droughty; difficult to vegetate.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability; fair to good compaction properties; poor resistance to piping; medium to rapid seepage rate.
Not needed	Not needed	High water table; rapid seepage rate at depth of 18 to 42 inches, slow below; suited to pit-type ponds; flotation of organic material likely.	12 to 42 inches of organic material; not suitable; poor to fair stability and compaction properties; poor to fair resistance to piping; low to moderate shrink-swell potential; slow seepage rate for underlying loamy material.
Not needed	Not needed	High water table; rapid seepage rate; suited to pit-type ponds; flotation of organic material likely.	Organic material; not suitable.
Generally not needed; 0 to 6 percent slopes; little runoff; cobbly in some areas.	Seasonal high water table; cobblestones in some areas.	Seasonal high water table; medium to slow seepage rate.	Poor to fair stability and compaction properties; poor to fair resistance to piping; slow seepage rate; cobblestones in some areas.
0 to 50 percent slopes; slopes too steep and irregular in many areas; slow to rapid runoff; moderately erodible; difficult to vegetate.	0 to 50 percent slopes; slow to rapid runoff; moderately erodible; droughty; difficult to vegetate.	Medium to rapid seepage rate in subsoil; seal blanket required where very gravelly sand is exposed.	Fair stability; fair to good compaction properties; medium to rapid seepage rate.
Not needed	Not needed	High water table; rapid seepage rate; suited to pit-type ponds; flotation of organic material likely.	Not suitable; 18 to 42 inches of organic material; fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate for underlying sandy material.
0 to 12 percent slopes; slow to medium runoff; moderately erodible; sandy; difficult to vegetate.	0 to 12 percent slopes; medium runoff; moderately erodible; droughty; difficult to vegetate.	Rapid seepage rate above depth of 18 to 42 inches, slow below; seal blanket required if sandy material is not removed.	Fair stability; poor to fair compaction properties; poor to fair resistance to piping; low to moderate shrink-swell potential; slow seepage rate.
Not needed	Not needed	High water table; medium seepage rate above depth of 18 to 42 inches, slow below; suited to pit-type ponds.	Poor to fair stability and compaction properties; poor to fair resistance to piping; low to high shrink-swell potential; medium seepage rate.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
*Nester: NsB, NsC, NsD, NsE, NEB, NEC, NEE. For Emmet part of NEB, NEC, and NEE, see Emmet series.	Well drained or moderately well drained; moderately slow permeability; small, wet areas may need random tile; stony in a few areas.	High available water capacity; slow to medium intake rate; hazard of water erosion in sloping areas; stony in a few areas.
Onaway. Mapped only in complexes with Emmet soils.	Well drained; moderate permeability; small, wet areas may need random tile.	High available water capacity; medium intake rate; hazard of water erosion in sloping areas.
Otisco: OtB	Somewhat poorly drained; moderately rapid permeability; seasonal high water table; wet depressions; ditchbanks unstable.	Low available water capacity; rapid intake rate; drainage needed.
Roscommon: Rc	Poorly drained; rapid permeability; high water table; ditchbanks unstable.	Low available water capacity; rapid intake rate; drainage needed.
Rubicon: RdB, RdC, RdE	Well drained; rapid permeability	Low available water capacity; rapid intake rate; hazard of soil blowing.
Rubicon, loamy substratum: RoB	Well drained; rapid permeability in upper 42 to 60 inches of sandy material; moderately slow permeability in underlying loamy material.	Low available water capacity; rapid intake rate; hazard of soil blowing.
Rudyard: RrB	Somewhat poorly drained; very slow permeability; seasonal high water table; blinding and close spacing of tile required; surface drainage needed.	Moderate available water capacity; slow to medium intake rate; drainage needed.
Ruse: Ru	Poorly drained; very slow permeability; impractical to drain because of shallow depth to bedrock.	Moderate available water capacity; rapid intake rate; shallow depth to bedrock.
Saugatuck: SaB	Somewhat poorly drained; slow permeability in cemented subsoil; rapid permeability below; seasonal high water table; wet depressions; ditchbanks unstable.	Low available water capacity; rapid intake rate; drainage needed; shallow depth to cemented subsoil.
Sims. Mapped only in a complex with a Bergland soil.	Poorly drained; slow permeability; high water table; close spacing of tile required; surface drainage needed.	High available water capacity; slow intake rate; drainage needed.
Stony land: St. Too variable to be rated. Onsite investigation required.		
Summerville: SuB	Well drained; moderate permeability; shallow to bedrock.	Moderate available water capacity; medium intake rate; stony; shallow depth to bedrock.

for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir area	Embankment
0 to 50 percent slopes; slopes too steep and irregular in many areas; slow to rapid runoff; highly erodible; siltation of channels; stony in a few areas.	0 to 50 percent slopes; slow to rapid runoff; highly erodible; difficult to vegetate; stony in a few areas.	Slow seepage rate	Poor to fair stability and compaction properties; moderate to high shrink-swell potential; slow seepage rate; stony in a few areas.
0 to 50 percent slopes; slopes too steep and irregular in many areas; slow to rapid runoff; moderately erodible; stoney in some areas.	0 to 50 percent slopes; slow to rapid runoff; moderately erodible.	Medium to slow seepage rate	Poor to fair stability; fair compaction properties; low to moderate shrink-swell potential; slow seepage rate; stony in some areas.
Not needed; 0 to 6 percent slopes; sandy; little runoff.	Not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; too sandy and porous to hold water unless seal blanket is used.	Fair stability and compaction properties; poor resistance to piping; rapid seepage rate.
Not needed	Not needed	High water table; rapid seepage rate; suited to pit-type ponds.	Fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.
0 to 50 percent slopes; slopes too steep and irregular in many areas; sandy; difficult to vegetate.	0 to 50 percent slopes; sandy; little runoff; droughty; difficult to vegetate.	Rapid seepage rate; too sandy and porous to hold water unless seal blanket is used.	Fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.
Not needed; 0 to 6 percent slopes; sandy; little runoff.	Not needed; 0 to 6 percent slopes; sandy; little runoff.	Upper 42 to 60 inches has rapid seepage rate; too sandy and porous to hold water unless seal blanket is is used; underlying loamy material has slow seepage rate.	Sandy material has fair stability and compaction properties, poor to fair resistance to piping, and a rapid seepage rate; the underlying loamy material has poor to fair stability and compaction properties, poor to fair resistance to piping, and a slow seepage rate.
Generally not needed; 0 to 6 percent slopes; clayey subsoil difficult to vegetate.	0 to 6 percent slopes; cuts expose clayey material; difficult to vegetate.	Seasonal high water table; slow seepage rate.	Poor to fair stability and compaction properties; high shrink-swell potential; slow seepage rate.
Not needed	Not needed	High water table; rapid seepage rate; shallow depth to bedrock; not suitable for pit-type ponds.	Not suitable; shallow depth to bedrock.
Not needed; 0 to 6 percent slopes; sandy; little runoff.	Not needed; 0 to 6 percent slopes; sandy; little runoff.	Seasonal high water table; slow seepage rate above cemented subsoil; rapid below; seal blanket generally required.	Fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate.
Not needed	Not needed	High water table; slow seepage rate; suited to pit-type ponds.	Fair to good stability and compaction properties; moderate to high shrink-swell potential; slow seepage rate.
0 to 6 percent slopes; medium runoff; moderately erodible; shallow depth to bedrock hinders construction.	0 to 6 percent slopes; medium runoff; moderately erodible; shallow depth to bedrock.	Shallow to bedrock; medium to rapid seepage; water seeps through fractures in rock.	Shallow to bedrock; not suitable.

TABLE 8.—*Engineering interpretations*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
*Tawas: Ta, TC For Carbondale part of TC, see Carbondale series.	Very poorly drained; moderately rapid to rapid permeability; high water table; impractical to drain because of frost hazard.	High available water capacity; rapid intake rate; hazard of soil blowing.
Ubly: UbB, UbC	Well drained or moderately well drained; moderate to moderately slow permeability.	Moderate available water capacity; rapid intake rate; hazard of water erosion in sloping areas.
Wallace: WaC	Well drained; slow permeability in cemented subsoil; rapid permeability below.	Low available water capacity; rapid intake rate; hazard of soil blowing; shallow depth to cemented subsoil.
Warners: Wr	Very poorly drained; moderately slow permeability; high water table; impractical to drain because of frost hazard.	Variable available water capacity; rapid intake rate.
Wet alluvial land: Wt. Too variable to be rated. Onsite investigation required.		

Engineering interpretations

Engineering interpretations in this survey are given in tables 7 and 8. The data in these tables apply to the representative profile described for the soil series in the section "Descriptions of the Soils."

Table 7 gives the suitability of the soils as a source of topsoil, sand, gravel, and road fill and lists features that affect the use of soils in locating highways, foundations for low buildings, and winter grading. Also given in table 7 are limitations for septic tank disposal fields and ratings for the corrosion potential for conduits.

The ratings for suitability as a source of topsoil were based largely on texture and organic-matter content. Topsoil is material, preferably rich in organic matter, that is used to topdress back slopes, embankments, lawns, gardens, and the like. Unless otherwise indicated, only the surface layer was considered in making these ratings.

Ratings of suitability of the soils as a source of sand and gravel apply only to material within a depth of 5 feet. Some soils that are rated "not suited" in table 7 may have sand and gravel at a depth of more than 5 feet. In some of the soils, sand and gravel is at a depth of less than 5 feet and extends to a depth of more than 5 feet. Where suitability is questionable, the availability of the sand and gravel can be determined by digging test pits. Soils of the Alpena, East Lake, Kiva, and Mancelona series have fair to good potential as sources of gravel.

Ratings of the suitability of the soils as a source of road fill are based on performance of soil material used as borrow for subgrade. Both the subsoil and substratum are rated if they have contrasting characteristics. The most suitable material is sand that has enough fines for binding; the least suitable is clay.

Also listed in table 7 are soil features affecting locations for highways. The soil features considered were those that affect the overall performance of the soil, such as a high water table or steep slopes. The entire soil profile, undisturbed and without artificial drainage, was evaluated. Good materials for road subbase are well distributed throughout the county in the sandy and gravelly soils. Additional information can be obtained from the State Highway Department of Michigan, which has rated the major soil series in the State for their suitability for highway construction. This information is in the "Field Manual of Soil Engineering" (*2*).

Of special concern to engineers involved with highway locations are the silty soils of the county, particularly the Bruce and Brimley soils. These soils consist of stratified silt and very fine sand that are soft and very unstable and have low bearing capacity and are highly susceptible to frost action.

The soils are also rated in table 7 for their suitability for foundations for buildings that are no more than three stories high. The suitability of the soils as a base for low buildings depends mainly on the characteristics of the substratum, which generally provides the base for foundations. Ratings are therefore for the substratum. Important factors considered in determining the suitability of the soils for foundations for low buildings are susceptibility to frost heaving, depth to water table, compressibility, and shrink-swell potential. Engineers and others should not apply specific values to the estimates given.

for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir area	Embankment
Not needed	Not needed	High water table; rapid seepage rate; suited to pit-type ponds; flotation of organic material likely.	18 to 42 inches of organic material: not suitable; fair stability and compaction properties; poor to fair resistance to piping; rapid seepage rate in underlying sandy material.
2 to 12 percent slopes; slow to medium runoff; moderately erodible.	2 to 12 percent slopes; slow to medium runoff; moderately erodible.	Medium seepage rate	Fair to good stability and compaction properties; poor to fair resistance to piping; low to moderate shrink-swell potential; slow seepage rate.
0 to 12 percent slopes; sandy; difficult to vegetate; wind may deposit soil material in channels.	0 to 12 percent slopes; sandy; little runoff; droughty; difficult to vegetate.	Slow seepage rate above cemented subsoil; rapid below; seal blanket generally required.	Fair stability and compaction properties; poor to fair reresistance to piping; rapid seepage rate.
Not needed	Not needed	High water table; rapid seepage rate; suited to pit-type ponds; flotation of organic material likely.	Marl over organic material; not suitable.

The poor stability of the Brimley and Bruce soils is likely to result in cracks in basement walls and settling of foundations, particularly in buildings of more than one story. Frost heaving is a relatively high hazard on the somewhat poorly drained and poorly drained soils, such as the Brimley, Bruce, Kawkawlin, and Sims soils. Paved sidewalks, driveways, and garage or carport floors on these soils are likely to be damaged by frost heaving unless a foot or more of coarse-textured material is placed below the paving. Soils that have a high shrink-swell potential, such as the Bergland and Rudyard soils, are severely limited for foundations and structures.

Among the soil features that affect winter grading are those that, in winter, affect the crossing of areas of soil and the handling of soil material with ordinary construction equipment. Important factors considered are texture of the soil material, natural content of water, and depth to the water table.

Limitations of the soils for use as disposal fields for septic tanks and soil features that affect their use for this purpose are also shown in table 7. Some of the limiting factors are permeability, depth to water table, depth to bedrock, flooding hazard, and relief. Soils that have somewhat poor or poor drainage, a seasonal high water table, or slow or very slow permeability are poor sites. A sewage disposal system does not function properly in such soils. A percolation rate of 60 minutes per inch or less is desirable for a septic tank disposal field. This is equivalent to a permeability rate of 1 inch per hour. Permeability rates for the soils in Charlevoix County are given in table 6.

The soils are also rated in table 7 according to the degree that they encourage the corrosion of conduits laid in them. Ratings are given for uncoated steel conduits and concrete conduits. The texture and natural drainage of a soil affect this potential through their influence on aeration, content of water, and movement of water. The pH of the soil also may be important.

Table 8 lists features that affect the use of the soils for agricultural drainage, irrigation, terraces and diversions, grassed waterways, and farm ponds.

Listed under agricultural drainage are features that affect the installation and performance of surface and subsurface drainage systems. Among these features are texture, permeability, relief, restricting layers, and depth to water table.

Artificial drainage is needed in many areas that have been cleared for farming. Many wet areas in the county that are used for pasture would be suited to crops if adequately drained and managed. Less than one-third of the total acreage of the Charlevoix, Mackinac, Kawkawlin, Belding, Breckenridge, Bruce, and Sims soils is used for crops. Tile drains are suitable for draining these soils, but adequate outlets are lacking in many areas. In many places drainage ditches can be installed, however, as outlets for tile. The Rudyard and Bergland soils are very slowly permeable. In these soils closer spacing of tile is needed for adequate drainage than on more permeable soils. Seepy areas and small, wet spots are common in some areas of the Nester soils, even though these soils are dominantly well drained or moderately well drained. In many of these areas, random tile lines are needed to provide drainage.

Few of the organic soils in the county are drained and used for farming. In many areas these soils have a high frost hazard, and draining these areas is not practical in the foreseeable future.

The major features affecting suitability of the soils for irrigation are available water capacity and rate of water intake. Also important are relief, the need for drainage, and depth to soil material that restricts growth of roots. Little irrigation is now done in the county, though many of the soils are suitable for irrigation. If irrigated, the large acreage of sandy soils in the county would be suitable for many crops, including many specialty crops that are suited to the climate but presently are not grown. In many areas water for irrigation can be obtained from shallow wells or lakes.

Important features that affect the layout and construction of terraces and diversions are relief, texture of the soil material, and depth to material that restricts growth of roots. Most areas of the sloping soils on uplands in the county have properties that are suitable for the construction of terraces and diversions. In many places, however, the slopes are too irregular for terraces. On the Nester soils, cuts into the lower part of the subsoil expose material that is low in productivity and difficult to till.

The success of grassed waterways depends on soil features that affect the construction and maintenance of the waterways and the growth of plants in them. Important features are fertility, available moisture capacity, rate of surface runoff, and susceptibility to erosion. Establishing a good, dense sod that is resistant to erosion is needed for well-constructed waterways.

Establishing grassed waterways on the limy glacial till of the Nester soils is possible, even though these soils have poor structure and low organic-matter content. On these soils liberal applications of manure are needed for establishing seedlings.

The seepage rate in undisturbed soil material is the most important feature affecting the reservoir area of a farm pond. Features affecting embankments are compaction properties, stability, seepage rate, and the piping hazard. Because of the slow seepage rate, the soils that formed in loam, clay loam, and silty clay or clay are favorable for construction of farm ponds. The soils that formed in sandy loam have a rapid seepage rate, and this results in wide fluctuations in the water level. Successful ponds can be constructed on these soils, however, by careful selection of materials from the subsoil for use in blanketing the reservoir area and by compacting the material. The soils that formed in sand and loamy sand have an excessive seepage rate and are not suitable sites for ponds. Springs in many low areas in the county provide a good flow of water. Good ponds can be constructed in these areas, even though the seepage rate is rapid. Careful study of the areas is needed before constructing the ponds.

Many of the soil features affecting farm ponds are also applicable to sewage lagoons. In addition to these features, relief, depth of the water table, and organic-matter content are important features affecting sewage lagoons. Level relief, a low water table, and low organic-matter content are desirable features for lagoons.

Town and country planning

Some features important to development of sites for residences already have been discussed, such as suitability of the soils for domestic sewage disposal systems. Further information that should be considered is discussed in the paragraphs that follow.

Important factors to consider in using the soils for residential development are soil drainage, permeability, stability, and the frequency of flooding. Soils that are somewhat poorly drained or poorly drained, that have a seasonal high water table, or that have slow or very slow permeability are poor sites for residential construction.

On wet and slowly permeable soils, basements are difficult to keep dry. The best soils in the county for residential use are the well-drained soils that formed in sandy loam and loamy sand material. The most favorable soils are those of the Blue Lake, Emmet, Leelanau, and Mancelona series. The very sandy, well-drained Eastport, Kalkaska, and Rubicon soils also are suited, except for droughtiness. On these soils good lawns and shrubs can be established and maintained if they are watered regularly. Blanketing the areas with a loamy topsoil makes them less droughty.

Wet alluvial land and the Kerston soils on the flood plains of streams in the county are severely limited for residential development because of the hazard of flooding.

Formation, Morphology, and Classification of Soils [6]

This section consists of three main parts. The first part tells how the factors of soil formation have affected the development of soils in Charlevoix County. The second part discusses the morphology of the soils. The third part explains the system of soil classification and places each soil series in the county in the various categories of the system.

Factors of Soil Formation

Soil is developed by soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil formation have acted on the parent material.

Climate and plant and animal life are active factors of soil formation. They act on the parent material and slowly change it to a natural body of soil that has genetically related layers called horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent

[6] R. W. JOHNSON, State soil scientist, and H. R. SINCLAIR, JR., assistant State soil scientist, Soil Conservation Service, assisted in the preparation of this section.

material into a soil profile. It may be long or short, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

Parent material is the unconsolidated mass in which a soil is formed. The parent materials of the soils of Charlevoix County were deposited by glaciers or by melt water from the glaciers. Some of these materials were reworked and redeposited by subsequent actions of water and wind. These glaciers covered the county from about 10,000 to 12,000 years ago. Parent material determines the limits of the chemical and mineralogical composition of the soil. Although parent materials are of common glacial origin, their properties vary greatly, sometimes within small areas, depending on how the materials were deposited. The dominant parent materials in Charlevoix County were deposited as glacial till, outwash deposits, lacustrine deposits, alluvium, and organic material.

Glacial till is material laid down directly by glaciers with a minimum of water action. It consists of particles of different sizes that are mixed together. The small pebbles in glacial till have sharp corners, indicating that they have not been worn by water washing. The glacial till in Charlevoix County is effervescent and ranges from loose to very firm. Its texture is loamy sand, sandy loam, loam, clay loam, or silty clay loam. The till contains few to many coarse fragments. An example of soils formed in glacial till are those of the Leelanau series.

Outwash materials are deposited by running water from melting glaciers. The size of the particles that make up outwash material varies according to the speed of the stream of water that carried them. When the water slows down, the coarser particles are deposited. Finer particles, such as very fine sand, silt, and clay, can be carried by slowly moving water. Outwash deposits generally consist of layers of particles of similar size, such as loamy sand, sand, gravel, and other coarse particles. The East Lake soils, for example, formed in deposits of outwash material in Charlevoix County.

Lacustrine materials are deposited from still, or ponded, glacial melt water. Because the coarser fragments drop out of moving water as outwash, only the finer particles, such as very fine sand, silt, and clay, remain to settle out in still water. Lacustrine deposits are silty or clayey in texture. In Charlevoix County the soils formed in lacustrine deposits are typically loamy or clayey. The Rudyard series is an example of soils formed in lacustrine materials.

Alluvium material is deposited by floodwaters of present streams in Recent time. This material varies in texture, depending on the speed of the water from which it was deposited. The Kerston series is an example of alluvial soils.

Organic material is made up of deposits of plant remains. After the glaciers withdrew from the area, water was left standing in depressions on outwash, lake, and till plains. Grasses and sedges growing around the edges of these lakes died, and their remains fell to the bottom. Because of the wetness of these areas, the plant remains did not decompose but remained around the edges of the lakes. Later, white-cedar and other water-tolerant trees grew in these areas. As these trees died, their residue became a part of the organic accumulation. The lakes were eventually filled with organic material and developed into areas of muck and peat. In some of these areas, the material has changed little since deposition. Soils of the Lupton series are an example of soils formed in organic material.

Plant and animal life

Plants have been the principal organisms influencing the soils in Charlevoix County; however, bacteria, fungi, earthworms, and the activities of man have also been important. The chief contribution of plant and animal life is the addition of organic matter and nitrogen to the soil. The kind of organic material on and in the soil depends on the kind of plants that grew on the soil. The remains of these plants accumulate on the surface, decay, and eventually become organic matter. Roots of the plants provide channels for downward movement of water through the soil and also add organic matter as they decay. Bacteria in the soil help to break down the organic matter so that it can be used by growing plants.

The vegetation in Charlevoix County was mainly mixed trees. Differences in natural soil drainage and minor changes in parent material have affected the composition of the tree species.

In general, the well drained or moderately well drained soils on uplands, such as East Lake, Leelanau, and Nester soils, were covered with sugar maple, beech, red pine, white pine, and hemlock. The Deer Park soils dominantly were covered with jack pine, red oak, white birch, and aspen. The wet soils dominantly were covered with white-cedar, Tarmerack, black spruce, elm, soft maple, and balsam fir. A few wet soils also had sphagnum and other mosses that contributed substantially to the accumulation of organic matter. The Bruce and Munuscong soils formed under wet conditions and contain a considerable amount of organic matter. Thus, the soils of Charlevoix County that dominantly formed under forest vegetation generally have less total accumulated organic matter than soils in other parts of the county that dominantly formed under grass vegetation.

Climate

Climate is important in the formation of soils. It determines the kind of plant and animal life on and in the soil. It determines the amount of water available for weathering of minerals and the transporting of soil materials. Climate, through its influence on temperature in the soil, determines the rate of chemical reaction that occurs in the soil. These influences are important, but they affect large areas rather than a relatively small area, such as a county.

The climate in Charlevoix County is cool and humid. This is presumably similar to that which existed when the soils were being formed. The soils in Charlevoix County differ from soils formed in a dry, warm climate or from those that formed in a hot, moist climate. Climate is uniform throughout the county, although its effect is modified locally by proximity to large bodies of water. There-

fore, the differences in the soils of Charlevoix County, to a minor extent, are the result of the differences in climate.

Relief

Relief or topography has a marked influence on the soils of Charlevoix County through its influence on natural drainage, erosion, plant cover, and soil temperature. In Charlevoix County slopes range from nearly level to very steep. Natural soil drainage ranges from well drained on the ridgetops to very poorly drained in the depressions.

Relief influences the formation of soils by affecting runoff and drainage; drainage, in turn, through its affect on aeration of the soil, determines the color of the soil. Runoff of water is greatest on the steeper slopes, and water is temporarily ponded in low areas. Water and air move freely through soils that are well drained but slowly through soils that are very poorly drained. In soils that are well aerated, the iron and aluminum compounds that give most soils their color are bright colored and oxidized. Poorly aerated soils are dull gray in color and are mottled. The Leelanau series is an example of well-drained, well-aerated soils. The Breckenridge series is an example of very poorly drained, poorly aerated soils.

Time

Time, generally a long time, is required for the formation of distinct horizons in soils. The differences in the length of time that the parent materials have been in place are commonly reflected in the degree of development of the soil profile. Some soils develop rapidly, others slowly.

The soils in Charlevoix County range from young to mature. The glacial deposits in which many of the soils formed have been exposed to soil-forming influences long enough to allow distinct horizons to develop within the soil profile. Some soils, however, such as those forming in recent alluvial sediments, have not been in place long enough for distinct horizons to develop.

The Kerston series is an example of young soils formed in alluvial material. The Alpena and Kiva series are examples of the effect of time on the leaching of lime from the soil. The solum of the Alpena and Kiva soils once had about the same amount of lime as the IIC horizon of these soils has today. The Alpena soils were submerged under glacial lake water and protected from leaching, but the Kiva soils were above glacial lake water longer than the Alpena soils and were subject to leaching. The difference in the length of time of leaching is reflected in the Kiva soils, some of which are leached of lime to a depth of 18 inches. On the other hand, the Alpena soils are leached of lime to a depth of only 10 inches.

Morphology of Soils

Several processes were involved in the formation of soil horizons in the soils of Charlevoix County. These processes are (1) accumulation of organic matter, (2) leaching of lime (calcium carbonates) and other bases, (3) reduction and transfer of iron, and (4) formation and translocation of silicate clay minerals. In most of the soils in Charlevoix County, more than one of these processes has been active in the development of the horizons.

Organic matter has accumulated at the surface to form an A1 horizon. The A1 horizon is mixed into a plow layer if the soil is plowed. The soils of Charlevoix County have a surface horizon that ranges from very high to low in organic-matter content. The Ruse series is an example of soils that have very high organic-matter content in the surface layer. The Deer Park soils have low organic-matter content in the surface layer.

Leaching of carbonates and other bases has occurred in most of the soils in the county. Soil scientists generally agree that leaching of bases in soils usually precedes translocation of silicate clay minerals. Many of the soils are moderately to strongly leached, and this contributed to the development of horizons.

Reduction and transfer of iron, a process called gleying, is evident in the somewhat poorly drained to very poorly drained soils. The grayish color in the subsoil horizons indicates the reduction and loss of iron. Munuscong soils are an example of gleying and the reduction processes. Some horizons contain mottles and concretions, which indicates the segregation of iron. This process has taken place in the Charlevoix and Otisco soils.

In some soils the translocation of clay minerals has contributed to horizon development. In these soils the eluviated (leached) A2 horizon above the illuviated (accumulation) B horizon has a platy structure, is lower in content of clay, and generally is lighter in color. The B horizon generally has an accumulation of clay (clay films) in pores and on the surfaces of peds. These soils were probably leached of carbonates and soluble salts to a considerable extent before translocation of silicate clay took place. Leaching of bases and translocation of silicate clays are among the more important processes in horizon differentiation in the soils. The Nester soils are an example of soils having translocated silicate clays accumulated in the B horizon in the form of clay films.

In some of the soils in Charlevoix County, iron, aluminum, and humus have moved from the surface to the B horizon. The Wallace, Kalkaska, and Leelanau soils are examples of such soils.

Classification of Soils

Soils are classified so that their significant characteristics can be more easily remembered. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us understand their behavior and their response to manipulation.

The system of classification was adopted by the National Cooperative Soil Survey in 1965. This system is under continual study (*4*, *6*). Therefore, readers interested in new developments of this soil classification system should search the latest available literature. The soil series in Charlevoix County are placed in the system in table 9.

The system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped together. The six categories of the system are briefly defined in the following paragraphs.

TABLE 9.—*Classification of soil series* [1]

Soil series	Family	Subgroup	Order
Alpena	Sandy-skeletal, mixed	Typic Haploborolls	Mollisols.
Angelica [2]	Fine-loamy, mixed, nonacid, frigid	Aeric Haplaquepts	Inceptisols.
Au Gres	Sandy, mixed, frigid	Entic Haplaquods	Spodosols.
Barker	Fine-loamy, mixed	Mollic Eutroboralfs	Alfisols.
Barker, shallow variant	Fine, mixed, frigid	Aeric Ochraqualfs	Alfisols.
Belding [2]	Coarse-loamy, mixed, frigid	Alfic Haplaquods	Spodosols.
Bergland [2]	Very-fine, illitic, nonacid, frigid	Aeric Haplaquepts	Inceptisols.
Blue Lake	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols.
Breckenridge [2]	Coarse-loamy, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Brevort [2]	Sandy over loamy, mixed, noncalcareous, frigid	Mollic Haplaquents	Entisols.
Brimley	Fine-loamy, mixed, frigid	Alfic Haplaquods	Spodosols.
Bruce [2]	Fine-loamy, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Carbondale [3]	Euic	Hemic Borosaprists	Histosols.
Cathro [3]	Loamy, euic	Terric Borosaprists	Histosols.
Charlevoix [2]	Coarse-loamy, mixed, frigid	Alfic Haplaquods	Spodosols.
Croswell	Sandy, mixed, frigid	Entic Haplorthods	Spodosols.
Deer Park [2]	Mixed, frigid	Spodic Udipsamments	Entisols.
Detour	Fine-loamy, mixed, frigid	Aquic Eutrochrepts	Inceptisols.
East Lake	Sandy, mixed, frigid	Typic Haplorthods	Spodosols.
Eastport	Mixed, frigid	Spodic Udipsamments	Entisols.
Edmore [2]	Sandy, mixed, mesic	Mollic Haplaquents	Entisols.
Edwards [2 3]	Marly, euic, mesic	Limnic Medisaprists	Histosols.
Emmet	Coarse-loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Ensley	Coarse-loamy, mixed, nonacid, frigid	Aeric Haplaquepts	Inceptisols.
Epoufette [2]	Sandy, mixed, frigid	Mollic Haplaquents	Entisols.
Gladwin	Sandy, mixed, frigid	Alfic Haplaquods	Spodosols.
Greenwood [3]	Euic	Typic Borohemists	Histosols.
Hessel	Coarse-loamy, mixed, calcareous, frigid	Mollic Haplaquepts	Inceptisols.
Iosco [2]	Sandy over loamy, mixed, frigid	Aqualfic Haplorthods	Spodosols.
Johnswood	Loamy-skeletal, mixed	Typic Haploborolls	Mollisols.
Kalkaska	Sandy, mixed, frigid	Typic Haplorthods	Spodosols.
Kawkawlin [2]	Fine, mixed	Aquic Eutroboralfs	Alfisols.
Kerston [2 3]	Euic, mesic	Fluventic Medisaprists	Histosols.
Kiva	Sandy, mixed, frigid	Entic Haplorthods	Spodosols
Leelanau [2]	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols.
Linwood [2 3]	Loamy, euic, mesic	Terric Medisaprists	Histosols.
Lupton [3]	Euic	Typic Borosaprists	Histosols.
Mackinac [2]	Fine-loamy, mixed, frigid	Alfic Haplaquods	Spodosols.
Mancelona	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols
Markey [3]	Sandy or sandy-skeletal, euic	Terric Borosaprists	Histosols.
Menominee [2]	Sandy over loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Munuscong [2]	Coarse-loamy over clayey, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Nester	Fine, mixed	Typic Eutroboralfs	Alfisols.
Onaway	Fine-loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Otisco	Sandy, mixed, frigid	Entic Haplaquods	Spodosols.
Roscommon [2]	Mixed, frigid	Mollic Psammaquents	Entisols.
Rubicon	Sandy, mixed, frigid	Entic Haplorthods	Spodosols.
Rudyard [2]	Very-fine, illitic	Aquic Eutroboralfs	Alfisols.
Ruse [2]	Loamy, mixed, nonacid, frigid	Lithic Haplaquepts	Inceptisols.
Saugatuck [2]	Sandy, mixed, mesic, orstein	Aeric Haplaquods	Spodosols.
Sims [2]	Fine, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Summerville	Loamy, mixed, frigid	Entic Lithic Haplorthods	Spodosols.
Tawas [3]	Sandy, euic	Terric Borosaprists	Histosols.
Ubly	Coarse-loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Wallace	Sandy, mixed, frigid, orstein	Typic Haplorthods	Spodosols.
Warners [2]	Fine-silty, mixed, calcerous, mesic	Typic Haplaquolls	Mollisols.

[1] Classification is as of February 1971. Placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

[2] These soils are taxadjuncts. The features outside the defined range for the series are discussed in the descriptions of the soil series.

[3] The classification of the organic soils in this table shows the placement of these soil series in the current system of classification. It is based on how similar soils are currently mapped and defined. The profile descriptions of these soils in this survey, however, were made prior to 1968, and they do not reflect current horizon nomenclature and should not be used to place the soils into the current classification.

Order. Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which may occur in many different climates.

The soil orders in Charlevoix County are Alfisols, Entisols, Histosols, Inceptisols, Mollisols, and Spodosols.

Alfisols are soils that have a clay-enriched B horizon that is high in base saturation. The Kawkawlin, Nester, and Barker soils represent the Alfisols in Charlevoix County.

Entisols are recent soils. They lack genetic horizons or have only the beginnings of such horizons. The Brevort soils are an example of the Entisols in Charlevoix County.

Histosols are soils formed in organic material. They include soils commonly called mucks, peats, organic soils, or bogs. The Carbondale soils are an example of the Histosols in Charlevoix County.

Inceptisols most often are on young but not recent land surfaces. The Detour and Munuscong soils are examples of the Inceptisols in Charlevoix County.

Mollisols are soils that have a thick, dark-colored surface layer. The Johnswood soils are an example of Mollisols in the county.

Spodosols are soils that have a B horizon that is enriched with iron, aluminum, and humus. In Charlevoix County the Spodosols are represented by the Kalkaska and Wallace soils.

Suborder. Each order is subdivided into suborders, primarily on the basis of those soil characteristics that seem to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect the presence or absence of waterlogging or soil differences resulting from the climate or vegetation. An example of the suborder category is Saprists and Orthods.

Great group. Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that have pans that interfere with the growth of roots or movement of water. The features used are some properties of clays, soil temperature, and major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium).

Subgroup. Great groups are subdivided into subgroups, one representing the central concept of the group and others called intergrades and extragrades. Intergrade subgroups have properties of the group and also one or more properties of another great group, suborder, or order. Extragrade subgroups have properties of the group and have characteristics that are not diagnostic of another great group, suborder, or order. Examples of subgroup names are Typic Borosaprists for central concept, Hemic Borosaprists for intergrades, and Terric Borosaprists for extragrades.

Family. Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, depth, slope, consistence, and coatings. A family name consists of a series of adjectives, which are the class names for texture, mineralogy, and so on, that are used as family differentiae. An example is the sandy, mixed, frigid family.

Series. The series is a group of soils that have major horizons that, except for texture of the surface layer, are similar in important characteristics and in arrangement in the profile. They are commonly given the name of a geographic location near the place where that series was first observed and mapped. An example is the Charlevoix series.

General Nature of the County

This section first discusses briefly the climate of Charlevoix County. Then it discusses farming.

Climate [7]

All of Charlevoix County has a climate modified by the nearness of Lake Michigan. There are two weather stations in the county, one at East Jordan and the other at Boyne Falls. Records at these two locations do not show a great deal of difference, except that the length of the growing season is 98 days at Boyne Falls and 120 days at East Jordan. The growing season is longer at East Jordan because it is closer to Lake Michigan and there is a greater modification of extreme temperatures. Tables 10 and 11 give weather data recorded at East Jordan and at Boyne Falls.

Weather records are more complete at East Jordan, so the information in the following paragraphs is for the East Jordan location. Available records at Boyne Falls, however, indicate very similar conditions.

Weather data for East Jordan show that the highest temperature ever recorded was 103° F. on July 13, 1936, and the lowest was —39° on February 9, 1934. Temperatures reach 90° an average of 10 days a summer and have reached 100° only twice in 30 years. At the other extreme, temperatures fall below zero an average of 12 times a year.

February 1934, which had a mean temperature of 8.6°, was the coldest month on record; July 1955, which had a mean temperature of 75.6°, was the warmest month on record. The average dates of the last freezing temperature in spring and the first freezing temperature in fall are May 31 and September 28, respectively. The probabilities of the last freezing temperature in spring and the first in fall are given for East Jordan and Boyne Falls in table 11.

Precipitation is heaviest during the summer months, and an average of 57 percent of the annual total falls during the period from April through September. Heaviest rainfall is in September, when the average is 4.33 inches. The greatest total monthly rainfall on record was 10.13 inches in August 1959. The driest month on record was February 1929, when the total precipitation was only 0.22 inch. The heaviest intensity of rainfall occurs in

[7] NORTON D. STROMMEN, climatologist for Michigan, National Weather Service, U.S. Department of Commerce, helped to prepare this subsection.

TABLE 10.—*Temperature and precipitation data at Boyne Falls and at East Jordan, Charlevoix County, Michigan*

BOYNE FALLS [1]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One year in 10 will have—		Days with snow cover	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	28.0	11.5	40	−7	2.01	1.0	3.3	31	13.3
February	30.6	11.4	45	−14	1.61	.8	2.9	28	17.2
March	37.1	16.1	53	−3	1.82	.8	3.1	30	14.2
April	53.9	30.2	76	17	2.47	.9	3.9	8	4.9
May	68.0	39.0	84	25	2.88	1.5	4.9	(2)	1.0
June	76.9	49.2	90	34	3.91	1.8	8.4	0	
July	81.3	53.3	92	41	3.28	1.2	4.9	0	
August	79.9	52.2	91	38	3.08	1.8	4.6	0	
September	69.7	45.9	86	31	4.33	2.4	6.3	0	
October	60.9	38.0	78	25	2.75	.6	5.6	(2)	3.3
November	43.1	27.4	62	15	2.91	1.4	3.8	10	5.0
December	31.5	17.5	47	−2	2.40	1.8	3.0	26	9.8
Year	55.1	32.6			33.45			133	
EAST JORDAN [3]									
January	29.0	14.7	40	−2	2.02	1.1	3.2	30	12.4
February	29.8	12.3	42	−13	1.24	.6	1.7	28	14.7
March	37.9	18.9	57	−2	1.55	.7	2.6	26	10.7
April	53.4	31.4	72	19	2.36	1.0	3.6	3	3.2
May	66.7	41.3	82	28	3.10	1.6	5.1	0	
June	76.8	51.8	88	37	3.02	1.2	4.4	0	
July	81.7	56.5	92	44	2.84	1.6	4.1	0	
August	79.6	55.5	91	41	3.43	1.4	5.9	0	
September	70.4	48.9	86	34	4.03	2.3	6.0	0	
October	59.5	39.8	75	27	2.76	1.0	4.4	(2)	1.9
November	43.8	30.1	61	17	3.24	1.8	4.6	8	3.3
December	32.5	20.3	47	3	2.11	1.2	3.0	25	7.3
Year	55.1	35.1			31.70			120	

[1] For period 1950–64.
[2] Less than 1 day.
[3] For period 1935–64.

connection with thundershower activity, and the heaviest recorded 24-hour amount was 3.59 inches on August 21, 1959. An hourly intensity of as much as 1.0 inch occurs an average of once in 2 years.

Snowfall averages 79.2 inches per season, but it varies considerably from year to year. Seasonal totals in the last 30 years have ranged from 133 inches in the 1958–59 season to 35 inches in the 1959–60 season. January has the greatest average snowfall, 21.6 inches. The greatest amount recorded for a single day was 13.1 inches on March 15, 1959.

Cloudiness is greatest late in fall and early in winter. Prevailing westerly winds pick up warmth and moisture while passing over Lake Michigan. Instability results, which is augmented by the air being forced to a somewhat higher altitude when it reaches land. This causes low cloudiness and a considerable amount of light drizzle or snow flurry activity late in fall and early in winter. This weather condition, to some extent, covers all of the lower peninsula, but it is most pronounced near Lake Michigan.

Farming

The total land area of Charlevoix County is about 264,960 acres. Of this, about 27 percent, or 71,466 acres, is in farms (*8*). The rest consists mainly of State land, privately owned woodland, abandoned farmland, and resort, urban, recreational, and industrial areas. Of the acreage in farms in 1964, 18,828 acres was in harvested crops, and 10,227 acres was used only for pasture.

There were 405 farms in the county in 1964. Of these farms, 66 were from 1 to 49 acres in size, 76 were from 50 to 99 acres, 181 were from 100 to 259 acres, 63 were from 260 to 499 acres, and 18 were from 500 to 999 acres. Only one farm was larger than 1,000 acres.

Of the 405 farms in the county, 217 farms were miscellaneous or unclassified farms, 72 were dairy farms, 68 were poultry and livestock farms other than dairy, and the rest were vegetable field crop, fruit, and general farms.

Corn is the chief row crop grown, and in 1964 there

TABLE 11.—*Probabilities of last freezing temperatures in spring and first in fall at Boyne Falls and at East Jordan, Charlevoix County, Michigan*

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
BOYNE FALLS [1]					
Spring:					
1 year in 10 later than	April 23	May 8	May 25	June 7	June 19
2 years in 10 later than	April 18	May 3	May 20	June 2	June 14
5 years in 10 later than	April 8	April 23	May 10	May 23	June 4
Fall:					
1 year in 10 earlier than	November 4	October 18	October 2	September 12	August 25
2 years in 10 earlier than	November 9	October 23	October 7	September 17	August 30
5 years in 10 earlier than	November 20	November 3	October 18	September 28	September 10
EAST JORDAN [2]					
Spring:					
1 year in 10 later than	April 15	April 29	May 16	May 30	June 15
2 years in 10 later than	April 10	April 24	May 11	May 25	June 10
5 years in 10 later than	March 31	April 14	May 1	May 15	May 31
Fall:					
1 year in 10 earlier than	November 11	November 3	October 18	October 3	September 12
2 years in 10 earlier than	November 22	November 14	October 29	October 14	September 23
5 years in 10 earlier than	November 27	November 19	November 3	October 19	September 28

[1] For period 1950–64.

[2] For period 1935–64.

was 1,467 acres harvested for grain and 1,488 acres cut for silage. Small grain also is grown in the county, and in 1964 there was 393 acres of wheat, 1,980 acres of oats, 123 acres of barley, and 82 acres of rye. Of the hay crops harvested, 10,197 acres was alfalfa and alfalfa mixtures, 1,322 acres was clover or timothy, and 346 acres was other hay crops. There was only 37 acres of potatoes grown for sale and 64 acres of beans. There was 729 acres of fruit harvested for sale and 232 acres of vegetables.

Of fruits harvested, there were 2,648,129 pounds of apples, 7,986 pounds of peaches, 28,120 pounds of pears, 2,450,088 pounds of cherries, 16,670 pounds of plums and prunes, and 2,748 pounds of grapes. Of berries harvested for sale, 8,898 pounds were strawberries. Of woodland products harvested for sale, there were 60 cords of firewood and fuel wood, 72,000 board feet of saw logs and veneer logs, and 400 Christmas trees.

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Glossary

Acidity. See Reaction, soil.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkalinity. See Reaction, soil.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Cover crop. A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and in Podzolic soils they commonly have mottling below 6 to 16 inches in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Drumlin (geology). A streamlined hill or ridge of glacial deposits with a long axis that is parallel to the direction of flow of a former glacier.

Genesis, soil. The manner in which a soil originates. Refers especially to the processes initiated by climate and organisms that are responsible for the development of the solum, or true soil, from the unconsolidated parent material, as conditioned by relief and age of the landform.

Glacial outwash. Sandy and gravelly materials deposited in layers on plains or in old glacial drainageways by water from melting glaciers.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Green manure (agronomy). A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residue.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizons; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Kame (geology). An irregular, short ridge or hill of stratified glacial drift.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Mineral soil. Soil composed mainly of inorganic (mineral) material and low in content of organic material. Its bulk density is greater than that of organic soil.

Miscellaneous land type. A mapping unit for areas of land that have little or no natural soil; or that are too nearly inaccessible for orderly examination; or that occur where, for other reasons, it is not feasible to classify the soil.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical mineralogical, and biological properties of the various horizons, and their thickness and arrangement in the soil profile.

Muck. Well-decomposed, organic soil material developed from peat. Muck generally has a higher mineral or ash content than peat and the original plant parts cannot be identified. See also peat.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Organic soil. A general term applied to a soil or to a soil horizon that consists primarily of organic matter, such as peat soils, muck soils, and peaty soil layers. In chemistry, organic refers to the compounds of carbon.

Ortstein. The B horizon in a Spodosol that is cemented by accumulated sesquioxides, by organic matter, or by both.

Peat. Unconsolidated soil material, largely undecomposed organic matter that has accumulated where there has been excess moisture.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Phase, soil. A subdivision of a soil, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil series, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects its management but not its behavior in the natural landscape.

pH value. A numerical means for designating relatively weak acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slope. The inclination of the land surface from the horizontal; percentage of slope is the vertical distance, divided by horizontal distance times 100. Thus a slope of 10 percent is a drop of 10 feet in 100 feet of horizontal distance.

Soil separates. Mineral particles, less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0 millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

Solodized soil. A soil that has been subjected to the processes responsible for the development of a Soloth and having at least some of the characteristics of a Soloth.

Solom. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Taxadjunct. Soils handled as taxadjuncts are considered adjuncts but not parts of the series furnishing a name for their identification. They are so much like the soils of the defined series in morphology, composition, and behavior that little would be gained by adding a new series.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Valley train. The material deposited by the stream in the valley below a glacier.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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