Issued October 1968

Soil Survey

MUSKEGON COUNTY MICHIGAN

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
MICHIGAN AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1938–40. Soil names and descriptions were approved in 1966. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1965. This survey was made cooperatively by the Soil Conservation Service and Michigan Agricultural Experiment Station as part of the technical assistance furnished to the North Muskegon and South Muskegon Soil Conservation Districts.

This published soil survey uses some phases of sloping soils and of eroded soils and some names of soil series that have been correlated by the Soil Conservation Service differently from those used earlier by the Soil Conservation Service and the Michigan Agricultural Experiment Station. In the following, the Michigan Agricultural Experiment Station prefers the soil series names that are in parentheses: Chelsea (Graycalm), Saranac (Gormer), Sloan (Pinora), and the loamy substratum phase of the Rubicon (Melita).

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of Muskegon County contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

Locating Soils

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

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. 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 in the survey. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit. It also gives the woodland suitability group or any other group in which the soil has been placed.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. 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 in the descriptions of the soils and in the discussions of the capability units and woodland suitability groups.

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

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the section "Use of the Soils for Wildlife."

Community planners and others concerned with suburban development can read about the soil properties that affect the choice of homesites, industrial sites, schools, and other uses in the section "Use of Soils in Community Developments."

Engineers and builders will find under "Engineering Uses of the Soils" tables that give engineering test data for the soils in the county and that name soil properties and features that affect engineering practices and structures.

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

Newcomers in Muskegon 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 section "General Nature of the County."

Cover Picture: Rolling landscape of Nester, Kawkawlin, and Sims soils in the southern part of Muskegon County, where apples are an important crop.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Contents

Issued October 1968

SOIL SURVEY OF MUSKEGON COUNTY, MICHIGAN

BY KARL E. PREGITZER, SOIL CONSERVATION SERVICE

FIELDWORK BY H. BUCKLEY, D. HERST, R. D. HALL, L. R. JONES, T. J. LONGWELL, W. MYER, K. E. PREGITZER, AND E. C. SEASE

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH MICHIGAN AGRICULTURAL EXPERIMENT STATION

MUSKEGON COUNTY is in the western part of the Lower Peninsula of Michigan, along the shore of Lake Michigan (fig. 1). It has a land area of 322,560 acres, or 504 square miles. Muskegon, the county seat and largest city, is in the southwestern part of the county.

Agriculture is the principal enterprise in Muskegon County, and corn, small grains, hay, and fruit are the principal crops. Dairy cows and other livestock are kept on most farms. Large areas of the county are wooded. Recreation is important in the county, especially in areas adjacent to Lake Michigan.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Muskegon 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 or proportion.

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 farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The eight soil associations in Muskegon County are described briefly in this section. More information about the individual soils in each soil association can be obtained from the detailed soil map at the back of this survey and from the section "Descriptions of the Soils."

1. Rubicon-Croswell-Deer Park Association

Nearly level to steep, well drained and moderately well drained, sandy soils on outwash plains, beach ridges, and dunes

This association consists of steep sand dunes along Lake Michigan and of rolling hills and nearly level plains that extend inland from the lake. The association covers 38 percent of the county.

The Rubicon soils make up 65 percent of this association; the Croswell soils, 20 percent; and the Deer Park soils, 5 percent. The remaining 10 percent consists mostly of Au Gres and Roscommon soils and organic soils.

The Rubicon soils occupy the nearly level to rolling uplands. Croswell soils are in nearly level to gently sloping areas in which the water table is near the surface during wet periods. Deer Park soils occupy the sand dunes along Lake Michigan. The Au Gres soils are somewhat poorly drained and sandy, and the Roscommon soils are poorly drained and sandy.

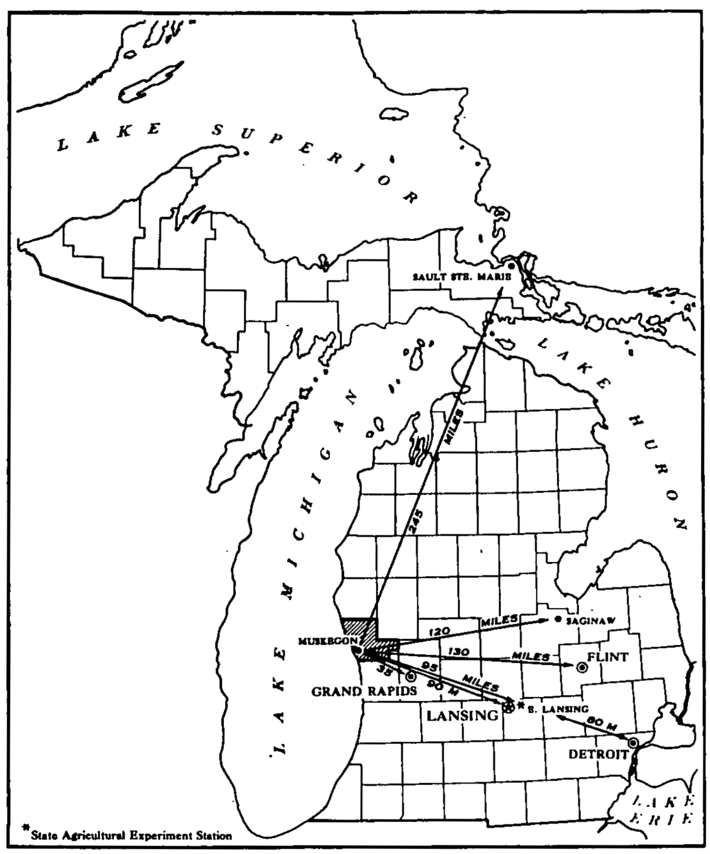

Figure 1.—**Location of Muskegon County in Michigan.**

[1] HENRY DIERKING, Soil Conservation Service, helped prepare this section.

The most droughty and sandy soils in the county are in this association. In these soils sand extends to a depth of 4 feet or more. Available moisture capacity and natural fertility are low, and soil blowing is likely in cultivated areas. In many areas where soil blowing has been severe, practices are needed for stabilizing the soil.

The soils of this association originally supported a dense pine forest that was almost completely harvested by 1900. Except for the dunes along Lake Michigan, much of the area was cleared for farming. Because soil blowing was severe and productivity was low, the soils were soon abandoned. The cutover woodland was repeatedly swept by fire. Areas that were not planted were taken over by scrubby black and white oaks. Because fire control has been improved, these areas now have a dense understory of naturally reproduced white pine. Releasing this white pine by thinning is a much needed management practice.

This soil association is one of the best in the county for recreational and community development. In it are the city of Muskegon and its subdivisions. Sites for houses and other buildings are generally good. The soils provide good foundations for buildings, highways, and other structures. Tourists and residents, especially in the dune area, enjoy many miles of scenery. Foot and horse trails extend through this association, and there are many camps and parks. Private and public holdings are rapidly being converted to wildlife and recreational areas. Scout camps, public parks, and other recreational facilities are numerous and cover approximately 50,000 acres.

2. Rubicon-Au Gres-Roscommon Association

Gently sloping, well-drained and poorly drained, sandy soils on outwash plains and uplands

This association consists of sloping, dry sands intermingled with dark-colored wet sands that lie at the base of slopes and in depressions. The association is less sloping than association 1. It occupies 17 percent of the county.

The Rubicon soils make up 35 percent of this association; the Au Gres soils, 25 percent; and the Roscommon soils, 25 percent. The remaining 15 percent consists of Granby, Saugatuck, and Tawas soils.

The well-drained Rubicon soils occupy the sloping areas. The somewhat poorly drained Au Gres soils are generally less sloping than the Rubicon soils and are lighter colored than the Roscommon soils. The Roscommon soils are in depressions and are poorly drained. Also in this association are dark-colored, wet fine sands that contain thin lenses of clay.

Although the soils are poor for farming, more farms are located in this association than in association 1. The farms are generally in the wetter areas of dark-colored soils. The farms generally range from 20 to 160 acres.

The soils in this association, like those in association 1, were cleared of trees and farmed, were severely damaged by soil blowing, and were abandoned. Because they contained more moisture than the soils in association 1, they were not abandoned so soon. After the logging period, nearly all farms in association 2 consisted of a combination of Rubicon, Au Gres, and Roscommon soils. The dry, sloping Rubicon soils were planted largely to grape vineyards and orchards, and the wetter Au Gres and Roscommon soils were used for general crops. The vineyards and orchards did not last long, because they could not withstand the frost, drought, erosion, and low fertility. Some of the worst wind-eroded areas in the county were these old vineyards and orchards and tracts of Rubicon soils. Blowouts, 5 to 10 feet deep, appeared on many of the dry sand ridges. In Sullivan Township, a blowout area of 2,000 acres was widely known as Sullivan Sahara.

People are moving back into the abandoned areas, are building new homes on the better drained sites, and are farming part time on a small scale. Under irrigation, small fruits, vegetables, ornamental plants, and other specialized crops are grown. These crops are planted mainly in the wetter areas of Au Gres and Roscommon soils. Shallow wells and ponds of the pit type supply a limited amount of irrigation water. Wildlife is benefited by the intermixing of small part-time farms, idle fields, and wooded areas. The soils in this association are suited as woodland and for community developments, limited farming, and recreation.

3. Au Gres-Roscommon-Granby Association

Nearly level and slightly depressional, poorly drained, sandy soils on outwash plains, uplands, and lake plains

This association consists of nearly level and depressional areas on outwash and lake plains and on low benches in old river channels and lakes. It consists mainly of wet sands, whereas association 1 consists of dry sands and association 2 consists of both wet and dry sands. A few areas of well-drained sands occur in association 3, and some of the more poorly drained areas have a cemented layer in the subsoil. The association covers 16 percent of the county.

The Au Gres soils make up 35 percent of this association; the Roscommon soils, 30 percent; and the Granby soils, 25 percent. The remaining 10 percent consists mainly of the Saugatuck, Deford, and Tawas soils.

The soils in this association have a high water table. In the Roscommon and Granby soils, the water table remains near the surface during much of the year, and in the Au Gres soils it is near the surface during wet periods. Granby soils have a thicker surface layer and are less acid than Roscommon soils.

The soils in this association are low in natural fertility and commonly are poor for farming. Farming is generally limited to blueberries and other special crops and to truck crops grown under irrigation. General farm crops grow poorly because the soils are cold and wet, and in low areas, crops are susceptible to damage by early frost. Drainage is difficult because adequate outlets are lacking. Trees are abundant in this association, but they generally grow slowly and are of low quality. Reforestation is limited mainly to Christmas tree plantations on the better drained Au Gres soils.

Some houses are being built in this association, but the soils generally have severe limitations as homesites. The high water table restricts the proper functioning of sewage disposal systems. Sewage effluent sometimes pollutes shallow wells because it is not adequately filtered by these porous soils. This association is probably best adapted to open areas for recreation, such as hunting and nature study. Wildlife is abundant because native plants furnish an ample supply of food and cover.

4. Nester-Ubly-Sims Association

Gently sloping to hilly, well drained, moderately well drained, and poorly drained, loamy soils on lake plains and uplands

This association is in the southeastern and northwestern parts of the county. In most places it is gently sloping to rolling, but some of the steepest slopes and the highest elevations in the county occur in this association. The soils are finer textured and more fertile than those of associations 1, 2, and 3. This association covers 8 percent of the county.

The Nester soils make up 45 percent of this association; the Ubly soils, 20 percent; and the Sims soils, 20 percent. Most of the remaining 15 percent consists of Kawkawlin and Belding soils.

The well drained and moderately well drained Nester and Ubly soils occupy the steepest areas, and the poorly drained, fertile Sims soils occupy the lower slopes and basins between the slopes. The Ubly soils are coarser textured in the upper part of the profile than the Nester soils. The somewhat poorly drained Kawkawlin and Belding soils lie along the lower margins of the slopes.

The soils of this association are well suited to general farming. Most of the livestock are on dairy farms, but there are also poultry farms and beef-cattle farms. Corn, small grains, and hay are the main cultivated crops. Much of the association, especially that at the higher sites, is in orchards, for here air drainage is good. Apples and cherries are the main orchard crops, but peaches, pears, and plums also are grown.

Because water erosion is a serious hazard in the rolling areas, it is essential that a suitable cropping system is selected and that practices for conserving soil and water are used. Among these practices are contour farming and stripcropping. Where contour farming is not practical, these soils are farmed across the slope and a good cropping system is used.

Practically all orchards have a permanent cover of a sod crop. Chewing fescue is commonly used. In some orchards, the trees are planted on the contour. Other orchards are terraced or are designed and managed in other ways for controlling erosion.

The soils in this association produce high-quality hardwoods. Nearly every farm has a small woodlot 5 to 20 acres in size. Wildlife that inhabit open farmland is abundant in this association. This association has many miles of scenery and attracts many visitors.

5. Belding-Allendale-Rubicon Loamy Substratum-Montcalm Association

Nearly level and gently sloping, poorly drained and well-drained, loamy and sandy soils on lake plains

This association lies between the fertile clay uplands and the sandy lake plain. It is generally nearly level to gently sloping, but it is broken in places by short steep slopes that adjoin depressions and old glacial drainageways. This association occurs in a small area in the northwestern corner of the county, and in a much larger area in the southeastern part. It covers about 4 percent of the county.

The Belding soils make up 25 percent of this association; Allendale soils, 25 percent; Rubicon soils that have a loamy substratum, 15 percent; and Montcalm soils, 15 percent. Most of the remaining 20 percent consists of Nester, Au Gres, and Tonkey soils.

The Belding soils are somewhat poorly drained, are nearly level to gently sloping, and underlain by clay loam glacial till at a depth of about 30 inches. The Allendale soils are similar to the Belding soils but are sandier in the upper part and are underlain by lake-laid clays at a depth of 18 to 42 inches. The Rubicon soils that have a loamy substratum are well drained, are sandy to a depth ranging from 42 to 66 inches, and have clay loam to clay material below that depth. The well-drained Montcalm soils are sandy to a depth of 5 feet or more. The Nester soils have finer textured material within a depth of 18 inches, and the somewhat poorly drained Au Gres soils are sandy to a depth of 5 feet or more.

Farms in this association are mainly of the general type. Corn, small grains, and hay are the main crops, but beans, cucumbers, and other crops are also grown. Natural fertility is medium. The wet soils need artificial drainage, and the well-drained areas need moisture during prolonged dry periods. To improve drainage, supply water for irrigation and livestock, and control erosion, farmers use tile and open ditches, pit-type ponds, and field stripcropping.

Much of the association is in mixed hardwoods. The wetter sites support mostly red maple, poplar, and elm. The well-drained Rubicon and Montcalm soils produce red oak, white oak, basswood, hickory, and largetooth aspen. Careful management of woodland is needed in this association.

6. Montcalm-Nester-Belding-Kawkawlin Association

Gently sloping to rolling, somewhat poorly drained and well-drained, sandy and loamy soils on lake plains, outwash plains, and glaciated uplands

This association is made up of sloping to rolling uplands in the southeastern, northeastern, and northwestern parts of the county. It covers about 9 percent of the county.

Montcalm soils make up about 25 percent of this association; Nester soils, 20 percent; Belding soils, 20 percent; and Kawkawlin soils, 10 percent. The remaining 25 percent consists mostly of Rubicon soils that have a loamy substratum, and of Sims and Menominee soils.

The texture of the surface layer of the soils in this association ranges from moderately heavy clay loam to light loamy sand within short distances. In depressions and other low positions are the somewhat poorly drained Belding and Kawkawlin soils and the poorly drained Sims soils. Rubicon soils that have a loamy substratum are in well-drained sandy areas and are underlain by clay loam at a depth of 42 to 66 inches. Montcalm soils are deep and occur in the sandy uplands. The Nester soils are moderately fine textured.

The soils of this association are used mainly for general farming. A few sites are suitable for fruit orchards. The main crops are corn, small grains, and pickling cucumbers. Dairy herds of 25 to 100 cows graze throughout this association.

The soils of this association are susceptible to erosion. Practices used to control erosion are stripcropping, contour farming, use of field strips, and use of sodded waterways.

In the Montague-Whitehall area, near Lake Michigan, farmland is rapidly being converted to golf links, riding trails, and camping areas. Also, communities are being developed. The larger farms are being subdivided into farms 5 to 25 acres in size. Generally, these small farms are operated by part-time farmers who are employed in the greater Muskegon area.

Most farms in this association have woodlots 10 to 20 acres in size in which good-quality mixed hardwoods grow. Also, food and cover for wildlife are abundant, and wildlife is plentiful.

7. Carlisle-Tawas Association

Nearly level and depressional, poorly drained peats and mucks

This association consists of depressional areas along the major streams, old drainageways, and small embayments of Lake Michigan. The soils were derived mainly from plant remains, but some mineral soils occur. The association covers about 6 percent of the county.

Carlisle soils make up about 35 percent of the association, and Tawas soils make up 25 percent. The remaining 40 percent consists mostly of Saranac and Sloan soils.

The organic material is more than 42 inches thick in the Carlisle soils and less than 42 inches thick in the Tawas soils. The underlying material is generally sandy, though in a few places it consists of marl or loamy material. The Saranac and Sloan soils are mineral soils on bottom lands and are medium textured to fine textured.

The organic soils are used for general farming or specialized farming. General farms normally include some mineral soils on uplands, but drained areas of organic soils are used for corn and other general crops. Cleared, undrained areas are pastured.

Celery and onions are the two main special crops. Most celery farms are near the mouths of the White River, the Muskegon River, and Black Creek. Celery farms are smaller than onion farms and generally range from 5 to 50 acres in size, though a few are larger than 50 acres. Celery is grown almost exclusively on these farms.

Onion farms are concentrated farther inland. The Moorland muck area, which is concentrated in sections 11, 12, 13, and 14 of Moorland Township, specializes in onions, but other crops are also grown. Among these are carrots and peppermint and small acreages of lettuce, spinach, and melons.

Nearly all organic farms along Lake Michigan are diked against seasonal flooding. All cultivated fields are drained artificially by tile and open ditches. Nearly all diked areas and many other areas depend on pumps for drainage. Where possible, open ditches are rapidly being replaced by tile. Irrigation is common on the muck farms and may be overhead by means of sprinklers or underground by control of the water table.

Most of the better muck and peat areas have been cleared and developed for crops. The undeveloped areas remain wooded. A large part of the valley of the Muskegon River that includes both organic and mineral soils is being considered for development as recreational and wildlife areas.

Soil blowing is the major concern in organic areas. Common practices used against soil blowing are establishing windbreaks, planting cover crops, using minimum tillage, and controlling the water table. Most inland farms that specialize in onions mainly use windbreaks of willows and narrow bands of rye for controlling erosion. Fewer windbreaks are used in muck areas along Lake Michigan. There, erosion is controlled by maintaining a high water table and planting strips of rye.

Adequate drainage is required for nearly all crops, though drains are difficult to maintain. Because of their location and moisture content, these soils are subject to damage by frost. The available moisture capacity is high, but naturally fertility is low. Complete and expensive fertilizer programs are needed for specialty crops. Drained organic soils are likely to erode, subside, and decompose. Unless careful management is followed, the organic deposit soon may be depleted and the underlying material exposed.

8. Selkirk-Kent-Kawkawlin Association

Nearly level and gently sloping, poorly drained, moderately well drained, and well drained, loamy soils on lake plains

This association is on a nearly level to gently sloping area of the lake plain in the extreme northeastern part of the county. Slopes are generally long and gradual, but some short steeper slopes occur along breaks to drainageways. This association covers about 2 percent of the county.

The Selkirk soils make up about 30 percent of this association; the Kent soils, 25 percent; and the Kawkawlin soils, 25 percent. The rest of the association consists mostly of Allendale, Hettinger, and Ogemaw soils. Most of the soils in this asociation are fine textured, but there are some very fine sands and some silty soils. The Kent soils are on short steep slopes and are fine textured and moderately well drained.

This association is suitable for dairy farming and general farming. The soils are naturally fertile and produce favorable yields if drainage is adequate and management is good. Because adequate outlets are available, artificial drainage is not difficult.

This association consists mostly of open cropland, but there are a few woodlots and, near Brunswick, a few orchards at the higher elevations. Maintenance of good soil structure is needed for continued above-average yields. Practices needed on the soils of this association are tillage at a minimum and at the right time, return of crop residues, artificial drainage, maintenance of fertility, and selection of a good cropping system.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Muskegon County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; 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 roots of plants.

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. To use this survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

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. Au Gres and Rubicon, 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 go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Nester loam and Nester sandy loam are two soil types in the Nester series. The difference in texture of their surface layers is apparent from their names.

Some types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Nester loam, 6 to 12 percent slopes, is one of several phases of Nester loam, a soil type that ranges from nearly level to rolling.

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 greatly help in drawing boundaries accurately. The soil map in the back of this survey 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 management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of soil type. 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 type or soil phase. As much as 15 percent of a mapping unit may consist of other kinds of soil. The mapping unit is generally named for the soil or soils that make up most of the area.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Au Gres-Saugatuck sands, 0 to 6 percent slopes.

Another kind of mapping unit is the undifferentiated soil group, which consists of two or more soils not separated on the map because differences among them are small or they are too difficult to delineate. An example is Belding and Allendale soils, 0 to 6 percent slopes. Also, on most soil maps, some areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they cannot be classified by soil series. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Lake beaches or Marsh, and are called land types.

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 soils 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 soils. 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 a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil surveys. On basis of the yield and practice tables and other data, the soil scientists set up trial groups, and test these by further study and by consultation with farmers, agronomists, engineers, and others. The scientists 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.

Descriptions of the Soils

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

The procedure in this section is first to describe the soil series and then to give, in small print, a profile description representative of the series, the range of soil characteristics within the series, and a comparison with soils of other series. Next, in larger print, are the descriptions of the mapping units within the series. The farmer and general reader probably will be interested only in the material in larger print, or the descriptions of the series and of the mapping units. The soil scientists and others who require more information need to read this material and the material in finer print as well.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of soil series. Blown-out land, 0 to 6 percent slopes, and 6 to 50 percent slopes, Dune land, Lake beaches, Marsh, and Wind eroded land, sloping, are miscellaneous land types and do not be-

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

Soil	Acres	Percent	Soil	Acres	Percent
Au Gres-Saugatuck sands, 0 to 6 percent slopes	30, 320	9. 4	Menominee and Ubly soils, 2 to 6 percent slopes	2, 604	0. 8
Belding and Allendale soils, 0 to 6 percent slopes	5, 797	1. 8	Menominee and Ubly soils, 6 to 12 percent slopes	184	. 1
Belding-Ubly sandy loams, 2 to 6 percent slopes	2, 495	. 8	Montcalm and Chelsea soils, 2 to 6 percent slopes	913	. 3
Blown-out land, 0 to 6 percent slopes	4, 585	1. 4	Nester loam, 2 to 6 percent slopes	9, 028	4. 8
Blown-out land, 6 to 50 percent slopes	2, 747	. 9	Nester loam, 6 to 12 percent slopes	1, 730	. 5
Chelsea-Mancelona loamy sands, 2 to 6 percent slopes	808	. 3	Nester sandy loam, 6 to 12 percent slopes	547	. 2
Chelsea-Mancelona loamy sands, 6 to 12 percent slopes	364	. 1	Nester soils, 12 to 25 percent slopes	976	. 3
Chelsea and Montcalm sands, 12 to 25 percent slopes	656	. 2	Nester soils, 12 to 25 percent slopes, severely eroded	167	. 1
Chelsea and Montcalm sands, 25 to 45 percent slopes	802	. 3	Nester soils, 25 to 45 percent slopes	497	. 1
Croswell and Au Gres sands, 0 to 6 percent slopes	30, 219	9. 4	Nester soils, 25 to 45 percent slopes, severely eroded	220	. 1
Deer Park fine sand, 12 to 50 percent slopes	811	. 3	Nester-Kawkawlin loams, 2 to 6 percent slopes	2, 712	. 8
Deford fine sand	1, 907	. 6	Nester-Ubly sandy loams, 2 to 6 percent slopes	14, 219	4. 4
Dune land	812	. 3	Ogemaw loamy sand, 0 to 6 percent slopes	289	. 1
Granby loamy sand	4, 929	1. 5	Roscommon and Au Gres sands	29, 949	9. 3
Grayling-Rubicon sands, 6 to 12 percent slopes	7, 360	2. 3	Rousseau fine sand, 0 to 6 percent slopes	755	. 2
Grayling-Rubicon sands, 12 to 25 percent slopes	9, 883	3. 1	Rubicon sand, 0 to 6 percent slopes	71, 106	21. 9
Grayling-Rubicon sands, 25 to 45 percent slopes	8, 873	2. 7	Rubicon sand, 6 to 25 percent slopes	1, 441	. 4
Hettinger and Pickford soils	1, 383	. 4	Rubicon loamy substratum and Montcalm soils, 0 to 6 percent slopes	4, 592	1. 4
Houghton peat and muck	1, 182	. 4	Rubicon loamy substratum and Montcalm soils, 6 to 12 percent slopes	173	. 1
Kalkaska-Wallace sands, 2 to 6 percent slopes	511	. 1	Saranac loam	4, 309	1. 3
Kawkawlin loam, 0 to 2 percent slopes	950	. 3	Sims loam	1, 273	. 4
Kawkawlin loam, 2 to 6 percent slopes	941	. 3	Sloan soils	4, 912	1. 5
Kawkawlin and Selkirk loams, 0 to 2 percent slopes	1, 155	. 3	Sparta sand, 0 to 2 percent slopes	677	. 2
Kawkawlin and Selkirk loams, 2 to 6 percent slopes	1, 021	. 3	Tawas and Carlisle mucks	5, 826	1. 8
Kent silt loam, 25 to 45 percent slopes	206	. 1	Tonkey and Deford soils	4, 725	1. 5
Kerston muck	9, 963	3. 1	Warners muck	212	. 1
Lake beaches	65	(1)	Wind eroded land, sloping	687	. 2
Marsh	993	. 3	Urban, built up, and miscellaneous	26, 100	8. 1
			Total	322, 560	100. 0

[1] Less than 0.05 percent.

long to a soil series; nevertheless, they are listed in alphabetic order along with the series.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit are the capability unit followed by the management group in parentheses, woodland suitability group, wildlife suitability group, and community development group in which the mapping unit had been placed. The page on which each capability unit is described can be found by referring to the "Guide to Mapping Units" at the back of this survey.

In the description of the soil series and of the mapping units, terms for structure, consistence and other soil properties are used. Some of these terms require explanation.

Structure is the arrangement of soil particles into aggregates, or clusters, that are separated in the soil mass from adjoining aggregates. The shape of these aggregates are described by terms such as *granular*, *angular blocky*, and *subangular blocky*.

Terms for consistence denote the feel of the soil and the ease with which a lump can be crushed by the fingers. Common terms of consistence are *loose*, *friable*, *plastic*, and *firm*. Consistence is given for a dry, wet, or moist material. Unless otherwise specified, the consistence given in this survey is for a moist material.

Terms for available moisture capacity denote the ability of a soil to hold water that plants can use. *Low*, *moderate*, and *high* are examples of terms used to indicate available moisture capacity.

Other terms used in this survey are defined in the Glossary, and some of them are explained in detail in the "Soil Survey Manual" (*9*).[2]

Allendale Series

The Allendale series consist of somewhat poorly drained sandy soils that are underlain by silty clay or clay at a depth of 18 to 42 inches. These soils occur in lake plain areas and are nearly level to undulating. They are mostly in the northeastern and south-central parts of the county. The native vegetation consisted of mixed lowland hardwoods and conifers. Red maple, elm, ash, and birch were the main trees, but there were small amounts of white pine and hemlock.

The surface layer of these soils is very dark gray loamy sand about 3 inches thick. It has granular structure and is very friable. The subsurface layer is about 7 inches thick and consists of gray loamy sand that has many dark-gray mottles. It has subangular blocky structure and is very friable.

[2] Italic numbers in parentheses refer to Literature Cited, p. 89.

The subsoil is mainly sand. It is strong brown in the upper part and yellowish brown and brown in the lower part. The subsoil is mottled with yellowish-brown specks, which are most numerous in the lower part. The subsoil is mainly granular and is loose or very friable.

Below the subsoil, at a depth of about 40 inches, is brown silty clay that has many gray and yellowish-brown mottles. It has angular blocky structure, is very firm, and is calcareous.

The Allendale soils are permeable to air and water above the clayey layer, but water moves very slowly through this layer. Artificial drainage is needed because these soils are naturally wet. Mottles in the subsoil indicate extended periods of saturation. These soils are moderately low in natural fertility and, where drained, are moderately low in available moisture capacity. They are used for general farm crops.

In this county Allendale soils are mapped only with Belding soils in an undifferentiated unit.

A typical profile of Allendale loamy sand in SW¼SE¼ NW¼ sec. 29, T. 9 N., R. 15 W.:

A1—0 to 3 inches, very dark gray (10YR 3/1) loamy sand; weak, fine, granular structure; very friable; slightly acid; abrupt, wavy boundary.

A2—3 to 10 inches, gray (10YR 6/1) loamy sand that has many, medium, distinct mottles of dark gray (10YR 4/1); very weak, fine, subangular blocky structure; very friable; medium acid; clear, irregular boundary.

B21ir—10 to 17 inches, strong-brown (7.5YR 5/6) sand that has few, medium, faint mottles of yellowish brown (10YR 5/8); single grain; loose; medium acid; clear, wavy boundary.

B22ir—17 to 24 inches, strong-brown (7.5YR 5/8) sand that has few, medium, distinct mottles of light yellowish brown (10YR 6/4); single grain; loose; medium acid; clear, irregular boundary.

B23ir—24 to 30 inches, yellowish-brown (10YR 5/8) loamy sand that has many, medium, faint mottles of light yellowish brown (10YR 6/4); very weak, medium, subangular blocky structure; very friable; slightly acid; clear, smooth boundary.

B3—30 to 40 inches, brown (10YR 5/3) sand that has many, medium, distinct mottles of yellowish brown (10YR 5/6); single grain; loose; neutral; abrupt, smooth boundary.

IIC—40 to 60 inches +, brown (7.5YR 5/4) silty clay that has many, medium, distinct mottles of gray (10YR 6/1) and yellowish brown (10YR 5/8); strong, medium, angular blocky structure; very firm; calcareous.

In cultivated areas of Allendale soils the surface layer is a mixture of the original surface soil and the subsurface layer. It is very dark gray and about 8 inches thick. In some places the subsoil contains chunks of cemented sand. The underlying material is clay or silty clay. In a fairly large area of the lake plain a thin layer of sandy material has been deposited over lake-laid clay.

Allendale soils have a coarser textured subsoil and finer textured underlying material than the Belding soils. Allendale soils lack the cemented layer that is present in the subsoil of the Saugatuck soils.

Au Gres Series

The Au Gres series consists of somewhat poorly drained soils that developed in sandy outwash at least 66 inches deep. The Au Gres are some of the most extensive soils in the county. They occupy large areas in the western part and occur locally throughout. These soils are common in the wetter parts of outwash areas and lake plains and on the low benches along old river channels and near lakes. The native vegetation consisted of white pine and hemlock and of mixed hardwoods, including aspen, birch, elm, ash, and to some extent, red maple.

The surface layer in uncultivated areas is about 5 inches thick and consists of black sand that has granular structure and is very friable. The subsurface layer is light-gray sand that is about 6 inches thick and has subangular blocky structure.

The subsoil consists of brownish sand mottled with light yellowish brown. It is subangular blocky to single grain and very friable in the upper part and loose in the lower part.

Underlying the subsoil, at a depth of about 34 inches, is very pale brown sand mottled with light yellowish brown. It is single grain and loose.

The Au Gres soils are very permeable to water and have low available moisture capacity and natural fertility. Mottles indicate periodic wetness. During spring free water is often within 2 or 3 feet of the surface, but this water recedes during summer, and for extended periods there is not enough moisture available to crops. Drainage is difficult because these soils are sandy. Overdrainage and droughtiness are likely.

Most areas of these soils are idle or are used for pasture. Some areas remain wooded, and some are used for blueberries, cucumbers, and other special crops.

A typical profile of Au Gres sand in SW¼SW¼ sec. 12, T. 11 N., R. 16 W., Dalton Township:

A1—0 to 5 inches, black (10YR 2/1) sand; very weak, medium, granular structure; very friable; strongly acid; abrupt, irregular boundary.

A2—5 to 11 inches, light-gray (10YR 7/2) sand; very weak, medium, subangular blocky structure; very friable; strongly acid; abrupt, irregular boundary.

B21ir—11 to 18 inches, brownish-yellow (10YR 6/8) sand that has many, medium, faint mottles of light yellowish brown (10YR 6/4); weak, coarse, subangular blocky structure; very friable; strongly acid; clear, irregular boundary.

B22ir—18 to 34 inches, brownish-yellow (10YR 6/6) sand that has common, coarse, faint mottles of light yellowish brown (10YR 6/4); single grain; loose; medium acid; gradual, wavy boundary.

C—34 to 60 inches +, very pale brown (10YR 7/3) sand that has common, medium, distinct mottles of light yellowish brown (10YR 6/4); single grain; loose; medium acid.

The surface layer is sand or loamy sand, but the other soil layers are sand in almost all places. On the surface of some undisturbed areas is a thin layer of partly decomposed, very strongly acid organic material. In some places the subsoil contains enough organic material to impart a loamy feel. In some areas the subsoil contains weakly cemented chunks of hardpan. The mottling in the subsoil is a result of a high water table during part of the year. These soils range from very strongly acid to slightly acid.

Au Gres soils have a thinner and less well developed subsoil than the Saugatuck soils. They are more poorly drained and more highly mottled than Croswell soils but are better drained and not so gray as Roscommon soils.

Au Gres-Saugatuck sands, 0 to 6 percent slopes (AsB).—Au Gres sand and Saugatuck sand were mapped together in this complex because they occur in such an intricate pattern that it was not practical to map the separate areas of each soil. Each of these soils has a profile similar to the one described for its respective series. These soils occur throughout the sandy parts of the county. They are most extensive on the broad, level to gently sloping sandy plains in soil associations 2 and 3, but they also

***Figure 2.*—Blueberries on Au Gres-Saugatuck sands, 0 to 6 percent slopes.**

occur in scattered, small, wet depressions of the sandy uplands. In the sandy plains a water table rises close to the surface during part of the year. In cultivated areas and in areas slightly eroded by wind and water, the surface has a gray salt-and-pepper appearance because the surface layer has been mixed with the grayish subsurface layer.

The soils in this complex are low in natural fertility and become very droughty during dry periods.

Most areas of these soils have been cleared and cultivated but later abandoned. Grown up in most of these areas are grasses and weeds and a few clumps of aspen, sassafras, and sumac of poor quality. Some of the cleared areas have been planted to Scotch pine, red pine, white pine, and some spruce. In the second growth are jack pine, aspen, elm, and some white pine and red pine. Because they are low in natural fertility and are droughty, these soils are poorly suited to most crops. Because they are naturally acid, wet, and nearly level, however, some areas are suited to and are used for blueberries (fig. 2). Melons and pickling cucumbers are also grown on a small acreage. These special crops generally require supplemental irrigation during the dry parts of the growing season. If these soils are left bare, they are easily eroded by wind and water.

Both soils are in capability unit IVw-2 (5b, 5b-h); woodland suitability group F; wildlife suitability group 1; community development group 6.

Belding Series

The Belding series consists of somewhat poorly drained soils that developed in sandy loam deposits underlain by loamy materials at a depth of 18 to 42 inches. These soils are nearly level to undulating. They occur on the lake plain and in upland pockets of the rolling morainic areas of the county. The native vegetation consisted of mixed hardwoods and conifers that included hard and soft maple, ash, birch, and some white pine and hemlock.

The surface layer is the plow layer and consists of very dark brown sandy loam about 8 inches thick. It is friable and has granular structure.

The subsoil is mainly sandy loam. It is reddish brown in the upper part and strong brown in the lower part. This layer is distinctly mottled. It has subangular blocky structure and is friable in the upper part and firm in the lower part.

Underlying the subsoil, at a depth of about 30 inches, is light brownish-gray clay loam that is distinctly mottled. This material has angular blocky structure, is firm, and is calcareous.

Permeability is moderately rapid in the upper 18 to 42 inches and is moderately slow below that depth. Available moisture capacity is moderately high. Because these soils are naturally wet, artificial drainage is required before most crops can be grown. The water table is near the surface in spring, but it recedes in summer. Because the underlying material has moderately slow permeability, the upper part of these soils is saturated during wet periods. This wetness hinders the development of plant roots and the operation of farm machinery. Fertility is medium.

Most areas of these soils are cultivated to the general crops of the area. A small amount is idle or in woodlots.

A typical profile of Belding sandy loam in SW$\frac{1}{4}$ sec. 24, T. 9 N., R. 14 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) sandy loam; weak, coarse, granular structure; friable; medium acid; abrupt, smooth boundary.

Bir—8 to 11 inches, reddish-brown (5YR 4/4) sandy loam that has many, medium, faint mottles of reddish brown (5YR 5/4) and many, medium, distinct mottles of grayish brown (10YR 5/2); weak, medium, subangular blocky structure; friable; strongly acid; clear, irregular boundary.

A'2 & B'21—11 to 18 inches, very pale brown (10YR 7/3) sandy loam, representing the A'2 horizon, and yellowish-brown (10YR 5/6) sandy loam that has many, fine, distinct mottles of brown (10YR 5/3), representing the B'21 horizon; weak, medium, subangular blocky structure; friable; medium acid; clear, irregular boundary.

B'22t—18 to 30 inches, strong-brown (7.5YR 5/8) heavy sandy loam that has many, coarse, distinct mottles of light brownish gray (10YR 6/2); moderate, medium, subangular blocky structure; firm; slightly acid; abrupt, wavy boundary.

IIC—30 to 48 inches +, light brownish-gray (10YR 6/2) clay loam that has many, medium, distinct mottles of yellowish brown (10YR 5/6), few, fine, distinct mottles of brownish yellow (10YR 6/8), and few, medium, faint mottles of grayish brown (10YR 5/2); moderate, fine, angular blocky structure; firm; calcareous.

In areas of Belding soils that have never been plowed or disturbed, the surface layer is a very dark grayish-brown sandy loam 3 to 5 inches thick. Below this lies a grayish subsurface layer 3 to 5 inches thick. Cultivation mixes these two layers into a plow layer. In some areas a weakly cemented grayish layer is present just above a depth of 30 inches. This layer is especially noticeable during dry periods. The lower part of the subsoil ranges from sandy loam to clay loam or sandy clay loam. Below a depth of 30 inches, the material ranges from loam to clay loam or silty clay loam. The surface layer and upper part of the subsoil generally range from medium acid to strongly acid, and the lower part of the subsoil ranges from medium acid to neutral.

Belding soils are more poorly drained and more highly mottled than Ubly soils. They have finer textured upper layers but coarser textured lower layers than the Allendale soils. Belding soils are similar to the Kawkawlin soils in drainage but are coarser textured.

Belding and Allendale soils, 0 to 6 percent slopes (BaB).—This mapping unit consists of Belding sandy loam and Allendale loamy sand. Some areas are dominantly Belding sandy loam, and other areas are dominantly Allendale loamy sand. Only a few areas contain both of these soils. Each of these soils has a profile similar to the one described for its respective series.

These soils are on nearly level lake plains and are near the edges of and within the rolling uplands. These areas occur in the western parts of Casnovia and Ravenna Townships, the eastern parts of Sullivan and Moorland Townships, the southwestern part of Holton Township, and in White River Township. Belding and Allendale soils are both somewhat poorly drained, but they have different texture.

The Belding soil has a very dark brown sandy loam surface layer. This soil is near the extreme edge of the lake plain and in the nearly level depressions and draws of the rolling uplands.

Allendale loamy sand has a sandier surface layer and subsoil than the Belding soil. Sticky silty clay is at a depth ranging from 18 to 42 inches. This clayey material is finer textured than the material at a corresponding depth in the areas that are dominantly Belding sandy loam. The Allendale soil occupies broad, nearly level lake plains, and it also is scattered throughout the county. Clayey material lies below a depth of 3$\frac{1}{2}$ feet in some areas of Allendale soil and at less than 12 inches in a few other areas.

Included with these soils in the mapping, on slopes of 2 to 6 percent, were areas of Kawkawlin soils that are underlain by clay loam at a depth of less than 18 inches. The Kawkawlin soils generally occur in areas that are dominantly Belding soil. These areas are small and do not alter the use and management of this mapping unit. Also included, but in areas that are dominantly Allendale soil, are small shallow depressions of poorly drained soils. Water ponds in these depressions during wet periods and sometimes hinders field operations.

Artificial drainage is needed on the soils of this unit if they are to be used for crops. Because the underlying material is fine textured and of variable depth, artificial drainage is difficult. Drained areas, however, are productive if they are properly managed. Undrained areas are used for hay and pasture, or they remain in woodlots.

Belding soil is in capability unit IIw–8 (3/2b); woodland suitability group G; wildlife suitability group 3; community development group 5. Allendale soil is in capability group IVw–2 (4/1b); woodland suitability group G; wildlife suitability group 3; community development group 5.

Belding-Ubly sandy loams, 2 to 6 percent slopes (BbB).—This mapping unit consists of Belding sandy loam and Ubly sandy loam. These somewhat similar soils differ mainly in drainage. The Belding soil is somewhat poorly drained, and the Ubly soil is moderately well drained and well drained. Many areas are dominantly Belding sandy loam, and some areas are dominantly Ubly sandy loam. In other areas these soils occur in about equal amounts. Each of these soils has a profile similar to the one described for its respective series. These soils are in the gently sloping and rolling areas of glacial till in the northwestern and southeastern parts of the county. A thin layer of sandy loam material overlies the loamy glacial till.

In some areas, Belding sandy loam is in the dish-shaped areas between rises occupied by the Ubly sandy loam. In other areas, the Belding soil is at the base of slopes and is also in flat areas in the draws. The Ubly sandy loam is on lower side slopes in the rolling landscape. It receives runoff from higher slopes.

Included with these soils in the mapping were many areas that differ from typical Belding or Ubly soils. In some areas slopes range from 6 to 12 percent. These sloping areas are eroded and have a lighter colored surface layer than uneroded areas. Areas on some of the hillocks are better drained than areas of these soils. On these hillocks the underlying material is exposed in spots. Other areas have a sandy loam surface layer and subsoil. In places the depth to the loamy underlying material is more than 42 inches. Also included are poorly drained shallow depressions that have a dark-colored surface layer and are slow to dry up after rains in spring. Seepy areas occur in the Ubly soils. Areas of Nester soils are included where the loamy underlying material is less than 18 inches from the surface. The Menominee soils and the Rubicon soils that have a loamy substratum occur where the surface layer and subsoil are sandier than normal. Poorly drained Sims soils are in the wettest dish-shaped areas between rises. None of these included areas greatly affects use and management.

Artificial drainage is required in seepy spots and in areas that are dominantly Belding sandy loam. Drainage, however, is difficult because the depth to the underlying loamy material varies. Drained areas that are properly managed have favorable yields of most crops.

This unit is extensive. Adequately drained areas are used for general crops. Undrained areas are used mainly for hay and pasture. A few areas remain wooded.

Belding soil is in capability unit IIw–8 (3/2b); woodland suitability group G; wildlife suitability group 3; community development group 5. Ubly soil is in capability unit IIe–3 (3/2a); woodland suitability group A; wildlife suitability group 9; community development group 2.

Blown-out Land

Blown-out land was mapped in two units according to slope. Neither unit has much value as cropland.

Blown-out land, 0 to 6 percent slopes (BoB).—This land is in scattered areas throughout the open sandy parts of the county where the original forest has been cleared. The original surface layer and the subsoil have been removed by soil blowing and water erosion. Loose sand is at the surface. Active blowouts make up from 20 to 50 percent of individual areas. Some areas between blowouts show evidence of stabilization.

Included with this land in the mapping were some areas that are not so severely eroded.

The present vegetation consists of mosses and lichens and a few stunted trees of scrub oak or fire cherry. Some areas are covered only by lag gravel. Many areas, especially those along Lake Michigan, are raw and open.

This land has no value as cropland, but it will support trees. Some areas have been stabilized with plantings of beachgrass. Other areas have been stabilized with beachgrass and then planted to red, Scotch, pitch, or jack pines. In all areas careful management is needed for protection from further damage by erosion.

Capability unit VIIIs–1 (5a); woodland suitability group Y; wildlife suitability group 4; community development group 3.

Blown-out land, 6 to 50 percent slopes (BoE).—This land occurs throughout the open sandy areas of the county. It occupies short, steep and very steep slopes that have been cleared and left bare to the eroding force of wind and water. The original surface layer and subsoil have been removed by erosion in most areas, and the former substratum of loose sand is at the surface in most places. Remnants of the subsoil are on the lee slopes, in protected pockets, and in other sheltered spots. Active blowouts make up from 20 to 50 percent of individual areas. Accumulations of soil occur as overburden at the base of slopes and on the leeward side of slopes.

Included with this land in the mapping were areas that have slopes of less than 6 percent. Also included were less severely eroded areas. A few areas have a sparse cover of mosses and lichens, and other areas have a thin mantle of lag gravel on the surface. Many areas consist of raw, shifting sand.

This land has little value as cropland, though trees grow if the sand is stabilized. Some areas have been stabilized by planting beachgrass. Other areas that were first stabilized by planting beachgrass have been planted to pitch, red, or jack pines, or in a few places to locust. In all areas careful management is needed for protection from further damage through soil blowing.

Capability unit VIIIs–1 (5a); woodland suitability group Y; wildlife suitability group 4; community development group 3.

Carlisle Series

The Carlisle series consists of very poorly drained soils that developed in deep, organic material. These soils occur in nearly level areas, in depressions, and on broad depressional flats of the lake plain and outwash plain. They also occur along streams and are in scattered pockets and swales of the uplands. The native vegetation consisted of lowland hardwoods and included elm, ash, soft maple, and some tamarack, cherry, and willow. A few white pines grow in some places.

The upper 25 inches of these soils consist of black muck that has granular or subangular blocky structure. Woody fragments are common in these layers.

Below a depth of 25 inches, and extending to a depth of 42 inches or more, the material consists of fibrous peat containing a considerable amount of woody fragments.

Carlisle soils have high available moisture capacity but are low in natural fertility. They are deficient in micronutrients. Artificial drainage is required for optimum yields, but drainage is difficult and costly. Runoff from Carlisle soils is slow, and additional runoff is received from higher adjacent soils. Water ponds in the lowest areas. Also, a high water table saturates these soils, especially in spring, and the planting of crops is delayed. Excess water also impairs the use of machinery. Soil blowing is a serious hazard during dry periods.

Carlisle soils are highly valued because of their suitability for celery, mint, carrots, onions, and other special crops. Corn is the most important field crop. Undrained areas are in pasture, including pasture of reed canarygrass, or are in second-growth forest.

In this county Carlisle soils are mapped only with Tawas soils in an undifferentiated unit.

Typical profile of Carlisle muck in NW¼NE¼ sec. 14, T. 10 N., R. 14 W.:

1—0 to 14 inches, black (10YR 2/1) well-decomposed muck; weak, coarse, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

2—14 to 18 inches, black (5YR 2/1) muck; weak, fine, granular structure; very friable; slightly acid; clear, smooth boundary.

3—18 to 25 inches, black (5YR 2/1) muck; moderate, medium, subangular blocky structure; firm; slightly acid; clear, smooth boundary.

4—25 to 36 inches, dark-gray (10YR 4/1) fibrous peat that has many woody fragments; weak, coarse, subangular blocky structure; friable; medium acid; clear, smooth boundary.

5—36 to 48 inches, dark-brown (10YR 3/3) finely divided fibrous peat mixed with collodial material; massive; friable; slightly acid.

The surface layer of Carlisle soils is black, well-decomposed muck in most places, but in some places it contains a considerable amount of mineral material. The layers below the surface layer range from reddish brown through brown to gray. Carlisle soils range from medium acid to neutral. The organic materials that make up the layers below the surface layer are normally fibrous. In the upper 24 inches of these soils, there are few to many partly decomposed fragments of wood. One or more layers may be made up of a jellylike organic material that is very fine and impermeable.

Carlisle soils contain more fragments of wood than the Houghton soils and have thicker organic deposits than the Tawas or Warners soils. They are less stratified and more uniform in composition than Kerston soils.

Chelsea Series

The Chelsea series consists of well-drained sandy soils. These soils developed in deep deposits of sand that are underlain by thin layers of loamy sand at a depth of 42 to 66 inches. Chelsea soils occur in gentle to very steep areas of the till plains and moraines. The native vegetation consisted of mixed hardwoods and included oak, aspen, hickory, and sugar maple. Some areas supported stands of white pine.

The surface layer is very dark grayish-brown loamy sand about 9 inches thick. It has granular structure and is very friable.

The subsoil to a depth of about 33 inches consists mainly of sand. It is yellowish brown or brownish yellow, has subangular blocky structure, and is very friable. Below this are alternate layers of sand and loamy sand. The sand layers are very pale brown and loose. The loamy sand layers are yellowish red and brownish yellow, have subangular blocky structure, and are very friable. The loamy sand layers are ¼ inch to 2 inches thick, are 6 to 12 inches apart, and extend to a depth of 6 feet or more.

Chelsea soils have rapid permeability and low natural fertility and available moisture capacity. Because of the low available moisture capacity, growth of plants is slowed in midsummer and throughout the dry summers. These soils are easily eroded by wind and water.

Typical profile of Chelsea loamy sand in NE¼NW¼SW¼ sec. 36, T. 12 N., R. 15 W., Holton Township:

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

B21ir—9 to 19 inches, strong-brown (7.5YR 5/8) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, irregular boundary.

B22ir—19 to 28 inches, yellowish-brown (10YR 5/8) sand; very weak, coarse, subangular blocky structure; very friable; medium acid; gradual, wavy boundary.

B23ir—28 to 33 inches, brownish-yellow (10YR 6/6) sand; very weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

A'21—33 to 42 inches, very pale brown (10YR 7/4) sand; single grain; loose; medium acid; clear, smooth boundary.

B't1—42 to 43 inches, yellowish-red (5YR 4/8) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

A'22—43 to 48 inches, very pale brown (10YR 7/3) sand; single grain; loose; medium acid; abrupt, wavy boundary.

B't2—48 to 50 inches, brownish-yellow (10YR 6/8) loamy sand; very weak, coarse, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

A'2&B't—50 to 60 inches +, very pale brown (10YR 7/3) sand representing A'2 horizons; single grain; loose; medium acid; brownish-yellow (10YR 6/8) heavy sand representing B't horizons.

In uncultivated areas of Chelsea soils the surface layer is 2 to 4 inches thick and consists of black loamy sand. It is underlain by a layer of grayish sand 1 to 4 inches thick. Brown of various shades is the color of the sand or loamy sand subsoil. The lowest layer of loamy sand is normally at a depth of less than 66 inches and is underlain by slightly acid sand. In some places the underlying material is coarse sand and contains some fragments of gravel size.

Chelsea soils have thinner layers in the subsoil than those in Montcalm and Mancelona soils, but the subsoil in Chelsea soils extends to a greater depth. They have a finer textured subsoil than the Kalkaska, Rubicon, and Grayling soils.

Chelsea-Mancelona loamy sands, 2 to 6 percent slopes (CmB).—Chelsea loamy sand and Mancelona loamy sand have been mapped together in this complex because they occur in an intricate pattern and cannot be mapped separately. Each of these soils has a profile similar to the one described for its respective series. These soils occupy the rolling uplands in the southeastern part of the county. They generally occur on long, narrow foot slopes or on gently sloping crests of cone-shaped sandy hills.

Included with these soils in mapping were areas on short, choppy slopes of 6 to 12 percent that are severely eroded in some places. In these areas the surface layer is brownish colored and gritty. Also included were a few areas that have a sticky, gravelly surface layer and other areas that have a light yellowish-brown sand surface layer. In many areas the Mancelona soil has a gravelly surface layer and subsoil and sand and gravel at a depth of more than 2 feet. The depth to the clay loam material in the Mancelona soil varies greatly in some places. None of these included areas greatly affects use and management.

Chelsea and Mancelona loamy sands are permeable to water and air. They are deficient in plant nutrients and have a low available moisture capacity. They are susceptible to soil blowing and water erosion. These soils are suited to the crops commonly grown in the county. Most areas are small, however, and make up only part of cultivated fields.

Chelsea soil is in capability unit IVs–2 (5a); woodland suitability group E; wildlife suitability group 7; community development group 3. Mancelona soil is in capability unit IIIs–4 (4a); woodland suitability group C; wildlife suitability group 7; community development group 3.

Chelsea-Mancelona loamy sands, 6 to 12 percent slopes (CmC).—Chelsea loamy sand and Mancelona loamy sand have been mapped together in this complex because they occur in such an intricate pattern that they cannot be mapped separately. Each of these soils has a profile similar to the one described for its respective series. These soils are in the rolling uplands mainly in the eastern part of the county. They occur on the sides and tops of knoblike sandy hills and on short narrow breaks.

Included with these soils in the mapping were areas of Au Gres and Croswell soils in long, narrow draws. Also included were areas where the clay loam material is within 42 inches of the surface. Other included areas are hummocky and have moderately eroded spots. In these eroded spots the surface layer is lighter colored than normal and is gravelly. In some places the hummocky areas have slopes of more than 12 percent, and in the long narrow draws slopes are less than 6 percent.

These soils are permeable to water and air. Their available moisture capacity and supply of plant nutrients are low. Because slopes are strong and the soils are loose, soil blowing and water erosion are likely. These soils are poorly suited to row crops, because they are sandy, low in fertility, and strongly sloping.

Chelsea soil is in capability unit VIs–1 (5a); woodland suitability group E; wildlife suitability group 7; community development group 3. Mancelona soil is in capability unit IIIe–9 (4a); woodland suitability group C; wildlife suitability group 7; community development group 3.

Chelsea and Montcalm sands, 12 to 25 percent slopes (CnD).—This mapping unit consists of Chelsea sand and Montcalm sand. Most areas consist dominantly of the Chelsea soil or of the Montcalm soil. Each of these soils has a profile similar to the one described under its respective series.

The soils of this mapping unit are similar in texture and drainage. The subsoil in the Montcalm soil, however, is closer to the surface and finer textured than that in the Chelsea soil. These Chelsea and Montcalm soils are in rolling areas of the eastern part of the county. They are on short breaks and the sides and tops of small, sandy knoblike hills.

Included with these soils in the mapping were small areas of deep, sandy Rubicon soils. Also included were areas where the clay loam material is within 42 inches of the surface. These areas generally are at the top of slopes. Some of these areas are moderately eroded, and their plow layer is lighter colored than that in uneroded areas.

These Chelsea and Montcalm soils are permeable to air and water. Their available moisture capacity and supply of plant nutrients are low. The Montcalm soil is generally more productive than the Chelsea soil because it has more fine-textured material in the subsoil.

Most areas of these soils have been cleared and cultivated, but a few areas remain wooded. Because the soils are steep and loose, they are easily eroded by wind and water. They are best suited to permanent vegetation, such as grasses, legumes, and trees.

Chelsea soil is in capability unit VIIs–1 (5a); woodland suitability group E; wildlife suitability group 7; community development group 3. Montcalm soil is in capability unit VIIs–1 (4a); woodland suitability group C; wildlife suitability group 7; community development group 3.

Chelsea and Montcalm sands, 25 to 45 percent slopes (CnE).—Most areas of this mapping unit are dominantly Chelsea sand, but some areas are dominantly Montcalm sand. Each of these soils has a profile similar to the one described for its respective series. These soils are similar in texture and drainage, but the Montcalm soil is finer textured in the subsoil than the Chelsea soil. These soils are on short slope breaks in the rolling areas of the eastern quarter of the county.

The finer textured soil layers that are common in these soils are thinner and fewer than those described as typical of each series. Also, the surface layer is lighter colored.

Included with these soils in the mapping were areas where the loamy material is below a depth of 60 inches. Also included were severely eroded spots that have a brownish sandy loam surface layer and contain little organic matter. Many small pebbles are scattered on the surface of eroded areas. Also included were areas of severely eroded Nester soils.

These Chelsea and Montcalm soils are permeable to water and air. They have a low natural supply of plant nutrients. Because they are steep and loose, they are easily eroded by wind and water. Permanent grasses or trees can be established and maintained to reduce the hazard of erosion.

Chelsea soil is in capability unit VIIs–1 (5a); woodland suitability group E; wildlife suitability group 7; community development group 3. Montcalm soil is in capability group VIIs–1 (4a); woodland suitability group C; wildlife suitability group 7; community development group 3.

Croswell Series

The Croswell series consists of moderately well drained soils that developed in deep sands. These soils are in nearly level to gently sloping areas and on narrow low ridges of the broad outwash plains of the county. The natural vegetation was hardwoods and conifers that included white pine, hard maple, soft maple, aspen, and some red pine, hemlock, and elm.

The surface layer is very dark brown sand about 8 inches thick. It is underlain by a subsurface layer of gray sand about 4 inches thick. Both of these layers have granular structure and are very friable.

The subsoil consists of sand. It is mottled with reddish yellow, dark red, and yellowish red in the lower part. The upper part has subangular blocky structure, and the lower part is single grain and loose.

The material below the subsoil, at a depth of about 42 inches, is pale-brown sand that is mottled with yellowish red. This material is single grain and loose.

Above the fluctuating water table, water moves very rapidly through the Croswell soils. These soils are saturated during rainy periods in spring, but the water disappears quickly after rains stop. The upper layers of these soils dry out quickly, but the layers below a depth of 36 inches remain wet. Croswell soils are low in natural fertility and available moisture capacity. They are very susceptible to soil blowing if their protective cover is removed. As summer progresses, rain normally is not adequate to meet the needs of the plants. Crops show the need for moisture during extended dry periods.

Typical profile of Croswell sand in SE¼NE¼ sec. 24, T. 10 N., R. 16 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) sand; weak, medium, granular structure; very friable; slightly acid; abrupt, wavy boundary.

A2—8 to 12 inches, gray (10YR 5/1) sand; weak, medium, granular structure; very friable; strongly acid; abrupt, wavy boundary.

B21ir—12 to 18 inches, brown (10YR 4/3) sand; weak medium, subangular blocky structure; very friable; strongly acid; clear, wavy boundary.

B22ir—18 to 24 inches, strong-brown (7.5YR 5/6) sand that has many, fine, faint mottles of reddish yellow (7.5YR 6/6); weak, medium, subangular blocky structure; very friable; medium acid; gradual, wavy boundary.

B3—24 to 42 inches, strong-brown (7.5YR 5/6) sand that has few, coarse, distinct mottles of dark red (2.5YR 3/6) and many, medium, distinct mottles of yellowish red (5YR 5/6); single grain; loose; medium acid; gradual, wavy boundary.

C—42 to 60 inches +, pale-brown (10YR 6/3) sand that has few, medium, distinct mottles of yellowish red (5YR 5/6); single grain; loose; medium acid.

The surface layer of Croswell soils ranges from neutral to medium acid. Generally, the water table is high in spring and fall. Evidence of a seasonally high water table is the mixture of colors, normally between depths of 18 and 40 inches. Where Croswell soils grade to the well-drained sands, the mixture of colors is at a depth of about 3 feet. Where Croswell soils grade to the somewhat poorly drained Au Gres soils, the mixture of colors is at a depth of about 18 inches. In areas where Croswell soils grade to the Wallace soils, the subsoil contains a few chunks of weakly cemented sand that are irregular in size and shape.

Croswell soils are more moist and more mottled than the Rubicon and Kalkaska soils. Croswell soils lack the cemented layer that is common in the Wallace soils. They are better drained and not so highly mottled as Au Gres soils.

Croswell and Au Gres sands, 0 to 6 percent slopes (CrB).—This mapping unit consists of Croswell sand and Au Gres sand. The Croswell sand makes up most of the unit. Each of these soils has a profile similar to the one described for its respective series. This unit occurs throughout most of the county. It has a fluctuating high water table. The water table is closer to the surface in the Au Gres soil than in the Croswell soil. The Croswell soil is slightly higher and better drained and is lighter colored than the Au Gres soil. The Au Gres soil is in depressions in some places.

Areas of these soils that have never been cultivated and still retain a protective cover have a slightly thicker surface layer than cultivated areas. Soil blowing has thinned the surface layer where these soils have lost their vegetation. Overwash has accumulated in a thin layer over the Au Gres sand in those places where the soil occurs in shallow depressions or at the base of slopes.

These soils are low in plant nutrients. They become droughty in the summer when the water table drops. During dry periods, unprotected areas are easily eroded by wind.

Large areas of these soils have been cultivated, but now most areas are idle. The vegetation is Canada bluegrass, quackgrass, goldenrod, and bracken fern. A few small aspen, birch, and elm trees also are present.

Croswell soil is in capability unit IVs-2 (5a), woodland suitability group E; wildlife suitability group 1; community development group 3. Au Gres soil is in capability unit IVw-2 (5b); woodland suitability group F; wildlife suitability group 1; community development group 6.

Deer Park Series

The Deer Park series consists of well-drained soils developed in weathered sand. These soils are on the stabilized dunes and beach ridges along the shore of Lake Michigan. The native vegetation consisted of beech, sugar maple, red oak, hemlock, white pine, and ash. Greenbrier, wintergreen, and blueberry made up the ground cover.

The upper 3 inches of these soils is black and consists of the organic remains of plants mixed with some mineral material. The subsurface layers are gray or light brownish-gray fine sand or sand about 6 inches thick. This sand is single grain and loose.

The subsoil is light yellowish-brown sand about 12 inches thick. It is single grain and loose.

Underlying the subsoil is very pale brown sand that is single grain and loose.

Deer Park soils are very permeable and have low available moisture capacity and natural fertility. Where the protective vegetation has been removed, soil blowing is likely on these loose, dry sands. These soils can be used for recreation.

Typical profile of Deer Park fine sand in SW¼SW¼ sec. 15, T. 12 N, R. 18 W.:

O1—3 inches to 0, black (10YR 2/1) organic matter containing some sand; very weak, fine, granular structure; very friable; slightly acid; medium acid; abrupt, irregular boundary.

A21—0 to 2 inches, gray (10YR 5/1) fine sand stained very dark gray (10YR 3/1) by organic matter; single grain; loose; medium acid; clear, irregular boundary.

A22—2 to 6 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; medium acid; clear, irregular boundary.

B—6 to 18 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; medium acid; clear, irregular boundary.

C—18 to 60 inches +, very pale brown (10YR 7/3) sand; single grain; loose; medium acid.

In some areas, the subsurface layer is thicker than that described and the subsoil is very thin. Near Lake Michigan, the subsoil layer (B horizon) is normally absent. Farther from the lake, this layer occurs, and it becomes thicker and brighter colored as distance from the lake increases. The profile ranges from medium acid to slightly acid. The texture of the entire profile is fine sand in some areas. About ⅛ to ¼ mile inland, Deer Park soils are adjacent to Rubicon or Grayling soils, or both.

Deer Park soils have a more distinct subsurface layer than the Grayling soils but a less distinct subsoil than the Rubicon soils. Deer Park soils are less acid than the Rubicon or the Grayling soils.

Deer Park fine sand, 12 to 50 percent slopes (DpE).—This soil occupies the sloping to very steep areas of sand dunes and beach ridges along Lake Michigan. Much of the area is covered with a forest of mixed hardwoods consisting of beech, maple, red oak, white pine, and hemlock. Some areas are covered only with beachgrass and briers, and in these areas the subsoil is absent and the organic mat at the surface is very thin or absent.

Included with this soil in mapping were very severely eroded, bare areas in which the soil is very pale brown, infertile sand.

Deer Park fine sand, 12 to 50 percent slopes, contains only small amounts of plant nutrients. It is droughty and is easily eroded by wind if its protective cover is removed. It is unsuitable as cropland, because it is sloping to very steep and droughty. It produces excellent timber products, because of the influence of Lake Michigan. Areas of this soil are highly regarded for their esthetic value and recreational potential.

Capability unit VIIs-1 (5.3a); woodland suitability group H; wildlife suitability group 4; community development group 3.

Deford Series

The Deford series consists of deep, poorly drained fine sands. These soils are in nearly level to depressional areas of the lake plain and the outwash plain. The native vegetation consisted of lowland hardwoods and a few conifers and included elm, red maple, swamp white oak, and some black spruce and white-cedar.

The surface layer is black fine sand about 5 inches thick. This layer has granular structure, is very friable, and is very high in organic-matter content.

Below the surface layer are alternate layers of fine sand and very fine sand. The dominant color is light brownish gray, and the material is mainly very friable or loose. Most of these layers are single grain, but some have subangular blocky or platy structure. These layers are highly mottled with brownish yellow and yellow.

Deford soils are very permeable to water and have low available moisture capacity. They are low in natural fertility. Unless these soils are drained, they are saturated by a high water table and the excess water severely limits the growth of plants and use of farm machinery. Drainage, however, is difficult because the sandy material caves into ditches and into trenches dug for tile. Only fair yields can be expected under careful management. Much of the acreage of these soils is idle or is used for pasture. Some areas are forested.

Typical profile of Deford fine sand in SW¼NW¼ sec. 15, T. 11 N., R. 16 W.:

A1—0 to 5 inches, black (10YR 2/1) fine sand; moderate, fine, granular structure; very friable; medium acid; very high content of organic matter; abrupt, wavy boundary.

C1g—5 to 9 inches, light-gray (10YR 6/1) fine sand that has common, medium, faint mottles of grayish brown (10YR 5/2) and common, coarse, prominent mottles of black (10YR 2/1); weak, medium, subangular blocky structure; very friable; medium acid; abrupt, irregular boundary.

C2—9 to 11 inches, pale-brown (10YR 6/3) fine sand that has many, medium, distinct mottles of yellowish brown (10YR 5/8), many, coarse, faint mottles of light brownish gray (10YR 6/2), and common, medium distinct mottles of brownish yellow (10YR 6/8); weak, medium, subangular blocky structure; very friable; slightly acid; clear, irregular boundary.

C3—11 to 20 inches, light brownish-gray (10YR 6/2) fine sand that has many, medium, distinct mottles of brownish yellow (10YR 6/6) and few, fine, faint mottles of light yellowish brown (10YR 6/4); single grain; neutral; clear, irregular boundary.

C4—20 to 28 inches, light brownish-gray (10YR 6/2) very fine sand that has many, medium, distinct mottles of brownish yellow (10YR 6/8); vertical streaks of black (10YR 2/1) 2 millimeters wide; weak, thick, platy structure; very friable; mildly alkaline; clear, irregular boundary.

C5—28 to 32 inches, light brownish-gray (10YR 6/2) fine sand that has many, medium, distinct mottles of brownish yellow (10YR 6/6) and many, fine, distinct mottles of yellow (10YR 7/8); single grain; loose; calcareous; clear, wavy boundary.

C6—32 to 38 inches, light brownish-gray (10YR 6/2) very fine sand that has common, medium, faint mottles of pale brown (10YR 6/3); single grain; loose; calcareous; gradual, wavy boundary.

C7—38 to 60 inches +, pinkish-gray (7.5YR 6/2) fine sand; single grain; loose; calcareous.

In cultivated areas of Deford soils the gray subsurface layer has been mixed with the black surface layer and the plow layer is dark gray. Thin layers of silt and very fine sand occur in the subsurface layer in some areas. The amount of mottling varies considerably throughout the profile, but mottles are dominantly grayish in color. The upper 11 inches of these soils range from acid to neutral, and the material below is neutral or calcareous. As the distance to Roscommon soils decreases, texture of the sand in the Deford soils becomes coarser with depth, and the thin layers of finer textured material occur above a depth of 42 inches or are absent.

Deford soils have a thinner surface layer and developed in finer sand than the Granby soils. Also, they developed in finer sand than the Roscommon soils.

Deford fine sand (0 to 2 percent slopes) (Ds).—This soil consists of fine sand and has a black or very dark gray surface layer. The soil occurs mainly in broad, flat areas of the lake plain near Moorland, but other areas are elsewhere in slight depressions of the lake plain.

Included with this soil in the mapping were areas that have a sand surface layer and areas that have a mucky surface layer. Also included were small areas that have slopes of 2 to 6 percent and a lighter colored surface layer than that described in the typical profile.

This soil is wet because its water table is high. Drainage improves this soil as cropland, but drained areas have low available moisture capacity. Exposed areas are easily eroded by wind. Rotations that provide a high proportion of meadow and hay crops are well suited. Undrained areas are used mainly for pasture or are idle.

Capability unit IIIw-6 (4c); woodland suitability group W; wildlife suitability group 5; community development group 8.

Dune Land

Dune land (Du) is in areas of sand dunes near Lake Michigan (fig. 3). Slopes range from 12 to 35 percent. Most areas do not have a protective plant cover and are actively eroding. Beachgrass grows in clumps, and some trees and woody shrubs grow in sheltered coves. In several areas the dunes are advancing into the lower areas. Evidence of this advance is the treetops that protrude above the sand on the leeward side of the dunes. Stabilization of the dunes has been attempted in a few places but generally has not been successful. Dune land is used primarily for recreation.

Capability unit VIIIs-1 (Sa); woodland suitability group Y; wildlife suitability group 4; community development group 3.

Granby Series

The Granby series consists of poorly drained soils that developed in deep deposits of neutral sand. These soils occupy broad, nearly level to depressional areas of lake plain and outwash plain in the central part of the county. The native vegetation consisted of lowland hardwoods, mainly elm, red maple, and swamp white oak and some willow. There were also some spruce and white-cedar.

In cultivated areas the surface layer is black loamy sand about 10 inches thick. It has granular structure and is very friable.

Figure 3.—Dune land near Lake Michigan.

The material underlying the surface layer is dominantly gray and brownish sand. It has very weak subangular blocky structure in the upper part and is single grain in the lower part. Brownish-yellow mottles occur at variable depths.

Granby soils have rapid permeability and low available moisture capacity. Natural fertility is low. A high water table saturates these soils in undrained areas.

Most of the acreage of these soils is cleared and used for hay and pasture, though some areas are used for crops. Drainage is generally needed, but it is difficult because the sandy material readily caves into the ditches. If these soils are overdrained, they become droughty and susceptible to severe soil blowing.

Typical profile of Granby loamy sand in NE¼NE¼ sec. 25, T. 12 N., R. 15 W.:

Ap—0 to 10 inches, black (10YR 2/1) loamy sand; weak, medium, granular structure; very friable; neutral; abrupt, smooth boundary.

Clg—10 to 20 inches, gray (10YR 6/1) loamy sand; very weak, coarse, subangular blocky structure; very friable; slightly acid; clear, smooth boundary.

IIC2g—20 to 30 inches, gray (10YR 5/1) sand that has common, fine, distinct mottles of brownish yellow (10YR 6/6); very weak, coarse, subangular blocky structure; very friable; slightly acid; gradual, smooth boundary.

IIC3—30 to 38 inches, brown (10YR 5/3) sand; single grain; loose; slightly acid; gradual, smooth boundary.

IIC4—38 to 60 inches +, grayish-brown (10YR 5/2) sand; single grain; loose; neutral.

In areas of Granby soils that have never been plowed, the surface layer ranges from 6 to 15 inches in thickness and consists of black sand, loamy sand, and sandy loam that are very high in organic-matter content. The mottling in the subsoil is faint in some areas. A layer of finer textured material, 1 to 3 inches thick, is in the subsoil in places. The upper 20 inches of these soils ranges from medium acid to neutral, and below 20 inches, the material ranges from slightly acid to neutral or is calcareous.

Granby soils are similar to the Roscommon soils in drainage but have a thicker surface layer. The sand in the Granby soils is coarser than that in the Deford soils.

Granby loamy sand (0 to 2 percent slopes) (Ga).—This soil occupies the broad, nearly level outwash plain and low, wet depressions throughout the county. The depressions are dish shaped, and there are some gently sloping areas near their edges. The surface layer is high in organic-matter content. Where the soil has been cultivated for some time, the surface layer is lighter colored than that described in the typical profile.

Included with this soil in the mapping were areas that have been eroded by the wind and have a salt-and-pepper appearance and a dark-gray surface layer. In some cultivated areas all of the dark-colored surface layer has been removed by erosion. Also included were depressions that have 12 inches of organic matter at their surface. Other inclusions are areas of Tawas soils and areas of Au Gres soils. The Au Gres soils are slightly higher and better drained than Granby loamy sand.

This soil is wet because its water table is high. Its supply of plant nutrients is low because the texture is sandy.

Much of this soil is idle or is used for native pasture. The smaller depressional areas remain in forest or are in grasses and reeds. Some areas on the flat, sandy plains have been cleared and drained artificially. These areas are easily eroded by wind and require careful management that maintains the content of organic matter.

Capability unit IIIw-11 (5c); woodland suitability group Q; wildlife suitability group 5; community development group 9.

Grayling Series

The Grayling series consists of well-drained sandy soils on the rolling sand hills of the county. The native vegetation consisted of white pine, red pine, aspen, black oak, and white oak. The present forest consists of black oak, white oak, and aspen, and there are some white pine and red pine trees. A considerable acreage has a sparse cover of little bluestem, lichens and mosses, and scattered clumps of scrubby black oak, sumac, and sassafras.

The surface layer is black sand about 1 inch thick. It is underlain by a 1-inch layer of dark-gray sand. Both of these thin layers are single grain and loose.

The subsoil is weakly developed and consists of sand about 14 inches thick. It is yellowish brown in the upper part and light yellowish brown in the lower part. This layer is single grain and loose.

Below the subsoil is a very pale brown sand that is single grain and loose.

Grayling soils have very rapid permeability. Their natural fertility and available moisture capacity are low. The effects of drought on plants are shown sooner on these soils than on most other soils in the county. These loose, dry soils are susceptible to soil blowing and water erosion where the vegetative cover has been removed. Only a few areas are used for crops.

Typical profile of Grayling sand in NE¼NE¼ sec. 18, T. 11 N., R. 16 W., Dalton Township:

A1—0 to 1 inch, black (10YR 2/1) sand; single grain; loose; medium acid; high in organic-matter content; clear, wavy boundary.

A2—1 to 2 inches, dark-gray (10YR 4/1) sand; single grain; loose; strongly acid; clear, irregular boundary.

Bir—2 to 11 inches, yellowish-brown (10YR 5/8) sand; single grain; loose; medium acid; abrupt, irregular boundary.

B3—11 to 16 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; medium acid; clear, wavy boundary.

C—16 to 60 inches +, very pale brown (10YR 7/3) sand; single grain; loose; medium acid.

The surface layer of Grayling soils ranges from dark gray to black and in some areas is high in organic-matter content. The grayish subsurface layer is absent in some areas. Depth to the very pale brown, loose sand ranges from 12 to 24 inches. The profile ranges from medium acid to strongly acid.

Grayling soils have a less well-developed subsoil than either the Rubicon or the Kalkaska soils. Unlike the Wallace soils, Grayling soils lack a cemented layer in the subsoil. Grayling soils are more acid and have a thinner subsurface layer than Deer Park soils.

Grayling-Rubicon sands, 6 to 12 percent slopes (GrC).—These soils occur together in such an intricate pattern that they could not be mapped separately. Each of these soils has a profile similar to the one described for its respective series. These soils occur throughout the sandy areas of the county. They are on the sides of hills in sandy rolling areas in the north-central part of the county. They also occupy short slopes adjacent to closed depressions, along drainageways, and on breaks from one broad level area to another at a lower elevation. Other areas are on long, narrow ridges of the plains.

Grayling and Rubicon soils are similar, but the Rubicon has a redder subsoil than the Grayling.

Included with these soils in the mapping were moderately eroded areas that have a surface layer of grayish-brown sand that contains little organic matter. Also included were a few areas with slopes of more than 12 percent and a few with slopes of less than 6 percent.

The soils in this mapping unit have severe limitations to use as cropland. They are droughty and have a very low supply of plant nutrients. Erosion by wind and water is likely where protective vegetation has been removed. These soils can be used to produce forest products. Much of the acreage is woodland, and open areas can be planted to adapted trees.

Capability unit VIIs-1 (5.7a, 5.3a); woodland suitability group H; wildlife suitability group 8; community development group 3.

Grayling-Rubicon sands, 12 to 25 percent slopes (GrD).—These soils occur together in such an intricate pattern that they could not be mapped separately. Each of these soils has a profile similar to the one described for its respective series. These soils are on short, steep slopes in the rolling, sandy upland of the north-central part of the county. They are also along sandy terrace breaks and in pits in the flat, sandy areas of the outwash plain and the lake plain.

The soils in this mapping unit have a very thin surface layer that is slightly lighter colored than the surface layer in less sloping areas of Grayling and Rubicon soils.

Included with these soils in the mapping were eroded areas that lack their original surface layer. Also included were severely eroded spots that are bare or are covered with mosses and lichens. These severely eroded spots have a yellowish-brown, loose sand surface layer. A few small included areas have slopes of more than 25 percent.

Limitations to use as cropland are severe. These soils are very droughty and have very low fertility. Because slopes are steep, and these soils are loose and dry, both soil blowing and water erosion are likely.

Much of the acreage is forested and is valuable for forest products. Cleared areas are being reforested to adapted pines.

Capability unit VIIs-1 (5.7a, 5.3a); woodland suitability group H; wildlife suitability group 8; community development group 3.

Grayling-Rubicon sands, 25 to 45 percent slopes (GrE).—These soils occur together in such an intricate pattern that they could not be mapped separately. Each of these soils has a profile similar to the one described for its respective series. These soils are on the short, very steep slopes in the rolling, sandy uplands of the county. Some areas are along sandy terrace breaks and in pits in the flat, sandy outwash plain and lake plain.

The surface layer is thinner and less distinct than that of typical Grayling and Rubicon soils. Also, the depth to the substratum is much less. The gray subsurface layer is absent in many areas.

Included with these soils in the mapping were moderately eroded areas that have a grayish-brown surface layer. Also included were severely eroded areas that have shallow blowouts and U-shaped gullies. In a small included acreage slopes are less than 25 percent.

These soils are extensive in this county. Their value as cropland is low, but they are valuable as woodland. Some open areas have been reforested to adapted pines, and others could be. The main concerns in managing these steep soils are erosion and the very low fertility and available moisture capacity.

Capability unit VIIs-1 (5.7a, 5.3a); woodland suitability group H; wildlife suitability group 8; community development group 3.

Hettinger Series

The Hettinger series consists of poorly drained to very poorly drained soils. These soils developed in stratified silty and clayey deposits on the lake plain. They are not extensive in this county and occur only on the lake plain in the northeastern and central parts. The native vegetation consisted of lowland hardwoods and included elm, ash, red maple, and swamp white oak.

The surface layer is black loam about 7 inches thick. It has granular structure, is friable, and has a high content of organic matter.

The subsoil is stratified and consists mainly of gray silty clay loam but has a thin layer or layers of silt loam. The subsoil is about 24 inches thick. It has angular blocky and subangular blocky structure. Brownish-yellow and yellowish-brown mottles are common throughout the subsoil and extend into the underlying material.

The underlying material is stratified. It consists mainly of silty clay loam but contains thin layers of coarser textured material. It is massive, firm, and calcareous.

Hettinger soils have moderately slow permeability and high available moisture capacity. Natural fertility is high. A high water table saturates these soils unless they are drained, and the excess water hinders plant growth and use of farm machinery. Because these soils are stratified, a system of artificial drainage is difficult to install.

These soils warm slowly in spring. Careful management is required to insure maintenance of good soil structure and fertility.

Typical profile of Hettinger loam in SE¼SE¼ sec. 11, T. 12 N., R. 15 W.:

Ap—0 to 7 inches, black (10YR 2/1) loam; moderate, fine, granular structure; friable; slightly acid; abrupt, irregular boundary.

B21g—7 to 18 inches, gray (10YR 5/1) silty clay loam that has many, fine distinct mottles of brownish yellow (10YR 6/6) and many, fine, faint mottles of grayish brown (2.5Y 5/2); strong, fine, angular blocky structure; firm; neutral; clear, wavy boundary.

IIB22g—18 to 21 inches, gray (10YR 5/1) silt loam that has many, medium, faint mottles of dark gray (10YR 4/1) and few, fine, distinct mottles of brownish yellow (10YR 6/6); weak, medium, subangular blocky structure; friable; mildly alkaline; clear, wavy boundary.

IIIB23g—21 to 31 inches, light-gray (10YR 6/1) silty clay loam that has common, medium, faint mottles of gray (10YR 5/1) and many, medium, distinct mottles of yellowish brown (10YR 5/8); weak, medium, subangular blocky structure; firm; mildly alkaline; abrupt, smooth boundary.

IVC—31 to 36 inches, light brownish-gray (10YR 6/2) very fine sandy loam that has many, medium, distinct mottles of yellowish brown (10YR 5/4); massive; friable; mildly alkaline; abrupt, smooth boundary.

VC2g—36 to 48 inches +, gray (10YR 5/1) silty clay loam that has many, medium, distinct mottles of brown (10YR 5/3), many, fine, faint mottles of gray (N 5/0), and few, fine, distinct mottles of brownish yellow (10YR 6/6); massive; firm; calcareous.

Undisturbed areas of Hettinger soils have a black or very dark brown surface layer 6 to 10 inches thick. The subsoil is dominantly silty clay loam or clay loam, but in some areas it has layers of silt loam, loam, or fine sandy loam 1 to 6 inches thick. The material below the subsoil also is dominantly silty clay loam or clay loam, but in some areas there are layers of very fine sandy loam, silt loam, loam, and fine sand 1 to 6 inches thick. The subsoil ranges from slightly acid to mildly alkaline. Below a depth of 36 inches the material is calcareous.

In some areas these soils are limy within 10 inches of the surface, but in other areas they are free of lime in the upper 60 inches. The surface layer is dominantly loam but is silty clay loam in some places.

Hettinger soils are similar to Sims soils in texture, but are more stratified. They are coarser textured than Pickford soils. Hettinger soils are more poorly drained and are grayer than Kawkawlin soils.

Hettinger and Pickford soils (0 to 6 percent slopes) (Hp).—This mapping unit consists of Hettinger loam and Pickford silty clay loam. These soils were mapped as a single unit because they are similar, and, for the purpose of this survey, it was not necessary to map them separately. Most mapped areas are dominantly Hettinger loam, but some are dominantly Pickford silty clay loam, and a few consist of each soil in about equal amounts. Each of these soils has a profile similar to the one described for its respective series.

These soils are on nearly level to gentle slopes of the lake plain. They occupy the beds of former lakes. The Pickford soil is finer textured than the Hettinger soil and lacks distinct stratification in the upper layers.

Included with these soils in the mapping, in areas of Hettinger loam, were small areas of coarse-textured soils. Also included, in areas dominantly of Pickford silty clay loam, were small areas of Selkirk soils that are gently sloping and slightly higher than the Pickford soils.

Hettinger and Pickford soils are wet. Water and air move through them at a moderately slow to very slow rate. Natural fertility and available moisture capacity are high.

In the level or nearly level areas, these soils are difficult to drain because of the relief. Undrained areas of these soils are used mainly for hay, pasture, or trees.

Hettinger soil is in capability unit IIw–2 (1.5c); woodland suitability group P; wildlife suitability group 6; community development group 7. Pickford soil is in capability unit IIIw–2 (1c); woodland suitability group P; wildlife suitability group 6; community development group 7.

Houghton Series

The Houghton series consists of very poorly drained soils that developed in dark-colored, fibrous organic deposits more than 42 inches thick. These soils occur mainly along flowing streams and in shallow beds of old lakes, but some areas are scattered in very wet swales and potholes throughout the uplands. The native vegetation consisted mainly of marsh grasses, sedges, reeds, cattails, and other fibrous plants. A few herbaceous plants, willows, and elm trees occur.

The surface layer is black muck about 6 inches thick. It has granular structure and is friable.

Below the surface layer, and extending to a depth of 60 inches or more the material consists of mucky peat and fibrous peat. This material is massive and is black, dark brown, very dark gray, and very dark grayish brown.

Except in drained areas, a high water table saturates Houghton soils. These soils have moderately rapid permeability and high available moisture capacity. The supply of plant nutrients, especially micronutrients, is low. Cultivated areas are susceptible to soil blowing.

Houghton soils are highly valued as cropland used for celery, mint, and other special crops, but artificial drainage is necessary before crops can be grown. Controlled drainage is advisable because it reduces subsidence of the soil. All drainage, however, is difficult and costly. Many areas are idle because outlets are lacking. Also needed are special mixtures of fertilizer.

Typical profile of Houghton muck in SW¼SE¼NE¼ sec. 16, T. 10 N., R. 15 W.:

1—0 to 6 inches, black (10YR 2/1) muck; moderate, fine, granular structure; friable; medium acid; clear, wavy boundary.

2—6 to 12 inches, dark-brown (10YR 3/3) mucky peat; massive; friable; slightly acid; clear, wavy boundary.

3—12 to 15 inches, black (10YR 2/1) colloidal peat that has many, fine, dark yellowish-brown (10YR 3/4) fibers; massive; slightly acid; clear, smooth boundary.

4—15 to 45 inches, very dark gray (10YR 3/1) peat that has dark-brown (10YR 3/3) fibers; massive; friable; neutral; clear, wavy boundary.

5—45 to 60 inches +, very dark grayish-brown (10YR 3/2) fibrous peat; approximately 10 percent of horizon is light-gray (10YR 7/1) sand; massive; friable; neutral.

In some areas the surface layer of Houghton soils consists of only partly decomposed organic material and is lighter colored than that in the profile described. The layers underlying the surface layer vary in color and thickness and contain a few woody fragments. This soil is generally medium acid to slightly acid, but a few areas are strongly acid or neutral. In some areas, a 2- to 10-inch layer of loamy mineral material is at the surface. In the beds of old lakes, sandy material is just below a depth of 42 inches.

Houghton soils have a lower content of woody fragments than Carlisle soils and thicker organic deposits than Tawas or Warners soils. Houghton soils are less stratified than Kerston soils and consist of more uniform material.

Houghton peat and muck (0 to 2 percent slopes) (Ht).—This soil lies in low, flat areas and in potholes or depressions in the outwash plain, lake plain, and till plain. It has a profile like the one described for the series.

Included with this soil in the mapping were areas of Tawas muck. These areas consist of shallow deposits of peat over sandy material. Also included were scattered spots of woody peat. None of these included areas greatly influences use and management.

This soil is wet and has high available moisture capacity. Natural fertility is low.

Artificial drainage is required before this soil can be used as cropland. Drained areas are used for celery, mint, lettuce, onions, carrots, and other special crops. Corn is also grown. Care is needed to prevent overdrainage, for overdrainage increases susceptibility to soil blowing. Special mixtures of fertilizer are needed on this soil.

Capability unit IIIw–15 (Mc); woodland suitability group U; wildlife suitability group 5; community development group 10.

Kalkaska Series

The Kalkaska series consists of well-drained sandy soils on low, long, narrow ridges that occur on the nearly level, wet outwash plain. A few areas are in the rolling sandy uplands. The native forest vegetation consisted of beech, maple, hemlock, white birch, and some blackgum. Many of the narrow ridges are in grasses, weeds, scattered sassafras, fire cherry, gum, and sumac.

The surface layer is a mixture of black and gray sand about 4 inches thick. It has granular structure and is very friable. A subsurface layer of light-gray sand underlies the surface layer. It has subangular blocky structure and is very friable.

The subsoil is sand about 16 inches thick. It is dark reddish brown in the upper part and yellowish red in the lower part. The subsoil has subangular blocky structure and is very friable.

Underlying the subsoil, at a depth of about 26 inches, is light yellowish-brown sand. This material is single grain and loose.

Kalkaska soils have rapid permeability and low available moisture capacity. The content of moisture is seldom adequate for crop growth, and plants are especially in need of moisture during dry summers. If cultivated, these soils are easily eroded by wind and water. They are of little value as cropland but are valuable as woodland. Many areas have been replanted to pine.

Typical profile of Kalkaska sand in SE¼SE¼ sec. 15, T. 9 N., R. 14 W., Ravenna Township:

01—1 inch to 0, needles from jack pine.

A1—0 to 4 inches, black (10YR 2/1) mixed with gray (10YR 5/1) sand; very weak, fine, granular structure; very friable; very strongly acid; abrupt, irregular boundary.

A2—4 to 10 inches, light-gray (10YR 6/1) sand; weak, coarse, subangular blocky structure; very friable; strongly acid; clear, wavy boundary.

B21hir—10 to 15 inches, dark reddish-brown (2.5YR 3/4) sand; weak, medium, subangular blocky structure; very friable; very strongly acid; clear, irregular boundary.

B22ir—15 to 21 inches, dark-red (2.5YR 3/6) sand; weak, coarse, subangular blocky structure; very friable; very strongly acid; clear, irregular boundary.

B23ir—21 to 26 inches, yellowish-red (5YR 5/8) sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

C—26 inches +, light yellowish-brown (10YR 6/4) sand; single grain; loose; medium acid.

In cultivated areas of Kalkaska soils the dark-colored surface layer and subsurface layer are mixed and form a dark-gray plow layer. The thickness of the subsurface layer ranges from 2 to 12 inches, but this layer is absent in some areas. The surface layer and subsoil combined, range from 18 to 36 inches in thickness. Chunks of cemented material occur in the subsoil in some areas. The surface layer and subsoil range from very strongly acid to medium acid.

The layers in the subsoil of Kalkaska soils are more developed than those of the Rubicon soils but are less developed than those of the Wallace soils. Kalkaska soils lack the cemented layer in the subsoil that is typical of the Wallace soils.

Kalkaska-Wallace sands, 2 to 6 percent slopes (KaB).—Kalkaska sand and Wallace sand generally occur together in such an intricate pattern that they could not be mapped separately. Each of these soils has a profile similar to the one described for its respective series. These two soils are somewhat similar, but the Wallace soil has a cemented layer in the subsoil, and the Kalkaska soil does not. The unit occupies gently sloping, narrow, long and low dune-like ridges within areas of the flat, wet outwash plain and lake plain. These soils are normally moderately well drained, although some higher positions are well drained.

Included with these soils in the mapping were eroded areas in which the surface layer consists of brownish former subsoil material and has a few chunks of cemented material on the surface. Also included were small areas of Au Gres and Saugatuck sands in some of the shallow depressions and at their outer edges. In a few included areas, slopes are 6 to 12 percent.

These soils have low available moisture capacity and natural fertility. They are susceptible to erosion. The cemented layer in the subsoil retards the penetration of roots in some places.

These soils have little value as cropland, but they are valuable for their forest products.

Capability unit VIIs–1 (5a; 5a–h); woodland suitability group H; wildlife suitability group 8; community development group 3.

Kawkawlin Series

The Kawkawlin series consists of somewhat poorly drained loamy soils that commonly occur on lower slopes and around the edges of depressions in the gently sloping to hilly areas of the southeastern part of the county. Some areas are on the level to gently sloping lake plain. Small areas are near Holton in the northeastern part of the county and west of Montague in the northwestern part. The native vegetation consisted of mixed hardwoods and conifers and included sugar maple, red maple, oak, ironwood, birch, aspen, white pine, and hemlock.

The surface layer is very dark gray loam about 10 inches thick. It has granular structure and is friable.

The upper part of the subsoil is about 8 inches thick and consists of a mixture of the subsurface layer and material from the subsoil. The subsurface material is grayish-brown loam, and the subsoil material is yellowish-brown heavy loam. The lower part of the subsoil consists of reddish-brown or brown clay loam about 18 inches thick. This horizon is distinctly mottled with yellowish brown, grayish brown, and gray. It has angular blocky structure and is firm.

Under the subsoil is light-gray clay loam mottled with gray or light olive brown. This material has angular blocky structure and is firm and calcareous.

These soils have moderately slow permeability and high available moisture capacity. They are naturally fertile.

Artificial drainage is needed for maximum use in farming, but this drainage is not difficult.

Typical profile of Kawkawlin loam in SW¼SE¼ sec. 14, T. 9 N., R. 14 W., Ravenna Township:

Ap—0 to 10 inches, very dark gray (10YR 3/1) loam; moderate, coarse, granular structure; friable; neutral; abrupt, smooth boundary.

A2&B21t—10 to 18 inches, grayish-brown (10YR 5/2) loam representing the A2 horizon; yellowish-brown (10YR 5/6) heavy loam that has many, coarse, distinct mottles of brown (10YR 5/3) representing the B21t horizon; weak, medium, subangular blocky structure; friable; medium acid; clear, irregular boundary.

B22t—18 to 25 inches, reddish-brown (5YR 4/3) clay loam that has common, medium, distinct mottles of yellowish brown (10YR 5/8) and many, coarse, distinct mottles of grayish brown (10YR 5/2); moderate, medium, angular blocky structure; firm; slightly acid; clear, wavy boundary.

B23t—25 to 36 inches, brown (10YR 5/3) clay loam that has many, fine, faint mottles of gray (10YR 5/1) and many, medium, distinct mottles of yellowish brown (10YR 5/8); moderate, coarse, angular blocky structure; firm; neutral; abrupt, irregular boundary.

Cg—36 to 48 inches +, light-gray (10YR 7/1) clay loam that has common, medium, faint mottles of gray (N 6/0) and common, coarse, distinct mottles of light olive brown (2.5Y 5/4); moderate, coarse, angular blocky structure; firm; calcareous.

Undisturbed areas of Kawkawlin soils have a very dark gray or very dark grayish-brown surface layer 2 to 5 inches thick. It is underlain by a grayish-brownish layer 3 to 7 inches thick. Depth to mottling ranges from 6 to about 16 inches. The subsoil ranges from clay loam to silty clay loam or light clay. The profile is neutral to medium acid. Depth to the light-gray clay loam material ranges from 24 to 40 inches. In drainageways the surface layer is thicker than that described because loamy material from higher lying areas has been deposited on the surface.

Kawkawlin soils occur near Nester, Belding, and Kent soils. They are more poorly drained and more highly mottled than Nester soils but are better drained and not so gray as the Sims soils. Texture is coarser in the Kawkawlin soils than it is in the Selkirk soils.

Kawkawlin loam, 0 to 2 percent slopes (KkA).—This soil occupies lower parts of nearly level to gently undulating lake plains in the northeastern part of the county and the nearly level upland depressions in the rolling landscape in the southeastern part.

Included with this soil in the mapping were small areas of poorly drained, dark-colored soils. These included areas dry up slowly after prolonged rains in spring.

This soil has no serious limitations to intensive row-cropping in drained areas. After this soil has been drained, the maintenance of organic matter and tilth is the main concern of management.

Capability unit IIw–2 (1.5b); woodland suitability group Z; wildlife suitability group 3; community development group 4.

Kawkawlin loam, 2 to 6 percent slopes (KkB).—This soil occupies the gentle slopes of the nearly level to gently sloping lake plain in the northeastern part of the county. It is also on the lower side slopes and foot slopes of the rolling landscape of the southeastern part.

Included with this soil in mapping were many areas where so much of the original surface layer has been removed by water erosion that tillage mixes some of the clayey subsoil into the plow layer. In small spots, especially those on the upper parts of slopes, the plow layer is made up entirely of clayey subsoil material. These small spots are better drained and lighter colored than the uneroded Kawkawlin loam. The total acreage of the included areas is small.

This soil generally requires some artificial drainage for best results. Because slopes are gentle, water ordinarily does not stand on the surface. Exceptions are in the small depressional areas. Management is needed that provides control of water erosion. Also needed are practices for maintaining adequate amounts of organic matter.

Capability unit IIw–3 (1.5b); woodland suitability group Z; wildlife suitability group 3; community development group 4.

Kawkawlin and Selkirk loams, 0 to 2 percent slopes (KsA).—This mapping unit generally consists of Kawkawlin or Selkirk loam or silt loam, but areas of Kawkawlin loam are more extensive. Each of these soils has a profile similar to the one described for its respective series. These soils occur in the nearly level areas of the gently undulating lake plain in the northeastern part of the county.

The Kawkawlin soil and the Selkirk soil are similar in drainage, but the Selkirk soil generally has a silt loam plow layer and finer textured subsoil and substratum. The Kawkawlin loam has a plow layer only 7 inches thick in some places, but this layer is thicker and darker colored in low pockets.

Included with these soils in the mapping were areas of Sims loam. These areas were in some of the low pockets or depressions. Also included were eroded areas that have a dark-brown plow layer that is a mixture of the original surface layer and material from the subsoil. In these areas the plow layer is finer textured and contains less organic matter than that in noneroded areas, where the plow layer does not contain subsoil material. These inclusions are in areas of the Kawkawlin soil.

Also included, in areas of Selkirk loam, were some severely eroded areas that have a clay loam or silty clay loam plow layer. Included in small, slight depressions were Pickford soils. Other areas have a black plow layer that is high in content of organic matter.

Most areas of this mapping unit have been drained and are used for hay, grain, and pasture. The Selkirk soil is harder to drain than the Kawkawlin. The finer texture of the Selkirk soil makes it better suited to hay and pasture than to grain. Some undrained areas of Selkirk soil remain wooded.

Kawkawlin soil is in capability unit IIw–2 (1.5b); woodland suitability group Z; wildlife suitability group 3; community development group 4. Selkirk soil is in capability unit IIIw–2 (1b); woodland suitability group Z; wildlife suitability group 3; community development group 4.

Kawkawlin and Selkirk loams, 2 to 6 percent slopes (KsB).—This mapping unit is made up of either Kawkawlin loam or Selkirk loam, but Kawkawlin loam is most extensive. Each of these soils has a profile similar to the one described for its respective series. These soils occur on the gentle slopes of the nearly level to gently undulating lake plain in the northeastern part of the county. Other areas are on the lower slopes and gently sloping sides of natural drainageways in the gently undulating to rolling till plain in the southeastern and northwestern parts of the county.

The Kawkawlin soil and the Selkirk soil are similar in drainage, but the Selkirk soil generally has a very dark grayish-brown loam or clay loam plow layer and is finer textured in the subsoil and substratum. The plow layer of the Kawkawlin soil is dark-gray or dark grayish-brown loam and is generally about 7 inches thick.

Included with these soils in the mapping were small areas of Sims soils in shallow depressions. Also included, on the upper parts of slopes, were areas of Nester and of Menominee soils. In a few small included areas the surface layer is sandy loam or loamy sand. These included soils are in areas that are mainly Kawkawlin soils.

Also included in mapping, in areas of Selkirk soils, were areas of Pickford soils in small depressions and, at the upper parts of slopes, areas of Kent soils. Some of the upper parts of slopes were severely eroded and have a plow layer that is reddish-colored to grayish-brown clay loam or silty clay. The substratum is calcareous and is 18 to 24 inches below the surface. Soils in a few shallow, eroded drainageways are also included. Although the inclusions in this mapping unit vary in characteristics, they are so small that they are not managed separately.

Most areas of this mapping unit have been drained and are used for hay, grain, and pasture. The finer texture of the Selkirk soil makes it better suited to hay and pasture than to grain. The Selkirk soil is harder to drain than the Kawkawlin. Many areas are not suited to a complete drainage system, but random drainage and surface drainage are helpful in level areas. Some undrained areas of Selkirk soil remain wooded.

Kawkawlin soil is in capability unit IIw–2 (1.5b); woodland suitability group Z; wildlife suitability group 3; community development group 4. Selkirk soil is in capability unit IIIw–2 (1b); woodland suitability group Z; wildlife suitability group 3; community development group 4.

Kent Series

The Kent series consists of well drained and moderately well drained, medium-textured soils that occupy short, steep breaks in gently sloping areas of the lake plain. The native vegetation consisted of northern hardwoods and some conifers and included hard maple, red oak, and beech and some elm, hemlock, and white pine.

These soils have a dark grayish-brown silt loam surface layer about 10 inches thick. This layer has granular structure and is friable.

The subsoil is strong-brown and reddish-brown silty clay and clay that is mottled or coated with reddish brown in the lower part. It has angular blocky structure and is very firm.

Underlying the subsoil, at a depth of about 29 inches, is reddish-brown silty clay that is distinctly mottled with yellow, pinkish gray, and yellowish red. This material has angular blocky structure and is very firm and calcareous.

Water and air move slowly through these moderately fine textured soils. Natural fertility and available moisture capacity are high. Because slopes are steep and erosion is a hazard, these soils are used mainly for hay crops or permanent pasture.

Typical profile of Kent silt loam in SW¼SW¼NW¼ sec. 13, T. 12 N., R. 15 W.:

Ap—0 to 10 inches, dark grayish-brown (10YR 4/2) silt loam; moderate, coarse, granular structure; friable; slightly acid; abrupt, smooth boundary.

B21—10 to 17 inches, strong-brown (7.5YR 5/8) silty clay that has many, medium, distinct mottles of reddish brown (5YR 5/3 or 5/4) and light yellowish brown (10YR 6/4); moderate, medium, angular blocky structure; very firm; medium acid; clear, irregular boundary.

B22—17 to 29 inches, reddish-brown (5YR 4/4) clay that has many, fine, faint coats of reddish brown (5YR 5/3); strong, fine, angular blocky structure; very firm; slightly acid; abrupt, wavy boundary.

C—29 to 36 inches +, reddish-brown (5YR 5/3) silty clay that has many, medium, distinct mottles of yellow (10YR 7/6), pinkish gray (7.5YR 6/2), and yellowish red (5YR 5/6); strong, medium, angular blocky structure; very firm; calcareous.

Undisturbed areas of Kent soils have a very dark gray or very dark grayish-brown surface layer 1 to 4 inches thick. This layer is underlain by a grayish-brown or brown layer that is 1 to 4 inches thick. The combined thickness of the surface layer and upper part of the subsoil ranges from 25 to about 34 inches. In some areas in the northeastern part of the county, layers of silt, less than 6 inches thick, are in the soil profile.

Kent soils are finer textured than Nester soils and are better drained than Selkirk soils.

Kent silt loam, 25 to 45 percent slopes (KtE).—This soil occupies the short, steep slopes along streams that have cut into the gently sloping lake plain. It is near areas of Allendale soils and Selkirk soils.

The surface soil is a dark gray to a very dark grayish brown. Mottling is closer to the surface than is typical of this series. Depth to calcareous material ranges from 25 to 34 inches.

Included with this soil in the mapping were small areas that have slopes of less than 25 percent. These included areas do not greatly influence use and management.

Water moves slowly through this soil. Many small areas are wet where water moves laterally and seeps out at the surface. This soil is too steep to be used as cropland. The steep slopes limit the use of machinery. In cultivated areas runoff is very rapid and severe water erosion is likely. Some areas are used for pasture, and others support a second growth of mixed hardwoods.

Capability unit VIIe–1 (1a); woodland suitability group B; wildlife suitability group 9; community development group 1.

Kerston Series

The Kerston series consists of very poorly drained soils in which layers of organic material alternate with layers of mineral material. These soils occupy the lowest areas of stream bottoms and are flooded when the streams are high. A considerable acreage of these soils occurs along the Muskegon River where it flows into Muskegon Lake, along the branches of the White River near Montague, and along other streams in the county. The native vegetation consisted of alder, elm, red maple, white-cedar, and hemlock.

The upper part of the surface layer is black muck about 10 inches thick. The lower part is very dark grayish brown and consists of muck mixed with sandy material and is about 6 inches thick. The surface layer is friable.

Below the surface layer are alternate layers of sand and muck. The sand is dominantly gray, single grain, and loose. The muck is black or very dark gray, massive, and friable. In some places the layer of muck makes up about 75 percent of the total thickness of Kerston soils.

Air and water move through these soils at a moderately rapid rate. Available moisture capacity is moderately high, but natural fertility is low. The water table is at the surface or within 1 foot of the surface throughout most of the year.

A considerable acreage of these soils along the White and Muskegon Rivers is drained and planted to celery, lettuce, onions, and other crops of high value. These soils are difficult to drain and are subject to flooding. Crops are susceptible to damage by frost in spring.

Typical profile of Kerston muck in SW¼SE¼SE¼ sec. 15, T. 12 N., R. 17 W.:

1—0 to 10 inches, black (10YR 2/1) muck; weak, medium, platy structure; friable; slightly acid; clear, smooth boundary.

2—10 to 16 inches, very dark grayish-brown (10YR 3/2) muck and very dark gray (10YR 3/1) sand mixed together; weak, coarse, subangular blocky structure; friable; medium acid; abrupt, irregular boundary.

3—16 to 18 inches, light brownish-gray (10YR 6/2) sand that has many, medium, distinct mottles of dark gray (10YR 4/1); single grain; loose; medium acid; abrupt, smooth boundary.

4—18 to 22 inches, black (10YR 2/1) muck containing grayish-brown (10YR 5/2) stems of plants; massive; friable; medium acid; abrupt, smooth boundary.

5—22 to 25 inches, dark-gray (10YR 4/1) sand that has many, fine, faint mottles of gray (10YR 5/1) and many, medium, distinct mottles of very dark gray (10YR 3/1); considerable organic material; very weak, coarse, subangular blocky structure; very friable; slightly acid; abrupt, smooth boundary.

6—25 to 29 inches, gray (10YR 5/1) sand that has many, medium, faint mottles of light brownish gray (10YR 6/2); single grain; loose; slightly acid; abrupt, smooth boundary.

7—29 to 34 inches, very dark gray (10YR 3/1) muck that has many, medium, faint mottles of very dark brown (10YR 2/2); massive; friable; neutral; abrupt, smooth boundary.

8—34 to 40 inches +, olive-gray (5YR 4/2) coarse sand that has many, medium, distinct mottles of very dark gray (5Y 3/1); some organic materials; single grain; loose; neutral.

The muck surface layer of Kerston soils ranges from 6 to about 20 inches in thickness. The thickness of the alternate layers of muck and mineral material ranges from 2 to 12 inches. The mineral horizons are dominantly sand but are loamy sand or sandy loam in some areas.

Kerston soils are in sites similar to those of Sloan soils but have layers of organic material that are lacking in Sloan soils. The layers of organic material in the Kerston soils are thinner than those in the Carlisle and Houghton soils.

Kerston muck (0 to 2 percent slopes) (Ku).—This soil is in depressions or in ponded areas on first bottoms along flowing streams. It is most extensive near the mouth of the Muskegon and White Rivers.

Included with this soil in the mapping were some areas of Roscommon sand and coarse-textured alluvium that make up as much as 25 percent of the area mapped.

Much management is needed on this soil before it can be used for crops. Optimum yields are difficult to obtain unless artificial drainage is provided. Overdrainage accelerates erosion and the decomposition of the organic matter. Ferility is low, and in many places special mixtures of fertilizer are required. Available moisture capacity, however, is moderately high.

Where this soil is diked and drained, celery, onions, and other special crops are grown. Other areas are covered with second-growth forest consisting of elm, ash, soft maple, and brush. Cleared areas that are frequently flooded and remain flooded for long periods are used for pasture.

Capability unit IIIw–12 (L-Mc); woodland suitability group O; wildlife suitability group 5; community development group 10.

Lake Beaches

Lake beaches (La) occur both along inland lakes and along Lake Michigan. Slopes range from 0 to 12 percent. The soil material is light-colored sand that is not in definite layers, as are the layers in the Deer Park and Rubicon soils. The sand ranges from grayish brown to light gray. Because Lake beaches extend from the edge of the water to elevations of as much as 15 feet above the level of the lake, their water table ranges from very shallow to deep. The lowest parts of these beaches, particularly when the lakes are at a high level, are intermittently covered with water. The beaches along Lake Michigan are calcareous, but those along Mona Lake and Wolf Lake are not.

In most places Lake beaches slope gently toward the lake, but slopes are short and steep in some areas. In the driest areas the pattern of low humps and pits is changed by the wind. Beachgrass grows near the edge of the water in some areas, and a few scattered trees are present. Recreation is the main use; cottages have been built in a few areas.

Capability unit VIIIs–1 (Sa); woodland suitability group Y; wildlife suitability group 4; community development group 3.

Mancelona Series

The Mancelona series consists of well-drained sandy soils that are underlain by calcareous stratified sand and gravel at a depth of 18 to 42 inches. These soils are in the gently sloping and rolling, water-worked, sandy area in the southeastern part of the county. The native vegetation consisted mainly of mixed hardwoods and conifers and included oaks, maple, aspen, white pine, and red pine. The present vegetation is mainly grasses and weeds, and there is some second-growth aspen and oak.

The surface layer is very dark grayish-brown loamy sand about 7 inches thick. It has granular structure and is very friable.

The subsoil is dominantly brown, yellowish brown, or dark yellowish brown. The upper and lower parts are very friable loamy sand, but the middle part is firm sandy clay loam about 9 inches thick. The lower part contains pebbles and cobbles as much as 6 inches in size. The subsoil is subangular or angular blocky.

Below the subsoil, at a depth of about 36 inches, is stratified sand and gravel. This material is single grain, loose, and calcareous.

Mancelona soils have moderately rapid permeability and low available moisture capacity. Their supply of plant nutrients is low. These soils have many gravel pits and are used mainly as sources of sand and gravel.

In this county Mancelona soils are mapped only in complexes with Chelsea soils.

Typical profile of Mancelona loamy sand in SE¼ sec. 33, T. 10 N., R. 13 W., Casnovia Township:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, coarse, granular structure; very friable; medium acid; abrupt, smooth boundary.

Bir—7 to 17 inches, brown (7.5YR 4/4) loamy sand; weak, medium, subangular blocky structure; very friable; strongly acid; clear, wavy boundary.

B'2t—17 to 26 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; weak, medium, angular blocky structure; firm; medium acid; clear, irregular boundary.
B'3—26 to 36 inches, yellowish-brown (10YR 5/4) loamy sand streaked with grayish brown (10YR 5/2) and yellowish brown (10YR 5/8); weak, coarse, subangular blocky structure; very friable; slightly acid; contains cobbles as much as 6 inches in diameter; abrupt, irregular boundary.
IIC1—36 to 41 inches, pale-brown (10YR 6/3) coarse sand; single grain; loose; calcareous; clear, wavy boundary.
IIIC2—41 to 60 inches +, very pale brown (10YR 7/3) stratified sand and gravel; single grain; loose; calcareous.

In undisturbed areas Mancelona soils have a very dark gray or very dark grayish-brown surface layer 2 to 5 inches thick. It is underlain by a grayish-brown or light brownish-gray layer 2 to 6 inches thick. The layer of sandy clay loam in the subsoil ranges from dark yellowish brown to dark brown or strong brown. Its texture ranges from sandy clay loam to clay loam, and its thickness ranges from 6 to 10 inches. Above the stratified sand and gravel, the material ranges from strongly acid to slightly acid. The stratified sand and gravel are calcareous. Depth to stratified sand and gravel ranges from 24 to about 36 inches. The stratified material is dominantly sand, dominantly gravel, or stratified sand and gravel.

Mancelona soils have a finer textured subsoil than the Chelsea or Montcalm soils. Mancelona soils are underlain by coarser sand and gravel than are Rubicon soils and have a finer textured subsoil.

Marsh

Marsh (Ma) is made up of old bayous and wet areas along streams that empty into Lake Michigan and of very wet, inland areas. Slopes range from 0 to 2 percent. The vegetation consists of cattails, sedges, water weeds, and a few clumps of tamarack, willow, elder, and other water-tolerant trees. The soil material is a very friable, finely divided peat. It is saturated during the entire year.

Most Marsh is used only by wildlife. Waterfowl, muskrats, and other water-loving wildlife use the areas for nesting and shelter. A few of these areas have been diked and artificially drained and are now producing flowers, bulbs, celery, onions, and other special crops. Draining these areas so that they can be used as cropland is very expensive. It is advisable to make special studies to determine the feasibility of drainage.

Capability unit VIIIw-1 (Sc); woodland suitability group U; wildlife suitability group 5; community development group 10.

Menominee Series

The Menominee series consists of well drained and moderately well drained, sandy soils. These soils are scattered in gently sloping to rolling areas in the southeastern, northeastern, and northwestern parts of the county. They developed in sandy deposits that are underlain by loamy material at a depth of 18 to 42 inches. The native vegetation consisted of mixed hardwoods and conifers and included sugar maple, beech, ash, oak, hickory, and white pine.

The surface layer consists of very dark grayish-brown loamy sand that has granular structure and is very friable. It is about 3 inches thick. The subsurface layer, about 4 inches thick, is dark-gray loamy sand that has subangular blocky structure and is very friable.

The upper part of the subsoil is loamy sand and sand about 11 inches thick. In most places it is strong brown or yellowish brown, has subangular blocky structure, and is very friable. The lower part is yellowish-red clay loam about 8 inches thick. It has angular blocky structure and is firm. Between the upper and lower parts of the subsoil is brownish-yellow and light yellowish-brown, loose sand about 15 inches thick. The lower part of the subsoil is mottled with pinkish gray.

Below the subsoil, at a depth of about 41 inches, is yellowish-red clay loam that is massive, firm, and calcareous.

These soils are rapidly permeable to water in their upper sandy part and are moderately slowly permeable in their lower part. These soils are low in natural fertility and are droughty during dry periods. They have moderately low available moisture capacity.

Most of the acreage of these soils is cleared and cultivated. The main concerns of management are low fertility, droughtiness, soil blowing, and water erosion.

Typical profile of Menominee loamy sand in SE¼SE¼SE¼ sec. 15, T. 10 N., R. 14 W., Moorland Township:

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, granular structure; very friable; neutral; abrupt, wavy boundary.
A2—3 to 7 inches, dark-gray (10YR 4/1) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, irregular boundary.
B21ir—7 to 11 inches, strong-brown (7.5YR 5/8) loamy sand; weak, medium, subangular blocky structure; very friable; strongly acid; clear, irregular boundary.
B22ir—11 to 18 inches, yellowish-brown (10YR 5/8) sand; weak, coarse, subangular blocky structure; very friable; medium acid; clear, wavy boundary.
B3—18 to 26 inches, brownish-yellow (10YR 6/6) sand; single grain; loose; medium acid; gradual, diffuse boundary.
A'2—26 to 33 inches, light yellowish-brown (10YR 6/4) sand that has many, fine, distinct mottles of strong brown (7.5YR 5/8); single grain; loose; slightly acid; abrupt, wavy boundary.
IIB't—33 to 41 inches, yellowish-red (5YR 4/8) clay loam that has many, medium, distinct mottles of pinkish gray (7.5YR 6/2); weak, coarse, angular blocky structure; firm; neutral; abrupt, wavy boundary.
IIC—41 to 48 inches +, yellowish-red (5YR 4/8) clay loam; massive; firm; calcareous.

In cultivated areas of Menominee soils the surface layer and part or all of the subsurface layer are mixed together into a loamy sand plow layer that is very dark grayish brown or dark grayish brown and 6 to 10 inches thick. The texture of the underlying loamy substratum ranges from clay loam to silty clay loam.

Menominee soils have coarser textured upper layers than Ubly soils and coarser textured lower layers than Allendale soils. Menominee soils lack the cemented layer in the subsoil that is present in the Ogemaw soils and are somewhat better drained.

Menominee and Ubly soils, 2 to 6 percent slopes (MeB).—In most areas of these soils, either Menominee loamy sand or Ubly sandy loam is dominant, but a few areas contain nearly equal proportions of both soils. These soils are somewhat similar, but Menominee loamy sand has a coarser textured plow layer and subsoil than the Ubly soil. Each of these soils has a profile similar to the one described for its respective series.

In areas that contain Menominee loamy sand and Ubly sandy loam in about equal proportions, the Menominee loamy sand is on the upper parts of slopes and is well drained. Ubly sandy loam is generally on the gentle side slopes and is moderately well drained.

In the Menominee and Ubly soils, clay loam underlies sandy material at a depth of 18 to 42 inches. Water moves rapidly or moderately rapidly through the sandy upper part, but it moves moderately slowly through the finer textured lower part. In many places water that seeps along the tops of the clay loam layer causes wet spots in both the Menominee and Ubly soils.

Areas of Menominee loamy sand have a very dark grayish-brown loamy sand surface layer. These areas are generally moderately well drained, and there is faint mottling in the lower part of the sandy subsoil. The crests and upper parts of the gentle slopes are somewhat better drained, and in these areas the subsoil is not mottled.

Areas of Ubly sandy loam have a very dark grayish-brown sandy loam surface soil. The sandy loam lower subsoil in these areas is faintly mottled with brown and grayish colors, an indication of moderately good drainage. The crests and upper parts of slopes are well drained, and in these areas the subsoil is not mottled.

Included with these soils in the mapping were areas of Rubicon soils that have a loamy substratum and Nester, Kawkawlin, Belding, and Au Gres soils. Also included were small areas at the top of hills that are moderately eroded, areas that have slopes of 0 to 2 percent, and areas that have slopes of 6 to 12 percent.

The included Rubicon soils are in areas where clay loam is below a depth of 42 inches. Nester and Kawkawlin soils are in areas where the clay loam is near the surface. The Belding and Au Gres soils are in the wetter, darker colored areas at the lower parts of slopes of less than 2 percent. In some places Belding soils make up 30 percent of these lower parts of slopes.

This mapping unit is used for the crops generally grown in the county. Many areas are used for hay and pasture, and a few are idle.

Menominee soil is in capability unit IIIs–4 (4/2a); woodland suitability group C; wildlife suitability group 9; community development group 2. Ubly soil is in capability unit IIe–3 (3/2a); woodland suitability group A; wildlife suitability group 9; community development group 2.

Menominee and Ubly soils, 6 to 12 percent slopes (MeC).—This mapping unit occupies moderately steep hillsides and ridges in the northwestern and southeastern parts of the county. It consists of Menominee loamy sand and Ubly sandy loam, but some mapped areas consist of only one of these soils. These soils are somewhat similar, but the Menominee loamy sand has a coarser textured plow layer and subsoil than the Ubly soil. Each of these soils has a profile similar to the one described for its respective series.

In these soils the clay loam material underlies the sandy material at a depth of 18 to 42 inches or more. Permeability to water is rapid or moderately rapid in the sandy material and is moderately slow in the finer textured material. In areas of Ubly sandy loam, the clay loam material is at a depth of more than 24 inches in only a few places, and in some places it is within 18 inches of the surface.

Included with these soils in mapping were areas of Rubicon, Nester, and Belding soils. Also included were eroded areas in which light-colored clay loam is at the surface.

The included Rubicon soils are in areas where the clay loam material dips below a depth of 42 inches. The included Nester soils are in areas on the crests of slopes where the clay loam is near the surface. Some of these areas are eroded and have a plow layer of reddish-brown clay loam. Nester soils are generally adjacent to Menominee loamy sand. Belding soils are normally at the lower parts of slopes in wet, seepy spots. They are adjacent to Ubly sandy loam.

Because of the slopes, these soils are best suited to long-term rotations in which meadow is grown for much of the time.

Menominee soil is in capability unit IIIe–9 (4/2a); woodland suitability group C; wildlife suitability group 9; community development group 2. Ubly soil is in capability unit IIIe–9 (3/2a); woodland suitability group A; wildlife suitability group 9; community development group 2.

Montcalm Series

The Montcalm series consists of well-drained sandy soils. These soils are in nearly level to steep areas of the till plains and moraines in the eastern and northwestern parts of the county. In most areas the native vegetation consisted of mixed hardwoods, such as oak, hickory, and hard maple. Other areas supported nearly pure stands of white pine.

These soils have a very dark grayish-brown loamy sand surface layer about 11 inches thick. It has granular structure and is very friable.

The upper part of the subsoil is yellowish-brown loamy sand about 7 inches thick. It has subangular blocky structure and is very friable. Below this, to a depth of 60 inches or more, there are alternate layers of sand and sandy loam or loamy sand. The layers of sand are pale brown or yellowish brown, single grain, and loose. The layers of loamy sand and sandy loam are dark brown, massive, and very friable.

Montcalm soils have moderately rapid permeability and moderately low available moisture capacity. Natural fertility is moderately low to low. The main concerns in managing these soils are drought, low fertility, soil blowing, and water erosion. Because the available moisture capacity is low, the growth of plants is slowed by lack of moisture. Crop yields are seriously reduced during dry summers.

Typical profile of Montcalm loamy sand in SE¼ sec. 33, T. 10 N., R. 13 W.

Ap—0 to 11 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, coarse, granular structure; very friable; slightly acid; abrupt, smooth boundary.

Bir—11 to 18 inches, yellowish-brown (10YR 5/8) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B'21t—18 to 26 inches, dark-brown (7.5YR 4/4) sandy loam; moderate, medium, subangular blocky structure; friable; medium acid; clear, wavy boundary.

A'2—26 to 36 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; slightly acid; abrupt, wavy boundary.

B'22t—36 to 40 inches, dark-brown (7.5YR 4/4) sandy loam; massive; friable; slightly acid; clear, wavy boundary.

A'2&B't—40 to 60 inches +, pale-brown (10YR 6/3) sand representing the A'2 horizons; bands, 1 to 3 inches thick, of dark-brown (7.5YR 4/4) loamy sand representing the B't horizons; the A'2 horizons are single grain; loose; medium acid. The B't horizons are massive; very friable; medium acid; abrupt, wavy boundaries; alternating horizons continue to a depth of 8 feet or more.

Undisturbed areas of Montcalm soils have a very dark gray or very dark grayish-brown loamy sand surface layer 1 to 4 inches thick. It is underlain by light-gray or gray loamy sand 3 to 8 inches thick. The depth to the first layer of sandy loam ranges from about 16 to 40 inches. The thin layer of sandy loam that occurs below the first layer in the subsoil ranges from 1/8 inch to 8 inches in thickness. Between the layers of sandy loam (B'21t and B'22t) are layers of coarser textured material that range from 2 to 12 inches in thickness. The finer textured material is light sandy clay loam in some areas. Gravel occurs below a depth of 42 inches in some areas.

Montcalm soils have thicker, generally finer textured layers in the subsoil than the Chelsea soils. They are similar to the Mancelona soils in drainage but lack the stratified sand and gravel that underlie those soils.

Montcalm and Chelsea soils, 2 to 6 percent slopes (MhB).—This mapping unit consists of areas of Montcalm loamy sand and Chelsea sandy loam. Some areas are made up almost entirely of either soil. Each of these soils has a profile similar to the one described for its respective series. These soils are mainly in the eastern quarter of the county, but a few areas are in the northwestern part. Areas of these soils are generally rolling. In these areas the Montcalm and Chelsea soils are on gentle slopes and side slopes and the rounded crests of small sandy hills.

Included with these soils in the mapping were areas where clay loam material is generally at a depth of 24 to 60 inches. In some eroded areas, this clay loam is within 24 inches of the surface. Also included, near the top and the bottom of the hillsides, were small areas that have slopes of 6 to 12 percent. These included areas have a surface layer of loamy sand that is lighter colored than that of the Montcalm or Chelsea soils. Use and management of all these inclusions are similar to those of Montcalm and Chelsea soils.

These soils are permeable to water and air. They have a low natural supply of plant nutrients and are low or moderately low in available moisture capacity. The Montcalm soil is finer textured than the Chelsea soil and generally is more productive.

These soils are easily eroded by wind and water. They are best suited to long-term rotations that provide a high proportion of meadow or hay crops.

Montcalm soil is in capability unit IIIs-4 (4a); woodland suitability group C; wildlife suitability group 7; community development group 3. Chelsea soil is in capability unit IVs-2 (5a); woodland suitability group E; wildlife suitability group 7; community development group 3.

Nester Series

The Nester series consists of well drained and moderately well drained soils that developed in limy clay loam material. These soils occupy rolling to hilly areas on till plains and moraines (fig. 4). They occur in the southeastern and northwestern parts of the county and, to a lesser extent, in the northeastern part. The native vegetation consisted mostly of mixed hardwoods, dominantly sugar maple, beech, and ash, but there were also some hemlock, white pine, and red oak trees.

The surface layer is very dark grayish-brown loam about 5 inches thick. It has granular structure and is friable. A subsurface layer of grayish-brown loam occurs above the subsoil.

The subsoil is mainly dark reddish-brown or reddish-brown clay loam that is firm and has mainly angular blocky structure. The upper part of the subsoil is a mixture of the material from the subsurface layer and the subsoil.

Brown clay loam underlies the subsoil. It is angular blocky, firm, and calcareous.

Nester soils make up some of the best cropland in the county. These soils are naturally fertile and have high available moisture capacity and moderately slow permeability. Many of the orchards in the county are on these soils. Management is needed to control water erosion and to maintain fertility and the content of organic matter.

Typical profile of Nester loam NE1/4NE1/4 sec. 26, T. 10 N., R. 13 W., Casnovia Township:

Ap—0 to 5 inches, very dark grayish-brown (10YR 3/2) loam; weak, medium, granular structure; friable; neutral; abrupt, smooth boundary.

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

A2&B21—10 to 14 inches, grayish-brown (10YR 5/2) loam (A2) and reddish-brown (5YR 4/4) clay loam (B21); moderate, medium, subangular blocky structure; firm; slightly acid; clear, irregular boundary.

B22—14 to 36 inches, dark reddish-brown (5YR 3/4) clay loam; strong, medium, angular blocky structure; firm; thin clay films on many peds; slightly acid; abrupt, wavy boundary.

C—36 to 48 inches +, brown (7.5YR 5/4) clay loam; moderate, medium, angular blocky structure; firm; calcareous.

Undisturbed areas of Nester soils have a very dark grayish-brown or very dark gray surface layer 2 to 5 inches thick. The subsurface layer described in the typical profile is missing in some places. The subsoil ranges from clay loam to silty clay loam or clay. Mottling occurs between depths of 30 and 42 inches. Depth to the calcareous underlying material ranges from about 20 to 40 inches. The surface layer and subsoil range from slightly acid to medium acid, but below 36 inches the material is calcareous.

Nester soils are similar to the Kent soils in drainage but are coarser textured. They are better drained and less mottled than Kawkawlin soils and have a finer textured subsoil than Ubly soils.

Nester loam, 2 to 6 percent slopes (NeB).—This gently sloping soil is in the southeastern and northwestern parts of the county. On the lower slopes and in wooded areas, the surface layer is darker colored than it is in other places. This soil is deep, is naturally fertile, and has high available moisture capacity.

Included in mapping were eroded areas that have a surface layer made up largely of clay loam from the subsoil. A few spots on the upper parts of slopes have been eroded by very small rills. Also included were small uneroded nearly level areas along the tops of the slight slopes. In other included areas the plow layer is sandy loam. None of these inclusions greatly influences the use and management of this soil.

This soil is one of the best in the county for crops and is suited to most crops commonly grown. A large acreage that has good air drainage is planted to fruit trees. Management is needed mainly for maintaining fertility and organic matter and for controlling erosion.

Capability unit IIe-1 (1.5a); woodland suitability group B; wildlife suitability group 9; community development group 1.

Nester loam, 6 to 12 percent slopes (NeC).—This soil occupies rolling hillsides in the southeastern and north-

***Figure 4.*—Contour stripcropping in a typical area of Nester soils.**

western parts of the county. It is also in the northeastern part on short slopes where small waterways have cut the nearly level to gently sloping lake plain. This soil is deep, is naturally fertile, and has high available moisture capacity.

Included with this soil in the mapping, in the southeastern and northwestern parts of the county, were areas where slopes are 2 to 6 percent. These slopes are generally dome shaped, but some areas are bowl shaped. The bowl-shaped areas have slight accumulations of transported material on the surface and are wet in spots. Some areas, especially those near the tops of slopes, have been eroded, and the brownish subsoil is exposed at the surface. Also included were small areas of Ubly sandy loam or Menominee loamy sand in which thin sandy deposits overlie clayey material. These inclusions do not have a large total acreage, and they do not affect the use and management of this soil.

This soil has been cleared and cultivated. Much of it is in apple and peach orchards. Common grain and forage crops are also grown. Because slopes are generally strong, this soil is best suited to rotations and management practices that control erosion.

Capability unit IIIe-4 (1.5a); woodland suitability group B; wildlife suitability group 9; community development group 1.

Nester sandy loam, 6 to 12 percent slopes (NrC).—This soil occupies rolling hillsides in the southeastern and northwestern parts of the county. It also occurs on the short slopes where small waterways have cut into the nearly level to gently sloping lake plain. The plowed layer is very dark grayish-brown or dark grayish-brown sandy loam in most places. This soil is deep, is naturally fertile, and has high available moisture capacity.

Included with this soil in mapping were areas that have a dark grayish-brown loam plow layer. Also included were areas of Ubly sandy loam that have a sandy loam subsoil. In other included areas are short slopes of more than 12 percent and a few bowl-shaped areas. The steeper slopes show evidence of water erosion, and the areas between them are dark colored and contain wet spots. None of these inclusions greatly influence the use and management of this soil.

Most areas of this soil have been cleared and cultivated; a large part is in apple and peach orchards. Also grown are the common grain and forage crops. Because slopes are steep, crop rotations and management are needed that reduce soil erosion.

Capability unit IIIe-4 (1.5a); woodland suitability group B; wildlife suitability group 9; community development group 1.

Nester soils, 12 to 25 percent slopes (NsD).—These soils occupy the rolling hillsides of the southeastern and northwestern parts of the county. They also occur on short, steep slopes where small waterways have cut the nearly level to gently sloping lake plain. These soils are deep, are fertile, and have high available moisture capacity.

Included with these soils in mapping were areas that have slopes of 2 to 6 percent and a few wet spots. In these areas the surface layer is mainly loam or sandy loam. Some areas, especially those near the top of slopes, are eroded and have a plow layer containing material from the clayey subsoil. The short, steep slopes in the northwestern part of the county are severely eroded in a few spots and have a few shallow waterways that are eroded. These inclusions do not have a large total acreage, nor do they greatly affect use and management.

These soils have been cleared and cultivated. In the southeastern part of the county, much of the acreage is in apple and peach orchards. In other areas these soils are used mainly for hay and small grains. Because slopes are steep, crops are needed that reduce soil erosion.

Capability unit VIe–1 (1.5a); woodland suitability group B; wildlife suitability group 9; community development group 1.

Nester soils, 12 to 25 percent slopes, severely eroded (NsD3).—These soils occupy the upper part of hillsides in the rolling southeastern and northwestern parts of the county. They also occur on short, steep, knoblike slopes. Individual areas are small. The plow layer is generally reddish-brown clay loam. The limy underlying material is generally within 2 feet of the surface, but in a few small areas it is exposed. A few shallow gullies occur. In some slight depressions the plow layer is darker and more friable than it is in other places.

These soils have been cleared and cultivated, but most areas are now partly covered with grass. Some areas are in orchards. These severely eroded soils are in poor tilth and are difficult to cultivate. A grass or a grass-legume cover helps to reduce further erosion.

Capability unit VIe–1 (1.5a); woodland suitability group B; wildlife suitability group 9; community development group 1.

Nester soils, 25 to 45 percent slopes (NsE).—These soils occur on the steepest slopes of the rolling landscape in the southeastern and northwestern parts of the county. Most areas are in the southeastern part. The slopes are generally short. The surface layer is mainly loam or sandy loam. Layers in these soils are generally thinner than those described in the soil representative of the series, and the limy underlying material is generally within 30 inches of the surface. But these soils are naturally fertile and have high available moisture capacity.

Included in the mapping were severely eroded spots that have a surface layer of brown clay loam.

Most areas of this mapping unit have been cleared and cultivated. Some areas are now in orchards, but most of the acreage is used for hay and pasture. The steepest areas are used mainly for native pasture or are idle. Hawthorn, briers, and other brush have grown up in many idle areas. A few spots have been reforested.

Water quickly runs off these very steep soils unless vegetation is thick enough to hold the water until it soaks into the ground. The very steep slopes also restrict the use of machinery. Because of these factors, these soils are better suited to hay and pasture than to crops.

Capability unit VIIe–1 (1.5a); woodland suitability group B; wildlife suitability group 9; community development group 1.

Nester soils, 25 to 45 percent slopes, severely eroded (NsE3).—These soils occupy the steepest slopes of the rolling landscape in the southeastern and northwestern parts of the county. Most areas are in the southeastern part. Slopes are short and choppy. These soils are in small areas that are generally long and narrow. The plow layer is a reddish-brown sticky clay loam, and the limy underlying material is generally within 2 feet of the surface. The brownish, limy underlying material is exposed at the surface in small areas. Shallow gullies are common.

These soils have been cleared and cultivated, but severe erosion and steep slopes restrict use to hay and pasture. A cover of suitable grass or legumes can be established to reduce further erosion.

Capability unit VIIe–1 (1.5a); woodland suitability group B; wildlife suitability group 9; community development group 1.

Nester-Kawkawlin loams, 2 to 6 percent slopes (NtB).—Nester loam and Kawkawlin loam were not mapped separately, because they occur together in an intricate pattern. These soils are similar in many respects, but they differ in their natural drainage. Each of these soils has a profile similar to the one described for its respective series. The areas of this mapping unit occur in the northwestern and southeastern parts of the county.

Included with these soils in the mapping were a few areas of poorly drained Sims soils in depressions. Also included were some sandy spots and some areas of Selkirk soils.

The soils of this complex are generally in undulating areas on gentle slopes. In places they are in hummocky areas that have many small depressions and waterways. The small depressions are generally occupied by the Kawkawlin loams. Nester soils are in the higher more exposed spots and are eroded in many places. These eroded spots have a reddish-brown clay loam plow layer that contains little organic matter. The surface soil is hard and compact when dry and sticky when wet. The lower slopes are occupied by the Kawkawlin soils. The material underlying these Nester and Kawkawlin soils is slightly finer textured and has a higher percentage of clay than the material underlying other areas of Nester and Kawkawlin soils.

Water and air move moderately slowly through these soils, and the Kawkawlin loams normally require some artificial drainage. Also, the supply of plant nutrients and available moisture capacity are good. Under careful management, these soils are well suited to most crops commonly grown in the county.

Nester soil is in capability unit IIe–1 (1.5a); woodland suitability group B; wildlife suitability group 9; community development group 1. Kawkawlin soil is in capability unit IIw–2 (1.5b); woodland suitability group Z; wildlife suitability group 3; community development group 4.

Nester-Ubly sandy loams, 2 to 6 percent slopes (NuB).—Nester and Ubly sandy loams are so closely intermingled that they were not mapped separately. They are extensive and occur on the gently sloping hillsides of the southeastern and northwestern parts of the county. Both soils have a sandy loam surface layer. In the Nester soil, however, clay loam lies just below the plow layer, and in the Ubly sandy loam, it is at a depth ranging from 18 to 42 inches. Each of these soils has a profile somewhat similar to the one described as representative of its series.

These two soils occur together, but not in a repetitive pattern. The fine-textured material occurs at a depth of 36 to 42 inches in one place and, within a few feet, is exposed at the surface.

Included with these soils in the mapping were a few moderately well drained areas that have slopes of less than 2 percent. Also included were areas of darker colored, wetter Belding soils on the lower parts of slopes and areas of the sandy, lighter colored Menominee or Rubicon soils on the upper parts of slopes. In cultivated fields there were eroded areas that have a brownish clay loam surface layer that is hard when dry and sticky when wet.

Management is needed for controlling water erosion, but these soils are fertile and have moderately high to high available moisture capacity. They are productive if management is good.

Nester soil is in capability unit IIe–1 (1.5a); woodland suitability group B; wildlife suitability group 9; community development group 1. Ubly soil is in capability unit IIe–3 (3/2a); woodland suitability group A; wildlife suitability group 9; community development group 2.

Ogemaw Series

The Ogemaw series consists of somewhat poorly drained to poorly drained sandy soils that have a hardpan in the subsoil. Limy silty clay is at a depth of 18 to 42 inches. Ogemaw soils occur in the northeastern part of the county on the nearly level to gently sloping lake plain. The native vegetation consisted of mixed lowland hardwoods, white pine, and some hemlock and northern white-cedar.

The surface layer is very dark gray loamy sand about 5 inches thick. It has granular structure and is very friable. The subsurface layer is light-gray loamy sand about 4 inches thick.

The upper part of the subsoil is a hardpan consisting of cemented, dark reddish-brown and dark-brown loamy sand. This material is mottled, massive, and indurated. The lower part of the subsoil is reddish-gray silty clay. It is mottled, has angular blocky structure, and is firm.

Underlying the subsoil, at a depth of about 32 inches, is brown silty clay mottled with light gray and reddish brown. It has angular blocky structure and is firm and calcareous.

Permeability is rapid above the hardpan and very slow in it. The hardpan also restricts the development of roots. The material above the hardpan is saturated in spring and after prolonged rains in other seasons. Natural fertility and available moisture capacity are low.

Most areas of these soils have been cleared, and most of this acreage is used for legume-grass hay and for small grains. Some areas are wooded.

Typical profile of Ogemaw loamy sand in NW¼NE¼NW¼NW¼ sec. 1, T. 12 N., R. 15 W., Holton Township:

A1—0 to 5 inches, very dark gray (10YR 3/1) loamy sand; weak, fine, granular structure; very friable; neutral; abrupt, irregular boundary.

A2—5 to 9 inches, light-gray (10YR 6/1) loamy sand that has many, medium, faint mottles of gray (10YR 5/1) and few, fine, distinct mottles of dark gray (10YR 4/1); weak, medium, subangular blocky structure; very friable; slightly acid; abrupt, irregular boundary.

B21hirm—9 to 12 inches, dark reddish-brown (5YR 3/3) loamy sand that has few, medium, distinct mottles of brown (10YR 5/3) and common, medium, distinct mottles of dark red (2.5YR 3/6); massive; indurated; strongly acid; abrupt, irregular boundary.

B22hirm—12 to 19 inches, dark-brown (7.5YR 4/4) loamy sand that has common, fine, distinct mottles of dark red (2.5YR 3/6) and few, medium, distinct mottles of dark reddish brown (2.5YR 2/4); massive; indurated; very strongly acid; clear, irregular boundary.

B3—19 to 23 inches, pale-brown (10YR 6/3) loamy sand that has many, medium, faint mottles of very pale brown (10YR 7/3) and few, fine, distinct mottles of dark brown (10YR 3/3); weak, medium, subangular blocky structure; very friable; strongly acid; abrupt, irregular boundary.

IIB'tg—23 to 32 inches, reddish-gray (5YR 5/2) silty clay that has few, fine, distinct mottles of yellowish red (5YR 5/6) and many, fine, distinct mottles of light gray (5YR 7/1); strong, medium, angular blocky structure; firm, slightly acid; abrupt, wavy boundary.

IICg—32 to 48 inches +, brown (7.5YR 5/2) silty clay that has many, coarse, distinct mottles of light gray (N 7/0) and many, fine, distinct mottles of reddish brown (5YR 5/3); strong, medium, angular blocky structure breaking to strong, fine, angular blocky structure; firm, calcareous.

Cultivated areas of Ogemaw soils have a very dark gray surface layer 6 to 10 inches thick. Where it occurs, the subsurface layer ranges from 2 to 8 inches in thickness, but this layer is absent in many cultivated areas. Sandy material extends from the surface to a depth of 18 to 42 inches. The texture of the finer textured material in the lower part of the profile ranges from silty clay to clay, clay loam, or silty clay loam. The profile ranges from slightly acid to very strongly acid.

Ogemaw soils are similar to the Allendale soils in texture, though the Allendale soils do not have a hardpan in the subsoil. Ogemaw soils have finer textured underlying material than the Saugatuck soils.

Ogemaw loamy sand, 0 to 6 percent slopes (OgB).—This nearly level to gently sloping soil is on the gently undulating lake plain in the northeastern part of the county. Most of it is in the northeastern part of Holton Township along the boundary of the county.

Included with this soil in the mapping were a few areas of Selkirk soils that are clayey and dry out slower than the Ogemaw soil.

This soil has a low supply of plant nutrients. During dry periods, the upper 24 inches is droughty and susceptible to soil blowing.

Most of this soil has been cleared and cultivated. Hay and pasture can be grown, but artificial drainage is needed in many areas before this soil can be used as cropland. Diversions, installed on higher slopes above this soil, intercept excess runoff and are helpful in controlling erosion.

Capability unit IVw–2 (5b–h); woodland suitability group F; wildlife suitability group 1; community development group 5.

Pickford Series

The Pickford series consists of poorly drained soils that developed in clayey deposits in old lakes. These soils are not extensive in this county. They occur in nearly level to slightly depressional areas of the lake plain in the northeastern and central parts. The native vegetation consisted of lowland hardwoods and some conifers and included elm, ash, soft maple, swamp white oak, and a few hemlock and spruce trees.

The surface layer is black silty clay loam about 8 inches thick. It has subangular blocky structure and is firm.

The subsoil is dark grayish-brown silty clay. It has angular blocky structure and is very firm.

Underlying the subsoil, at a depth of about 21 inches, is light brownish-gray silty clay mottled with yellowish brown. It has angular blocky structure, is firm, and is calcareous.

Water and air move very slowly through the Pickford soils. Natural fertility and available moisture capacity are high. These soils warm slowly in spring. They require careful management to insure the maintenance of good soil structure and fertility. Artificial drainage is required for most crops, but drainage is difficult because of the high proportion of clay.

In this county Pickford soils are mapped only with Hettinger soils in an undifferentiated soil group.

Typical profile of Pickford silty clay loam in SW¼SE¼SE¼ sec. 11, T. 12 N., R. 15 W.:

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; moderate, medium, subangular blocky structure; firm; neutral; abrupt, smooth boundary.

Bg—8 to 21 inches, dark grayish-brown (2.5Y 4/2) silty clay that has few, medium, distinct mottles of yellowish brown (10YR 5/6); moderate, medium, angular blocky structure; very firm; slightly acid; abrupt, wavy boundary.

Cg—21 to 48 inches +, light brownish-gray (2.5Y 6/2) silty clay that has many, medium, distinct mottles of yellowish brown (10YR 5/4); weak, coarse, angular blocky structure; very firm; calcareous.

A layer of muck is on the surface in some areas. Undisturbed areas have a black surface layer 4 to 7 inches thick. Layers of silt and very fine sand, ¼ inch to 2 inches thick, occur below a depth of 20 inches in some places.

Pickford soils are finer textured than Sims and Hettinger soils but are similar to them in drainage. They are more poorly drained and grayer than Selkirk soils and have a darker surface layer.

Roscommon Series

The Roscommon series consists of deep, poorly drained, sandy soils. These soils are in nearly level to slightly depressional areas on the outwash plains and the sandy uplands of the county. The native vegetation consisted of elm, ash, aspen, willow, and hoary alder.

The surface layer is very dark gray sand about 5 inches thick. It has granular structure and is very friable.

Light-gray, pale-brown, or light brownish-gray sand is below the surface layer and extends to a depth of more than 60 inches. This material is mainly single grain and loose.

Roscommon soils are very permeable to water and air and have low available moisture capacity. The supply of plant nutrients is also low. A high water table saturates these soils, especially during spring, and impairs use as cropland. Artificial drainage is needed for most cultivated crops, but it should be carried out with extreme care to avoid overdrainage. Overdrained areas become droughty and susceptible to severe soil blowing.

These soils are extensive but are of little value for farming. A small acreage is planted to blueberries, melons, pickling cucumbers, and other special crops. Most areas remain wooded or are used for pasture. Some areas are idle.

Typical profile of Roscommon sand in SW¼SW¼ sec. 15, T. 11 N., R. 16 W., Dalton Township:

A1—0 to 5 inches, very dark gray (10YR 3/1) sand; very weak, medium, granular structure; very friable; strongly acid; abrupt, irregular boundary.

C1—5 to 9 inches, light-gray (10YR 7/2) sand that has many, medium, faint mottles of light brownish gray (10YR 6/2); very weak, medium, subangular blocky structure; very friable; medium acid; clear, irregular boundary.

C2—9 to 18 inches, pale-brown (10YR 6/3) sand that has few, medium, faint mottles of light gray (10YR 7/2); single grain; loose; medium acid; gradual, wavy boundary.

C3—18 to 36 inches, light brownish-gray (10YR 6/2) sand that has many, coarse, faint mottles of gray (10YR 5/1); single grain; loose; slightly acid; gradual, wavy boundary.

C4—36 to 60 inches +, light brownish-gray (10YR 6/2) sand that has few, medium faint mottles of grayish brown (10YR 5/2); single grain; loose; neutral.

A layer of muck, 1 to 12 inches thick, is at the surface in some areas. The original surface layer ranges from very dark gray to black in color and from 3 to 8 inches in thickness. Cultivated areas have a dark grayish-brown or very dark grayish-brown surface layer 6 to 10 inches thick. The reaction, to a depth of 36 inches, ranges from medium acid to mildly alkaline and below 36 inches ranges from neutral to mildly alkaline. In some areas clay loam occurs below 42 inches.

Roscommon soils consist of coarser sand than Deford soils and have a thinner surface layer than Granby soils. Roscommon soils are more poorly drained and grayer than Au Gres soils.

Roscommon and Au Gres sands (0 to 6 percent slopes) (Ra).—This mapping unit consists of Roscommon sand and Au Gres sand. Most areas are Roscommon sand. Each of these soils has a profile similar to the one described for its respective series. These soils are on nearly level, wet, sandy plains in the central part of Fruitland and Laketon Townships and are in Norton, Fruitport, and Sullivan Townships. They also are in shallow depressions adjacent to the long, narrow sand ridges in the western part of the county. Low hummocks and soft swells that are mostly Au Gres sand also occur and have slopes of 2 to 6 percent.

In cultivated areas the plow layer of the Roscommon soil is very dark gray. Areas eroded by wind have a very dark brown plow layer that has had material from the grayish subsoil mixed into it. The depressional areas have a black plow layer of mucky sand. Generally the Roscommon soil is in low, shallow, dish-shaped depressions and the Au Gres soil is in the adjacent higher areas. Cultivated or eroded areas of Au Gres sand have a lighter colored plow layer than undisturbed areas.

Included with these soils in the mapping were eroded areas that have a plow layer consisting of brown sand that contains little organic material. On the crests of some of the hummocks are areas of Croswell sand. The included areas do not greatly affect use and management of this mapping unit.

Roscommon and Au Gres sands have a low supply of plant nutrients. They are wet most of the time because the water table is generally high. In dry periods, when the water table drops, these soils become droughty and are easily eroded by wind.

Some areas of these soils are planted to pine. A large acreage is idle and has a ground cover of quackgrass, Canadian bluegrass, weeds, and briers. Some areas are in pasture. A small acreage is used for general crops, but yields are normally low. Blueberries, pickling cucumbers, melons, and other special crops are grown successfully in a small acreage.

Roscommon soil is in capability unit IIIw-11 (5c); woodland suitability group Q; wildlife suitability group 1; community development group 9. Au Gres soil is in capability unit IVw–2 (5b); woodland suitability group F; wildlife suitability group 1; community development group 6.

Rousseau Series

The Rousseau series consists of well drained and moderately well drained soils in which fine sand extends from the surface to a depth of more than 26 inches. These soils occur in nearly level to gently sloping areas of the lake plain in the eastern part of Holton and Cedar Creek Townships. The native vegetation consisted of mixed hardwoods in which black oak and white oak are dominant. In many areas there is an understory of white pine.

The surface layer is very dark grayish-brown fine sand that has subangular blocky structure and is very friable. In wooded areas this layer is covered with a 2- to 3-inch layer of partly decomposed oak litter.

The subsoil is yellowish-brown or brownish-yellow fine sand. It has subangular blocky structure and is very friable.

Very pale brown fine sand is at a depth of 26 inches. This material is single grain and loose.

Rousseau soils have low available moisture capacity and a low supply of plant nutrients. Permeability is rapid. These soils are easily eroded by wind or water.

Most areas of these soils are used for the farm crops commonly grown in the county. Corn, small grains, and hay are the principal crops. The growth of crops is slowed during midsummer because there is not enough moisture. The content of moisture is seldom adequate for optimum growth of crops.

Typical profile of Rousseau fine sand in NE¼NW¼ sec. 10, T. 12 N., R. 15 W., Holton Township:

01—3 inches to 0, black (10YR 2/1) partly decomposed oak litter; massive; soft; very strongly acid; abrupt, smooth boundary.

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

B21ir—2 to 16 inches, yellowish-brown (10YR 5/8) fine sand; weak, coarse, subangular blocky structure; very friable; strongly acid; gradual, wavy boundary.

B22ir—16 to 26 inches, brownish-yellow (10YR 6/6) fine sand; weak, medium, subangular blocky structure; very friable; medium acid; gradual, wavy boundary.

C—26 to 60 inches +, very pale brown (10YR 7/4) fine sand; single grain; loose; medium acid.

In areas of Rousseau soils that have been cultivated, the surface layer and subsurface layer are mixed and form a dark-brown plow layer. These soils range from very strongly acid to medium acid and are less acid as depth increases. In some areas the lower part of the subsoil and the underlying material are mottled. In some areas very thin layers of finer textured material are below a depth of 30 inches.

The sand particles in the Rousseau soils are finer than those in the Rubicon or Grayling soils. Rousseau soils have a thinner surface layer and finer particles of sand than the Sparta soils.

Rousseau fine sand, 0 to 6 percent slopes (RoB).—This soil is on the nearly level to undulating lake plain in the northeastern part of the county.

Included with this soil in the mapping were severely eroded areas that have a light-colored plow layer containing little organic matter. Also included were small, slightly depressional areas that are somewhat poorly drained. These included areas have a small acreage, and they do not influence use and management.

This soil has low fertility and available moisture capacity. Cultivated areas are easily eroded by wind and water. In summer lack of water retards the growth of crops.

This soil can be used for crops in rotation if practices are used for controlling erosion, conserving moisture, improving fertility, and maintaining the supply of organic matter. Rotations that include a high proportion of hay or meadow are well suited.

Capability unit IIIs–4 (4a); woodland suitability group C; wildlife suitability group 7; community development group 3.

Rubicon Series

The Rubicon series consists of well-drained, deep, sandy soils on the nearly level, dry outwash plain and the rolling sandhills of the county. In some areas these soils are underlain by clay loam to clay at a depth of 42 to 66 inches. The original vegetation was white pine, red pine, black oak, and white oak, but now the forest cover is mainly black oak, and there are some white oaks and a few white pines. A few areas of white pine and red pine remain. Many areas are now covered only with little bluestem, Canada bluegrass, lichens and mosses, and a scattering of staghorn sumac, sassafras, fire cherry, and clumps of scrubby black oak.

The surface layer is black sand about 3 inches thick. It has granular structure and is very friable. A subsurface layer consists of gray sand about 2 inches thick.

The subsoil also is sand, but it is dark brown or strong brown to brownish yellow, subangular blocky, and very friable. The upper part of the subsoil is darker and redder than the lower part.

Below the subsoil is very pale brown sand that is single grain and loose.

These soils are permeable, have a low supply of plant nutrients, and are low in available moisture capacity. The content of moisture is seldom adequate for optimum growth of crops. Acidity is very strong or strong to a depth of about 19 inches.

Rubicon soils cover a large acreage in Muskegon County. They are largely in forest, or they have been cleared and are now idle. They are well suited to plantations of Christmas trees and to other forest products. Only a small acreage is used for cultivated crops.

Typical profile of Rubicon sand in NW¼NE¼NW¼ sec. 22, T. 10 N., R. 15 W.:

A1—0 to 3 inches, black (10YR 2/1) sand; weak, medium, granular structure; very friable; very high content of organic material; very strongly acid; abrupt, smooth boundary.

A2—3 to 5 inches, gray (10YR 5/1) sand; single grain; loose; very strongly acid; abrupt, irregular boundary.

B21hir—5 to 10 inches, dark-brown (7.5YR 4/4) sand; weak, coarse, subangular blocky structure; very friable; strongly acid; clear, irregular boundary.

B22ir—10 to 19 inches, strong-brown (7.5YR 5/8) sand; weak, coarse, subangular blocky structure; very friable; strongly acid; clear, irregular boundary.

B3—19 to 28 inches, brownish-yellow (10YR 6/6) sand; weak, coarse, subangular blocky structure; very friable; medium acid; gradual, wavy boundary.

C—28 to 60 inches +, very pale brown (10YR 7/4) sand; single grain; loose; medium acid.

In some areas the surface layer has been removed by erosion. In other areas it is mixed with the subsoil and the plow layer is brownish. Rubicon soils range from very strongly acid to medium acid. Cultivated areas have a very dark grayish-brown surface layer 6 to 10 inches thick. The subsurface layer is 2 to 6 inches thick.

Rubicon soils consist of coarser sands than Rousseau soils and have a better developed, redder subsoil than Grayling soils. Drainage is better in the Rubicon soils than in Croswell soils and mottling is less. Rubicon soils have a thinner surface layer than Sparta soils. They lack the cemented layer in the subsoil that is typical of the Wallace soils and have less well developed subsoil layers than Kalkaska soils.

Rubicon sand, 0 to 6 percent slopes (RsB).—This is the most extensive soil in the county. It occupies broad areas of the nearly level to gently sloping sandy outwash plain and lake plain. It also occurs in nearly level to gently sloping areas of the sandy uplands. The sandy plain appears flat, but it has many small depressions, swells, shallow pits, and slightly domed areas. The shallow depressions in these plains are normally oval and somewhat dish shaped. They are flat on the bottom and gently sloping near the edge. They are elongated where they occur at the base of slopes in the rolling sandy uplands and at the base of long gentle wavelike slopes of the sandy plain.

Included with this soil in the depressions and at the base of slopes in the sandy uplands were the darker colored, moderately well drained Croswell soils. These depressions have small accumulations of outwash on their surface. Their edges have a lighter colored surface layer. Also included were areas of Grayling sand that have a thinner, less well developed subsoil than this Rubicon sand. Other inclusions were areas of Kalkaska soil, which are generally on gentle slopes and in wavy areas of the sandy plain. These areas are darker colored and have a more distinct subsoil than this Rubicon soil. Chunks of dark reddish-brown cemented sand occur in places.

In the northeastern part of Blue Lake Township and in the northwestern part of Holton Township, this soil differs slightly from the Rubicon sand in other parts of the county, but not enough to affect use and management. In these areas, this soil is covered by a well-stocked stand of black oak and white oak mixed with white pine. The surface layer is slightly thicker than normal, and in many places the subsurface layer is missing. Also the upper part of the subsoil is darker colored than it is in other areas.

In cultivated areas the plow layer of this soil is a mixture of the surface layer, subsurface layer, and upper part of the subsoil. Many small areas are eroded and have a dark-brown sand surface layer. Small, severely eroded areas have a loose, yellowish-brown sand surface layer that is several feet thick. Some open areas that have not been cultivated have been eroded by wind.

Many areas of this soil are in second-growth forest in which there are some open areas. The forested areas are not eroded, but the open areas are and have a thin, grayish-brown surface layer. In some places a new, thin surface layer has developed. Many areas are cleared of trees, and most of these have been burned over several times.

The second-growth forest consists of black oak, white oak, and a few large white pines. In many places the understory is mainly white pine. Areas cleared of trees are covered with native grasses and weeds. In some places the cover consists of mosses and lichens, clumps of little bluestem, and a few scrubby black oak, sassafras, or fire cherry trees.

This soil contains only a small amount of plant nutrients, and it has low available moisture capacity. Exposed areas are easily eroded by wind.

This soil has little value as cropland, but it is valuable as woodland. Open areas can be reforested to suitable trees. Many open areas are planted to Scotch pine for Christmas trees or to red and white pines for timber products. A few areas are cultivated to crops commonly grown in the county. In a few irrigated areas, pickling cucumbers, melons, and small fruits are grown. A few areas are in native pasture.

Capability unit VIIs–1 (5.3a); woodland suitability group H; wildlife suitability group 8; community development group 3.

Rubicon sand, 6 to 25 percent slopes (RsD).—This soil occurs throughout the sandy areas of the county. It is on long, narrow ridges of the sandy plain and on the steeper hillsides of the rolling sandy areas.

Included with this soil in the mapping were areas of moderately well drained Croswell soils that make up 20 percent of some mapped areas. These included areas are on the lower parts of slopes. Also included were small depressional pockets of somewhat poorly drained Au Gres soils. In these pockets the water table is close to the surface. Eroded spots that have a brownish surface layer are included in open areas. A few spots are severely eroded.

This soil has a low supply of plant nutrients and is low in available moisture capacity. Cultivated areas are susceptible to soil blowing and water erosion.

Some areas of this soil are covered by a second-growth forest. Other areas have been cleared and cultivated. This soil has little value as cropland, but it is well suited as woodland. Its vegetation is mainly grasses, weeds, and some young aspen, sassafras, black oak, and white pine trees.

Capability unit VIIs–1 (5.3a); woodland suitability group H; wildlife suitability group 8; community development group 3.

Rubicon loamy substratum and Montcalm soils, 0 to 6 percent slopes (RtB).—This mapping unit consists of Rubicon soil that has a loamy substratum and of Montcalm loamy sand. Most areas are Rubicon soil, but a few areas contain both of these soils. Each of these soils has a profile similar to the one described for its respective series.

These soils occur throughout the county. Areas are generally small except in the northwestern and eastern parts of the county. These soils are on gently sloping, sandy hillsides and level hilltops. They are also on gently sloping, broad, sandy beaches that lie above small streambeds. In the southeastern and northwestern parts of the county, a large acreage is at the edge of the rolling areas of loamy till.

In the Rubicon soil the plow layer is dark-brown sand or loamy sand and a loamy substratum lies at a depth of 42 to 66 inches. The Montcalm soil lacks the loamy substratum that occurs at a depth of 42 to 66 inches in the Rubicon soil.

Included with these soils in the mapping, in areas of Rubicon soil, were small areas of Menominee soils that have a moderately fine textured substratum within 42 inches of the surface. Also in areas of Rubicon soils were shallow, wet sags occupied by Au Gres soils. These depressions have a darker colored and thicker plow layer than the Rubicon soil. Included in areas of Montcalm soil were a few wet spots and some small areas that have a sandier, lighter colored surface than is typical of Montcalm soils. Some areas of Rubicon and Montcalm soils that have been eroded by wind and water were also included in the mapping. Near the top of slopes in these places, the color of the plow layer is a mixture of dark gray and yellowish brown. The lower parts of slopes and small depressions have a thicker surface layer because material that washed in has accumulated. Severely eroded spots were also included. None of the included areas affect the use and management of this mapping unit.

These soils are permeable to water and air. They are low in fertility and in available moisture capacity. Bare areas are easily eroded by wind and water.

Many areas of these soils are now idle, and other areas are used mainly for hay and pasture. A few areas remain wooded or are covered with brush.

Rubicon soil is in capability unit VIs–1 (5/2a); woodland suitability group C; wildlife suitability group 7; community development group 3. Montcalm soil is in capability unit IIIs–4; (4a) woodland suitability group C; wildlife suitability group 7; community development group 3.

Rubicon loamy substratum and Montcalm soils, 6 to 12 percent slopes (RtC).—Most areas of this mapping unit are either Rubicon soil or Montcalm soil, but a few areas contain both of these soils. Each of these soils has a profile similar to the one described for its respective series. The Montcalm soil has a thinner subsoil than the soil described as representative of the Montcalm series. This mapping unit occurs throughout the county. It is generally in small, elongated areas on small, ridgelike hills and on long breaks that slopes to streambeds.

Included with these soils in the mapping, in areas of the Rubicon soil, were areas where the finer textured material is within 42 inches of the surface. This material is exposed at the top of slopes. Also included in areas of the Rubicon soil were seepy spots that have a thick, dark-colored surface layer that is high in content of organic matter. A few eroded spots have a surface layer of yellowish-brown sand. Included in areas of the Montcalm soils were areas of Chelsea loamy sand and of Rubicon sand. Some small included areas have slopes of 2 to 6 percent, and others have slopes of more than 12 percent. These included areas do not greatly influence use and management of this mapping unit.

These soils are permeable to water and air. They are low in natural fertility and in available moisture capacity. Because slopes are strong and the soil is loose, exposed areas of these soils are susceptible to soil blowing and water erosion.

Many areas of this mapping unit are now idle or are used only for pasture. Some areas have been reforested to pine trees for timber or for Christmas trees. A few areas are used for corn, small grains, hay, and other crops commonly grown in the county. Crop rotations generally include 3 or more years of hay.

Rubicon soil is in capability unit VIs–1 (5/2a); woodland suitability group C; wildlife suitability group 7; community development group 3. Montcalm soil is in capability unit IIIe–9(4a); woodland suitability group C; wildlife suitability group 7; community development group 3.

Saranac Series

The Saranac series consists of very poorly drained, medium-textured soils. These soils are in nearly level to depressional areas on the flood plains and in the bayous of the county. The native vegetation consisted mainly of lowland hardwoods, including elm, ash, maple, cottonwood, and willow, but there was also some arborvitae.

The surface layer of these soils is very dark gray loam about 10 inches thick. It has granular structure and is friable.

The subsoil is weakly developed and about 9 inches thick. This layer consists of dark-gray and gray silty clay loam mottled with dark brown and gray or dark gray. It has angular blocky structure and is firm.

Below the subsoil are alternate layers of clay loam and silty clay loam and thin layers of sandy loam, loam, silt loam, and loamy sand. This material is gray mottled with yellowish brown and gray or dark gray.

These soils are naturally fertile but are very wet. Permeability is moderately slow, and available moisture capacity is high. Since these soils occur on first bottoms along flowing streams, frequent flooding is likely. Flooding seriously restricts use as cropland. Forest and native pasture are the main uses.

Typical profile of Saranac loam in SW¼SW¼ sec. 26, T. 9 N., R. 16 W.:

A1—0 to 10 inches, very dark gray (10YR 3/1) loam; moderate, medium, granular structure; friable; mildly alkaline; clear, wavy boundary.

B21g—10 to 13 inches, dark-gray (10YR 4/1) light silty clay loam that has many, fine, faint mottles of dark brown and common, medium, faint mottles of gray (10YR 5/1); moderate, medium, angular blocky structure; firm; mildly alkaline; clear, irregular boundary.

B22g—13 to 19 inches, gray (5YR 5/1) silty clay loam that has common, medium, distinct mottles of dark brown (7.5YR 4/4) and few, medium, faint mottles of dark gray (10YR 4/1); moderate, medium, angular blocky structure; very firm; mildly alkaline; clear, wavy boundary.

C1g—19 to 27 inches, gray (10YR 5/1) clay loam that has many, coarse, distinct mottles of yellowish brown (10YR 5/6) and common, medium, faint mottles of gray; moderate, medium, angular blocky structure; firm; mildly alkaline; clear, wavy boundary.

C2g—27 to 36 inches, gray (10YR 5/1) light clay loam that has many, medium, distinct mottles of yellowish brown (10YR 5/6) and common, medium, faint mottles of gray (10YR 6/1); weak, coarse, subangular blocky structure; firm; mildly alkaline; clear, wavy boundary.

C3g—36 to 48 inches +, gray (N 5/0) silty clay loam that has common, medium, distinct mottles of yellowish brown (10YR 5/6–5/8) and few, medium, distinct mottles of dark gray (10YR 4/1); massive; firm; calcareous.

In a few cultivated areas, the plow layer is lighter colored than the surface layer described because plowing has mixed the dark surface layer and the grayish subsoil. Because each flood lays down different kinds and amounts of materials, layers of varying thickness and texture are common. The texture of the upper 30 inches is normally clay loam, silty clay loam, or sandy clay loam. Below 30 inches the texture varies a great deal. These soils are normally slightly acid to mildly alkaline in the upper 24 inches and neutral to calcareous below. Shells, which are high in line, occur within the soil profile.

Saranac soils are at sites similar to those of the Sloan soils but are finer textured. They are similar to the Sims soils in texture but are more stratified and occupy bottom lands instead of morainic areas.

Saranac loam (0 to 2 percent slopes) (Sa).—This soil is on first bottoms along the major streams, such as Muskegon and White Rivers and Crockery, Cedar, and Black Creeks. These bottoms are nearly level, but they contain many slight depressions. Normally, this soil is in the lowest areas, where floodwaters remain the longest. The material deposited varies in texture from one flood to another.

Included with this soil in the mapping were areas that have slopes of 2 to 6 percent. These areas are on the short side slopes of the depressions. Also included were areas of the coarser textured Sloan soils. These included areas do not greatly affect use and management.

Saranac soils are naturally fertile, but they are cold and very wet. Artificial drainage is difficult to install, and most areas remain wooded or are used for native pasture. Some areas are idle and are densely covered with grasses, weeds, and brush.

Capability unit IIIw-12 (L-2c); woodland suitability group O; wildlife suitability group 6; community development group 7.

Saugatuck Series

The Saugatuck series consists of somewhat poorly drained to poorly drained, acid sands that have a cemented hardpan in the subsoil. These soils are in broad, nearly level areas of the outwash plain. The native vegetation consisted of white pine, red pine, birch, aspen, gum, pin oak, and elm.

In undisturbed areas the surface layer is black, partly decayed organic material about 3 inches thick. This material is friable and very strongly acid. The subsurface layer is about 11 inches thick and consists of pinkish-gray sand distinctly mottled with dark gray. It has subangular blocky structure and is very friable.

The upper part of the subsoil is dark reddish-brown or very dusky red sand or fine sand about 23 inches thick. It is a strongly cemented hardpan. The lower part is dark-brown fine sand about 11 inches thick. It is single grain and loose. Both parts of the subsoil are mottled.

Below the subsoil is light yellowish-brown fine sand that is mottled. It is single grain and loose.

Permeability is very rapid above the cemented layers and is slow in them. Natural fertility is very low, and available moisture capacity is low. These soils are often wet because their water table fluctuates and is within a few feet of the surface during parts of the year. This water table drops during the summer months, and the soil becomes very droughty. During dry periods soil blowing is likely. A large part of these soils is cleared of timber and is now idle, but some areas remain in trees. Some areas are used for blueberries.

Saugatuck soils are mapped only with Au Gres soils in a complex.

Typical profile of Saugatuck sand in NE¼NW¼NW¼SW¼ sec. 21, T. 10 N., R. 14 W.:

01—3 inches to 0, black (10YR 2/1) partly decayed organic material; massive; friable; very strongly acid; abrupt, wavy boundary.

A2—0 to 11 inches, pinkish-gray (7.5YR 7/2) sand that has many, coarse, distinct mottles of dark gray (10YR 4/1); very weak, coarse, subangular blocky structure; very friable; very strongly acid; abrupt, irregular boundary.

B21hirm—11 to 15 inches, dark reddish-brown (5YR 2/2) sand that has many, medium, distinct mottles of red (2.5YR 4/8); massive; indurated; very strongly acid; gradual, wavy boundary.

B22hirm—15 to 24 inches, very dusky red (10R 2/2) fine sand that has many, coarse, distinct mottles of yellowish red (5YR 4/8) and many, coarse, distinct mottles of dark red (2.5YR 3/6); massive; indurated; very strongly acid; clear, irregular boundary.

B23irm—24 to 34 inches, dark reddish-brown (5YR 3/4) fine sand that has many, coarse, prominent mottles of yellowish red (5YR 5/8); indurated; very strongly acid; clear, wavy boundary.

B24ir—34 to 45 inches, dark-brown (7.5YR 4/4) fine sand that has few, medium, distinct mottles of dark reddish brown (5YR 3/3); single grain; loose; very strongly acid; gradual, wavy boundary.

C—45 to 60 inches +, light yellowish-brown (10YR 6/4) fine sand that has few, fine, faint mottles of brownish yellow (10YR 6/6) and few, fine, faint mottles of light brownish gray (10YR 6/2); single grain; loose; medium acid.

A very dark gray or black surface layer, 1 to 6 inches thick, occurs in some areas. In thickness, the subsurface layer ranges from 6 to 20 inches or more, and the cemented hardpan ranges from 8 to 30 inches.

Saugatuck soils are similar to the Au Gres soils in drainage, though the Au Gres soils do not have a cemented hardpan. Saugatuck soils have upper sandy layers similar to those in the Ogemaw soils but do not have clayey underlying material. Saugatuck soils are better drained than the Roscommon and Deford soils and are not so gray.

Selkirk Series

The Selkirk series consists of somewhat poorly drained soils on the lake plain. These soils developed in limy, clayey deposits. The native vegetation consisted of mixed hardwoods and conifers and included red maple, sugar maple, beech, elm, ash, white pine, and hemlock.

The surface layer is generally a plow layer consisting of very dark grayish-brown silt loam about 10 inches thick. It has granular structure and is friable.

The upper part of the subsoil is 7 inches of gray heavy silty clay loam. The lower part is grayish-brown silty clay about 9 inches thick. Both parts have angular blocky structure, are firm to very firm, and are mottled with yellowish brown.

Underlying the subsoil is light-gray silty clay. This material is mottled, has angular blocky structure, and is very firm and calcareous.

Selkirk soils are slowly permeable. They are high in fertility and in available moisture capacity. The mottled subsoil indicates that these soils are saturated with water for extended periods. Most of the acreage is cleared and used for meadows or for small grains, but a large part remains idle. Management is needed for removing excess water and for maintaining soil tilth.

In this county Selkirk soils are mapped only with Kawkawlin soils in undifferentiated units.

Typical profile of Selkirk silt loam in NW¼SW¼ sec. 17, T. 9 N., R. 14 W., Ravenna Township.

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

B21g—10 to 17 inches, gray (10YR 5/1) heavy silty clay loam that has common, coarse, distinct mottles of yellowish brown (10YR 5/8) and many, medium, faint mottles of dark gray (10YR 4/1); strong, fine, angular blocky structure; firm; neutral; gradual, irregular boundary.

B22g—17 to 26 inches, grayish-brown (10YR 5/2) silty clay that has common, coarse, faint mottles of gray (10YR 5/1) and many, medium, distinct mottles of yellowish brown (10YR 5/6); strong, medium, angular blocky structure; very firm; mildly alkaline; abrupt, wavy boundary.

Cg—26 to 48 inches +, light-gray (5Y 7/2) silty clay that has many, fine, faint mottles of gray (5Y 6/1) and many, medium, distinct mottles of olive (5Y 4/4); moderate, medium, angular blocky structure; very firm; calcareous.

Undisturbed areas of Selkirk soils have a very dark grayish-brown or very dark gray surface layer 1 to 3 inches thick. It is underlain by a gray or light-gray layer 3 to 6 inches thick. Depth to the calcareous silty clay ranges from 24 to 36 inches. The surface layer and subsoil range from slightly acid to mildly alkaline, and the material below a depth of about 26 inches is calcareous.

Selkirk soils are better drained than Pickford soils and are not so gray. They are more poorly drained and more highly mottled than Kent soils. Selkirk soils are finer textured than the Kawkawlin soils, though similar to them in drainage.

Sims Series

The Sims series consists of poorly drained loamy soils. These soils are in nearly level and depressional areas of the rolling, morainic landscape in the southeastern and the extreme northwestern parts of the county. The native forest consisted of lowland hardwoods and included elm, ash, red maple, and swamp white oak.

The surface layer is black loam about 9 inches thick. It has granular structure and is friable.

The upper 3 inches of the subsoil is dark-gray loam that has subangular blocky structure and is friable. The rest of the subsoil is light brownish-gray or gray clay loam that is mottled. It has subangular or angular blocky structure and is firm.

Underlying the subsoil, at a depth of about 32 inches, is grayish-brown clay loam distinctly mottled with yellowish brown. This material has angular blocky structure and is firm and calcareous.

Sims soils are moderately slow in permeability. They have high available moisture capacity and are naturally fertile. A high water table saturates these soils, especially during spring.

Maintaining fertility and good tilth are main concerns of management. Areas that are artificially drained are planted to crops. Yields of most crops are favorable. Undrained areas remain wooded or are used for pasture.

Typical profile of Sims loam in SE¼NE¼ sec. 12, T. 10 N., R. 13 W.:

Ap—0 to 9 inches, black (10YR 2/1) loam; moderate, coarse, granular structure; friable; mildly alkaline; clear, wavy boundary.

B21g—9 to 12 inches, dark-gray (10YR 4/1) loam that has many, coarse, faint mottles of gray (10YR 5/1) and few, medium, distinct mottles of yellowish brown (10YR 5/4); weak, medium, subangular blocky structure; friable; neutral; abrupt, wavy boundary.

B22g—12 to 17 inches, light brownish-gray (10YR 6/2) clay loam that has many, coarse, distinct mottles of yellowish brown (10YR 5/8) and many, coarse, faint mottles of light gray (10YR 7/2); moderate, coarse, subangular blocky structure; firm; neutral; gradual, irregular boundary.

B23g—17 to 32 inches, gray (10YR 6/1) clay loam that has many, medium, distinct mottles of yellowish brown (10YR 5/8) and common, medium, distinct mottles of dark brown (7.5YR 4/4); thin gray (10YR 6/1) clay films on many peds; moderate, medium, angular blocky structure; firm; neutral; abrupt, wavy boundary.

Cg—32 to 48 inches +, grayish-brown (10YR 5/2) clay loam that has many, medium, faint mottles of light gray (10YR 6/1) and many, medium, distinct mottles of yellowish brown (10YR 5/8); weak, coarse, angular blocky structure; firm; calcareous.

In cultivated areas of Sims soils the lower part of the surface layer is slightly darker colored than the upper part. The layer of loam at the top of the subsoil is absent in many areas. The texture of the subsoil ranges from loam to silty clay loam in some places. Layers of fine sand, silt, and clay, 1 to 3 inches thick, occur below a depth of 36 inches in some areas. The surface layer and subsoil range from slightly acid to mildly alkaline; below a depth of 32 inches the material is calcareous.

Sims soils are similar to the Pickford soils in drainage but are coarser textured. They have a darker colored surface layer than Kawkawlin soils and are more poorly drained and grayer. Sims soils lack the stratification that occurs in the Hettinger soils.

Sims loam (0 to 2 percent slopes) (Sm).—This nearly level to gently sloping soil occupies wet depressions and flats in the rolling landscape of the southeastern and northwestern parts of the county. These areas are shaped like a dish, and normally they occur between higher areas. In some places soil material that washed from adjoining slopes is deposited on these soils. This material is most noticeable near the edges of the wet areas. The material is lighter colored and coarser textured than that of the surface layer in the profile representative of the Sims series.

Included with Sims loam in mapping were areas that have slopes of 2 to 6 percent. These areas are on knolls in the nearly level topography, or they are at the edges of better drained soils of the uplands. Some of the slopes of 2 to 6 percent are occupied by Kawkawlin loam, which is not so wet and is lighter colored than Sims loam. These included areas are used and managed in about the same way as are areas of Sims loam.

Sims loam is naturally poorly drained, but it is productive and can be cropped intensively if adequate drainage is provided. After this soil has been drained, the main practices needed are those that maintain organic-matter content, fertility, and soil structure.

Capability unit IIw-2 (1.5c); woodland suitability group P; wildlife suitability group 6; community development group 7.

Sloan Series

The Sloan series consists of very poorly drained soils. These soils are on nearly level to gently sloping first bottoms along streams. They developed in loamy alluvium. The native vegetation consisted of elm, ash, cottonwood, soft maple, willow, and some arborvitae.

The surface layer is about 13 inches thick and consists of very dark gray loam that is mottled. It has granular structure and is friable.

Below the surface layer is stratified material of varied texture. Texture is dominantly silt loam, but the individual layers are sand, loam, sandy loam, clay loam, and silty clay loam. This material is grayish brown, very pale brown, pale brown, or gray and is mottled. Except in the layer of sand, structure is angular blocky or subangular blocky.

Permeability is moderate. The water table is high unless artificial drainage is provided. Natural fertility is high.

Most of the acreage of these soils is wooded or is used for native pasture. Some areas are idle and are densely covered with grasses, weeds, and brush.

Typical profile of Sloan loam in NE¼NE¼ sec. 25, T. 11 N., R. 15 W.:

A1—0 to 13 inches, very dark gray (10YR 3/1) loam that has common, fine, distinct mottles of grayish brown (10YR 5/2); moderate, coarse, granular structure; friable; neutral; abrupt, smooth boundary.

Bg—13 to 21 inches, grayish-brown (10YR 5/2 silt loam that has few, fine, distinct mottles of black (10YR 2/1) and many, fine, distinct mottles of dark yellowish brown (10YR 4/4); fine subangular blocky structure; firm; neutral; abrupt, irregular boundary.

IIC1—21 to 24 inches, very pale brown (10YR 7/3) sand; single grain; loose; neutral; abrupt, irregular boundary.

IIC2g—24 to 27 inches, gray (10YR 5/1) heavy silt loam that has many, fine, distinct mottles of dark yellowish brown (10YR 4/4); moderate, medium, angular blocky structure; firm; neutral; clear, wavy boundary.

IVC3—27 to 34 inches, pale-brown (10YR 6/3) sandy loam that has many, coarse, faint mottles of grayish brown (10YR 5/2); weak, medium, subangular blocky structure; friable; mildly alkaline; clear, wavy boundary.

VC4g—34 to 48 inches +, gray (10YR 5/1) silt loam that has many, fine, faint mottles of grayish brown (10YR 5/2); weak, fine, subangular blocky structure; firm; mildly alkaline.

The surface layer of Sloan soils ranges from very dark gray to black in color and from 7 to 14 inches in thickness. The material between depths of 13 and 21 inches ranges from silt loam to loam, heavy sandy loam, or light clay loam. Below a depth of 21 inches, the layers range from loam to silt loam, sandy loam, light clay loam or light silty clay loam, and there are thin layers of sand. The thickness of the layers below 21 inches ranges from 1 to 12 inches. The soil material ranges from slightly acid to mildly alkaline to a depth of 21 inches and from neutral to calcareous below 21 inches.

Sloan soils are at sites similar to those of Saranac soils but are coarser textured. Sloan soils lack the organic layers that are common in the Kerston soils.

Sloan soils (0 to 6 percent slopes) (So).—These soils are on nearly level to gently sloping first bottoms along streams. These bottoms contain many slight depressions and raised areas. Flooding deposits new material of variable texture. The texture of the surface layer is sandy loam, silt loam, and occasionally loamy sand. Texture changes from one flood to another.

Included with these soils in mapping were many small areas of Saranac soils in slight depressions in the bottom land. These included areas, and the changes in texture of the surface layer, do not greatly affect use and management.

Artificial drainage is beneficial in removing excess water from these fertile soils, but drainage is difficult to install because of the variable texture and the flooding. Much of the area remains wooded or is used for native pasture. Some areas are idle and are densely covered with grasses, weeds, and brush.

Capability unit IIIw–12 (L–2c); woodland suitability group O; wildlife suitability group 6; community development group 8.

Sparta Series

The Sparta series consists of well-drained, acid sands that have a thick, dark-colored surface layer. These soils are on the nearly level to gently sloping outwash plain and stream terraces. They developed under grasses in open areas in the northeastern part of the county.

The surface layer is very dark brown or very dark grayish-brown sand about 14 inches thick. It is mainly granular and very friable.

The subsoil is mainly dark yellowish-brown or yellowish-brown sand about 18 inches thick. It has subangular blocky structure and is very friable in the upper part and is single grain and loose in the lower part.

Below the subsoil the material is very pale brown sand that is single grain and loose.

Sparta soils are low in natural fertility. Permeability is very rapid, and available moisture capacity is low.

These soils are of little value as cropland, but they are of value as sites for Christmas trees or other planted trees.

Typical profile of Sparta sand in NW¼NW¼NW¼ sec. 5, T. 12 N., R. 15 W.:

A11—0 to 10 inches, very dark brown (10YR 2/2) sand; weak, medium, granular structure; very friable; strongly acid; clear, irregular boundary.

A12—10 to 14 inches, very dark grayish-brown (10YR 3/2) sand; weak, fine, subangular blocky structure; very friable; strongly acid; clear, wavy boundary.

B21—14 to 19 inches, dark yellowish-brown (10YR 4/4) sand; weak, medium, subangular blocky structure; very friable; medium acid; gradual, irregular boundary.

B22—19 to 25 inches, yellowish-brown (10YR 5/4) sand; weak, medium, subangular blocky structure; very friable; medium acid; gradual, wavy boundary.

B3—25 to 32 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; medium acid; gradual, wavy boundary.

C—32 to 60 inches +, very pale brown (10YR 7/3) sand; single grain; loose; medium acid.

The surface layer of Sparta soils ranges from very dark brown to very dark grayish brown in color and from 10 to 16 inches in thickness. It is very strongly acid to strongly acid in undisturbed or unlimed areas. Below a depth of 16 inches the material ranges from medium acid to strongly acid.

Sparta soils have a thicker surface layer than the Rubicon and Rousseau soils and are coarser textured than the Rousseau.

Sparta sand, 0 to 2 percent slopes (Sp).—This nearly level soil is on the outwash plain in the northeastern part of the county. It lies in the scattered dry basins in this plain. In these basins the surface layer is from 12 to 14 inches thick and is darker colored than the surface layer described in the representative profile. Normally, the sand grains are coarser than they are in the higher areas of the plain. The few areas that have been cultivated have a thinner and lighter colored surface layer than that described in the representative profile.

Included with this soil in mapping were small areas that have slopes of 2 to 6 percent. These gently sloping areas are at the outer edge of the basin.

This soil has low fertility and low available moisture capacity. If the soil is cultivated, the organic matter in the surface layer decomposes rapidly. Soil blowing is likely if the protective cover of grass and trees is removed.

Except in irrigated areas, this soil is too sandy and droughty to be used as cropland. Most of it is idle or has been planted to pine trees.

Capability unit IVs–2 (5a); woodland suitability group V; wildlife suitability group 8; community development group 3.

Tawas Series

The Tawas series consists of very poorly drained, shallow, organic soils that have sand or loamy sand at a depth ranging from 18 to 42 inches. These soils are extensive in this county. They occur in the Moorland muck area and in other level and depressional areas. The native vegetation consisted of mixed lowland hardwoods and conifers and included red maple, elm, ash, and white cedar. The vegetation today is the same in uncleared areas, but areas that have been cleared and left idle have a dense growth of hoary alder, red-osier dogwood, willow, balm-of-gilead, greenbrier, and similar plants.

A typical Tawas soil consists of about 31 inches of muck and peat over sand. The muck is at the surface. It is black, contains woody material, has granular structure, and is friable. The muck is underlain by peaty muck or peat that is dark reddish brown or dark brown. It is subangular blocky and friable. Dark-brown peat is at a depth of about 25 inches. It has subangular blocky structure that breaks to platy structure.

The material underlying the muck and peat is gray sand that is single grain and loose.

Tawas soils are rapidly permeable and have high available moisture capacity. They are naturally wet and require artificial drainage before they can be used as cropland.

Many areas of these soils have been cleared and are used for celery, onions, and other special crops. Drainage is difficult. After these soils are drained and cultivated, the organic matter decomposes and settles rapidly. Controlled drainage is desirable. Soil blowing is likely in cultivated areas.

Typical profile of Tawas muck in SW¼NW¼ sec. 14, T. 10 N., R. 14 W., Moorland Township:

1—0 to 17 inches, black (10YR 2/1) muck that contains considerable woody material; moderate, medium, granular structure; friable; medium acid; clear, smooth boundary.

2—17 to 25 inches, dark reddish-brown (5YR 2/2) peaty muck; weak, medium, subangular blocky structure; friable; medium acid; clear, smooth boundary.

3—25 to 31 inches, dark-brown (10YR 3/3) peat; weak, coarse, subangular blocky structure that breaks to weak, medium, platy structure; friable; strongly acid; clear, smooth boundary.

IICg—31 to 48 inches +, gray (10YR 6/1) sand; single grain; loose; mildly alkaline.

The surface layer is peaty muck or mucky peat in some areas. Depth to the sandy material ranges from 12 to 42 inches. The organic material ranges from strongly acid to slightly acid.

Tawas soils have a thinner organic layer than the Houghton or the Carlisle soils. The underlying material is sand in the Tawas soils but is marl in the Warners soils.

Tawas and Carlisle mucks (0 to 2 percent slopes) (Tc).—In this unit Tawas muck and Carlisle muck are mapped together as one unit. Each of these soils has a profile similar to the one described for its respective series. These two soils differ mainly in the thickness of the organic material. The organic material is more than 42 inches thick in the Carlisle soil and is 12 to 42 inches thick in the Tawas soil. These two soils occur together throughout the county in areas that range from less than an acre in size to a hundred acres or more. The largest areas are in Moorland Township and on the flood plains of the major streams in the county. These soils are in nearly level places; they have a high water table and are poorly drained.

In many areas the Tawas muck is at the edge of the soil areas and the deeper Carlisle muck is in the central part. In other areas there is no pattern and depth to the sandy material varies within short distances.

Included with these soils in the mapping, especially along streams, were small areas of Kerston soils in which there are layers of organic and mineral materials. Also included, in some areas adjacent to uplands, were areas where as much as 18 inches of mineral material has been deposited over the organic material. In small areas that have been cultivated for many years, the thickness of the organic material has been reduced to only a few inches by soil blowing, settling, and decomposition. Small parts of these areas have a grayish sand surface layer.

Tawas and Carlisle soils have high available moisture capacity but contain only small amounts of plant nutrients. They are especially deficient in micronutrients. Cultivated areas are easily eroded by the wind (fig. 5). Because these soils decompose and settle rapidly if they are drained and cultivated, the thickness of the organic material decreases as time passes.

Most of the acreage of these soils has been cleared and cultivated. Special crops, such as vegetables and mint, are grown in these areas. Some areas are used for producing sod for commercial purposes.

Special practices of management and programs of fertilization are needed if favorable crop yields are to be obtained. Lowering the water table enough for special crops is difficult where outlets are lacking. Laying tile is difficult in places because depth to the sandy material varies within short distances. The tile moves out of line where laid in both organic material and sandy material. Controlled drainage helps reduce the rate of decomposition and settling. Soil blowing is reduced by windbreaks.

Tawas soil is in capability unit IVw-5 (M/4c); woodland suitability group U; wildlife suitability group 5; community development group 10. Carlisle soil is in capability unit IIIw-15 (Mc); woodland suitability group U; wildlife suitability group 5; community development group 10.

Tonkey Series

The Tonkey series consists of poorly drained soils that developed in stratified sand, loamy sand, and sandy loam. These soils are in nearly level to slightly depressional areas of the lake plain and old drainage channels. The native vegetation consisted of mixed hardwoods and conifers and included elm, red maple, arborvitae, spruce, and some hoary alder and willows. Idle areas now support

Figure 5.—Wind erosion on the Carlisle soil of Tawas and Carlisle mucks.

native grasses and sedges, goldenrod and other weeds, and dwarf willows.

The surface is very dark gray sandy loam about 10 inches thick. It has granular structure and is friable.

In the subsoil the individual layers range from 2 to 12 inches in thickness. The texture of these layers is sandy loam, loamy sand, and sandy clay loam. Color ranges from pinkish gray in the upper part of the subsoil to light gray in the lower part. The subsoil is mottled. It has subangular and angular blocky structure.

Below the subsoil the material is dominantly brown clay loam, but there are lenses of sandy loam, loamy sand, and fine sand. Dark-brown and light-gray mottles are present. This material is massive, firm, and calcareous.

Tonkey soils have moderately rapid permeability. Available moisture capacity and natural fertility are medium to low. Because the water table is high, especially during spring, these soils are so wet that the growth of plants and operation of farm machinery are hindered. Crop yields vary from fairly favorable to favorable in drained areas. Artificial drainage, however, is difficult because texture varies within short distances.

Typical profile of Tonkey sandy loam in NW¼NW¼NW¼ sec. 25, T. 12 N., R. 15 W., Holton Township:

Ap—0 to 10 inches, very dark gray (10YR 3/1) sandy loam; weak, coarse, granular structure; friable; mildly alkaline; abrupt, smooth boundary.

B21—10 to 23 inches, pinkish-gray (7.5YR 6/2) loamy sand that has common, medium, distinct mottles of dark gray (10YR 4/1) and few, medium, distinct mottles of very dark brown (10YR 2/2); very weak, medium, subangular blocky structure; very friable; neutral; clear, irregular boundary.

B22—23 to 26 inches, dark reddish-brown (5YR 3/3) sandy loam that has many, medium, distinct mottles of strong brown (7.5YR 5/6) and many, medium, distinct mottles of reddish yellow (7.5YR 6/8); weak, medium, subangular blocky structure; slightly acid; clear, irregular boundary.

B23g—26 to 33 inches, light-gray (10YR 7/2) sandy clay loam that has many, medium, distinct mottles of yellowish brown (10YR 5/8) and many, fine, prominent mottles of reddish brown (5YR 5/3); moderate, medium, angular blocky structure; firm; neutral; clear, wavy boundary.

C—33 to 48 inches +, brown (7.5YR 5/2) clay loam and lenses of sandy loam, loamy sand, and fine sand; many, medium, distinct mottles of dark brown (7.5YR 4/4) and many medium, distinct mottles of light gray (N7/0); massive; firm; calcareous.

The surface layer of Tonkey soils ranges from very dark gray to very dark grayish brown or black in color and from 6 to 10 inches in thickness. The layers that make up the subsoil range from sandy loam to sandy clay loam, loam, or heavy loamy sand and from 2 to 12 inches in thickness. In some places there are also 1-inch to 3-inch layers of silt, very fine sand, and clay in the profile. A layer of gravelly sand, 2 to 5 inches thick, occurs below a depth of 30 inches in some areas. The subsoil ranges from medium acid to mildly alkaline. Below a depth of 30 inches, the material is calcareous.

Tonkey soils developed in coarser sand than Deford soils and are finer textured than Roscommon and Granby soils.

Tonkey and Deford soils (0 to 6 percent slopes) (Td).—This mapping unit consists of Tonkey soils and Deford soils. Most mapped areas are Tonkey sandy loam, but some are dominantly Deford loamy sand. A few areas consist of both soils in nearly equal parts. Each of these soils has a profile similar to the one described for its respective series.

These soils are mostly in large areas in broad, wet, nearly level basins in the southeastern part of the county. A smaller amount is in the northeastern and other parts of the county. The largest areas are in Moorland Township along Cranberry Creek and in Ravenna Township along Crockery Creek and its tributaries. Other areas are in Sullivan and Casnovia Townships.

The surface layer is very dark gray in the Tonkey soil and very dark gray or black in the Deford soil. This layer is generally sandy loam in the Tonkey soil, but it is loam in some areas. The surface layer of the Deford soil is generally loamy sand, but it is loamy fine sand in some areas. Within a few feet, texture varies from sandy loam to loamy sand. The Tonkey and Deford soils do not occur in a distinct pattern.

Included with these soils in the mapping, in the southeastern part of the county, were areas of Roscommon sand and areas that have a thin layer of muck at the surface. Also included, in other parts of the county, were areas that have fine-textured material within 42 inches of the surface. These included areas do not greatly affect use and management.

Drainage is required on these soils if crops are grown, but drainage is difficult because of the content of sand. The Tonkey sandy loam has a better supply of plant nutrients than the Deford loamy sand and has higher available moisture capacity. Many areas of this mapping unit are cultivated, but some undrained areas are idle or are used for hay and pasture. Many areas remain wooded.

Tonkey soil is in capability unit IIw-6 (3c); woodland suitability group W; wildlife suitability group 5; community development group 8. Deford soil is in capability unit IIIw-6 (4c); woodland suitability group W; wildlife suitability group 5; community development group 8.

Ubly Series

The Ubly series consists of well drained and moderately well drained sandy loams in which clay loam is at a depth of 18 to 42 inches. These soils are scattered in the gently sloping landscape in the southeastern, northwestern, and northeastern parts of the county. The native vegetation consisted of mixed hardwoods and some conifers and included sugar maple, beech, ash, white oak, black oak, and some hickory and white pine.

The surface layer is very dark grayish-brown sandy loam about 4 inches thick. It has granular structure and is friable. The subsurface layer is gray or light brownish-gray loamy sand that has subangular blocky structure and is very friable.

The upper part of the subsoil is dark-brown or yellowish-red sandy loam that is mottled. It is friable and has subangular blocky structure or is massive. The lower part is brown clay loam. It is firm and has angular blocky structure.

Below the subsoil, at a depth of about 36 inches, is light brownish-gray clay loam. It has angular blocky structure and is firm and calcareous.

Permeability is moderately rapid in the upper part of Ubly soils and moderately slow in the lower part. These soils are moderate in natural fertility and moderately high in available moisture capacity. Yields of most crops are favorable if management is good. Management is needed mainly for maintaining fertility and organic matter and for controlling soil blowing and water erosion.

Although Ubly soils are widespread in this county, they are not mapped separately. They are mapped with Menominee soils in an undifferentiated soil unit and with Belding and Nester soils in a complex.

Profile of Ubly sandy loam in SE¼SE¼ sec. 22, T. 9 N., R. 14 W.:

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, coarse, granular structure; friable; medium acid; clear, wavy boundary.

A21—4 to 6 inches, gray (10YR 5/1) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

A22—6 to 10 inches, light brownish-gray (10YR 6/2) loamy sand; very weak, medium, subangular blocky structure; very friable; strongly acid; clear, irregular boundary.

B21ir—10 to 17 inches dark-brown (7.5YR 4/4) sandy loam; moderate, medium subangular blocky structure; friable; medium acid; clear, irregular boundary.

B22ir—17 to 25 inches, yellowish-red (5YR 5/8) sandy loam that has few, medium, distinct mottles of dark brown (7.5YR 4/4) in lower part; massive; friable; slightly acid; clear, wavy boundary.

A'2—25 to 32 inches; pale-brown (10YR 6/3) sandy loam; weak, medium, angular blocky structure; friable; medium acid; clear, irregular boundary.

IIB't—32 to 36 inches, brown (10YR 4/3) clay loam; strong, medium, angular blocky structure; firm; medium acid; clear, irregular boundary.

IIC—36 to 48 inches +, light brownish-gray (10YR 6/2) clay loam; moderate, medium, angular blocky structure; firm; calcareous.

Cultivated areas of Ubly soils have a dark-brown or grayish-brown surface layer 7 to 10 inches thick. The upper part of the subsoil ranges from sandy loam to sandy clay loam. In some areas the middle of the subsoil is hard and brittle during dry periods. The underlying material ranges from clay loam to silty clay loam or loam and is at a depth ranging from 18 to 42 inches. These soils range from strongly acid to slightly acid in the upper 24 to 36 inches. Below 36 inches, they are mildly alkaline or calcareous.

In their upper layers, Ubly soils are finer textured than Menominee soils but are coarser textured than Nester soils. Ubly soils are better drained and less mottled than Belding soils.

Wallace Series

The Wallace series consists of well drained and moderately well drained, sandy soils that have a cemented hardpan in the subsoil. These soils are on long, narrow ridges of sand in the lake and outwash plains. The native forest consisted of mixed conifers and hardwoods and included white pine, red pine, and some aspen, birch, and oak.

The surface layer is very dark grayish-brown sand about 7 inches thick. It has granular structure and is very friable. The subsurface layer is light-gray sand about 5 inches thick. It has subangular blocky structure and is very friable.

The upper part of the subsoil is a hardpan consisting of strongly cemented, massive, black sand about 3 inches thick. The lower part is dark reddish-brown or yellowish-brown sand that has subangular blocky structure and is very friable.

Below the subsoil the material also is sand. It is light yellowish brown, single grain, and loose.

Wallace soils are poorly suited for farming. They are very droughty and infertile. Permeability is rapid above and below the cemented layer, but is slow within it. Soil blowing and water erosion are likely in cultivated areas. Practically all areas are either in forest or are idle. These soils are suited to trees, and many areas have been replanted to pine.

In this county Wallace soils are mapped only in a complex with Kalkaska soils.

Typical profile of Wallace sand in SW¼SW¼ sec. 1, T. 12 N., R. 15 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) sand; weak, medium, granular structure; very friable; very strongly acid; abrupt, smooth boundary.

A2—7 to 12 inches, light-gray (10YR 7/1) sand; very weak, medium, subangular blocky structure; very friable; medium acid; abrupt, irregular boundary.

B21hirm—12 to 15 inches, black (5YR 2/1) sand; massive; indurated; very strongly acid; abrupt, irregular boundary.

B22hir—15 to 30 inches, dark reddish-brown (5YR 3/3) sand; weak, coarse, subangular blocky structure; very friable; strongly acid; gradual, wavy boundary.

B3—30 to 40 inches, yellowish-brown (10YR 5/4) sand that has common, fine, prominent mottles of red (2.5YR 4/6); weak, coarse, subangular blocky structure; very friable; medium acid; gradual, wavy boundary.

C—40 to 60 inches +, light yellowish-brown (10YR 6/4) sand that has many, medium, faint mottles of yellowish brown (10YR 5/4) and few, medium, distinct mottles of dark yellowish brown (10YR 4/4); single grain; loose; medium acid.

Undisturbed areas of Wallace soils have a very dark gray or very dark grayish-brown surface layer that is 2 to 4 inches thick and is underlain by a layer of light sand 5 to 7 inches thick. The hardpan varies in the degree of cementation. In some areas it is well cemented and difficult to break, but in other areas it is broken and only weakly cemented. The subsoil ranges from very strongly to medium acid. Below a depth of 40 inches the material ranges from medium acid to slightly acid.

The cemented layer in the subsoil of the Wallace soils is lacking in the Kalkaska and Rubicon soils. Wallace soils are better drained than Saugatuck soils.

Warners Series

The Warners series consists of very poorly drained soils that have a surface layer of muck mixed with fragments of marl. These soils formed on deposits of marl that varied in purity. They generally occur in low ponded areas along the outer rims of flood plains. A few areas are on seepy hillsides, and there are small areas in depressions in the rolling areas of Ravenna and Casnovia Townships. The present vegetation consists of marsh grasses and some northern white-cedar and tamarack.

The surface layer consists of black muck mixed with light-gray fragments of marl. It has granular structure, is very friable, and is calcareous.

Underlying the surface layer is light-gray or white marl. This material is massive, friable, and calcareous.

Warners soils are very slowly permeable. They have high available moisture capacity.

These soils are in only a small acreage in Muskegon County. A small part of this has been cleared and is used for corn, small grains, and hay. Crops sensitive to lime are not suited. Most of the acreage remains in forest or has been cleared and is used for pasture.

Typical profile of Warners muck in SW¼SW¼ sec. 23, T. 10 N., R. 13 W., Casnovia Township:

Ap—0 to 8 inches, black (10YR 2/1) muck mixed with a few, medium, light-gray (10YR 7/1) fragments of marl; weak, fine, granular structure; very friable; calcareous; abrupt, smooth boundary.

C1—8 to 20 inches, light-gray (10YR 7/1) marl and very dark gray (10YR 3/1) organic material along root channels; massive; friable; calcareous; gradual, diffuse boundary.

C2—20 to 48 inches +, white (10YR 8/1) marl that has many, fine, faint mottles of very pale brown (10YR 8/3); massive; friable; calcareous.

In some areas of Warners soils the surface layer is as much as 60 percent marl. In other areas a considerable amount of silt occurs in the upper 6 to 10 inches. The calcium carbonate in the marl ranges from 20 to 70 percent. Small fragments of snail shells occur in the marl and on the surface in many areas.

Warners soils have a thinner organic layer than the Carlisle or the Houghton soils. Marl underlies the organic material of the Warners soils, whereas sand underlies the organic material of the Tawas soils.

Warners muck (0 to 2 percent slopes) (Wa).—Most of this soil is in low areas along the edge of flood plains. A few areas are on seepy hillsides, and small areas are in upland depressions. The areas at the edge of the flood plains are likely to be ponded.

The surface layer of this soil is black, well-granulated muck. It is underlain by marl.

Included with this soil in the mapping were areas that have a silt loam or loam surface layer. Also included were a few small spots that have a plow layer that is mostly marl. In places the organic layer is thick. These included areas are small and have no effect on use and management.

This soil is difficult to drain because the marl is near the surface. Most areas are not suitable as cropland, but they can be used for forest or pasture.

Capability unit IVw-5 (M/Mc); woodland suitability group U; wildlife suitability group 5; community development group 10.

Wind Eroded Land, Sloping

Wind eroded land, sloping (We) consists of sandy soils that are severely damaged by soil blowing. Blowouts and small dune-shaped knolls occur in many places. Slopes range from 0 to 12 percent. This land is mainly in areas that were Croswell and Au Gres soils, but some areas were the better drained Chelsea and Montcalm soils.

On this land severe erosion has removed all or nearly all of the original surface layer and, in local areas, even the subsoil. The present surface layer is loose sand that has a low content of organic matter and is susceptible to soil blowing.

This land has low fertility and available moisture capacity. It is droughty during summer, and may be wet during the rest of the year. The water table fluctuates in most areas and is within 24 inches of the surface during spring. Poorly drained depressions occur locally.

This mapping unit has been cleared of trees and cultivated, but it is now idle and has little or no plant cover. During spring, fall, and winter, further erosion may be retarded by the water table. Soil blowing, droughtiness, and excess water severely limit use of this land as cropland. Planting suitable trees helps to stabilize this land and to protect it against soil blowing.

Capability unit VIs-1 (Sa); woodland suitability group E; wildlife suitability group 2; community development group 3.

Use and Management of the Soils

The soils of Muskegon County are used mainly for crops and pasture. This section tells how the soils can be used for these main purposes, and it gives predicted yields of the principal crops. In addition, it explains how the soils can be managed as woodland, for wildlife, in building highways, farm ponds, and other engineering structures, and in community development.

In discussing management of cropland and pasture and of soils used for wildlife, the procedure in this section is to describe groups of soils that require similar management and then to suggest management suitable for the groups. Management of woodland is also described for groups, but information about these groups is in a table.

Crops and Pasture

In this subsection, the capability classification and management groups are explained and the management of soils by capability units is discussed. A table lists predicted yields under two levels of management.

Capability groups of soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops, or to rice and other crops that have their own special requirements. The soils are classified according to degree and kind of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible but unlikely major reclamation projects.

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 grouping, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I. Soils have few limitations that restrict their use. (None in Muskegon County.)

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

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

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

Class V. Soils subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover. (None in Muskegon 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 food and cover.

Class VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII. Soils and landforms have limitations that preclude their use for commercial plant production 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*, used in some parts of the United States but not in Muskegon County, 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 subclasses indicated by *w*, *s*, and *c*, because the soils in it 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-1 or IIIe-4. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass. In the following pages the capability units in Muskegon County are described and suggestions for the use and management of the soils are given. In this survey, the Arabic numerals are not consecutive, because not all the capability units used in Michigan are represented in Muskegon County.

In this soil survey, symbols made up of Arabic numerals and small or capital letters follow the symbols of each capability unit. These symbols in parentheses identify the management group or groups, all or portions of which are represented by the soils in the capability unit. These 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 Crops" (*5*).

Management by capability units

This subsection describes the soils in each capability unit, tells of their use and suitability for crops and pasture, and discusses management practices. The soil series represented in each capability unit are named, but this does not mean that all the soils in the series are in the capability unit. To find the names of the soils in any given unit, refer to the "Guide to Mapping Units" at the back of this survey.

CAPABILITY UNIT IIe-1 (1.5a)

This capability unit consists of gently sloping, slightly eroded to uneroded Nester soils that are well drained or moderately well drained. These soils have a clay loam subsoil and underlying material.

Water moves moderately slowly through these soils. Available moisture capacity is moderately high to high. These soils are fertile. They are acid in the upper part and are alkaline in the lower part. A few areas are moderately eroded and have poorer tilth and lower fertility than the uneroded or slightly eroded areas.

These soils are well suited to most crops grown in the county if management is provided for controlling runoff and erosion and for maintaining soil structure and the content of organic matter. Because these soils dry out and warm up slowly in spring, planting dates are later than on soils of coarser texture.

Good management provides return of crop residue, selection of a suitable sequence of crops, and use of practices that control erosion. Soil tilth, especially that of eroded soils, is improved by adding organic material. Yields are reduced where erosion has removed the surface layer. The subsoil is tight and difficult to till.

These soils are well suited to forage crops. The soils puddle, however, and have poor tilth, if grazing is permitted in wet periods.

CAPABILITY UNIT IIe-3 (3/2a)

This capability unit consists of well drained or moderately well drained, gently sloping, slightly eroded or uneroded soils. These soils have a sandy loam to clay loam subsoil and clay loam underlying material. They are in the Ubly series.

Permeability is moderately rapid in the upper part of these soils and is moderately slow in the lower part. Available moisture capacity is moderately high, but crops lack moisture during prolonged dry periods. Fertility is moderate. The upper part of these soils is acid, and the lower part is alkaline. Erosion is a hazard.

These soils are suited to most crops grown in the county if management is provided for maintaining fertility and the content of organic matter, for controlling erosion, and for overcoming slight droughtiness.

If cultivated crops are grown, use of terraces, stripcropping, contour tillage, and other practices help to control erosion. A sequence of crops that returns a large amount of organic matter helps to conserve soil and water.

These soils are well suited to forage crops and to trees and plants that provide food and cover for wildlife.

CAPABILITY UNIT IIw-2 (1.5b, 1.5c)

This capability unit consists of nearly level to gently sloping, somewhat poorly drained to very poorly drained soils. These soils have a clay loam or silty clay loam subsoil and underlying material. Their water table fluctuates and is at or near the surface in spring. These soils are in the Hettinger, Kawkawlin, and Sims series.

Permeability is moderately slow. Available moisture capacity and fertility are high, and the content of organic matter is moderately high.

These soils are some of the most productive in the county. They are well suited to crops commonly grown in the county if management is provided for removing excess water, for maintaining fertility and content of organic matter, and for improving the poor soil structure. Planting may be delayed because these soils, especially the very poorly drained Hettinger soils, warm up and dry out slowly in spring. The Hettinger soils are in depressions and remain wet for extended periods. Crops grown in the depressions are subject to damage from frost.

A combination of tile and open ditches can be used to drain these soils. The soils are generally stable, and ditches require little maintenance. Tile drainage is more successful if soil structure is improved by adding crop residue and by tilling at a minimum. By delaying tillage during wet periods, puddling is prevented.

These soils are well suited to forage crops. The selection of grasses and legumes depends on the degree of wetness. Tilth is impaired unless grazing is prevented during wet periods.

CAPABILITY UNIT IIw-3 (1.5b)

This capability unit consists of gently sloping, poorly drained soils that have a clay loam subsoil and clay loam underlying material. These soils are in undulating areas in which closed depressions are numerous. The water table fluctuates and is at or near the surface in spring. Thse soils are in the Kawkawlin series.

Permeability is moderately slow. Available moisture capacity and fertility are high, and the content of organic matter is moderately high.

The soils in this unit are among the most productive in the county. If adequately drained, they are well suited to crops grown in the county. In addition to drainage, management is needed that helps to control erosion, maintain fertility and content of organic matter, and improve tilth. Planting may be delayed on the soils in depressions because they are wet and dry out slowly in spring. Crops grown in the depressions are subject to damage from frost.

A combination of tile and surface drains can be used to drain these soils. Because the soils are generally stable, ditches used as surface drains require little maintenance. It is difficult, however, to lay out and install a drainage system in the undulating topography. Only tile laid at random and surface drains can be used in many areas. Drainage is more successful if soil structure is maintained by adding large amounts of crop residue and by tilling at a minimum.

These soils are well suited to forage crops. The selection of grasses and legumes depends on the degree of wetness. In undrained areas tilth is impaired unless grazing is prevented during wet periods.

CAPABILITY UNIT IIw-6 (3c)

This capability unit consists of nearly level, poorly drained Tonkey soils that formed in stratified sand, loamy sand, and sandy loam. These soils have a high water table in spring.

The soils of this unit are fertile and are well supplied with organic matter. Their high water table restricts internal drainage, but water moves rapidly through these soils in drained areas where the water table has receded. Crops may benefit from the moisture they receive from the water table.

These soils are suited to the crops commonly grown in the county, such as corn, small grains, and hay, but artificial drainage is required for optimum yields. In addition to drainage, management is needed that helps to maintain fertility and the content of organic matter. Crops grown in depressions and low places are subject to damage from flooding and frost.

Drainage is difficult on these soils because the soil material is unstable when wet. The drainage system should be installed during dry periods because trenches dug for laying tile and ditches for surface drains cave in readily. The tile lines may become filled with soil material unless care is used in blinding. Both surface drains and tile are needed in undulating areas.

These soils are well suited to forage crops. In undrained areas it is necessary to select legumes and grasses that are tolerant of wet conditions. In all areas, grazing should be prevented during wet periods so that puddling is prevented and good tilth is maintained.

CAPABILITY UNIT IIw-8 (3/2b)

This capability unit consists of nearly level to gently sloping soils that are somewhat poorly drained. These soils formed in sandy loam material that was 18 to 42 inches thick and underlain by loam to silty clay loam material. They have a high water table that fluctuates. These soils are in the Belding series.

The movement of water is moderately rapid through the upper part of the soils and moderately slow through the finer textured lower part. These soils are fertile and are moderately well supplied with organic matter. They are able to furnish the moisture needed by growing crops.

Where these soils have been successfully drained, they are well suited to the crops commonly grown in the county. In addition to drainage, management is needed that helps to maintain fertility and the content of organic matter. Depressions are likely to be ponded during wet periods. In spring they dry out slowly, and planting may be delayed.

Tile drains and ditches can be used to lower the water table and remove excess water. The depth and the spacing of tile lines depend on the depth to loam or silty clay loam material. Installation of tile lines is difficult because there are pockets of unstable wet sand.

The soils are well suited to forage crops. The selection of grasses and legumes depends on degree of wetness. Grazing during wet periods is not advisable, because the trampling animals damage tilth and cause puddling.

CAPABILITY UNIT IIIe-4 (1.5a)

This capability unit consists of sloping, well drained or moderately well drained soils. These soils have a clay loam subsoil and underlying material. They are in the Nester series.

The movement of water through these soils is moderately slow. Both available moisture capacity and natural fertility are high, but the content of organic matter is low, especially in moderately eroded areas.

These soils are suited to crops commonly grown in the county, but management is needed that helps to maintain soil structure, control erosion, and return crop residue. Because these soils warm up slowly in spring, planting may be delayed. These soils puddle if they are worked when they are too wet. A few spots are wet and need random tile drainage or surface drainage.

Good management provides the return of crop residue, selection of a suitable sequence of crops, and use of practices that control erosion. Soil structure can be improved by using a sequence of crops that returns large amounts of organic residue. Because the subsoil is tight and difficult to till, yields are reduced where erosion has removed the surface layer.

CAPABILITY UNIT IIIe-9 (4/2a, 3/2a, 4a)

This capability unit consists of rolling, well-drained soils that are uneroded or only slightly eroded. The subsoil of most of these soils is loamy sand or sandy loam that is underlain by sandy material, but in the Menominee soil the subsoil is underlain by clay loam material. These soils are in the Mancelona, Menominee, Montcalm, and Ubly series.

The soils in this unit have moderately rapid to rapid permeability. Available moisture capacity is low or moderately low, and fertility and the content of organic matter are low. In cultivated areas soil blowing and water erosion are likely.

Because these soils warm up early in spring but are droughty in summer, they are best suited to crops that can be planted early and that mature before the soils become too droughty. Favorable yields, however, are difficult to obtain. Practices are needed to control erosion and to increase fertility, the content of organic matter, and available moisture.

These soils are moderately well suited to forage crops, but yields are not so favorable, particularly during the dry summer months.

CAPABILITY UNIT IIIw-2 (1b, 1c)

This capability unit consists of nearly level or gently sloping, somewhat poorly drained to poorly drained soils. These soils have a clayey subsoil and clayey underlying material. The water table is at or near the surface in spring. These soils are in the Pickford and Selkirk series.

Permeability is slow or very slow. Both available moisture capacity and natural fertility are high, but the content of organic matter is low to medium.

These soils are well suited to most crops grown in the county if management is provided for disposing of excess water, for maintaining or increasing the content of organic matter, and for maintaining good soil tilth. Because these soils dry out and warm up slowly in spring, planting may be delayed.

Tile drains are suitable for removing excess water. The functioning of the tile lines is insured by blinding them with liberal amounts of straw or grass, or with topsoil rich in organic matter. In some areas backfilling to the surface with porous material is necessary. In gently sloping areas, surface drainage is helpful in supplementing the tile. Tile drainage is more successful if good structure is maintained by planting deep-rooted legumes, using minimum tillage, and returning crop residues. Structure and tilth are poor if these soils are worked when wet.

These soils are well suited to forage crops. Grasses and legumes that tolerate wetness grow well. Grazing during wet periods is not advisable, because the trampling animals damage structure and impair tilth.

CAPABILITY UNIT IIIw-6 (4c)

This capability unit consists of poorly drained, nearly level soils that formed in fine sand and very fine sand. These soils are wet because their water table is near the surface during much of the year. They are in the Deford series.

Above the water table, permeability is rapid. Available moisture capacity and fertility are low. Frost damage is likely in low areas.

These soils are suited to cultivated crops only if management is provided for removing excess water and for improving fertility and the content of organic matter.

Tile drains and open ditches can be used to remove excess water, but installing a drainage system is difficult. Installation is best during dry periods because the sides of ditches, and of trenches dug for tile, cave in readily when these sandy soils are wet. Because these soils are droughty after they are drained, controlled drainage is needed to regulate the amount of water available to plants.

Forage crops are well suited to these soils. The grasses and legumes selected depend on the degree of wetness. Undrained areas furnish good forage during dry summers, but in these areas wetness may delay seeding and grazing during spring.

CAPABILITY UNIT IIIw-11 (5c)

This capability unit consists of nearly level, poorly drained, sandy soils. The water table of these soils is at or near the surface during much of the year. These soils are in the Granby and Roscommon series.

Above the water table, water moves rapidly or very rapidly through these soils. Available moisture capacity and fertility are low. The content of organic matter is moderately high.

If these soils are adequately drained and otherwise well managed, they are fairly well suited to most crops commonly grown in the county. Selected sites, however, are suited to cucumbers and other truck crops. A few areas of Roscommon sand are suited to blueberries.

Tile drains and open ditches can be used to remove excess water, but installing a drainage system is difficult. The walls of trenches dug for tile cave in, and proper alinement of the tile is difficult. Also, the sandy soil material readily fills the tile lines. Unless the banks of open ditches are seeded and kept in sod, they cave in readily and the ditches become clogged. After these soils are drained, they are droughty unless drainage is controlled so as to regulate the amount of moisture available to crops.

These soils are better suited to forage crops than to cultivated crops. They produce moderately good pasture if grazing is restricted during wet periods.

CAPABILITY UNIT IIIw-12 (L-2c, L-Mc)

This capability unit is made up of nearly level, very poorly drained Kerston, Saranac, and Sloan soils that occur on bottom lands and are subject to flooding. These soils vary in texture and drainage within short distances. The Sloan and Saranac soils consist of alternating layers that range from moderately coarse to moderately fine in texture. The Kerston soil is made up of alternate layers of organic material and sandy material. The soils in this unit have a high water table and are saturated in spring and after floods.

These soils have high or moderately high available moisture capacity. Fertility ranges from high to low. The content of organic matter is high in the Kerston soils and moderately high in Sloan and Saranac soils. Permeability is moderately rapid in the Kerston soil, moderate in Sloan soils, and moderately slow in the Saranac soil. If the soils in this unit are drained and protected from floods, they are well suited to cultivated crops. The crops, however, are susceptible to frost drainage. Celery, onions, and other special crops are grown on the Kerston soil.

Tile drains and open ditches can be used to remove excess water, but drainage is difficult because the texture of the soil material varies within short distances. Also, drainage outlets are lacking in some areas. The Kerston soil is difficult to drain because it consists of sandy and organic material that is unstable when wet. Crops grown on the soils of this unit can be protected from flooding by diking.

Where drainage is not practical, these soils are used for pasture. Restricting grazing during wet periods helps to maintain soil tilth and structure.

CAPABILITY UNIT IIIw-15 (Mc)

This unit consists of poorly drained organic soils in which the organic material is more than 42 inches thick. These soils are in the Carlisle and Houghton series.

These soils have low fertility, high available moisture capacity, and moderate to rapid permeability. Surface runoff is slow to ponded. The soils are generally low in content of phosphorus and potassium and in the micronutrients manganese, boron, copper, molybdenum, and zinc.

Under good management, the soils in this unit are suited to specialized crops such as celery, carrots, mint, and onions. Good management provides practices that control the height of the water table, maintain and improve fertility, lessen the frost hazard, control soil blowing, and eradicate weeds, pests, and diseases. Drained areas of these soils produce favorable yields of short-season, frost-resistant truck crops. Small grains have rank growth and lodge before harvest.

Much damage is caused by soil blowing. The wind blows away newly seeded plants and damages older ones. It also thins the layer of organic material. Drainage ditches are filled by sand and organic material. Soil blowing can be reduced by compacting the surface, by irrigating, by stripcropping, and by using buffer strips and windbreaks. Rows of grain 2 or 3 feet apart protect the soil until the main crop is high enough to add its protection. Besides protecting the soil, the windbreaks provide nesting places and cover for wildlife.

Artificial drainage is needed before these soils can be cultivated intensively, but drainage is not practical in some areas because suitable outlets are lacking. The water table needs to be kept at a height that will allow good growth of plants and yet keep subsidence of the soils low. The water table can be controlled by using dams, dikes, subirrigation through tile, pumps and irrigation wells, and a system of tile and open ditches. Subsidence is reduced by keeping the water table high when these soils are not cropped.

These soils are commonly irrigated by sprinklers so that yields are increased, young transplants are benefited, and frost damage is reduced. Frost damage is also reduced by selecting hardy plants, providing good air drainage, and applying a large amount of potash fertilizer.

CAPABILITY UNIT IIIs-4 (4/2a, 4a)

This capability unit consists of soils that are nearly level or gently sloping and well drained or moderately well drained. These soils are in the Mancelona, Menominee, Montcalm, and Rousseau series. Most of these soils are coarse textured, but the Menominee soils are underlain by clay loam material at a depth of 18 to 42 inches.

Except in the Menominee soils, permeability is moderately rapid or rapid. In the Menominee soils, permeability is rapid above a depth of 18 to 42 inches and is moderately slow below that depth. Available moisture capacity is low in the Mancelona and Rousseau soils and is moderately low in the Menominee and Montcalm soils. The soils in this unit have low fertility and content of organic matter. Runoff is slow, and erosion generally is not a hazard. Tillage is easy and can be performed throughout a wide range of moisture content without clodding or crusting of the soils.

Under good management, these soils are suited to corn, small grains, and meadows. Because they warm up early in spring, they are well suited to small grains and other crops that are seeded early. Small grains are more dependable than corn because they mature before there is a serious shortage of moisture. Good management on these soils provides practices that maintain and increase fertility and the content of organic matter, that increase the moisture available during dry periods, and that control soil blowing. The Rousseau soils are more droughty than the other soils in this unit and are more susceptible to soil blowing.

Large additions of crop residues and manure and the use of green-manure crops help to increase fertility and the content of organic matter. Large additions of commercial fertilizer are not profitable in dry years.

Because these soils are generally moist and warm up early in spring, forage crops grow well early in the growing season. But growth is reduced during the dry summer months. Deep-rooted, drought-resistant plants grow best. Lime is generally needed if legumes are grown.

CAPABILITY UNIT IVw-2 (4/1b, 5b, 5b-h)

This capability unit is made up of nearly level or gently sloping, somewhat poorly drained soils. These soils are in the Allendale, Au Gres, Ogemaw, and Saugatuck series. The Au Gres and Saugatuck soils in this unit formed in sand more than 42 inches thick. The Ogemaw and the Allendale soils formed in a layer of sand, 18 to 42 inches thick, over clay material. The Ogemaw and Saugatuck soils have a cemented hardpan in their subsoil. The soils of this unit have a fluctuating water table that is near the surface during wet periods.

If the water table is lowered by artificial drainage, water moves rapidly or very rapidly through the sandy part of these soils. The movement of water is restricted by the cemented hardpan and the underlying material in the Ogemaw soil, by the cemented hardpan in the Saugatuck soil, and by the underlying clayey material in the Allendale soil. The cemented subsoil also restricts the growth of roots in Ogemaw and Saugatuck soils. Available moisture capacity, the content of organic matter, and fertility are low. Reaction is acid.

These soils are not well suited to cultivated crops but can be used for forage. If they are drained and well managed, they can be used for crops. Selected areas are suited to blueberries. Sites that meet the exacting requirements of this special crop are relatively valuable.

If these soils are cultivated, management is needed that lowers the water table, controls water erosion and soil blowing, and improves fertility and content of organic matter. A cropping system that returns large amounts of crop residue helps to improve fertility and content of organic matter.

Drainage systems are difficult to install and relatively expensive. Because trenches dug for tile readily cave in, the tile should be installed during the driest part of the year. In some areas sand flows into the completed tile lines and clogs them. The banks of open ditches are unstable and cave in readily. These soils are droughty if the water table is lowered too much. Soil blowing, especially in intensively cultivated areas, also is a hazard.

Where these soils are used for forage, lime and fertilizer are needed more frequently than on most other soils in the county. Grazing should be restricted during wet periods in undrained areas.

CAPABILITY UNIT IVw-5 (M/4c, M/mc)

This capability unit consists of very poorly drained soils that formed in organic material that overlies sand or marl. Thickness of the organic material ranges from 8 to 42 inches. These soils are in the Tawas and Warners series. The Tawas soil has a thicker layer of organic material than Warners soil and is underlain by sand instead of marl.

The soils in this unit are saturated because the water table is high. Available moisture capacity is high, but the soils are droughty if the water table is lowered too much. Runoff is very slow or ponded. Permeability is rapid in the Tawas soil and is very slow in the Warners soil. In the Warners soil downward movement of water and roots is restricted by the marl. The content of plant nutrients, especially of the micronutrients, is low. Alkalinity reduces availability of plant nutrients in the Warners soil.

The Warners soil in this unit generally is not suited to cultivated crops, but it can be used for grasses and trees. A few areas are used for corn and small grains. The Tawas soil is suited to onions, celery, and other specialized crops if management is used that lowers the water table, maintains or improves fertility, controls soil blowing, prevents fires, and eradicates weeds, pests, and diseases.

Soil blowing is a serious hazard, for it carries away newly planted seed, and it thins the layer of organic material. Drainage ditches are filled with drifting soil material. Soil blowing can be reduced by compacting the surface, by irrigating, by stripcropping, and by using buffer strips and windbreaks. Rows of grain planted 2 or 3 feet apart protect the soil until the main crop is tall enough to add its protection. Windbreaks, besides protecting the soil, provide nesting places and cover for wildlife.

Artificial drainage generally is required before the Tawas soil can be used for crops. By controlling the height of the water table, subsidence of the soil is reduced and yields are increased. Grasses generally tolerate a high water table better than do crops. In most areas of the Warners soil drainage is not practical, because the marl is near the surface and outlets are lacking.

The water table of the soils in this unit can be controlled by the use of dams, dikes, subirrigation through tile lines, pumps, irrigation wells, and a system of tile and open ditches. Subsidence is reduced if the water table is allowed to rise when crops are not grown. Wind erosion is also reduced by allowing the water table to rise.

These soils, both Tawas and Warners, are commonly irrigated by sprinklers so that yields are increased, soil blowing is decreased, young transplants are benefited, and frost damage is reduced. Frost damage is also reduced by selecting hardy plants, providing good air drainage, and applying a large amount of potash fertilizer.

In most places additions of phosphate and potash are needed, as are additions of manganese, boron, copper, molybdenum, and zinc. The amount and kind of fertilizer applied depend on soil reaction and the crop to be grown.

CAPABILITY UNIT IVs-2 (5a)

This capability unit consists of nearly level or gently sloping, well drained or moderately well drained soils. These soils are in the Chelsea, Croswell, and Sparta series. Except for the Chelsea soil, these soils have sand throughout their profile. The Chelsea soil contains layers of loamy sand. The Sparta soil is darker colored than the other soils of this unit. In the Croswell soil the water table is within 2 to 3 feet of the surface during wet periods.

Water moves rapidly or very rapidly through these soils. Available moisture capacity and fertility are low. The content of organic matter is high in the Sparta soil and low in the other soils in this unit. Organic matter decomposes readily in these soils. Runoff is slow, and water erosion generally is not a hazard. The soils are easily tilled and can be cultivated throughout a wide range of moisture content.

Use of these soils for crops is severely limited by low fertility and available moisture capacity and by the hazard of soil blowing. If crops are grown, they show signs of drought sooner than do crops on most other soils in the county. Early season crops are better suited than crops planted late in spring, for these soils dry out and warm up early in spring. Also, they can be worked earlier than loamy and clayey soils.

Large additions of crop residue and manure, including green manure, help increase fertility and the content of organic matter. Large additions of commercial fertilizer are not profitable in dry seasons. Crops planted as winter cover and trees planted in windbreaks protect these soils from soil blowing.

Forage crops are most abundant early in the growing season before these soils become too dry. Deep-rooted, drought-resistant forage crops grow best. If legumes are grown, lime is generally required.

CAPABILITY UNIT VIe-1 (1.5a)

This capability unit is made up of steep, well drained or moderately well drained soils of the Nester series. These soils have a clay loam subsoil and underlying material. Most areas are severely eroded, but a small acreage is only moderately eroded.

Permeability is moderately slow. Available moisture capacity and fertility are high. In severely eroded areas fertility, tilth, and the content of organic matter are lower than in less eroded areas. Runoff is rapid, especially in severely eroded areas.

These soils are better suited to hay, pasture, or trees than to cultivated crops. Plants may lack moisture because runoff is rapid and little moisture enters the soil. Also, it is difficult to operate farm machines safely and efficiently on the steepest slopes.

Good management provides practices that reduce runoff, improve structure and tilth, and control erosion.

CAPABILITY UNIT VIs-1 (5a, 5/2a, Sa)

This capability unit consists of nearly level to sloping, well-drained to somewhat poorly drained Chelsea and Rubicon soils and Wind eroded land. These soils formed in sand that is generally more than 60 inches deep, but in the Rubicon soil that has a loamy substratum, loamy material is at a depth of 42 to 66 inches. The surface layer of Wind eroded land has been removed by soil blowing, and blowouts occur in some areas.

Water moves rapidly or very rapidly through these soils. Available moisture capacity and fertility are low, and runoff is slow to medium. The content of organic matter is low, especially in the Wind eroded land.

The soils in this unit are poorly suited as cropland. They are subject to severe soil blowing if large areas are exposed by tillage. Available moisture is seldom adequate for the growth of crops, especially during the hot summer months.

These soils are not well suited to forage crops or pasture. Yields are not dependable; pastures dry up and yield little food during dry periods. Trees, especially pines, can be grown.

CAPABILITY UNIT VIIe-1 (1a, 1.5a)

This capability unit consists of very steep, well drained or moderately well drained soils in the Kent and Nester series. These soils have a clay or clay loam subsoil and underlying material. A small acreage is severely eroded.

Erosion is a severe hazard if these soils are cultivated. Available moisture capacity is high, but runoff is very rapid and little water that can be used by plants is absorbed. In severely eroded areas tilth and structure are poor and the content of organic matter is lower than that in uneroded areas.

These soils are too steep for use as cropland. The severely eroded areas were cultivated at one time but are now in pasture or are idle. Management that keeps these soils in pasture or trees helps to control further erosion. Fruit trees are grown in a few areas, and here special care is needed to reduce the hazard of erosion. These soils are suited as woodland.

CAPABILITY UNIT VIIs-1 (5a, 4a, 5.3a, 5a-h, 5.7a)

This capability unit consists of nearly level to very steep, well drained to moderately well drained sandy soils. These soils consist of sand that extends from the surface to a depth of 66 inches or more. They are in the Chelsea, Deer Park, Grayling, Kalkaska, Montcalm, Rubicon, and Wallace series.

Water moves through these soils rapidly or very rapidly. Available moisture capacity, fertility, and the content of organic matter are low. If these soils are tilled, the organic material decomposes rapidly and soil blowing is likely.

These soils generally are not suited as cropland, though a few areas are irrigated and are used for special crops. The use of farm machines is severely limited on the steep and very steep slopes. Yields of forage crops and pasture are not dependable, for these soils dry out readily during the dry summer months. They are suitable for various species of trees.

CAPABILITY UNIT VIIIs-1 (5a, Sa)

This capability unit consists of nearly level to very steep, well-drained sands that are deep, very loose, and dry. These sands are very low in fertility and in content of organic matter. They are subject to severe soil blowing, and the wind is constantly changing the shape of their landforms. Blown-out land, Dune land, and Lake beaches are in this capability unit.

The areas of Dune land in this unit can support trees after they are stabilized and adapted species are established. The land can be stabilized by planting beachgrass or by using a brush-type mulch. Hand labor must be used to plant and maintain both trees and grasses.

The areas of Lake beaches in this unit normally do not support permanent vegetation. These areas, however, have esthetic value and are well suited to recreation.

CAPABILITY UNIT VIIIw-1 (Sc)

This capability unit consists only of the mapping unit Marsh. Saturated organic material or sediments from rivers make up the soil material of Marsh.

The vegetation consists mainly of cattails, rushes, sedges, water lilies, and other water-tolerant plants. Tamarack, aspen, and willow also grow in a few places. Marsh is well adapted to use as a habitat for wetland wildlife.

Predicted yields

The predicted average acre yields of the principal crops grown in Muskegon County are given in table 2. The estimates are given for the soil at two levels of management. Only the arable soils, those suitable for cultivation, are listed in table 2. The estimates are based on information obtained from farmers, from members of the staff of the Michigan Agricultural Experiment Station, from Soil Conservation Service personnel, and from others familiar with the soils and crops of the county.

In columns A are average yields obtained under the management that was common in the county when the survey was made. In this management, lime and fertilizer are applied, but normally not in amounts sufficient to insure good yields. Barnyard manure produced on the farm is returned to the soil. Some areas have been artificially drained, but many of the low areas still require drainage. In most areas, a crop rotation is used that includes mixed grasses and legumes, but the mixture is not used long enough in rotations on the steep or the sandy soils.

The yields in columns B are obtained under improved management. In this management, lime and fertilizer are applied in amounts indicated by soil tests and according to the need of the crop grown. Where needed, a complete drainage system is installed. The plants are of adapted and improved varieties, and the seed of high quality. If needed, other conservation practices are used to control erosion and to conserve moisture. The cropping system used is adapted to the soils, and seeding, spraying, and cultivation are done at the proper time.

Because of the influence of Lake Michigan, the range in climate and the resulting yields vary from one part of the county to another. This influence of Lake Michigan also allows a number of special crops to be grown, though yields of these crops have not been predicted.

TABLE 2.—*Predicted average acre yields under two levels of management*

[Yields in columns A are those expected under ordinary management; those in columns B are for improved management. Dashes indicate soil is not suited to the crop, or that the crop ordinarily is not grown]

Mapping unit	Corn (grain)		Corn (silage)		Oats		Wheat		Alfalfa or alfalfa-brome hay		Clover-grass 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*
Au Gres-Saugatuck sands, 0 to 6 percent slopes	25	45	4	7	20	40	16	25	1.3	2.1	1.1	1.8
Belding and Allendale soils, 0 to 6 percent slopes:												
Belding soil	45	70	7	11	40	75	28	45	2.1	3.8	1.7	2.4
Allendale soil	30	55	5	9	32	50	22	32	1.5	3.0	1.2	2.0
Belding-Ubly sandy loams, 2 to 6 percent slopes:												
Belding soil	45	70	7	11	40	75	28	45	2.1	3.8	1.7	2.4
Ubly soil	50	85	8	13	40	75	32	45	2.4	4.0	1.5	2.2
Chelsea-Mancelona loamy sands, 2 to 6 percent slopes	20	40	3	6	18	34	13	22	1.2	2.0	1.0	1.5
Chelsea-Mancelona loamy sands, 6 to 12 percent slopes	15	35	2	5	15	30	10	20	1.2	2.0	1.0	1.5
Chelsea and Montcalm sands, 12 to 25 percent slopes	--	---	---	---	--	--	--	--	.8	1.7	.7	1.2
Croswell and Au Gres sands, 0 to 6 percent slopes	25	45	4	7	20	40	16	25	1.3	2.1	1.1	1.8
Deford fine sand	38	70	6	11	35	58	22	35	1.8	3.0	1.5	2.3
Granby loamy sand	25	48	4	7	22	45	12	25	1.2	2.2	1.0	1.8
Hettinger and Pickford soils:												
Hettinger soil	55	90	8	14	50	80	30	48	2.5	3.8	2.0	2.9
Pickford soil	35	70	5	11	45	65	27	40	2.4	3.5	2.0	3.0
Houghton peat and muck	60	100	9	15	--	--	--	--	---	---	---	---
Kalkaska-Wallace sands, 2 to 6 percent slopes	20	40	3	6	18	34	13	22	1.2	2.0	1.0	1.5
Kawkawlin loam, 0 to 2 percent slopes	55	90	8	14	48	75	30	48	2.3	3.5	1.8	2.6
Kawkawlin loam, 2 to 6 percent slopes	55	90	8	14	48	75	30	48	2.3	3.5	1.8	2.6
Kawkawlin and Selkirk loams, 0 to 2 percent slopes:												
Kawkawlin soil	55	90	8	14	48	75	30	48	2.3	3.5	1.8	2.6
Selkirk soil	55	90	8	13	48	75	30	45	2.3	3.5	1.8	2.6
Kawkawlin and Selkirk loams, 2 to 6 percent slopes:												
Kawkawlin soil	55	90	8	14	48	75	30	48	2.3	3.5	1.8	2.6
Selkirk soil	55	90	8	13	48	75	30	48	2.3	3.5	1.8	2.6
Kerston muck	50	90	8	14	--	--	--	--	---	---	---	---
Menominee and Ubly soils, 2 to 6 percent slopes:												
Menominee soil	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Ubly soil	50	85	8	13	40	75	32	45	2.4	4.0	1.5	2.2
Menominee and Ubly soils, 6 to 12 percent slopes:												
Menominee soil	30	60	4	9	25	45	16	26	1.5	2.6	1.2	2.0
Ubly soil	45	80	7	12	35	70	28	40	2.4	4.0	1.5	2.2
Montcalm and Chelsea soils, 2 to 6 percent slopes	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Nester loam, 2 to 6 percent slopes	50	90	8	14	48	70	32	45	2.3	4.0	1.8	2.6
Nester loam, 6 to 12 percent slopes	50	90	8	14	42	65	32	45	2.3	4.0	1.8	2.6
Nester sandy loam, 6 to 12 percent slopes	50	90	8	14	42	65	32	45	2.3	4.0	1.8	2.6
Nester soils, 12 to 25 percent slopes	--	---	---	---	25	55	15	30	2.0	3.7	1.5	2.3
Nester-Kawkawlin loams, 2 to 6 percent slopes	50	90	8	14	48	70	32	45	2.3	4.0	1.8	2.6
Nester-Ubly sandy loams, 2 to 6 percent slopes	50	85	8	13	40	75	32	45	2.4	4.0	1.5	2.2
Ogemaw loamy sand, 0 to 6 percent slopes	25	45	4	7	20	40	16	25	1.2	2.2	1.1	1.8
Roscommon and Au Gres sands	25	48	4	7	22	45	12	25	1.2	2.2	1.0	1.8
Rousseau fine sand, 0 to 6 percent slopes	30	60	4	9	25	45	16	26	1.5	2.6	1.2	2.0
Rubicon loamy substratum and Montcalm soils, 0 to 6 percent slopes:												
Rubicon soil	20	40	3	6	18	34	13	22	1.2	2.0	1.0	1.5
Montcalm soil	35	65	5	10	30	50	20	30	1.5	2.6	1.2	2.0
Rubicon loamy substratum and Montcalm soils, 6 to 12 percent slopes:												
Rubicon soil	15	35	2	5	15	30	10	20	1.2	2.0	1.0	1.5
Montcalm soil	30	60	4	9	25	45	16	26	1.5	2.6	1.2	2.0
Saranac loam	40	90	6	14	40	70	20	40	1.9	3.5	1.8	2.9
Sims loam	55	90	8	14	50	80	30	48	2.5	3.8	2.0	2.9
Sloan soils	40	90	6	14	40	70	20	40	1.9	3.5	1.8	2.9
Tawas and Carlisle mucks	50	80	8	12	--	--	--	--	---	---	---	---
Tonkey and Deford soils:												
Tonkey soil	50	80	8	12	40	75	27	45	2.1	3.3	1.7	2.5
Deford soil	38	70	6	11	35	58	22	35	1.8	3.0	1.5	2.3
Warners muck	45	71	7	11	--	--	--	--	---	---	---	---

Woodland [3]

The area that is now Muskegon County originally was covered almost entirely by forest. White oak, beech, and maple (fig. 6) grew on the finer textured soils in morainic areas, and pine was common in the sandy parts of the county.

In 1837, the first sawmill was established on Lake Michigan at the mouth of the Muskegon River. From this beginning, the lumber industry grew and flourished until, at its peak, nearly a billion board feet of lumber was cut each year for the mills along Lake Michigan alone. By the turn of the century, this cutting and great forest fires had eliminated much of the timber on the watershed of the rivers in the county and the mills were moved or abandoned.

Today a paper company and a bowling equipment company still operate, partly because the Great Lakes provide transportation. Also, hard maple of high quality still grows in the county and in the southern part of Michigan. The white pine trees cut for timber are being replaced, in small part, by plantations of pines sold as Christmas trees. This new industry is growing.

About 50 percent of the land area of the county is still woodland, most of which is privately owned. The public land is in the Manistee National Forest, in State parks and game areas, in county parks, and in school-owned forests. Because of the large population in and near the county, the woodland of the county is used for several purposes, especially recreation.

Much of the woodland is on droughty, infertile soils where the trees are black and white oaks of low quality and the understory is white pine in many places. This pine is valuable and needs to be released and properly managed (fig. 7). Adapted species of other trees can be underplanted in many existing stands, and desirable species can be planted in other areas if they are managed well. The growth of trees can be increased by protecting them from grazing animals, by killing the cull trees, and by removing undesirable species.

Woodland suitability groupings

The soils of Muskegon County have been placed in woodland suitability groups to assist farmers and others in planning use of the soils as woodland. Each group con-

[3] By E. R. Wilson, woodland conservationist, Soil Conservation Service.

***Figure 6.*—A virgin forest of beech and maple on Nester loam, 2 to 6 percent slopes.**

sists of soils that have similar potential productivity and require similar management. These groups are described in table 3. To determine the soils in each group, refer to the "Guide to Mapping Units" at the back of this survey.

Table 3 shows for each woodland suitability group, potential productivity for stands of pine, spruce-fir, aspen-birch, oaks, and mixed hardwoods and gives the species to favor in existing stands and those to plant in new or cutover stands. Table 3 also rates the major limitations and hazards that affect management. These ratings do not consider the use of soils for growing Christmas trees and other special woodland crops. The terms used in table 3 are explained in the following paragraphs.

Potential productivity ratings.—In table 3, potential productivity is rated very high, high, medium, low, and very low. *Very high* potential productivity indicates annual growth of more than 325 board feet or 1.2 cords per acre; *high*, 275 to 325 board feet or 0.8 to 1.2 cords; *medium*, 200 to 275 board feet or 0.5 to 0.8 cords; *low*, 125 to 200 board feet or 0.2 to 0.5 cords; and *very low*, less than 125 board feet or 0.2 cords. The ratings are for well-managed, fully stocked stands, and they express approximate annual growth. The name of a woodland type designates the dominant species in the type. Because the ratings cover a range of productivity, each soil should be considered separately in determining its potential productivity for trees. A detailed description of each soil is given in the section "Descriptions of the Soils."

Species priority.—The two columns under the heading "Species priority" show the kinds of trees to favor in existing stands and those suitable for planting. In both columns the trees are listed in order of preference, the most desirable first. Priorities are based on the productivity rating of the soils and the potential commercial value of the trees.

Seedling mortality.—This term refers to the expected loss of seedlings that is caused by unfavorable features of the soil or topography but not by competing plants. Depth to water table and droughtiness were the two most important soil features that were considered in rating the soils. The rating *slight* indicates that adequate natural regeneration ordinarily will take place. The water table is seldom within reach of the main part of roots of seedlings, and the soil furnishes adequate moisture to seedlings throughout the growing season. *Moderate* indicates that natural regeneration cannot always be relied on for adequate and immediate restocking, probably because the water table is at the level of the tree roots during the early part of the growing season, or because the soil does not furnish sufficient moisture for the seedlings during the driest part of the growing season. In extremely dry years moisture is insufficient during much of the growing season. Seedling mortality is *severe* if the water table is at or near the surface throughout the first half of the growing season, or if there is a shortage of water during much of the growing season. If seedling mortality is severe, much replanting, special preparation of the seedbed, and superior planting techniques are needed to assure adequate restocking.

Plant competition.—When a site has been disturbed by fire, by cutting, or by some other means, the invasion of undesirable brush, trees, or other plants may delay or prevent the establishment of desirable trees. The degree

***Figure 7.*—Scrubby black and white oaks with an understory of white pine on sandy Rubicon soils. Release of the white pine is needed.**

that unwanted plants compete with the desirable trees is rated slight, moderate, or severe. A rating of *slight* means that competition from other plants is no special problem. *Moderate* means that there is plant competition but that it generally does not prevent establishment of an adequate stand. *Severe* means that competing plants prevent desired trees from restocking naturally and that careful management is needed to control these plants in areas where seedlings are planted.

Insect and disease hazards.—The hazards that trees may be damaged by insects and diseases are also rated as slight, moderate, or severe. Because little information is available on how soils affect damage by insects and diseases, the ratings are more general than ratings for other hazards in table 3.

Equipment limitations.—The use of equipment commonly used in tending or harvesting trees may be limited or prevented by features of the soil and topography. This limitation is rated slight, moderate, or severe. *Slight* means that there is no special problem in use of equipment. *Moderate* means 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. Equipment limitation is *severe* if the type of equipment that can be used without damage to the trees is limited and if there is a seasonal restriction of more than 3 months when equipment cannot be used.

279-229—68——4

TABLE 3.—*Woodland suitability groups, their potential productivity, species,*

[Absence of rating for potential productivity indicates

Woodland suitability group [1]	Potential productivity ratings for woodland types: Pine	Spruce-fir	Aspen-birch	Oaks	Mixed hardwoods
Group A: Well drained and moderately well drained gently sloping to rolling, loamy soils over clay loam.	Medium to high.	Medium to high.	Medium	Medium to very high.	Medium to high.
Group B: Well drained and moderately well drained soils with a clayey or loamy subsoil over silty clay or clay loam. Permeability is slow or moderately slow, and available moisture capacity is high.	Low to medium.	Medium to high.	Medium to high.	High	High to very high.
Group C: Well drained or moderately well drained soils with a sandy to loamy subsoil over clay loam or sand and gravel below a depth of 18 inches. Permeability is moderately rapid to rapid, and available moisture capacity is low or moderately low.	High to very high.	------------	Medium to high.	Medium to high.	Medium to high.
Group E: Well drained or moderately well drained sandy soils. Permeability is rapid or very rapid, and available moisture capacity is low.	High to very high.	Medium	Medium to high.	Medium	Low to medium.
Group F: Somewhat poorly drained or poorly drained sandy soils that have a hardpan in some areas and a water table near the surface during wet periods. Permeability is very rapid or rapid above the water table, and available moisture capacity is low.	Low to medium.	Low to medium.	Low to medium.	Very low	Very low
Group G: Somewhat poorly drained soils formed in sandy or loamy material over loam to clay at a depth of 18 to 42 inches. A high water table is at or near the surface during wet periods. Permeability is moderately slow to very slow, and available moisture capacity is moderately low to moderately high.	Low	Medium	Low to medium.	Low	Low
Group H: Well drained and moderately well drained sandy soils that have a cemented hardpan in some areas. Above the hardpan, permeability is rapid or very rapid and available mositure capacity is low or very low.	Medium to high.	------------	Low	Very low	Very low
Group O: Soils on nearly level bottom land along streams that are very poorly drained, have sandy or loamy subsoils, and are subject to flooding. Permeability is moderate to moderately slow, and available moisture capacity is moderately high to high.	------------	------------	------------	------------	------------
Group P: Poorly drained and very poorly drained soils with a loamy or loamy and clayey profile and a high water table, especially in spring. Permeability is moderately slow or very slow, and available moisture capacity is high.	------------	Low to medium.	Low to medium.	Low	Low
Group Q: Poorly drained sandy soils with a high water table. Permeability is rapid or very rapid, and available moisture capacity is low.	Very low	Very low	Very low	------------	Very low to low.
Group U: Very poorly drained organic soils with a high water table. These soils are saturated with water most of the year.	------------	------------	------------	------------	------------
Group V: Well-drained, nearly level sandy soils that are dark colored and droughty. Permeability is very rapid, and available moisture capacity is low.	Medium	------------	Medium	------------	------------
Group W: Poorly drained, moderately coarse textured and coarse textured soils with a high water table. Permeability is rapid, or moderately rapid, and available moisture capacity is low to medium.	Very low	Low	Medium	------------	Very low to low.
Group Y: This group consists of sand dunes, lake beaches, and severely eroded sandy soils. Available moisture capacity is low, and the soils are difficult to stabilize.[3]	------------	------------	------------	------------	------------
Group Z: Somewhat poorly drained soils that have a clayey or loamy subsoil over clayey or loamy material and a fluctuating water table. Permeability is moderately slow or slow, and available moisture capacity is high.	Very low	Medium	Medium	Low to medium.	Low to medium.

[1] The soils are grouped into woodland suitability groups on a statewide basis; some groups are not represented in this county.
[2] Where soils are subject to flooding.

priority, and ratings for major limitations and hazards affecting management

trees are not suited or data are not available]

Species priority—		Limitations and hazards affecting management					
To favor in existing stands	For planting	Seedling mortality	Plant competition	Insect and disease hazards	Equipment limitations	Erosion hazard	Windthrow hazard
Red oak, sugar maple, white oak, basswood, white ash, black cherry, black walnut	White pine, red pine, white spruce.	Slight to moderate.	Moderate	Slight	Slight	Slight	Slight.
Sugar maple, red oak, basswood, black cherry, black walnut.	White spruce, Norway spruce, white pine.	Moderate	Moderate to severe.	Slight	Moderate to severe; severe on steeper slopes.	Moderate to severe; severe on steeper slopes.	Slight.
White pine, red oak, white oak, sugar maple.	White pine, red pine, white spruce.	Slight	Slight	Slight	Slight to severe; limitations increase with slope.	Slight to severe; hazard increases with slope.	Slight.
White pine, red oak, white oak, aspen, beech.	Red pine, white pine, jack pine.	Slight	Slight	Slight	Slight to severe; limitations increase with slope.	Slight to severe; hazard increases with slope.	Slight.
Aspen, soft maple, white pine, white birch, pin oak.	White pine, white spruce, Norway spruce.	Moderate to severe.	Moderate	Moderate	Moderate	Slight to moderate.	Moderate.
White ash, red maple, swamp white oak, cottonwood, aspen.	White spruce, white pine, Norway spruce.	Severe	Moderate to severe.	Moderate	Slight to moderate.	Slight	Moderate.
White pine, red pine, white oak, black oak.	Red pine, white pine, jack pine.	Moderate	Slight	Moderate	Moderate to severe.	Moderate to severe.	Slight.
White ash, red maple, basswood, sycamore, elm. [2]	Cottonwood [2], sycamore.	Moderate to severe.	Moderate to severe.	Moderate	Severe	Slight	Moderate.
Soft maple, white ash, basswood, elm.	White spruce, Norway spruce, white pine.	Severe	Moderate to severe.	Moderate	Severe	Slight	Moderate to severe.
Soft maple, white ash, pin oak, white birch.	None suitable	Severe	Moderate	Moderate	Moderate to severe.	Slight	Moderate to severe.
Soft maple, elm, white cedar, willow.	In windbreaks only—Austrian pine, white pine, Scotch pine, willows.	Severe	Severe	Moderate	Severe	Slight	Severe.
----------	Red pine, white pine, white spruce.	Moderate	Moderate to severe.	Slight to moderate.	Slight	Moderate	Slight.
White ash, soft maple, basswood, elm.	None suited	Severe	Severe	Moderate	Severe	Slight	Moderate to severe.
----------	----------	----------	----------	----------	----------	----------	
White oak, red oak, basswood, red maple, white ash, cottonwood.	White spruce, white pine, white cedar.	Moderate to severe.	Moderate to severe.	Moderate	Moderate	Slight	Moderate.

[3] After these areas are stabilized, they have ratings and limitations similar to group H.

Erosion hazard.—A soil is well protected from erosion if it is under a dense stand of trees, undergrowth, shrubs, and other plants and a fairly thick cover of litter. Erosion is likely, however, if this cover is removed through fire, harvesting of trees, or poor management. Erosion is also likely unless care is taken in constructing and maintaining roads, skid trails, and loading areas.

In table 3 *slight* indicates that damage from erosion is not likely if ordinary methods of clear cutting are used. *Moderate* means that in clear-cut areas some protective cover must be maintained and that care must be taken to prevent gullies from forming in skid trails. 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. A rating of *slight* means that the trees are well anchored and windthrow is not common. *Moderate* means 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. The rating *severe* indicates that a high water table or a hardpan or some other restrictive layer limits the depth of rooting so that stability is not adequate.

Use of the Soils for Wildlife[4]

If management of wildlife is to be successful, food, cover, and water must be available in a suitable combination, for an imbalance of these or a lack of any one may account for the absence of desired kinds of wildlife. Most managed wildlife habitats are created, improved, or maintained by planting suitable vegetation, by manipulating the existing vegetation so that the desired plants are encouraged, or by a combination of such measures. The influence of a soil on the growth of plants can be inferred from knowledge about the properties of the soil. The properties of a particular soil indicate whether that soil is suitable for establishing and maintaining various combinations of plants. By evaluating the combinations of plants that can be produced on a soil, a manager of wildlife habitat can estimate the suitability of that soil for different kinds of wildlife.

In table 4 groups of soils of the county are rated according to their suitability for elements of wildlife habitat and according to their suitability as habitat for openland, woodland, and wetland wildlife. These groups of soils are called wildlife suitability groups and are described later in this subsection. Explanations are needed for the elements of wildlife habitats, for openland, wetland, and woodland wildlife, and for the ratings used in table 4.

The following gives examples of plants in the plant categories in table 4 and tells something about the properties of soils suitable for water developments.

[4] Merle Raber, Michigan Department of Conservation, helped prepare this subsection.

Grain and seed crops: Valuable as food for wildlife are corn, buckwheat, rye, soybeans, oats, barley, and other grain grown for grain and seed.

Grasses and legumes: Alfalfa, alsike clover, ladino clover, bromegrass, beachgrass, orchardgrass, and timothy are planted grasses and legumes valued as wildlife food and cover.

Wild herbaceous upland plants: Among these plants that wildlife use for food and cover are little bluestem, Canada bluestem, and other native grasses and native herbs.

Hardwood forest plants: This group includes trees and shrubs typical of northern hardwood forest. Among the native shrubs are staghorn sumac, fire cherry, greenbrier, wintergreen, and blueberry. Common hardwoods are aspen and birch; white and black oaks; beech, maple, red oak, hickory, and other upland hardwoods; and elm, ash, red maple, cottonwood, and other swamp hardwoods. These trees and shrubs generally seed or sprout naturally, and if openings are made for wildlife, they respond favorably. Areas of hardwood forest plants provide food, cover for nesting, and protection in winter.

Conifer forests and plantations: Plants include cone-bearing shrubs and white, red, Scotch, and jack pines, Norway and black spruce, and other conifers. They are established by natural seeding or by planting. Although these trees and shrubs provide some food, they are used mostly as nesting areas and winter cover.

Wetland food and cover plants: These are wild herbaceous plants that grow in moist to wet sites. Examples are cattails, sedges, and water weeds.

Shallow impoundments: These are floodings, generally less than 6 feet deep. They provide feeding, loafing, and breeding areas for wetland wildlife (fig. 8).

Excavated ponds: These are ditches, ponds, or potholes developed by dredging or blasting. They require a permanently high water table and provide feeding, loafing, and breeding areas for wetland wildlife.

The following defines and gives examples of wildlife in the three classes of wildlife for which the suitability of groups of soils is rated in table 4.

Openland wildlife: Birds and mammals that normally frequent croplands, pastures, meadows, lawns, and areas supporting herbaceous and shrubby plants. Examples are quail, pheasants, cottontail rabbits, meadow larks, field sparrows, red foxes, and woodchucks.

Woodland wildlife: Birds and mammals that normally frequent wooded areas of hardwood or coniferous trees and shrubs. Among these are ruffed grouse, woodcock, thrushes, vireos, scarlet tanagers, gray, red and fox squirrels, white-tailed deer, and raccoons.

Wetland wildlife: Birds and mammals that normally frequent ponds, marshes, swamps, and other wet areas. They include ducks, geese, herons, shorebirds, rails, mink, and muskrat.

TABLE 4.—*Suitability of soils for elements of wildlife habitat and kinds of wildlife*

[A rating of 1 means well suited; 2 means moderately well suited; 3 means poorly suited; 4 means very poorly suited]

Wildlife suitability group	Wildlife habitat elements											Wildlife		
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood forest plants				Conifer forests and plantations	Wetland food and cover plants	Shallow impoundments	Excavated ponds	Openland	Woodland	Wetland
				Aspen-birch	Oaks	Upland	Swamp							
1	3	3	3	3	4	4	3	2	3	4	3	3	2	3
2	4	4	3	3	3	3	3	2	4	4	3	3	2	3
3	2	2	2	2	3	2	2	3	2	2	2	2	2	2
4	4	3	4	3	4	[1] 4	4	3	4	4	4	4	[1] 3	4
5	[2] 3	[2] 3	[2] 3	[2] 3	[2] 4	4	[2] 2	3	3	4	1	3	[2] 2	1
6	3	2	3	3	4	4	1	2	1	2	1	2	1	1
7	3	3	3	3	2	3	4	1	4	3	4	3	1	3
8	4	4	3	4	3	4	4	2	4	4	4	3	2	4
9	1	1	1	2	1	1	4	2	4	1	4	1	1	1

[1] Deer Park soils are rated 1 because of favorable climate along Lake Michigan.

[2] Areas on Marsh are not suited to these elements.

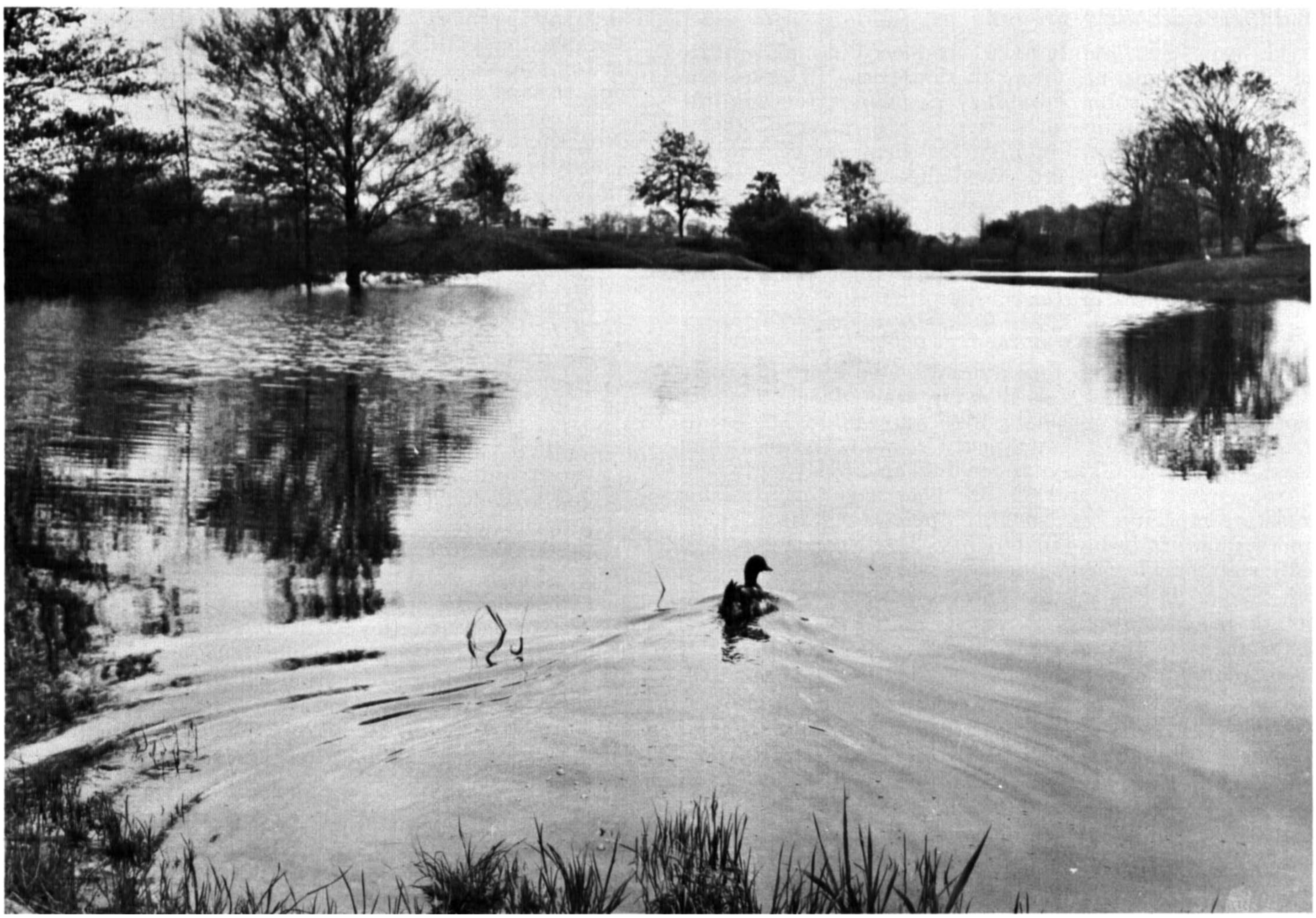

***Figure 8.*—Mallard duck at home in a newly constructed pond on Sims loam. This pond was built for wildlife, recreation, and irrigation.**

In table 4 groups of soils have been rated according to their suitability for the eight elements of wildlife habitat and according to their suitability for openland, woodland, and wetland wildlife. The ratings are based on a system described by Allen, Garland, and Dugan (*1*). A rating of *well suited* means the elements of the wildlife habitat occur naturally on the soils in the group or can easily be established and maintained. A rating of *moderately well suited* indicates that drainage, fertility, or some other natural factor limits suitability or that the habitat is difficult to establish and maintain. The soils are *poorly suited* if the elements of the habitat rarely occur naturally in quantity or quality or are expensive to establish and maintain. The soils are rated *very poorly suited* if the elements of the habitat do not occur naturally or are impractical to establish and maintain at a level necessary for sustained production of most wildlife.

Not considered in the ratings in table 4 are present use of the land, existing vegetation, or the ability of wildlife to move from place to place. Although these factors are important to managers of wildlife, they are subject to change and are not practical to determine. Also, the soils are rated without considering their position in relation to adjoining soils.

Wildlife suitability groups

The soils in the county have been placed in nine wildlife suitability groups according to similarities in characteristics that determine suitability as habitat for wildlife. These are the groups of soils that are rated in table 4 according to their suitability for elements of wildlife habitat and for openland, woodland, and wetland wildlife. The soil series represented in each of these groups are named, but this does not mean that all the soils in the series are in the group. To determine the soils in each wildlife suitability group, refer to the "Guide to Mapping Units" at the back of this survey.

WILDLIFE SUITABILITY GROUP 1

This group consists of moderately well drained to poorly drained, deep, sandy soils that are nearly level to gently sloping and have a seasonally high water table. These soils are in the Au Gres, Saugatuck, Croswell, Ogemaw, and Roscommon series. They are medium acid to strongly acid in the surface layer and subsoil. They have low available moisture capacity, are droughty during long dry periods, and are naturally low in fertility. The Roscommon soils have a slightly higher water table and are wetter than the other soils in this group. The Saugatuck and Ogemaw soils have a hard, cemented subsoil.

On the soils of this group, the natural cover of herbaceous plants is sparse and the variety of plants is small. Among the woody plants are quacking aspen and willow. Openings in the wooded areas can be seeded to alsike and Ladino clovers, if they are seeded in summer and if lime and fertilizer are applied. The life of these plants, however, is generally short. The soils in this group are generally poorly suited to grain and seed crops and to grasses and legumes. White pine, Norway spruce, black spruce, and other conifers can be planted to provide winter cover and nesting places for wildlife. Areas of Roscommon sand are well suited as sites for dug ponds and for potholes because these soils have a high water table.

WILDLIFE SUITABILITY GROUP 2

Only Wind eroded land, sloping, is in this group. This land is moderately well drained to poorly drained, deep, and sandy, and it has been severely eroded by wind. The water table is seasonally high, but this land is droughty during long dry periods. It is medium acid to strongly acid and has low available moisture capacity and fertility.

In openings of any kind, this land is susceptible to erosion unless a cover of trees is established and maintained. It may be necessary to stabilize severely eroded areas before trees are planted. Brush mulch and beachgrass help to stabilize the openings and also benefit wildlife. White, red, Scotch, and jack pines are adapted, and they provide cover and places for wildlife to roost and nest.

WILDLIFE SUITABILITY GROUP 3

This group consists of somewhat poorly drained nearly level to gently sloping soils that are moderately coarse textured to moderately fine textured to a depth of 18 to 42 inches. Below that depth the soils are moderately fine textured to fine textured. These soils are in the Allendale, Belding, Kawkawlin, and Selkirk series. They have a seasonally high water table and are seepy in some spots. Available moisture capacity and fertility range from moderately low to high. Reaction is medium acid to neutral. These soils support natural cover of herbaceous plants favorable for wildlife. Also, it is easy to establish food plots of rye, buckwheat, corn, and other seed and grain crops. In some areas, artificial drainage is beneficial. Nesting places are excellent in meadows of Ladino clover, alsike clover, timothy, bromegrass, and orchardgrass, but management is needed to prevent invasion by brush and then by mixed hardwoods. The gentle relief provides many sites favorable for constructing shallow impoundments. Ditches are easily dug in the shallow depressions, and potholes occur in the small wet areas. These ditches and potholes are used by wetland wildlife.

WILDLIFE SUITABILITY GROUP 4

This group consists of well-drained, nearly level to very steep sands, some uneroded, and some very severely eroded by wind. In the group are Deer Park soils and Blown-out land, Dune land, and Lake beaches. These mapping units have very low fertility and available moisture capacity. Reaction ranges from strongly acid to slightly acid, but Lake beaches are calcareous and do not support vegetation.

Because the soils in open areas are subject to severe soil blowing, a cover of trees should be established and maintained on the soils of this group. In many places, the steep slopes and the loose sands hinder the use of machines for planting. Blown-out land normally is stabilized by using brush mulch and beachgrass, and then the land is planted to conifers. Many areas of Blown-out land have been stabilized and now support plantations of red, jack, and Scotch pines. These trees provide protection in winter and nesting and roosting places at other times. Areas of Deer Park soils near Lake Michigan support dense stands of beech and maple and of hemlock and associated shrubs. In these areas squirrels and raccoons are common and sometimes are a nuisance to property owners.

WILDLIFE SUITABILITY GROUP 5

This group consists of poorly drained to very poorly drained sandy soils and of shallow or deep organic soils.

In the group are Marsh and Warners, Deford, Tonkey, Tawas, Carlisle, Granby, Kerston, and Houghton soils. A high water table saturates these soils unless they are artificially drained. Available water capacity is higher in the Houghton, Kerston, Tawas, Carlisle, and Tonkey soils than in the Deford and Granby. The Tonkey soils are medium in natural fertility, but fertility is low in all other soils in this group. Reaction ranges from medium acid to neutral.

Because these soils have a high water table, they can be developed for use by wetland wildlife. It is possible to blast in these soils and create shallow potholes and ditches that can be used by wildlife. Larger areas for water can be dug with draglines. Wetland wildlife is naturally well suited to Marsh because it is covered with free water during most of the year and supports aquatic plants. Because the Tonkey soils are slightly higher in natural fertility than the other soils in this unit, they are more suitable for the production of grain and seed crops, adapted grasses and legumes, and food and cover suitable for wetland wildlife.

WILDLIFE SUITABILITY GROUP 6

This group consists of poorly drained or very poorly drained soils of the bottom lands, which are moderately coarse textured to moderately fine textured; and of moderately fine textured to fine textured soils, which are on uplands. These soils are in the Hettinger, Pickford, Saranac, Sims, and Sloan series. They supply much moisture and large amounts of nutrients to plants. The water table is high, and internal drainage is slow. Reaction ranges from slightly acid to moderately alkaline. Slopes are less than 6 percent.

These soils generally can be developed into habitat suitable for many kinds of wildlife. Because drainage is poor, however, grain and seed crops grown for wildlife food are somewhat difficult to establish, though buckwheat, soybeans, and rye are generally suited. The Hettinger, Pickford, and Sims soils occur on uplands and are poorly drained, but in many areas they are artificially drained. In these areas, a number of grain and seed crops can be grown. Although the Saranac and Sloan soils are difficult to drain because they are subject to periodic flooding, migrating waterfowl are attracted to the corn that has been planted in some areas. In some open areas lowland herbaceous and woody plants are common, but these areas require constant cutting and spraying of undesired plants.

WILDLIFE SUITABILITY GROUP 7

This group consists of well drained or moderately well drained, acid, sandy soils that have very rapid to moderately rapid internal drainage. These soils are in the Rubicon, Montcalm, Chelsea, Rousseau, and Mancelona series. They are well aerated, have moderately low to low available moisture capacity, and low fertility. They range from nearly level to very steep and are easily eroded by wind and water.

The soils in this group are well suited to planted conifers; though planting by hand may be necessary where slopes are more than 12 percent. Although erosion is likely, it can be retarded by planting trees on the natural contour. Openings for use by wildlife can be left when trees are planted. On the more gentle slopes, buckwheat, rye, or other grain and seed crops can be established and maintained. Seedings of grasses, legumes, and other food plants for wildlife can be established if management is good and provides use of lime and fertilizer. Growth, however, is limited by lack of moisture during the growing season.

WILDLIFE SUITABILITY GROUP 8

This group consists of well-drained very sandy soils that have rapid internal drainage. These soils are in the Grayling, Rubicon, Kalkaska, Wallace, and Sparta series. They have low to very low fertility and available moisture capacity and are acid throughout the profile. These soils are nearly level to very steep and are easily eroded by wind and water.

The soils in this group are well suited to planted conifers and adapted shrubs, though planting by machines is difficult where slopes are more than 12 percent. Planting by machines on the natural contour helps to retard erosion. Adequate opening for wildlife food plants should be maintained. A mixture of fast- and slow-growing plants lasts a long time. In open areas, the Sparta soils support a better stand of grasses and weeds than do the other soils in this group.

WILDLIFE SUITABILITY GROUP 9

This group consists of nearly level to rolling, moderately coarse textured to fine textured soils that are mainly well drained or moderately well drained. These soils are in the Kent, Menominee, Nester, and Ubly series. They have moderate to high available moisture capacity and natural fertility, are generally acid, and are underlain by limy material. Aeration ranges from good to fair.

In this group are some of the better soils for farming in the county, and on these soils are the largest numbers of birds and animals. Also, habitat suitable for all three types of wildlife can be developed on the soils of this group. Common practices that benefit wildlife are planting shrubs along field borders, planting grain and seed crops in odd areas, and leaving strips or corners of unmowed hay. Commonly growing in natural openings are dense stands of native grasses and legumes, but these openings are rapidly invaded by woody shrubs and then by mixed hardwoods. Habitat for wetland wildlife can be developed by impounding runoff water.

Engineering Uses of the Soils

This subsection describes those properties of soils that are important to engineering. 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 erosion control, and drainage systems.

Engineers can use the information in this subsection 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 that are pertinent to the particular area.

It should be emphasized, however, these estimates may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper than the depths of layers here reported. Even in these situations, however, the soil map is useful for planning more detailed field investigation and for suggesting the kinds of problems that may be expected.

Much of the information in this subsection is given in tables 5, 6, 7, and 8. Table 5 contains test data for soils

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	Horizon	Mechanical analysis [1]	
					Percentage passing sieve—	
					No. 4 (4.7 mm.)	No. 10 (2.0 mm.)
			Inches			
Belding sandy loam:						
NE¼NE¼ sec. 27, T. 9 N., R. 14 W. (Modal).	Glacial till.	S-39973	0-6	A1	--------	100
		S-39974	17-26	A'2	--------	100
		[5] S-39975	34-66	IIC	98	97
700 feet south and 700 feet west of northeast corner of sec. 27, T. 12 N., R. 18 W. (Grading to Iosco).	Glacial till.	S-39976	7-16	B2hir	--------	100
		S-39977	16-33	B23ir	--------	100
		S-39978	40-66	IIC	--------	100
Kent silt loam:						
SW¼SW¼NW¼ sec. 13, T. 12 N., R. 15 W. (Modal).	Stratified silty clay.	S-39979	0-10	Ap	--------	---------
		S-39980	17-29	B22	--------	---------
		S-39981	29-66	C	--------	---------
SE¼NE¼SW¼NW¼ sec. 10, T. 9 N., R. 14 W. (Coarser textured than modal profile).	Glacial till.	S-39982	0-7	Ap	--------	100
		S-39983	14-26	B22	--------	---------
		S-39984	26-66	C	--------	100
Rubicon sand:						
NW¼NE¼NW¼ sec. 22, T. 10 N., R. 15 W. (Modal).	Sandy glacial outwash.	S-39985	0-3	A1	--------	100
		S-39986	10-19	B2ir	--------	100
		S-39987	28-66	C	99	98
SE¼SE¼SW¼ sec. 28, T. 11 N., R. 15 W. (Grading to Grayling soils).	Sandy glacial outwash.	[5] S-39988	4-12	B21ir	98	96
		[5] S-39989	12-20	B22ir	96	93
		[5] S-39990	24-66	C	98	95
NE¼NE¼SE¼ sec. 2, T. 12 N., R. 18 W. (Grading to Rousseau and Kalkaska soils).	Sandy glacial outwash.	S-39991	10-15	Bir22	--------	100
		S-39992	15-21	Bir23	--------	100
		S-39993	21-66	C	--------	100
Saugatuck sand:						
NE¼NW¼NW¼SW¼ sec. 21, T. 10 N., R. 14 W. (Modal).	Glacial lake sediments.	S-39994	0-11	A2	--------	100
		S-29995	11-15	Bh	--------	100
		S-39996	15-24	Bhir	--------	100
		S-39997	45-66	C	--------	100
NE¼NE¼NW¼ sec. 4, T. 10 N., R. 17 W. (Grading to Au Gres soils).	Glacial lake sediments.	S-39998	0-6	A1	--------	100
		S-39999	6-14	A2	--------	100
		S-40000	20-27	Bir	--------	100
		S-40001	27-66	C	--------	100

[1] Mechanical analyses according to the AASHO Designation T 88-57(*2*). 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 is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

of four series in the county. In table 6 properties of the soils that are important to engineering are estimated. In tables 7 and 8 are interpretations of engineering properties of soils and soil features that affect specified engineering uses. From the data in these tables and the soil maps, the engineer can make a preliminary evaluation of the suitability of the soils for a specific use in any part of the county.

In addition to this subsection, other sections of the survey, including "General Soil Map," "Descriptions of the Soils," and "Use of Soils in Community Developments," contain information useful for engineering. Some of the terms used by the soil scientists may be unfamiliar to engineers and some words, for example, soil, clay, silt, and sand may have special meanings in soil science. These and other special terms that are used are defined in the Glossary at the back of this survey.

Engineering classification systems

Two systems for classifying soils are in general use among engineers. Many highway engineers classify soil materials according to the system approved by the American Association of State Highway Officials (AASHO) (*2*). Others prefer to use the Unified system, which was adopted by the Corps of Engineers, U.S. Army (*11*). Both systems differ from the system of classification used by soil scientists of the United States Department of Agriculture (USDA). In the USDA system, classification is based on the percentages of sand, silt, and clay in the soil. The engineering systems are explained in the following para-

test data

procedures of the American Association of State Highway Officials (AASHO) (*2*)]

Mechanical analysis [1]—Continued						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued		Percentage smaller than—							
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]
95	31	29	24	14	8	[4] NP	[4] NP	A-2-4(0)	SM.
95	47	42	33	21	13	15	3	A-4(2)	SM.
93	58	53	41	27	19	22	10	A-4(5)	CL.
92	23	21	17	11	8	NP	NP	A-2-4(0)	SM.
91	18	16	13	8	6	NP	NP	A-2-4(0)	SM.
97	70	66	57	42	33	33	18	A-6(10)	CL.
100	89	83	60	38	27	34	13	A-6(9)	CL.
------------	99	99	92	73	58	68	42	A-7-6(20)	CH.
------------	99	99	93	76	56	54	30	A-7-6(19)	CH.
98	72	68	59	41	31	27	9	A-4(7)	CL.
100	90	87	75	58	46	56	31	A-7-6(19)	CH.
99	91	88	74	53	39	43	22	A-7-6(13)	CL.
80	12	12	10	6	4	NP	NP	A-2-4(0)	SP-SM.
82	8	8	6	5	4	NP	NP	A-3(0)	SP-SM.
68	2	2	1	1	1	NP	NP	A-3(0)	SP.
64	5	5	4	4	3	NP	NP	A-3(0)	SP-SM.
64	4	4	4	4	3	NP	NP	A-3(0)	SP.
63	1	1	1	1	1	NP	NP	A-3(0)	SP.
84	17	15	6	4	2	NP	NP	A-2-4(0)	SM.
85	7	7	6	4	3	NP	NP	A-3(0)	SP-SM.
86	2	2	0	0	0	NP	NP	A-3(0)	SP.
94	9	8	6	3	2	NP	NP	A-3(0)	SP-SM.
92	8	7	6	3	2	NP	NP	A-3(0)	SP-SM.
96	12	10	5	2	1	NP	NP	A-2-4(0)	SP-SM.
96	6	4	1	1	1	NP	NP	A-3(0)	SP-SM.
90	10	9	7	3	2	NP	NP	A-3(0)	SP-SM.
91	5	4	3	2	1	NP	NP	A-3(0)	SP-SM.
90	3	3	2	2	2	NP	NP	A-3(0)	SP.
90	2	2	2	2	1	NP	NP	A-3(0)	SP.

[2] Based on AASHO Designation M 145-49 (*2*).

[3] Based on the Unified Soil Classification System (*11*). The Soil Conservation Service and Bureau of Public Roads have agreed that all soils having plasticity indexes within two points from A-line are to be given a borderline classification. An example of borderline classification thus obtained is SP-SM.

[4] NP=nonplastic.

[5] All of the material in samples Nos. S-39975, S-39988, S-39989, and S-39990 passed a ¾-inch sieve.

TABLE 6.—*Estimated*

Soil name [1]	Depth to water table	Depth from surface	Classification	
			USDA texture	Unified
		Inches		
Allendale (Mapped only with the Belding series.)	3 to 10 feet or more.	0 to 10	Loamy sand	SM
		10 to 40	Sand, loamy sand, or both	SP or SM
		40 to 66	Silty clay or clay	CH
Au Gres (AsB) (For properties of the Saugatuck soil in this mapping unit, refer to the Saugatuck series.)	Less than 3 feet during wet periods.	0 to 5	Sand	SM or SP-SM
		5 to 66	Sand	SP-SM or SP
Belding (BaB, BbB) (For properties of the Allendale soil in mapping unit BaB and the Ubly soil in mapping unit BbB, refer to their respective series.)	3 to 10 feet or more.	0 to 26	Sandy loam, fine sandy loam, loamy fine sand.	SM
		26 to 60	Loam, sandy clay loam, clay loam, silty clay loam.	ML or CL
Carlisle (Mapped only with the Tawas series.)	Water table at or near the surface during part of the year.	0 to 42	Muck and peat	Pt
Chelsea (CmB, CmC, CnD, CnE) (For properties of the Mancelona soils in mapping units CmB and CmC and of Montcalm soils in mapping units CnD and CnE, refer to their respective series.)	More than 10 feet.	0 to 9	Loamy sand	SM
		9 to 40	Sand	SP
		40 to 66	Sand with loamy sand in ¼ to 2 inch bands at intervals of 6 to 12 inches.	SP with bands of SP-S M or SM.
Croswell (CrB) (For properties of Au Gres soil in this mapping unit, refer to the Au Gres series.)	Less than 5 feet during wet periods.	0 to 8	Sand	SP or SM
		8 to 24	Sand	SP or SP-SM
		24 to 66	Sand	SP or SP-SM
Deer Park (DpE)	More than 10 feet.	0 to 66	Sand	SP or SM
Deford (Ds)	1 to 5 feet.	0 to 5	Fine sand or loamy sand	SP or SM
		5 to 20	Fine sand to loamy fine sand	SP or SM
		20 to 42	Very fine sand to loamy fine sand.	SM
Dune land (Du)	More than 10 feet.	0 to 66	Sand	SP or SM
Granby (Ga)	Water table at or near the surface during wet wet periods.	0 to 20	Loamy sand	SM
		20 to 30	Sand	SP or SM
		30 to 38	Sand with thin layers of loamy fine sand or fine sandy loam in places.	SM
		38 to 66	Sand	SP or SM
Grayling (GrC, GrD, GrE) (For properties of the Rubicon soils in these mapping units, refer to the Rubicon series.)	More than 10 feet.	0 to 66	Sand	SP
Hettinger (Hp) (For properties of the Pickford soil in this mapping unit, refer to the Pickford series.)	Near the surface during wet periods.	0 to 7	Loam	ML or CL
		7 to 18	Clay loam or silty clay loam	CL or CH
		18 to 21	Stratified very fine sand to silt loam.	SM, ML, or CL
		21 to 66	Stratified silty clay loam, clay loam, very fine sandy loam, and silt.	CL or ML
Houghton (Ht)	0 to 3 feet.	0 to 42	Muck and peat	Pt
Kalkaska (KaB) (For properties of the Wallace soil in this mapping unit, refer to the Wallace series.)	5 to 20 feet.	0 to 10	Sand	SP or SP-SM
		10 to 21	Sand, very weakly cemented in places.	SP or SP-SM
		21 to 66	Sand	SP
Kawkawlin (KkA, KkB, KsA, KsB) (For properties of the Selkirk soils in mapping units KsA and KsB, refer to the Selkirk series.)	3 to 8 feet.	0 to 11	Loam	ML or CL
		11 to 25	Light to heavy clay loam	CL
		25 to 36	Clay loam or silty clay loam	CL
		36 to 66	Clay loam	CL

See footnotes at end of table.

properties of soils

Classification—Cont.	Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4	No. 10	No. 200				
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-2	100	95 to 100	15 to 35	5.0 to 10.0+	0.08	5.5 to 6.5	Low.
A-2 or A-3	100	95 to 100	2 to 15	5.0 to 10.0+	.03	5.5 to 7.0	Low.
A-7	95 to 100	90 to 100	80 to 100	0.00 to 0.2	.16	7.5 to 8.4 [2]	High.
A-2 or A-3	100	95 to 100	5 to 15	10.0 or more	.04	4.5 to 6.0	Low.
A-3	100	95 to 100	0 to 10	10.0 or more	.02	5.0 to 6.0	Low.
A-2 or A-4	100	85 to 100	30 to 50	2.5 to 5.0	.12	4.5 to 6.0	Low.
A-4 or A-6	90 to 100	85 to 95	55 to 85	0.05 to 1.5	.17	6.0 to 8.0 [3]	Moderate.
				5.0 to 10.0	.50	5.5 to 6.5	Variable.
A-2	85 to 100	80 to 100	15 to 30	5.0 to 10.0	.06	5.5 to 6.5	Low.
A-3	95 to 100	90 to 100	0 to 5	5.0 to 10.0	.03	5.5 to 6.5	Low.
A-3 with bands of A-2 or A-3.	85 to 100	80 to 100	0 to 5 with bands having 5 to 15.	5.0 to 10.0	.04	5.5 to 7.0	Low.
A-2 or A-3	100	95 to 100	2 to 15	>10.0	.04	5.5 to 6.5	Low.
A-2 or A-3	100	95 to 100	2 to 12	>10.0	.03	5.0 to 6.0	Low.
A-3	100	95 to 100	0 to 10	>10.0	.02	5.5 to 6.0	Low.
A-2 or A-3	100	95 to 100	2 to 20	>10.0	.02	5.0 to 6.5	Low.
A-3 or A-2	100	95 to 100	2 to 20	5.0 to 10.0	.10	5.5 to 6.5	Low.
A-3 or A-2	100	95 to 100	2 to 30	5.0 to 10.0	.07	5.5 to 7.0	Low.
A-2 or A-4	100	95 to 100	15 to 40	5.0 to 10.0	.10	7.0 to 8.0 [3]	Low.
A-2 or A-3	100	95 to 100	2 to 20	>10.0	.02	5.0 to 6.5	Low.
A-2	100	90 to 100	15 to 25	2.5 to 10.0	.10	6.0 to 7.5	Low.
A-2 or A-3	100	90 to 100	0 to 15	10 or more	.03	5.5 to 7.0	Low.
A-2	100	90 to 100	5 to 35	5 to 10	.07	6.0 to 7.5	Low.
A-3 or A-2	100	90 to 100	0 to 15	10 or more	.04	6.0 to 7.5	Low.
A-3	100	95 to 100	0 to 5	10.0 or more	.02	5.0 to 6.0	Low.
A-4 or A-6	100	95 to 100	60 to 80	0.8 to 2.0	.18	6.0 to 7.0	Low.
A-6 or A-7	95 to 100	95 to 100	60 to 90	0.05 to 0.8	.17	6.5 to 8.0	Moderate.
A-2, A-4, or A-6	95 to 100	95 to 100	20 to 70	1.5 to 5.0	.14	6.5 to 8.0 [3]	Low.
A-4, A-6	95 to 100	95 to 100	60 to 90	0.05 to 0.8	.16	7.0 to 8.4 [3]	Low to moderate.
				2.0 to 5.0	.50	5.0 to 7.0	Variable.
A-3	90 to 100	90 to 100	0 to 10	5.0 to 10.0	.03	4.5 to 6.0	Low.
A-3	95 to 100	95 to 100	0 to 10	5.0 to 10.0	.05	4.5 to 6.0	Low.
A-3	100	95 to 100	0 to 5	10.0 or more	.02	5.5 to 6.0	Low.
A-4 or A-6	95 to 100	90 to 100	55 to 80	0.8 to 2.5	.20	6.0 to 7.0	Low.
A-6	95 to 100	90 to 100	60 to 80	0.2 to 0.8	.18	5.5 to 6.5	Moderate.
A-6 or A-7	95 to 100	90 to 100	55 to 90	0.5 to 0.8	.16	6.0 to 7.5 [3]	High to moderate.
A-6	95 to 100	90 to 100	55 to 80	0.2 to 0.8	.16	7.5 to 8.4 [2]	Moderate.

TABLE 6.—*Estimated properties*

Soil name [1]	Depth to water table	Depth from surface	Classification	
			USDA texture	Unified
		Inches		
Kent (KtE)	10 feet or more.	0 to 10	Silt loam	ML
		10 to 29	Silty clay or clay	CH
		29 to 66	Silty clay	CH
Kerston (Ku)	Water table at or near the surface during part of the year.	0 to 16	Alternating layers of organic material and sand.	Pt
		16 to 20	Alternating layers of organic material and sand.	SP or SM
		20 to 42	Alternating layers of organic material and sand.	Variable
Lake beaches (La)	Variable—0 to 10 feet.	0 to 60	Sand	SP or SP–SM
Mancelona (Mapped only with the Chelsea series.)	More than 10 feet.	0 to 17	Loamy sand	SM
		17 to 26	Sandy clay loam or clay loam	SC or CL
		26 to 60	Coarse sands, gravel, or both	GP or SP
Marsh (Ma)	Water table at the surface throughout the year in most areas.	0 to 66	Peat	Pt
Menominee (MeB, MeC) (For properties of the Ubly soils in these mapping units, refer to the Ubly series.)	10 feet or more.	0 to 7	Loamy sand	SM
		7 to 33	Sand or loamy sand	SP or SM
		33 to 66	Clay loam or silty clay loam	CL
Montcalm (MhB) (For properties of Chelsea soil in this mapping unit, refer to the Chelsea series.)	5 to 20 feet or more.	0 to 18	Loamy sand	SM
		18 to 26	Sandy loam or sandy clay loam.	SM or SC
		26 to 66	Alternate layers of sand 2 to 10 inches thick and loamy sand or sandy loam 1 to 3 inches thick.	SP or SP–SM SM
Nester (NeB, NeC, NrC, NsD, NsD3, NsE, NsE3, NtB, NuB). (For properties of the Kawkawlin soil in mapping unit NtB and of the Ubly soil in mapping unit NuB, refer to their respective series.)	5 to 20 feet or more.	0 to 14	Loam, sandy loam, or clay loam.	SM or CL
		14 to 36	Clay loam or silty clay loam.	CL or CH
		36 to 66	Clay loam or silty clay loam.	CL
Ogemaw (OgB)	2 to 10 feet or more.	0 to 9	Loamy sand	SM
		9 to 19	Loamy sand or sand, cemented.	SP or SM
		19 to 23	Sand or loamy sand	SP or SM
		23 to 66	Silty clay, clay, clay loam, or silty clay loam.	CH or CL
Pickford (Mapped only with the Hettinger series.)	Water table at or near the surface during wet periods.	0 to 8	Silty clay loam	CL
		8 to 21	Silty clay or clay	CH
		21 to 66	Silty clay or clay	CH
Roscommon (Ra) (For properties of the Au Gres soil in this mapping unit, refer to the Au Gres series.)	1 to 4 feet.	0 to 5	Sand	SP or SP–SM
		5 to 42	Sand	SP or SP–SM
		42 to 66	Sand	SP
Rousseau (RoB)	5 to 20 feet or more.	0 to 26	Fine sand to loamy fine sand	SM
		26 to 66	Fine sand	SM or SP–SM
Rubicon:				
Sand (RsB, RsD)	10 to 20 feet or more.	0 to 3	Sand	SP or SM
		3 to 28	Sand	SP or SP–SM
		28 to 66	Sand	SP
Loamy substratum (RtB, RtC) (For properties of the Montcalm soils in these mapping units, refer to the Montcalm series.)	5 to 20 feet or more.	0 to 5	Sand	SP or SM
		5 to 55	Sand	SP or SM
		55 to 66	Clay loam, silty clay loam, silty clay or clay.	CL or CH

See footnotes at end of table.

of soils—Continued

Classification—Cont.	Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4	No. 10	No. 200				
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-4	95 to 100	90 to 100	60 to 90	0.2 to 1.5	0.18	6.0 to 7.0	Moderate to high.
A-7	95 to 100	95 to 100	80 to 100	0.5 to 0.2	.17	5.5 to 7.0	High.
A-7	95 to 100	95 to 100	80 to 100	0.05 to 0.2	.16	7.5 to 8.4 [2]	High.
----------	----------	----------	----------	2.0 to 5.0	.50	5.0 to 7.0	Variable.
A-3 or A-2	100	95 to 100	0 to 25	Variable	Variable	6.0 to 7.0	Low.
Variable	----------	----------	----------	----------	----------	----------	
A-3	95 to 100	90 to 100	0 to 10	10.0 or more	.02	5.5 to 6.5 or 7.5 to 8.4.[4]	Low.
A-2	60 to 95	55 to 95	10 to 20	2.5 to 10.0	.08	5.0 to 6.5	Low.
A-4 or A-6	85 to 100	80 to 95	35 to 80	0.2 to 0.8	.16	5.5 to 6.5	Moderate.
A-1	40 to 60	30 to 60	0 to 5	10.0 or more	.02	7.0 to 8.4 [3]	Low.
----------	----------	----------	----------	----------	.5+	6.0 to 8.0	Variable.
A-2	95 to 100	95 to 100	15 to 20	5.0 to 10.0	.05	5.5 to 7.0	Low.
A-3 or A-2	95 to 100	95 to 100	0 to 15	5.0 to 10.0+	.03	5.0 to 6.5	Low.
A-6	95 to 100	90 to 100	60 to 90	0.2 to 2.5	.16	7.0 to 8.4 [2]	High to moderate.
A-2	90 to 100	90 to 100	15 to 25	2.5 to 5.0	.08	5.0 to 6.5	Low.
A-2, A-4, or A-6	95 to 100	95 to 100	20 to 50	0.8 to 3.0	.14	5.0 to 6.0	Low to moderate.
A-3	95 to 100	95 to 100	0 to 10	5.0 to 10.0	.04	5.5 to 7.0	Low.
A-2	95 to 100	95 to 100	15 to 30	2.5 to 5.0	.08	5.5 to 7.0[5]	Low.
A-4 or A-6	95 to 100	90 to 100	35 to 80	0.04 to 2.5	.17	5.0 to 7.0	Low to moderate.
A-6 or A-7	100	95 to 100	65 to 85	0.02 to 0.8	.17	5.0 to 7.0	Moderate to high.
A-6	100	95 to 100	65 to 85	0.05 to 0.8	.17	7.5 to 8.4 [2]	Moderate.
A-2	100	95 to 100	15 to 35	5.0 to 10.0	.06	5.0 to 7.0	Low.
A-3 or A-2	100	95 to 100	2 to 15	0.2 to 2.5	.04	4.5 to 5.5	Low.
A-3 or A-2	100	95 to 100	0 to 15	5.0 to 10.0	.02	5.0 to 7.0	Low.
A-7 or A-6	100	95 to 100	60 to 90	0.03 to 1.0	.16	7.5 to 8.4 [2]	Moderate to high.
A-6 or A-4	100	95 to 100	80 to 90	0.2 to 2.0	.19	6.0 to 7.0	Moderate.
A-7	100	95 to 100	75 to 100	0.05 to 0.2	.17	6.0 to 7.50	High.
A-7	100	95 to 100	75 to 100	0.02 to 0.2	.16	7.5 to 8.4 [2]	High.
A-3	100	95 to 100	2 to 10	>10.0	.04	5.0 to 6.0	Low.
A-3 or A-2	100	95 to 100	0 to 10	>10.0	.02	5.5 to 6.0	Low.
A-3	100	95 to 100	0 to 5	>10.0	.02	6.0 to 7.0	Low.
A-2	100	95 to 100	15 to 35	5.0 to 10.0	.07	4.5 to 6.0	Low.
A-2 or A-3	100	95 to 100	5 to 20	5.0 to 10.0	.05	5.0 to 7.0	Low.
A-3 or A-2	95 to 100	95 to 100	5 to 15	5.0 to 10.0	.05	4.5 to 6.0	Low.
A-3	95 to 100	90 to 100	0 to 10	10.0 or more	.03	4.5 to 6.0	Low.
A-3	95 to 100	95 to 100	0 to 5	10.0 or more	.02	6.0 to 6.5	Low.
A-3 or A-2	95 to 100	95 to 100	2 to 15	5.0 to 10.0	.05	5.0 to 6.5	Low.
A-3 or A-2	95 to 100	95 to 100	0 to 15	10.0 or more	.02	5.0 to 7.0	Low.
A-6 or A-7	95 to 100	95 to 100	60 to 90	0.00 to 1.0	.16	7.5 to 8.4 [2]	Moderate to high.

TABLE 6.—*Estimated properties*

Soil name [1]	Depth to water table	Depth from surface	Classification	
			USDA texture	Unified
		Inches		
Saranac (Sa)	Water table at or near the surface during wet periods.	0 to 10	Loam and clay loam	ML or CL
		10 to 36	Clay loam or silty clay loam	CL
		36 to 66	Variable	SM, ML, or CL.
Saugatuck (Mapped only with the Au Gres series.)	1 to 6 feet.	0 to 11	Sand, fine sand, or loamy sand.	SM or SP-SM
		11 to 34	Sand or fine sand, indurated.	SP or SM
		34 to 45	Sand or fine sand, weakly cemented.	SP or SM
		45 to 66	Sand or fine sand	SP or SP-SM
Selkirk (Mapped only with the Kawkawlin series.)	3 to 10 feet.	0 to 10	Silt loam	ML
		10 to 26	Silty clay loam, silty clay, or clay.	CH
		26 to 66	Silty clay or clay	CH
Sims (Sm)	1 to 4 feet.	0 to 9	Loam	ML or CL
		9 to 32	Clay loam or silty clay loam	CL
		32 to 48	Clay loam or silty clay loam	CL
Sloan (So)	0 to 4 feet.	0 to 21	Stratified loam, sandy loam, and silt loam.	ML
		21 to 48	Stratified silt loam to sandy loam.	ML or CL
Sparta (Sp)	10 to 20 feet or more.	0 to 14	Sand	SM or SP
		14 to 60	Sand	SP
Tawas (Tc) (For properties of the Carlisle soil in this mapping unit, refer to the Carlisle series.)	0 to 4 feet.	0 to 31	Muck, peat, or both	Pt
		31 to 48	Sand or loamy sand	SP or SM
Tonkey (Td) (For properties of the Deford soil in this mapping unit, refer to the Deford series.)	1 to 4 feet.	0 to 10	Sandy loam	SM
		10 to 42	Loamy sand stratified with sandy loam. Some clay loam.	Stratified ML and SM.
Ubly (Mapped only in complexes with the Belding, Menominee, and Nester series.)	5 to 20 feet or more.	0 to 25	Sandy loam or loamy fine sand.	SM or ML
		25 to 36	Sandy loam, sandy clay loam, or clay loam. Fragipans in places.	SM, SC, or CL.
		36 to 66	Clay loam or silty clay loam	CL
Wallace (Mapped only with the Kalkaska series.)	Within a depth of 6 inches in some places during wet periods.	0 to 12	Sand	SP-SM or SP
		12 to 15	Indurated sand	SP
		15 to 40	Sand	SP
Warners (Wa)	Water table at or near the surface during wet periods.	0 to 8	Muck, marl, or both	Pt, ML, or both.
		8 to 42	Marl	----------
Wind eroded land, sloping (We)	2 to 20 feet or more.	0 to 66	Sand	SP or SP-SM

[1] Blown-out land (BoB, BoE) is so variable that properties were not estimated.
[2] Calcareous.
[3] Calcareous in places

of soils—Continued

Classification—Cont.	Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4	No. 10	No. 200				
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-4 or A-6	100	95 to 100	55 to 90	0.2 to 2.5	0.21	6.0 to 8.0	Low to moderate.
A-6	100	95 to 100	55 to 90	0.05 to 0.8	.17	6.5 to 8.0 [3]	Moderate.
A-2, A-4, or A-6	100	95 to 100	20 to 90	0.07 to 5.0	.07 to .17	7.0 to 8.4 [3]	Variable.
A-3 or A-2	100	95 to 100	5 to 25	10.0 or more	.04	4.5 to 5.5	Low.
A-3 or A-2	100	95 to 100	0 to 20	0.2 to 2.5	.03	4.5 to 5.5	Low.
A-3 or A-2	100	95 to 100	0 to 20	0.7 to 2.5	.03	4.5 to 5.5	Low.
A-3	100	95 to 100	0 to 10	10.0 or more	.02	5.0 to 6.0	Low.
A-4	100	95 to 100	60 to 90	0.2 to 1.5	6.0 to 7.0	6.0 to 7.0	Moderate.
A-7	100	95 to 100	65 to 95	0.2 to 1.5	.20	6.0 to 7.5 [2]	High.
A-7	100	95 to 100	75 to 95	0.00 to 0.2	.16	7.5 to 8.4 [2]	High.
A-4 or A-6	100	95 to 100	60 to 80	0.8 to 1.5	.20	6.0 to 7.5	Moderate to low.
A-6	100	90 to 100	75 to 95	0.2 to 0.8	.18	6.0 to 8.0 [6]	Moderate.
A-6	100	90 to 100	75 to 95	0.05 to 0.2	.17	7.5 to 8.4 [2]	Moderate.
A-4	100	95 to 100	55 to 90	0.2 to 5.0	.19	6.0 to 7.5	Low.
A-4	100	95 to 100	55 to 90	0.2 to 2.5	.17	6.5 to 8.0 [3]	Low.
A-2 or A-3	95 to 100	95 to 100	0 to 15	5.0 to 10.0	.07	4.0 to 5.5	Low.
A-3	95 to 100	95 to 100	0 to 5	10.0 or more	.03	5.0 to 6.0	Low.
				5.0 to 10.0	.50	5.0 to 6.5	Variable.
A-3 or A-2	100	95 to 100	0 to 15	5.0 to 10.0	.03	6.0 to 8.0 [3]	Low.
A-2 or A-4	100	95 to 100	25 to 45	2.5 to 5.0	.15	6.0 to 7.5	Low.
Stratified A-4 and A-2.	100	95 to 100	20 to 60 with strata having as little as 5.	2.5 to 5.0	.10	5.5 to 8.0 [6]	Low.
A-2 or A-4	90 to 100	85 to 95	20 to 55	0.8 to 2.5	.12	5.0 to 6.5	Low.
A-2 or A-6	95 to 100	95 to 100	20 to 60	0.2 to 0.8	.15	5.0 to 6.5	Low.
A-6	95 to 100	90 to 100	70 to 90	0.05 to 1.5	.17	7.5 to 8.4 [2]	Moderate.
A-3	100	95 to 100	2 to 10	5.0 to 10.0	.03	4.5 to 6.5	Low.
A-3	100	95 to 100	0 to 5	0.2 to 2.5	.03	4.0 to 5.0	Low.
A-3	100	95 to 100	0 to 5	10.0 or more	.02	5.0 to 6.2	Low.
A-4 organic, or both				2.5 to 5.0	.50	7.0 to 8.4 [3]	Variable.
	Marl	Marl	Marl	<.05	Variable	7.5 to 8.4 [2]	Variable.
A-3	100	95 to 100	0 to 10	>10.0	.02	5.0 to 6.0	Low.

[4] Beaches on Lake Michigan are calcareous.
[5] pH value is 7.0–8.0 below a depth of 50 inches in some places.
[6] Calcareous below a depth of 20 inches in some places.

TABLE 7.—*Engineering interpretations: Suitability of soils as construction*

Soil series and map symbol [1]	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill for highway subgrade
Allendale (Mapped only with the Belding series.)	Fair	Poor or not suited, even though sandy to a depth of 18 to 42 inches.	Not suited	Poor; surface layer is too fine and contains little sandy material.
Au Gres (AsB) (For interpretations of the Saugatuck soil in this mapping unit, refer to the Saugatuck series.)	Poor	Good; poorly graded, medium-grained sand.	Not suited	Good; sand is wet below a depth of 3 or 4 feet.
Belding (BaB, BbB) (For interpretations of the Allendale soil in mapping unit BaB and the Ubly soil in mapping unit BbB, refer to those respective series.)	Good	Not suited	Not suited	Poor; generally wet below a depth of 4 feet; fine textured.
Carlisle (Mapped only with the Tawas series.)	Fair to poor; well decomposed to moderately decomposed organic soil; no mineral material.	Not suited; organic soil	Not suited	Not suited; organic soil.
Chelsea (CmB, CmC, CnD, CnE) (For interpretations of the Mancelona soils in mapping units CmB and CmC and of the Montcalm soils in mapping units CnD and CnE, refer to those respective series.)	Not suited	Good; poorly graded sand; lenses of fine material in some places.	Poorly suited	Good; easily eroded; good to fair bearing capacity.
Croswell (CrB) (For interpretations of the Au Gres soil in this mapping unit, refer to the Au Gres series.)	Not suited; very sandy; little organic matter.	Good; poorly graded, medium sands.	Not suited	Good; wet below a depth of 5 feet in places.
Deer Park (DpE)	Not suited; very sandy; very little organic matter.	Good; medium to fine sand.	Not suited	Good; sand is fine in places.
Deford (Ds)	Fair to good; upper surface 5 to 7 inches may be loamy sand.	Poor; sand is fine and poorly graded.	Not suited	Fair; wet below a depth of 1 to 3 feet; sand is fine and has low volume change.
Dune land (Du)	Not suited; material is very sandy and contains little organic matter.	Good; medium to fine sands	Not suited	Good; sand is fine in places.
Granby (Ga)	Fair to good; surface layer extends to a depth of 14 inches in some places and is sandy loam in places.	Fair; sand is poorly graded and contains fines in some places.	Not suited	Fair; generally wet below a depth of 2 to 3 feet; low volume change.
Grayling (GrC, GrD, GrE) (For interpretations of the Rubicon soils in these mapping units, refer to the Rubicon series.)	Not suited	Good; sand is poorly graded and medium grained.	Not suited	Good; erodes easily; low volume change.

See footnote at end of table.

material and soil features affecting engineering practices and structures

Suitability as source of—Continued	Soil features affecting—			Corrosion potential for conduits
Impermeable material	Highway location	Winter grading	Foundations for low buildings	
Poor to a depth of 18 to 42 inches; fair in substratum; material below 18 to 42 inches is wet and difficult to compact.	Seasonal high water table; susceptible to frost heaving; side slopes are seepy in places.	High content of moisture; poor stability when thawing.	Seasonal high water table; subject to frost heaving; low bearing capacity and high shrink-swell potential below a depth of 18 to 42 inches.	Very high for metal; low for concrete.
Poor; porous sands	Seasonal high water table; high erodibility.	High content of moisture hinders operations some of the time.	Seasonal high water table; low volume change; very low compressibility; piping hazard.	High for metal; low for concrete.
Fair to a depth of 18 to 42 inches; needs compaction; good below a depth of 18 to 42 inches, but often wet.	Seasonal high water table; slopes are seepy in places.	High content of moisture; poor stability when thawing.	Seasonal high water table; subject to frost heaving.	High for metal; low for concrete.
Not suited	High water table; unstable organic material.	High water table; unstable organic material.	Low bearing capacity; unstable organic material; high water table; not suitable for construction.	Very high for metal; moderate for concrete.
Poor; sandy	High erodibility; cuts and fills often needed; material easily excavated but difficult to haul.	Low content of moisture; good drainage; sandy material.	No limiting features	Low for metal; low for concrete.
Not suited	High water table for limited period; loose sands hinder hauling.	Low content of moisture most of the time; good stability when thawing.	Seasonal high water table; piping hazard; good bearing capacity; low volume change during wetting and drying; becomes liquid and flows when wet.	Low for metal; low for concrete.
Not suited	High erodibility; no other limitations; cuts and fills needed in many places.	Low content of moisture; good stability when thawing.	Low volume change on wetting and drying; low compressibility; becomes liquid and flows when wet.	Low for metal; low for concrete.
Poor; sandy material	High water table; may contain thin layers of unstable material; susceptible to frost heaving.	High water table; high content of moisture.	High water table; contains thin layers of unstable material; subject to frost heaving; piping hazard; material may become liquid and flow when wet.	High for metal; low for con; crete.
Not suited	High erodibility; easily eroded, no other restrictions; cuts and fills needed in many places.	Low content of moisture; good stability when thawing.	Low volume change on wetting and drying; low compressibility; material becomes liquid and flows when wet.	Low for metal; low for concrete.
Not suited	High water table	High water table; wet conditions.	High water table; subject to frost heaving; subject to piping.	High for metal; low for concrete.
Not suited	High erodibility; cuts and fills needed in places; hauling difficult.	Low content of moisture; sandy material; good drainage.	No limiting features	Low for metal; low for concrete.

279-229—68——5

TABLE 7.—*Engineering interpretations: Suitability of soils as construction*

Soil series and map symbol [1]	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill for highway subgrade
Hettinger (Hp) (For interpretations of the Pickford soil in this mapping unit, refer to the Pickford series.)	Good	Not suited	Not suited	Poor; generally wet; contains materials that have an undesirable texture.
Houghton (Ht)	Fair to poor; well decomposed to partly decomposed organic material.	Not suited	Not suited	Not suited; organic soil.
Kalkaska (KaB) (For interpretations of the Wallace soil in this mapping unit, refer to the Wallace series.)	Not suited	Good; sand is medium and poorly graded.	Not suited	Good; erodes easily
Kawkawlin (KkA, KkB, KsA, KsB). (For interpretations of the Selkirk soils in mapping units KsA and KsB, refer to the Selkirk series.)	Good	Not suited	Not suited	Fair to poor; generally poor below a depth of 3 or 4 feet because of wetness.
Kent (KtE)	Poor	Not suited	Not suited	Poor; unstable when wet; difficult to work and compact.
Kerston (Ku)	Fair to good; good if mineral and organic materials are mixed.	Not suited	Not suited	Poor; unstable when wet; difficult to work and to compact.
Lake beaches (La)	Not suited	Good; medium to coarse, rounded grains of clean sand.	Not suited	Good above water table.
Mancelona (Mapped only with the Chelsea series.)	Poor; gravelly in places.	Good; sandy to a depth of 18 to 42 inches; loose sand and gravel below a depth of 18 to 42 inches.	Good; sandy to a depth of 18 to 42 inches; loose sand and gravel below depth of 18 to 42 inches.	Good
Marsh (Ma)	Not suited	Not suited	Not suited	Not suited; high water table.
Menominee (MeB, MeC) (For interpretations of the Ubly soils in these mapping units, refer to the Ubly series.)	Poor	Fair to a depth of only 18 to 42 inches.	Not suited	Good to a depth of 18 to 42 inches; fair below a depth of 18 to 42 inches.
Montcalm (MhB) (For interpretations of the Chelsea soil in this mapping unit, refer to the Chelsea series.)	Poor	Poor to fair; loamy sand to a depth of 42 inches; sand below 42 inches in places.	Not suited	Good

See footnote at end of table.

material and soil features affecting engineering practices and structures—Continued

Suitability as source of—Continued	Soil features affecting—			Corrosion potential for conduits
Impermeable material	Highway location	Winter grading	Foundations for low buildings	
Fair to poor; wetness makes compaction difficult; contains layers of fine sand, silt, or fine clay.	High water table; occasional ponding; contains layers of unstable soil material; subject to frost heaving.	High water table; poor stability when thawing.	High water table; occasional ponding; contains unstable materials; subject to frost heaving; contains layers that have low bearing capacity; moderate shrink-swell potential.	High for metal; low for concrete.
Not suited	Organic soil; high water table; occasional ponding.	High water table; unstable organic material.	Low bearing capacity; unstable organic soils not suited to construction.	Very high for metal; moderate for concrete.
Not suited	High erodibility; cuts and fills needed in places.	Low content of moisture; sandy material; good drainage.	No limiting features	Low for metal; low to moderate for concrete.
Good to fair, depending on content of moisture; difficult to compact when wet or dry.	Seasonal high water table; subject to some frost heaving.	Content of moisture is too high for good compaction; poor stability when thawing.	Seasonal high water table; subject to some frost heaving; moderate shrink-swell potential.	High for metal; low for concrete.
Fair; fine-textured material; difficult to compact.	Plastic soil materials subject to slight frost heaving; cuts and fills needed in places.	Periods when content of moisture is high; poor stability when thawing.	Low shear strength; subject to slight frost heaving; low bearing capacity; high shrink-swell potential.	High for metal; low for concrete.
Not suited	Organic materials; high water table; occasional ponding.	High water table; unstable organic material.	Low bearing capacity; high water table; unstable organic material; suitable for construction.	Very high to high for metal; low for concrete.
Not suited	High water table in some places; unstable sands; high erodibility.	Variable features, depending on depth to water table.	High to low bearing capacity; fluctuating water table.	Moderate for metal; low for concrete.
Generally poor; good in subsoil between depths of 4 and 10 inches.	Cuts and fills needed in many places.	Low content of moisture; good drainage and stability when thawing.	No limiting features	Low to moderate for metal; low for concrete.
Not suited	Organic soil; high water table; ponding.	Marsh	Organic material not suited to construction.	Very high for metal; moderate for concrete.
Poor to a depth of 18 to 42 inches; good below a depth of 18 to 42 inches.	High erodibility; slightly plastic clays at a depth of 18 to 42 inches; cuts and fills needed in many places.	Poor stability when thawing; content of moisture varies.	Fairly low to low bearing capacity; moderate to high volume change on wetting and drying; possible seepage at a depth of 18 to 42 inches.	Moderate for metal; low for concrete.
Generally poor; good in finer textured subsoil between depths of 4 and 8 inches.	Cuts and fills needed in some places.	Low content of moisture; good drainage; sandy material.	No limiting features	Low for metal; low for concrete.

TABLE 7.—*Engineering interpretations: Suitability of soils as construction*

Soil series and map symbol [1]	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill for highway subgrade
Nester (NeB, NeC, NrC, NsD, NsD3, NsE, NsE3, NtB, NuB). (For interpretations of the Kawkawlin soil in mapping unit NtB and of the Ubly soil in mapping unit NuB, refer to those respective series.)	Generally fair; poor in eroded areas.	Not suited	Not suited	Fair; slightly plastic material.
Ogemaw (OgB)	Fair	Poor; sandy material to a depth of 24 inches but contains a hardpan.	Not suited	Poor below a depth ot 18 to 42 inches because soil is commonly wet and contains plastic clay; fair above.
Pickford (Mapped only with the Hettinger series.)	Good; very fine textured in places.	Not suited	Not suited	Not suited; wet, plastic clays.
Roscommon (Ra) (For interpretations of the Au Gres soil in this mapping unit, refer to the Au Gres series.)	Fair	Good; poorly graded, medium to coarse sand.	Poor; gravel in places below a depth of 42 inches.	Fair; commonly wet; low volume change.
Rousseau (RoB)	Poor	Poor; fine sand that contains thin layers of finer material.	Not suited	Fair; fine sands may be unstable.
Rubicon:				
Sand (RsB, RsD)	Not suited	Good; medium sand	Not suited	Good; erodes easily
Loamy substratum (RtB, RtC). (For interpretations of the Montcalm soils in these mapping units, refer to the Montcalm series.)	Poor	Good; poorly graded sand.	Not suited	Good to a depth of 42 to 66 inches; fair to poor below a depth 42 to 66 inches.
Saranac (Sa)	Good	Not suited; gravel below a depth of 3½ feet in places.	Not suited or fair	Poor; commonly wet and contains fine-textured material.
Saugatuck (Mapped only with the Au Gres series.)	Poor	Good below a depth of 42 inches; contains hardpan above 3½ feet.	Not suited	Poor to fair; commonly wet and subsoil contains cemented material.
Selkirk (Mapped only with the Kawkawlin series.)	Good; too fine textured in some places.	Not suited	Not suited	Poor; commonly wet plastic clay below a depth of 3 or 4 feet.
Sims (Sm)	Good	Nor suited	Not suited	Poor; wet, slightly plastic material.

See footnote at end of table.

material and soil features affecting engineering practices and structures—Continued

Suitability as source of—Continued	Soil features affecting—			Corrosion potential for conduits
Impermeable material	Highway location	Winter grading	Foundations for low buildings	
Good, but do not use when material is extremely wet or dry.	Slightly plastic clays; cuts and fills needed in many places.	Very high content of moisture; poor stability when thawing.	Moderate shrink-swell potential; fairly low to low bearing capacity; medium shear strength and compressibility; slight hazard of frost heaving.	Low to moderate for metal; low for concrete.
Poor; soil is sandy to a depth of 18 to 42 inches; it is fine-textured and difficult to compact and work below a depth of 18 to 42 inches.	Seasonal high water table; cemented sand in subsoil; plastic clays below a depth of 18 to 42 inches; subject to frost heaving.	Poor stability when thawing; seasonal high water table; often wet.	Susceptibility to frost heaving; low bearing strength below a depth of 18 to 42 inches; high shrink-swell potential; high water table.	High for metal; low for concrete.
Poor; wet plastic clays; difficult to compact and work.	High water table, at times ponded; plastic clays; subject to frost heaving.	High water table; wetness limits operations; poor stability when thawing.	Low shear strength; subject to frost heaving; low bearing capacity; high water table; high shrink-swell potential; piping hazard; poor stability.	Very high for metal; low for concrete.
Not suited; wet sands	High water table; occasional ponding.	High water table; often wet.	High water table; occasional ponding; piping hazard.	High for metal; low for concrete.
Poor; fine sands	High erodibility; fine sand contains thin layers of silt; subject to slight frost heaving; cuts and fills needed in some places.	Variable content of moisture and compaction properties; sandy material may be unstable when thawing.	Slight susceptibility to frost heaving; may contain layers with low stability; piping hazard.	Low for metal; low for concrete.
Not suited	High erodibility; cuts and fills needed in many places.	Low content of moisture; good drainage; good stability when thawing.	No limiting features	Very high for metal; low for concrete.
Generally not suited; good below a depth of 42 to 66 inches.	High erodibility; cuts and fills needed in many places.	Low content of moisture; good drainage.	Moderate to high shrink-swell potential below a depth of 42 to 66 inches; possible seepage at a depth of 42 to 66 inches.	Low for metal in sandy material, high in loamy substratum; low to moderate for concrete.
Fair to good; wetness makes compaction difficult.	High water table; subject to flooding; contains layer of unstable soil material in some places; subject to frost heaving.	High water table; subject to flooding.	High water table; subject to flooding; subject to frost heaving; contains layers of unstable material and layers subject to piping.	High for metal; low for concrete.
Not suited	High water table; subsoil contains cemented sand; subject to frost heaving.	Seasonal high water table; normally wet.	High water table; subject to frost heaving; piping hazard; subsoil contains cemented material.	High for metal; low for concrete.
Poor; wet plastic clay below a depth of 3 to 4 feet; difficult to compact and work.	Seasonal high water table; plastic soil material; subject to frost heaving.	High content of moisture; poor stability when thawing.	Low shear strength; high compressibility; subject to frost heaving; low bearing capacity; high shrink-swell potential; seasonal high water table.	Very high for metal; low for concrete.
Fair; wet in plow material; difficult to compact or handle, or both.	High water table; slightly plastic soil material; subject to frost heaving.	High water table; poor stability when thawing.	High water table; subject to frost heaving.	High for metal; low for concrete.

279-229 O - 68 - 6

TABLE 7.—*Engineering interpretations: Suitability of soils as construction*

Soil series and map symbol [1]	Suitability as source of— Topsoil	Sand	Gravel	Road fill for highway subgrade
Sloan (So)	Good	Poor; lenses of sand in places.	Not suited	Poor; contains layers that have an undesirable texture.
Sparta (Sp)	Poor; material has high content of organic matter but is very sandy.	Good; medium to coarse sand.	Not suited	Good; erodes easily
Tawas (Tc) (For interpretations of the Carlisle soil in this mapping unit, refer to the Carlisle series.)	Fair to poor; organic matter is partly decomposed or undecomposed.	Fair below a depth of 18 to 42 inches; overburden of organic material.	Poor; gravel in places below a depth of 42 inches.	Not suited; organic soil
Tonkey (Td) (For interpretations of the Deford soil in this mapping unit, refer to the Deford series.)	Good	Poor; lenses of sand in some places.	Not suited	Poor; generally wet and contains layers that have an undesirable texture.
Ubly (Mapped only in complexes with the Belding, Menominee, and Nester series.)	Fair	Not suited	Not suited	Generally fair; good above a depth of 18 to 42 inches.
Wallace (Mapped only with the Kalkaska series.)	Not suited	Good below hardpan	Not suited	Good; subsoil contains hardpan; may be wet at a depth of 5 feet.
Warners (Wa)	Poor to fair; organic material normally contains bits of marl.	Not suited	Not suited	Not suited; marl
Wind eroded land (We)	Not suited	Good; poorly graded, medium-grained sand.	Not suited	Good; sand is wet below a depth of 3 or 4 feet in some places.

[1] Interpretations were not made for Blown-out land (BoB, BoE).

TABLE 8.—*Engineering interpretations: Soil features*

Soil series and map symbol [1]	Farm ponds — Reservoir area	Farm ponds — Embankment
Allendale (Mapped only with the Belding series.)	Rapid permeability and rapid seepage in sandy material to a depth of 18 to 42 inches; slow permeability and very slow seepage below that depth.	Rapid seepage in sandy material to a depth of 18 to 42 inches; subject to piping; underlying clay is unstable when wet and has high shrink-swell potential and low bearing capacity.
Au Gres (AsB) (For interpretations of the Saugatuck soil in this mapping unit, refer to the Saugatuck series.)	Rapid permeability; rapid seepage	Good compaction; rapid seepage; subject to piping; fairly stable.

See footnote at end of table.

material and soil features affecting engineering practices and structures—Continued

Suitability as source of—Continued	Soil features affecting—			Corrosion potential for conduits
Impermeable material	Highway location	Winter grading	Foundations for low buildings	
Fair; wet and contains layers that have an undesirable texture.	High water table; subject to flooding; contains layers of undesirable soil material.	High water table; wetness limits operations; poor stability when thawing.	Piping hazard and poor stability; subject to frost heaving; high water table; subject to flooding.	Moderate for metal; low for concrete.
Not suited	High erodibility	Low content of moisture; good drainage; good stability when thawing.	No limiting features	Low for metal; low for concrete.
Not suited	High water table; frequent ponding; organic soil material.	High water table; unstable organic material.	Low bearing capacity; high water table; unstable organic materials not suited to construction.	High for metal; low for concrete.
Fair to poor; wet; contains layers of sand or silty materials or both.	High water table; contains layers of unstable soil materials; subject to frost heaving.	High water table; poor stability when thawing.	Low stability; subject to frost heaving; piping hazard and low bearing capacity; high water table; subject to flooding.	High for metal; low for concrete.
Good	Slight susceptibility to frost heaving; side slopes are seepy in places.	Medium to high content of moisture during most of the year; poor stability when thawing.	Slight hazard of frost heaving; possible seepage at a depth of 18 to 42 inches.	Moderate for metal; low for concrete.
Not suited	High erodibility; cemented sand subsoil.	Low content of moisture; good drainage; good stability when thawing; sandy material.	No limiting features	Low for metal; low for concrete.
Not suited; wet and contains marl; extremely difficult to compact or work, or both.	High water table; subject to flooding or ponding; organic material over marl; unstable and plastic.	High water table; organic material over marl.	Low bearing capacity; high water table; ponding; unstable organic material and marl not suited to construction.	Very high for metal; low for concrete.
Poor; sandy and porous	High water table in places; stabilization necessary.	High water table in some areas; in those areas poor stability when thawing.	Piping hazard; seasonal high water table in places.	Low for metal; low for concrete.

affecting agricultural practices and structures

Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Somewhat poor drainage; seasonal high water table; improving drainage is difficult in places because of uneven slopes and silty clay to clay at a depth of 18 to 42 inches; blind and backfill with porous material.	Low water-holding capacity; rapid intake rate; side slopes may develop seepy spots.	Generally not needed	Nearly level to short gentle slopes.
Somewhat poor drainage; rapid permeability; seasonal high water table; tile drainage is difficult in some places because material is sandy; install tile and ditch during dry periods; soil can be overdrained.	Low water-holding capacity; rapid intake rate; frequent applications of water required; very low fertility.	Not needed	Sandy soil; short gentle slopes; low water-holding capacity; low fertility.

TABLE 8.—*Engineering interpretations: Soil features*

Soil series and map symbol [1]	Farm ponds	
	Reservoir area	Embankment
Belding (BaB, BbB) (For interpretations of the Allendale soil in mapping unit BaB and the Ubly soil in mapping unit BbB, refer to those respective series.)	Moderate seepage above a depth of 18 to 42 inches; slow seepage below that depth.	Good compaction; moderate permeability above a depth of 18 to 42 inches; slow permeability below that depth; mixing of material above depth of 18 to 42 inches with the finer textured material below results in material well suited to impervious cores and blankets.
Carlisle (Mapped only with the Tawas series.)	High water table; rapid seepage; organic soil; possible site for pit-type pond; flotation possible.	Organic material; unstable for embankments.
Chelsea (CmB, CmC, CnD, CnE) (For interpretations of the Mancelona soils in mapping units CmB and CmC and of the Montcalm soils in mapping units CnD and CnE, refer to those respective series.)	Rapid permeability; rapid seepage; material is too sandy to hold water unless seal blanket is used.	Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting and drying.
Croswell (CrB) (For interpretations of the Au Gres soil in this mapping unit, refer to the Au Gres series.)	Rapid seepage; rapid or very rapid permeability; sandy soil.	Rapid seepage; rapid or very rapid permeability; good compaction; subject to piping; fair stability; very sandy material.
Deer Park (DpE)	Rapid seepage; rapid or very rapid permeability; sandy soil.	Rapid seepage; rapid or very rapid permeability; good compaction; subject to piping; fair stability; very sandy material.
Deford (Ds)	High water table; rapid seepage; rapid permeability.	Good compaction; rapid seepage; rapid permeability; subject to piping; fair to poor stability and bearing capacity; fine sand.
Dune land (Du)	Rapid seepage; rapid or very rapid permeability; sandy soil.	Rapid seepage; rapid or very rapid permeability; good compaction; subject to piping; fair stability; very sandy.
Granby (Ga)	High water table; rapid permeability; rapid seepage.	High water table; fair stability and compaction; rapid seepage; subject to piping.
Grayling (GrC, GrD, GrE) (For interpretations of the Rubicon soils in these mapping units, refer to the Rubicon series.)	Rapid permeability; rapid seepage; soil is too porous to hold water unless seal blanket is used.	Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting and drying.
Hettinger (Hp) (For interpretations of the Pickford soil in this mapping unit, refer to the Pickford series.)	High water table; slow to moderately slow permeability and seepage; contains thin layers that have rapid seepage in places.	High water table; fair to good compaction and stability; contains layers that have rapid seepage in places and are subject to piping in places.
Houghton (Ht)	High water table; moderately rapid permeability; rapid seepage; suited to pit-type ponds; flotation of organic material possible.	High water table; unstable organic material.

See footnote at end of table.

affecting agricultural practices and structures—Continued

Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Somewhat poor drainage; seasonal high water table; drainage is difficult in places because of uneven slopes and clay loam at a depth of 18 to 42 inches; on side slopes or toe slopes, tile may be needed to intercept seepage.	Medium water-holding capacity; medium intake rate; side slopes develop seepy spots in places.	Generally not needed	Seepy spots may delay construction; no other limiting features.
Very poor drainage; high water table; unstable organic soil; subject to subsidence; requires system that controls water table; walls of ditches subject to cave in; special blinding material needed; interceptor ditches commonly effective.	Very high water-holding capacity; rapid intake rate; permeable; low natural fertility; organic soil; poor natural drainage.	Not needed	Not needed.
Not needed; naturally good drainage	Low water-holding capacity; rapid intake rate; rapid permeability; low fertility; uneven slopes.	Generally not needed	Droughty sand; construction difficult with plow; low fertility; vegetation difficult to establish.
Generally not needed; moderately good drainage.	Low water-holding capacity; rapid intake rate; low natural fertility; rapid or very rapid permeability; very frequent applications of water required.	Not needed	Low water-holding capacity; low fertility; little runoff; easily eroded sandy soil.
Not needed; good natural drainage	Not used for farming	Not needed	Low water-holding capacity; low fertility; high erodibility; construction difficult in steep sandy soil.
Poor drainage; high water table; tile generally not used; fine sandy soil requires special investigation and methods; surface drainage and control of water table needed for special crops; construct drains during dry period.	Low water-holding capacity; rapid intake rate; low fertility; poor natural drainage.	Not needed	Generally not needed.
Not needed; good natural drainage	Not used for farming	Not needed	Low water-holding capacity; low fertility; high erodibility; steep slopes; difficult to construct in sand.
Poor drainage; tile generally not used; sandy soil requires special investigation and methods; shallow ditches and control of water table generally needed; install during dry periods.	Low water-holding capacity; rapid intake rate; low fertility; rapid permeability; poor natural drainage.	Not needed	Generally not needed.
Not needed; not used for farming	Not used for farming	Not needed	Generally not needed.
Poor drainage; high water table; layers of unstable material require special attention; shallow ditches are needed to remove surface water.	High water-holding capacity; medium to low intake rate; occurs in pockets in places; poor natural drainage.	Not needed	Generally not needed.
Very poor drainage; high water table; unstable organic soil that is subject to subsidence; drainage by pumps and control of water table needed; walls of ditches subject to immediate cave in; special blinding material and intercepter ditches needed.	Very high water-holding capacity; rapid intake rate; low fertility; organic soil; poor natural drainage.	Not needed	Not suited or needed.

TABLE 8.—*Engineering interpretations: Soil features*

Soil series and map symbol [1]	Farm ponds	
	Reservoir area	Embankment
Kalkaska (KaB) (For interpretations of the Wallace soil in this mapping unit, refer to the Wallace series.)	Rapid to very rapid permeability; rapid seepage; too sandy to hold water unless seal blankets used.	Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting and drying.
Kawkawlin (KkA, KkB, KsA, KsB) (For interpretations of the Selkirk soils in mapping units KsA and KsB, refer to the Selkirk series.)	Seasonal high water table; moderately slow permeability; slow seepage.	Fair to good stability and compaction; slow seepage.
Kent (KtE)	Slow to moderately slow permeability; slow seepage.	Slow seepage; fair to poor compaction and stability; high volume change on wetting and drying.
Kerston (Ku)	High water table; variable permeability; rapid seepage; suited to pit-type ponds; flotation of organic material possible.	High water table; unstable organic material.
Lake beaches (La)	Very rapid permeability; very rapid seepage; too porous to hold water.	Rapid seepage; fair to good stability and compaction; subject to piping.
Mancelona (Mapped only with the Chelsea series.)	Moderately rapid to rapid permeability and rapid seepage above a depth of 18 to 42 inches; coarse sand, gravel, or both below; very rapid seepage.	Rapid seepage; fair stability; subject to piping; fair to good compaction.
Marsh (Ma)	Very rapid seepage; submerged during parts of the year; suited to pit-type ponds.	Very high water table; unstable organic material.
Menominee (MeB, MeC) (For interpretations of the Ubly soils in these mapping units, refer to the Ubly series.)	Rapid permeability and rapid seepage above a depth of 18 to 42 inches; slow seepage below; seal blanket required unless sandy material is removed.	Fair stability, rapid seepage, subject to piping above a depth of 18 to 42 inches; fair to good stability and slow seepage below.
Montcalm (MhB) (For interpretations of the Chelsea soil in this mapping unit, refer to the Chelsea series.)	Moderately rapid to rapid permeability; rapid seepage; too porous to hold water unless seal blanket is used.	Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting and drying.
Nester (NeB, NeC, NrC, NsD, NsE, NsE3, NsD3, NtB, NuB). (For interpretations of the Kawkawlin soil in mapping unit NtB and of the Ubly soil in mapping unit NuB, refer to the respective series.)	Moderately slow permeability; slow seepage.	Fair to poor stability and compaction; slow seepage; high volume change on wetting and drying.
Ogemaw (OgB)	Rapid seepage above a depth of 18 to 42 inches; slow or very slow permeability and slow seepage below that depth.	Piping hazard; rapid seepage in sandy material; slow seepage in slightly plastic substratum.
Pickford (Mapped only with the Hettinger series.)	High water table; slow or very slow permeability; slow seepage.	High water table; poor compaction; slow seepage; high volume change on wetting and drying.

See footnote at end of table.

affecting agricultural practices and structures—Continued

Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Not needed; good natural drainage; low fertility.	Very low water-holding capacity; rapid intake rate; low fertility; short, uneven slopes.	Not needed	Short slopes; very sandy soil that has rapid infiltration and low fertility; droughty; vegetation difficult to establish; waterways difficult to construct with a plow.
Somewhat poor drainage; shallow ditches needed for surface drainage, especially where surface is irregular.	High water-holding capacity; slow intake rate; uneven slopes in some places.	Generally not needed	Avoid construction during wet periods.
Drainage generally not needed except in draws or seep spots; soil may warm up earlier if random tile is used.	High water-holding capacity; slow intake rate; moderately slow to very slow permeability; steep uneven slopes.	Short uneven slopes in places; material difficult to work.	Rapid runoff; high erodibility; difficult to work when dry.
Very poor drainage; high water table; unstable organic soil that is subject to subsidence; lack adequate outlets in some places; control of water table needed; walls of ditches subject to cave in; special blinding material required.	Very high water-holding capacity; rapid intake rate; low fertility; organic soil.	Not needed	Generally not needed.
Not used for farming	Not used for farming	Not needed	Not needed.
Not needed; good natural drainage	Low water-holding capacity; rapid intake rate; short, uneven slopes in places.	High erodibility; slow runoff; avoid cuts into substratum below a depth of 18 to 42 inches.	Low fertility; droughty sandy soil; vegetation difficult to establish; high erodibility.
Very poor drainage; material has extreme limitations that require special investigation and methods; some areas have been successfully drained using dikes, pumps, and other practices and used for special crops.	Soil is submerged most of the year; saturated during entire year.	Not needed	Not needed.
Generally not needed; low spots and draws require random tile in some places.	Low water-holding capacity and rapid intake rate to a depth of 18 to 42 inches; slow permeability below that depth; uneven slopes in some places.	Sandy material above a depth of 18 to 42 inches; cuts exposing substratum make construction difficult in places.	Sandy material to a depth of 18 to 42 inches; low fertility; droughty; high erodibility; vegetation difficult to establish.
Not needed; good natural drainage	Low water-holding capacity; rapid intake rate; short, uneven slopes in some places; require frequent applications of water.	Sandy material; uneven slopes in some places.	Not needed.
Not needed; good natural drainage	High water-holding capacity; slow to medium intake rate; steep uneven slopes in some places.	Short, uneven slopes in some areas; subsoil may be difficult to work.	Rapid runoff; subsoil difficult to handle when dry.
Poor to somewhat poor drainage; cemented subsoil; sandy material to a depth of 18 to 42 inches; slow or very slow permeability below; shallow surface ditches are beneficial.	Low water-holding capacity; rapid intake rate above hardpan in subsoil; require frequent but small applications of water.	Not needed	Generally not needed.
Poor drainage; high water table; frequent ponding; slow or very slow permeability; close spacing of tile and special blinding and backfilling material needed; requires surface water removal.	High water-holding capacity; very slow intake rate; slow or very slow permeability; poor natural drainage; pockets in places.	Not needed	Wet fine-textured soil; construct during dry periods.

TABLE 8.—*Engineering interpretations: Soil features*

Soil series and map symbol [1]	Farm ponds	
	Reservoir area	Embankment
Roscommon (Ra) (For interpretations of the Au Gres soil in this mapping unit, refer to the Au Gres series.)	High water table; very rapid permeability; very rapid seepage.	High water table; fair stability and compaction; rapid seepage; subject to piping.
Rousseau (RoB)	Rapid permeability; rapid seepage	Fair to poor stability; moderate seepage; fair to poor compaction; subject to piping.
Rubicon:		
Sand (RsB, RsD)	Very rapid permeability; very rapid seepage; too sandy to hold water unless seal blanket is used.	Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting and drying.
Loamy substratum (RtB, RtC) (For interpretations of the Montcalm soils in these mapping units, refer to the Montcalm series.)	Rapid to very rapid permeability and rapid seepage rate above a depth of 42 to 66 inches; very slow to slow seepage below that depth.	Rapid seepage in sandy material; subject to piping; fair to good stability and slow seepage in substratum.
Saranac (Sa)	Subject to flooding; high water table; moderately slow to slow permeability; slow seepage above a depth of 3 feet; variable seepage below.	High water table; subject to flooding; wetness makes compaction difficult; contains layers subject to piping.
Saugatuck (Mapped only with the Au Gres series.)	Fluctuating high water table; rapid permeability; rapid seepage.	Seasonal high water table; rapid seepage; subject to piping.
Selkirk (Mapped only with the Kawkawlin series.)	Seasonal high water table; very slow to slow permeability; very slow seepage.	Seasonal high water table; high volume change on wetting and drying; slow seepage; plastic materials.
Sims (Sm)	Slow to moderately slow permeability; slow seepage.	High water table; slightly plastic material; slow seepage.
Sloan (So)	High water table; subject to flooding; moderate seepage; contains layers that have rapid seepage.	High water table; fair to good compaction; moderate seepage; subject to piping.
Sparta (Sp)	Very rapid permeability; very rapid seepage; seal blanket required.	Rapid seepage; fair stability and compaction subject to piping; low volume change on wetting and drying.
Tawas (Tc) (For interpretations of the Carlisle soil in this mapping unit, refer to the Carlisle series.)	High water table; rapid seepage; suitable for pit-type pond; flotation of organic material possible.	High water table, unstable organic material to a depth of 18 to 42 inches; sandy substratum below is subject to piping and has rapid seepage.
Tonkey (Td) (For interpretations of the Deford soil in this mapping unit, refer to the Deford series.)	Rapid seepage	High water table; low stability, subject to piping; subject to flooding.

See footnote at end of table.

affecting agricultural practices and structures—Continued

Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Poor drainage; high water table; shallow open ditches and control of water table generally effective; tile requires special investigation and methods; install during dry periods.	Very low water-holding capacity; rapid intake rate; frequent applications of water required.	Not needed	Wet sandy soil; low fertility; rapid infiltration; hazard of water erosion.
Generally not needed; good natural drainage.	Low water-holding capacity; rapid intake rate; frequent applications of water required.	Short slopes; no other limiting features.	High erodibility; low fertility and droughtiness make vegetation difficult to establish in places.
Not needed; good natural drainage	Very low water-holding capacity; very rapid intake rate; uneven relief; very poorly suited to farming.	Not needed	Low fertility; very droughty; high erodibility; sandy material that is difficult to construct with a plow; vegetation difficult to establish.
Not needed; good natural drainage	Very low water-holding capacity; rapid intake rate; slow permeability below a depth of 42 to 66 inches; short, uneven slopes in places.	Sandy material; little runoff.	Sandy material; low fertility; droughty; high erodibility; vegetation hard to establish.
Poor drainage; subject to flooding; high water table; special investigation and methods required; shallow ditches generally needed to remove surface water.	High water-holding capacity; medium to slow intake rate; poor natural drainage; pockets in places.	Not needed	Generally not needed.
Poor to somewhat poor drainage; seasonal high water table; acid sandy material; cemented subsoil; shallow ditches needed for surface drainage.	Very low water-holding capacity; rapid intake rate above the hardpan in subsoil; low fertility; frequent applications of water in small amounts required.	Generally not needed	Wet sandy soil; cemented subsoil; low fertility.
Somewhat poor drainage; seasonal high water table; very slow or slow permeability; surface drainage needed; close spacing of tile and special blinding and backfilling materials needed.	High water-holding capacity; slow intake rate; very slow to slow permeability; pockets in places.	Generally not needed	Rapid runoff; wet fine-textured soil.
Poor drainage; high water table; surface drainage needed.	High water-holding capacity; medium to slow intake rate; poor natural drainage.	Not needed	Wet fine-textured soils.
Poorly drained; subject to flooding; high water table; contains layers of unstable material requiring special investigation and methods; outlet lacking in places.	High water-holding capacity; medium intake rate; poor natural drainage; depressional in places.	Not needed	Generally not needed.
Not needed; good natural drainage	Low water-holding capacity; rapid intake rate; low fertility; frequent applications of water required.	Not needed	Low fertility; droughty; high erodibility; sandy material that is difficult to work with a plow; vegetation difficult to establish.
Very poor drainage; high water table; shallow organic soil that is subject to subsidence over sand at a depth of 18 to 42 inches; shallow open ditches and control of water table are generally better than tile drains.	Very high water-holding capacity; rapid intake rate; poor natural drainage; organic soil.	Not needed	Not needed.
Poor drainage; high water table; rapid seepage; contains layers of unstable soil; requires special investigation and methods and special blinding; walls of ditches subject to cave in; install during dry periods.	Medium water-holding capacity; medium intake rate; poor natural drainage.	Generally not needed	Wet soil.

TABLE 8.—*Engineering interpretations: Soil features*

Soil series and map symbol [1]	Farm ponds	
	Reservoir area	Embankment
Ubly (Mapped only in complexes with the Belding, Menominee, and Nester series.)	Moderate to moderately slow permeability and seepage above a depth of 18 to 42 inches; slow seepage below.	Fair stability and compaction in subsoil; fair to good stability and compaction and slow seepage in substratum.
Wallace (Mapped only with the Kalkaska series.)	Very rapid permeability; very rapid seepage.	Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting and drying.
Warners (Wa)	High water table; moderate permeability; slow seepage.	High water table; slow seepage; unstable organic material and marl.
Wind eroded land (We)	Very rapid seepage; very sandy material; rapid or very rapid permeability.	Rapid seepage; rapid or very rapid permeability; subject to piping, fair stability.

[1] Soil features were not listed for Blown-out land (BoB, BoE).

graphs. The explanations are taken largely from the PCA Soil Primer (*6*).

AASHO classification system.—The AASHO system is based on the performance of soil material in the field. The soil material is classified on the basis of gradation, liquid limit, and plasticity index into seven principal groups. The groups range from A–1 consisting of gravelly soils that have high bearing strength and are the best soils for subgrade, to A–7, consisting of clayey soils that have low strength when wet and are the poorest soils for subgrade. Within each of the principal groups, the relative engineering value of the soil material is indicated by the group index. Group indexes range from 0 for the best material to 20 for the poorest material. For the soils tested, the group indexes are shown in table 5 following the soil group symbol. The estimated AASHO classification of the soils in the county, without group indexes, is given in table 6.

Unified classification system.—Some engineers prefer to use the Unified system. In this system soils 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, SC), fine grained (ML, CL, OL, MH, CH, OH), and highly organic (Pt). The tested soils are classified according to the Unified system in table 5. The classification for the soils that were not tested is estimated in table 6.

Engineering test data

Engineering test data for four series sampled from nine locations in Muskegon County are given in table 5. These data were obtained from tests performed in accordance with the standard procedures of the American Association of State Highway Officials, in the laboratories of the Bureau of Public Roads.

The soil samples represented in table 5 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 of those properties within the four 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 plastic limit. The mechanical analyses were made by the combined sieve and hydrometer methods. 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" (*9*).

The tests for liquid limit and 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 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

affecting agricultural practices and structures—Continued

Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Not needed; good drainage	Medium water-holding capacity; medium intake rate; moderate to moderately slow permeability below a depth of 18 to 42 inches; slopes are uneven in places; side slopes develop seep spots in places.	Short uneven slopes in many places; no other limitation.	High erodibility.
Not needed; good natural drainage; not used for farming.	Not used for farming	Not needed	High erodibility; low fertility; droughty; cemented subsoil; vegetation difficult to establish.
Very poor drainage; contains marl, tile not generally effective; shallow open ditches and control of water table most effective.	High water-holding capacity; generally wet; medium intake rate; very slow permeability below surface layer.	Not needed	Not needed.
Not used for farming	Not used for farming	Not needed	High erodibility; sandy material that is hard to work with a plow; vegetation difficult to establish.

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 of soils

Table 6 gives estimated physical and chemical data for each soil series. Following the series name are the symbols for all the soils within that series. Since many of the soils are mapped as complexes and undifferentiated units, their symbols are placed under more than one series. Following the first listing of a symbol for a complex or undifferentiated unit is a reference to the series to which the associated soil belongs.

The estimates in this table are based on the actual test data in table 5, on a comparison of the untested soils with those that were sampled and tested, and on experience gained from working with and observing similar soils in other areas.

In general, the information in table 6 applies to a depth of 5 feet or less. Depth from the surface is normally given only for the major horizons, but other horizons are listed if they have engineering properties significantly different from adjacent horizons.

Also given in table 6 are the textural classification of the U.S. Department of Agriculture, estimates of the Unified classification, and estimates of the classification used by the American Association of State Highway Officials. The figures showing the percentages of material passing through sieves Nos. 4, 10, and 200 are rounded off to the nearest 5 percent. The percentage of material 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 approximate amount of capillary water in a soil when wet to field capacity. When the soil is at the wilting point of common crops, this amount of water will wet the soil to a depth of 1 inch without deeper penetration.

Reaction as shown in table 6 is the estimated range in pH values for each major horizon of the 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 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.

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, road fill, and impermeable material and lists features that affect the use of soils in highways, winter grading, and foundations for low buildings. Also given in table 7 are ratings for the corrosive potential for conduits.

The ratings for suitability as a source of topsoil were based largely on texture and content of organic matter.

Topsoil is material, preferably material 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 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 have sand and gravel at a depth of 5 feet or more. In these places the availability of the sand and gravel can be determined by digging test pits.

Ratings of the suitability of the soil for 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; the least suitable is clay.

In table 7 the ratings of suitability of the soils as a source of impermeable material are based on the permeability of soil material when compacted. Permeability affects uses of soil material as linings for reservoirs and sewage lagoons and as fill for embankments.

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. 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" (*4*).

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 features are texture, natural content of water, and depth to water table.

The features named as affecting the foundations of low buildings (not more than three stories) are those of the substratum because the substratum is generally the base of foundations. Important features are susceptibility to frost heaving, bearing capacity, and shrink-swell potential. Engineers and others should not apply specific values to the estimates given for bearing capacity of soils.

In the last column of table 7, the soils are rated according to the degree that they encourage the corrosion of conduits laid in them. Ratings are given for metal 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.

In table 8 are listed features that affect the use of soils for farm ponds, agricultural drainage, irrigation, terraces and diversions, and grassed waterways.

The seepage rate of undisturbed soil material is the most important feature affecting the reservoir area of a farm pond (fig. 9). Features affecting embankments are compaction properties, stability, permeability, seepage, and the piping hazard.

Tested under agricultural drainage are features that affect the installation and performance of surface and subsurface drainage systems. Such features are texture, permeability, topography, restricting layers, and depth to water table.

The major features affecting suitability for irrigation are water-holding capacity and rate of water intake. Also important are depth to the water table, topography, and depth to soil material that restricts root growth.

Important features that affect the layout and construction of terraces and diversions are topography, texture of the soil material, and depth to material that restricts root growth.

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, water-holding capacity, and susceptibility to erosion.

Use of Soils in Community Developments [5]

The information in this subsection can be useful to many groups in the community, including planners, developers, builders, contractors, real estate brokers, engineers, public health officials, and school boards. If the soil map at the back of the survey is properly interpreted, it is helpful in locating soils suitable for residential and industrial areas; streets, highways, and material for road building; parks and other recreational areas; schools; cemeteries; and other uses.

Additional information helpful in developing communities is also provided in the subsection "Engineering Uses of the Soils." In that subsection are listed soil features that affect the suitability of soils for foundations, highways, road fill, winter grading, and artificial drainage. The engineering subsection differs from this subsection on community development mainly in that it lists the soil features affecting engineering. This subsection rates the degree of soil limitations for specified uses in community development.

The selection of areas for community development depends on the suitability of soils as sites for the structures and other facilities that are to be built. In table 9 the limitations of groups of soils used for specified purposes in community development are rated, and soil features that affect these uses are given. Listed for each group are the map symbols for the soils in the group.

The limitations of each group of soils are rated slight, moderate, severe, or very severe. A rating of *slight* means that the soil has few or no limitations for the use specified or that the limitations can be easily overcome. A rating of *moderate* indicates that some planning and engineering practices are needed to overcome the limitations. A rating of *severe* indicates that the soil is poorly suited to the use specified and that intensive engineering practices are needed to overcome the limitations. A rating of *very severe* indicates that the soil is very poorly suited to the use specified and that practices to overcome the limitations may not be economically feasible. These ratings apply to a depth of 5 feet or less.

The ratings in table 9 are for residential developments with public sewers, filter fields for septic tanks, buildings for commerce and light industry, and trafficways. Some explanation is required.

Residential developments with public sewers.—The ratings in this column of table 9 apply to residences of

[5] By BRUCE G. WATSON, soil scientist, Soil Conservation Service.

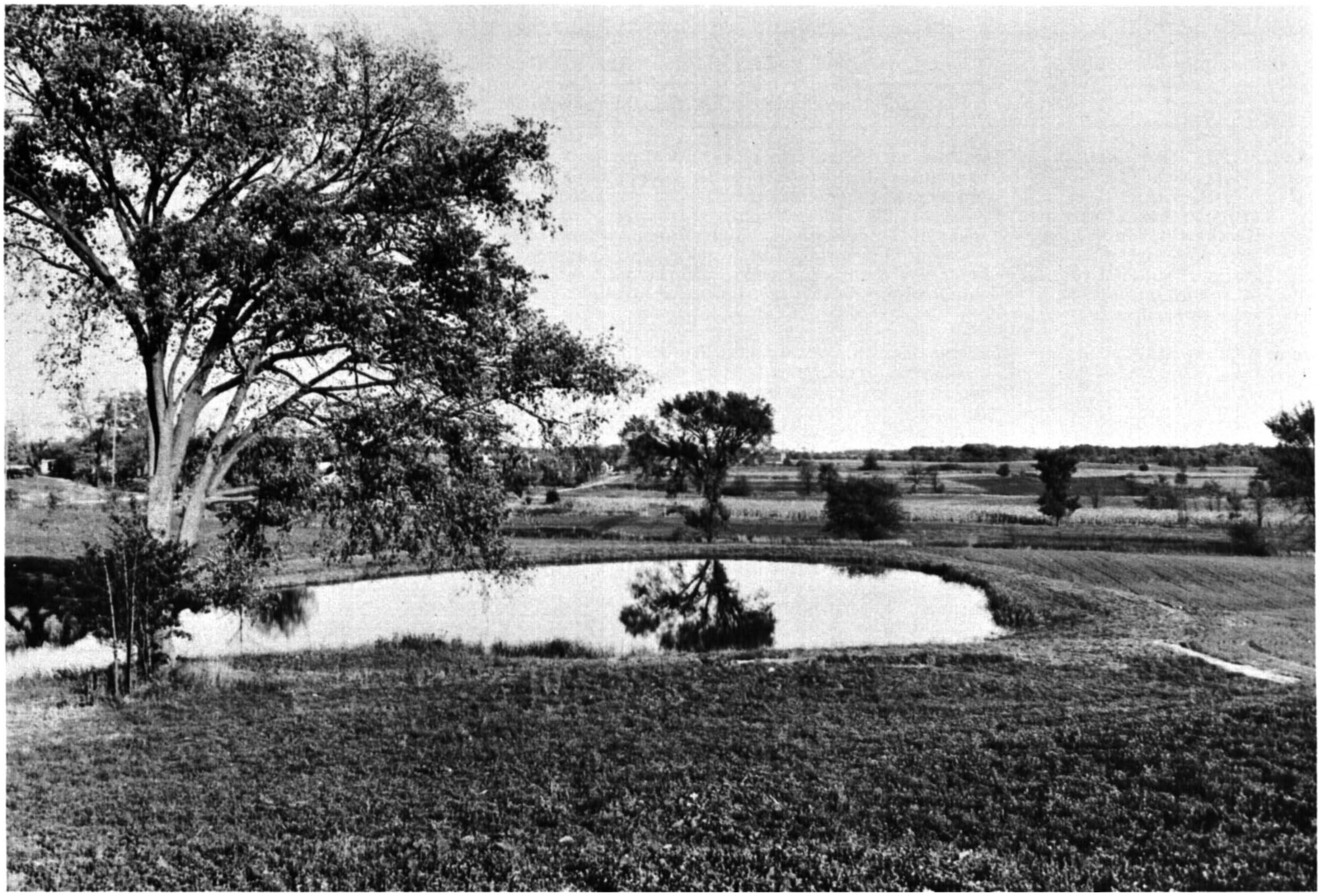

***Figure 9.*—A farm pond constructed on Nester soils.**

three stories or less that have basements and are served by a public sewerage system. The major properties important in evaluating the soils for this use are wetness, hazard of flooding, slope, volume change on wetting and drying, hazard of erosion, suitability for growing lawns and shrubs, and bearing capacity. Engineers and others should not apply specific values to the estimates for bearing capacity of soils.

Filter fields for septic tanks.—Important properties that affect the use of soils for filter fields for septic tanks are depth to the water table, hazard of flooding, slope, and permeability, or rate of percolation.

Buildings for commerce and light industry.—The ratings in this column apply to stores, offices, and small factories that are not more than three stories high and that have public or community facilities for sewage disposal. Important soil features are wetness, slope, hazard of erosion, volume change on wetting and drying, and bearing capacity. Specific values should not be applied to the estimates given for bearing capacity.

Trafficways.—The ratings in this column apply to streets and highways within or adjacent to residential and industrial developments. Features considered in rating the soils are frost heaving, ease of excavating and grading, seepage, and slope.

Limitations to use of soils in community developments

Community developments on the Hettinger, Roscommon, and similar soils are limited mainly by poor drainage and a high water table. In these soils basements are difficult to keep dry, and disposal fields for septic tanks do not function well. Fills are needed for raising the grade of streets and highways above the water table.

Soils that have a high content of clay, such as the Kent, Selkirk, and Pickford, shrink and swell excessively on wetting and drying. Foundations in these soils are likely to crack and shift. Streets and highways are subject to frost heaving, and they crack readily. Disposal fields for septic tanks become saturated because percolation is slow. Construction of any kind is difficult on these soils when they are wet.

Strongly sloping and steep soils are subject to severe erosion where intensive construction is attempted. For example, steep areas of the Nester, Ubly, and Montcalm soils erode readily. Gullies form readily and are difficult to control. Soil blowing is likely in areas of Rubicon, Rousseau, and other sandy soils.

TABLE 9.—*Limitations of soils for residential and*

Community development groups	Degree of limitation and soil features affecting use for—	
	Residential developments [1] with public sewers	Filter fields for septic tanks
Group 1 (KtE, NeB, NeC, NrC, NsD, NsD3, NsE, NsE3, NtB, NuB). (For limitations of the Kawkawlin soil in mapping unit NtB, refer to group 4; and of Ubly soil in mapping unit NuB, refer to group 2.)	Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; and severe on slopes of 12 to 45 percent. Features: Wet depressions on slopes of 0 to 6 percent; moderate to high volume change on wetting and drying; fair to poor bearing capacity; severe erosion on steeper slopes; steeper slopes hinder construction and layout of utilities.	Limitation: Severe. Features: Moderately slow to slow permeability; layout and construction is difficult on slopes over 10 percent.
Group 2 (BbB, MeB, MeC, NuB).	Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; and severe on slopes of 12 to 25 percent. Features: Moderate to high volume change on wetting and drying; fair to poor bearing capacity; severe erosion on steeper slopes; steep slopes hinder layout and construction of utilities; small wet depressions on slopes of 0 to 6 percent.	Limitations: Severe. Features: Moderately slow permeability in loamy substratum; layout and construction is difficult on slopes over 10 percent; effluent seeps out on side slopes; areas where the sandy material is 42 inches deep or more are only moderately limited.
Group 3 (BoB, BoE, CmB, CmC, CnD CnE, CrB, DpE, Du, GrC, GrD, GrE, KaB, La, MhB, RoB, RsB, RsD, RtB, RtC, Sp, We). (For limitations of the Au Gres soil in mapping unit CrB, refer to group 6.)	Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; and severe on slopes of 12 to 45 percent. Features: Susceptibility to wind erosion; droughty; difficult to establish and maintain lawns; frequent watering required; stable material for roadbeds and foundations; steep slopes hinder layout and construction of utilities.	Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; severe on slopes of 12 to 45 percent slopes. Features: Favorable percolation rate; possible contamination of nearby water supplies.
Group 4 (KkA, KkB, KsA, KsB, NtB).	Limitation: Severe. Features: Seasonal high water table; subject to ponding; fair to poor material for foundations; moderate to high volume change on wetting and drying; fair to poor bearing capacity; poor for roadbeds; subject to frost heaving; construction difficult when wet.	Limitation: Severe. Features: Seasonal high water table; subject to ponding; moderately slow to slow permeability.
Group 5 (BaB, OgB)	Limitation: Severe. Features: Seasonal high water table; subject to ponding; fair to poor material for foundations; moderate to high volume change; fair to poor bearing capacity in substratum.	Limitation: Severe. Features: Seasonal high water table; moderately slow permeability; subject to ponding.
Group 6 (AsB, CrB, Ra) (For limitations of the Roscommon soil in mapping unit Ra, refer to group 9.)	Limitation: Moderate. Features: Seasonal high water table; difficult to obtain dry basements; areas subject to ponding are severely limited; good material for foundations; low volume change; fair to good bearing capacity.	Limitation: Severe. Features: High water table; subject to ponding.
Group 7 (Hp, Sa, Sm)	Limitation: Severe. Features: High water table; subject to ponding; difficult to obtain dry basements; moderately to severely limited for foundations; moderate to high volume change; fair to poor bearing capacity.	Limitation: Severe. Features: High water table; moderately slow to slow permeability; subject to ponding.
Group 8 (Ds, So, Td)	Limitation: Severe. Features: High water table; subject to ponding; moderately limited for foundations; poor bearing capacity when wet; difficult to obtain dry basements; subject to frost heaving.	Limitation: Severe. Features: High water table; inoperative during wet periods.

See footnote at end of table.

industrial development, and related nonfarm uses

Degree of limitation and soil features affecting use for—Continued	
Buildings for commerce and light industry [2]	Trafficways
Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; and severe on slopes of 12 to 45 percent. Features: Wet depressions on slopes of 0 to 6 percent; moderately to severely limited for foundations; moderate to high volume change; fair to poor bearing capacity; severe erosion on steeper slopes; grading and land shaping required in sloping and steep areas.	Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; and severe on slopes of 12 to 45 percent. Features: Fair to poor bearing capacity; subject to frost heaving; seep spots in some areas; cuts and fills needed in sloping to steep areas; sloping areas subject to erosion.
Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; and severe on slopes of 12 to 25 percent. Features: Wet depressions on slopes of 0 to 6 percent; moderately limited for foundations; moderate to high volume change; fair to poor bearing capacity; severe erosion on steeper slopes; grading and land shaping required in sloping and steep areas.	Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; and severe on slopes of 12 to 25 percent. Features: Substratum has fair to poor bearing capacity and is subject to frost heaving; seep spots in some areas; cuts and fills needed in sloping to steep areas; severe erosion in steeper areas.
Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; and severe on slopes of 12 to 45 percent. Features: Susceptibility to wind erosion; good foundation material; low volume change; good bearing capacity; grading and land shaping required in sloping and steep areas.	Limitations: Slight on slopes of 0 to 6 percent; moderate on slopes of 6 to 12 percent; and severe on slopes of 12 to 45 percent. Features: Good bearing capacity; good material for subbase and subgrade; cuts and fills needed in sloping to steep areas; severe erosion in steeper areas.
Limitation: Moderate. Features: Seasonal high water table; fair to poor material for foundations; moderate to high volume change; fair to poor bearing capacity; subject to frost heaving; construction difficult when wet; minimum of cuts and fills needed.	Limitation: Severe. Features: Seasonal high water table; fair to poor bearing capacity; poor material for subgrade; subject to frost heaving; fill required in some areas to raise grade above water table; excavating and grading are severely limited during winter and wet periods.
Limitation: Moderate. Features: Seasonal high water table; fair to poor material for foundations; moderate to high volume change; fair to poor bearing capacity in substratum; minimum of cuts and fills needed.	Limitation: Moderate. Features: Seasonal high water table; material above 18 to 42 inches has good bearing capacity and is only slightly limited for subgrade; substratum is of severely limited use for subgrade; fill required in some areas to raise grade above water table.
Limitation: Moderate. Features: Seasonal high water table; good material for foundations; low volume change; fair to good bearing capacity; minimum of cuts and fills required.	Limitation: Moderate. Features: Seasonal high water table; fair to good bearing capacity; good material for subgrade; fill required in low areas to raise grade above water table; sandy material is unstable and flows when wet.
Limitation: Severe. Features: High water table; subject to ponding; moderately to severely limited for foundations; moderate to high volume change; fair to poor bearing capacity; minimum of land shaping and grading; fill required to raise grade above water table; poor for excavating and grading during winter and wet periods.	Limitation: Severe. Features: High water table; subject to ponding and flooding; wetness hinders construction; subject to frost heaving; fair to poor bearing capacity; poorly adapted for subgrade; fill needed to raise grade above water table; poor for excavating and grading during winter and wet periods.
Limitation: Severe. Features: High water table; subject to ponding; moderately limited for foundations; poor bearing capacity when wet; subject to frost heaving; fill required to raise grade above water table; poor for excavating and grading during winter and wet periods.	Limitation: Severe. Features: High water table; subject to ponding; subject to frost heaving; material is unstable and flows when wet; fill needed to raise grade above water table; construction and grading difficult during winter and wet periods.

TABLE 9.—*Limitations of soils for residential and industrial*

Community development groups	Degree of limitation and soil features affecting use for—	
	Residential developments [1] with public sewers	Filter fields for septic tanks
Group 9 (Ga, Ra)	Limitation: Severe. Features: High water table; subject to ponding; slight limitations for foundations; but dry basements difficult to obtain.	Limitation: Severe. Features: High water table; inoperative during wet periods.
Group 10 (Ht, Ku, Ma, Tc, Wa).	Limitation: Very severe. Features: High water table; unstable organic material with low bearing capacity and high compressibility; severely limited for foundations; organic material must be removed before construction; subject to ponding and flooding.	Limitation: Very severe. Features: High water table; unstable organic material.

[1] Based on lots of 1 acre or less.

The Rubicon, Deer Park, Grayling, Wallace, and other sandy soils are well suited as sites for buildings, streets, and highways, but nearby water supplies may be contaminated if these soils are used for septic tank disposal fields. On these sandy soils lawns are difficult to establish, and they require frequent applications of water and fertilizer after they are established. During construction, soil blowing and water erosion are hazards in sloping areas.

The organic soils, Carlisle and Houghton, have a high water table and are subject to ponding. The organic material does not support buildings, roads, or other structures. It has a low bearing capacity and shrinks greatly when it is compressed. All organic material must be removed before construction.

The Saranac, Sloan, and Kerston soils are subject to flooding and have severe limitations for use in community developments unless they are protected from this hazard. These soils are suited to recreational or other uses that are not affected by flooding.

Formation and Classification of Soils [6]

This section tells how the factors of soil formation have affected the development of soils in Muskegon County. It also defines the classes in the current system of classification and, in a table, places each soil series of the county in its family, subgroup, and order of that system, and in its great soil group of the older system. More information about the soils, as well as a profile representative of each soil series, is given in the section "Descriptions of the Soils."

Factors of Soil Formation

Soil is formed by weathering and other processes that act on parent material. The characteristics of the soil at any given point depend on (1) parent material, (2) climate, (3) plant and animal life, (4) relief and drainage, and (5) time, or age.

The factors of soil formation are so closely interrelated in their effects that few generalizations can be made about one factor unless conditions are specified for the other four factors. Each factor and its effect on the formation of the soils in this county are discussed in the following paragraphs.

Parent material.—The parent material of the soils in Muskegon County is largely of glacial origin because the county was covered by ice during the late Wisconsin age. This glacial material consisted of boulders, stones, gravel, sand, silt, and clay. Because these deposits were several feet thick, the underlying bedrock did not directly affect the development of soils.

As the glacial ice melted, large flows of melt water carved out valleys and deposited fairly uniformly sorted material in basins or along drainageways. Today this material is in the form of outwash plains and terraces, valley trains, and old lakebed plains. The lake or lakes from which Lake Michigan formed were larger than the present lake and covered an extensive area in the western part of the State. After the water receded to the present level of Lake Michigan, a large lake plain made up of stratified material was exposed. This plain was altered by intensive geologic erosion by wind and water and by the subsequent deposition of eroded materials. Erosion continued until protective vegetation stabilized the land surface. The upper 5 feet of the stabilized glacial material, in which some of the soils formed, is uniform in texture and differs mainly in mineral composition.

In places other than the lake plain, the soils developed in a highly heterogeneous mixture of varying proportions of gravel, sand, silt, and clay. This mixture ranged from strongly acid to neutral or was calcareous. These widely different mixtures occur as strata of varying thickness, as small separate bodies, as long narrow strips, or in areas of the broad outwash plains where fairly uniform layers are stratified. Because the glacial deposits and the relief vary widely, many different kinds of soils occur within relatively short distances.

Climate.—The soils of Muskegon County formed in a cool, moist climate that was influenced by Lake Michigan. Winters are long and cool, and summers are warm. The average annual precipitation is about 29 inches. Precipitation falls in about equal amounts in each season, but slightly more in summer. Areas adjacent to Lake Michi-

[6] By O. C. ROGERS, soil correlator, Soil Conservation Service.

development, and related nonfarm uses—Continued

Degree of limitation and soil features affecting use for—Continued	
Buildings for commerce and light industry [2]	Trafficways
Limitation: Severe. Features: High water table; subject to ponding; slightly limited for foundations; low volume change; fair to good bearing capacity; fills required to obtain grade levels above the water table; material easily excavated.	Limitation: Severe. Features: High water table; subject to ponding; unstable material flows when wet; fill needed to raise grade above water table; construction and grading difficult during winter and wet periods.
Limitation: Very severe. Features: High water table; subject to flooding and ponding; very severely limited for foundations; low bearing capacity and high compressibility; unstable organic material that must be excavated before fill is placed; fill required to raise grade above water table.	Limitation: Very severe. Features: High water table; unstable organic material that must be removed before fill is placed; low bearing capacity and high compressibility; fill required to raise grade above water table.

[2] Ratings are for buildings of three stories or less.

gan and eastward for a few miles receive somewhat more precipitation, especially snowfall, than other parts of the county. These differences, however, are slight and have not caused significant differences among the soils.

Plant and animal life.—The native vegetation in this county, as elsewhere, was affected by the nature of the soil, and the soil, in turn, was influenced by the vegetation it supported. The characteristics of the organic matter in the surface layers are directly related to the vegetation. The kind of vegetation affected not only the nature of the organic matter that accumulated on the surface, but also the depth and color of the leached mineral layer directly beneath the organic matter.

Except for areas of marsh and small areas of tall prairie grasses, Muskegon County was originally covered by forest. Dense stands of northern hardwoods and some conifers grew on the more fertile, moderately fine textured to moderately coarse textured, well-drained soils. Mixed hardwoods and white pine grew on the moderately coarse textured to coarse textured, well-drained soils. Some of the coarse-textured, well-drained soils supported pine and oak.

Relief and drainage.—Natural drainage is largely determined by relief, or the irregularities of the land surface. In different relief, and therefore under different conditions of drainage, different kinds of mineral soils formed from the same kind of parent material. Organic soils, the peats and mucks, formed in low-lying, poorly drained areas. In these areas more than a foot of organic material has accumulated over the mineral material.

Time, or age.—After the glaciers melted, the processes of soil formation began to alter the glacial material, and at the same time the material was reworked by streams and lakes. As a result, many different kinds of soils developed in the county. In some of the mineral soils, well-defined horizons have formed, but in recent lake deposits, eolian deposits, or alluvium, the soils are weakly developed and are much like the material from which they formed. In very poorly drained areas, organic soils formed and have a thick accumulation of organic material over mineral material.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationships to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First, through classification and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys, so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*3*) and later revised (*8*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study. Therefore, readers interested in developments of this system should search the latest literature available (*7*, *10*). The soil series of Muskegon County are placed in the current system in table 10. The classes in the current system are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized in the current system. 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. Two exceptions, Entisols and Histosols, occur in many different climates. The soil orders represented in Muskegon County are Alfisols, Entisols, Inceptisols, Histosols, Mollisols, and Spodosols.

SUBORDER: Each order is subdivided into suborders, primarily on the basis of those soil characteristics that seem to produce classes having the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to sepa-

279-229 O - 68 - 7

TABLE 10.—*Classification of soil series according to the current system and 1938 system*

Series	Current system [1]			1938 system
	Family	Subgroup	Order	Great soil group
Allendale	Sandy over clayey, mixed, frigid.	Aqualfic Haplorthods	Spodosols	Podzols.
Au Gres	Sandy, mixed, frigid	Entic Haplaquods	Spodosols	Podzols.
Belding	Coarse, loamy, mixed, frigid	Alfic Haplaquods	Spodosols	Podzols intergrading toward Gray-Wooded soils.
Carlisle [2]			Histosols	Bog (Organic) soils.
Chelsea [3]	Sandy, mixed, mesic	Alfic Udipsamments	Entisols	Gray-Brown Podzolic intergrading toward Regosols.
Croswell	Sandy, mixed, frigid	Entis Haplorthods	Spodosols	Podzols.
Deer Park	Sandy, mixed, frigid	Spodic Udipsamments	Entisols	Brown Podzolic soils.
Deford	Sandy, mixed, frigid	Typic Psammaquents	Entisols	Humic Gley soils.
Granby	Sandy, mixed, noncalcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Grayling	Sandy, mixed, frigid	Typic Udipsamments	Entisols	Brown Podzolic soils.
Hettinger	Fine-loamy, mixed, nonacid, frigid.	Mollic Haplaquepts	Inceptisols	Humic Gley soils.
Houghton [2]			Histosols	Bog (Organic) soils.
Kalkaska	Sandy, mixed, frigid	Typic Haplorthods	Spodosols	Podzols.
Kawkawlin	Fine, mixed, frigid	Aquic Eutroboralfs	Alfisols	Gray Wooded soils.
Kent	Fine, illitic, frigid	Typic Eutroboralfs	Alfisols	Gray Wooded soils.
Kerston [2]			Histosols	Alluvial soils intergrading toward Bog (Organic) soils.
Mancelona	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols	Podzols.
Menominee	Sandy over loamy, mixed, frigid.	Alfic Haplorthods	Spodosols	Podzols.
Montcalm	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols	Podzol sequum over Gray Wooded sequum.
Nester	Fine, mixed, frigid	Typic Eutroboralfs	Alfisols	Gray Wooded soils.
Ogemaw	Sandy over loamy, mixed, frigid, ortstein.	Aquic Haplorthods	Spodosols	Ground Water Podzols.
Pickford	Very-fine, illitic, nonacid, frigid	Aeric Haplaquepts	Inceptisols	Humic Gley soils.
Roscommon	Sandy, mixed, frigid	Mollic Psammaquents	Entisols	Low-Humic Gley soils.
Rousseau	Sandy, mixed, frigid	Entic Haplorthods	Spodosols	Podzols.
Rubicon [3]	Sandy, mixed, frigid	Entic Haplorthods	Spodosols	Podzols.
Saugatuck	Sandy, mixed, mesic, ortstein	Aeric Haplaquods	Spodosols	Ground Water Podzols.
Saranac [3]	Fine, mixed, noncalcareous, mesic.	Fluventic Haplaquolls	Mollisols	Humic Gley intergrading toward Alluvial soils.
Selkirk	Fine, illitic, frigid	Aquic Eutroboralfs	Alfisols	Gray Wooded soils.
Sims	Fine, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols	Humic Gley soils.
Sloan [3]	Fine-loamy, mixed, noncalcareous, mesic.	Fluventic Haplaquolls	Mollisols	Alluvial soils.
Sparta	Sandy, mixed, mesic	Entic Hapludolls	Mollisols	Brunizems intergrading toward Brown Podzolic soils.
Tawas [2]			Histosols	Bog (Organic) soils.
Tonkey	Coarse-loamy, mixed, nonacid, frigid.	Mollic Haplaquepts	Inceptisols	Humic Gley soils.
Ubly	Coarse-loamy, mixed, frigid	Alfic Haplorthods	Spodosols	Podzol sequum over Gray Wooded sequum.
Wallace	Sandy, mixed, frigid, ortstein	Typic Haplorthods	Spodosols	Podzols.
Warners	Loamy-carbonatic, calcareous, mesic.	Histic Humaquepts	Inceptisols	Regosols.

[1] Placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

[2] Development of families and subgroups, within the order of Histosols has not been completed.

[3] In material published by the Michigan Agricultural Experiment Station, the loamy substratum phase of the Rubicon series is listed as part of the Melita series. Also, Chelsea is shown as Graycalm, Saranac as Gormer, and Sloan as Pinora.

rate suborders mainly reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUP: Soil suborders are separated into great groups on basis of uniformity in the kinds of major soil horizons in sequence of these horizons, and in characteristics these horizons possess. The horizons used to make separations into great groups are those in which clay, iron, or humus have accumulated or those that have pans interferring with growth of roots or movement of water. Among the characteristics considered are the self-mulching properties of clays, soil temperature, and major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium). The great group is not shown separately in table 10, because it is the last word in the name of the subgroup.

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

SERIES: As explained in the section "How This Survey Was Made", 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 arrangement in the profile. New soil series must be established and concepts of some established series, especially older ones that have been used little in recent years, must be revised in the course of the soil survey program across the country. A proposed new series has tentative status until review of the series concept at State, regional, and national levels of responsibility for soil classification results in a judgment that new series should be established. Most of the soil series described in this publication have been established earlier.

General Nature of the County

In this section the climate, physiography and drainage, water supply, settlement and population, and industry and transportation are discussed. Also discussed are the more outstanding features of agriculture. The statistics given are from reports published by the U.S. Bureau of the Census and the U.S. Weather Bureau.

Climate

Muskegon County has a quasimarine or continental climate. Because the county borders Lake Michigan and prevailing winds are westerly, much of the time the air reaching the county has passed over a large amount of water. When the wind changes, however, and is from the southeast or east, the air moves over a large amount of land and the climate changes to continental. Because of the prevailing westerlies, the influence of the lake is strong. Winters are milder, summers are cooler, and snowfall is greater than they would be if the lake were not there.

In spring the waters from Lake Michigan cool the warm air that reaches the area. Growth of plants is therefore delayed until frost is no longer likely. In fall the lake waters, still warm from the summer sun, warm the cool air moving into the area and delay the first frost. Plants therefore have time to mature. Sharp contrasts in temperature occur as the air is warmed by contact with the warm water. This causes heavy snow storms and squalls that are of greatest intensity near the lake.

Table 11 gives data on temperature and precipitation at Muskegon, near Lake Michigan, in the western part of the county and at Grand Rapids in Kent County. Grand Rapids is used for comparison because there is no weather station in the eastern part of Muskegon County and because the climate at Grand Rapids is considered representative of the eastern part of Muskegon.

[7] DONALD HEARL, director of the Muskegon Cooperative Extension Service, assisted in writing this section.

The highest temperature ever recorded at Muskegon was 97° in June 1953, and the lowest was −14° in November 1950. At Grand Rapids, the highest temperature of record was 102° in June 1953, and the lowest was −22° in January 1951.

The influence of Lake Michigan on temperature is shown by the higher maximum and minimum temperatures in January at Muskegon, as compared to those at Grand Rapids. Also, temperatures in April and May are lower at Muskegon. The latest freezing temperature ever recorded at Muskegon was on May 20, and that at Grand Rapids was on May 27. In fall the average date of the first 32° temperature is October 19 at Muskegon and October 6 at Grand Rapids. The probabilities of the last freezing temperature in spring and the first in fall at Muskegon and Grand Rapids are given in table 12.

Average annual snowfall in Muskegon County is 74 inches, as compared to about 40 inches in central and east-central parts of the Lower Peninsula. This heavy snowfall is a direct result of the influence of Lake Michigan.

The moderating influence of Lake Michigan has a pronounced effect on farming in the county. Because spring days are cooler near the lake, the dormancy of fruit trees is not broken early in spring and the buds do not open until the danger of frost is past. Frost does not occur so early in fall near the lake as it does farther inland. The nearness to Lake Michigan makes the soils in this county suitable for fruit trees and other special crops. Also, the longer growing season near Lake Michigan favors the growing of other crops. Corn grown for grain is more likely to mature before the first frost in fall.

After snow melts in spring, most soils are near saturation. Subsequent rainfall often delays planting, especially on soils that are somewhat poorly drained or poorly drained and that have inadequate artificial drainage. Late in spring and early in summer, rainfall on sloping cultivated soils that are saturated or near saturation causes severe erosion unless the soils are well protected.

In fall, moisture is generally favorable for preparation of the seedbed and germination of seeds. The cool weather during the bloom stage promotes good yields of oats. This cool, moist growing season also favors hay and pasture, yields of which are commonly good if the soils are not too wet, sandy, or steep, and are well fertilized. For several days a year the wind is strong enough to cause soil blowing on mucky and sandy soils that are left unprotected.

Physiography and Drainage

The physiography of Muskegon County, for the most part, results from the Wisconsin, or latest, glacial period. The glacial ice that once covered the State melted about 8 to 12 thousand years ago. As this ice melted, a covering of raw soil material was left on the surface of the county. This glacial deposit ranges from about 150 feet to more than 400 feet in thickness.

The present surface of the county ranges from nearly level to rolling and hilly. Along the shore of Lake Michigan is a belt of strongly rolling sand dunes. These dunes are postglacial in origin but are now generally stationary. After vegetation covers these dunes, a soil profile begins to develop. For several miles inland, smaller dunes are scattered throughout the poorly drained areas of the lake plain.

TABLE 11.—*Temperature and precipitation data at Muskegon in Muskegon County and at Grand Rapids in Kent County, Michigan*

Month	Temperature [1]				Precipitation [2]				
	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
MUSKEGON, MUSKEGON COUNTY									
January	32.3	19.7	42	2	2.24	1.2	3.4	24	7.1
February	32.6	18.7	43	3	1.78	.8	2.7	22	8.6
March	40.5	25.2	58	10	2.37	1.3	3.3	12	4.7
April	54.8	35.6	73	24	3.01	1.1	4.4	(3)	1.4
May	66.3	45.3	80	34	2.90	1.2	4.5	0	----------
June	77.7	55.7	88	43	2.70	1.1	4.3	0	----------
July	81.9	60.6	89	49	2.50	1.0	4.2	0	----------
August	80.7	59.8	89	47	2.74	1.4	4.2	0	----------
September	72.5	53.4	85	37	3.14	1.2	5.9	0	----------
October	61.4	43.6	75	30	2.51	.5	5.2	0	----------
November	46.3	32.9	61	20	3.03	1.4	4.3	5	2.8
December	36.0	23.8	49	8	2.30	1.3	3.9	17	5.9
Year	56.9	39.5	-------------	-------------	31.22	------	------	80	----------
GRAND RAPIDS, KENT COUNTY [4]									
January	31.5	17.3	44	1	2.03	1.2	3.5	22	12.4
February	32.4	16.6	45	1	1.67	.6	2.6	20	6.6
March	40.9	23.9	59	10	2.44	1.1	3.5	10	4.5
April	56.2	35.2	76	24	3.64	2.4	4.9	1	2.5
May	68.3	45.7	84	34	2.87	1.3	5.1	0	----------
June	78.6	56.2	90	45	3.03	1.1	5.5	0	----------
July	83.6	60.1	91	50	3.08	1.3	5.3	0	----------
August	82.1	58.9	92	48	2.61	1.1	4.4	0	----------
September	73.4	50.9	89	38	2.84	.9	4.7	0	----------
October	61.9	40.4	79	29	2.35	.4	5.6	(3)	2.0
November	45.8	30.5	64	17	2.37	1.1	3.7	5	2.8
December	34.5	21.4	51	3	1.88	1.2	3.0	16	4.6
Year	57.4	38.1	-------------	-------------	28.78	------	------	74	----------

[1] Based on period 1931–60.
[2] Based on period 1940–64.
[3] Less than 1 day.
[4] Based on period 1921–64.

A wide plain with little relief lies east of the dunes. Rolling to hilly areas are toward the eastern side of the county and in the extreme northwestern part. Parts of the central plain are somewhat broken by stream channels and lake basins. Most of the county ranges from 600 to about 800 feet above sea level, but a small area in Casnovia Township is more than 800 feet.

The central plain of Muskegon County is a part of the bed of glacial Lake Chicago. The deposits in this lakebed are sandy, underlain by clayey deposits in many areas. Another broad, gently undulating lake plain is in the northeastern part of the county. This plain is mainly in Holton Township, but it extends into the western part of Newaygo County. The soil material of this lake plain is finer textured than that of the plain in the central part of the county.

The principal morainic areas of the county are (1) most of Casnovia Township; (2) a smaller area north of the valley of the Muskegon River; and (3) an area that begins at a point north of Whitehall and extends for several miles south and east of that town.

The county is drained mainly by three major river systems, but some areas are drained by streams that flow directly into Lake Michigan. The Muskegon River cuts the county into two parts and empties into Muskegon Lake, which is an inlet from Lake Michigan. The main tributary within the county is Cedar Creek, which receives the drainage waters from the northeast. White River drains the northwestern part of the county and empties into White Lake, another inlet on Lake Michigan. Directly south of Muskegon is another small inlet, Mona Lake, into which Little Black and Black Creeks empty water that drains from the west-central part of the county. Crockery Creek and Norris Creek, both tributaries of the Grand River, drain the southeastern and southern parts.

Water Supply

The abundant water in the numerous lakes and streams is one of the greatest assets in Muskegon County. The three major lakes, inlets from Lake Michigan, are Muskegon Lake, Mona Lake, and White Lake. Muskegon Lake

TABLE 12.—*Probabilities of last freezing temperatures in spring and first in fall at Muskegon in Muskegon County and at Grand Rapids in Kent 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
MUSKEGON, MUSKEGON COUNTY [1]					
Spring:					
1 year in 10 later than	March 31	April 7	April 22	May 5	May 18
2 years in 10 later than	March 26	April 2	April 17	April 30	May 13
5 years in 10 later than	March 16	March 23	April 7	April 20	May 3
Fall:					
1 year in 10 earlier than	November 22	November 12	November 1	October 15	October 3
2 years in 10 earlier than	November 27	November 17	November 6	October 20	October 8
5 years in 10 earlier than	December 8	November 28	November 17	October 31	October 19
GRAND RAPIDS, KENT COUNTY [2]					
Spring:					
1 year in 10 later than	April 4	April 11	April 23	May 3	May 19
2 years in 10 later than	March 30	April 6	April 18	April 28	May 14
5 years in 10 later than	March 20	March 27	April 8	April 18	May 4
Fall:					
1 year in 10 earlier than	November 12	November 7	October 24	October 7	October 20
2 years in 10 earlier than	November 17	November 12	October 29	October 12	October 25
5 years in 10 earlier than	November 28	November 23	November 9	October 23	November 6

[1] Based on period 1931–60.

[2] Based on period 1921–64.

provides an excellent supply of water for industrial uses, and Mona Lake and White Lake are important as residential, tourist, and recreational areas. Muskegon Lake is also one of the major harbors of the St. Lawrence Seaway on Lake Michigan.

Many other lakes, mostly north of the Muskegon River, provide areas for recreation, summer homes, youth camps, and other recreational facilities. An inventory taken in 1962 lists 262 lakes and ponds in the county covering 11,453 acres.

Settlement and Population

The area that is now Muskegon County was first settled in 1834. The county was organized in 1859, and Muskegon was named the county seat. The construction of wagon roads and a rail line hastened the settlement of the county. Many of the settlers were of Dutch and Scandinavian origin. By 1870, the population had grown to 14,894. The population continued to grow until 1890, but after 1890, it declined for a short period.

In 1960, the population in the county was 149,943, of which 66 percent was urban, 31.7 percent was rural but nonfarm, and 2.3 percent was farm. About 80 percent of the urban population lives in the Muskegon metropolitan area. The population of the city of Muskegon was 46,485 in 1960.

Industry and Transportation

Manufacturing is important and varied in Muskegon County. Products include automotive engines, parts, and equipment; foundry products; office furniture and supplies; bowling, billiards, and store equipment; paper; machinery; tools and dies; petroleum products; wire products; and coil springs. Muskegon is the center of the tool, die, and pattern industry in the State.

The port of Muskegon, on Muskegon Lake, is the gateway of the western part of Michigan to the St. Lawrence Seaway and world trade. As such it is the greatest economic asset of Greater Muskegon. In 1962, the port of Muskegon received 81 foreign ships. These ships carried 23,365 tons of imports and 35,691 tons of exports. Among the agricultural imports were agricultural machinery, cheese, cookies, preserved vegetables, sugar, and woodpulp. The agricultural exports included agricultural machinery, cherries, fruit juices, onions, and wax beans.

All major cities, towns, and villages except Ravenna are joined by major highways. These are Interstate Highway No. 96, U.S. Highway No. 31, and State routes 46, 37, 20, and 213. The county is served by the Chesapeake and Ohio, Grand Trunk Western, and Pennsylvania Railroads. An airport in Muskegon County provides adequate commercial, industrial, and private air service for the area.

Agriculture

Agriculture was begun in Muskegon County in about 1845 by the early lumberjacks. As the land was cleared, farms were established, but many of them were soon abandoned because the soils were sandy. Growing food for home use was the main concern of the first farmers. Agriculture was stimulated by the influx of settlers and by the building of roads and railroads. Farms increased in number, and by 1870 there was a surplus of crops that could be sold outside of the county. The number of farms in the county continued to increase and amounted to 1,821 in 1890 and 2,373 in 1910. After 1910 the number of farms began to decrease.

In 1959, 949 farms remained in the county, and their average size was 104.4 acres. These farms include 226 dairy farms; 61 livestock farms; 36 vegetable farms; 25 poultry farms; 16 general farms; and 5 field-crop farms. The remaining were miscellaneous or unclassified farms. Full owners operated 79 percent of the farms; part owners, 17 percent; managers, 0.2 percent; and tenants, 3.8 percent.

Table 13 shows the acreage on farms of important crops grown in Muskegon County in 1954 and 1959 and the number of fruit trees. The number of livestock on farms in 1954 and 1959 is given in table 14.

TABLE 13.—*Acreage of the principal crops and number of fruit trees in 1954 and 1959*

Crops	1954	1959
	Acres	*Acres*
Corn:		
Grown for grain	7, 731	9, 604
Grown for silage	2, 954	2, 593
Wheat	4, 517	4, 864
Oats	7, 057	4, 163
Barley	190	490
Rye	948	572
Buckwheat	82	30
Soybeans	11	34
Field beans	1, 115	165
Hay:		
Alfalfa	6, 303	8, 678
Timothy and clover	7, 165	4, 654
Other	737	427
Seed harvested:		
Alfalfa	10	81
Other	642	310
Potatoes	96	15
Vegetables	2, 135	1, 845
Strawberries	87	81
Raspberries	22	23
Blueberries	282	400
Mint	195	91
Onions	87	159
Nursery products	80	40
	Number	*Number*
Fruit trees of all ages:		
Apples	37, 449	34, 822
Peaches	32, 221	24, 732
Pears	5, 194	4, 634
Plums	2, 690	1, 683
Cherries	39, 281	44, 831
Grape vines	8, 604	1, 156

TABLE 14.—*Number of livestock on farms*

Livestock	1954	1959
Cattle and calves	12, 618	11, 519
Milk cows	5, 662	4, 819
Sheep and lambs	160	202
Hogs and pigs	3, 312	3, 349
Chickens [1]	108, 308	56, 812

[1] 4 months old and older.

Glossary

Acidity. See Reaction.

Alkalinity. See Reaction.

Alluvium. Soil or rock material, such as gravel, sand, silt, or clay deposited on land by a stream.

Available moisture capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Blowout. An excavation produced by wind action in loose soil, usually sand.

Calcareous. Containing enough calcium carbonate to effervesce (fizz) when treated with dilute hydrochloric acid.

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. See also Texture.

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; will not hold together in a mass.

Friable.—When moist, crushes easily under gentle to moderate 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; tends to stretch somewhat and pull apart, rather than pull free from other material.

Hard.—When dry, moderately resistant to pressure, can be broken with difficulty between thumb and forefinger.

Compact.—A combination of firm consistence and close packing or arrangement of soil particles.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Depressional area. A low-lying area that lacks surface outlets for removal of water or has only poorly developed ones.

Drainage, artificial. The removal of excess water on or within the soil by means of surface or subsurface drains.

Drainage, natural. Soil drainage 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.

Eolian soil material. Soil parent material accumulated through wind action; commonly refers to sandy material in dunes.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Glacial outwash. Sandy and gravelly materials deposited in layers on plains or in old glacial drainageways by water from melting glaciers.

Hardpan. A hardened or cemented soil horizon, or layer. This soil material may be sandy, or clayey, and it may be cemented by iron oxide, silica, calcium carbonate, or other substance.

Horizon, soil. Layer or part of the soil profile, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major soil horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the mineral horizon in which living organisms are most active, and it is therefore 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 has (a) distinctive characteristics caused by accumulation of clay, sesquioxides, humus, or some combination of these; (b) prismatic or blocky structure; and (c) redder or stronger colors than the A horizon; or (d) some combination of these characteristics. The 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. This layer, commonly called the soil parent material, is presumed to be like that from which the overlying horizons were formed in most soils. If the underlying 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.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils generally indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*Few, common,* and *many; size—fine, medium* and *coarse;* contrast—*faint, distinct,* and *prominent.*

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 3/2 is a color with a hue of 10YR, a value of 3, and a chroma of 2 (9).

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.

Parent material (soil). The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Peat. Unconsolidated soil material, largely undecomposed organic matter, that has accumulated where there has been excess moisture.

Percolation. The downward movement of water through the soil.

pH. See Reaction.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material. See Horizon, soil.

Reaction. The degree of acidity or alkalinity of a soil, expressed in words and in pH values, as follows:

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Relief. Elevations and inequalities of the land surface, considered collectively. Relief in this survey refers to a particular area rather than separate slope.

Sand. Individual fragments of rocks or minerals that range from 0.05 millimeter (0.002 inch) to 2.0 millimeters (0.078 inch) in diameter. Most sand grains consist of quartz, but they may be of any mineral composition. The term also is applied to a 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). A 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. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

Solum, soil. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active.

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 unaggregated primary soil particles. Structure is described by grade (*weak, moderate,* or *strong*), that is, the distinctness and durability of the aggregates; by the size of the aggregates (*very fine, fine, medium, coarse,* or *very coarse*); and by their shape (*platy, prismatic, columnar, blocky, granular,* or *crumb*). A soil is described as structureless if there are no observable aggregates. Structureless soil may be *massive* (coherent) *or single grain* (noncoherent).

Subsidence. A settling or packing down of the soil material, as exemplified by muck that has been drained and cultivated many times.

Substratum. Any layer lying beneath the solum, or true soil; the C or R horizon.

Subsoil. Technically the B horizon; roughly, the part of the profile below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plow layer.

Terrace, stream. An area that is fairly level and formerly was the flood plain of a stream but now lies above the present flood plain; the area is generally underlain by stratified stream sediments.

Texture, soil. The relative proportion of sand, silt, and clay particles in a 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."

Till plains. A level or undulating land surface covered by till, which is unstratified glacial drift consisting of clay, sand, gravel, and boulders intermingled.

Weathering. The physical and chemical disintegration and decomposition of rocks and minerals. Soil is the result of weathering and other chemical, physical, and biological alterations that have changes in the upper part of the earth's crust through various periods of time.

Literature Cited

(1) ALLEN, P. F., GARLAND, L. E., and DUGAN, R. F.
1963. RATING NORTHEASTERN SOILS FOR THEIR SUITABILITY FOR WILDLIFE HABITAT. N. Am. Wildlife and Natural Res. Conference Trans., pp. 247–261, illus.

(2) AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS.
1955. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 8, 2 v., illus.

(3) BALDWIN, M., KELLOGG, C. E., and THORP, J.
1938. SOIL CLASSIFICATION. U.S. Dept. of Agr. Ybk: 979–1001.

(4) MICHIGAN STATE HIGHWAY DEPARTMENT.
1960. FIELD MANUAL OF SOIL ENGINEERING. Ed. 4, 368 pp., illus.

(5) MICHIGAN STATE UNIVERSITY.
1963. FERTILIZER RECOMMENDATIONS FOR MICHIGAN CROPS. Ext. Bul. E 159 (rev.), 51 pp.

(6) PORTLAND CEMENT ASSOCIATION.
1956. PCA SOIL PRIMER. 86 pp., illus. Chicago, Ill.

(7) SIMONSON, ROY W.
1962. SOIL CLASSIFICATION IN THE UNITED STATES. Sci. 137: 1027–1034.

(8) THORP, JAMES, and SMITH, GUY D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 117–126.

(9) UNITED STATES DEPARTMENT OF AGRICULTURE.
1951. SOIL SURVEY MANUAL. U.S. Dept. of Agr. Handbook 18, 503 pp., illus.

(10) ———
1960. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM, 7TH APPROXIMATION. 265 pp., illus. [Supplement issued in March 1967]

(11) WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS.
1953. THE UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. 3-357, 2 v., illus. and app.

GUIDE TO MAPPING UNITS

[For a full description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which it belongs.

[See table 1, p. 6, for approximate acreage and proportionate extent of the soils and table 2, p. 45, for predicted average yields. For information significant to woodlands, wildlife, engineering, and community developments, see subsections beginning on pp. 46, 50, 53, and 78 respectively.

[In material published by the Michigan Agricultural Experiment Station, the loamy substratum phase of Rubicon in mapping units RtB and RtC is shown as Melita; Chelsea in units CmB, CmC, CnD, CnE, and MhB is shown as Graycalm; unit Sa is shown as Gormer; and unit So is shown as Pinora]

Map symbol	Soil	Described on page	Capability unit and management group 1/		Woodland suitability group	Wildlife suitability group	Community development group
			Symbol	Page	Symbol	Number	Number
AsB	Au Gres-Saugatuck sands, 0 to 6 percent slopes	7	IVw-2 (5b, 5b-h)	42	F	1	6
BaB	Belding and Allendale soils, 0 to 6 percent slopes	9					
	Belding soil	--	IIw-8 (3/2b)	40	G	3	5
	Allendale soil	--	IVw-2 (4/1b)	42	G	3	5
BbB	Belding-Ubly sandy loams, 2 to 6 percent slopes	9					
	Belding soil	--	IIw-8 (3/2b)	40	G	3	5
	Ubly soil	--	IIe-3 (3/2a)	39	A	9	2
BoB	Blown-out land, 0 to 6 percent slopes	10	VIIIs-1 (5a)	44	Y	4	3
BoE	Blown-out land, 6 to 50 percent slopes	10	VIIIs-1 (5a)	44	Y	4	3
CmB	Chelsea-Mancelona loamy sands, 2 to 6 percent slopes	11					
	Chelsea soil	--	IVs-2 (5a)	43	E	7	3
	Mancelona soil	--	IIIs-4 (4a)	42	C	7	3
CmC	Chelsea-Mancelona loamy sands, 6 to 12 percent slopes	11					
	Chelsea soil	--	VIs-1 (5a)	44	E	7	3
	Mancelona soil	--	IIIe-9 (4a)	41	C	7	3
CnD	Chelsea and Montcalm sands, 12 to 25 percent slopes	12					
	Chelsea soil	--	VIIs-1 (5a)	44	E	7	3
	Montcalm soil	--	VIIs-1 (4a)	44	C	7	3
CnE	Chelsea and Montcalm sands, 25 to 45 percent slopes	12					
	Chelsea soil	--	VIIs-1 (5a)	44	E	7	3
	Montcalm soil	--	VIIs-1 (4a)	44	C	7	3
CrB	Croswell and Au Gres sands, 0 to 6 percent slopes	13					
	Croswell soil	--	IVs-2 (5a)	43	E	1	3
	Au Gres soil	--	IVw-2 (5b)	42	F	1	6
DpE	Deer Park fine sand, 12 to 50 percent slopes	13	VIIs-1 (5.3a)	44	H	4	3
Ds	Deford fine sand	14	IIIw-6 (4c)	41	W	5	8
Du	Dune land	14	VIIIs-1 (Sa)	44	Y	4	3
Ga	Granby loamy sand	15	IIIw-11 (5c)	41	Q	5	9
GrC	Grayling-Rubicon sands, 6 to 12 percent slopes	16	VIIs-1 (5.7a, 5.3a)	44	H	8	3
GrD	Grayling-Rubicon sands, 12 to 25 percent slopes	16	VIIs-1 (5.7a, 5.3a)	44	H	8	3
GrE	Grayling-Rubicon sands, 25 to 45 percent slopes	16	VIIs-1 (5.7a, 5.3a)	44	H	8	3

GUIDE TO MAPPING UNITS--Continued

Map symbol	Soil	Described on page	Capability unit and management group 1/ Symbol	Page	Woodland suitability group Symbol	Wildlife suitability group Number	Community development group Number
Hp	Hettinger and Pickford soils---------	17					
	Hettinger soil-------------------	--	IIw-2 (1.5c)	39	P	6	7
	Pickford soil--------------------	--	IIIw-2 (1c)	41	P	6	7
Ht	Houghton peat and muck---------------	17	IIIw-15 (Mc)	42	U	5	10
KaB	Kalkaska-Wallace sands, 2 to 6 percent slopes------------------------	18	VIIs-1 (5a, 5a-h)	44	H	8	3
KkA	Kawkawlin loam, 0 to 2 percent slopes----------------------------	19	IIw-2 (1.5b)	39	Z	3	4
KkB	Kawkawlin loam, 2 to 6 percent slopes----------------------------	19	IIw-3 (1.5b)	40	Z	3	4
KsA	Kawkawlin and Selkirk loams, 0 to 2 percent slopes---------------------	19					
	Kawkawlin soil-------------------	--	IIw-2 (1.5b)	39	Z	3	4
	Selkirk soil---------------------	--	IIIw-2 (1b)	41	Z	3	4
KsB	Kawkawlin and Selkirk loams, 2 to 6 percent slopes---------------------	19					
	Kawkawlin soil-------------------	--	IIw-2 (1.5b)	39	Z	3	4
	Selkirk soil---------------------	--	IIIw-2 (1b)	41	Z	3	4
KtE	Kent silt loam, 25 to 45 percent slopes----------------------------	20	VIIe-1 (1a)	44	B	9	1
Ku	Kerston muck------------------------	21	IIIw-12 (L-Mc)	41	O	5	10
La	Lake beaches------------------------	21	VIIIs-1 (Sa)	44	Y	4	3
Ma	Marsh-------------------------------	22	VIIIw-1 (Sc)	44	U	5	10
MeB	Menominee and Ubly soils, 2 to 6 percent slopes-----------------------	22					
	Menominee soil-------------------	--	IIIs-4 (4/2a)	42	C	9	2
	Ubly soil-----------------------	--	IIe-3 (3/2a)	39	A	9	2
MeC	Menominee and Ubly soils, 6 to 12 percent slopes---------------------	23					
	Menominee soil------------------	--	IIIe-9 (4/2a)	41	C	9	2
	Ubly soil-----------------------	--	IIIe-9 (3/2a)	41	A	9	2
MhB	Montcalm and Chelsea soils, 2 to 6 percent slopes---------------------	24					
	Montcalm soils-------------------	--	IIIs-4 (4a)	42	C	7	3
	Chelsea soil--------------------	--	IVs-2 (5a)	43	E	7	3
NeB	Nester loam, 2 to 6 percent slopes---	24	IIe-1 (1.5a)	39	B	9	1
NeC	Nester loam, 6 to 12 percent slopes--	24	IIIe-4 (1.5a)	40	B	9	1
NrC	Nester sandy loam, 6 to 12 percent slopes----------------------------	25	IIIe-4 (1.5a)	40	B	9	1
NsD	Nester soils, 12 to 25 percent slopes----------------------------	25	VIe-1 (1.5a)	43	B	9	1
NsD3	Nester soils, 12 to 25 percent slopes, severely eroded-----------	26	VIe-1 (1.5a)	43	B	9	1
NsE	Nester soils, 25 to 45 percent slopes----------------------------	26	VIIe-1 (1.5a)	44	B	9	1
NsE3	Nester soils, 25 to 45 percent slopes, severely eroded-----------	26	VIIe-1 (1.5a)	44	B	9	1
NtB	Nester-Kawkawlin loams, 2 to 6 percent slopes-----------------------	26					
	Nester soil---------------------	--	IIe-1 (1.5a)	39	B	9	1
	Kawkawlin soil------------------	--	IIw-2 (1.5b)	39	Z	3	4
NuB	Nester-Ubly sandy loams, 2 to 6 percent slopes-----------------------	26					
	Nester soil---------------------	--	IIe-1 (1.5a)	39	B	9	1
	Ubly soil-----------------------	--	IIe-3 (3/2a)	39	A	9	2
OgB	Ogemaw loamy sand, 0 to 6 percent slopes----------------------------	27	IVw-2 (5b-h)	42	F	1	5

GUIDE TO MAPPING UNITS--Continued

Map symbol	Soil	Described on page	Capability unit and management group 1/ Symbol	Capability unit and management group 1/ Page	Woodland suitability group Symbol	Wildlife suitability group Number	Community development group Number
Ra	Roscommon and Au Gres sands----------	28					
	Roscommon soil-------------------	--	IIIw-11 (5c)	41	Q	1	9
	Au Gres soil---------------------	--	IVw-2 (5b)	42	F	1	6
RoB	Rousseau fine sand, 0 to 6 percent slopes-----------------------------	29	IIIs-4 (4a)	42	C	7	3
RsB	Rubicon sand, 0 to 6 percent slopes--	30	VIIs-1 (5.3a)	44	H	8	3
RsD	Rubicon sand, 6 to 25 percent slopes-	30	VIIs-1 (5.3a)	44	H	8	3
RtB	Rubicon loamy substratum and Montcalm soils, 0 to 6 percent slopes-------	30					
	Rubicon soil---------------------	--	VIs-1 (5/2a)	44	C	7	3
	Montcalm soil--------------------	--	IIIs-4 (4a)	42	C	7	3
RtC	Rubicon loamy substratum and Montcalm soils, 6 to 12 percent slopes------	31					
	Rubicon soil---------------------	--	VIs-1 (5/2a)	44	C	7	3
	Montcalm soil--------------------	--	IIIe-9 (4a)	41	C	7	3
Sa	Saranac loam------------------------	31	IIIw-12 (L-2c)	41	O	6	7
Sm	Sims loam---------------------------	33	IIw-2 (1.5c)	39	P	6	7
So	Sloan soils-------------------------	34	IIIw-12 (L-2c)	41	O	6	8
Sp	Sparta sand, 0 to 2 percent slopes---	34	IVs-2 (5a)	43	V	8	3
Tc	Tawas and Carlisle mucks------------	35					
	Tawas soil-----------------------	--	IVw-5 (M/4c)	43	U	5	10
	Carlisle soil--------------------	--	IIIw-15 (Mc)	42	U	5	10
Td	Tonkey and Deford soils-------------	36					
	Tonkey soil----------------------	--	IIw-6 (3c)	40	W	5	8
	Deford soil----------------------	--	IIIw-6 (4c)	41	W	5	8
Wa	Warners muck------------------------	38	IVw-5 (M/Mc)	43	U	5	10
We	Wind eroded land, sloping-----------	38	VIs-1 (Sa)	44	E	2	3

1/
The symbol in parentheses are management groups of soils in a statewide system.

U.S. GOVERNMENT PRINTING OFFICE: 1968 O—279-229

Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (http://directives.sc.egov.usda.gov/33081.wba) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

Supplemental Nutrition Assistance Program

For additional information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, call either the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish, or the State Information/Hotline Numbers (http://directives.sc.egov.usda.gov/33085.wba).

All Other Inquires

For information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices (http://directives.sc.egov.usda.gov/33086.wba).