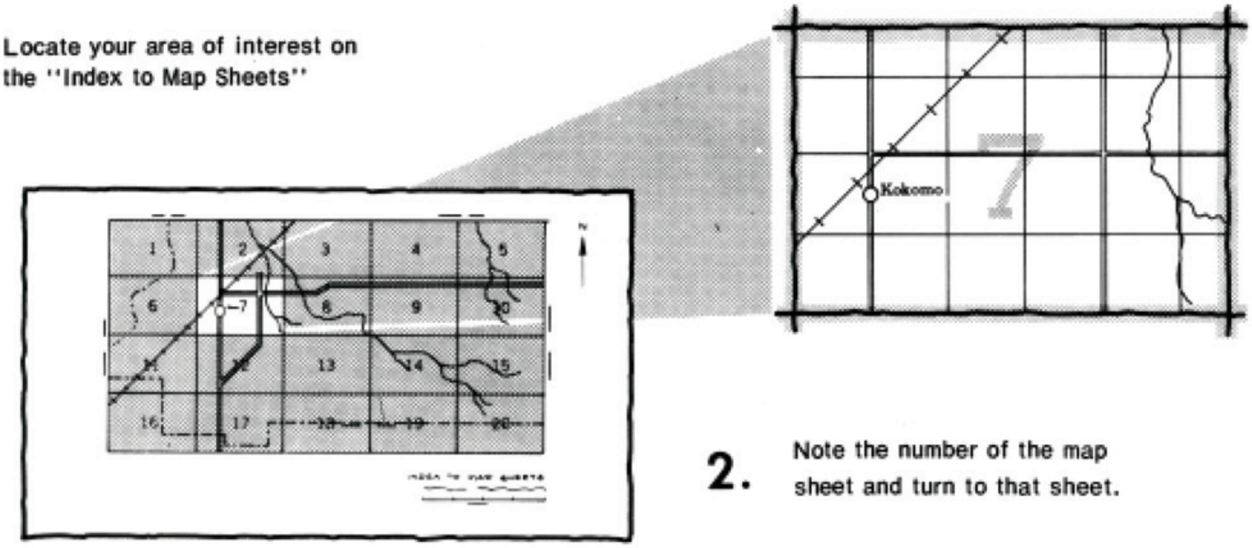
SOIL SURVEY OF

Johnson County, Kansas

United States Department of Agriculture
Soil Conservation Service
in cooperation with
Kansas Agricultural Experiment Station

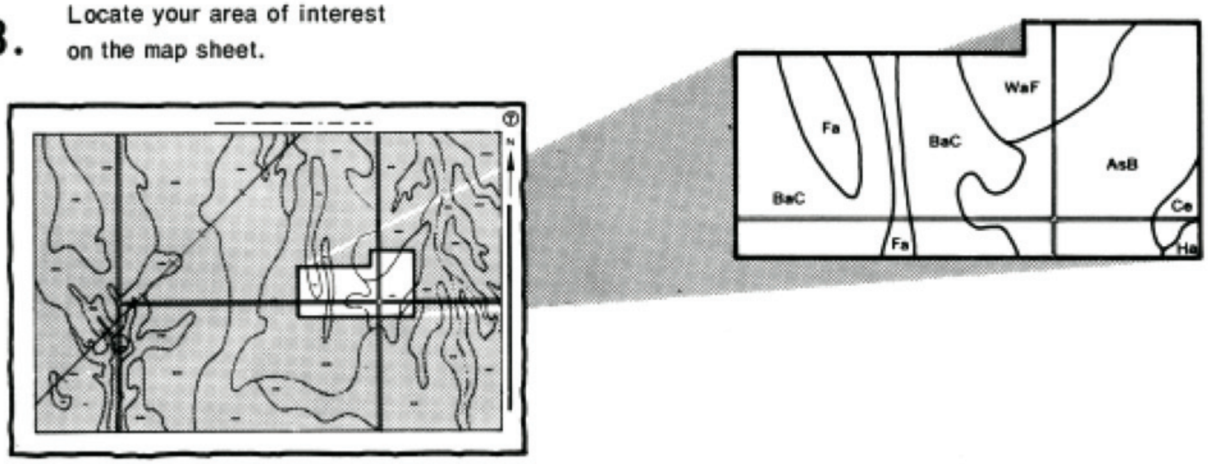
HOW TO USE

1. Locate your area of interest on the "Index to Map Sheets"

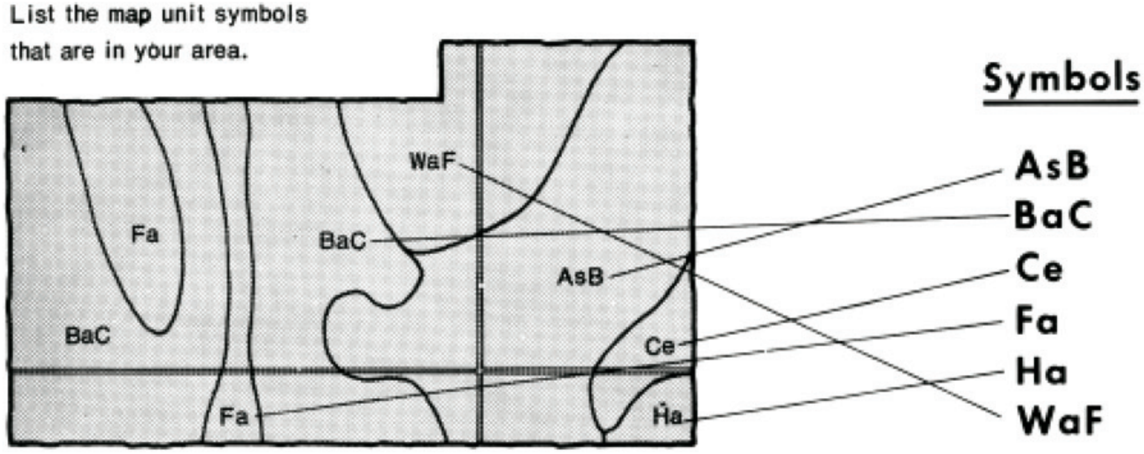


2. Note the number of the map sheet and turn to that sheet.

3. Locate your area of interest on the map sheet.

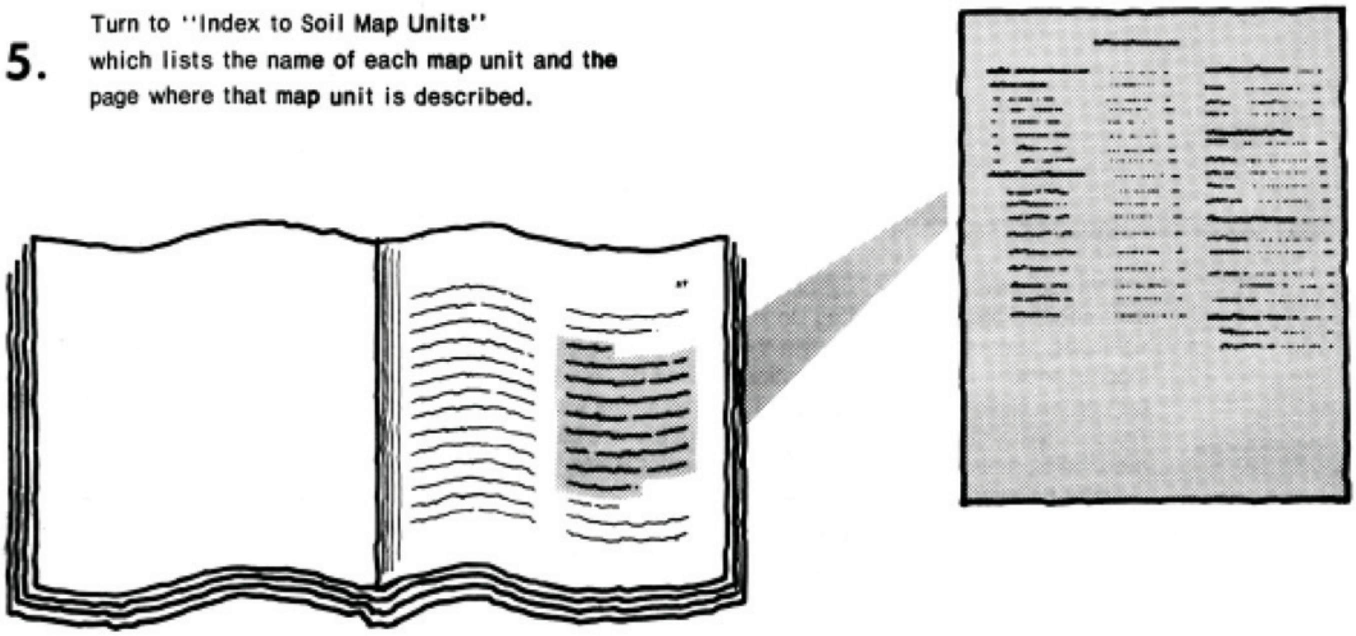


4. List the map unit symbols that are in your area.

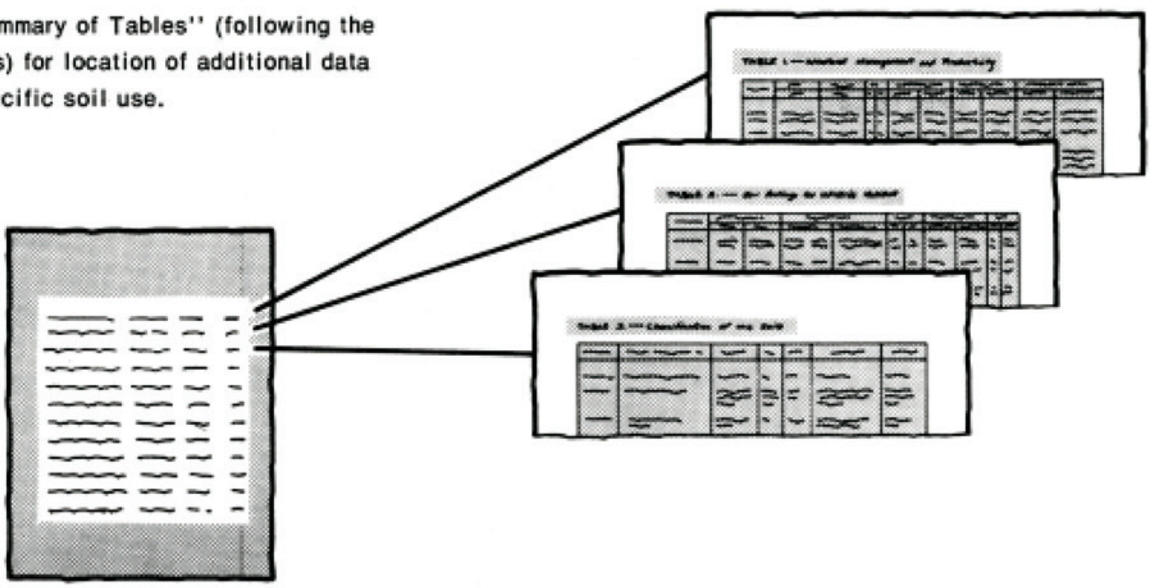


THIS SOIL SURVEY

5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.



6. See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.



7. Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1970-1974. Soil names and descriptions were approved in 1975. Unless otherwise indicated, statements in the publication refer to conditions in the survey area in 1975. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Johnson County Conservation District.

Soil maps in this survey may be copied without permission, but any enlargement of these maps can cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

Cover: Urban area adjoining pasture land.

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Issued January 1979

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Summary of Tables

Foreword

The Soil Survey of Johnson County, Kansas contains much information useful in any land-planning program. Of prime importance are the predictions of soil behavior for selected land uses. Also highlighted are limitations or hazards to land uses that are inherent in the soil, improvements needed to overcome these limitations, and the impact that selected land uses will have on the environment.

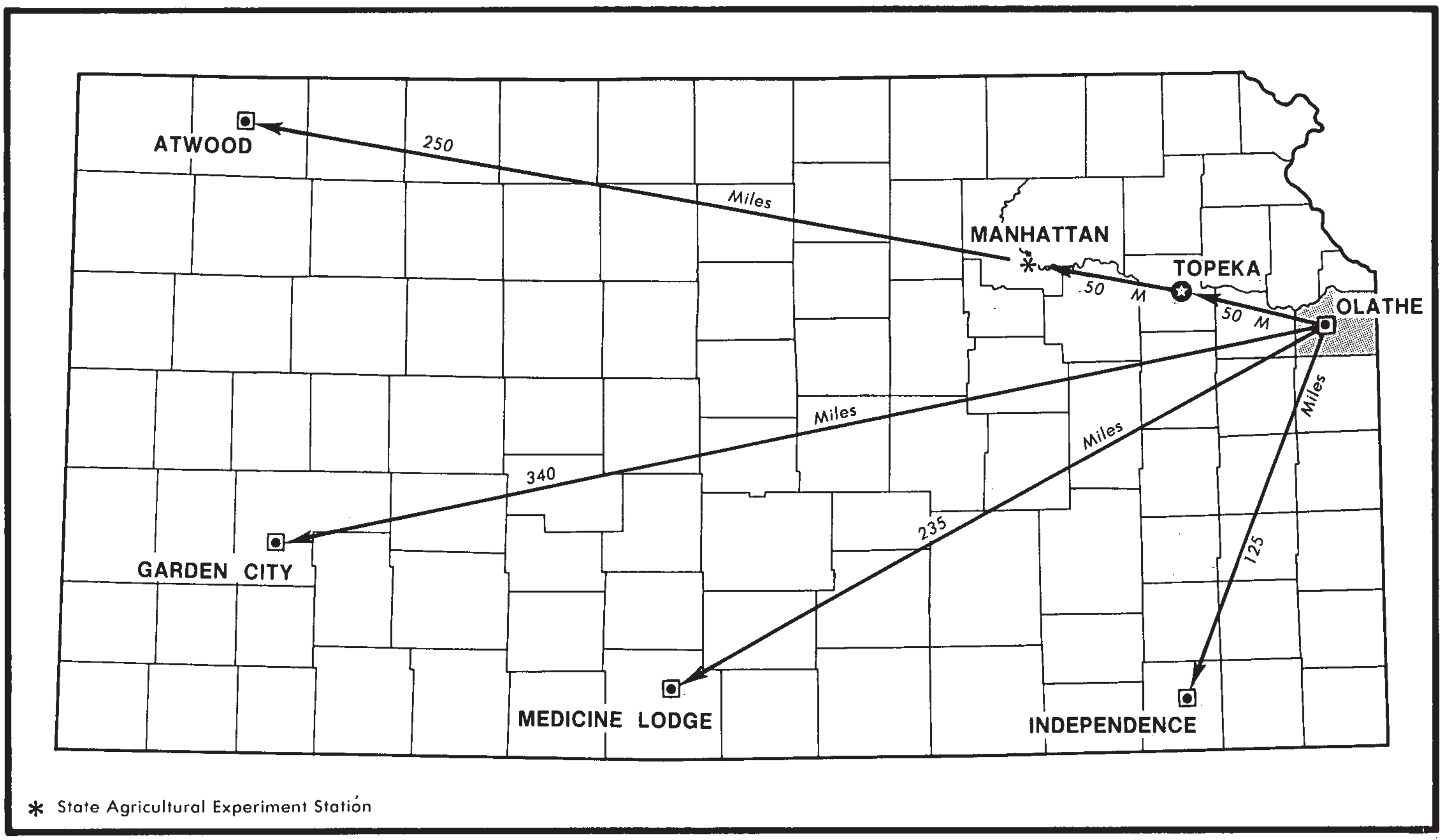
This soil survey has been prepared for many different users. Farmers, ranchers, foresters, and agronomists can use it to determine the potential of the soil and the management practices required for food and fiber production. Planners, community officials, engineers, developers, builders, and homebuyers can use it to plan land use, select sites for construction, develop soil resources, or identify any special practices that may be needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the soil survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur even within short distances. Soils may be seasonally wet or subject to flooding. They may be shallow to bedrock. They may be too unstable to be used as a foundation for buildings or roads. Very clayey or wet soils are poorly suited to septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map; the location of each kind of soil is shown on detailed soil maps. Each kind of soil in the survey area is described, and much information is given about each soil for specific uses. Additional information or assistance in using this publication can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

This soil survey can be useful in the conservation, development, and productive use of soil, water, and other resources.

Robert K. Griffin
State Conservationist
Soil Conservation Service



Location of Johnson County in Kansas.

SOIL SURVEY OF JOHNSON COUNTY, KANSAS

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Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service,
in cooperation with Kansas Agricultural Experiment Station

JOHNSON COUNTY is in the northeastern part of Kansas. It has a total area of 476 square miles, or 304,704 acres. Population in 1975 was 242,000 in the county, and Olathe, the county seat, had a population of 22,400. About 140,000 acres of this county are used for field crops, 55,000 acres are used for pastureland, 25,000 acres are used for woodland, and 75,000 acres are used for urban land. The rest is in roads, water areas, and other miscellaneous uses.

The county is in the Central Lowland province of the Interior Plains. The Kansas River has cut a wide valley along the western half of the northern boundary of the county. The western part of Johnson County is made up of gently rolling and undulating uplands. Cedar Creek, Kill Creek, Captain Creek, and Mill Creek dissect the county and flow north to the Kansas River. The eastern part of the county consists of the valley of the Blue River and its tributaries and gently rolling and undulating uplands. Elevation of the land ranges from about 742 feet in the north central section along the valley of the Kansas River to about 1,134 feet in the south central part, near Bonita.

General nature of the county

This section gives general information concerning the county. It discusses climate, industry and transportation, settlement, natural resources, and farming.

Climate

By L. Dean Bark, climatologist, Kansas Agricultural Experiment Station, Manhattan, Kansas.

The climate of Johnson County is a typical continental type as would be expected from its location in the interior of a large land mass in the middle latitudes. Such climates are characterized by wide daily and annual variations in temperature. Winters are cold because of the frequent outbreaks of air from the Polar regions. Winter conditions prevail from December to February. Warm temperatures of summer last for about six months every year, and the transition seasons of spring and fall are relatively short. The warm temperatures provide a long growing season for crops in the county.

Johnson County is in the path of a fairly dependable current of moisture-laden air from the Gulf of Mexico. Precipitation is heaviest late in spring and early in summer with a good portion of it coming in late-evening or nighttime thunderstorms. Although the total precipitation is generally adequate for any crop, its distribution may cause problems in some years. Prolonged dry periods of several weeks duration are not uncommon during the growing season in this area. A surplus of precipitation often results in muddy fields that delay planting and harvest operations.

Table 1 gives data on temperature and precipitation for Johnson County, as recorded at Olathe for the period 1941 to 1970. Table 2 shows probable dates of the first freeze in fall and last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature is 32.3 degrees F., and the average daily minimum is 22.5 degrees F. The lowest temperature on record, -29 degrees F., occurred at Olathe on February 12, 1899. In summer the average temperature is 76.0 degrees F., and the average daily minimum is 86.5 degrees F. The highest temperature was 111 degrees F., recorded on July 7, 1913 and again on August 14, 1936.

The annual precipitation is 38.52 inches. Of this total, 27.48 inches or 71 percent usually falls during the period April through September, which includes the growing season for most crops. Two years in 10, the April-September rainfall is less than 21.37 inches. The heaviest one-day rainfall during the period of record was 7.00 inches at Olathe on September 7, 1914.

Average annual snowfall is 19.0 inches. The greatest snowfall, 82.1 inches, occurred during the winter of 1911-12. In an average year, 22 days have at least one inch of snow on the ground, but it is unusual for the snow cover to last over seven consecutive days.

The prevailing wind is from the south. Average annual windspeed is 10 miles per hour; it is highest, at 12 miles per hour, in March. An average of 72 percent of possible sunshine is received in summer, and 53 percent is received in winter.

Tornadoes and severe thunderstorms occur occasionally in Johnson County. These storms are usually local in extent and of short duration so that risk is small. Hail occurs during the warmer part of the year, but again, it is infrequent and of local nature. Crop damage by hail occurs less in this part of the state than in western Kansas.

Industry and transportation

Johnson County is served by four railroads: the Atchison, Topeka and Santa Fe; the St. Louis and San Francisco (Frisco); the Missouri, Kansas and Texas (Katy); and the Missouri Pacific. In addition to the extensive railroad network, the county is crossed by Interstates 35, 435, and 635; U.S. Highways 50, 56, 69, and 169; and Kansas Highways 7, 10, 58, and 158. Several airports are located in the county, and the Kansas City International and Municipal Airports are within a one-hour drive for county residents.

Nearly all of the industry in Johnson County is located within the Greater Kansas City Area and Olathe. Manufactured items include structural steel, aluminum and other metal products, custom made boots and other leather products, battery production, aviation products, construction and farm equipment, veterinary supply products, candy production, building supplies, and the manufacturing of cooking utensils. Athletic supplies are also manufactured, in Gardner. Sunflower Ordinance Works near DeSoto produce and manufacture explosives and propellant fuels.

Settlement of the county

Francisco de Coronado and a group of Spaniards came to Kansas in 1541. These were the first explorers to see Kansas. The area was claimed by Spain, England, France, Mexico, the Republic of Texas, and finally the United States.

The Santa Fe trail crossed Johnson County from east to west. It was established between Westport, Missouri (now Kansas City) and Santa Fe, New Mexico in 1822.

On May 30, 1854, the Kansas-Nebraska Bill was signed. The two territories of Kansas and Nebraska were formed, and during the next few years thousands of settlers came to the area. The term "Bleeding Kansas" originated as a result of conflicts between pro-slavery and anti-slavery factions during this time.

The first territorial legislature met at Shawnee Methodist Mission in 1855, moving there from Pawnee (now Fort Riley). The Shawnee area is now known as Fairway, part of the greater Kansas City area. Johnson County was created and organized in 1855. Kansas became the 34th state six years later on January 29, 1861.

Population has increased in Johnson County from approximately 17,000 in 1880; 27,000 in 1930; 35,000 in 1940; 60,000 in 1950; 175,000 in 1960; to 220,000 in 1970.

The Greater Kansas City area consists of the cities of Fairway, Leawood, Merriam, Overland Park, Mission, Prairie Village, Roeland Park, Shawnee, Mission Hills, Westwood, and Lenexa. Other cities and municipalities within Johnson County include DeSoto, Gardner, Ocheltree, Spring Hill, Stanley, Olathe, Stilwell, Aubry, Sunflower Village, Wilder, Edgerton, Monticello, Holliday, and Zarah.

Natural resources

Limestone is one of the most important natural resources in Johnson County. In addition, oil, gas, sand, and gravel are produced commercially. There are 10 named areas of gas and oil production in the county. Two have produced oil and gas, and the remaining eight have produced gas only. Several fields have been abandoned or produce noncommercial gas only.

Sand and gravel are dredged from the Kansas River Valley or from pits in the Kansas River Valley alluvium. The Wyandotte Limestone is the most important geologic unit in the county. Crushed limestone material is used for concrete aggregate, roadstone, agricultural purposes, and building stone.

Water is another important resource in Johnson County. Nearly all of the water required for industry is pumped from alluvium in the Kansas River Valley. The municipalities within the county obtain water from either the Kansas River alluvium, ground water from wells, or runoff trapped in lakes.

Several rural water districts have been organized across the county. Small drilled wells throughout the county are used for private residences. These wells yield small quantities of water that range in quality from fresh to very saline. Many of the wells yield water that also contains varying amounts of bicarbonates, nitrates, sulfates, or iron. Some of these wells supply water that is suitable for livestock watering purposes only.

Farming

The first settlers in the county settled along valleys and margins between woodland and prairie land in order to be near water, wood, fish, and game. Crops were grown only in sufficient quantities to supply local needs. Cattle constituted their main source of income. Grain production was slow because of a lack of equipment, droughts, and no suitable and effective method of controlling grasshoppers and other pests.

Agricultural development has undergone several changes since these early days. Several crops that were grown 100 or more years ago such as flax, hemp, tobacco, buckwheat, rice, millet, cotton, castor beans, and broom corn are no longer produced.

Prior to 1873 the only wheat variety grown was spring wheat. After the introduction of hard red winter wheat in 1875 by Mennonite farmers, the wheat growing industry in Kansas rapidly increased. After 1900 cash grain crop production became the main source of farm income in the county. The main crops presently produced in Johnson County are soybeans, corn, sorghum, alfalfa, and wheat.

Cattle, dairy, and hog production has decreased since 1960. At that time there were 25,900 cattle on farms in the county compared to 22,000 in 1970. The number of dairy cattle has decreased from 6,100 to 3,000. Hog production declined slightly from 14,300 to 14,000 in 1970.

Urbanization is constantly decreasing the amount of land being cultivated. From 1954 to 1974 approximately 31,000 acres were developed. This rate is increasing yearly.

Irrigation is utilized, to a small degree, on truck farms in the Kansas River Valley. In 1971 approximately 600 acres were irrigated with water that was pumped from this alluvium. The principal irrigated crops are field corn, grain sorghum, and turf grasses. The following vegetable crops are also irrigated: sweet corn, sweet potatoes, parsley, watermelons, pumpkins, cantaloupes, turnips, and radishes. Much of this produce is sold in the metropolitan Kansas City area.

How this survey was made

Soil scientists made this survey to learn what kinds of soil are in the survey area, where they are, and how they can be used. The soil scientists went into the area knowing they likely would locate many soils they already knew something about and perhaps identify some they had never seen before. They observed the steepness, length, and shape of slopes; the size of streams and the general pattern of drainage; the kinds of native plants or crops; the kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material, which has been changed very little by leaching or by the action of plant roots.

The soil scientists recorded the characteristics of the profiles they studied, and they compared those profiles with others in counties nearby and in places more distant. Thus, through correlation, they classified and named the soils according to nationwide, uniform procedures.

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

The areas shown on a soil map are called soil map units. Some map units are made up of one kind of soil, others are made up of two or more kinds of soil, and a few have little or no soil material at all. Map units are discussed in the sections "General soil map for broad land-use planning" and "Soil maps for detailed planning."

While a soil survey is in progress, samples of soils are taken as needed for laboratory measurements and for engineering tests. The soils are field tested, and interpretations of their behavior are modified as necessary during the course of the survey. New interpretations are added to meet local needs, mainly through field observations of different kinds of soil in different uses under different levels of management. Also, data are assembled from other sources, such as test results, records, field experience, and information available from state and local specialists. For example, data on crop yields under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil.

But only part of a soil survey is done when the soils have been named, described, interpreted, and delineated on aerial photographs and when the laboratory data and other data have been assembled. The mass of detailed information then needs to be organized so that it is readily available to different groups of users, among them farmers, managers of rangeland and woodland, engineers, planners, developers and builders, homebuyers, and those seeking recreation.

General soil map for broad land-use planning

The general soil map at the back of this publication shows, in color, map units that have a distinct pattern of soils and of relief and drainage. Each map unit is a unique natural landscape. Typically, a map unit consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one unit can occur in other units but in a different pattern.

The general soil map provides a broad perspective of the soils and landscapes in the survey area. It provides a basis for comparing the potential of large areas for general kinds of land use. Areas that are, for the most part, suited to certain kinds of farming or to other land uses can be identified on the map. Likewise, areas of soils having properties that are distinctly unfavorable for certain land uses can be located.

Because of its small scale, the map does not show the kind of soil at a specific site. Thus, it is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The kinds of soil in any one map unit differ from place to place in slope, depth, stoniness, drainage, or other characteristics that affect their management.

Nearly level and undulating soils that formed in alluvium on flood plains and terraces

These nearly level and undulating soils make up about 10 percent of the survey area. They are on flood plains and terraces along the major streams and are frequently to rarely flooded. Most of the acreage is cultivated to corn, grain sorghum, soybeans, and small grain. The principal management needs are controlling flooding, improving drainage, and maintaining fertility and tilth. Soil blowing is a hazard on some of these soils. Flooding, permeability, and drainage are the main limitations for urban use.

1. Kennebec-Chase

Deep, moderately well drained and somewhat poorly drained, nearly level soils that have a loamy or clayey subsoil; on flood plains and low terraces

This map unit consists of nearly level soils on low bottom lands, on high bottom lands where backwater areas are adjacent to uplands, and on low terraces (fig. 1).

This unit makes up about 8 percent of the county. It is about 55 percent Kennebec soils, 15 percent Chase soils, and 30 percent soils of minor extent.

Kennebec soils are nearly level and moderately well drained soils. They are on low bottom lands that are subject to frequent flooding. The surface layer is very dark grayish brown silt loam. The next layer is very dark gray, friable silt loam. The substratum is very dark gray silt loam.

Chase soils are nearly level, somewhat poorly drained and moderately well drained soils on low terraces. They are subject to occasional flooding. The surface layer is very dark brown silt loam. The subsoil is black, firm silty clay loam and very dark gray and black, very firm silty clay. The substratum is very dark gray silty clay loam.

The soils of minor extent are Wabash and Reading soils. The Wabash soils are nearly level and are in backwater areas on high terraces. The Reading soils are nearly level and are on terraces that are subject to rare flooding.

Most of the acreage is cultivated. Kennebec and Chase soils are suited to most crops grown in the county. The Wabash soils are better suited to grain sorghum, soybeans, and water-tolerant grasses than to other crops. Because the Kennebec soils are subject to frequent flooding, they are not suited to alfalfa. These soils are high in natural fertility. The main concerns of management are controlling flooding, improving drainage, and maintaining fertility and tilth. Flooding is the main limitation for urban uses of these soils.

2. Eudora-Kimo

Deep, well drained and somewhat poorly drained, nearly level and undulating soils that have a loamy substratum; on flood plains

This map unit consists of nearly level to undulating soils with some abandoned stream channels on flood plains (fig. 2).

This unit makes up about 2 percent of the county. It is about 70 percent Eudora soils, 15 percent Kimo soils, and 15 percent soils of minor extent.

Eudora soils are nearly level to undulating, well drained soils on terraces that are subject to rare flooding. The surface layer is very dark grayish brown silt loam. The substratum is dark grayish brown and grayish brown, friable coarse silt loam and very friable very fine sandy loam.

Kimo soils are nearly level or depressional soils that are in the low lying areas of old meander scars. Ponding is a problem. The surface layer is very dark gray silty clay loam and silty clay. Below that is very dark grayish brown, firm silty clay loam. The substratum is dark grayish brown silt loam.

The soils of minor extent are similar to the Eudora soils, but they contain more coarse sand in the surface. They are adjacent to the river and are nearly level to undulating. Also included in mapping are small areas of Wabash soils. The nearly level Wabash soils are adjacent to the uplands.

With the exception of the industrial and urban areas, nearly all of this map unit is cultivated. Some areas adjacent to the river are wooded. All crops grown in the county are suited to this unit, including vegetable crops and orchards. Natural fertility is high on these soils. The soils can be irrigated with water from wells or the river. The main concerns of management are controlling wind erosion and maintaining organic matter content and fertility. The limitations for urban development are possible flooding and contamination of ground water by sewage effluents.

Gently sloping to strongly sloping soils that formed in loess, residuum, old alluvium, and glacial deposits on uplands

These gently sloping to strongly sloping soils make up about 24 percent of the survey area. They are on loess-covered hills and in the glacial till areas. About half the acreage is cultivated. The rest is in grass, woodland, or urban expansion. Corn, grain sorghum, soybeans, and small grains are the principal crops grown on the gently sloping to sloping soils. Pasture grasses, hay, and trees are grown on the steeper soils. The principal management needs are controlling soil erosion, reducing runoff, and maintaining fertility. Slope and permeability are the main limitations for urban use.

3. Ladoga-Sharpsburg

Deep, moderately well drained, moderately sloping and strongly sloping soils that have a loamy subsoil; on uplands

This map unit consists of moderately sloping to strongly sloping soils on dissected uplands that formed in loess. The soils adjacent to the river valley are strongly sloping and have many outcrops of limestone.

This map unit makes up about 2 percent of the county. It is about 30 percent Ladoga soils, 30 percent Sharpsburg soils, and 40 percent soils of minor extent.

Ladoga soils are moderately sloping and strongly sloping, moderately well drained soils on side slopes. The surface layer is very dark grayish brown and dark brown silt loam. The subsoil is dark yellowish brown, firm silty clay loam.

Sharpsburg soils are moderately sloping, moderately well drained soils on upper side slopes and ridgetops. The surface layer is very dark grayish brown silt loam and silty clay loam. The subsoil is dark brown, firm silty clay loam.

The soils of minor extent are Oska, Sogn, and Vinland soils. Vinland soils are on steep side slopes and are less than 20 inches deep to sandy and silty shales. Oska soils are on the side slopes and are underlain by limestone at a depth of 20 to 40 inches. Sogn soils are on steeper side slopes and are less than 20 inches deep to limestone.

About 70 percent of the acreage is cleared. The rest is in woodland. The sloping soils are well suited to small grains, grain sorghum, corn, and soybeans. Hay and tame pasture also grow well. Sogn soils are not suited to cultivated crops. The main concerns of management are controlling erosion, reducing runoff, and maintaining organic matter content and fertility. Management is necessary for improving the stands of timber and maintaining a vigorous stand of tame grass. The main limitations for urban use are steep slopes, permeability, and shallowness over rock.

4. Woodson-Pawnee

Deep, moderately well drained and somewhat poorly drained, gently sloping and moderately sloping soils that have a loamy or clayey subsoil; on uplands

This map unit consists of gently sloping and moderately sloping soils on uplands. These soils formed in glacial till, old alluvium, and clayey sediment (fig. 3).

This map unit makes up about 6 percent of the county. It is about 35 percent Woodson soils, 25 percent Pawnee soils, and 40 percent soils of minor extent.

Woodson soils are gently sloping, somewhat poorly drained soils on broad convex ridgetops that formed in old alluvial and clayey sediment and loess. The surface layer is black silt loam. The subsoil is very dark gray and grayish brown, very firm silty clay. The substratum is very dark gray silty clay.

Pawnee soils are moderately sloping, moderately well drained soils on upper side slopes, downslope from the Woodson soils. They formed in glacial till. The surface layer is black clay loam. The subsoil is black, dark grayish brown, and very dark grayish brown, firm and very firm clay loam and clay. The substratum is dark grayish brown and dark brown clay loam.

The soils of minor extent are Kennebec, Oska, Sibleyville, Morrill, Sogn, and Vinland soils. Kennebec soils are nearly level and are along streams. They are subject to frequent flooding. Oska, Sibleyville, Morrill, Sogn, and Vinland soils are all on moderately sloping or steep side slopes.

Most of the acreage in this unit is cultivated or planted to hay or tame pasture. Soybeans, grain sorghum, and wheat are the main crops. The main concerns of management are controlling water erosion, reducing runoff, and maintaining fertility. Good management practices are necessary in order to maintain tame pasture in a vigorous condition. The main limitation for urban use is soil permeability which limits the use of these soils for septic tank absorption fields.

5. Sharpsburg-Oska

Deep and moderately deep, well drained and moderately well drained, moderately sloping soils that have a loamy or clayey subsoil; on uplands

This map unit consists of moderately sloping soils on loess-covered ridgetops and side slopes. These soils formed in loess and in residuum from limestone. Rock outcrops are on lower side slopes (fig. 4).

This map unit makes up about 16 percent of the county. It is about 60 percent Sharpsburg soils, 15 percent Oska soils, and 25 percent soils of minor extent.

Sharpsburg soils are deep, moderately sloping, and moderately well drained. They are on convex ridgetops and upper side slopes. These soils formed in loess. The surface layer is very dark grayish brown silt loam and silty clay loam. The subsoil is dark brown, firm silty clay loam.

Oska soils are moderately deep, moderately sloping, and well drained. Slopes are convex to concave. These soils are lower on the landscape than Sharpsburg soils. They formed in loess and in residuum from limestone. The surface layer is very dark grayish brown silty clay loam. The subsoil is dark brown and dark reddish brown, firm silty clay loam and very firm silty clay. Depth to limestone is mainly 20 to 40 inches.

The soils of minor extent are Grundy, Ladoga, and Sogn soils. Also in this unit are areas of Urban land. Grundy soils contain more clay and are on the broader ridgetops. Ladoga soils have a lighter colored surface layer than the major soils and are on steeper side slopes. Sogn soils are shallow, moderately sloping and strongly sloping soils on side slopes.

About 70 percent of the acreage is used for urban development. The rest is used for hay, tame pasture, or cultivated crops. Small tracts are used for truck crops. Tame pasture can be kept vigorous through good grazing management and proper fertilization. The main concerns of management are controlling erosion and reducing runoff. The main limitations for urban uses are depth to limestone and soil permeability.

Nearly level to moderately sloping soils that formed in loess and residuum on uplands

These nearly level to moderately sloping soils make up about 66 percent of the survey area. They are in upland areas. Most of the acreage is cultivated. Corn, grain sorghum, soybeans, and wheat are the main crops. Some of the acreage is used for hay and tame pasture. The steeper rocky areas are used primarily for native grasses, woody plants, and wildlife habitat. The principal management concerns are controlling erosion and improving soil fertility and tilth. The main soil limitations for urban development are slow permeability, high shrink-swell potential, and depth to bedrock. Most of the active limestone quarries are in this group of map units.

6. Polo-Oska

Deep and moderately deep, well drained, moderately sloping soils that have a loamy or clayey subsoil; on uplands

This map unit consists of moderately sloping soils on concave and convex side slopes. Deep and moderately deep soils are on the upper side slopes, and moderately deep soils are on the lower side slopes (fig. 5).

This unit makes up about 42 percent of the county. It is about 40 percent Polo soils, 20 percent Oska soils, and 40 percent soils of minor extent.

Polo soils are deep, moderately sloping, and well drained soils on upper side slopes. These soils formed in loess over residuum from limestone. The surface layer is very dark brown silt loam. The upper part of the subsoil is very dark grayish brown and dark brown, firm silty clay loam, and the lower part of the subsoil is dark reddish brown, firm silty clay loam.

Oska soils are moderately deep, moderately sloping, and well drained soils that have convex to concave slopes. These soils are lower on the landscape than Polo soils. They formed in residuum from limestone. The surface layer is very dark grayish brown silty clay loam. The subsoil is dark brown, firm silty clay loam and dark reddish brown and dark brown, very firm silty clay. Depth to limestone is mainly 20 to 40 inches.

The soils of minor extent are Kennebec, Martin, Sharpsburg, Sogn, and Vinland soils. The deep Kennebec soils formed in alluvium and are next to drains. The deep Martin soils formed in material weathered from shale and are between rock outcrops and on lower side slopes. The shallow Sogn soils formed in residuum from limestone and are on side slopes. The shallow Vinland soils formed in residuum from interbedded sandstone and shale and are on steeper side slopes.

Most of the acreage is cultivated. Corn, grain sorghum, soybeans, and wheat are the main crops. The rest is used for hay, pasture, and woodland. Tame pasture can be kept vigorous through good grazing management, controlling erosion, and maintaining fertility and soil tilth. The main limitations for urban use are depth to bedrock and high shrink-swell potential.

7. Polo-Grundy

Deep, somewhat poorly drained and well drained, gently sloping and moderately sloping soils that have a loamy or clayey subsoil; on uplands

This map unit consists of gently sloping and moderately sloping soils on narrow ridgetops and upper side slopes. The deep soils are on the ridgetops and side slopes.

This unit makes up about 8 percent of the county. It is about 40 percent Polo soils, 30 percent Grundy soils, and 30 percent soils of minor extent.

Polo soils are deep, moderately sloping, and well drained soils on upper side slopes. These soils formed in loess over residuum from limestone. The surface layer is very dark brown silt loam. The upper part of the subsoil is very dark grayish brown and dark brown, firm silty clay loam, and the lower part of the subsoil is dark reddish brown, firm silty clay loam.

Grundy soils are deep, gently sloping, and somewhat poorly drained soils on narrow ridgetops. They formed in loess. The surface layer is black silt loam and silty clay loam. The subsoil is very dark gray, very firm silty clay and dark grayish brown and grayish brown, very firm silty clay. The substratum is grayish brown silty clay loam.

The soils of minor extent are Sharpsburg, Oska, and Sogn soils. The deep Sharpsburg soils formed in loess and are on upper side slopes. Oska soils are moderately deep, moderately sloping soils on side slopes. The shallow Sogn soils are moderately sloping to strongly sloping on side slopes.

Most of the acreage is cultivated. Corn, grain sorghum, soybeans, and wheat are the main crops. The rest is used for hay and tame pasture. The main concerns of management are controlling erosion and maintaining soil fertility and tilth. Urban and industrial development is occurring rapidly in the northeastern part of this map unit. The main limitations for urban use are high shrink-swell potential and slow permeability.

8. Woodson-Martin

Deep, somewhat poorly drained and moderately well drained, nearly level to moderately sloping soils that have a clayey subsoil; on uplands

This map unit consists of nearly level to moderately sloping soils on broad, flat ridgetops and upper side slopes in the southwest part of the county. These soils developed from old alluvium and clayey sediment, and in residuum from shale.

This map unit makes up about 12 percent of the county. It is about 60 percent Woodson soils, 20 percent Martin soils, and 20 percent soils of minor extent.

Woodson soils are nearly level and gently sloping, somewhat poorly drained soils on broad, convex ridgetops. These soils formed in loess or old clayey alluvial sediment. The surface layer is black silt loam. The subsoil is very dark gray and grayish brown, very firm silty clay. The substratum is very dark gray silty clay.

Martin soils are moderately sloping and moderately well drained soils on convex upper side slopes. These soils formed in residuum from silty shales. The surface layer is black and very dark grayish brown silty clay loam. The upper part of the subsoil is very dark grayish brown and dark grayish brown, very firm silty clay, and the lower part of the subsoil is grayish brown, very firm silty clay with many mottles.

The soils of minor extent are Kennebec, Oska, Polo, and Grundy soils. The deep Kennebec soils formed in alluvium and are adjacent to drains. The moderately deep Oska soils formed in residuum from limestone and usually are on side slopes and lower on the landscape than Martin soils. The deep Polo soils formed in loess over residuum and are in the same position as the Martin soils. The deep Grundy soils formed in loess and usually are on narrower ridgetops.

Most of the acreage in this unit is cultivated or planted to hay or tame pasture. Soybeans, grain sorghum, and wheat are the main crops. The main concerns of management are controlling water erosion, reducing runoff, and maintaining fertility. Good management practices are necessary in order to maintain tame pasture in a vigorous condition. The main limitations for urban use are soil permeability and high shrink-swell potential.

9. Sibleyville-Martin

Moderately deep and deep, well drained and moderately well drained, moderately sloping soils that have a loamy and clayey subsoil; on uplands

This map unit consists of moderately sloping soils on convex and concave side slopes. These soils formed in residuum from sandy and silty shale.

This map unit makes up about 4 percent of the county. It is about 55 percent Sibleyville soils, 20 percent Martin soils, and 25 percent soils of minor extent.

Sibleyville soils are moderately sloping and well drained soils on concave and convex side slopes. These soils formed in residuum from sandy shales, and they usually are lower on the landscape than the Martin soils. The surface layer is very dark brown loam. The upper part of the subsoil is very dark grayish brown, friable clay loam, and the lower part of the subsoil is dark brown, friable clay loam. The substratum is strong brown clay loam. Depth to weathered sandy shales is usually 30 to 40 inches.

Martin soils are moderately sloping and moderately well drained soils on upper side slopes. These soils formed in residuum from silty shale. The surface layer is black and very dark grayish brown silty clay loam. The upper part of the subsoil is very dark grayish brown and dark grayish brown, very firm silty clay, and the lower part of the subsoil is grayish brown, very firm silty clay with many mottles.

The soils of minor extent are Oska, Vinland, and Woodson soils. The moderately deep Oska soils formed in residuum from limestone and are on side slopes. The shallow Vinland soils formed in residuum from sandy and silty shales and are on steeper areas of the landscape. The deep Woodson soils formed in silty and clayey sediment and are on broad flat ridgetops.

Most of this unit is cultivated. The steeper areas are used mainly for pasture and wildlife. Corn, grain sorghum, soybeans, and wheat are the main crops. The main concerns of management for the soils in this unit are controlling erosion and maintaining soil fertility and tilth. The main limitations for urban development are depth to bedrock, soil permeability, and high shrink-swell potential.

Soil maps for detailed planning

The map units shown on the detailed soil maps at the back of this publication represent the kinds of soil in the survey area. They are described in this section. The descriptions together with the soil maps can be useful in determining the potential of a soil and in managing it for food and fiber production; in planning land use and developing soil resources; and in enhancing, protecting, and preserving the environment. More information for each map unit, or soil, is given in the section "Use and management of the soils."

Preceding the name of each map unit is the symbol that identifies the soil on the detailed soil maps. Each soil description includes general facts about the soil and a brief description of the soil profile. In each description, the principal hazards and limitations are indicated, and the management concerns and practices needed are discussed.

The map units on the detailed soil maps represent an area on the landscape made up mostly of the soil or soils for which the unit is named. Most of the delineations shown on the detailed soil map are phases of soil series.

Soils that have a profile that is almost alike make up a *soil series*. Except for allowable differences in texture of the surface layer or of the underlying substratum, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement in the profile. A soil series commonly is named for a town or geographic feature near the place where a soil of that series was first observed and mapped. The Eudora series, for example, was named for the town of Eudora in Douglas County.

Soils of one series can differ in texture of the surface layer or in the underlying substratum and in slope, erosion, stoniness, salinity, wetness, or other characteristics that affect their use. On the basis of such differences, a soil series is divided into phases. The name of a *soil phase* commonly indicates a feature that affects use or management. For example, Eudora silt loam is one of several phases within the Eudora series.

Some map units are made up of two or more dominant kinds of soil. Such map units are called soil complexes.

A *soil complex* consists of areas of two or more soils that are so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area includes some of each of the two or more dominant soils, and the pattern and proportion are somewhat similar in all areas. Sogn-Vinland complex is an example.

Most map units include small, scattered areas of soils other than those that appear in the name of the map unit. Some of these soils have properties that differ substantially from those of the dominant soil or soils and thus could significantly affect use and management of the map unit. These soils are described in the description of each map unit. Some of the more unusual or strongly contrasting soils that are included are identified by a special symbol on the soil map.

Most mapped areas include places that have little or no soil material and support little or no vegetation. Such places are called *miscellaneous areas*; they are delineated on the soil map and given descriptive names. Pits, quarries is an example. Some of these areas are too small to be delineated and are identified by a special symbol on the soil map.

The acreage and proportionate extent of each map unit are given in table 4, and additional information on properties, limitations, capabilities, and potentials for many soil uses is given for each kind of soil in other tables in this survey. (See "Summary of tables.") Many of the terms used in describing soils are defined in the Glossary.

Ca—Chase silt loam. This soil is deep, nearly level, and somewhat poorly drained or moderately well drained. It formed in alluvial sediment on low stream terraces along the major streams. It is subject to occasional flooding. Individual areas of this unit range from 5 to 200 acres in size.

Typically, the surface layer is very dark brown silt loam, about 10 inches thick. The subsoil is about 32 inches thick. The upper part of the subsoil is black and very dark gray, very firm silty clay. The substratum, to a depth of about 60 inches, is very dark gray silty clay loam. In places there is a light colored subsurface horizon, and in some areas the subsoil is less clayey.

Included with this soil in mapping and making up 5 to 10 percent of the map unit are small areas of very poorly drained Wabash soils. They are in nearly level or slightly depressional areas where clayey sediment has been deposited by backwater.

Permeability and runoff are slow. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is high. This soil is medium acid in the surface layer and in the subsoil.

Most areas of this soil are cultivated. The soil has good potential for hay, tame and native grasses, and trees. It has good potential for openland and woodland wildlife habitat and poor potential for most engineering uses.

This soil is well suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and wheat are the main crops. Management practices that include minimum tillage, proper management of crop residue, and adequate commercial fertilizers will maintain organic matter content, fertility, and soil tilth. This soil is subject to occasional flooding, but providing protection from flooding is generally not feasible.

Flooding, high shrink-swell potential, and low strength are severe limitations for dwellings on this soil. Constructing dikes and levees reduces the hazard of flooding. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by low strength and high shrink-swell potential.

Low strength and high shrink-swell potential are severe limitations for local roads and streets on this soil. This can be reduced by strengthening or replacing the base material.

The slow percolation rate is a severe limitation for septic tank absorption fields on this soil. Using a sewage lagoon or increasing the size of the absorption fields helps improve the function of the septic system. This soil has slight limitations for sewage lagoons. Occasional flooding and the clayey cover material are severe limitations for landfills on this soil. Capability subclass II*w*.

Ea—Eudora silt loam. This soil is deep, nearly level, and well drained. It formed in loamy alluvium on high bottom lands. Flooding is rare. Individual areas of this unit range from 10 to 200 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 13 inches thick. The substratum, to a depth of about 60 inches, is dark grayish brown and grayish brown, friable coarse silt loam and very friable very fine sandy loam. In some areas there is loamy or sandy overwash material covering this soil.

Included with this soil in mapping are small areas of the somewhat poorly drained Kimo soils in lower depressional areas where fine textured sediment has been deposited by backwater. Kimo soils make up about 10 percent of the unit.

Permeability is moderate, and runoff is slow. Available water capacity, natural fertility, and organic matter content are high. The shrink-swell potential is low. This soil is neutral in the surface layer, and mildly alkaline in the substratum.

Most areas of this soil are cultivated. The soil has good potential for hay, tame grasses, and trees. It has good potential for truck garden crops (fig. 6). It also has good potential for openland and woodland wildlife habitat.

This soil is well suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and small grains are the main crops. Management practices that include minimum tillage, proper management of crop residue, and adequate amounts of commercial fertilizers can improve soil tilth and reduce soil blowing.

Flooding is a severe limitation for dwellings on this soil. Constructing dikes and levees reduces the hazard of flooding. Frost action is a severe limitation for local roads and streets. This can be reduced by strengthening or replacing the base material.

Rare flooding is a moderate limitation for septic tank absorption fields. Seepage is a moderate limitation for sewage lagoons. This can be reduced by sealing the sides and bottom of the lagoon with more clayey soil material. Rare flooding is also a moderate limitation for landfills. Constructing dikes and levees reduces the hazard of flooding. Capability class I.

Eb—Eudora soils, overwash. These soils are deep, nearly level, and well drained. The soils are covered with overwash of lighter colored fine sand or very fine sand 10 to 20 inches thick. They formed in loamy alluvium on bottom lands. Flooding is rare. Individual areas range from 15 to 750 acres in size.

Typically, the Eudora soil has a layer of very dark grayish brown silt loam about 13 inches thick below the overwash. The substratum is about 47 inches thick. The upper part of the substratum is dark grayish brown, very friable very fine sandy loam. The middle part is dark grayish brown, friable coarse silt loam. The lower part is grayish brown, loose very fine sandy loam.

Most areas have been plowed to a depth of 18 to 24 inches. The surface layer is a mixture of silt loam, very fine sandy loam, fine sandy loam, and loamy very fine sand. In some places the soils are sandy throughout.

Included with these soils in mapping are small areas of somewhat poorly drained Kimo soils in depressions and low areas. They make up 10 to 15 percent of the map unit.

Permeability is moderate, and surface runoff is slow. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is low. These soils are neutral in the surface layer and mildly alkaline in the substratum.

Most areas of these soils are cultivated. These soils are especially well suited to vegetable crops that can be irrigated. They have good potential for hay, tame grasses, and trees.

These soils are suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and small grains are the main crops. Soil blowing is a hazard because the overwash layer is sandy. This hazard can be controlled by management practices that include minimum tillage and stubble mulching.

Flooding is a severe limitation for dwellings on these soils. Constructing dikes and levees reduces the hazard of flooding. Frost action is a severe limitation for local roads and streets. This can be reduced by strengthening or replacing the base material. Rare flooding is a moderate limitation for septic tank absorption fields on these soils. Seepage is a moderate limitation for sewage lagoons. This can be reduced by sealing the sides and bottom of the lagoon with more clayey soil material. Rare flooding is a moderate limitation for landfills. Constructing dikes and levees reduces the hazard of flooding. Capability class I.

Ec—Eudora-Kimo complex. These soils are nearly level to undulating and are on flood plains. Flooding is rare. Individual areas are 10 to 200 acres in size. This complex is about 60 to 80 percent Eudora soil and 20 to 30 percent Kimo soil. The Eudora soil is on higher parts of the landscape and the Kimo soil is in depressions. These soils are so intricately mixed and are in such narrow bands that it was not practical to map them separately.

Typically, the Eudora soil has a surface layer of very dark grayish brown silt loam about 13 inches thick. The substratum, to a depth of about 60 inches, is dark grayish brown and grayish brown, friable coarse silt loam and very friable very fine sandy loam. In some places the soils are sandy throughout.

Typically, the Kimo soil has a surface layer of very dark gray silty clay loam and silty clay about 20 inches thick. The next layer is very dark grayish brown, firm silty clay loam and is underlain by dark grayish brown silt loam at a depth of 24 inches. In some places the upper part of the soil is less clayey than is typical.

Permeability is moderate in the Eudora soil and slow in the Kimo soil. Runoff is slow. Available water capacity, organic matter content, and natural fertility are high. The Eudora soil has low shrink-swell potential, but the Kimo soil has high shrink-swell potential. The Eudora soil is neutral in the surface layer and mildly alkaline in the substratum. The Kimo soil is mildly alkaline in the surface layer and moderately alkaline in the substratum.

Most areas of these soils are cultivated. They have good potential for hay, tame grasses, and trees. They are especially well suited to vegetable crops that can be irrigated. They have good potential for openland wildlife habitat.

These soils are suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and small grains are the main crops. Soil blowing is a slight hazard on the Eudora soil, and ponding is a slight hazard on the Kimo soil. Soil blowing can be controlled by management practices that include minimum tillage and stubble mulching.

Flooding is a severe limitation for dwellings on these soils. The Kimo soil has high shrink-swell potential. Constructing dikes and levees reduces the hazard of flooding. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce the structural damage caused by high shrink-swell potential.

Frost action of the Eudora soil and low strength and high shrink-swell potential of the Kimo soil are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

The Eudora soil has rare flooding which is a moderate limitation for septic tank absorption fields. The Kimo soil has slow percolation rate and seasonal wetness. These are severe limitations for septic tank absorption fields. Using a sewage lagoon or increasing the size of the absorption field by installing perimeter drains helps improve the function of a septic system.

Seepage is a slight limitation for sewage lagoons on the Kimo soil and a moderate limitation for sewage lagoons on the Eudora soil. This can be reduced by sealing the sides and bottom of the lagoon with clayey soil material.

Flooding is a moderate limitation for landfills on the Eudora soil, and seasonal wetness is a severe limitation for landfills on the Kimo soil. Constructing dikes and levees reduces the hazard of flooding. Capability subclass II*w*.

Ed—Eudora-Kimo complex, overwash. These soils are nearly level to undulating and are on lower parts of flood plains. Flooding is rare. Individual areas are 50 to 200 acres in size. About 70 percent of this complex is Eudora soil, and 20 percent is Kimo soil. These soils are covered with 10 to 20 inches of lighter colored fine sand or very fine sand. Most areas have been deep plowed to a depth of 18 to 24 inches. The Eudora soil is on higher parts of the landscape and the Kimo soil is in depressions. These soils are in such narrow bands that it was not practical to map them separately.

The Eudora soil has a layer of dark grayish brown silt loam about 13 inches thick below the overwash. The substratum, to a depth of 60 inches, is dark grayish brown and grayish brown coarse silt loam and very friable very fine sandy loam. In some places the soil is sandy throughout.

The Kimo soil has a layer of very dark gray silty clay loam or silty clay about 20 inches thick below the overwash. The next layer is very dark grayish brown, firm silty clay loam. The substratum is dark grayish brown silt loam.

Permeability is moderate in the Eudora soil and slow in the Kimo soil. Runoff is slow. Available water capacity, organic matter content, and natural fertility are high. The Eudora soil has low shrink-swell potential, but the Kimo soil has high shrink-swell potential. The Eudora soil is neutral in the surface layer and mildly alkaline in the substratum. The Kimo soil is mildly alkaline in the surface layer and moderately alkaline in the substratum.

Most areas of these soils are cultivated. They have good potential for hay, tame grasses, and trees. They are especially well suited to vegetable crops that can be irrigated.

These soils are suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and small grains are the main crops. Wetness or ponding on the depressional Kimo soil following excessive rainfall (fig. 7) and soil blowing on the Eudora soil are moderate hazards. Stripcropping is recommended for areas where soil blowing is a problem. Surface drainage systems and land leveling corrects most wetness problems.

Rare flooding is a severe limitation for dwellings on these soils. The Kimo soil also has high shrink-swell potential. Constructing dikes and levees reduces the hazard of flooding. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce the structural damage caused by high shrink-swell potential.

Frost action of the Eudora soil and low strength and high shrink-swell potential of the Kimo soil are severe limitations for local roads and streets. This can be reduced by strengthening or replacing the base material.

Rare flooding is a moderate limitation for septic tank absorption fields on the Eudora soil. Slow percolation rate and seasonal wetness are severe limitations for septic tank absorption fields on the Kimo soil. Use of a sewage lagoon or increasing the size of the absorption field by installing perimeter drains helps improve the function of the septic system.

Seepage is a slight limitation for sewage lagoons on the Kimo soil and a moderate limitation for sewage lagoons on the Eudora soil. These limitations can be reduced by sealing the sides and bottom of the lagoon with clayey soil material.

Flooding is a moderate limitation for landfills on the Eudora soil, and seasonal wetness is a severe limitation for landfills on the Kimo soil. Constructing dikes and levees reduces the hazard of flooding. Capability subclass II*w*.

Ga—Grundy silt loam, 1 to 3 percent slopes. This soil is deep, gently sloping, and somewhat poorly drained. It is on narrow ridgetops, and it formed in loess. Individual areas range from 20 to 500 acres in size.

Typically, the surface layer is black silt loam and silty clay loam about 15 inches thick. The subsoil is about 29 inches thick. The upper part of the subsoil is very dark gray, very firm silty clay; the middle part is dark grayish brown, very firm silty clay loam; and the lower part is grayish brown, firm silty clay loam. The substratum is grayish brown silty clay loam. There are some small areas of soil that formed in glacial till. In some places depth to the clayey subsoil is less than typical, and in other areas the subsoil is less clayey.

Permeability is slow, and runoff is slow or medium. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is high. This soil is neutral in the surface layer and slightly acid in the subsoil.

Most areas of this soil are cultivated. The soil has good potential for hay, tame grasses, and trees. It has fair potential for most engineering uses and for openland wildlife habitat. In places this soil becomes waterlogged during periods of above average rainfall.

This soil is well suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and wheat are the main crops. Erosion is not a serious hazard, and it can be controlled by contour farming, minimum tillage, stubble mulching, or by a combination of these.

High shrink-swell potential and low strength are severe limitations for dwellings on this soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by low stength and high shrink-swell potential.

Low strength and high shrink-swell potential are severe limitations for local roads and streets on this soil. This can be lessened by strengthening or replacing the base material.

Slow percolation rate and seasonal wetness are severe limitations for septic tank absorption fields. Use of a sewage lagoon or increasing the size of the absorption field and installing perimeter drains help improve the function of the septic system. Slope is a moderate limitation for sewage lagoons. By placing lagoons in less sloping areas this can be reduced. Seasonal wetness and clayey cover material are moderate limitations for landfills. Capability subclass II*e*.

Ka—Kennebec silt loam. This soil is deep, nearly level, and moderately well drained. It is on bottom lands, and it formed in loamy alluvium along the major streams of the county. It is subject to occasional flooding. Individual areas range from 10 to 200 acres in size.

Typically, the surface layer is very dark grayish brown silt loam, about 36 inches thick. The next layer is very dark gray, friable silt loam about 12 inches thick. The substratum is very dark gray silt loam. In some places there is a more clayey subsoil than is typical.

Included with this soil in mapping are small areas of very poorly drained Wabash soils. They are more clayey throughout and are in nearly level to depressional areas adjacent to uplands. These inclusions make up about 5 percent of the unit.

Permeability is moderate, and runoff is slow. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is moderate. This soil is neutral in the surface layer and slightly acid in the substratum.

Most areas of this soil are cultivated. The soil has good potential for hay, tame grasses, and trees. It has good potential for openland and woodland wildlife habitat.

This soil is well suited to all crops grown in the county. Corn, grain sorghum, soybeans, and wheat are the main crops. Flooding is common, but in most years flooding is not of such a long duration as to seriously damage crops. Providing protection from flooding is generally not feasible. Management practices that include minimum tillage and adequate commercial fertilizers improve organic matter content and soil tilth.

Flooding is a severe limitation for dwellings on this soil. Constructing dikes and levees reduces the hazard of flooding. Frost action and low strength are severe limitations on this soil for local roads and streets. This can be reduced by strengthening or replacing the base material.

Occasional flooding and seasonal wetness are severe limitations for septic tank absorption fields. Installing perimeter drains helps improve the function of the septic system. Flooding is a severe limitation for sewage lagoons and landfills. Constructing dikes and levees reduces the hazard of flooding. Capability subclass II*w*.

Kb—Kennebec silt loam, channeled. This soil is nearly level and moderately well drained. It is on narrow flood plains that contain meandering stream channels and is subject to frequent flooding. This unit ranges from 150 to 400 feet wide. Individual areas range from 5 to 100 acres in size.

The surface layer is variable in color and texture as a result of recent deposits of silt loam or silty clay loam. Typically, it is very dark grayish brown silt loam about 36 inches thick. The next layer is very dark gray, friable silt loam about 12 inches thick. The substratum is very dark gray silt loam to a depth of 60 inches.

Included with this soil in mapping and making up 5 to 10 percent of the unit are small areas of Martin soils. They are on adjacent lower side slopes.

Permeability is moderate, and runoff is slow. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is moderate. This soil is neutral in the surface layer and slightly acid in the substratum.

Nearly all of this unit is used for pasture, woodland, or wildlife habitat. Only small areas are cultivated because of their inaccessibility and frequency of flooding.

Frequent flooding is a severe limitation for dwellings, local roads and streets, septic tank absorption fields, sewage lagoons, and landfills on this soil. Other areas that flood less frequently can be used. Constructing dikes and levees reduces the hazard of flooding. Capability subclass VI*w*.

Kc—Kimo silty clay loam. This soil is deep, nearly level, and somewhat poorly drained. It formed in alluvium consisting of clayey sediment underlain by coarse silty sediment. It is on slightly concave slopes of old meander scars. Flooding is rare. Individual areas of this unit range from 20 to 160 acres in size.

Typically, the surface layer is very dark gray silty clay loam over silty clay about 20 inches thick. The next layer is very dark grayish brown, firm silty clay loam about 4 inches thick. The substratum is dark grayish brown silt loam (fig. 8).

Included with this soil in mapping are small areas of the well drained Eudora soils and very poorly drained Wabash soils. The Eudora soils are slightly higher on the landscape than the Kimo soils and are less clayey in the upper part. Wabash soils are clayey throughout and usually are on the major tributaries of upland drains. These inclusions make up about 15 percent of the unit.

Permeability and runoff are slow. Available water capacity, organic matter content, and natural fertility are high.

The shrink-swell potential is high. This soil is mildly alkaline in the surface layer and moderately alkaline in the substratum. A high water table exists at a depth greater than 2 feet.

Most areas of this soil are cultivated. The soil has good potential for water tolerant grasses and trees.

This soil is suited to all crops grown in the county. Corn, grain sorghum, soybeans, and wheat are the main crops. Wetness is the main problem caused by ponding or rare flooding. Management practices that include minimum tillage, proper crop residue management, and adequate commercial fertilizers will improve organic matter content and soil tilth.

Rare flooding and high shrink-swell potential are severe limitations for dwellings on this soil. Constructing dikes and levees reduces the hazard of flooding. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce the structural damage caused by high shrink-swell potential. Low strength and high shrink-swell potential are severe limitations for local roads and streets. This can be reduced by strengthening or replacing the base material.

Slow percolation rate and seasonal wetness are severe limitations for septic tank absorption fields. Use of a sewage lagoon or increasing the size of the absorption field by installing perimeter drains helps improve the function of the septic system. This soil has slight limitations for sewage lagoons. Seasonal wetness is a severe limitation for landfills. Capability subclass II*w*.

La—Ladoga silt loam, 3 to 8 percent slopes. This soil is deep, moderately sloping, and moderately well drained. It is on narrow ridgetops and convex side slopes. It formed in loess. Individual areas of this map unit range from 20 to 200 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 8 inches thick. The subsurface layer is dark brown silt loam about 5 inches thick. The subsoil, to a depth of 60 inches, is dark yellowish brown, firm silty clay loam. In some places the surface layer is darker colored than is typical.

Included with this soil in mapping are small areas of Martin soils. They are darker colored and more clayey throughout than Ladoga soils. Martin soils are on lower side slopes and lower on the landscape than Ladoga soils, and they make up about 10 percent of the unit.

Permeability is moderately slow, and runoff is medium. Available water capacity is high, organic matter content is moderate, and natural fertility is medium. The shrink-swell potential is moderate. This soil is slightly acid in the surface layer and medium acid in the subsoil.

Most areas of this soil are cultivated. The soil has good potential for tame grasses and woodland. It has good potential for woodland wildlife habitat.

This soil is well suited to most crops commonly grown in the county. The principal crops are wheat and grain sorghum and only a limited amount of corn and soybeans. Water erosion is a serious hazard, but it can be controlled by terraces, contour farming, minimum tillage, stubble mulching, or a combination of these practices. These same management practices will improve organic matter content and soil tilth.

Moderate shrink-swell potential is a moderate limitation for dwellings on this soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by moderate shrink-swell potential. Frost action and low strength are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Moderately slow percolation rate is a severe limitation for septic tank absorption fields. Use of a sewage lagoon or increasing the size of the absorption field helps improve the function of the septic system. Slope is a moderate limitation for sewage lagoons. Lagoons need to be placed in less sloping areas. Clayey cover material is a moderate limitation for landfills. Capability subclass III*e*.

Lb—Ladoga silt loam, 8 to 15 percent slopes. This soil is deep, strongly sloping, and moderately well drained. It is on strongly dissected uplands and formed in loess. Individual areas of this unit range from 10 to 150 acres in size.

Typically, the surface layer is very dark grayish brown silt loam about 8 inches thick. The subsurface layer is dark brown silt loam about 5 inches thick. The subsoil is dark yellowish brown, firm silty clay loam. In some places the surface layer is darker colored than is typical.

Included with this soil in mapping are small areas of Martin soils and Vinland soils. The Martin soils formed in material that weathered from shale, and they are on lower side slopes. Vinland soils are shallow, somewhat excessively drained, and formed in residuum from interbedded sandstone and shale. These inclusions make up about 15 percent of this map unit.

Permeability is moderately slow, and runoff is rapid. Available water capacity is high, organic matter content is moderate, and natural fertility is medium. The shrink-swell potential is moderate. This soil is slightly acid in the surface layer and medium acid in the subsoil.

Much of the acreage is cleared. This soil has good potential for tame grasses, which respond well to fertilizer and can be kept vigorous if they are under good grazing management. It has limited potential for small grain if it is farmed on the contour and if residue is managed for erosion control. It has slight limitations for woodland development and fair to good potential for woodland wildlife habitat. Woodland stand reduction and selective cutting are needed.

Moderate shrink-swell potential is a moderate limitation for dwellings on this soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by moderate shrink-swell potential. Frost action and low strength are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Moderately slow percolation rate is a severe limitation for septic tank absorption fields. Use of a sewage lagoon or increasing the size of the absorption field helps improve the function of the septic system. Slope is a severe limitation for sewage lagoons. Lagoons need to be placed in less sloping areas. Clayey cover material is a moderate limitation for landfills. Capability subclass IV*e*.

Ma—Martin silty clay loam, 2 to 5 percent slopes. This soil is deep, moderately sloping, and moderately well drained. It is on convex upper side slopes and convex lower side slopes. This soil formed in residuum from shales. In most areas the soil in this map unit is below limestone outcrops. Individual areas of this unit range from 10 to 300 acres in size.

Typically, the surface layer is black and very dark grayish brown silty clay loam, about 15 inches thick. The subsoil to a depth of 60 inches is very dark grayish brown, dark grayish brown, and grayish brown, very firm silty clay (fig. 9). In some places the change to a dense clayey subsoil is more abrupt than is typical.

Included with this soil in mapping are small areas of well drained Oska soils and somewhat excessively drained Vinland soils. Oska soils are underlain by limestone at a depth of 20 to 40 inches. Vinland soils are shallow and usually are on steeper slopes. These inclusions make up about 10 percent of the unit.

Permeability is slow, and runoff is medium. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is high. This soil is mildly alkaline to slightly acid in the surface layer and slightly acid in the subsoil.

Most areas of this soil are cultivated. The soil has good potential for hay and tame pasture. It has good potential for openland wildlife habitat.

This soil is well suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and wheat are the main crops. Erosion is a serious hazard, but it can be controlled by the use of terraces, contour farming, minimum tillage, stubble mulching, or a combination of these practices. These management practices also will improve organic matter content and soil tilth.

High shrink-swell potential is a severe limitation for dwellings on this soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by high shrink-swell potential. Low strength and high shrink-swell potential are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Slow percolation rate is a severe limitation for septic tank absorption fields. Use of a sewage lagoon or increasing the size of the absorption field helps improve the function of the septic system. Slope is a moderate limitation for sewage lagoons. Lagoons need to be placed in less sloping areas. Clayey cover material is a severe limitation for landfills. Capability subclass III*e*.

Mb—Martin-Vinland silty clay loams, 7 to 15 percent slopes. This soil is strongly sloping and is on convex and concave slopes below limestone outcrops. Individual areas are mostly elongated and narrow, ranging from 200 to 1,000 feet wide, and they are between 10 and 600 acres in size. About 35 to 45 percent of this unit is the Martin soil, and about 30 to 40 percent is the Vinland soil. The Vinland soil is in the steeper areas below the rock outcrops, and the Martin soil is on the lower side slopes. These soils are in such narrow areas that it was not practical to map them separately.

Typically, the Martin soil has a surface layer of black and very dark grayish brown silty clay loam about 15 inches thick. The subsoil to a depth of 60 inches is very dark grayish brown, dark grayish brown, and grayish brown, very firm silty clay.

Typically, the Vinland soil has a surface layer of very dark grayish brown silty clay loam about 4 inches thick. The subsoil is very dark grayish brown, firm silty clay loam about 7 inches thick. The substratum is olive brown silty clay loam. Depth to weathered interbedded sandy and silty shales is about 18 inches. In some places the depth to shales is 20 to 40 inches.

Included with these soils in mapping and making up about 10 percent of the unit are small areas of Sogn soils and rock outcrops. Rock outcrops are in narrow areas near the center of this mapping unit or at higher elevations than the Martin and Vinland soils. Sogn soils are immediately above the rock outcrops.

Permeability is slow in the Martin soil and moderate in the Vinland soil. Available water capacity is high for the Martin soil and low for the Vinland soil. Organic matter content is high for the Martin soil and moderate for the Vinland soil. Natural fertility is high for the Martin soil and medium for the Vinland soil. The shrink-swell potential is high for the Martin soil and moderate for the Vinland soil. The Martin soil is mildly alkaline in the surface layer and slightly acid in the subsoil. The Vinland soil is slightly acid in the surface layer and medium acid in the subsoil.

Most of the acreage of this map unit is used for pasture. It is best suited to tame pasture, which responds well to fertilizer and can be kept vigorous if it is under good grazing management. Only small acreages are cultivated because of the severe hazard of erosion. It has good to fair potential for openland wildlife habitat.

High shrink-swell potential is a severe limitation for dwellings on the Martin soil. Depth to bedrock is a moderate limitation for dwellings on the Vinland soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by high shrink-swell potential.

Low strength and high shrink-swell potential on the Martin soil are severe limitations for local roads and streets. Depth to bedrock is a moderate limitation on the

Vinland soil. Low strength can be reduced by strengthening or replacing the base material.

Slow percolation rate of the Martin soil and depth to bedrock of the Vinland soil are severe limitations for septic tank absorption fields. Slope and depth to bedrock are severe limitations for sewage lagoons on these soils. Using deep soils in less sloping areas for sewage lagoons reduces the severity of these limitations. Clayey cover material is a severe limitation for landfills on the Martin soil. The Vinland soil is shallow to bedrock. Capability subclass VI*e*.

Mc—Morrill loam, 3 to 8 percent slopes. This soil is deep, moderately sloping, and well drained. It is on upper side slopes and formed in moderately coarse textured glacial till. Individual areas of this map unit range from 10 to 200 acres in size.

Typically, the surface layer is very dark brown loam about 9 inches thick. The subsoil is about 30 inches thick. The upper part of the subsoil is very dark grayish brown, friable loam, and the lower part is dark brown and brown, firm clay loam. The substratum is brown clay loam. In some places the soil is more clayey throughout than is typical.

Included with this soil in mapping are small areas of the somewhat poorly drained Grundy soil and the moderately well drained Ladoga soil. These soils are on ridgetops, and they formed in loess. The Ladoga soil has a subsurface layer. These inclusions make up about 15 to 20 percent of the unit.

Permeability is moderately slow, and runoff is medium. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is moderate. This soil is neutral in the surface layer and slightly acid or medium acid in the subsoil.

Most of the acreage is cultivated. This soil is better suited to grain sorghum, soybeans, and small grain than to other crops. It is also suited to alfalfa, tame pasture, and woodland. Erosion is a serious hazard, but it can be controlled by the use of terraces, contour farming, minimum tillage, stubble mulching, or a combination of these practices.

Moderate shrink-swell potential and low strength are moderate limitations for dwellings on this soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce the structural damage caused by low strength and moderate shrink-swell potential.

Moderate shrink-swell potential and low strength are moderate limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Moderately slow percolation rate is a severe limitation for septic tank absorption fields. Use of a sewage lagoon or increasing the size of the absorption fields helps improve the function of the septic system. Slope is a moderate limitation for sewage lagoons. Lagoons need to be placed in less sloping areas. Clayey cover material is a moderate limitation for landfills. Capabilty subclass III*e*.

Oa—Orthents. This map unit is made up of areas where soil material has been excavated and used as fill material for roads. Individual areas range from 10 to 100 acres in size. They are on uplands and bottom lands. Most areas are excavated to a depth of more than 4 feet, and in many places the excavations have been made to the depth of limestone or shale bedrock.

In areas of Orthents on bottom lands, the upper part of the soil profile has been removed during excavation and the less fertile underlying material is exposed. Some of these areas are farmed, but low fertility, frequent flooding, and ponding are hazardous to crops. Orthents are not placed in a capability grouping.

Ob—Oska silty clay loam, 3 to 6 percent slopes. This soil is moderately deep, moderately sloping, and well drained. It is on convex ridgetops and upper side slopes. It formed in residuum from limestone or interbedded limestone and shales. This soil usually is above limestone or limestone outcrops. Individual areas range from 10 to 300 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 8 inches thick. The subsoil is dark brown, firm silty clay loam and dark reddish brown and dark brown, very firm silty clay. Depth to limestone is about 32 inches. In some places depth to limestone is more than 40 inches.

Included with this soil in mapping are small areas of Sogn and Vinland soils. Sogn soils are shallow over limestone, and Vinland soils are shallow over shale. These soils are somewhat excessively drained and are on steeper slopes below the Oska soil. These inclusions make up about 10 to 15 percent of the unit.

Permeability is slow, and runoff is medium. Available water capacity is low. Organic matter content and natural fertility are high. The shrink-swell potential is high. This soil is medium acid in the surface layer and neutral in the subsoil.

Most of the acreage is cultivated. This soil is better suited to wheat and grain sorghum. It is well suited to tame grass and hay. It has good potential for openland wildlife habitat. Erosion is a serious hazard, but it can be controlled by the use of terraces, contour farming, minimum tillage, or a combination of these. Adequate commercial fertilizer, along with these practices, maintains soil tilth and organic matter content.

High shrink-swell potential is a severe limitation for dwellings on this soil. Placing foundations on bedrock and using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by this limitation. High shrink-swell potential is also a severe limitation for local roads and streets. This can be reduced by strengthening or replacing the base material.

Slow percolation rate and depth to bedrock are severe limitations for septic tank absorption fields. Using a sewage lagoon or connecting to a public or commercial sewer helps reduce the severity of these limitations. Depth to bedrock is a severe limitation for sewage lagoons. Onsite investigation may be needed to determine the location of deeper soils that are suitable for sewage lagoons. Depth to bedrock is also a severe limitation for landfills. Capability subclass III*e*.

Oc—Oska-Martin silty clay loams, 4 to 8 percent slopes. These soils are deep and moderately deep, moderately sloping, and moderately well drained and well drained. It is above limestone outcrops. Individual areas of this map unit range from 40 to 500 acres in size, and contain 40 to 60 percent Oska soil and 25 to 35 percent Martin soil. These soils formed in material weathered from interbedded limestone and shales. These soils are in narrow areas, and it was not practical to map them separately.

Typically, the Oska soil has a surface layer of very dark grayish brown silty clay loam about 8 inches thick. The subsoil is about 24 inches thick. The upper part of the subsoil is dark brown, firm silty clay loam, and the lower part is dark reddish brown and dark brown, very firm silty clay. Limestone is at a depth of 32 inches.

Typically, the Martin soil has a surface layer of black and very dark grayish brown silty clay loam about 15 inches thick. The subsoil to a depth of 60 inches is very dark grayish brown, dark grayish brown, and grayish brown, very firm silty clay.

Included with these soils in mapping and making up 5 to 15 percent of the unit are small areas of Sharpsburg, Sibleyville, Sogn, and Vinland soils. Sharpsburg soils formed from loess, have browner colors than the Martin soil and become less clayey with depth. These soils are higher on the landscape than the Martin soil and are on the upper side slopes or ridgetops. Sibleyville soils are moderately deep over weathered sandstone, are lower on the landscape than Oska and Martin soil, and are on convex side slopes. Sogn soils are shallow over limestone. Vinland soils are shallow over shale. They are on steeper slopes adjacent to the drainageways.

Permeability is slow in the Oska and Martin soils. Available water capacity is high for the Martin soil and low for the Oska soil. Runoff is medium for these soils, and organic matter content and natural fertility are high.

Most areas of these soils were cultivated, but many are now used for brome hay or pasture. They have good potential for openland wildlife habitat and poor potential for most engineering uses.

If cultivated, these soils are better suited to small grain crops or grain sorghum than to other crops. Management practices that include minimum tillage, proper management of crop residue, and adequate commercial fertilizers maintain organic matter content, fertility, and soil tilth. Terraces and contour farming can be used to control runoff.

The soils in this unit are better suited to some type of permanent grass cover. Management practices should include proper stocking rates, uniform grazing distribution, timely deferment of grazing, and a planned grazing system to help keep the range and soil in good condition. Potential pond reservoir sites are plentiful, but they should be located in areas of deeper soils.

High shrink-swell potential is a severe limitation for dwellings on these soils. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by high shrink-swell potential. Low strength and high shrink-swell potential are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Slow percolation rate and depth to bedrock of the Oska soil are severe limitations for septic tank absorption fields on these soils. Using a sewage lagoon or connecting to a public or commercial sewer helps reduce the severity of these limitations. Depth to rock is a severe limitation for sewage lagoons on the Oska soil, and slope is a moderate limitation for sewage lagoons on the Martin soil. Sewage lagoons may be constructed in less sloping areas of the Martin soil, and deeper areas of the Oska soil should be used. Clayey cover material of the Martin soil and moderate depth to bedrock of the Oska soil are severe limitations for landfills on these soils. Capability subclass IV*e*.

Pa—Pawnee clay loam, 3 to 6 percent slopes. This soil is deep, moderately sloping, and moderately well drained. It is on plane and convex upper side slopes and formed in moderately fine textured glacial till. Individual areas of this map unit range from 15 to 400 acres in size.

Typically, the surface layer is black clay loam about 8 inches thick. The subsoil is about 41 inches thick. The upper part of the subsoil is very dark grayish brown, firm clay loam; the middle part is black and dark grayish brown, very firm clay; and the lower part is dark grayish brown, very firm clay loam. The substratum is dark grayish brown and dark brown clay loam. In some places the soils are less clayey throughout than is typical.

Included with this soil in mapping are small areas of Grundy and Woodson soils. Grundy soils formed in loess, do not have glacial sands and gravels, and are on adjacent ridgetops. Woodson soils do not have glacial sands and gravels and are on broad flat ridgetops. These inclusions make up about 15 to 20 percent of the map unit.

Permeability is slow, and runoff is medium. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is high. This soil is slightly acid in the surface layer and mildly alkaline or neutral in the subsoil.

Most of the acreage is cultivated. This soil is better suited to wheat, grain sorghum, and soybeans than to other crops. It is well suited to tame pasture and hay. It has fair potential for openland and rangeland wildlife habitat. Erosion can be controlled by the use of contour farming, minimum tillage, stubble mulching, or by a combination of these. Management is essential to maintaining fertility and tilth.

High shrink-swell potential is a severe limitation for dwellings on this soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by high shrink-swell potential. High shrink-swell potential is also a severe limitation for local roads and streets. This can be reduced by strengthening or replacing the base material.

Slow percolation rate is a severe limitation for septic tank absorption fields. Use of a sewage lagoon or increasing the size of the absorption field improves the function of the septic system. Slope is a moderate limitation for sewage lagoons. The lagoon should be constructed in less sloping areas. Clayey cover material is a severe limitation for landfills. Capability subclass III*e*.

Pc—Polo silt loam, 2 to 5 percent slopes. This soil is deep, moderately sloping, and well drained. It is on upper side slopes and formed in loess over residuum from limestone. Individual areas range from 15 to 1,200 acres in size.

Typically, the surface layer is very dark brown silt loam about 13 inches thick. The subsoil is very dark grayish brown, dark brown, and dark reddish brown, firm silty clay loam. In some places depth to limestone is less than 40 inches. Also in some places the soils are more clayey throughout than is typical. Some areas do not have the redder colors that are characteristic of the lower part of the subsoil.

Permeability is moderate, and runoff is medium. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is high. This soil is slightly acid in the surface layer and medium acid in the subsoil.

Most areas of this soil are cultivated. It has good potential for hay and tame grasses. It has good potential for openland wildlife habitat. It has fair potential for most engineering uses.

This soil is well suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and wheat are the main crops. Management practices that include minimum tillage, proper use of crop residue, and adequate commercial fertilizers help maintain organic matter content, fertility, and soil tilth.

High shrink-swell potential is a severe limitation for dwellings on this soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by high shrink-swell potential.

Low strength and high shrink-swell potential are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material. This soil has slight limitations for septic tank absorption fields. Slope and seepage are moderate limitations for sewage lagoons. These limitations can be reduced by sealing the sides and bottom of the lagoon with more clayey soil material. Clayey cover material is a moderate limitation for landfills. Capability subclass III*e*.

Qa—Pits, quarries. This map unit consists of areas where limestone has been removed to be used as building stone or as crushed limestone for concrete aggregate, roadstone, and agricultural lime. Individual areas range from 5 to 150 acres in size.

About half of these quarries are active today. Most of these areas consist of piles or mounds of reworked overburden material and limestone or shale basins. These basins usually have areas of water pockets with a few trees and weeds. Depth of these quarries ranges to about 100 feet.

Most areas of this unit are not suited for any kind of good vegetative cover because of the absence of topsoil. This unit has severe limitations for most uses. The abandoned quarries could possibly be used for parks, hiking trails, or camping areas. Some areas of this unit can be used for wildlife habitat. Pits, quarries are not placed in a capability grouping.

Ra—Reading silt loam. This soil is deep, nearly level, and well drained. It is on high bottom lands along the major streams in the county. This soil formed in moderately fine textured alluvium. Flooding is rare. Individual areas range from 10 to 160 acres in size.

Typically, the surface layer is very dark gray silt loam and silty clay loam about 15 inches thick. The subsoil is very dark grayish brown and dark brown, firm silty clay loam about 26 inches thick. The substratum is dark yellowish brown silty clay. In some places there is a light colored subsurface horizon. Also in some places the soil is less clayey throughout.

Included with this soil in mapping are small areas of somewhat poorly drained and moderately well drained Chase soils and very poorly drained Wabash soils. Chase soils have a more clayey subsoil than the Reading soil and are on low stream terraces. Wabash soils are more clayey throughout than the Reading soil and are in nearly level to depressional areas adjacent to the uplands. These inclusions make up about 15 percent of the unit.

Permeability is moderately slow, and runoff is slow. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is moderate. This soil is neutral in the surface layer and in the subsoil.

Most areas of this soil are cultivated. The soil has good potential for hay, tame grasses, and trees. It has good potential for openland and woodland wildlife habitat. It has fair potential for most engineering uses.

This soil is well suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and wheat are the main crops. Management practices that include minimum tillage and adequate commercial fertilizers help maintain organic matter content, fertility, and soil tilth.

Rare flooding is a severe limitation for dwellings on this soil. Constructing dikes and levees reduces the hazard of flooding. Low strength and frost action are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Moderately slow percolation rate is a moderate limitation for septic tank absorption fields. Increasing the size of the absorption field helps improve the function of the septic system. Seepage is a moderate limitation for sewage lagoons. This can be reduced by sealing the sides and bottom of the lagoon with more clayey soil material. Rare flooding is a moderate limitation for landfills. Constructing dikes and levees reduces the hazard of flooding. Capability class I.

Sa—Sharpsburg silt loam, 3 to 8 percent slopes. This soil is deep, moderately sloping, and moderately well drained. It is on upper side slopes and narrow ridgetops and formed in loess. Individual areas range from 10 to 400 acres in size.

Typically, the surface layer is very dark grayish brown silt loam and silty clay loam about 13 inches thick. The subsoil is dark brown, firm silty clay loam. In some places the subsoil is more clayey. Also in some places the surface layer is thinner and lighter colored.

Included with this soil in mapping and making up 10 to 15 percent of the unit are small areas of moderately well drained Martin soils and well drained Oska soils. Martin soils are on side slopes and are lower on the landscape than the Sharpsburg soil. Oska soils are browner than the soil in this unit and are underlain by limestone at a depth of 20 to 40 inches.

Permeability is moderately slow, and runoff is medium. Available water capacity, organic matter content, and natural fertility are high. The shrink-swell potential is high. This soil is neutral to slightly acid in the surface layer and slightly acid to medium acid in the subsoil.

Most areas of this soil are cultivated. The soil has good potential for openland and woodland wildlife habitat. It has fair potential for most engineering uses.

This soil is well suited to all crops commonly grown in the county. Corn, grain sorghum, soybeans, and wheat are the main crops. Erosion is a hazard, but it can be controlled by contour farming, minimum tillage, stubble mulching, or a combination of these. Adequate commercial fertilizers along with these practices help maintain natural fertility and soil tilth.

High shrink-swell potential is a severe limitation for dwellings on this soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by high shrink-swell potential. Low strength and high shrink-swell potential are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Moderately slow percolation rate is a severe limitation for septic tank absorption fields. Increasing the size of the absorption field helps improve the function of the septic system. Slope is a moderate limitation for sewage lagoons. Lagoons should be placed in less sloping areas. Clayey cover material is a moderate limitation for landfills. Capability subclass III*e*.

Sb—Sharpsburg-Urban land complex, 3 to 8 percent slopes. This map unit is made up of areas of Urban land and deep, moderately sloping, and moderately well drained soils on upper side slopes and narrow ridgetops. Individual areas of this unit range from 15 to 2,500 acres in size and contain from 40 to 50 percent Sharpsburg soil and from 30 to 40 percent Urban land. The Sharpsburg soil and the Urban land areas are so intricately mixed or so small in size, that it was not practical to map them separately.

Typically, the Sharpsburg soil has a surface layer of very dark grayish brown silt loam and silty clay loam about 13 inches thick. The subsoil is dark brown, firm silty clay loam. In some places the soil has been altered. Some of the low areas have been filled or leveled during construction, and other small areas have been cut.

The Urban land part of the unit is covered with streets, buildings, parking lots, and other structures that obscure or alter the soils to the extent that the original soil is no longer identifiable.

Included with this complex in mapping are small areas of Grundy, Oska, and Sogn soils. The somewhat poorly drained Grundy soils have more clay in the subsoil and are on higher ridgetop positions in the landscape than the Sharpsburg soil. The well drained Oska soils are moderately deep over limestone and are lower on the landscape than the Sharpsburg soil. The somewhat excessively drained Sogn soils are shallow over limestone and are also lower on the landscape than the Sharpsburg soil.

Many areas of this map unit are drained by sewer systems and concrete lined drainage ditches. Permeability of the Sharpsburg soil is moderately slow, and runoff is medium or rapid. Available water capacity, organic matter content, and natural fertility are high for the Sharpsburg soil. The shrink-swell potential is also high. This soil is neutral to slightly acid in the surface layer and slightly acid to medium acid in the subsoil.

The Sharpsburg soil is used for parks, open space, building sites, lawns, and gardens. It has good potential for lawns, vegetable and flower gardens, trees, and shrubs. It has poor potential for most engineering uses. Soil erosion is a major problem in this map unit, especially during periods of construction when these soils are disturbed and left bare for a considerable period of time. Management practices that include planting quick-growing vegetative ground cover or installing sediment basins help control erosion and keep the sediment from leaving the site.

High shrink-swell potential is a severe limitation for dwellings on Sharpsburg soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by high shrink-swell potential. Low strength and high shrink-swell potential are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Moderately slow percolation rate is a severe limitation for septic tank absorption fields. Increasing the size of the absorption field helps improve the function of the septic system. Slope is a moderate limitation for sewage lagoons. Lagoons should be placed in less sloping areas. Clayey cover material is a moderate limitation for landfills. Not placed in a capability grouping.

Sc—Sibleyville loam, 3 to 7 percent slopes. This soil is moderately deep, moderately sloping, and well drained. It is on convex side slopes and formed in residuum from sandstone and shales. Individual areas range from 5 to 120 acres in size.

Typically, the surface layer is very dark brown loam, about 8 inches thick. The subsoil is about 14 inches thick. The upper part of the subsoil is very dark grayish brown, friable clay loam, and the lower part is dark brown, friable clay loam. The substratum is strong brown clay loam. Depth to weathered sandstone is about 29 inches. In some places the depth to sandstone is more than 40 inches, and in other places the depth to sandstone and shale is less than 20 inches.

Included with this soil in mapping are small areas of Martin and Woodson soils. The moderately well drained Martin soils are deep, clayey, and are on lower side slopes than the Sibleyville soil. The somewhat poorly drained Woodson soils are deep, clayey, and are on adjacent ridgetops. These inclusions make up about 15 percent of the unit.

Permeability is moderate, and runoff is medium. Available water capacity and organic matter content are moderate. Natural fertility is medium. The shrink-swell potential is low. This soil is slightly acid in the surface layer and slightly acid to medium acid in the subsoil.

About half of the acreage of this soil is in grass and half is cultivated. It has good potential for hay and tame grasses. It has good potential for openland and rangeland wildlife habitat. It has fair potential for most engineering uses.

This soil is well suited to most crops commonly grown in the county. Grain sorghum and small grains are the main crops. Erosion is a serious hazard, but it can be controlled by contour farming, minimum tillage, stubble mulching, or by a combination of these. Fertility and organic matter content can be increased by applying farm manure and growing green manure crops. About half of this area is used for pasture or hay. Good grazing management is needed to keep tame and native pasture vigorous. Tame pasture responds well to fertilizer and lime.

Depth to bedrock and low strength are moderate limitations for dwellings on this soil. Placing foundations on bedrock, using properly designed and reinforced foundations, and installing foundation drains reduce structural damage caused by low strength. Low strength and frost action are moderate limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Depth to bedrock is a severe limitation for septic tank absorption fields. Using a sewage lagoon or connecting to a public or commercial sewer reduces the severity of this limitation. Depth to bedrock is also a severe limitation for sewage lagoons. Onsite investigation may be needed to determine areas of deeper soils where sewage lagoons may be constructed. Depth to bedrock is a severe limitation for landfills. Capability subclass III*e*.

Sd—Sibleyville-Vinland loams, 3 to 7 percent slopes. This map unit is made up of moderately deep and shallow, moderately sloping, and well drained and somewhat excessively drained soils on convex side slopes. These soils formed in residuum from sandstone and shales. Individual areas range from 5 to 100 acres in size and contain about 40 to 50 percent Sibleyville soils and 30 to 40 percent Vinland soils. These soils are so intricately mixed and are in such narrow areas that it was not practical to map them separately.

Typically, the Sibleyville soil has a surface layer of very dark brown loam about 8 inches thick. The subsoil is about 14 inches thick. The upper part of the subsoil is very dark grayish brown, friable clay loam, and the lower part is dark brown, friable clay loam. The substratum is strong brown clay loam. Depth to weathered sandstone is about 29 inches.

Typically, the Vinland soil has a surface layer of very dark grayish brown loam about 4 inches thick. The subsoil is very dark grayish brown, firm silty clay loam about 7 inches thick. The substratum is olive brown silty clay loam. Depth to weathered interbedded sandy and silty shales is about 18 inches.

Included with these soils in mapping and making up 10 to 15 percent of the unit are small areas of Martin and Sogn soils. The moderately well drained Martin soils contain more clay, are deeper, and are on lower, less sloping side slopes or foot slopes than the soils of this map unit. The somewhat excessively drained Sogn soils are shallow to limestone and are on breaks and upper side slopes.

Permeability is moderate for both the Sibleyville soil and the Vinland soil. Runoff is medium. Available water capacity is moderate for the Sibleyville soil and low for the Vinland soil. Organic matter content is moderate, and natural fertility is medium for these soils. The shrink-swell potential is low for the Sibleyville soil and moderate for the Vinland soil. Both soils are slightly acid in the surface layer and medium acid in the subsoil.

Most of the acreage of this unit is used for pasture. It is better suited to tame pasture, which responds well to fertilizer and can be kept vigorous under good grazing management.

The soils in this map unit have good potential for openland and rangeland wildlife habitat. They have fair to poor potential for most engineering uses. Only small acreages are cultivated because of shallow soils and the severe erosion hazard. Grain sorghum and small grains are the most common crops. Minimum tillage and proper management of residue are needed to help control erosion.

Depth to bedrock and low strength are moderate limitations for dwellings on these soils. Placing foundations on bedrock, using properly designed and reinforced foundations, and installing foundation drains reduce structural damage caused by low strength. Low strength and frost action of the Sibleyville soil and shallow depth to bedrock of the Vinland soil are moderate limitations for local roads and streets. The low strength and frost action can be offset by strengthening or replacing the base material.

Depth to bedrock is a severe limitation for septic tank absorption fields and sewage lagoons. Using other soils or connecting to a public or commercial sewer helps reduce the severity of this limitation. Depth to bedrock is a severe limitation for landfills. Capability subclass IV*e*.

Se—Sogn-Vinland complex, 5 to 20 percent slopes. This map unit is made up of shallow, moderately sloping to moderately steep, and somewhat excessively drained soils on breaks or upper side slopes. These soils formed in residuum from limestone and shales (fig. 10). Individual areas range from 5 to 200 acres in size and contain about 40 to 50 percent Sogn soil and 25 to 30 percent Vinland soil. These soils are in such small or narrow areas that it was not practical to map them separately.

Typically, the Sogn soil has a surface layer of very dark brown silt loam and silty clay loam about 9 inches thick. Depth to limestone is about 9 inches (fig. 11).

Typically, the Vinland soil has a surface layer of very dark grayish brown silty clay loam about 4 inches thick. The subsoil is very dark grayish brown, firm silty clay loam about 7 inches thick. The substratum is olive brown silty clay loam. Depth to weathered interbedded sandy and silty shales is about 18 inches.

Included with these soils in mapping and making up 15 to 25 percent of the unit are small areas of Martin and Oska soils and rock outcrops. The moderately well drained Martin soils contain more clay and are deeper than the Sogn or Vinland soils. They are on sloping side slopes or foot slopes. The well drained Oska soils are moderately deep over limestone and usually are higher on the landscape than the Sogn soils. Rock outcrops are on some of the steeper points and breaks.

Permeability is moderate for the soils in this complex. Available water capacity is low for the Vinland soil and very low for the Sogn soil. Organic matter content is moderate for these soils, and natural fertility is medium. The shrink-swell potential is moderate for these soils. The Sogn soil is neutral in the surface layer. The Vinland soil is slightly acid in the surface layer and medium acid in the subsoil.

Most of the acreage of this complex is used for pasture. Vegetation is made up of mid and tall native grasses, woody plants, and some tame grasses. The soils in this complex are not suited to cultivated crops. The Vinland soil has fair potential for woodland wildlife habitat. These soils have poor potential for most engineering uses.

Depth to bedrock is a severe limitation on the Sogn soil and a moderate limitation on the Vinland soil for dwellings and local roads and streets. Other soils that are deeper to bedrock are better for these uses.

Depth to bedrock is a severe limitation for septic tank absorption fields and sewage lagoons. Use other soils or connect to a public or commercial sewer. Connecting to a public sewer helps reduce the severity of this limitation. Capability subclass VI*e*.

Va—Vinland-Rock outcrop complex, 20 to 40 percent slopes. This map unit is made up of shallow soils and rock outcrops on steep uplands along the creeks and major streams in the county. Individual areas range from 10 to 500 acres in size and contain about 50 to 60 percent Vinland soil and 20 to 30 percent Rock outcrop. The Vinland soil is lower on the landscape than the Rock outcrop. This complex is in such narrow areas that it was not practical to map the components separately (fig. 12).

Typically, the Vinland soil has a surface layer of very dark grayish brown silty clay loam about 4 inches thick. The subsoil is very dark grayish brown, firm silty clay loam about 7 inches thick. The substratum is olive brown silty clay loam. Depth to weathered interbedded sandy and silty shales is about 18 inches.

The Rock outcrop generally is higher on the landscape than the Vinland soil; however, some narrow areas exist throughout the complex. The outcrops vary in thickness from less than 3 feet to more than 50 feet.

Included with these soils in mapping and making up 10 to 25 percent of the unit are small areas of Martin, Oska, and Sogn soils. The moderately well drained Martin soils contain more clay and are deeper than the Vinland soil. They are on sloping lower foot slopes. The well drained Oska soils are moderately deep over limestone and are higher on the landscape than the Rock outcrop. The somewhat excessively drained Sogn soils are shallow over limestone and are directly above the Rock outcrop.

Permeability is moderate, and runoff is rapid for the Vinland soil. Available water capacity is low. Organic matter content is moderate, and natural fertility is medium. The shrink-swell potential is moderate. The Vinland soil is slightly acid in the surface layer and medium acid in the subsoil.

Most of the acreage of this unit is used for pasture, or it is kept idle. Vegetation is mostly of the woody type with some mid and tall prairie grasses. This complex is not suited to cultivation. It has fair potential for woodland wildlife habitat, but it has poor potential for most engineering uses.

Slope is a severe limitation for dwellings and local roads and streets on the Vinland soil. Depth to bedrock is a severe limitation for septic tank absorption fields and sewage lagoons. Connecting to a public sewer helps reduce the severity of this limitation. Depth to bedrock is also a severe limitation for landfills. Capability subclass VII*e*.

Wa—Wabash silty clay loam. This soil is deep, nearly level, and very poorly drained. It is on low stream terraces along the major streams in the county and formed in fine-textured alluvium. It is subject to occasional flooding. Individual areas of this unit range from 5 to 200 acres in size.

Typically, the surface layer is black silty clay loam over silty clay, about 25 inches thick. The subsoil is very dark gray, very firm silty clay with mottling throughout. In some places the soil is less clayey in the surface layer.

Included with this soil in mapping are small areas of the moderately well drained Kennebec soils and the well drained Reading soils. These inclusions of Kennebec and Reading soils usually are closer to the stream than the Wabash soil. They are less clayey throughout and are better drained. These inclusions make up about 15 percent of the unit.

Permeability and runoff are very slow. Available water capacity is moderate, and organic matter content and natural fertility are high. The shrink-swell potential is very high. This soil is medium acid in the surface layer and slightly acid in the subsoil. Stickiness and plasticity during wet periods and surface hardness during dry periods make cultivation difficult. Ponding on the surface also hinders cultivation. Cultivated areas of this soil need to be adequately drained by utilizing ditches or by bedding.

Most areas of this soil are cultivated. It has good potential for water-tolerant grasses and trees. It has good potential for wetland wildlife habitat and poor potential for most engineering uses.

This soil is better suited to grain sorghum and soybeans than to other crops and is suited to only a limited amount of corn and small grains. Alfalfa will not survive in most years because of wetness and flooding. Management practices that include providing bedding systems for drainage and installing diversions or terraces on adjacent upland areas help control runoff onto this soil. Proper use of crop residue and crop rotation will improve soil tilth.

Flooding, very high shrink-swell potential, and wetness are severe limitations for dwellings on this soil. Constructing dikes and levees reduces the hazard of flooding. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce structural damage caused by very high shrink-swell potential. Filling and utilizing ditches to improve surface drainage helps to reduce the wetness hazard.

Wetness and very high shrink-swell potential are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material and providing drainage.

Slow percolation rate and wetness are severe limitations for septic tank absorption fields. A sewage lagoon can be used. Flooding and wetness are severe limitations for sewage lagoons. Constructing dikes or levees reduces the hazard of flooding. Wetness and clayey cover material are severe limitations for landfills. Capability subclass III*w*.

Wb—Woodson silt loam. This soil is deep, somewhat poorly drained, and nearly level or gently sloping. It formed in fine-textured sediment. Individual areas of this unit range from 5 to 1,500 acres in size.

Typically, the surface layer is black silt loam about 10 inches thick. The subsoil is very dark gray and grayish brown very firm silty clay about 38 inches thick. The substratum, to a depth of about 60 inches is very dark gray silty clay. In some places the substratum is clay loam. Also in some areas the depth is greater to the clayey subsoil. There are areas of soils that formed in glacial till. Where the upper part of the subsoil has been mixed with the soil of the surface layer by plowing, the surface layer is very dark gray or grayish brown silty clay loam.

Permeability is very slow, and runoff is slow. Available water capacity is moderate, and the shrink-swell potential is high. Organic matter content is moderate, and natural fertility is medium. This soil is medium acid in the surface layer and neutral in the subsoil.

Most areas of this soil are cultivated. The soil has good potential for hay and tame grasses. It has fair potential for openland, rangeland, and wetland wildlife habitat. It has poor potential for most engineering uses.

This soil is suited to most crops commonly grown in the county. Grain sorghum, soybeans, corn, and wheat are the main crops. During most years corn may not yield as much as grain sorghum or soybeans because of adverse moisture conditions during July and August. Erosion is a slight hazard. In the nearly level areas, ponding may adversely affect crops during periods of excessive rainfall. Management practices that include minimum tillage, proper management of crop residue, and adequate commercial fertilizers help maintain organic matter content, fertility, and soil tilth.

High shrink-swell potential and low strength are severe limitations for dwellings on this soil. Using properly designed and reinforced foundations, installing foundation drains, and backfilling with sand or gravel reduce the structural damage caused by low strength and high shrink-swell potential. Low strength and high shrink-swell potential are severe limitations for local roads and streets. These limitations can be reduced by strengthening or replacing the base material.

Slow percolation rate and wetness are severe limitations for setic tank absorption fields. Use of a sewage lagoon or increasing the size of the absorption fields and installing perimeter drains help improve the function of the septic system. This soil has slight limitations for sewage lagoons. Wetness and clayey cover material are severe limitations for landfills. Capability subclass II*s*.

Use and management of the soils

The soil survey is a detailed inventory and evaluation of the most basic resource of the survey area—the soil. It is useful in adjusting land use, including urbanization, to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in uses of the land.

While a soil survey is in progress, soil scientists, conservationists, engineers, and others keep extensive notes about the nature of the soils and about unique aspects of behavior of the soils. These notes include data on erosion, drought damage to specific crops, yield estimates, flooding, the functioning of septic tank disposal systems, and other factors affecting the productivity, potential, and limitations of the soils under various uses and management. In this way, field experience and measured data on soil properties and performance are used as a basis for predicting soil behavior.

Information in this section is useful in planning use and management of soils for crops and pasture and woodland, as sites for buildings, highways and other transportation systems, sanitary facilities, and parks and other recreation facilities, and for wildlife habitat. From the data presented, the potential of each soil for specified land uses can be determined, soil limitations to these land uses can be identified, and costly failures in houses and other structures, caused by unfavorable soil properties, can be avoided. A site where soil properties are favorable can be selected, or practices that will overcome the soil limitations can be planned.

Planners and others using the soil survey can evaluate the impact of specific land uses on the overall productivity of the survey area or other broad planning area and on the environment. Productivity and the environment are closely related to the nature of the soil. Plans should maintain or create a land-use pattern in harmony with the natural soil.

Contractors can find information that is useful in locating sources of sand and gravel, roadfill, and topsoil. Other information indicates the presence of bedrock, wetness, or very firm soil horizons that cause difficulty in excavation.

Health officials, highway officials, engineers, and many other specialists also can find useful information in this soil survey. The safe disposal of wastes, for example, is closely related to properties of the soil. Pavements, sidewalks, campsites, playgrounds, lawns, and trees and shrubs are influenced by the nature of the soil.

Crops and pasture

The major management concerns in the use of the soils for crops and pasture are described in this section. In addition, the crops or pasture plants best suited to the soil, including some not commonly grown in the survey area, are discussed; the system of land capability classification used by the Soil Conservation Service is explained; and the estimated yields of the main crops and hay and pasture plants are presented for each soil.

This section provides information about the overall agricultural potential of the survey area and about the management practices that are needed. The information is useful to equipment dealers, land improvement contractors, fertilizer companies, processing companies, planners, conservationists, and others. For each kind of soil, information about management is presented in the section "Soil maps for detailed planning." Planners of management systems for individual fields or farms should also consider the detailed information given in the description of each soil.

Approximately 195,000 acres of Johnson County was used for crops and pasture in 1967, according to the Conservation Needs Inventory. The 1974 Kansas Farm Facts shows Johnson County had 932 farms. The main crops were soybeans, 29,000 acres; corn, 24,000 acres; grain sorghum, 13,000 acres; wheat, 9,000 acres; and hay and pasture, 16,700 acres. The acreage of soybeans has increased over the past ten years, while the acreage of corn has declined. Smaller acreages are used for alfalfa, oats, and barley. Vegetable and garden crops are grown on many tracts in the Kansas River Valley.

The soils in Johnson County have good potential for maintaining production of food and fiber. The main problem is the constant loss of farmland to industrial and urban expansion. There has been an increase of over 30,000 acres of urban and built-up land in the county from 1954 to 1974.

The Kansas River Valley has excellent potential for intensive cropping of fruits and vegetables. Food production could be increased if the latest crop production technology were extended to all cropland in the county. This soil survey can greatly facilitate the application of such technology.

Soil erosion is a major problem on about 50 percent of the cropland in Johnson County. If slope is more than one percent, erosion is a hazard. Polo, Grundy, Oska, Martin, and Woodson soils are the principal soils used for cropland in the county.

Loss of the surface layer through erosion is damaging for two reasons. First, productivity is reduced as the surface layer is lost and as part of the subsoil is incorporated into the plow layer. Loss of the surface layer is expecially damaging on soils that have a clayey subsoil, including the Grundy, Martin, and Woodson soils. Second, soil erosion on farmland results in sediment entering streams. Control of erosion minimizes the pollution of streams by sediment and improves the quality of water for municipal use, recreation, and for fish and wildlife.

In many sloping fields, preparing a good seedbed and tilling the soil are difficult on clayey or hardpan spots because the original friable surface soil has been eroded away. Such spots are common in areas of Woodson soils.

Erosion control practices include providing protective surface cover, reducing runoff, and increasing infiltration. A cropping system that keeps vegetative cover on the soil for extended periods can hold soil losses at a level that does not reduce the productive capacity of the soils. On livestock farms, which require pasture and hay, the legume and grass forage crops in the cropping system reduce erosion on the sloping land, provide nitrogen, and improve tilth for the following crop.

Terraces and contour tillage are practical on most cultivated soils in Johnson County. Leaving crop residue on the surface either by minimum tillage or stubble mulching is a way to help increase infiltration and reduce the hazards of runoff and water erosion (fig. 13). The extra cover is essential to help prevent wind erosion during periods of crop production. Minimum tillage for sorghum and other row crops is becoming more common in the county and is effective in reducing erosion on sloping land. It can be adapted to most soils in the survey area.

Terraces and diversions shorten the length of slope and reduce runoff and erosion. They are practical on most soils that have regular slopes, including practically all soils except some moderately deep and shallow soils.

Contour tillage is a companion practice along with terraces but is rarely used by itself. Contouring is best suited to soils with smooth, uniform slopes where terracing is applicable.

Soil blowing is a hazard on the moderately coarse textured Eudora soils in the Kansas River Valley. Soil blowing damages these soils if they are dry and bare of vegetation or surface mulch. Maintaining vegetative cover, surface mulch, or rough surfaces through proper tillage minimizes soil blowing on these soils. Information concerning the design of erosion control practices for each kind of soil is contained in the Field Office Technical Guide which is available in the local office of the Soil Conservation Service.

Soil drainage is a management concern on less than one percent of the acreage used for crops and pasture in the survey area. Soils like the somewhat poorly drained Kimo soils and the very poorly drained Wabash soils, coupled with slow or very slow permeability, are likely to have crop damage some years.

Soil fertility is medium or high on all of the cultivated soils in the county. Additions of lime and fertilizer should be based on the results of soil tests for each soil, the need of the crop, and the expected level of yields. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer and lime to apply.

Soil tilth is an important factor in the germination of seeds and in the infiltration of water into the soil. Soils with good tilth are granular and porous.

A few of the soils used for crops in the survey area have a silt loam or loam surface layer and are lower in organic matter content. Generally, the structure of such soils is weak, and intense rainfall causes the formation of crust on the surface. The crust is hard when the soil is dry, and it is nearly impervious to water. Once the crust forms, it reduces infiltration and increases runoff. Regular additions of crop residue, manure, and other organic material help to improve soil structure and to reduce crust formation. Leaving residue on the surface also helps to prevent the formation of such a crust.

Field crops that are suited to the soils and climate of the survey area but are not grown to any extent include oats, barley, and alfalfa. Sunflowers, potatoes, and similar crops can be grown if economic conditions become favorable.

Deep soils that have good natural drainage and that warm-up early in spring are especially well suited to many vegetables and small fruits. In the survey area these are Eudora and Sharpsburg soils.

Most of the well drained soils in the survey area are suitable for orchards and nursery plants. Soils that are in low positions where frost is frequent and air movement is poor are generally poorly suited to early vegetables, small fruits, and orchards.

Latest information and suggestions concerning the growth of special crops can be obtained from local offices of the Cooperative Extension Service and the Soil Conservation Service.

Suitability of the soils for fruits, gardens, and lawns

Most of the soils of Johnson County are suitable for fruits, garden vegetables, truck crops, and lawn grasses. Among the fruits commonly grown are apples, peaches, bush fruits, and other fruits that include blackberries, grapes, and strawberries. Some of the garden vegetables and truck crops commonly grown are cantaloupes, potatoes, tomatoes, watermelons, and a variety of common vegetables. Among the lawn grasses are the "cool season" Kentucky bluegrass, Merion bluegrass, tall fescues, and the "warm season" Zoysia grass.

Fruit trees, bush fruits, other kinds of fruits, and garden vegetables grow best on soils that are deep, medium textured, and well drained. These soils have high natural fertility and high available water capacity. These soils respond well to irrigation (fig. 14). Gardens need topsoil that can be tilled easily. The best soils for this use are nearly level or gently sloping. Cantaloupes and watermelons are better suited to the more sandy Eudora and Sibleyville soils.

Lawns grow best on undisturbed, deep, and medium-textured soils that are well drained or moderately well drained. These soils have a topsoil that is high in organic matter content and easily tilled. A disturbed soil is one that has been excavated for footings and basements. This soil material contains more clay than an undisturbed soil, does not have organic matter, and it is difficult to establish a good seedbed on it. This soil material packs easily and does not take in water readily.

For additional information, pamphlets and bulletins are available at the County Extension Office or Soil Conservation Service office.

Yields per acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 5. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors. Absence of an estimated yield indicates that the crop is not suited to or not commonly grown on the soil.

The estimated yields were based mainly on the experience and records of farmers, conservationists, and extension agents. Results of field trials and demonstrations and available yield data from nearby counties were also considered.

The yields were estimated assuming that the latest soil and crop management practices were used. Hay and pasture yields were estimated for the most productive varieties of grasses and legumes suited to the climate and the soil. A few farmers may be obtaining average yields higher than those shown in table 5.

The management needed to achieve the indicated yields of the various crops depends on the kind of soil and the crop. Such management provides drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate tillage practices, including time of tillage and seedbed preparation and tilling when soil moisture is favorable; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residues, barnyard manure, and green-manure crops; harvesting crops with the smallest possible loss; and timeliness of all fieldwork.

The estimated yields reflect the productive capacity of the soils for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in table 5 are grown in the survey area, but estimated yields are not included because the acreage of these crops is small. The local offices of the Soil Conservation Service and the Cooperative Extension Service can provide information about the management concerns and productivity of the soils for these crops.

Capability classes and subclasses

Capability classes and subclasses show, in a general way, the suitability of soils for most kinds of field crops. The soils are classed according to their limitations when they are used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops that require special management. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for forest trees, or for engineering purposes.

In the capability system, all kinds of soil are grouped at three levels: capability class, subclass, and unit. The capability class and subclass are defined in the following paragraphs. A survey area may not have soils of all classes.

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

Class I soils have few limitations that restrict their use.

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

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

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

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and landforms have limitations that nearly preclude their use for commercial crop production.

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 only some parts of the United States, 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 contains only the subclasses indicated by *w, s,* or *c* because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

The capability subclass is identified in the description of each soil mapping unit in the section "Soil maps for detailed planning."

Woodland management and productivity

About 12,000 acres of woodland is in Johnson County. Most of the wooded areas are in small, irregular tracts along the streams. Only a small part of the woodland is managed for timber production. Much of the woodland is grazed by livestock. Wooded areas also provide food and cover for wildlife, and some areas are used for recreation. The principal native trees in the county are hackberry, bur oak, red oak, white oak, pin oak, sycamore, black walnut, pecan, hickory, cottonwood, and elm. Many of these trees are cut for saw logs when they reach adequate size. A few trees are cut for fuel or firewood. Hedgerows of osageorange are common throughout the county. Several areas are used for growing Christmas trees and nursery stock.

The bottom lands have a high potential for the production of trees that grow to timber size, but most of these soils are being used for small grains, row crops, and alfalfa. The uplands have low potential for the production of saw logs, but trees on the hilly uplands provide protection for watersheds.

Table 6 contains information useful to woodland owners or forest managers planning use of soils for wood crops. Map unit symbols for soils suitable for wood crops are listed for each soil.

In table 6 the soils are also rated for a number of factors to be considered in management. *Slight, moderate,* and *severe* are used to indicate the degree of major soil limitations.

Ratings of the *erosion hazard* indicate the risk of loss of soil in well managed woodland. The risk is *slight* if the expected soil loss is small, *moderate* if some measures are needed to control erosion during logging and road construction, and *severe* if intensive management or special equipment and methods are needed to prevent excessive loss of soil.

Ratings of *equipment limitation* reflect the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. A rating of *slight* indicates that use of equipment is not limited to a particular kind of equipment or time of year; *moderate* indicates a short seasonal limitation or a need for some modification in management or equipment; *severe* indicates a seasonal limitation, a need for special equipment or management, or a hazard in the use of equipment.

Seedling mortality ratings indicate the degree that the soil affects expected mortality of planted tree seedlings. Plant competition is not considered in the ratings. Seedlings from good planting stock that are properly planted during a period of sufficient rainfall are rated. A rating of *slight* indicates that the expected mortality of the planted seedlings is less than 25 percent; *moderate*, 25 to 50 percent; and *severe*, more than 50 percent.

Considered in the ratings of *windthrow hazard* are characteristics of the soil that affect the development of tree roots and the ability of the soil to hold trees firmly. A rating of *slight* indicates that trees in wooded areas are not expected to be blown down by commonly occurring winds; *moderate*, that some trees are blown down during periods of excessive soil wetness and strong winds; and *severe*, that many trees are blown down during periods of excessive soil wetness and moderate or strong winds.

Ratings of *plant competition* indicate the degree to which undesirable plants are expected to invade or grow if openings are made in the tree canopy. The invading plants compete with native plants or planted seedlings by impeding or preventing their growth. A rating of *slight* indicates little or no competition from other plants; *moderate* indicates that plant competition is expected to hinder the development of a fully stocked stand of desirable trees; *severe* means that plant competition is expected to prevent the establishment of a desirable stand unless the site is intensively prepared, weeded, or otherwise managed for the control of undesirable plants.

The *potential productivity* of merchantable or *important trees* on a soil is expressed as a *site index*. This index is the average height, in feet, that dominant and codominant trees of a given species attain in a specified number of years. The site index applies to fully stocked, even-aged, unmanaged stands. Important trees are those that woodland managers generally favor in intermediate or improvement cuttings. They are selected on the basis of growth rate, quality, value, and marketability.

Trees to plant are those that are suitable for commercial wood production and that are suited to the soils.

Engineering

This section provides information about the use of soils for building sites, sanitary facilities, construction material, and water management. Among those who can benefit from this information are engineers, landowners, community planners, town and city managers, land developers, builders, contractors, and farmers and ranchers.

The ratings in the engineering tables are based on test data and estimated data in the "Soil properties" section. The ratings were determined jointly by soil scientists and engineers of the Soil Conservation Service using known relationships between the soil properties and the behavior of soils in various engineering uses.

Among the soil properties and site conditions identified by a soil survey and used in determining the ratings in this section were grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock that is within 5 or 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure or aggregation, in-place soil density, and geologic origin of the soil material. Where pertinent, data about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of absorbed cations were also considered.

On the basis of information assembled about soil properties, ranges of values can be estimated for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, shear strength, compressibility, slope stability, and other factors of expected soil behavior in engineering uses. As appropriate, these values can be applied to each major horizon of each soil or to the entire profile.

These factors of soil behavior affect construction and maintenance of roads, airport runways, pipelines, foundations for small buildings, ponds and small dams, irrigation projects, drainage systems, sewage and refuse disposal systems, and other engineering works. The ranges of values can be used to (1) select potential residential, commercial, industrial, and recreational uses; (2) make preliminary estimates pertinent to construction in a particular area; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for location of sanitary landfills, onsite sewage disposal systems, and other waste disposal facilities; (5) plan detailed onsite investigations of soils and geology; (6) find sources of gravel, sand, clay, and topsoil; (7) plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; (8) relate performance of structures already built to the properties of the kinds of soil on which they are built so that performance of similar structures on the same or a similar soil in other locations can be predicted; and (9) predict the trafficability of soils for cross-country movement of vehicles and construction equipment.

Data presented in this section are useful for land-use planning and for choosing alternative practices or general designs that will overcome unfavorable soil properties and minimize soil-related failures. Limitations to the use of these data, however, should be well understood. First, the data are generally not presented for soil material below a depth of 5 or 6 feet. Also, because of the scale of the detailed map in this soil survey, small areas of soils that differ from the dominant soil may be included in mapping. Thus, these data do not eliminate the need for onsite investigations, testing, and analysis by personnel having expertise in the specific use contemplated.

The information is presented mainly in tables. Table 7 shows, for each kind of soil, the degree and kind of limitations for building site development; table 8, for sanitary facilities. Table 10 shows the kind of limitations for water management. Table 9 shows the suitability of each kind of soil as a source of construction materials.

The information in the tables, along with the soil map, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations and to construct interpretive maps for specific uses of land.

Some of the terms used in this soil survey have a special meaning in soil science. Many of these terms are defined in the Glossary.

Building site development

The degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets are indicated in table 7. A *slight* limitation indicates that soil properties generally are favorable for the specified use; any limitation is minor and easily overcome. A *moderate* limitation indicates that soil properties and site features are unfavorable for the specified use, but the limitations can be overcome or minimized by special planning and design. A *severe* limitation indicates that one or more soil properties or site features are so unfavorable or difficult to overcome that a major increase in construction effort, special design, or intensive maintenance is required. For some soils rated severe, such costly measures may not be feasible.

Shallow excavations are made for pipelines, sewerlines, communications and power transmission lines, basements, open ditches, and cemeteries. Such digging or trenching is influenced by soil wetness caused by a seasonal high water table; the texture and consistence of soils; the tendency of soils to cave in or slough; and the presence of very firm, dense soil layers, bedrock, or large stones. In addition, excavations are affected by slope of the soil and the probability of flooding. Ratings do not apply to soil horizons below a depth of 6 feet unless otherwise noted.

In the soil series descriptions, the consistence of each soil horizon is given, and the presence of very firm or extremely firm horizons, usually difficult to excavate, is indicated.

Dwellings and *small commercial buildings* referred to in table 7 are built on undisturbed soil and have foundation loads of a dwelling no more than three stories high. Separate ratings are made for small commercial buildings without basements and for dwellings with and without basements. For such structures, soils should be sufficiently stable that cracking or subsidence of the structure from settling or shear failure of the foundation does not occur. These ratings were determined from estimates of the shear strength, compressibility, and shrink-swell potential of the soil. Soil texture, plasticity and in-place density, potential frost action, soil wetness, and depth to a seasonal high water table were also considered. Soil wetness and depth to a seasonal high water table indicate potential difficulty in providing adequate drainage for basements, lawns, and gardens. Depth to bedrock, slope, and large stones in or on the soil are also important considerations in the choice of sites for these structures and were considered in determining the ratings (fig. 15). Susceptibility to flooding is a serious hazard.

Local roads and streets referred to in table 7 have an all-weather surface that can carry light to medium traffic all year. They consist of a subgrade of the underlying soil material; a base of gravel, crushed rock fragments, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. The roads are graded with soil material at hand, and most cuts and fills are less than 6 feet deep.

The load supporting capacity and the stability of the soil as well as the quantity and workability of fill material available are important in design and construction of roads and streets. The classifications of the soil and the soil texture, density, shrink-swell potential, and potential frost action are indicators of the traffic supporting capacity used in making the ratings. Soil wetness, flooding, slope, depth to hard rock or very compact layers, and content of large stones affect stability and ease of excavation.

Sanitary facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields, sewage lagoons, and sanitary landfills. The nature of the soil is important in selecting sites for these facilities and in identifying limiting soil properties and site features to be considered in design and installation. Also, those soil properties that affect ease of excavation or installation of these facilities will be of interest to contractors and local officials. Table 8 shows the degree and kind of limitations of each soil for such uses and for use of the soil as daily cover for landfills. It is important to observe local ordinances and regulations.

If the degree of soil limitation is expressed as *slight*, soils are generally favorable for the specified use and limitations are minor and easily overcome; if *moderate*, soil properties or site features are unfavorable for the specified use, but limitations can be overcome by special planning and design; and if *severe*, soil properties or site features are so unfavorable or difficult to overcome that major soil reclamation, special designs, or intensive maintenance is required. Soil suitability is rated by the terms *good*, *fair*, or *poor*, which, respectively, mean about the same as the terms *slight*, *moderate*, and *severe*.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into the natural soil. Only the soil horizons between depths of 18 and 72 inches are evaluated for this use. The soil properties and site features considered are those that affect the absorption of the effluent and those that affect the construction of the system.

Properties and features that affect absorption of the effluent are permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding. Stones, boulders, and shallowness to bedrock interfere with installation. Excessive slope can cause lateral seepage and surfacing of the effluent. Also, soil erosion and soil slippage are hazards if absorption fields are installed on sloping soils.

In some soils, loose sand and gravel or fractured bedrock is less than 4 feet below the tile lines. In these soils the absorption field does not adequately filter the effluent, and ground water in the area may be contaminated.

On many of the soils that have moderate or severe limitations for use as septic tank absorption fields, a system to lower the seasonal water table can be installed or the size of the absorption field can be increased so that performance is satisfactory.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons have a nearly level floor and cut slopes or embankments of compacted soil material. Aerobic lagoons generally are designed to hold sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Soils that are very high in content of organic matter and those that have cobbles, stones, or boulders are not suitable. Unless the soil has very slow permeability, contamination of ground water is a hazard where the seasonal high water table is above the level of the lagoon floor. In soils where the water table is seasonally high, seepage of ground water into the lagoon can seriously reduce the lagoon's capacity for liquid waste. Slope, depth to bedrock, and susceptibility to flooding also affect the suitability of sites for sewage lagoons or the cost of construction. Shear strength and permeability of compacted soil material affect the performance of embankments.

Sanitary landfill is a method of disposing of solid waste by placing refuse in successive layers either in excavated trenches or on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil material. Landfill areas are subject to heavy vehicular traffic. Risk of polluting ground water and trafficability affect the suitability of a soil for this use. The best soils have a loamy or silty texture, have moderate to slow permeability, are deep to a seasonal water table, and are not subject to flooding. Clayey soils are likely to be sticky and difficult to spread. Sandy or gravelly soils generally have rapid permeability, which might allow noxious liquids to contaminate ground water. Soil wetness can be a limitation, because operating heavy equipment on a wet soil is difficult. Seepage into the refuse increases the risk of pollution of ground water.

Ease of excavation affects the suitability of a soil for the trench type of landfill. A suitable soil is deep to bedrock and free of large stones and boulders. If the seasonal water table is high, water will seep into trenches.

Unless otherwise stated, the limitations in table 8 apply only to the soil material within a depth of about 6 feet. If the trench is deeper, a limitation of slight or moderate may not be valid. Site investigation is needed before a site is selected.

Daily cover for landfill should be soil that is easy to excavate and spread over the compacted fill in wet and dry periods. Soils that are loamy or silty and free of stones or boulders are better than other soils. Clayey soils may be sticky and difficult to spread; sandy soils may be subject to soil blowing.

The soils selected for final cover of landfills should be suitable for growing plants. Of all the horizons, the A horizon in most soils has the best workability, more organic matter, and the best potential for growing plants. Thus, for either the area- or trench-type landfill, stockpiling material from the A horizon for use as the surface layer of the final cover is desirable.

Where it is necessary to bring in soil material for daily or final cover, thickness of suitable soil material available and depth to a seasonal high water table in soils surrounding the sites should be evaluated. Other factors to be evaluated are those that affect reclamation of the borrow areas. These factors include slope, erodibility, and potential for plant growth.

Construction materials

The suitability of each soil as a source of roadfill, sand, gravel, and topsoil is indicated in table 9 by ratings of good, fair, or poor. The texture, thickness, and organic-matter content of each soil horizon are important factors in rating soils for use as construction materials. Each soil is evaluated to the depth observed, generally about 6 feet.

Roadfill is soil material used in embankments for roads. Soils are evaluated as a source of roadfill for low embankments, which generally are less than 6 feet high and less exacting in design than high embankments. The ratings reflect the ease of excavating and working the material and the expected performance of the material where it has been compacted and adequately drained. The performance of soil after it is stabilized with lime or cement is not considered in the ratings, but information about some of the soil properties that influence such performance is given in the descriptions of the soil series.

The ratings apply to the soil material between the A horizon and a depth of 5 to 6 feet. It is assumed that soil horizons will be mixed during excavation and spreading. Many soils have horizons of contrasting suitability within their profile. The estimated engineering properties in table 13 provide specific information about the nature of each horizon. This information can help determine the suitability of each horizon for roadfill.

Soils rated *good* are coarse grained. They have low shrink-swell potential, low potential frost action, and few cobbles and stones. They are at least moderately well drained and have slopes of 15 percent or less. Soils rated *fair* have a plasticity index of less than 15 and have other limiting features, such as moderate shrink-swell potential, moderately steep slopes, wetness, or many stones. If the thickness of suitable material is less than 3 feet, the entire soil is rated *poor.*

Sand and *gravel* are used in great quantities in many kinds of construction. The ratings in table 9 provide guidance as to where to look for probable sources and are based on the probability that soils in a given area contain sizable quantities of sand or gravel. A soil rated *good* or *fair* has a layer of suitable material at least 3 feet thick, the top of which is within a depth of 6 feet. Coarse fragments of soft bedrock material, such as shale and siltstone, are not considered to be sand and gravel. Fine-grained soils are not suitable sources of sand and gravel.

The ratings do not take into account depth to the water table or other factors that affect excavation of the material. Descriptions of grain size, kinds of minerals, reaction, and stratification are given in the soil series descriptions and in table 13.

Topsoil is used in areas where vegetation is to be established and maintained. Suitability is affected mainly by the ease of working and spreading the soil material in preparing a seedbed and by the ability of the soil material to support plantlife. Also considered is the damage that can result at the area from which the topsoil is taken (fig. 16).

The ease of excavation is influenced by the thickness of suitable material, wetness, slope, and amount of stones. The ability of the soil to support plantlife is determined by texture, structure, and the amount of soluble salts or toxic substances. Organic matter in the A1 or Ap horizon greatly increases the absorption and retention of moisture and nutrients. Therefore, the soil material from these horizons should be carefully preserved for later use.

Soils rated *good* have at least 16 inches of friable loamy material at their surface. They are free of stones and cobbles, are low in content of gravel, and have gentle slopes. They are low in soluble salts that can limit or prevent plant growth. They are naturally fertile or respond well to fertilizer. They are not so wet that excavation is difficult during most of the year.

Soils rated *fair* are loose sandy soils or firm loamy or clayey soils in which the suitable material is only 8 to 16 inches thick or soils that have appreciable amounts of gravel, stones, or soluble salt.

Soils rated *poor* are very sandy soils and very firm clayey soils; soils with suitable layers less than 8 inches thick; soils having large amounts of gravel, stones, or soluble salt; steep soils; and poorly drained soils.

Although a rating of *good* is not based entirely on high content of organic matter, a surface horizon is generally preferred for topsoil because of its organic-matter content. This horizon is designated as A1 or Ap in the soil series descriptions. The absorption and retention of moisture and nutrients for plant growth are greatly increased by organic matter.

Water management

Many soil properties and site features that affect water management practices have been identified in this soil survey. In table 10 soil and site features that affect use are indicated for each kind of soil. This information is significant in planning, installing, and maintaining water-control structures.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have a low seepage potential, which is determined by permeability and the depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage, erosion, and piping and has favorable stability, shrink-swell potential, shear strength, and compaction characteristics. Large stones and organic matter in a soil downgrade the suitability of a soil for use in embankments, dikes, and levees.

Drainage of soil is affected by such soil properties as permeability; texture; depth to bedrock, hardpan, or other layers that affect the rate of water movement; depth to the water table; slope; stability of ditchbanks; susceptibility to flooding; salinity and alkalinity; and availability of outlets for drainage.

Irrigation is affected by such features as slope, susceptibility to flooding, hazards of water erosion and soil blowing, texture, presence of salts and alkali, depth of root zone, rate of water intake at the surface, permeability of the soil below the surface layer, available water capacity, need for drainage, and depth to the water table.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to intercept runoff. They allow water to soak into the soil or flow slowly to an outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock, hardpan, or other unfavorable material; large stones; permeability; ease of establishing vegetation; and resistance to water erosion, soil blowing, soil slipping, and piping.

Grassed waterways are constructed to channel runoff to outlets at a nonerosive velocity. Features that affect the use of soils for waterways are slope, permeability, erodibility, wetness, and suitability for permanent vegetation.

Recreation

The soils of the survey area are rated in table 11 according to limitations that affect their suitability for recreation uses. The ratings are based on such restrictive soil features as flooding, wetness, slope, and texture of the surface layer. Not considered in these ratings, but important in evaluating a site, are location and accessibility of the area, size and shape of the area and its scenic quality, the ability of the soil to support vegetation, access to water, potential water impoundment sites available, and either access to public sewerlines or capacity of the soil to absorb septic tank effluent. Soils subject to flooding are limited, in varying degree, for recreation use by the duration and intensity of flooding and the season when flooding occurs. Onsite assessment of height, duration, intensity, and frequency of flooding is essential in planning recreation facilities.

The degree of the limitation of the soils is expressed as slight, moderate, or severe. *Slight* means that the soil properties are generally favorable and that the limitations are minor and easily overcome. *Moderate* means that the limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 11 can be supplemented by information in other parts of this survey. Especially helpful are interpretations for septic tank absorption fields, given in table 8, and interpretations for dwellings without basements and for local roads and streets, given in table 7.

Camp areas require such site preparation as shaping and leveling for tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils for this use have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing camping sites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for use as picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that will increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones or boulders, is firm after rains, and is not dusty when dry. If shaping is required to obtain a uniform grade, the depth of the soil over bedrock or hardpan should be enough to allow necessary grading.

Paths and trails for walking, horseback riding, bicycling, and other uses should require little or no cutting and filling. The best soils for this use are those that are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once during the annual period of use. They should have moderate slopes and have few or no stones or boulders on the surface.

Wildlife habitat

Robert J. Higgins, biologist, Soil Conservation Service, assisted in preparing this section.

Soils directly affect the kind and amount of vegetation that is available to wildlife as food and cover, and they affect the construction of water impoundments. The kind and abundance of wildlife that populate an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, is inadequate, or is inaccessible, wildlife either are scarce or do not inhabit the area.

If the soils have the potential, wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by helping the natural establishment of desirable plants.

In table 12, the soils in the survey area are rated according to their potential to support the main kinds of wildlife habitat in the area. This information can be used in planning for parks, wildlife refuges, nature study areas, and other developments for wildlife; selecting areas that are suitable for wildlife; selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat; and determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected if the soil is used for the designated purpose. A rating of *fair* means that the element of wildlife habitat or kind of habitat can be created, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* means that restrictions for the element of wildlife habitat or kind of wildlife are very severe, and that unsatisfactory results can be expected. Wildlife habitat is impractical or even impossible to create, improve, or maintain on soils having such a rating.

The elements of wildlife habitat are briefly described in the following paragraphs.

Grain and seed crops are seed-producing annuals used by wildlife. The major soil properties that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are corn, sorghum, wheat, oats, barley, millet, and soybeans.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Major soil properties that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, bluegrass, timothy, orchardgrass, bromegrass, clover, alfalfa, trefoil, and crownvetch.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds, that provide food and cover for wildlife. Major soil properties that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, indiangrass, switchgrass, lovegrass, goldenrod, wheatgrass, native lespedeza, partridge pea, clovers, and grama.

Hardwood trees and the associated woody understory provide cover for wildlife and produce nuts or other fruit, buds, catkins, twigs, bark, or foliage that wildlife eat. Major soil properties that affect growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness. Examples of native plants are oak, sycamore, elm, cottonwood, hackberry, hawthorn, persimmon, hickory, redbud, black walnut, honey locust, grape, mulberry, and ash. Examples of fruit-producing shrubs that are commercially available and suitable for planting on soils rated *good* are Russian-olive, autumn-olive, bush honeysuckle and crabapple.

Coniferous plants are cone-bearing trees, shrubs, or ground cover plants that furnish habitat or supply food in the form of browse, seeds, or fruitlike cones. Soil properties that have a major effect on the growth of coniferous plants are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are pine, spruce, yew, and juniper.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, or foliage used by wildlife or that provide cover and shade for some species of wildlife. Major soil properties that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and moisture. Examples of shrubs are sumac, buckbrush, blackberry, plum, and dogwood.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites, exclusive of submerged or floating aquatics. They produce food or cover for wildlife that use wetland as habitat. Major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, barnyardgrass, saltgrass, cordgrass, buttonbush, and indigobush anorphia and rushes, sedges, and cattails.

Shallow water areas are bodies of water that have an average depth of less than 5 feet and that are useful to wildlife. They can be naturally wet areas, or they can be created by dams or levees or by water-control structures in marshes or streams. Major soil properties affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. The availability of a dependable water supply is important if water areas are to be developed. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The kinds of wildlife habitat are briefly described in the following paragraphs.

Openland habitat consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to these areas include bobwhite quail, pheasant, mourning dove, field sparrow, crow, cottontail, striped skunk, and marmots.

Woodland habitat consists of areas of hardwoods or conifers, or a mixture of both, and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include wild turkey, cardinals, thrushes, vireos, woodpeckers, tree squirrels, gray fox, raccoon, opossum, and white-tailed deer.

Wetland habitat consists of open, marshy or swampy, shallow water areas where water-tolerant plants grow. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, redwing blackbirds, kingfishers, muskrat, mink, and beaver.

Rangeland habitat consists of areas of wild herbaceous plants and shrubs. Wildlife attracted to rangeland include mule deer, prairie dogs, jackrabbits, coyotes, badgers, killdeer, meadowlark, and lark bunting.

Soil properties

Extensive data about soil properties are summarized on the following pages. The two main sources of these data are the many thousands of soil borings made during the course of the survey and the laboratory analyses of selected soil samples from typical profiles.

In making soil borings during field mapping, soil scientists can identify several important soil properties. They note the seasonal soil moisture condition or the presence of free water and its depth. For each horizon in the profile, they note the thickness and color of the soil material; the texture, or amount of clay, silt, sand, and gravel or other coarse fragments; the structure, or the natural pattern of cracks and pores in the undisturbed soil; and the consistence of the soil material in place under the existing soil moisture conditions. They record the depth of plant roots, determine the pH or reaction of the soil, and identify any free carbonates.

Samples of soil material are analyzed in the laboratory to verify the field estimates of soil properties and to determine all major properties of key soils, especially properties that cannot be estimated accurately by field observation. Laboratory analyses are not conducted for all soil series in the survey area, but laboratory data for many soil series not tested are available from nearby survey areas.

The available field and laboratory data are summarized in tables. The tables give the estimated range of engineering properties, the engineering classifications, and the physical and chemical properties of each major horizon of each soil in the survey area. They also present data about pertinent soil and water features and engineering test data.

Engineering properties

Table 13 gives estimates of engineering properties and classifications for the major horizons of each soil in the survey area.

Most soils have, within the upper 5 or 6 feet, horizons of contrasting properties. Table 13 gives information for each of these contrasting horizons in a typical profile. *Depth* to the upper and lower boundaries of each horizon is indicated. More information about the range in depth and about other properties in each horizon is given for each soil series in the section "Soil series and morphology."

Texture is described in table 13 in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loam." Other texture terms are defined in the Glossary.

The two systems commonly used in classifying soils for engineering use are the Unified Soil Classification System (Unified) (*2*) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO) (*1*).

The *Unified* system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter, plasticity index, liquid limit, and organic-matter content. Soils are grouped into 15 classes—eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes have a dual classification symbol, for example, CL-ML.

The *AASHTO* system classifies soils according to those properties that affect their use in highway construction and maintenance. In this system a mineral soil is classified in one of seven basic groups ranging from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines. At the other extreme, in group A-7, are fine-grained soils. Highly organic soils are classified in group A-8 on the basis of visual inspection.

When laboratory data are available, the A-1, A-2, and A-7 groups are further classified as follows: A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, and A-7-6. As an additional refinement, the desirability of soils as subgrade material can be indicated by a group index number. These numbers range from 0 for the best subgrade material to 20 or higher for the poorest. The AASHTO classification for soils tested in the survey area, with group index numbers in parentheses, is given in table 16. The estimated classification, without group index numbers, is given in table 13. Also in table 13 the percentage, by weight, of rock fragments more than 3 inches in diameter is estimated for each major horizon. These estimates are determined mainly by observing volume percentage in the field and then converting that, by formula, to weight percentage.

Percentage of the soil material less than 3 inches in diameter that passes each of four sieves (U.S. standard) is estimated for each major horizon. The estimates are based on tests of soils that were sampled in the survey area and in nearby areas and on field estimates from many borings made during the survey.

Liquid limit and *plasticity index* indicate the effect of water on the strength and consistence of soil. These indexes are used in both the Unified and AASHTO soil classification systems. They are also used as indicators in making general predictions of soil behavior. Ranges in liquid limit and plasticity index are estimated on the basis of test data from the survey area or from nearby areas and on observations of the many soil borings made during the survey.

Physical and chemical properties

Table 14 shows estimated values for several soil characteristics and features that affect behavior of soils in engineering uses. These estimates are given for each major horizon, at the depths indicated, in the typical pedon of each soil. The estimates are based on field observations and on test data for these and similar soils.

Permeability is estimated on the basis of known relationships among the soil characteristics observed in the field—particularly soil structure, porosity, and gradation or texture—that influence the downward movement of water in the soil. The estimates are for vertical water movement when the soil is saturated. Not considered in the estimates are lateral seepage or such transient soil features as plowpans and surface crusts. Permeability of the soil is an important factor to be considered in planning and designing drainage systems, in evaluating the potential of soils for septic tank systems and other waste disposal systems, and in many other aspects of land use and management.

Available water capacity is rated on the basis of soil characteristics that influence the ability of the soil to hold water and make it available to plants. Important characteristics are content of organic matter, soil texture, and soil structure. Shallow-rooted plants are not likely to use the available water from the deeper soil horizons. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design of irrigation systems.

Soil reaction is expressed as a range in pH values. The range in pH of each major horizon is based on many field checks. For many soils, the values have been verified by laboratory analyses. Soil reaction is important in selecting the crops, ornamental plants, or other plants to be grown; in evaluating soil amendments for fertility and stabilization; and in evaluating the corrosivity of soils.

Shrink-swell potential depends mainly on the amount and kind of clay in the soil. Laboratory measurements of the swelling of undisturbed clods were made for many soils. For others the swelling was estimated on the basis of the kind and amount of clay in the soil and on measurements of similar soils. The size of the load and the magnitude of the change in soil moisture content also influence the swelling of soils. Shrinking and swelling of some soils can cause damage to building foundations, basement walls, roads, and other structures unless special designs are used. A high shrink-swell potential indicates that special design and added expense may be required if the planned use of the soil will not tolerate large volume changes.

Risk of corrosion pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle-size distribution, total acidity, and electrical conductivity of the soil material. The rate of corrosion of concrete is based mainly on the sulfate content, texture, and acidity of the soil. Protective measures for steel or more resistant concrete help to avoid or minimize damage resulting from the corrosion. Uncoated steel intersecting soil boundaries or soil horizons is more susceptible to corrosion than an installation that is entirely within one kind of soil or within one soil horizon.

Erosion factors are used to predict the erodibility of a soil and its tolerance to erosion in relation to specific kinds of land use and treatment. The soil erodibility factor (K) is a measure of the susceptibility of the soil to erosion by water. Soils having the highest K values are the most erodible. K values range from 0.10 to 0.64. To estimate annual soil loss per acre, the K value of a soil is modified by factors representing plant cover, grade and length of slope, management practices, and climate. The soil-loss tolerance factor (T) is the maximum rate of soil erosion, whether from rainfall or soil blowing, that can occur without reducing crop production or environmental quality. The rate is expressed in tons of soil loss per acre per year.

Wind erodibility groups are made up of soils that have similar properties that affect their resistance to soil blowing if cultivated. The groups are used to predict the susceptibility of soil to blowing and the amount of soil lost as a result of blowing. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are extremely erodible, so vegetation is difficult to establish. They are generally not suitable for crops.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible, but crops can be grown if intensive measures to control soil blowing are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible, but crops can be grown if measures to control soil blowing are used.

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible, but crops can be grown if measures to control soil blowing are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible, and crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible, and crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to soil blowing.

Soil and water features

Table 15 contains information helpful in planning land uses and engineering projects that are likely to be affected by soil and water features.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are placed in one of four groups on the basis of the intake of water after the soils have been wetted and have received precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils that have a layer that impedes the downward movement of water or soils that have moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding is the temporary covering of soil with water from overflowing streams, with runoff from adjacent slopes, and by tides. Water standing for short periods after rains or after snow melts is not considered flooding, nor is water in swamps and marshes. Flooding is rated in general terms that describe the frequency and duration of flooding and the time of year when flooding is most likely (fig. 17). The ratings are based on evidence in the soil profile of the effects of flooding, namely thin strata of gravel, sand, silt, or, in places, clay deposited by floodwater; irregular decrease in organic-matter content with increasing depth; and absence of distinctive soil horizons that form in soils of the area that are not subject to flooding. The ratings are also based on local information about floodwater levels in the area and the extent of flooding and on information that relates the position of each soil on the landscape to historic floods.

The generalized description of flood hazards is of value in land-use planning and provides a valid basis for land-use restrictions. The soil data are less specific, however, than those provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table is the highest level of a saturated zone more than 6 inches thick for a continuous period of more than 2 weeks during most years. The depth to a seasonal high water table applies to undrained soils. Estimates are based mainly on the relationship between grayish colors or mottles in the soil and the depth to free water observed in many borings made during the course of the soil survey. Indicated in table 15 are the depth to the seasonal high water table; the kind of water table, that is, perched, artesian, or apparent; and the months of the year that the water table commonly is high. Only saturated zones above a depth of 5 or 6 feet are indicated.

Information about the seasonal high water table helps in assessing the need for specially designed foundations, the need for specific kinds of drainage systems, and the need for footing drains to insure dry basements. Such information is also needed to decide whether or not construction of basements is feasible and to determine how septic tank absorption fields and other underground installations will function. Also, a seasonal high water table affects ease of excavation.

Depth to bedrock is shown for all soils that are underlain by bedrock at a depth of 5 to 6 feet or less. For many soils, the limited depth to bedrock is a part of the definition of the soil series. The depths shown are based on measurements made in many soil borings and on other observations during the mapping of the soils. The kind of bedrock and its hardness as related to ease of excavation is also shown. Rippable bedrock can be excavated with a single-tooth ripping attachment on a 200-horsepower tractor, but hard bedrock generally requires blasting.

Potential frost action refers to the likelihood of damage to pavements and other structures by frost heaving and low soil strength after thawing. Frost action results from the movement of soil moisture into the freezing temperature zone in the soil, which causes ice lenses to form. Soil texture, temperature, moisture content, porosity, permeability, and content of organic matter are the most important soil properties that affect frost action. It is assumed that the soil is not covered by insulating vegetation or snow and is not artificially drained. Silty and clayey soils that have a high water table in winter are most susceptible to frost action. Well drained very gravelly or sandy soils are the least susceptible.

Engineering test data

The results of analyses of engineering properties of several typical soils of the survey area are given in table 16.

The data presented are for soil samples that were collected from carefully selected sites. The soil profiles sampled are typical of the series discussed in the section "Soil series and morphology." The soil samples were analyzed by the Kansas Department of Transportation, Research and Materials Laboratory.

The methods used in obtaining the data are listed by code in the next paragraph. Most of the codes, in parentheses, refer to the methods assigned by the American Association of State Highway and Transportation Officials. The codes for Unified classification are those assigned by the American Society for Testing and Materials.

The methods and codes are AASHTO classification (M-145-66); Unified classification (D-2487-66T); mechanical analysis (T88-72); liquid limit (T89-68); and plasticity index (T90-70); moisture-density, method A (T99-74).

Soil series and morphology

In this section, each soil series recognized in the survey area is described in detail. The descriptions are arranged in alphabetic order by series name.

Characteristics of the soil and the material in which it formed are discussed for each series. The soil is then compared to similar soils and to nearby soils of other series. Then a pedon, a small three-dimensional area of soil that is typical of the soil series in the survey area, is described. The detailed descriptions of each soil horizon follow standards in the Soil Survey Manual (*3*). Unless otherwise noted, colors described are for moist soil.

Following the pedon description is the range of important characteristics of the soil series in this survey area. Phases, or map units, of each soil series are described in the section "Soil maps for detailed planning."

Chase series

The Chase series consists of deep, somewhat poorly drained and moderately well drained, slowly permeable soils on low terraces. These soils formed in loamy or clayey alluvium. Slope ranges from 0 to 2 percent.

Chase soils are similar to Martin and Reading soils and are near the Kennebec, Reading, and Wabash soils on the landscape. Martin soils have a thinner mollic epipedon and are on slopes higher on the landscape than the Chase soils. Kennebec soils are less clayey, and are in lower positions near the streams. Reading soils are in similar positions on the landscape but have a less clayey argillic horizon and are better drained than the Chase soils. Wabash soils do not have an argillic horizon, and they are on large flood plains and in backwater areas.

Typical pedon of Chase silt loam, 2,050 feet west and 75 feet north of the southeast corner of sec. 10, T. 14 S., R. 25 E.:

Ap—0 to 10 inches; very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) dry; moderate fine and medium granular structure; slightly hard, friable; few fine roots; medium acid; gradual smooth boundary.

B1—10 to 18 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate fine and medium subangular blocky structure; hard, firm; slightly acid; gradual smooth boundary.

B21t—18 to 30 inches; black (10YR 2/1) silty clay, dark gray (10YR 4/1) dry; few fine faint dark yellowish brown (10YR 4/4) mottles; moderate fine and medium blocky structure; very hard, very firm; medium acid; gradual smooth boundary.

B22t—30 to 42 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; common medium faint dark yellowish brown (10YR 4/4) mottles; moderate medium blocky structure grading to massive; very hard, very firm; medium acid; gradual smooth boundary.

C—42 to 60 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; common medium faint dark yellowish brown (10YR 4/4) mottles; massive; hard, firm; slightly acid.

Thickness of the solum ranges from 40 to 60 inches. Thickness of the mollic epipedon is greater than 40 inches.

The A horizon typically has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 1 or 2. It is silt loam or silty clay loam. Reaction ranges from medium acid to neutral. The B and C horizons have the same range in color and reaction as the A horizon. The B horizon is silty clay loam or silty clay, and it averages between 40 and 50 percent clay. The C horizon ranges from silty clay loam to clay. Mottles are in the lower part of the B and C horizons. They range in abundance from few to many and are usually of higher chroma than the soil mass. Some pedons contain iron-manganese concretions in the lower part of the B and C horizons.

Eudora series

The Eudora series consists of deep, well drained, moderately permeable soils on bottom lands. These soils formed in loamy alluvium. Slope ranges from 0 to 3 percent.

Eudora soils are similar to Kennebec soils and are near Kimo soils on the landscape. Kennebec soils are more clayey and are in small drainageways. Kimo soils have clayey over loamy textures and are in lower positions and in old meander scars.

Typical pedon of Eudora silt loam, 200 feet north of the center of sec. 34, T. 11 S., R. 23 E.:

A1—0 to 13 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine granular structure; slightly hard, friable; few fine roots; neutral; clear smooth boundary.

C1—13 to 38 inches; dark grayish brown (10YR 4/2) very fine sandy loam, grayish brown (10YR 5/2) dry; massive; soft, very friable; neutral; gradual smooth boundary.

C2—38 to 44 inches; dark grayish brown (10YR 4/2) coarse silt loam, grayish brown (10YR 5/2) dry; massive; slightly hard, friable; slight effervescence; mildly alkaline; gradual smooth boundary.

C3—44 to 60 inches; grayish brown (10YR 5/2) very fine sandy loam, light brownish gray (10YR 6/2) dry; single grain; loose; slight effervescence; mildly alkaline.

Thickness of the solum ranges from 10 to 20 inches. Depth to free carbonates ranges from 20 to 60 inches.

The A horizon has hue of 10YR, value of 2 or 3 (3 to 5 dry), and chroma of 1 or 2. It is dominantly silt loam, but in places it is very fine sandy loam or fine sandy loam. Reaction is slightly acid or neutral. The C horizon has hue of 10YR, value of 4 to 6 (5 to 7 dry), and chroma of 1 or 2. It is very fine sandy loam or coarse silt loam and commonly contains thin strata of coarser or finer textured material. Reaction ranges from neutral to moderately alkaline.

Grundy series

The Grundy series consists of deep, somewhat poorly drained, and slowly permeable soils on upland ridgetops. These soils formed in loess. Slope ranges from 1 to 3 percent.

Grundy soils are similar to the Martin and Woodson soils and are near the Morrill, Pawnee, Polo, and Sharpsburg soils on the landscape. Martin soils have a thicker mollic epipedon and are usually lower on the landscape than the Grundy soils. Pawnee soils formed in glacial till, contain more sand throughout, and are on upper side slopes lower on the landscape than the Grundy soils. Morrill soils have a less clayey argillic horizon and are in positions lower on the landscape than the Grundy soils. Polo soils are redder, having a higher chroma in the lower part of the solum, are on upper side slopes, and they are also lower on the landscape than the Grundy soils. Sharpsburg and Woodson soils are in similar positions on the landscape as Grundy soils. Sharpsburg soils have a less clayey argillic horizon and are better drained. Woodson soils have an abrupt transition between the A and B horizons.

Typical pedon of Grundy silt loam, 1 to 3 percent slopes, 1,600 feet north and 50 feet west of the southeast corner of sec. 28, T. 13 S., R. 25 E.:

Ap—0 to 9 inches; black (10YR 2/1) heavy silt loam, dark gray (10YR 4/1) dry; moderate fine and very fine granular structure; slightly hard, friable; common fine roots; neutral; abrupt smooth boundary.

A12—9 to 15 inches; black (10YR 2/1) light silty clay loam, dark gray (10YR 4/1) dry; weak fine and very fine subangular blocky structure parting to moderate fine granular; hard, firm; few fine roots; slightly acid; clear smooth boundary.

B21t—15 to 22 inches; very dark gray (10YR 3/1) silty clay, very dark grayish brown (10YR 3/2) crushed; dark gray (10YR 4/1) dry; few fine faint yellowish brown (10YR 5/6) mottles; moderate fine and very fine subangular blocky structure; very hard, very firm; few fine roots; slightly acid; clear smooth boundary.

B22t—22 to 29 inches; dark grayish brown (10YR 4/2) heavy silty clay loam, grayish brown (10YR 5/2) dry; common medium and fine faint yellowish brown (10YR 5/6) mottles; moderate fine and very fine subangular blocky structure; hard, very firm; dark stains on faces of peds; slightly acid; clear smooth boundary.

B3t—29 to 44 inches; grayish brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) dry; many fine distinct yellowish brown (10YR 5/6) mottles; moderate fine and very fine subangular blocky structure; hard, firm; dark stains on faces of peds; neutral; gradual smooth boundary.

C—44 to 60 inches; grayish brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) dry; many medium distinct yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure; hard, firm; dark stains on faces of peds and in old root channels; neutral.

Thickness of the solum ranges from 40 to 60 inches. The A horizon has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 1 or 2. It is silt loam or silty clay loam. Reaction ranges from medium acid to neutral. The B2t horizon has hue of 10YR or 2.5Y, value of 3 or 4 (5 or 6 dry), and chroma of 1 or 2. It has yellowish brown or strong brown mottles throughout. A few pedons have yellowish red mottles in the upper part of the B2t horizon. The B2t horizon is silty clay in the upper part and light silty clay or heavy silty clay loam in the lower part. Reaction is medium acid or slightly acid. The C horizon has hue of 2.5Y, value of 4 or 5 (5 or 6 dry), and chroma of 1 or 2. It has many yellowish brown mottles. Reaction is neutral or slightly acid.

Kennebec series

The Kennebec series consists of deep, moderately well drained, and moderately permeable soils on bottom lands. These soils formed in silty or loamy alluvium. Slope ranges from 0 to 2 percent.

Kennebec soils are similar to Eudora soils and are near the Chase, Reading, and Wabash soils on the landscape. Chase, Reading, and Wabash soils usually are on higher terraces or in bench positions further away from the stream channel. Chase and Wabash soils are more clayey than Kennebec soils. Reading soils have an argillic horizon. Eudora soils are less clayey and are in higher positions.

Typical pedon of Kennebec silt loam, 750 feet north and 400 feet west of the southeast corner of sec. 21, T. 13 S., R. 24 E.:

A11—0 to 10 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate fine granular structure; slightly hard, friable; many fine roots; neutral; clear smooth boundary.
A12—10 to 36 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate and weak fine granular structure; slightly hard, friable; many fine roots; slightly acid; diffuse smooth boundary.
AC—36 to 48 inches; very dark gray (10YR 3/1) silt loam, dark gray (10YR 4/1) dry; weak fine and medium subangular blocky structure; slightly hard, friable; few fine roots; slightly acid; gradual smooth boundary.
C—48 to 60 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; massive; slightly hard, friable; few fine roots; slightly acid.

Thickness of the solum and mollic epipedon is more than 40 inches. The A horizon has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 1 or 2. It is silt loam, and in a few places it is light silty clay loam. Reaction throughout the profile is slightly acid or neutral. The C horizon has hue of 10YR, value of 3 or 4 (4 or 5 dry), and chroma of 1 or 2. It is dominantly silt loam, but in a few places it is underlain by clayey textured material below a depth of 40 inches.

Kimo series

The Kimo series consists of deep, somewhat poorly drained, and slowly permeable soils on bottom lands. These soils formed in loamy and clayey alluvium that overlies coarse-silty alluvium. Slope ranges from 0 to 1 percent.

Kimo soils are similar to Wabash soils and are near Eudora soils on the landscape. Eudora soils do not have contrasting textures, are coarse-silty, and generally are in slightly higher positions on the landscape. Wabash soils are clayey throughout and are in backwater positions near small streams.

Typical pedon of Kimo silty clay loam, 2,400 feet east and 200 feet south of the northwest corner of sec. 35, T. 12 S., R. 21 E.:

Ap—0 to 6 inches; very dark gray (10YR 3/1) heavy silty clay loam, dark grayish brown (10YR 4/2) dry; weak medium granular structure; hard, firm; mildly alkaline; clear smooth boundary.
A12—6 to 20 inches; very dark gray (10YR 3/1) light silty clay, gray (10YR 5/1) dry; strong medium angular blocky structure; very hard, very firm; moderately alkaline; gradual smooth boundary.
AC—20 to 24 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky structure; hard, firm; moderately alkaline; abrupt smooth boundary.
IIC1—24 to 36 inches; dark grayish brown (10YR 4/2) silt loam, pale brown (10YR 6/3) dry; weak fine subangular blocky structure; slightly hard, friable; moderately alkaline; diffuse wavy boundary.
IIC2—36 to 60 inches; dark grayish brown (10YR 4/2) silt loam, very pale brown (10YR 7/3) dry; massive; slightly hard, very friable; moderately alkaline.

Thickness of the solum and depth to the IIC horizon ranges from 20 to 40 inches. Thickness of the mollic epipedon ranges from 17 to 24 inches.

The A horizon has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 1 or 2. It is typically silty clay loam, but in a few pedons it is light silty clay. Reaction in the A1 horizon ranges from neutral to moderately alkaline.

The AC horizon has hue of 10YR, value of 3 to 6 (4 to 7 dry), and chroma of 2 or 3.

The IIC horizon has hue of 10YR, value of 4 to 6 (5 to 7 dry), and chroma of 2 or 3. The IIC horizon is silt loam, fine sandy loam, or very fine sandy loam. In some places it contains thin stratified lenses of coarser or finer textured material. A few pedons contain free carbonates. Reaction ranges from neutral to moderately alkaline.

Ladoga series

The Ladoga series consists of deep, moderately well drained, and moderately slowly permeable soils on uplands. These soils formed in loess. Slope ranges from 3 to 15 percent.

Ladoga soils are similar to Morrill and Sharpsburg soils and are commonly adjacent to the Morrill, Sharpsburg, and Vinland soils on the landscape. Morrill soils formed in glacial till and contain coarse sand throughout the profile. Sharpsburg soils have thicker, darker colored A1 and B1 horizons and do not have an A2 horizon. They are higher on the landscape than the Ladoga soils, usually on ridgetops or upper side slopes. Vinland soils are in similar positions on the landscape as Ladoga soils. Vinland soils are shallow, and they formed in residuum from interbedded sandstone and shale.

Typical pedon of Ladoga silt loam, 3 to 8 percent slopes, 700 feet east and 400 feet north of the center of sec. 4, T. 12 S., R. 24 E.:

A1—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; slightly hard, friable; many fine roots; slightly acid; clear smooth boundary.
A2—8 to 13 inches; dark brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak fine subangular blocky structure parting to weak fine granular; slightly hard, friable; few fine roots; slightly acid; abrupt smooth boundary.
B21t—13 to 20 inches; dark yellowish brown (10YR 4/4) heavy silty clay loam, yellowish brown (10YR 5/4)

dry; moderate fine subangular blocky structure; hard, firm; few fine roots; light colored silt coatings on some peds; medium acid; gradual smooth boundary.

B22t—20 to 31 inches; dark yellowish brown (10YR 4/4) heavy silty clay loam, yellowish brown (10YR 5/4) dry; weak medium subangular blocky structure; hard, firm; few fine roots; light colored silt coatings on some peds; medium acid; gradual smooth boundary.

B3—31 to 60 inches; dark yellowish brown (10YR 4/4) light silty clay loam, yellowish brown (10YR 5/4) dry; weak medium prismatic structure parting to weak medium subangular blocky; hard, firm; light colored silt coatings on some peds; medium acid.

Thickness of the solum ranges from 36 to more than 60 inches. The A horizon has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 1 or 2. It is typically silt loam, but in a few pedons it is light silty clay loam. Reaction is slightly acid or medium acid. The A2 horizon has hue of 10YR, value of 4 or 5, and chroma of 2 or 3. In some areas where the soil is cultivated or eroded, the A2 horizon may be mixed with the Ap horizon. The B21t and B22t horizons have hue of 10YR, value of 4, and chroma of 3 or 4. It is typically heavy silty clay loam or light silty clay. Reaction is medium acid or strongly acid.

Martin series

The Martin series consists of deep, moderately well drained, and slowly permeable soils on uplands. These soils formed in residuum from interbedded silty and clayey shales. Slope ranges from 2 to 11 percent.

Martin soils are similar to Chase, Grundy, and Woodson soils and are near Oska and Sibleyville soils on the landscape. Chase soils have a thicker mollic epipedon, and are on high terraces, or benches, of flood plains lower on the landscape than the Martin soils. Grundy soils have a thinner mollic epipedon, formed in loess, and are on ridgetops higher on the landscape than the Martin soils. Woodson soils have an abrupt transition between the A and the B2t horizon and are on broad flat ridgetops higher on the landscape than the Martin soils. Oska soils have lithic contact within a depth of 40 inches, and they have hue of 7.5YR or redder in the B2t horizon. Sibleyville soils have a paralithic contact at a depth of 20 to 40 inches and have a less clayey argillic horizon.

Typical pedon of Martin silty clay loam, 2 to 5 percent slopes, 2,100 feet south and 300 feet east of the northwest corner of sec. 8 T. 15 S., R. 23 E.:

Ap—0 to 9 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure; slightly hard, friable; few fine roots; mildly alkaline; gradual smooth boundary.

A12—9 to 15 inches; very dark grayish brown (10YR 3/2) heavy silty clay loam, dark grayish brown (10YR 4/2) dry; few fine distinct strong brown (7.5YR 5/6) mottles; moderate fine and medium subangular blocky structure; hard, firm; slightly acid; gradual smooth boundary.

B21t—15 to 26 inches; very dark grayish brown (10YR 3/2) silty clay, dark grayish brown (10YR 4/2) dry; common fine distinct strong brown (7.5YR 5/6) mottles; moderate medium subangular blocky structure; very hard, very firm; slightly acid; gradual smooth boundary.

B22t—26 to 34 inches; dark grayish brown (2.5Y 4/2) silty clay, light brownish gray (2.5Y 6/2) dry; few fine distinct strong brown (7.5YR 5/6) mottles; moderate medium and fine subangular blocky structure; very hard, very firm; common dark stains on old root channels; neutral; diffuse boundary.

B3—34 to 60 inches; grayish brown (2.5Y 5/2) silty clay, light brownish gray (2.5Y 6/2) dry; many fine and medium distinct yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) mottles; weak coarse blocky structure; very hard, very firm; mildly alkaline.

Thickness of the solum ranges from 40 to more than 60 inches. Thickness of the mollic epipedon is between 24 and 36 inches. The A horizon has hue of 10YR, value of 2 or 3 (3 or 4 dry), and chroma of 1 or 2. It is typically silty clay loam, but in a few pedons it is heavy silt loam. The B2 horizon has hue of 10YR or 2.5Y, value of 3 or 4 (4 or 5 dry), and chroma of 1 or 2. It is silty clay or clay. Reaction is slightly acid or neutral. The B3 or C horizon has variegated colors ranging in hue from 7.5YR to 2.5Y. It is clay or silty clay. Reaction is neutral or mildly alkaline.

Morrill series

The Morrill series consists of deep, well drained, and moderately slowly permeable soils on uplands. These soils formed in glacial till. Slope ranges from 3 to 8 percent.

Morrill soils are similar to Ladoga soils and are near Grundy and Pawnee soils on the landscape. Grundy soils are on broad ridgetops higher on the landscape than the Morrill soils, and they have a more clayey argillic horizon. Ladoga soils formed in loess and do not have coarse sand throughout the profile. Pawnee soils are in the same position as Morrill soils, but they have a more clayey argillic horizon.

Typical pedon of Morrill loam, 3 to 8 percent slopes, 2,500 feet north and 50 feet west of the center of sec. 2, T. 13 S., R. 21 E.:

A1—0 to 9 inches; very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; moderate fine granular structure; slightly hard, friable; many fine and medium roots; neutral; clear smooth boundary.

B1—9 to 13 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; moderate fine and medium granular structure; slightly hard, friable; common fine and medium roots; slightly acid, clear smooth boundary.

B2t—13 to 22 inches; dark brown (7.5YR 3/3) clay loam, dark brown (7.5YR 4/3) dry; weak fine and medium subangular blocky structure; hard, firm; common fine roots; few glacial pebbles; slightly acid; clear smooth boundary.

B3—22 to 39 inches; brown (7.5YR 4/4) clay loam, brown (7.5YR 5/4) dry; common fine and medium distinct dark red (2.5YR 3/6) mottles; weak medium subangular blocky structure; hard, firm; common fine roots; few glacial pebbles; medium acid; gradual smooth boundary.

C—39 to 60 inches; brown (7.5YR 5/4) clay loam, light brown (7.5YR 6/4) dry; common medium distinct dark red (2.5YR 3/6) mottles; weak fine subangular blocky structure; hard, firm; few fine roots; few glacial pebbles; medium acid.

Thickness of the solum ranges from 36 to more than 60 inches. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3 (3 or 4 dry), and chroma of 1 or 2. It is typically loam, but in a few pedons it is light clay loam. Reaction is neutral or slightly acid. The B2t horizon has hue of 7.5YR, value of 3 or 4 (4 or 5 dry), and chroma of 3 or 4. It is slightly acid or medium acid. The B3 and C horizons have hue of 10YR to 5YR, value of 4 or 5 (5 or 6 dry), and chroma of 4 to 6. They are clay loam, loam, or sandy clay loam. Reaction ranges from medium acid to neutral.

Oska series

The Oska series consists of moderately deep, well drained, and slowly permeable soils on uplands. These soils formed in residuum from limestone or interbedded limestone and shales. Slope ranges from 3 to 6 percent.

Oska soils are similar to Polo and Sogn soils and are near Martin, Polo, Sibleyville, Sogn, and Vinland soils on the landscape. Martin soils do not have lithic contact within a depth of 40 inches and do not have hue of 7.5YR in the B2t horizon. Polo soils formed in loess over residuum and do not have lithic contact within a depth of 40 inches. They are on upper side slopes higher on the landscape than the Oska soils. Sogn soils have lithic contact within a depth of 20 inches. Sibleyville soils have a less clayey argillic horizon and paralithic contact at a depth of 20 to 40 inches. Vinland soils formed in shales and depth to weathered bedrock is less than 20 inches.

Typical pedon of Oska silty clay loam, 3 to 6 percent slopes, 1,180 feet south and 140 feet east of the northwest corner of sec. 5, T. 15 S., R. 23 E.:

A1—0 to 8 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; slightly hard, friable; many fine and medium roots; medium acid; gradual smooth boundary.

B1—8 to 16 inches; dark brown (7.5YR 3/2) silty clay loam, dark brown (7.5YR 4/2) dry; moderate fine subangular blocky structure; hard, firm; common fine and medium roots; medium acid; gradual smooth boundary.

B21t—16 to 20 inches; dark brown (7.5YR 3/2) heavy silty clay loam, dark brown (7.5YR 4/2) dry; moderate fine and medium subangular blocky structure; hard, firm; few fine roots; few gray coatings on faces of peds; medium acid; gradual smooth boundary.

B22t—20 to 28 inches; dark reddish brown (5YR 3/4) silty clay, reddish brown (5YR 4/4) dry; moderate fine and medium subangular blocky structure; very hard, very firm; few gray coatings on peds; few black concretions; neutral; clear smooth boundary.

B3—28 to 32 inches; dark brown (7.5YR 3/4) silty clay, dark brown (7.5YR 4/4) dry; many medium prominent light yellowish brown (2.5Y 6/4) mottles; weak medium subangular blocky structure; very hard, very firm; few medium roots; mildly alkaline; clear smooth boundary.

R—32 inches; limestone.

Thickness of the solum ranges from 20 to 40 inches, same as the depth of limestone. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3 (3 or 4 dry), and chroma of 2. Reaction is medium acid or slightly acid. The B2t horizon has hue of 7.5YR or 5YR, value of 3 to 5 (4 to 6 dry), and chroma of 3 to 5. It is typically silty clay, but in a few pedons it is heavy silty clay loam. Reaction ranges from medium acid to neutral.

Pawnee series

The Pawnee series consists of deep, moderately well drained, and slowly permeable soils on uplands. These soils formed in glacial till. Slope ranges from 3 to 6 percent.

Pawnee soils are similar to Woodson soils and are near Grundy, Morrill, Sharpsburg, and Woodson soils on the landscape. Grundy and Sharpsburg soils formed in loess, contain less sand, and are on ridgetops higher on the landscape than the Pawnee soils. Morrill soils are better drained, have a redder hue, and a less clayey argillic horizon. Woodson soils formed in old alluvium, have an abrupt change between the A and B2t horizons, and are on ridgetops higher on the landscape than the Pawnee soils.

Typical pedon of Pawnee clay loam, 3 to 6 percent slopes, 750 feet south and 150 feet west of the northeast corner of sec. 11, T. 13 S., R. 21 E.:

A1—0 to 8 inches; black (10YR 2/1) light clay loam, dark gray (10YR 4/1) dry; moderate fine granular structure; slightly hard, friable; many fine and medium roots; slightly acid; clear smooth boundary.

B1—8 to 12 inches; very dark grayish brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) dry; moderate fine and medium blocky structure; hard, firm; common fine and medium roots; medium acid; gradual smooth boundary.

B21t—12 to 24 inches; black (10YR 2/1) clay, very dark grayish brown (10YR 3/2) crushed; very dark gray (10YR 3/1) dry; few fine prominent reddish brown (5YR 4/4) mottles; weak medium and coarse blocky structure; very hard, very firm; few fine roots; neutral; gradual smooth boundary.

B22t—24 to 40 inches; dark grayish brown (10YR 4/2) clay, grayish brown (10YR 5/2) dry; few fine prominent reddish brown (5YR 4/4) mottles; weak medium and coarse blocky structure; very hard, very firm; few fine roots; mildly alkaline; gradual smooth boundary.

B3—40 to 49 inches; dark grayish brown (10YR 4/2) clay loam, grayish brown (10YR 5/2) dry; common fine distinct strong brown (7.5YR 5/6) mottles; weak medium and coarse blocky structure; hard, very firm; few black concretions; mildly alkaline; gradual smooth boundary.

C—49 to 60 inches; mixed dark grayish brown (10YR 4/2) and dark brown (10YR 4/3) clay loam, grayish brown (10YR 5/2) and brown (10YR 5/3) dry; common fine distinct strong brown (7.5YR 5/6) mottles; weak medium and coarse blocky structure; hard, firm; few black concretions; mildly alkaline.

Thickness of the solum ranges from 40 to more than 60 inches. The A horizon has hue of 10YR, value of 2 or 3 (3 or 4 dry), and chroma of 1 or 2. It is typically clay loam, but in a few pedons it is loam. Reaction is medium acid or slightly acid. The B2t horizon has hue of 10YR, value of 2.5 to 4, and chroma of 1 or 2. The B2t horizon is dominantly clay, but in some places it is clay loam. Reaction ranges from slightly acid to mildly alkaline. A few pebbles or coarse sand particles are throughout the profile.

Polo series

The Polo series consists of deep, well drained, and moderately permeable soils on uplands. These soils formed in loess and underlying residuum from limestone or shale. Slope ranges from 2 to 5 percent.

Polo soils are similar to Oska and Sharpsburg soils and are near Grundy, Oska, Sharpsburg, and Woodson soils on the landscape. Grundy soils are more poorly drained and are on ridgetops higher on the landscape than the Polo soils. Oska soils contain hard limestone bedrock at a depth of 20 to 40 inches. Sharpsburg soils are in a similar position on the landscape, but they formed in loess and do not have hue of 5YR in the lower part of the B horizon. Woodson soils are more poorly drained, contain more clay, and are on broad ridgetops higher on the landscape than the Polo soils.

Typical pedon of Polo silt loam, 2 to 5 percent slopes, 2,500 feet west and 350 feet south of the northeast corner of sec. 13, T. 14 S., R. 24 E.:

A1—0 to 13 inches; very dark brown (10YR 2/2) heavy silt loam, very dark grayish brown (10YR 3/2) dry; moderate fine and medium granular structure; slightly hard, friable; many fine roots; slightly acid; clear smooth boundary.

B1t—13 to 21 inches; very dark grayish brown (10YR 3/2) light silty clay loam, dark brown (10YR 3/3) dry; moderate fine and medium subangular blocky structure; hard, firm; many fine roots; strongly acid; gradual smooth boundary.

B2t—21 to 40 inches; dark brown (7.5YR 3/3) silty clay loam, dark brown (7.5YR 4/4) dry; moderate medium subangular blocky structure; hard, firm; few fine roots; common dark stains on peds; medium acid; gradual smooth boundary.

B3—40 to 60 inches; dark reddish brown (5YR 3/4) silty clay loam, reddish brown (5YR 4/4) dry; weak medium angular blocky structure; hard, firm; discontinuous clay films on peds; many dark stains on peds; medium acid.

Thickness of the solum ranges from 40 to more than 60 inches. Thickness of the mollic epipedon ranges from 20 to 30 inches. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3 (3 or 4 dry), and chroma of 2 or 3. It is silt loam or light silty clay loam. Reaction is slightly acid or medium acid. The B2t horizon has hue of 7.5YR or 10YR, value of 3 or 4 (4 or 5 dry), and chroma of 3 or 4. It is heavy silty clay loam or light silty clay. Reaction is medium acid or strongly acid. The B3 horizon has hue of 7.5YR or 5YR, value of 3 to 5, and chroma of 4 to 6. It is heavy silty clay loam or light silty clay.

Reading series

The Reading series consists of deep, well drained, and moderately slowly permeable soils on terraces of streams. These soils formed in thick clayey or loamy alluvium. Slope ranges from 0 to 2 percent.

Reading soils are similar to Chase soils and are near Chase, Kennebec, and Wabash soils on the landscape. Chase soils are in similar positions but have a more clayey argillic horizon and are somewhat poorly drained or moderately well drained. Kennebec soils do not have an argillic horizon and are in lower positions near the streams. Wabash soils are more clayey, do not have an argillic horizon, and are on large flood plains in backwater areas.

Typical pedon of Reading silt loam, 2,000 feet east and 100 feet south of the northwest corner of sec. 32, T. 13 S., R. 23 E.:

Ap—0 to 10 inches; very dark gray (10YR 3/1) silt loam, dark grayish brown (10YR 4/2) dry; moderate fine and medium granular structure; slightly hard, friable; many fine and medium roots; neutral; clear smooth boundary.

A12—10 to 15 inches; very dark gray (10YR 3/1) light silty clay loam, dark grayish brown (10YR 4/2) dry; weak medium granular structure; slightly hard, friable;

many fine and medium roots; neutral; gradual smooth boundary.

B1—15 to 21 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; moderate fine subangular blocky structure; hard, firm; many medium roots; neutral; gradual smooth boundary.

B2t—21 to 35 inches; very dark grayish brown (10YR 3/2) silty clay loam, brown (10YR 5/3) dry; moderate fine and medium subangular blocky structure; hard, firm; many medium roots; gray coatings on peds; neutral; gradual smooth boundary.

B3—35 to 41 inches; dark brown (10YR 3/3) silty clay loam, yellowish brown (10YR 5/4) dry; weak medium subangular blocky structure; hard, firm; few fine and medium roots; gray coatings on peds; neutral; gradual smooth boundary.

C—41 to 60 inches; dark yellowish brown (10YR 3/4) light silty clay, dark yellowish brown (10YR 4/4) dry; common fine distinct brown (7.5YR 5/4) mottles; weak medium subangular blocky structure; very hard, very firm; few medium roots; few gray coatings on peds; slightly acid.

Thickness of the solum ranges from 40 to more than 60 inches. Thickness of the mollic epipedon is more than 24 inches. The A horizon has hue of 10YR, value of 3 or less (3 to 5 dry), and chroma of 1 or 2. It is silt loam or light silty clay loam. Reaction is slightly acid or neutral. The B horizon has hue of 10YR or 7.5YR, value of 2 to 4 (3 to 5 dry), and chroma of 2 or 3. The B2t horizon averages between 30 and 35 percent clay. Reaction is slightly acid or neutral. The C horizon has hue of 10YR or 7.5YR, value of 3 to 5 (4 to 6 dry), and chroma of 2 to 4. It is silty clay loam or light silty clay. Reaction ranges from slightly acid to mildly alkaline.

Sharpsburg series

The Sharpsburg series consists of deep, moderately well drained, and moderately slowly permeable soils on uplands. These soils formed in loess. Slope ranges from 3 to 8 percent.

Sharpsburg soils are similar to Ladoga and Polo soils and are near Grundy, Ladoga, and Pawnee soils on the landscape. Grundy soils contain more clay in the argillic horizon and are on broader ridgetops. Ladoga soils have a thinner, dark colored A horizon and an A2 horizon. Pawnee soils formed in till and contain more coarse sand and gravel. Polo soils formed in loess over residuum and have hue of 5YR in the lower part of the B horizon. Polo soils generally are lower on the landscape than the Sharpsburg soils.

Typical pedon of Sharpsburg silt loam, 3 to 8 percent slopes, 1,400 feet east and 400 feet south of the northwest corner of sec. 18, T. 12 S., R. 24 E.:

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; slightly hard, friable; few fine roots; neutral; abrupt smooth boundary.

A12—9 to 13 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine and medium subangular blocky structure; hard, firm; few fine roots; slightly acid; gradual smooth boundary.

B21t—13 to 28 inches; dark brown (10YR 3/3) heavy silty clay loam, dark brown (10YR 4/3) dry; moderate fine and medium subangular blocky structure; hard, firm; few fine roots; slightly acid; gradual smooth boundary.

B22t—28 to 35 inches; dark brown (10YR 4/3) silty clay loam, brown (10YR 5/3) dry; moderate fine subangular blocky structure; hard, firm; gray silt coatings on peds; dark stains on old root channels; medium acid; gradual smooth boundary.

B3—35 to 60 inches; dark brown (10YR 4/3) silty clay loam, brown (10YR 5/3) dry; weak medium subangular blocky structure; hard, firm; few gray silt coatings on peds; dark stains on old root channels; medium acid.

Thickness of the solum ranges from 42 to more than 60 inches. The A horizon has hue of 10YR, value of 2 or 3 (3 or 4 dry), and chroma of 2 or 3. It is typically silt loam, but in a few pedons it is light silty clay loam. Reaction is neutral or slightly acid. The B2t horizon has hue of 10YR, value of 3 or 4 (4 or 5 dry), and chroma of 3 or 4. It is silty clay loam or light silty clay. Reaction is slightly acid or medium acid. The B3 horizon has hue of 10YR, value of 4 or 5 (5 or 6 dry), and chroma of 3 or 4. It is typically silty clay loam, but in a few pedons it is heavy silt loam.

Sibleyville series

The Sibleyville series consists of moderately deep, well drained, and moderately permeable soils on uplands. These soils formed in residuum from sandstone and shales. Slope ranges from 3 to 7 percent.

Sibleyville soils are similar to Vinland soils and are near Martin, Oska, and Vinland soils on the landscape. Martin soils contain more clay in the argillic horizon and do not have paralithic contact within a depth of 40 inches. Oska soils are in similar positions on the landscape, contain more clay in the argillic horizon, formed in residuum from limestone, and have lithic contact at a depth of 20 to 40 inches. Vinland soils do not have an argillic horizon and are less than 20 inches deep to shale.

Typical pedon of Sibleyville loam, from an area of Sibleyville-Vinland loams, 3 to 7 percent slopes, 1,300 feet east and 175 feet south of the northwest corner of sec. 23, T. 14 S., R. 21 E.:

A1—0 to 8 inches; very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; moderate fine and medium granular structure; slightly hard, very friable; many fine roots; slightly acid; gradual smooth boundary.

B21t—8 to 15 inches; very dark grayish brown (10YR 3/2) light clay loam, dark grayish brown (10YR 4/2) dry; moderate medium and coarse granular structure; slightly hard, friable; common medium and fine roots; slightly acid; clear smooth boundary.

B22t—15 to 22 inches; dark brown (7.5YR 4/3) light clay loam, brown (7.5YR 5/4) dry; weak fine and medium subangular blocky structure; slightly hard, friable; few fine roots; medium acid; clear smooth boundary.

C1—22 to 29 inches; strong brown (7.5YR 5/6) light clay loam, reddish yellow (7.5YR 6/6) dry; massive; slightly hard, friable; few fine roots; few coarse sandstone fragments; medium acid; gradual smooth boundary.

Cr—29 to 34 inches; partially weathered reddish yellow fine grained sandstone.

Thickness of the solum ranges from 20 to 34 inches. Depth to sandstone or sandy and silty shales ranges from 20 to 40 inches. Thickness of the mollic epipedon ranges from 10 to 20 inches. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3 (4 or 5 dry), and chroma of 2 or 3. It is loam or light clay loam. Reaction ranges from neutral to medium acid. The B2t horizon has hue of 10YR or 7.5YR, value of 3 or 4 (4 or 5 dry), and chroma of 2 to 4. It is clay loam or sandy clay loam. Reaction ranges from slightly acid to strongly acid. The C horizon has hue of 10YR or 7.5YR, value of 4 to 6 (5 to 7 dry), and chroma of 4 to 6. It is loam, clay loam, or sandy clay loam. Reaction is medium acid or strongly acid.

Sogn series

The Sogn series consists of shallow, somewhat excessively drained, and moderately permeable soils on uplands. These soils formed in residuum from the underlying limestone. Slope ranges from 5 to 20 percent.

Sogn soils are similar to Oska and Vinland soils and are near Oska and Vinland soils on the landscape. Oska soils are 20 to 40 inches deep over limestone and are higher on the landscape than the Sogn soils. Vinland soils are underlain by soft shale at a depth less than 20 inches and are lower on the landscape than the Sogn soils.

Typical pedon of Sogn silt loam, from an area of Sogn-Vinland complex, 5 to 20 percent slopes, 2,300 feet west and 200 feet south of the northeast corner of sec. 13, T. 14 S., R. 22 E.

A11—0 to 5 inches; very dark brown (10YR 2/2) heavy silt loam, very dark grayish brown (10YR 3/2) dry; moderate fine and medium granular structure; slightly hard, friable; many fine roots; neutral; clear smooth boundary.

A12—5 to 9 inches; very dark brown (7.5YR 2/2) light silty clay loam, dark brown (7.5YR 3/2) dry; strong medium granular structure; hard, firm; common fine roots; slightly acid; abrupt smooth boundary.

R—9 inches; limestone.

Thickness of the solum and depth to hard limestone range from 4 to 20 inches. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3 (3 or 4 dry), and chroma of 2 or 3. It is typically silt loam, but in a few pedons it is loam or silty clay loam. Reaction ranges from slightly acid to mildly alkaline.

Vinland series

The Vinland series consists of shallow, somewhat excessively drained, and moderately permeable soils on uplands. These soils formed in residuum from interbedded sandstone and shale. Slope ranges from 5 to 30 percent.

Vinland soils are similar to Sibleyville and Sogn soils and are near Ladoga, Oska, Sibleyville, and Sogn soils on the landscape. Ladoga soils are deeper and more clayey than Vinland soils, and they formed in loess. Oska soils formed from limestone, have lithic contact within a depth of 40 inches, and are higher on the landscape than the Vinland soils. Sibleyville soils have an argillic horizon and paralithic contact at a depth of 20 to 40 inches. Sogn soils are underlain by hard limestone at a depth less than 20 inches and are higher on the landscape than the Vinland soils.

Typical pedon of Vinland silty clay loam, from an area of Martin-Vinland silty clay loams, 7 to 15 percent slopes, 800 feet north and 100 feet east of the southwest corner of sec. 7, T. 13 S., R. 25 E.:

A1—0 to 4 inches; very dark grayish brown (10YR 3/2) light silty clay loam, grayish brown (10YR 5/2) dry; moderate fine and medium granular structure; slightly hard, friable; many fine and medium roots; slightly acid; gradual smooth boundary.

B2—4 to 11 inches; very dark grayish brown (2.5Y 3/2) silty clay loam, grayish brown (2.5Y 5/2) dry; weak fine and medium subangular blocky structure; hard, firm; few medium roots; medium acid; clear smooth boundary.

C1—11 to 18 inches; olive brown (2.5Y 4/4) silty clay loam, light yellowish brown (2.5Y 6/4) dry; few fine distinct brownish yellow (10YR 6/6) mottles; weak medium subangular blocky structure; hard, firm; medium acid; gradual smooth boundary.

Cr—18 inches; weathered interbedded sandy and silty shales.

Thickness of the solum and depth to bedrock are 10 to 20 inches. Thickness of the mollic epipedon ranges from 8 to 12 inches. The A horizon has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 1 or 2. It is typically silty clay loam, but in a few pedons it is loam. Reaction ranges from neutral to medium acid. The B2 horizon has hue of 10YR or 2.5Y, value of 3 or 4 (5 or 6 dry), and chroma of 2. Reaction is medium acid or slightly acid. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6 (5 to 7 dry), and chroma of 2 to 4. Reaction is medium acid or slightly acid.

Wabash series

The Wabash series consists of deep, very poorly drained, and very slowly permeable soils on bottom lands. These soils formed in clayey alluvium. Slope ranges from 0 to 2 percent.

Wabash soils are similar to Kimo soils and are near Chase, Kennebec, and Reading soils. Chase soils have an argillic horizon. Reading soils have an argillic horizon and are less clayey than Wabash soils. Kennebec soils contain less clay. In addition, Chase, Kennebec, and Reading soils are better drained and are closer to the streams than Wabash soils. Kimo soils have contrasting textures of silty clay loam over silt loam and are in the larger stream valleys.

Typical pedon of Wabash silty clay loam, 1,400 feet north and 300 feet east of the southwest corner of sec. 25, T. 12 S., R. 22 E.:

Ap—0 to 8 inches; black (10YR 2/1) heavy silty clay loam, very dark gray (10YR 3/1) dry; weak medium and fine granular structure; very hard, very firm; few fine roots; medium acid; clear smooth boundary.

A12—8 to 13 inches; black (10YR 2/1) light silty clay, very dark gray (10YR 3/1) dry; moderate medium and fine subangular blocky structure; very hard, very firm; few fine roots; medium acid; gradual smooth boundary.

A13—13 to 25 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; moderate medium subangular blocky structure; extremely hard, extremely firm; few fine roots; slightly acid; gradual smooth boundary.

B1g—25 to 40 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few fine faint grayish brown (2.5Y 5/2) mottles; moderate medium and fine subangular blocky structure; very hard, very firm; slightly acid; diffuse boundary.

B2g—40 to 60 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few fine faint grayish brown (2.5Y 5/2) mottles; weak medium and fine subangular blocky structure; very hard, very firm, neutral.

Thickness of the solum ranges from 40 to more than 60 inches. The A horizon has hue of 10YR or 2.5Y, value of 2 or 3 (3 or 4 dry), and chroma of 1 or 2. It is silty clay loam or silty clay. Reaction ranges from medium acid to neutral. The B horizon has the same range in color as the A horizon, but the value is higher. Texture is silty clay or clay. Reaction is slightly acid or neutral. Mottles of low chroma are common throughout many pedons.

Woodson series

The Woodson series consists of deep, somewhat poorly drained, and very slowly permeable soils on uplands. These soils formed in sediment high in silt and clay. Slope ranges from 0 to 3 percent.

Woodson soils are similar to Grundy, Martin, and Pawnee soils and are near Martin, Pawnee, and Polo soils on the landscape. Martin soils do not have the abrupt textural boundary between the A and B horizons that is characteristic of the Woodson soils. Martin soils are on the upper side slopes lower on the landscape than the Woodson soils. Pawnee soils formed in glacial till, and some pedons contain coarse sand throughout the profile. Polo soils contain less clay and have redder hue than Woodson soils. They formed in loess over residuum. Grundy soils are in similar positions on the landscape to Woodson soils but do not have an abrupt textural change between the A and Bt horizons.

Typical pedon of Woodson silt loam, 2,200 feet west and 300 feet south of the northeast corner of sec. 27, T. 14 S., R. 22 E.:

A1—0 to 10 inches; black (10YR 2.5/1) silt loam, dark gray (10YR 4/1) dry; moderate fine granular structure; slightly hard, friable; common fine roots; medium acid; abrupt smooth boundary.

B21t—10 to 21 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few fine distinct dark reddish brown (5YR 3/3) mottles; weak fine and medium blocky structure; extremely hard, very firm; few fine roots; gray silt coatings on some faces of peds; slightly acid; gradual smooth boundary.

B22t—21 to 30 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; common fine distinct strong brown (7.5YR 5/6) mottles; moderate fine blocky structure; extremely hard, very firm; few black concretions; neutral; gradual smooth boundary.

B3—30 to 48 inches; grayish brown (2.5Y 5/2) silty clay, light brownish gray (2.5Y 6/2) dry; few fine distinct strong brown (7.5YR 5/6) mottles; weak medium blocky structure; extremely hard, very firm; mildly alkaline; gradual smooth boundary.

C—48 to 60 inches; very dark gray (10YR 3/1) light silty clay, gray (10YR 5/1) dry; common fine distinct dark brown (7.5YR 4/2) mottles; massive; very hard, very firm; neutral.

Thickness of the solum ranges from 30 to 60 inches. The A horizon has hue of 10YR, value of 2 or 3 (4 or 5 dry), and chroma of 1. It is typically silt loam, but in a few pedons it is silty clay loam. Reaction is medium acid or slightly acid. The B2t horizon has hue of 10YR or 2.5Y, value of 2 or 3 (3 or 4 dry), and chroma of 1.5 or less. It is silty clay or clay. Reaction is slightly acid or neutral. The B3 and C horizons have hue of 10YR or 2.5Y, value of 3 to 5 (4 to 6 dry), and chroma of 1 or 2. They are silty clay loam, silty clay, or clay. Reaction is neutral or mildly alkaline. Mottles are common throughout the profile of many pedons.

Classification of the soils

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Readers interested in further details about the system should refer to "Soil taxonomy" (*4*).

The system of classification has six categories. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. In this system the classification is based on the different soil properties that can be observed in the field or those that can be inferred either from other properties that are observable in the field or from the combined data of soil science and other disciplines. The properties selected for the higher categories are the result of soil genesis or of factors that affect soil genesis. In table 17, the soils of the survey area are classified according to the system. Categories of the system are discussed in the following paragraphs.

ORDER. Ten soil orders are recognized as classes in the system. The properties used to differentiate among orders are those that reflect the kind and degree of dominant soil-forming processes that have taken place. Each order is identified by a word ending in *sol*. An example is Mollisol.

SUBORDER. Each order is divided into suborders based primarily on properties that influence soil genesis and are important to plant growth or that are selected to reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Udoll (*Ud*, meaning moist, plus *oll*, from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of expression of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and a prefix that suggests something about the properties of the soil. An example is Argiudolls (*Argi*, meaning with an argillic horizon, plus *udoll*, the suborder of Mollisols that have a moist moisture regime).

SUBGROUP. Each great group may be divided into three subgroups: the central (typic) concept of the great groups, which is not necessarily the most extensive subgroup; the intergrades, or transitional forms to other orders, suborders, or great groups; and the extragrades, which have some properties that are representative of the great groups but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that is thought to typify the great group. An example is Typic Argiudolls.

FAMILY. Families are established within a subgroup on the basis of similar physical and chemical properties that affect management. Among the properties considered in horizons of major biological activity below plow depth are particle-size distribution, mineral content, temperature regime, thickness of the soil penetrable by roots, consistence, moisture equivalent, soil slope, and permanent cracks. A family name consists of the name of a subgroup and a series of adjectives. The adjectives are the class names for the soil properties used as family differentiae. An example is fine, montmorillonitic, mesic, Typic Argiudolls.

SERIES. The series consists of soils that formed in a particular kind of material and have horizons that, except for texture of the surface soil or of the underlying substratum, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, texture, structure, reaction, consistence, and mineral and chemical composition.

Formation of the soils

This section discusses the factors of soil formation, relates them to the formation of soils in the survey area, and explains the processes of soil formation.

Factors of soil formation

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Generally, a long time is required for the development of distinct horizons.

Parent material

Parent material refers to the unconsolidated material from which soil develops. Through weathering, rock gives rise to parent material, and this is the first step in soil development. Rocks are weathered by such natural forces as freezing and thawing, abrasion and erosion by wind and water, and biological and chemical action. In the northwestern part of Johnson County, glacial action has increased the weathering process by scouring and grinding the rocks.

The nature of the parent material influences the kind of soil that develops and the rate of development. Also many chemical and physical properties of the soil are inherited from the parent material. Many different parent materials are present in Johnson County, and each parent material has influenced, to some degree, the kinds of soil that developed.

The parent materials are residuum from limestones, sandstones and shales, loess deposits, glacial sediment, and alluvial sediment. In many areas the rocks are covered with loess and, to a lesser extent, glacial till.

Climate

Climate has influenced soil formation in Johnson County. Temperature and precipitation have played an important role in the physical and chemical weathering of the parent material. Organisms acting upon the parent material and in the soil contribute organic matter and nutrients to the soil. Their activity is governed by climate. Chemical, physical, and biological processes in the soil are quite active in the humid, warm climate of Johnson County.

Plant and animal life

Vegetation is very important in the development of soils. Plants, especially grasses, provide the soil with much organic matter. Plants also draw nutrients from the soil and parent material. After dying, the plant material is attacked by micro-organisms. Through this process organic matter is formed and nutrients are released, thus the surface layer is enriched. Under grassland the soil develops a dark-colored surface layer that is rich in organic matter and nutrients. Plants also protect the surface layer from erosion.

Worms and other micro-organisms also influence soil formation. Worms pass large quantities of organic matter and soil through their digestive systems, thus altering them chemically and physically. Worms also incorporate organic matter and provide for drainage and aeration along their burrows.

Most soils in Johnson County are believed to have been formed under the cover of grasses. The surface layers are rich in organic matter content and nutrients. Some soils along drainageways on uplands have developed under a cover of deciduous trees. These soils have a grayish surface layer and have less organic matter content than grassland soils.

Relief

Relief or the lay of the land influences soil development through its effect upon runoff, erosion, drainage, temperature and moisture relations, and vegetation. Slope has a very pronounced effect upon soil development. Runoff is high on sloping landscapes, thus the amount of water percolating through the soil is reduced. Erosion is more likely to occur on sloping soils, thus reducing the rate of the soil development. Soil development is greatest on nearly level to gently sloping soils.

Time

The length of time required for a soil to develop depends upon the parent material, climate, vegetation and other living organisms, and relief.

Soil development on bedrock, such as sandstone and limestone, will require more time than soils being developed from loess. The Sibleyville soils, which formed in residuum from sandstone, are less developed than the Grundy soils, which formed in loess, even though the loess is the younger parent material.

Less time is required for a soil to develop in humid, warm climates. Assuming loess is the parent material, the soils in the western part of Kansas are less developed than those in the eastern part of Kansas, mainly because of climate (less rainfall) and the indirect influence of climate on vegetation.

More time is required for soil development on sloping land. Runoff is greater, thus reducing the amount of water percolating through the soil. Sharpsburg soils are on narrow sloping ridges and have a less clayey subsoil than the Grundy soils which are on the more broad, gentle landscapes.

Among some of the oldest soils in the county are the Grundy, Pawnee, and Martin soils which formed in loess, till, and shale residuum, respectively. They have well-developed subsoils or B horizons. Eudora and Kennebec soils are among the younger soils and formed in recent alluvium. They do not have distinct horizons.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bottom land. The normal flood plain of a stream, subject to frequent flooding.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coat, clay skin.

Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.

Coarse textured (light textured) soil. Sand or loamy sand.

Complex, soil. A map unit of two or more kinds of soil occurring in such an intricate pattern that they cannot be shown separately on a soil map at the selected scale of mapping and publication.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Contour stripcropping (or contour farming). Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

Erosion. The wearing away of the land surface by running water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes a bare surface.

Fine textured (heavy textured) soil. Sandy clay, silty clay, and clay.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Green manure (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water(geology). Water filling all the unblocked pores of underlying material below the water table, which is the upper limit of saturation.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum, the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered, but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Light textured soil. Sand and loamy sand.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Percolation. The downward movement of water through the soil.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are *very slow* (less than 0.06 inch), *slow* (0.06 to 0.20 inch), *moderately slow* (0.2 to 0.6 inch), *moderate* (0.6 to 2.0 inches), *moderately rapid* (2.0 to 6.0 inches), *rapid* (6.0 to 20 inches), and *very rapid* (more than 20 inches).

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from a semisolid to a plastic state.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	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

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils, formed from a particular type of parent material, having horizons that, except for the texture of the A or surface horizon, are similar in all profile characteristics and in arrangement in the soil profile. Among these characteristics are color, texture, structure, reaction, consistence, and mineralogical and chemical composition.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that 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, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Stubble mulch. Stubble or other crop residue left on the soil, or partly worked into the soil, to provide protection from soil blowing and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil (engineering). Presumably a fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

ILLUSTRATIONS

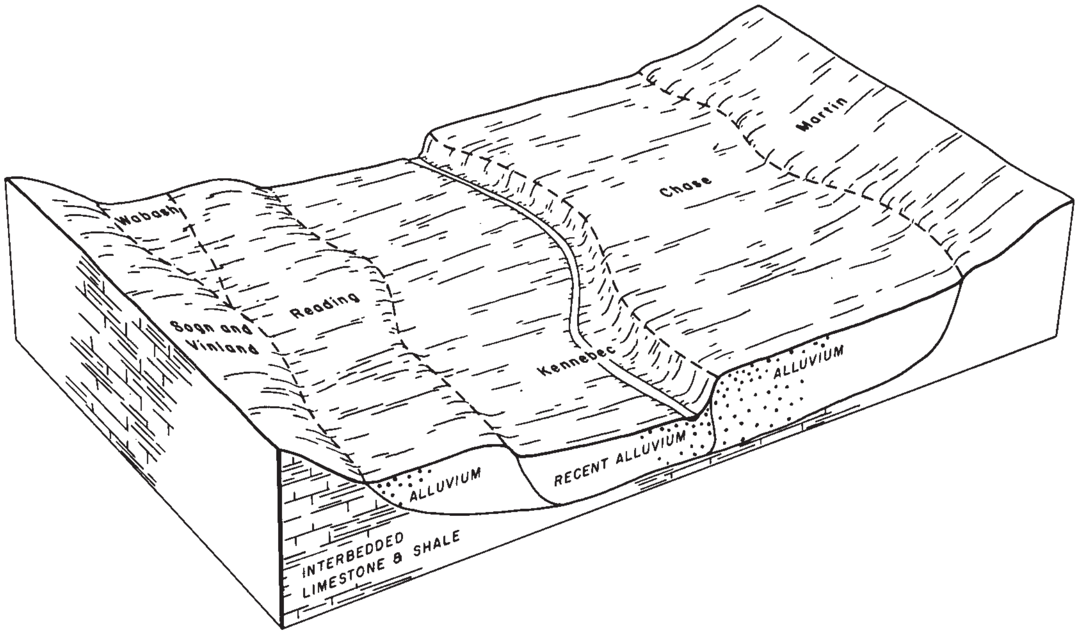

Figure 1.—Pattern of soils and underlying material in the Kennebec-Chase map unit.

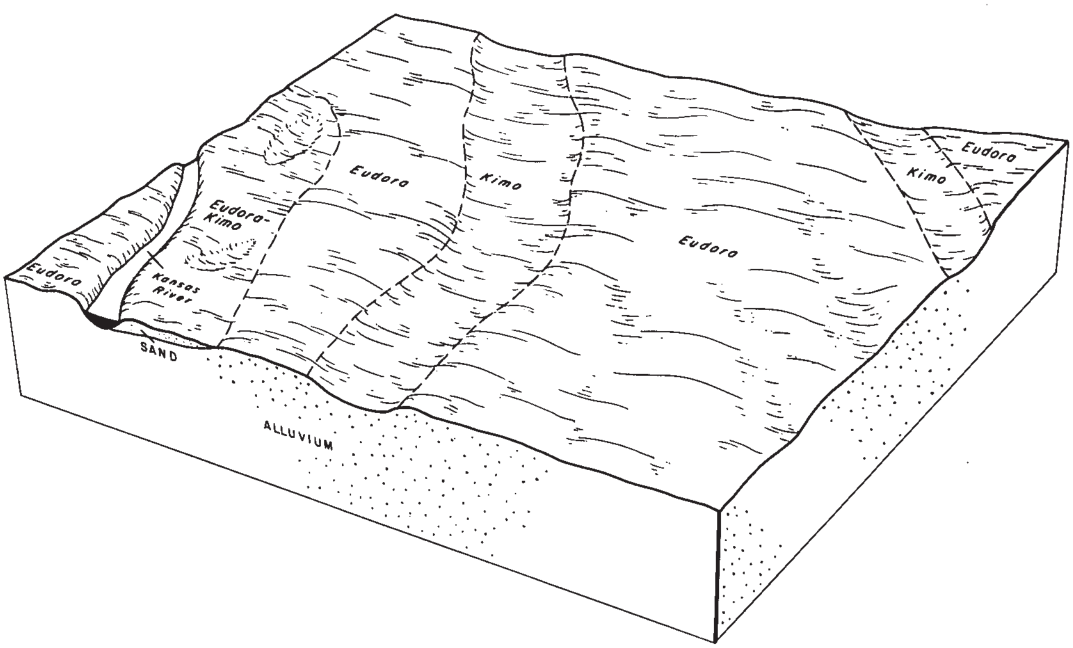

Figure 2.—Pattern of soils and underlying material in the Eudora-Kimo map unit.

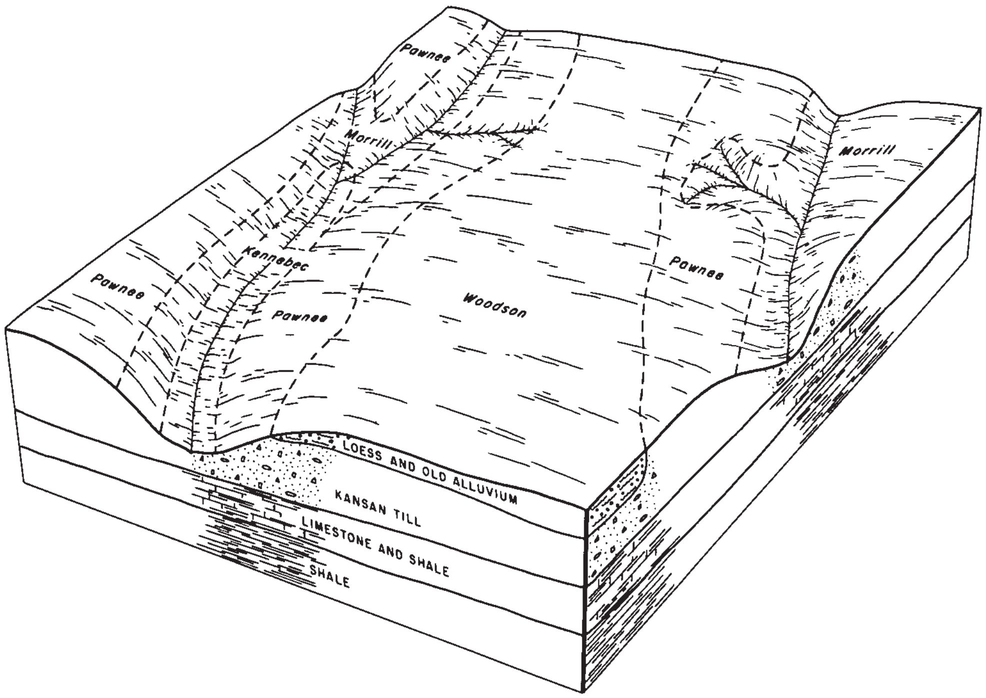

Figure 3.—Pattern of soils and underlying material in the Woodson-Pawnee map unit.

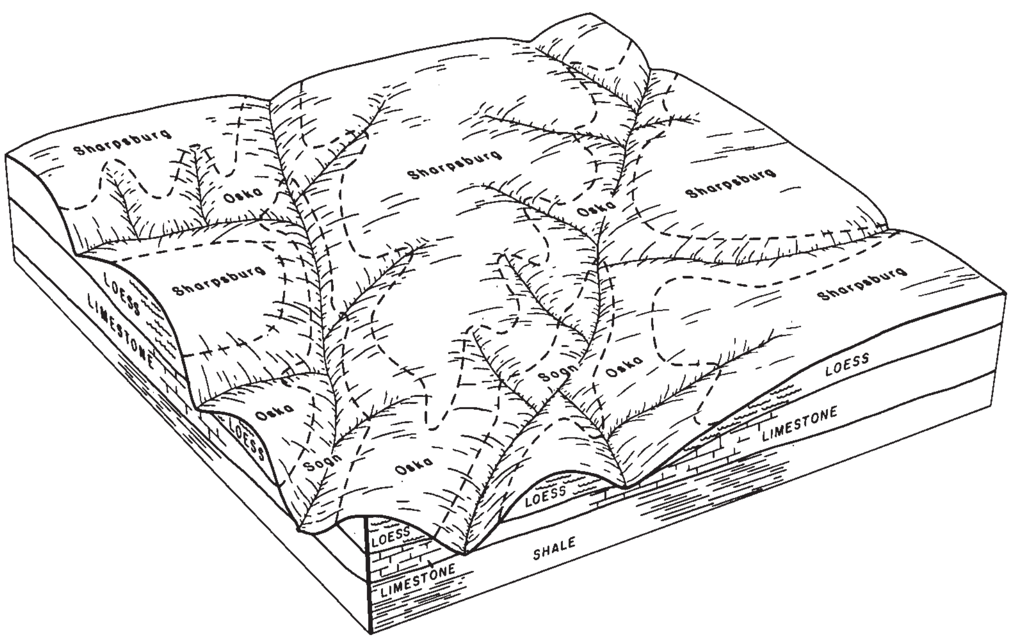

Figure 4.—Pattern of soils and underlying material in the Sharpsburg-Oska map unit.

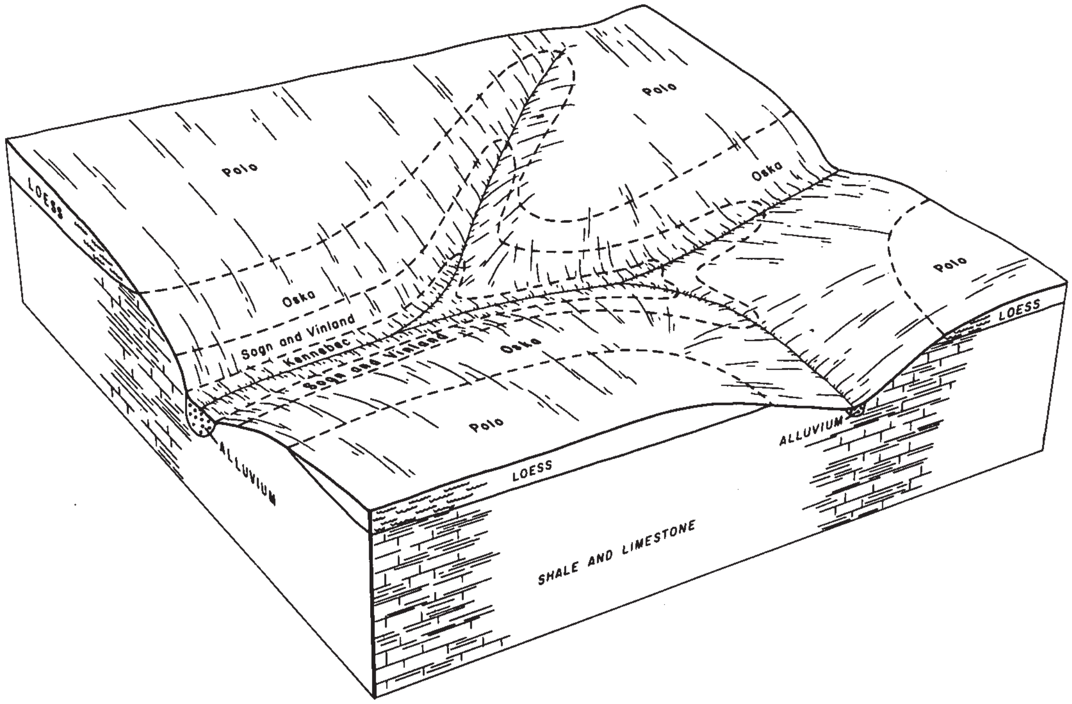

Figure 5.—Pattern of soils and underlying material in the Polo-Oska map unit.

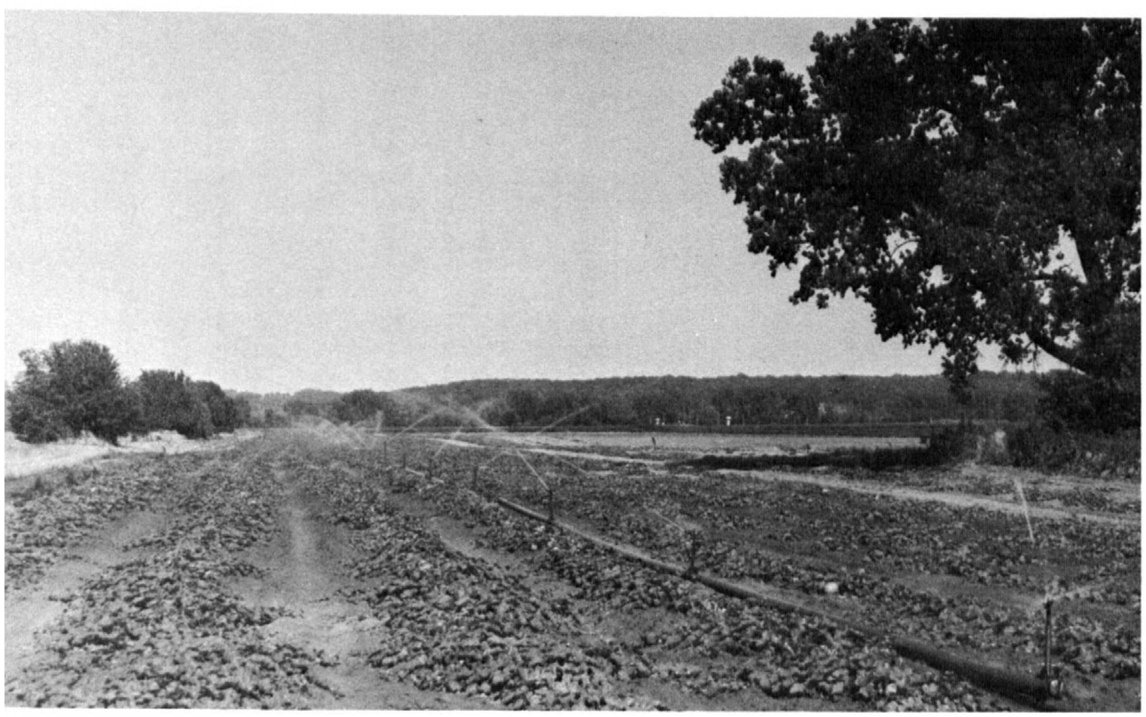

Figure 6.—Irrigating vegetable crops on Eudora silt loam.

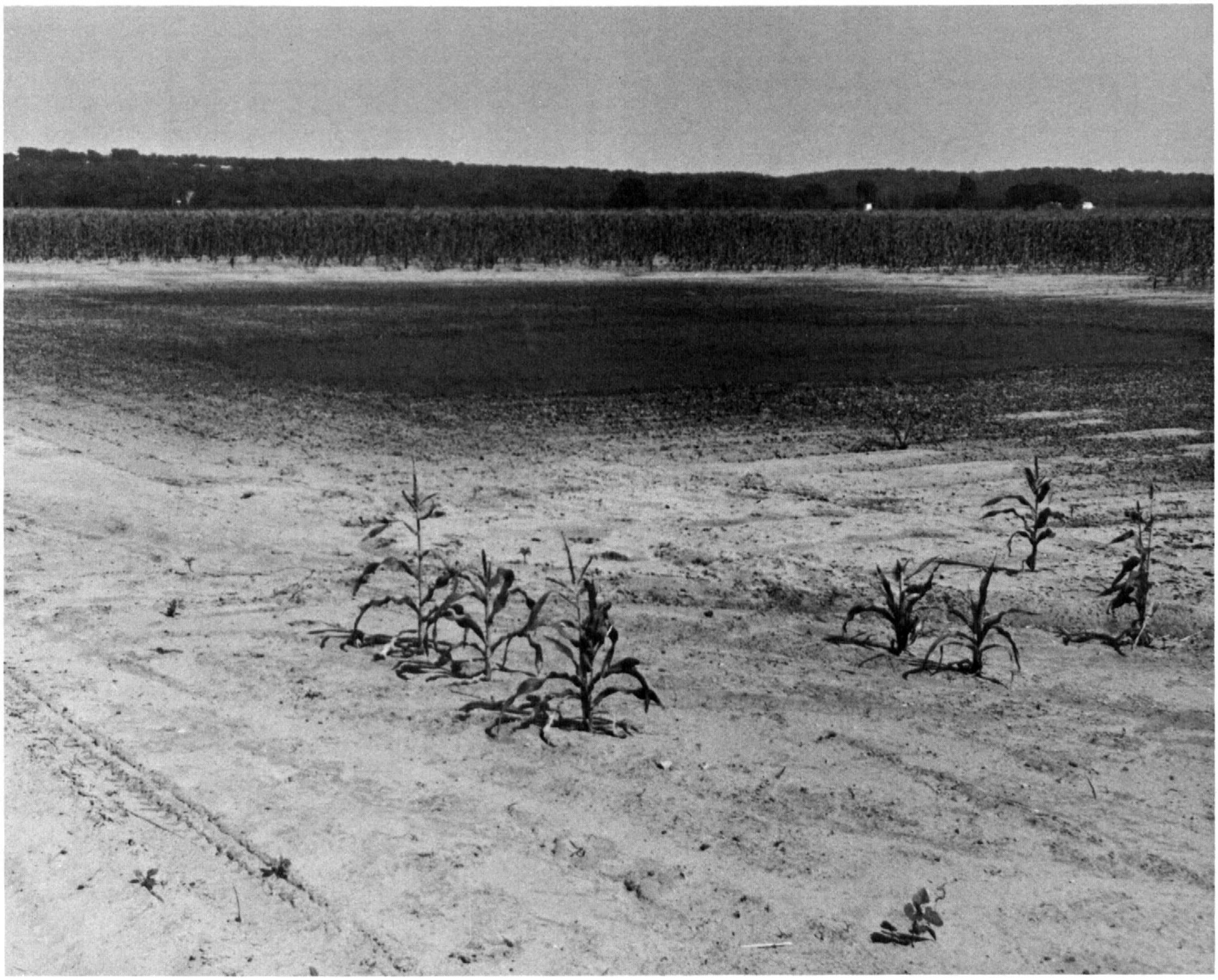

Figure 7.—Crop damage caused by ponding on Kimo soils.

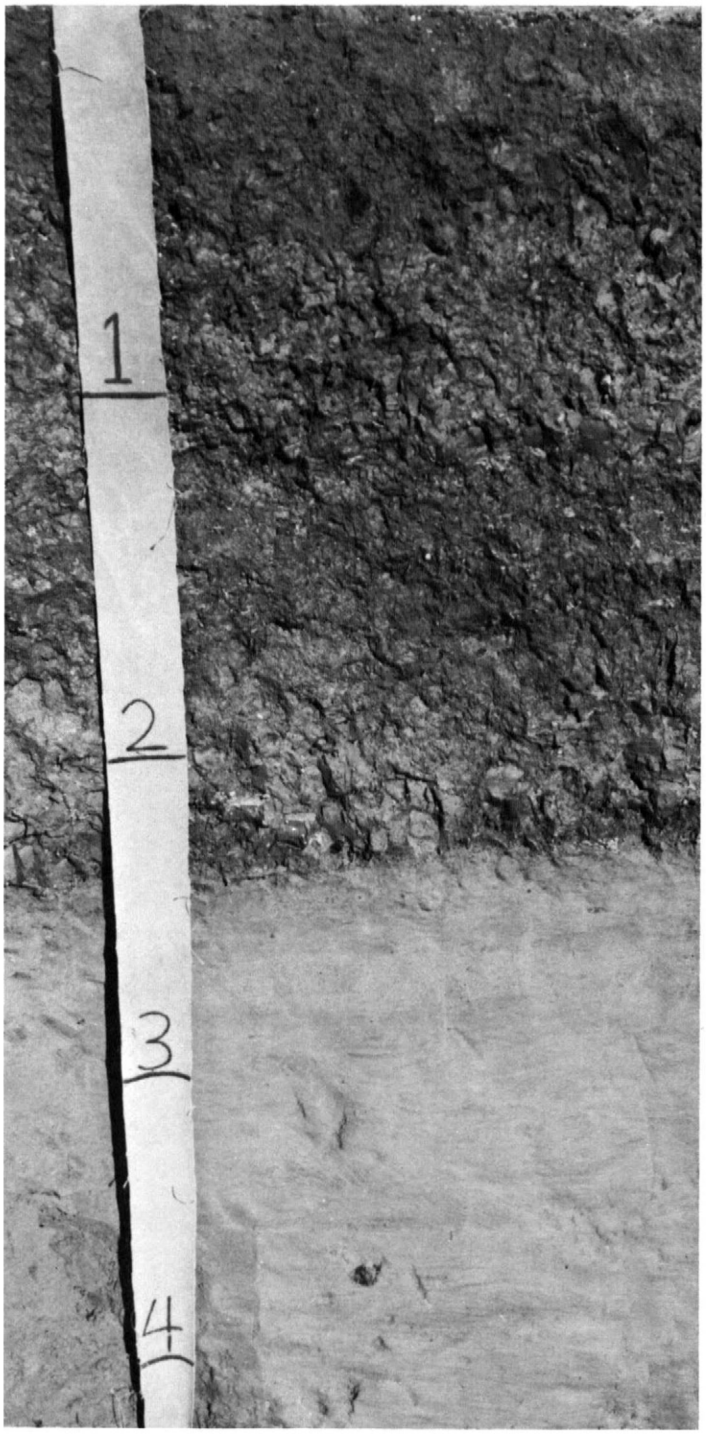

Figure 8.—Profile of Kimo silty clay loam.

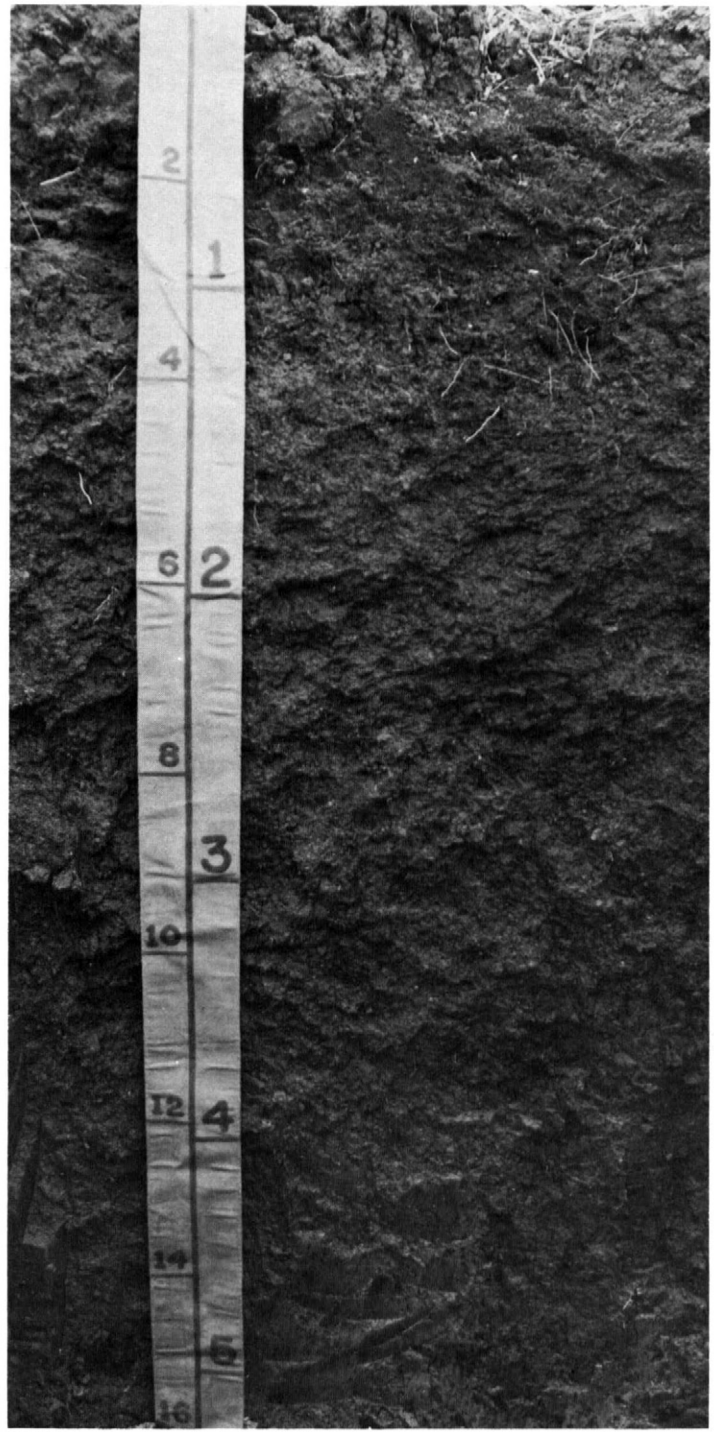

Figure 9.—Profile of Martin silty clay loam, 2 to 5 percent slopes.

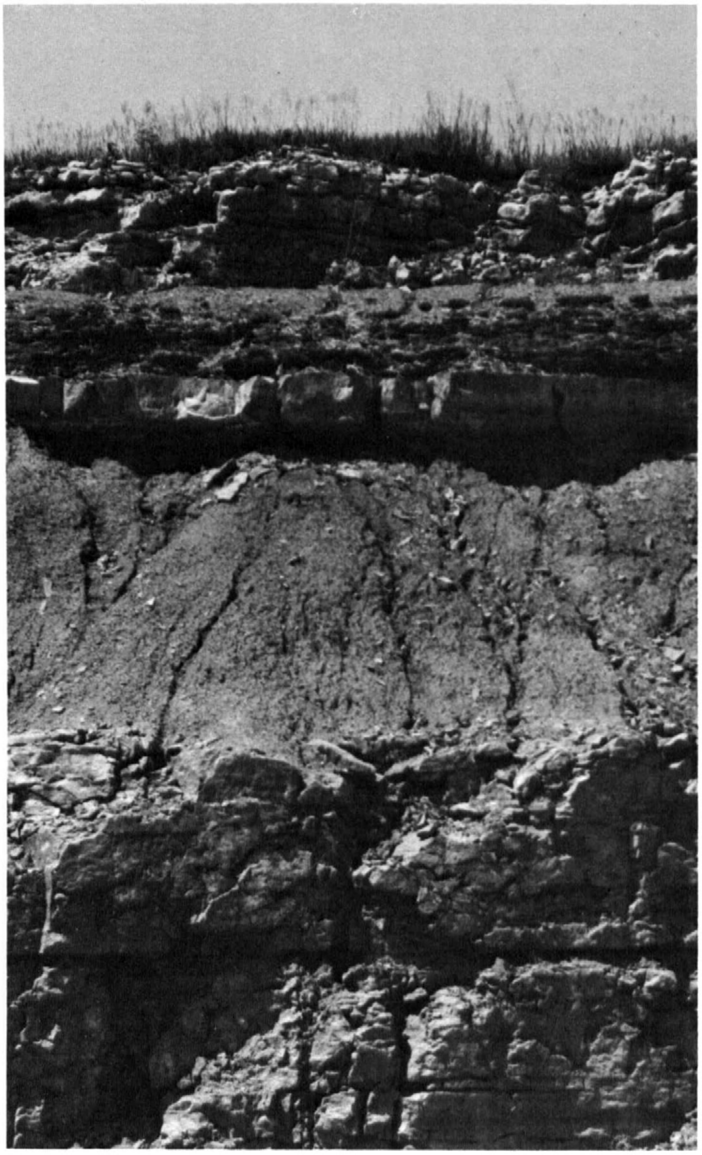

Figure 10.—Interbedded shale and limestone below Sogn and Vinland soils.

Figure 11.—Profile of Sogn silty clay loam.

Figure 12.—Area of Vinland-Rock outcrop complex, 20 to 40 percent slopes.

Figure 13.—Stubble mulching on Martin soils.

Figure 14.—Vegetable crops on Eudora soils.

Figure 15.—Basements are difficult to construct on shallow soils.

Figure 16.—Removal of surface layer for topsoil exposed the clay subsoil.

Figure 17.—Floods are damaging on lowland soils.

TABLES

TABLE 1.--TEMPERATURE AND PRECIPITATION DATA

Month	Temperature[1]					Precipitation[1]				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	In	In	In		In
January-----	38.9	19.5	29.2	69	-10	1.18	0.27	1.84	3	4.7
February----	44.2	24.0	34.1	71	- 2	1.19	0.68	1.97	3	3.1
March-------	52.9	31.2	42.0	82	3	2.27	1.03	3.32	4	4.4
April-------	66.3	44.1	55.2	87	23	4.03	1.77	5.59	6	0.7
May---------	75.2	54.2	64.7	90	34	4.48	2.85	6.15	7	0
June--------	83.3	63.2	73.3	96	45	6.10	3.16	9.13	8	0
July--------	88.4	67.0	77.7	103	53	4.60	2.30	6.35	6	0
August------	87.9	65.9	76.9	102	49	3.62	2.15	5.31	5	0
September---	80.2	57.3	68.8	98	37	4.55	1.46	7.11	6	0
October-----	70.4	47.4	58.9	89	25	3.35	0.96	6.84	5	0
November----	54.4	33.9	44.1	76	8	1.48	0.24	2.25	3	0.8
December----	42.6	24.4	33.5	68	- 6	1.40	0.77	1.92	3	4.0
Year------	---	---	---	103	-10	38.25	25.77	43.91	59	17.7

[1]Recorded in the period 1941-70 at Olathe.

TABLE 2.--FREEZE DATES IN SPRING AND FALL

Probability	Minimum temperature[1]		
	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	April 7	April 19	May 1
2 years in 10 later than--	April 2	April 14	April 26
5 years in 10 later than--	March 24	April 4	April 16
First freezing temperature in fall:			
1 year in 10 earlier than--	October 27	October 18	October 8
2 years in 10 earlier than--	November 1	October 23	October 12
5 years in 10 earlier than--	November 11	November 1	October 22

[1]Recorded in the period 1931-60 at Olathe.

TABLE 3.--GROWING SEASON LENGTH

Probability	Daily minimum temperature during growing season[1]		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	204	189	166
8 years in 10	212	197	174
5 years in 10	229	213	189
2 years in 10	244	219	204
1 year in 10	253	237	211

[1]Recorded in the period 1931-60 at Olathe.

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
Ca	Chase silt loam	3,650	1.2
Ea	Eudora silt loam	1,100	0.4
Eb	Eudora soils, overwash	1,250	0.4
Ec	Eudora-Kimo complex	1,700	0.6
Ed	Eudora-Kimo complex, overwash	1,326	0.4
Ga	Grundy silt loam, 1 to 3 percent slopes	17,200	5.6
Ka	Kennebec silt loam	9,700	3.2
Kb	Kennebec silt loam, channeled	8,300	2.7
Kc	Kimo silty clay loam	317	0.1
La	Ladoga silt loam, 3 to 8 percent slopes	6,600	2.2
Lb	Ladoga silt loam, 8 to 15 percent slopes	1,350	0.4
Ma	Martin silty clay loam, 2 to 5 percent slopes	16,700	5.5
Mb	Martin-Vinland silty clay loams, 7 to 15 percent slopes	1,700	0.6
Mc	Morrill loam, 3 to 8 percent slopes	4,850	1.6
Oa	Orthents	401	0.1
Ob	Oska silty clay loam, 3 to 6 percent slopes	6,400	2.1
Oc	Oska-Martin complex, 4 to 8 percent slopes	48,250	15.8
Pa	Pawnee clay loam, 3 to 6 percent slopes	5,200	1.7
Pc	Polo silt loam, 2 to 5 percent slopes	60,000	19.7
Qa	Pits, quarries	750	0.3
Ra	Reading silt loam	2,750	0.9
Sa	Sharpsburg silt loam, 3 to 8 percent slopes	12,000	3.9
Sb	Sharpsburg-Urban land complex, 3 to 8 percent slopes	15,500	5.1
Sc	Sibleyville loam, 3 to 7 percent slopes	4,700	1.5
Sd	Sibleyville-Vinland loams, 3 to 7 percent slopes	1,800	0.6
Se	Sogn-Vinland complex, 5 to 20 percent slopes	14,000	4.6
Va	Vinland-Rock outcrop complex, 20 to 40 percent slopes	9,900	3.3
Wa	Wabash silty clay loam	560	0.2
Wb	Woodson silt loam	46,750	15.3
	Total	304,704	100.0

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE

[Yields are those that can be expected under a high level of management. The estimates were made in 1975. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Corn	Grain sorghum	Soybeans	Wheat, winter	Smooth bromegrass
	Bu	Bu	Bu	Bu	AUM[1]
Chase:					
Ca	82	94	35	45	8.0
Eudora:					
Ea, Eb	100	100	45	50	6.5
[2]Ec	90	90	41	45	8.0
[2]Ed	85	85	38	42	8.0
Grundy:					
Ga	90	85	35	40	8.0
Kennebec:					
Ka	100	100	38	48	6.5
Kb	---	---	---	---	---
Kimo:					
Kc	80	90	38	40	9.5
Ladoga:					
La	100	100	41	42	7.5
Lb	90	90	38	38	7.0
Martin:					
Ma	75	80	35	35	5.5
[2]Mb	---	---	---	---	---
Morrill:					
Mc	80	85	32	38	6.5
Orthents:					
Oa	---	---	---	---	---
Oska:					
Ob	60	70	32	34	6.0
[2]Oc	66	75	34	36	6.5
Pawnee:					
Pa	70	75	30	35	6.0
Polo:					
Pc	80	80	36	40	7.3
Pits, quarries:					
Qa.					
Reading:					
Ra	92	94	44	52	7.5
Sharpsburg:					
Sa	100	95	41	40	7.3
[2]Sb	---	---	---	---	---
Sibleyville:					
Sc	55	65	22	30	6.0
[2]Sd	---	---	---	---	---
Sogn:					
[2]Se	---	---	---	---	---

See footnotes at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Grain sorghum	Soybeans	Wheat,winter	Smooth bromegrass
	Bu	Bu	Bu	Bu	AUM[1]
Vinland:					
[2]Va	---	---	---	---	---
Wabash:					
Wa	80	80	35	36	---
Woodson:					
Wb	65	75	28	35	5.0

[1]Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for a period of 30 days.

[2]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 6.--WOODLAND MANAGEMENT AND PRODUCTIVITY

[Only the soils suitable for production of commercial trees are listed]

Soil name and map symbol	Management concerns					Potential productivity		Trees to plant
	Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition	Important trees	Site index	
Chase:								
Ca	Slight	Moderate	Moderate	Slight	Slight	Bur oak	62	Pecan,
						Hackberry	69	green ash,
						Green ash	60	eastern cottonwood.
						Eastern cottonwood	66	
						Black walnut	66	
Eudora:								
Ea, Eb	Slight	Slight	Slight	Slight	Moderate	Eastern cottonwood	105	Eastern cottonwood,
						American sycamore	105	American sycamore.
						Hackberry	---	
						Black walnut	---	
						Green ash	---	
[1]Ec:								
Eudora part	Slight	Slight	Slight	Slight	Moderate	Eastern cottonwood	105	Eastern cottonwood,
						American sycamore	105	American sycamore.
						Hackberry	---	
						Black walnut	---	
						Green ash	---	
Kimo part	Slight	Moderate	Moderate	Slight	Slight	Eastern cottonwood	90	Eastern cottonwood,
						White oak	62	green ash,
						Northern red oak	---	American sycamore,
						Hackberry	---	pecan.
						Green ash	---	
[1]Ed:								
Eudora part	Slight	Slight	Slight	Slight	Moderate	Eastern cottonwood	105	Eastern cottonwood,
						American sycamore	105	American sycamore.
						Hackberry	---	
						Black walnut	---	
						Green ash	---	
Kimo part	Slight	Moderate	Moderate	Slight	Slight	Eastern cottonwood	90	Eastern cottonwood,
						White oak	62	green ash,
						Northern red oak	---	American sycamore,
						Hackberry	---	pecan.
						Green ash	---	
Kennebec:								
Ka, Kb	Slight	Slight	Slight	Slight	Moderate	Black walnut	75	Black walnut,
						Bur oak	63	bur oak,
						Hackberry	---	hackberry,
						Green ash	---	green ash,
						Eastern cottonwood	---	eastern cottonwood,
								American sycamore.
Kimo:								
Kc	Slight	Moderate	Moderate	Slight	Slight	Eastern cottonwood	85	Eastern cottonwood,
						White oak	60	green ash,
						Northern red oak	---	American sycamore,
						Hackberry	---	pecan.
						Green ash	---	
Ladoga:								
La, Lb	Slight	Slight	Slight	Slight	Moderate	White oak	65	Eastern white pine,
						Northern red oak	65	red pine,
								Norway spruce,
								Scotch pine,
								European larch,
								eastern redcedar,
								sugar maple,
								white spruce.

See footnote at end of table.

TABLE 6.--WOODLAND MANAGEMENT AND PRODUCTIVITY--Continued

Soil name and map symbol	Management concerns					Potential productivity		Trees to plant
	Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition	Important trees	Site index	
eading:								
Ra	Slight	Slight	Slight	Slight	Moderate	Black walnut Hackberry Bur oak Shagbark hickory Southern red oak	73 69 60 62 ---	Black walnut, green ash, hackberry, American sycamore, eastern cottonwood.
Sharpsburg:								
Sa, [1]Sb	Slight	Slight	Slight	Slight	Slight	Black oak Black walnut White oak Hackberry Green ash	60 60 --- --- ---	Black walnut, hackberry, green ash.
Wabash:								
Wa	Slight	Moderate	Moderate	Moderate	Severe	Pin oak	75	Pin oak, pecan, eastern cottonwood.

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit description for composition and behavior characteristics of the map unit.

TABLE 7.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Chase:					
Ca	Severe: too clayey.	Severe: floods, shrink-swell, low strength.	Severe: floods, shrink-swell, low strength.	Severe: floods, shrink-swell, low strength.	Severe. shrink-swell, low strength.
Eudora:					
Ea, Eb	Moderate: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: frost action.
[1]Ec:					
Eudora part	Moderate: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: frost action.
Kimo part	Severe: wetness.	Severe: floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: shrink-swell, low strength.
[1]Ed:					
Eudora part	Moderate: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: frost action.
Kimo part	Severe: wetness.	Severe: floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: shrink-swell, low strength.
Grundy:					
Ga	Severe: wetness.	Severe: shrink-swell, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.
Kennebec:					
Ka, Kb	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods, frost action, low strength.
Kimo:					
Kc	Severe: wetness.	Severe: floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: floods, shrink-swell.	Severe: shrink-swell, low strength.
Ladoga:					
La	Moderate: wetness.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: frost action, low strength.
Lb	Moderate: slope, wetness.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Severe: shrink-swell, slope.	Severe: frost action, low strength.
Martin:					
Ma	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.
[1]Mb:					
Martin part	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.
Vinland part	Moderate: depth to rock, slope.	Moderate: depth to rock, slope.	Moderate: depth to rock, slope.	Severe: slope.	Moderate: depth to rock, slope.

See footnote at end of table.

TABLE 7.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Morrill:					
Mc	Moderate: too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Moderate: shrink-swell, low strength.
Orthents:					
Oa.					
Oska:					
Ob	Severe: depth to rock.	Severe: shrink-swell.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell.	Severe: shrink-swell.
[1]Oc:					
Oska part	Severe: depth to rock.	Severe: shrink-swell.	Severe: shrink-swell, depth to rock.	Severe: shrink-swell.	Severe: shrink-swell.
Martin part	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.
Pawnee:					
Pa	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.
Polo:					
Pc	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Pits, quarries:					
Qa.					
Reading:					
Ra	Moderate: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, frost action.
Sharpsburg:					
Sa, [1]Sb	Slight	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Sibleyville:					
Sc	Moderate: depth to rock.	Moderate: depth to rock, low strength.	Moderate: depth to rock, low strength.	Moderate: depth to rock, low strength, slope.	Moderate: low strength, frost action.
[1]Sd:					
Sibleyville part	Moderate: depth to rock.	Moderate: depth to rock, low strength.	Moderate: depth to rock, low strength.	Moderate: depth to rock, low strength, slope.	Moderate: low strength, frost action.
Vinland part	Moderate: depth to rock.	Moderate: depth to rock.	Moderate: depth to rock.	Moderate: depth to rock, slope.	Moderate: depth to rock.
Sogn:					
[1]Se:					
Sogn part	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.
Vinland part	Moderate: depth to rock, slope.	Moderate: depth to rock, slope.	Moderate: depth to rock, slope.	Severe: slope.	Moderate: depth to rock, slope.

See footnote at end of table.

TABLE 7.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Vinland:					
[1]Va:					
Vinland part---	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
Rock outcrop part.					
Wabash:					
Wa----------------	Severe: wetness, floods, too clayey.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.
Woodson:					
Wb----------------	Severe: too clayey, wetness.	Severe: shrink-swell, low strength, wetness.	Severe: shrink-swell, low strength, wetness.	Severe: shrink-swell, low strength, wetness.	Severe: shrink-swell, low strength.

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," and "fair." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Chase:					
Ca	Severe: percs slowly.	Slight	Severe: too clayey.	Severe: floods.	Poor: too clayey.
Eudora:					
Ea, Eb	Moderate: floods.	Moderate: seepage.	Moderate: floods.	Moderate: floods.	Good.
[1]Ec:					
Eudora part	Moderate: floods.	Moderate: seepage.	Moderate: floods.	Moderate: floods.	Good.
Kimo part	Severe: percs slowly.	Slight	Severe: wetness.	Severe: wetness.	Fair: too clayey.
[1]Ed:					
Eudora part	Moderate: floods.	Moderate: seepage.	Moderate: floods.	Moderate: floods.	Good.
Kimo part	Severe: percs slowly.	Slight	Severe: wetness.	Severe: wetness.	Fair: too clayey.
Grundy:					
Ga	Severe: percs slowly, wetness.	Moderate: slope.	Moderate: too clayey, wetness.	Moderate: wetness.	Fair: too clayey.
Kennebec:					
Ka	Severe: floods, wetness.	Severe: floods.	Severe: floods, wetness.	Severe: floods, wetness.	Good.
Kb	Severe: floods, wetness.	Severe: floods.	Severe: floods, wetness.	Severe: floods, wetness.	Good.
Kimo:					
Kc	Severe: percs slowly.	Slight	Severe: wetness.	Severe: wetness.	Fair: too clayey.
Ladoga:					
La	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
Lb	Severe: percs slowly.	Severe: slope.	Moderate: too clayey.	Moderate: slope.	Fair: too clayey, slope.
Martin:					
Ma	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: thin layer.
[1]Mb:					
Martin part	Severe: percs slowly.	Severe: slope.	Severe: too clayey.	Moderate: slope.	Poor: thin layer.
Vinland part	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Moderate: slope.	Poor: thin layer.
Morrill:					
Mc	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.	Slight	Fair: too clayey.

See footnote at end of table.

TABLE 8.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Orthents:					
Oa.					
Oska:					
Ob	Severe: depth to rock, percs slowly.	Severe: depth to rock.	Severe: depth to rock.	Slight	Poor: too clayey.
[1]Oc:					
Oska part	Severe: depth to rock, percs slowly.	Severe: depth to rock.	Severe: depth to rock.	Slight	Poor: too clayey.
Martin part	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: thin layer.
Pawnee:					
Pa	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: too clayey.
Polo:					
Pc	Slight	Moderate: slope, seepage.	Moderate: too clayey.	Slight	Fair: too clayey.
Pits, quarries:					
Qa.					
Reading:					
Ra	Moderate: percs slowly.	Moderate: seepage.	Moderate: floods, too clayey.	Moderate: floods.	Fair: too clayey.
Sharpsburg:					
Sa, [1]Sb	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
Sibleyville:					
Sc	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Fair: thin layer.
[1]Sd:					
Sibleyville part	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Fair: thin layer.
Vinland part	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Slight	Poor: thin layer.
Sogn:					
[1]Se:					
Sogn part	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Moderate: slope.	Poor: thin layer, area reclaim.
Vinland part	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Moderate: slope.	Poor: thin layer.
Vinland:					
[1]Va:					
Vinland part	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Severe: slope.	Poor: thin layer.
Rock outcrop part.					

See footnote at end of table.

TABLE 8.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Wabash:					
Wa	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: wetness, too clayey.
Woodson:					
Wb	Severe: percs slowly, wetness.	Slight	Severe: too clayey.	Moderate: wetness.	Poor: too clayey.

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--CONSTRUCTION MATERIALS

["Shrink-swell" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and "poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Chase:				
Ca	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Eudora:				
Ea, Eb	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
[1]Ec:				
Eudora part	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Kimo part	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
[1]Ed:				
Eudora part	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Kimo part	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
Grundy:				
Ga	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Kennebec:				
Ka, Kb	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Kimo:				
Kc	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
Ladoga:				
La	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Lb	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer, slope.
Martin:				
Ma	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
[1]Mb:				
Martin part	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey, slope.
Vinland part	Poor: thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: area reclaim, thin layer.
Morrill:				
Mc	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.

See footnote at end of table.

TABLE 9.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Orthents:				
Oa.				
Oska:				
Ob	Poor: shrink-swell, low strength, thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer, too clayey.
[1]Oc:				
Oska part	Poor: shrink-swell, low strength, thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer, too clayey.
Martin part	Poor: low strength, shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
Pawnee:				
Pa	Poor: shrink-swell.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: too clayey.
Polo:				
Pc	Poor: shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: too clayey.
Pits, quarries:				
Qa.				
Reading:				
Ra	Poor: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Sharpsburg:				
Sa, [1]Sb	Poor: shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Good.
Sibleyville:				
Sc	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
[1]Sd:				
Sibleyville part	Fair: low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.
Vinland part	Poor: thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: area reclaim, thin layer.
Sogn:				
[1]Se:				
Sogn part	Poor: thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: area reclaim.
Vinland part	Poor: thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: area reclaim, thin layer.
Vinland:				
[1]Va:				
Vinland part	Poor: thin layer.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: area reclaim, thin layer.
Rock outcrop part.				

See footnote at end of table.

TABLE 9.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Wabash:				
Wa	Poor: wetness, shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: wetness, too clayey.
Woodson:				
Wb	Poor: shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Fair: thin layer.

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. Absence of an entry indicates that the soil was not evaluated]

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Chase:						
Ca	Favorable	Shrink-swell, low strength.	Floods, percs slowly.	Slow intake, floods.	Not needed	Percs slowly.
Eudora:						
Ea, Eb	Seepage	Low strength, piping.	Not needed	Favorable	Not needed	Not needed.
[1]Ec:						
Eudora part	Seepage	Low strength, piping.	Not needed	Favorable	Not needed	Not needed.
Kimo part	Favorable	Shrink-swell, low strength.	Wetness, poor outlets.	Wetness, floods, percs slowly.	Not needed	Not needed.
[1]Ed:						
Eudora part	Seepage	Low strength, piping.	Not needed	Favorable	Not needed	Not needed.
Kimo part	Favorable	Shrink-swell, low strength.	Wetness, poor outlets.	Wetness, floods, percs slowly.	Not needed	Not needed.
Grundy:						
Ga	Favorable	Low strength, shrink-swell.	Percs slowly, wetness.	Slow intake, percs slowly.	Percs slowly, wetness.	Percs slowly, wetness.
Kennebec:						
Ka, Kb	Seepage	Low strength, compressible, excess humus.	Floods, frost action.	Floods	Favorable	Favorable.
Kimo:						
Kc	Favorable	Shrink-swell, low strength.	Wetness, poor outlets.	Wetness, floods, percs slowly.	Not needed	Not needed.
Ladoga:						
La, Lb	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Martin:						
Ma	Favorable	Shrink-swell, low strength.	Not needed	Slow intake, slope.	Percs slowly	Favorable.
[1]Mb:						
Martin part	Favorable	Shrink-swell, low strength.	Not needed	Slow intake, slope.	Percs slowly	Favorable.
Vinland part	Depth to rock	Thin layer	Not needed	Rooting depth, slope.	Depth to rock	Rooting depth.
Morrill:						
Mc	Favorable	Low strength	Not needed	Slope, erodes easily.	Favorable	Favorable.
Orthents:						
Oa.						
Oska:						
Ob	Depth to rock	Low strength, thin layer, shrink-swell.	Not needed	Slow intake, erodes easily, droughty.	Depth to rock	Depth to rock, erodes easily.
[1]Oc:						
Oska part	Depth to rock	Low strength, thin layer, shrink-swell.	Not needed	Slow intake, erodes easily, droughty.	Depth to rock	Depth to rock, erodes easily.

See footnote at end of table.

TABLE 10.--WATER MANAGEMENT--Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Oska:						
Martin part	Favorable	Shrink-swell, low strength.	Not needed	Slow intake, slope.	Percs slowly	Favorable.
Pawnee:						
Pa	Favorable	Shrink-swell	Not needed	Percs slowly, slow intake.	Percs slowly, erodes easily.	Percs slowly.
Polo:						
Pc	Seepage	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Pits, quarries: Qa.						
Reading:						
Ra	Favorable	Shrink-swell, erodes easily.	Not needed	Slow intake	Favorable	Favorable.
Sharpsburg:						
Sa, [1]Sb	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Sibleyville:						
Sc	Depth to rock	Thin layer, erodes easily.	Not needed	Erodes easily, rooting depth.	Depth to rock, erodes easily.	Erodes easily.
[1]Sd:						
Sibleyville part	Depth to rock	Thin layer, erodes easily.	Not needed	Erodes easily, rooting depth.	Depth to rock, erodes easily.	Erodes easily.
Vinland part	Depth to rock	Thin layer	Not needed	Rooting depth, slope.	Depth to rock	Rooting depth.
Sogn:						
[1]Se:						
Sogn part	Depth to rock	Thin layer	Not needed	Rooting depth	Depth to rock	Rooting depth.
Vinland part	Depth to rock	Thin layer	Not needed	Rooting depth, slope.	Depth to rock	Rooting depth.
Vinland:						
[1]Va:						
Vinland part	Depth to rock	Thin layer	Not needed	Rooting depth, slope.	Depth to rock	Rooting depth.
Rock outcrop part.						
Wabash:						
Wa	Favorable	Shrink-swell, compressible, low strength.	Floods, percs slowly, wetness.	Slow intake, wetness, floods.	Percs slowly, wetness.	Percs slowly, wetness.
Woodson:						
Wb	Favorable	Low strength, shrink-swell.	Wetness, percs slowly.	Slow intake, wetness.	Wetness, percs slowly.	Percs slowly, wetness.

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Chase:				
Ca	Severe: floods.	Moderate: floods, wetness.	Moderate: percs slowly, wetness.	Slight.
Eudora:				
Ea, Eb	Severe: floods.	Slight	Slight	Slight.
[1]Ec:				
Eudora part	Severe: floods.	Slight	Slight	Slight.
Kimo part	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.
[1]Ed:				
Eudora part	Severe: floods.	Slight	Slight	Slight.
Kimo part	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.
Grundy:				
Ga	Moderate: percs slowly, wetness.	Moderate: wetness.	Moderate: percs slowly, wetness.	Moderate: wetness.
Kennebec:				
Ka	Severe: floods.	Moderate: floods.	Moderate: floods.	Slight.
Kb	Severe: floods.	Moderate: floods.	Moderate: floods.	Slight.
Kimo:				
Kc	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.
Ladoga:				
La	Moderate: percs slowly.	Slight	Moderate: percs slowly, slope.	Slight.
Lb	Moderate: percs slowly, slope.	Moderate: slope.	Severe: slope.	Slight.
Martin:				
Ma	Moderate: too clayey, percs slowly.	Moderate: too clayey.	Moderate: too clayey, percs slowly, slope.	Moderate: too clayey.
[1]Mb:				
Martin part	Moderate: too clayey, percs slowly, slope.	Moderate: too clayey, slope.	Severe: slope.	Moderate: too clayey.
Vinland part	Moderate: too clayey, slope.	Moderate: too clayey, slope.	Severe: depth to rock, slope.	Moderate: too clayey.

See footnote at end of table.

TABLE 11.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Morrill:				
Mc	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
Orthents:				
Oa.				
Oska:				
Ob	Moderate: percs slowly, too clayey.	Moderate: too clayey.	Moderate: percs slowly, too clayey, depth to rock.	Moderate: too clayey.
[1]Oc:				
Oska part	Moderate: percs slowly, too clayey.	Moderate: too clayey.	Severe: slope.	Moderate: too clayey.
Martin part	Moderate: too clayey, percs slowly.	Moderate: too clayey.	Severe: slope.	Moderate: too clayey.
Pawnee:				
Pa	Moderate: percs slowly.	Moderate: too clayey.	Moderate: percs slowly.	Moderate: too clayey.
Polo:				
Pc	Moderate: percs slowly.	Slight	Moderate: slope, percs slowly.	Slight.
Pits, quarries:				
Qa.				
Reading:				
Ra	Severe: floods.	Slight	Slight	Slight.
Sharpsburg:				
Sa, [1]Sb	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
Sibleyville:				
Sc	Slight	Slight	Moderate: depth to rock, slope.	Slight.
[1]Sd:				
Sibleyville part	Slight	Slight	Moderate: depth to rock, slope.	Slight.
Vinland part	Slight	Slight	Severe: depth to rock.	Slight.
Sogn:				
[1]Se:				
Sogn part	Moderate: too clayey, slope.	Moderate: too clayey, slope.	Severe: depth to rock.	Moderate: too clayey.
Vinland part	Moderate: too clayey, slope.	Moderate: too clayey, slope.	Severe: depth to rock, slope.	Moderate: too clayey.

See footnote at end of table.

TABLE 11.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Vinland:				
[1]Va:				
Vinland part	Severe: slope.	Severe: slope.	Severe: depth to rock, slope.	Moderate: too clayey.
Rock outcrop part.				
Wabash:				
Wa	Severe: floods, wetness, percs slowly.	Severe: wetness, floods, too clayey.	Severe: wetness, floods, percs slowly.	Severe: wetness, too clayey.
Woodson:				
Wb	Severe: percs slowly.	Moderate: wetness.	Severe: percs slowly.	Moderate: wetness.

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--WILDLIFE HABITAT POTENTIALS

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Potential for habitat elements								Potential as habitat for--			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife	Rangeland wildlife
Chase:												
Ca	Good	Good	Good	Good	Good	Good	Good	Fair	Good	Good	Fair	---
Eudora:												
Ea, Eb	Good	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor	---
[1]Ec:												
Eudora part	Good	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor	---
Kimo part	Good	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good	---
[1]Ed:												
Eudora part	Good	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor	---
Kimo part	Good	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good	---
Grundy:												
Ga	Fair	Good	Fair	Good	Good	Good	Fair	Poor	Fair	---	Poor	Fair.
Kennebec:												
Ka	Good	Good	Good	Good	Good	---	Poor	Poor	Good	Good	Poor	---
Kb	Poor	Poor	Good	Good	Good	---	Poor	Poor	Poor	Good	Very poor.	---
Kimo:												
Kc	Good	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good	---
Ladoga:												
La, Lb	Fair	Good	Fair	Good	Good	---	Very poor.	Poor	Fair	Good	Very poor.	---
Martin:												
Ma	Good	Good	Good	---	Good	Good	Poor	Poor	Good	---	Poor	Good.
[1]Mb:												
Martin part	Fair	Good	Good	---	Good	Good	Poor	Very poor.	Good	---	Very poor.	Good.
Vinland part	Poor	Poor	Fair	Fair	Fair	---	Very poor.	Very poor.	Poor	Fair	Very poor.	---
Morrill:												
Mc	Fair	Good	Good	Good	Good	Good	Poor	Very poor.	Good	---	Very poor.	Good.
Orthents:												
Oa.												
Oska:												
Ob	Fair	Good	Good	Fair	Fair	Good	Poor	Poor	Good	---	Poor	Good.
[1]Oc:												
Oska part	Fair	Good	Good	Fair	Fair	Good	Poor	Poor	Good	---	Poor	Good.
Martin part	Fair	Good	Good	Good	Good	Good	Poor	Very poor.	Good	---	Very poor.	Good.
Pawnee:												
Pa	Fair	Fair	Fair	---	Fair	Fair	Poor	Very poor.	Fair	---	Poor	Fair.

See footnote at end of table.

TABLE 12.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements								Potential as habitat for--			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife	Rangeland wildlife
Polo: Pc	Good	Good	Good	Good	Good	---	Poor	Very poor.	Good	---	Very poor.	---
Pits, quarries Qa.												
Reading: Ra	Good	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor	---
Sharpsburg: Sa, [1]Sb	Fair	Good	Good	Good	Good	---	Poor	Poor	Good	Good	Poor	---
Sibleyville: Sc	Fair	Good	Good	Good	Good	---	Poor	Very poor.	Good	---	Very poor.	Good.
[1]Sd: Sibleyville part	Fair	Good	Good	Good	Good	---	Poor	Very poor.	Good	---	Very poor.	Good.
Vinland part	Poor	Poor	Fair	Fair	Fair	---	Very poor.	Very poor.	Poor	Fair	Very poor.	---
Sogn: [1]Se: Sogn part	Very poor.	Very poor.	Poor	---	---	Poor	Very poor.	Very poor.	Very poor.	---	Very poor.	Poor.
Vinland part	Poor	Poor	Fair	Fair	Fair	---	Very poor.	Very poor.	Poor	Fair	Very poor.	---
Vinland: [1]Va: Vinland part	Poor	Poor	Fair	Fair	Fair	---	Very poor.	Very poor.	Poor	Fair	Very poor.	---
Rock outcrop part.												
Wabash: Wa	Poor	Poor	Poor	Poor	Poor	---	Good	Good	Poor	Poor	Good	---
Woodson: Wb	Fair	Good	Poor	---	---	Good	Poor	Good	Fair	---	Fair	Fair.

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the whole map unit.

TABLE 13.--ENGINEERING PROPERTIES AND CLASSIFICATIONS

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
Chase:											
Ca	0-10	Silt loam	CL	A-6, A-7	0	100	100	95-100	90-100	35-45	15-25
	10-60	Silty clay, silty clay loam, clay.	CH, CL	A-7-6	0	100	100	95-100	90-100	40-60	20-35
Eudora:											
Ea, Eb	0-14	Silt loam	ML, CL, CL-ML	A-4	0	100	100	95-100	60-98	20-35	2-10
	14-60	Silt loam, very fine sandy loam.	ML, CL, CL-ML	A-4	0	100	100	95-100	60-98	10-25	NP-10
[1]Ec:											
Eudora part	0-14	Silt loam	ML, CL, CL-ML	A-4	0	100	100	95-100	60-98	20-35	2-10
	14-60	Silt loam, very fine sandy loam.	ML, CL, CL-ML	A-4	0	100	100	95-100	60-98	10-25	NP-10
Kimo part	0-24	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	95-100	90-100	40-55	15-30
	24-60	Silt loam, very fine sandy loam.	ML, CL, CL-ML	A-4	0	100	100	95-100	60-100	<25	NP-10
[1]Ed:											
Eudora part	0-14	Silt loam	ML, CL, CL-ML	A-4	0	100	100	95-100	60-98	20-35	2-10
	14-60	Silt loam, very fine sandy loam.	ML, CL, CL-ML	A-4	0	100	100	95-100	60-98	10-25	NP-10
Kimo part	0-24	Silty clay loam	CH, CL	A-7	0	100	100	95-100	90-100	40-55	15-30
	24-60	Silt loam, very fine sandy loam.	ML, CL, CL-ML	A-4	0	100	100	95-100	60-100	<25	NP-10
Grundy:											
Ga	0-9	Silt loam	CL, ML	A-6, A-7, A-4	0	100	100	95-100	90-100	30-50	5-25
	9-15	Silty clay loam, silty clay.	CH, CL	A-7	0	100	100	95-100	95-100	45-55	30-40
	15-29	Silty clay, silty clay loam.	CH	A-7	0	100	100	95-100	95-100	50-70	30-45
	29-60	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	45-55	30-40
Kennebec:											
Ka, Kb	0-48	Silt loam	CL, ML, CL-ML	A-6, A-7	0	100	100	95-100	90-100	30-50	10-20
	48-60	Silt loam, silty clay loam.	CL, ML	A-6, A-7, A-4	0	100	100	95-100	90-100	30-50	5-20
Kimo:											
Kc	0-24	Silty clay loam silty clay.	CH, CL	A-7	0	100	100	95-100	90-100	40-55	15-30
	24-60	Silt loam, very fine sandy loam.	ML, CL, CL-ML	A-4	0	100	100	95-100	60-100	<25	NP-10
Ladoga:											
La, Lb	0-13	Silt loam	CL, CL-ML	A-6, A-4	0	100	100	100	95-100	25-40	5-15
	13-31	Silty clay loam	CL, CH	A-7	0	100	100	100	95-100	41-55	25-35
	31-60	Silty clay loam, silt loam.	CL	A-6	0	100	100	100	95-100	30-40	15-20

See footnote at end of table.

TABLE 13.--ENGINEERING PROPERTIES AND CLASSIFICATIONS--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag-ments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plas-ticity index
	In				Pct					Pct	
Martin:											
Ma----------------	0-15	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	80-99	35-50	15-25
	15-60	Silty clay, clay	CH, CL	A-7	0	100	100	95-100	80-98	41-70	25-40
[1]Mb:											
Martin part-----	0-15	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	80-99	35-50	15-25
	15-60	Silty clay, clay	CH, CL	A-7	0	100	100	95-100	80-98	41-70	25-40
Vinland part----	0-18	Silty clay loam	ML, CL	A-6, A-7	0	85-100	85-100	80-100	75-95	35-50	10-25
	18	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Morrill:											
Mc----------------	0-13	Loam------------	ML, CL, CL-ML	A-4, A-6	0	100	100	94-100	50-85	20-35	2-15
	13-22	Clay loam, sandy clay loam.	CL	A-4, A-6, A-7	0	100	100	90-100	55-85	30-45	8-20
	22-60	Loam, sandy clay loam, clay loam.	CL, ML, CL-ML	A-4, A-6	0	100	100	90-100	55-85	25-40	2-15
Orthents:											
Oa.											
Oska:											
Ob----------------	0-16	Silty clay loam	ML, CL	A-6, A-7	0	100	100	96-100	90-100	38-50	12-22
	16-32	Clay, silty clay, silty clay loam.	CH, CL	A-7-6	0	100	100	96-100	95-100	45-60	20-35
	32	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
[1]Oc:											
Oska part--------	0-16	Silty clay loam	ML, CL	A-6, A-7	0	100	100	96-100	90-100	38-50	12-22
	16-32	Clay, silty clay, silty clay loam.	CH, CL	A-7-6	0	100	100	96-100	95-100	45-60	20-35
	32	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Martin part-----	0-15	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	80-99	35-50	15-25
	15-60	Silty clay, clay	CH, CL	A-7	0	100	100	95-100	80-98	41-70	25-40
Pawnee:											
Pa----------------	0-12	Clay loam--------	CL	A-6	0	95-100	95-100	85-100	70-90	30-40	10-20
	12-49	Clay-------------	CH	A-7	0	95-100	95-100	85-100	70-85	50-70	25-45
	49-60	Clay loam, sandy clay loam.	CL, CH	A-7, A-6	0	95-100	95-100	80-100	70-90	35-55	20-40
Polo:											
Pc----------------	0-13	Silt loam--------	CL-ML, CL	A-4	0	100	100	95-100	90-100	10-25	5-10
	13-21	Silty clay loam	CL	A-6	0	100	100	95-100	90-100	25-40	10-20
	21-60	Silty clay, silty clay loam.	CL, CH	A-7	0	100	100	95-100	92-100	40-60	20-40
Pits, quarries:											
Qa.											
Reading:											
Ra----------------	0-15	Silt loam--------	CL, CL-ML	A-4, A-6	0	100	100	90-100	85-100	25-40	5-20
	15-41	Silty clay loam	CL	A-6, A-7	0	100	100	95-100	90-100	35-50	15-30
	41-60	Silty clay loam, clay loam, silty clay.	CL	A-6, A-7	0	100	100	95-100	80-100	35-50	15-30

See footnote at end of table.

TABLE 13.--ENGINEERING PROPERTIES AND CLASSIFICATIONS--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
Sharpsburg:											
Sa, [1]Sb	0-13	Silt loam	CL	A-6	0	100	100	100	95-100	25-40	10-20
	13-60	Silty clay loam, silty clay.	CH, CL	A-7, A-6	0	100	100	100	95-100	35-60	20-35
Sibleyville:											
Sc	0-8	Loam	CL, CL-ML	A-4, A-6	0	100	100	85-100	60-80	20-35	5-15
	8-22	Loam, clay loam, sandy clay loam.	CL, SC	A-4, A-6	0	100	100	80-90	40-60	20-40	8-25
	22-34	Loam, clay loam, sandy clay loam.	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	50-80	20-40	5-15
	34	Weathered bedrock.	---	---	---	---	---	---	---	---	---
[1]Sd:											
Sibleyville part	0-8	Loam	CL, CL-ML	A-4, A-6	0	100	100	85-100	60-80	20-35	5-15
	8-22	Loam, clay loam, sandy clay loam.	CL, SC	A-4, A-6	0	100	100	80-90	40-60	20-40	8-25
	22-34	Loam, clay loam, sandy clay loam.	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	50-80	20-40	5-15
	34	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Vinland part	0-18	Loam	ML, SM, CL, SC	A-4	0	85-100	85-100	75-95	45-70	20-35	NP-10
	18	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Sogn:											
[1]Se:											
Sogn part	0-9	Silty clay loam	CL	A-6, A-7	0-10	85-100	85-100	85-100	80-95	25-45	11-23
	9	Unweathered bedrock.	---	---	---	---	---	---	---	---	---
Vinland part	0-18	Silty clay loam	ML, CL	A-6, A-7	0	85-100	85-100	80-100	75-95	35-50	10-25
	18	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Vinland:											
[1]Va:											
Vinland part	0-18	Silty clay loam	ML, CL	A-6, A-7	0	85-100	85-100	80-100	75-95	35-50	10-25
	18	Weathered bedrock.	---	---	---	---	---	---	---	---	---
Rock outcrop part.											
Wabash:											
Wa	0-8	Silty clay loam	CL, CH	A-6, A-7	0	100	100	100	95-100	30-55	12-35
	8-60	Silty clay, clay	CH	A-7	0	100	100	100	95-100	52-78	30-55
Woodson:											
Wb	0-10	Silt loam	CL, CL-ML	A-4, A-6	0	100	100	90-100	85-100	25-40	5-20
	10-30	Silty clay, clay	CH	A-7-6	0	100	95-100	95-100	90-100	50-65	30-45
	30-60	Silty clay, clay, silty clay loam.	CH, CL	A-7-6	0	100	95-100	95-100	90-100	45-60	25-40

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS

[The symbol < means less than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	Erosion factors: K	Erosion factors: T	Wind erodibility group
	In	In/hr	In/in	pH						
Chase:										
Ca	0-10	0.2-0.6	0.21-0.24	5.6-7.3	High	High	Low	0.37	5	6
	10-60	0.06-0.2	0.11-0.19	5.6-7.8	High	High	Low	0.37		
Eudora:										
Ea, Eb	0-14	0.6-2.0	0.20-0.24	6.1-7.3	Low	Low	Low	0.32	5	5
	14-60	0.6-2.0	0.17-0.22	6.6-8.4	Low	Low	Low	0.43		
[1]Ec:										
Eudora part	0-14	0.6-2.0	0.20-0.24	6.1-7.3	Low	Low	Low	0.32	5	5
	14-60	0.6-2.0	0.17-0.22	6.6-8.4	Low	Low	Low	0.43		
Kimo part	0-24	0.06-0.2	0.13-0.22	6.6-8.4	High	High	Low	0.37	5	4
	24-60	0.6-6.0	0.17-0.22	6.6-8.4	Low	Low	Low	0.37		
[1]Ed:										
Eudora part	0-14	0.6-2.0	0.20-0.24	6.1-7.3	Low	Low	Low	0.32	5	5
	14-60	0.6-2.0	0.17-0.22	6.6-8.4	Low	Low	Low	0.43		
Kimo part	0-24	0.06-0.2	0.13-0.22	6.6-8.4	High	High	Low	0.37	5	4
	24-60	0.6-2.0	0.17-0.22	6.6-8.4	Low	Low	Low	0.37		
Grundy:										
Ga	0-9	0.6-2.0	0.22-0.24	5.6-7.3	Moderate	High	Low	0.37	3	6
	9-15	0.2-0.6	0.18-0.20	5.6-6.0	High	High	Low	0.37		
	15-29	0.06-0.2	0.11-0.13	5.1-6.5	High	High	Moderate	0.37		
	29-60	0.06-0.2	0.18-0.20	5.6-7.3	High	High	Low	0.37		
Kennebec:										
Ka, Kb	0-48	0.6-2.0	0.22-0.24	5.6-6.5	Moderate	Moderate	Low	0.32	5	6
	48-60	0.6-2.0	0.20-0.22	6.1-7.3	Moderate	Moderate	Low	0.43		
Kimo:										
Kc	0-24	0.06-0.2	0.13-0.22	6.6-8.4	High	High	Low	0.37	5	4
	24-60	0.6-2.0	0.17-0.22	6.6-8.4	Low	Low	Low	0.37		
Ladoga:										
La, Lb	0-13	0.6-2.0	0.22-0.24	6.1-6.5	Low	Moderate	Low	0.32	5	6
	13-31	0.2-0.6	0.18-0.20	5.1-6.0	Moderate	Moderate	Moderate	0.43		
	31-60	0.2-0.6	0.18-0.20	5.1-6.5	Moderate	Moderate	Moderate	0.43		
Martin:										
Ma	0-15	0.2-0.6	0.21-0.23	5.6-6.5	Moderate	High	Low	0.37	4	7
	15-60	0.06-0.2	0.12-0.18	5.6-7.8	High	High	Low	0.37		
[1]Mb:										
Martin part	0-15	0.2-0.6	0.21-0.23	5.6-6.5	Moderate	High	Low	0.37	4	7
	15-60	0.06-0.2	0.12-0.18	5.6-7.8	High	High	Low	0.37		
Vinland part	0-18	0.6-2.0	0.21-0.24	5.6-7.8	Moderate	Moderate	Low	0.37	2	6
	18	---	---	---	---	---	---	---		
Morrill:										
Mc	0-13	0.6-2.0	0.14-0.21	5.1-6.5	Low	Low	Moderate	0.28	5	6
	13-22	0.2-0.6	0.15-0.19	5.1-6.5	Moderate	Moderate	Moderate	0.28		
	22-60	0.2-2.0	0.15-0.18	5.1-7.3	Low	Low	Moderate	0.37		
Orthents:										
Oa.										
Oska:										
Ob	0-16	0.2-0.6	0.18-0.20	5.6-6.5	Moderate	Moderate	Moderate	0.43	3	7
	16-32	0.06-0.2	0.14-0.18	5.6-8.4	High	Moderate	Low	0.32		
	32	---	---	---	---	---	---	---		

See footnote at end of table.

TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	Erosion factors: K	Erosion factors: T	Wind erodibility group
	In	In/hr	In/in	pH						
Oska:										
[1]Oc:										
Oska part	0-16	0.2-0.6	0.18-0.20	5.6-6.5	Moderate	Moderate	Moderate	0.43	3	7
	16-32	0.06-0.2	0.14-0.18	5.6-8.4	High	Moderate	Low	0.32		
	32	---	---	---				---		
Martin part	0-15	0.2-0.6	0.21-0.23	5.6-6.5	Moderate	High	Low	0.37	4	7
	15-60	0.06-0.2	0.12-0.18	5.6-7.8	High	High	Low	0.37		
Pawnee:										
Pa	0-12	0.2-0.6	0.17-0.19	5.6-6.5	Moderate	Moderate	Low	0.37	4	6
	12-49	0.06-0.2	0.09-0.11	6.1-8.4	High	High	Low	0.37		
	49-60	0.2-0.6	0.14-0.16	7.9-8.4	High	High	Low	0.37		
Polo:										
Pc	0-13	0.6-2.0	0.22-0.24	5.6-6.5	Low	Low	Moderate	0.32	5	6
	13-21	0.6-2.0	0.18-0.20	5.1-6.0	Moderate	Low	Moderate	0.32		
	21-60	0.06-0.2	0.11-0.13	5.1-6.0	High	Moderate	Moderate	0.32		
Pits, quarries: Qa.										
Reading:										
Ra	0-15	0.6-2.0	0.21-0.23	5.6-7.3	Low	Low	Low	0.32	5	6
	15-41	0.06-0.2	0.18-0.20	5.6-7.3	Moderate	Moderate	Low	0.43		
	41-60	0.2-2.0	0.13-0.20	6.1-8.4	Moderate	Moderate	Low	0.43		
Sharpsburg:										
Sa, [1]Sb	0-13	0.6-2.0	0.21-0.23	5.1-6.5	Moderate	Moderate	Moderate	0.32	5	6
	13-60	0.2-0.6	0.18-0.20	5.1-6.0	High	Moderate	Moderate	0.43		
Sibleyville:										
Sc	0-8	0.6-2.0	0.18-0.21	5.6-7.3	Low	Low	Moderate	0.28	4	6
	8-22	0.6-2.0	0.16-0.19	5.1-7.3	Low	Low	Moderate	0.28		
	22-34	0.6-2.0	0.15-0.19	5.1-7.3	Low	Low	Moderate	0.28		
	34	---	---	---				---		
[1]Sd:										
Sibleyville part	0-8	0.6-2.0	0.18-0.21	5.6-7.3	Low	Low	Moderate	0.28	4	6
	8-22	0.6-2.0	0.16-0.19	5.1-7.3	Low	Low	Moderate	0.28		
	22-34	0.6-2.0	0.15-0.19	5.1-7.3	Low	Low	Moderate	0.28		
	34	---	---	---				---		
Vinland part	0-18	0.6-2.0	0.17-0.21	5.6-7.8	Moderate	Low	Low	0.37	2	6
	18	---	---	---				---		
Sogn:										
[1]Se:										
Sogn part	0-9	0.6-2.0	0.17-0.22	6.1-8.4	Moderate	Low	Low	0.28	1	4L
	9	---	---	---				---		
Vinland part	0-18	0.6-2.0	0.21-0.24	5.6-7.8	Moderate	Moderate	Low	0.37	2	6
	18	---	---	---				---		
Vinland:										
[1]Va:										
Vinland part	0-18	0.6-2.0	0.21-0.24	5.6-7.8	Moderate	Moderate	Low	0.37	2	6
	18	---	---	---				---		
Rock outcrop part.										
Wabash:										
Wa	0-8	0.06-0.2	0.21-0.24	5.6-7.3	High	High	Moderate	0.28	5	4
	8-60	<0.06	0.08-0.12	5.6-7.8	Very high	High	Moderate	0.28		
Woodson:										
Wb	0-10	0.2-0.6	0.22-0.24	5.6-6.5	Low	Moderate	Low	0.43	4	6
	10-30	<0.06	0.12-0.15	5.6-7.3	High	High	Low	0.32		
	30-60	<0.2	0.10-0.15	6.1-7.8	High	High	Moderate	0.32		

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--SOIL AND WATER FEATURES

[The definitions of "flooding" and "water table" in the Glossary explain terms such as "rare," "brief," "apparent," and "perched." The symbol > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard-ness	
					Ft			In		
Chase:										
Ca	C	Occasional	Very brief	Mar-Sep	>6.0	---	---	>60	---	Moderate.
Eudora:										
Ea, Eb	B	Rare	---	---	>6.0	---	---	>60	---	High.
[1]Ec:										
Eudora part	B	Rare	---	---	>6.0	---	---	>60	---	High.
Kimo part	C	Rare	---	---	2.0-6.0	Apparent	Mar-Jun	>60	---	High.
[1]Ed:										
Eudora part	B	Rare	---	---	>6.0	---	---	>60	---	High.
Kimo part	C	Rare	---	---	2.0-6.0	Apparent	Mar-Jun	>60	---	High.
Grundy:										
Ga	C	None	---	---	1.0-3.0	Perched	Mar-May	>60	---	Moderate.
Kennebec:										
Ka, Kb	B	Common	Brief	Feb-Nov	2.0-5.0	Apparent	Nov-May	>60	---	High.
Kimo:										
Kc	C	Rare	---	---	2.0-6.0	Apparent	Mar-Jun	>60	---	High.
Ladoga:										
La, Lb	B	None	---	---	>6.0	---	---	>60	---	High.
Martin:										
Ma	C	None	---	---	>6.0	---	---	>40	Rippable	High.
[1]Mb:										
Martin part	C	None	---	---	>6.0	---	---	>40	Rippable	High.
Vinland part	D	None	---	---	>6.0	---	---	10-20	Rippable	Moderate.
Morrill:										
Mc	B	None	---	---	>6.0	---	---	>60	---	Moderate.
Orthents:										
Oa.										
Oska:										
Ob	C	None	---	---	>6.0	---	---	20-40	Hard	Moderate.
[1]Oc:										
Oska part	C	None	---	---	>6.0	---	---	20-40	Hard	Moderate.
Martin part	C	None	---	---	>6.0	---	---	>40	Rippable	High.
Pawnee:										
Pa	D	None	---	---	>6.0	---	---	>60	---	High.
Polo:										
Pc	B	None	---	---	>6.0	---	---	>60	---	High.
Pits, quarries:										
Qa.										
Reading:										
Ra	C	Rare	---	---	>6.0	---	---	>60	---	High.
Sharpsburg:										
Sa, [1]Sb	B	None	---	---	>6.0	---	---	>60	---	High.

See footnote at end of table.

TABLE 15.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard-ness	
					Ft			In		
Sibleyville:										
Sc	B	None	---	---	>6.0	---	---	20-40	Rippable	Moderate.
[1]Sd:										
Sibleyville part	B	None	---	---	>6.0	---	---	20-40	Rippable	Moderate.
Vinland part	D	None	---	---	>6.0	---	---	10-20	Rippable	Moderate.
Sogn:										
[1]Se:										
Sogn part	D	None	---	---	>6.0	---	---	4-20	Hard	Moderate.
Vinland part	D	None	---	---	>6.0	---	---	10-20	Rippable	Moderate.
Vinland:										
[1]Va:										
Vinland part	D	None	---	---	>6.0	---	---	10-20	Rippable	Moderate.
Rock outcrop part.										
Wabash:										
Wa	D	Common	Brief to long.	Nov-May	0-1.0	Perched	Nov-May	>60	---	Moderate.
Woodson:										
Wb	D	None	---	---	0.5-2.0	Perched	Dec-Apr	>60	---	Low.

[1]This map unit is made up of two or more dominant kinds of soil. See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--ENGINEERING TEST DATA

[Tests were made in cooperation with the Federal Highway Administration, Department of Transportation]

Soil name, report number, horizon, and depth in inches	Classification		Grain size distribution[1]							Liquid limit	Plasticity index	Moisture density[2]	
			Percentage passing sieve				Percentage smaller than--						
	AASHTO	Unified	No. 4	No. 10	No. 40	No. 200	.02 mm	.005 mm	.002 mm			Max. dry density	Optimum moisture
										Pct		Lb/ft3	Pct
Polo (S75KS-091-001)													
A1------ 00 to 13	A-7-5(14)	ML	100	100	99	95	72	35	26	42	12	92	22
B2t----- 21 to 40	A-6 (13)	CL	100	100	100	97	80	49	39	38	11	97	22
B3------ 40 to 60	A-6 (16)	CL	100	100	100	96	77	47	37	38	15	100	22
Sibleyville loam (S75KS-091-002)													
A1------ 00 to 08	A-4 (05)	CL	100	100	99	65	43	22	16	33	10	100	18
B21t---- 08 to 15	A-4 (04)	CL	100	100	99	62	47	29	20	30	10	107	17
C1------ 22 to 29	A-6 (05)	CL	100	100	99	67	49	31	27	30	11	108	16

[1]Mechanical analyses according to the AASHTO designation T88-72 with the following variations: (1) all material is crushed in a laboratory steel jawed crusher; (2) sample is not soaked prior to dispersion; (3) dispersing time is 5 minutes at 7 psi using an Iowa air tube; (4) AASHTO T-133-74 is followed except for sample size to obtain SpG for the hydrometer analysis. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure, the fine material is analyzed by hydrometer method and 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 millimteres in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes of soils.

[2]Based on AASHTO designation T99-74, Method A, with the following variations: (1) all material is crushed in a laboratory steel jawed crusher after drying; and (2) no time is allowed for dispersion of the moisture after mixing with the soil material.

TABLE 17.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Chase	Fine, montmorillonitic, mesic Aquic Argiudolls
Eudora	Coarse-silty, mixed, mesic Fluventic Hapludolls
Grundy	Fine, montmorillonitic, mesic Aquic Argiudolls
Kennebec	Fine-silty, mixed, mesic Cumulic Hapludolls
Kimo	Clayey over loamy, montmorillonitic, mesic Aquic Hapludolls
Ladoga	Fine, montmorillonitic, mesic Mollic Hapludalfs
Martin	Fine, montmorillonitic, mesic Aquic Argiudolls
Morrill	Fine-loamy, mixed, mesic Typic Argiudolls
Orthents	Orthents
Oska	Fine, montmorillonitic, mesic Typic Argiudolls
Pawnee	Fine, montmorillonitic, mesic Aquic Argiudolls
Polo	Fine, montmorillonitic, mesic Typic Argiudolls
Reading	Fine-silty, mixed, mesic Typic Argiudolls
Sharpsburg	Fine, montmorillonitic, mesic Typic Argiudolls
Sibleyville	Fine-loamy, mixed, mesic Typic Argiudolls
Sogn	Loamy, mixed, mesic Lithic Haplustolls
Vinland	Loamy, mixed, mesic, shallow Typic Hapludolls
Wabash	Fine, montmorillonitic, mesic Vertic Haplaquolls
Woodson	Fine, mixed, thermic Abruptic Argiaquolls

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