United States
Department of
Agriculture

Soil
Conservation
Service

In cooperation with
Missouri Agricultural
Experiment Station

Soil Survey of Bates County, Missouri

How To Use This Soil Survey

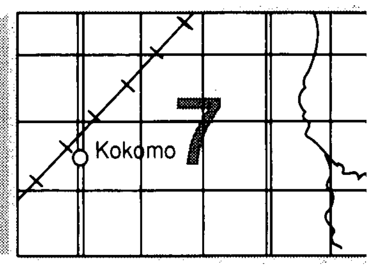
General Soil Map

The general soil map, which is the color map preceding the detailed soil maps, shows the survey area divided into groups of associated soils called general soil map units. This map is useful in planning the use and management of large areas.

To find information about your area of interest, locate that area on the map, identify the name of the map unit in the area on the color-coded map legend, then refer to the section **General Soil Map Units** for a general description of the soils in your area.

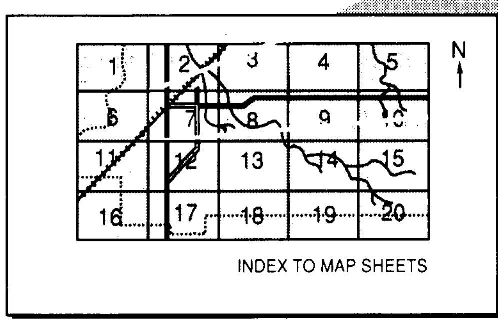
Detailed Soil Maps

The detailed soil maps follow the general soil map. These maps can be useful in planning the use and management of small areas.



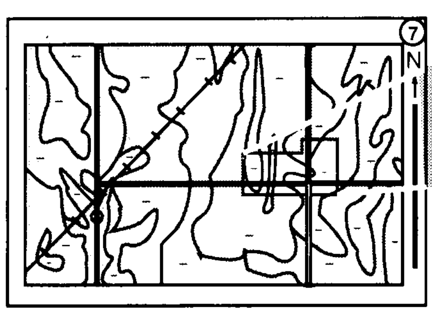
MAP SHEET

To find information about your area of interest, locate that area on the **Index to Map Sheets**, which precedes the soil maps. Note the number of the map sheet, and turn to that sheet.

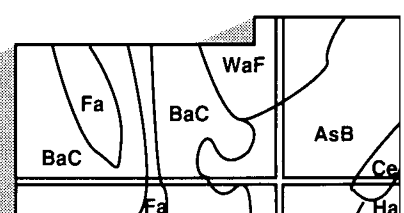


INDEX TO MAP SHEETS

Locate your area of interest on the map sheet. Note the map unit symbols that are in that area. Turn to the **Index to Map Units** (see Contents), which lists the map units by symbol and name and shows the page where each map unit is described.



MAP SHEET



AREA OF INTEREST

NOTE: Map unit symbols in a soil survey may consist only of numbers or letters, or they may be a combination of numbers and letters.

The **Summary of Tables** shows which table has data on a specific land use for each detailed soil map unit. See **Contents** for sections of this publication that may address your specific needs.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in 1989. Soil names and descriptions were approved in 1990. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1989. This survey was made cooperatively by the Soil Conservation Service and the Missouri Agricultural Experiment Station. The Missouri Department of Natural Resources provided a soil scientist to assist with the fieldwork. The Bates County Soil and Water Conservation District in conjunction with the Bates County Court also provided funds. The survey is part of the technical assistance furnished to the Bates County Soil and Water Conservation District.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

All programs and services of the Soil Conservation Service are offered on a nondiscriminatory basis, without regard to race, color, national origin, religion, sex, age, marital status, or handicap.

Cover: Cropland, hay, and pasture in the Kenoma-Hartwell-Deepwater association. The mixed hardwoods in the background are in the Summit-Eram-Balltown association.

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Issued July 1995

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Summary of Tables

Foreword

This soil survey contains information that can be used in land-planning programs in Bates County. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Farmers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow over bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as 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 soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.

Russell C. Mills
State Conservationist
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Soil Survey of Bates County, Missouri

By Larry E. Kichler and David A. Howard, Soil Conservation Service

Fieldwork by Larry E. Kichler and David A. Howard, Soil Conservation Service;
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United States Department of Agriculture, Soil Conservation Service,
in cooperation with
the Missouri Agricultural Experiment Station

BATES COUNTY is in the west-central part of Missouri (fig. 1). It is bordered by Kansas on the west. It has an area of 544,365 acres, or 850.6 square miles. In 1980, the population of Bates County was 15,873 *(14)*. Butler, the county seat, is in the central part of the county. In 1980, it had a population of 4,107. Other towns in the county include Adrian, Amoret, Amsterdam, Hume, Rich Hill, and Rockville.

Bates County is in the Cherokee Prairie major land resource area *(3)*. The topography is a slightly dissected plain. The plain is interrupted by a series of ridges that have southeast-facing escarpments.

Most of the county was once drained by the Marais des Cygnes River and its tributaries. The Bates County Drainage Ditch, completed in 1911, now drains most of the county into the Osage River. This drainage ditch shortened the natural drainage system by 40 miles. Since much of the flood plain is in the flood pool area of Harry S. Truman Reservoir, drainage is sometimes reduced and flooding occurs. The rest of the county is drained by the South Grand River along the northern boundary of the county. Elevation in the county ranges from 1,053 feet in the northwestern part to 698 feet in the southeastern part along the Osage River.

Soybeans, corn, grain sorghum, and winter wheat are the principal cash crops. Beef cattle, dairy cattle, and hogs are the dominant livestock.

Soil scientists have identified about 18 different kinds of soil in Bates County. The soils range widely in texture, depth, natural drainage, and other characteristics. Most of the soils are suited to the cultivated crops that are commonly grown in the area. Controlling erosion on sloping cropland is the most important management concern.

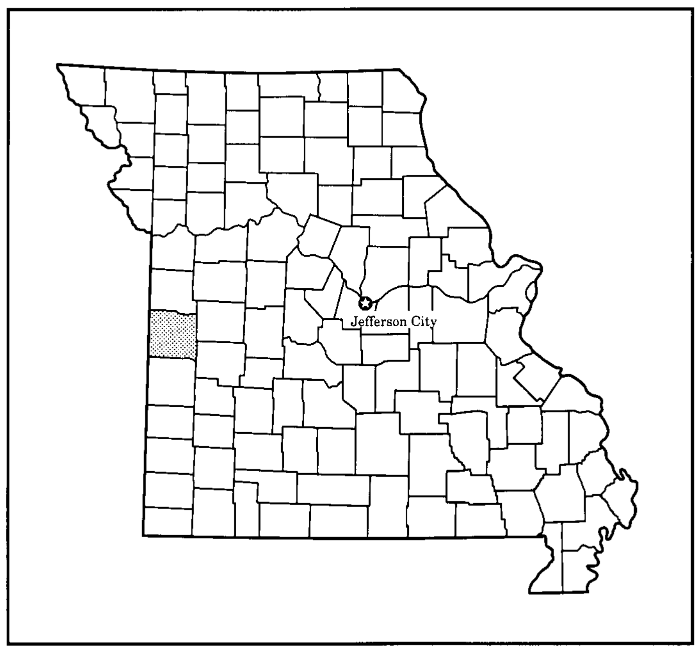

Figure 1.—Location of Bates County in Missouri.

This survey updates the soil survey of Bates County published in 1910 *(13)*. It provides additional information and has larger maps, which show the soils in greater detail.

General Nature of the County

This section provides general information about the county. It describes climate, natural resources, and transportation facilities.

Climate

Bates County has cold winters and long, hot summers. Heavy rains occur mainly in spring and early summer when moist air from the Gulf of Mexico interacts with the drier continental air. The annual rainfall is normally adequate for corn, soybeans, and all grain crops.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Appleton City, Missouri, in the period 1951 to 1987. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter, the average temperature is 34 degrees F and the average daily minimum temperature is 23 degrees. The lowest temperature on record, which occurred at Appleton City on February 9, 1979, is -19 degrees. In summer, the average temperature is 77 degrees and the average daily maximum temperature is 90 degrees. The highest recorded temperature, which occurred on July 14, 1954, is 116 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

The total annual precipitation is about 39 inches. Of this, 25 inches, or about 65 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 19 inches. The heaviest 1-day rainfall during the period of record was 9.10 inches at Appleton City on October 3, 1986. Thunderstorms occur on about 49 days each year.

The average seasonal snowfall is about 17 inches. The greatest snow depth at any one time during the period of record was 14 inches. On the average, 16 days of the year have at least 1 inch of snow on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 55 percent. Humidity is higher at night, and the average at dawn is about 75 percent. The sun shines 70 percent of the time possible in summer and 55 percent in winter. The prevailing wind is from the south. Average windspeed is highest, 12 miles per hour, in spring.

Tornadoes and severe thunderstorms occur occasionally but are local and of short duration. Damage from these storms varies and is spotty. Hailstorms occur in small, scattered areas during the warmer part of the year.

Natural Resources

Soil is the most important natural resource in Bates County. It provides a growing medium for cultivated crops, forage crops, and trees. Also, it can be a source of topsoil and gravel.

Another abundant resource in the county is the water supply. The Marais des Cygnes River and the South Grand River provide a good supply of surface water. The bedrock underlying the county also is a source of water. Some of this underground water is highly mineralized, but most of it is of fairly good quality. The bedrock units in Bates County generally are assigned to various aquifer groups. If the aquifer groups in a given area are ascertained, the yield and quality of water from wells can be predicted.

Mineral resources in the county include coal and limestone, both of which are currently being mined. Coal is mined mostly in the western part of the county. Limestone is quarried and is used as concrete aggregate, road material, or building stone, or it is crushed for use as agricultural lime.

Transportation Facilities

Bates County has good transportation facilities. The major thoroughfares are Federal Highway 71 and State Highways 52 and 18. Many farm-to-market roads are throughout the county.

Bates County also is served by three railroads. One runs north to south along the western part of the county, one runs north to south in the center of the county, and one runs through the southeast corner of the county.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

The soils in the survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil is associated with a particular kind of landscape or with a segment of the landscape. By observing the soils in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept, or model, of how the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. The system of taxonomic classification used in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot assure that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Map Unit Composition

A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by two or three kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural objects. In common with other natural objects, they have a characteristic variability in their properties. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of soils of other taxonomic classes. Consequently, every map unit is made up of the soil or soils for which it is named and some soils that belong to other taxonomic classes. These latter soils are called inclusions or included soils.

Most inclusions have properties and behavioral patterns similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting (similar) inclusions. They may or may not be mentioned in the map unit descriptions. Other inclusions, however, have properties and behavior divergent enough to affect use or require different management. These are contrasting (dissimilar) inclusions. They generally occupy small areas and cannot be shown separately on the soil maps because of the scale used in mapping. The inclusions of contrasting soils are mentioned in the map unit descriptions. A few inclusions may not have been observed and consequently are not mentioned in the descriptions, especially where the soil pattern was so complex that it was impractical to make enough observations to identify all of the kinds of soil on the landscape.

The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the soil data. The objective of soil mapping is not to delineate pure taxonomic classes of soils but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but onsite investigation is needed to plan for intensive uses in small areas.

General Soil Map Units

The general soil map at the back of this publication shows the soil associations in this survey area. Each association has a distinctive pattern of soils, relief, and drainage. Each is a unique natural landscape. Typically, an association consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one association can occur in another but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map 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 soils in any one association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The descriptions, names, and delineations of the soils identified on the general soil map of this county do not fully agree with those of the soils identified on the maps of adjacent counties published at a different date. Differences are the result of additional soil data, variations in the intensity of mapping, and correlation decisions that reflect local conditions.

Soil Descriptions

1. Summit-Eram-Balltown Association

Very deep, moderately deep, and shallow, gently sloping to moderately steep, moderately well drained and somewhat excessively drained soils that formed in material weathered from shale or limestone; on uplands

This association is on ridgetops, side slopes, and foot slopes that are dissected by drainageways and small creeks (fig. 2). Slopes range from 1 to 20 percent.

This association makes up about 22 percent of the county. It is about 41 percent Summit soils, 23 percent Eram soils, 15 percent Balltown soils, and 21 percent minor soils.

Summit soils are very deep, gently sloping and moderately sloping, and moderately well drained. They are on side slopes in the uplands and on foot slopes.

The typical sequence, depth, and composition of the layers of the Summit soils are as follows—

Surface layer:
0 to 8 inches, black, firm silty clay loam

Subsurface layer:
8 to 14 inches, very dark gray, firm silty clay loam

Subsoil:
14 to 60 inches, very dark gray, very dark grayish brown, and dark grayish brown, mottled, very firm silty clay

Eram soils are moderately deep, gently sloping to moderately steep, and moderately well drained. They are on side slopes in the uplands.

The typical sequence, depth, and composition of the layers of the Eram soils are as follows—

Surface layer:
0 to 10 inches, dark brown, friable silt loam

Subsoil:
10 to 21 inches, brown, mottled, firm silty clay
21 to 31 inches, yellowish brown, mottled, firm silty clay

Bedrock:
31 inches, weathered shale

Balltown soils are shallow, moderately sloping to moderately steep, and somewhat excessively drained. They are on narrow ridgetops and side slopes in the uplands.

The typical sequence, depth, and composition of the layers of the Balltown soils are as follows—

Surface layer:
0 to 8 inches, black, friable very flaggy silt loam

Substratum:
8 to 15 inches, very dark grayish brown, friable very flaggy silt loam

Bedrock:
15 inches, hard limestone

Of minor extent in this association are Bates, Catoosa, Clareson, Coweta, Newtonia, and Verdigris soils. Bates, Catoosa, and Clareson soils are

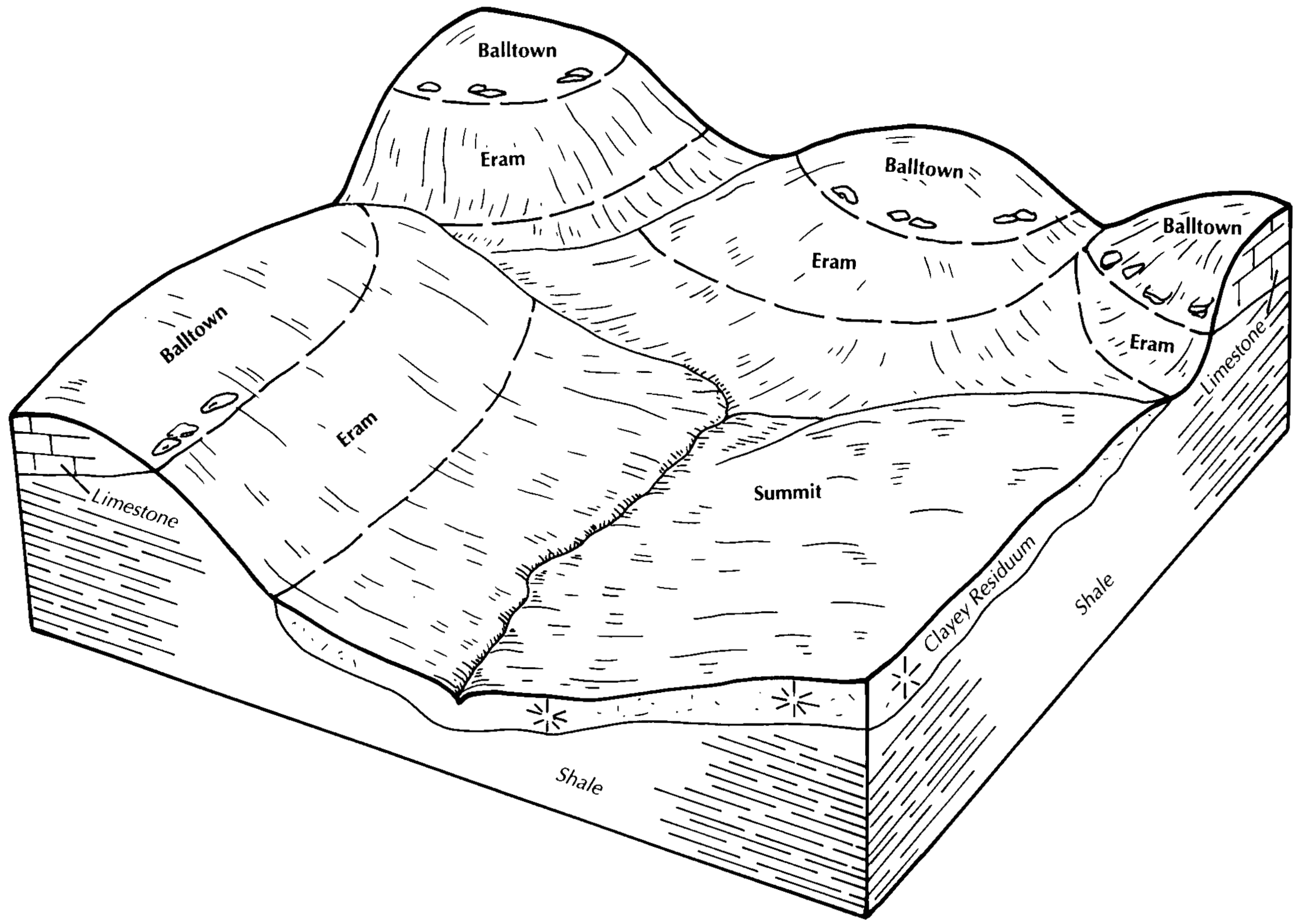

Figure 2.—Typical pattern of soils and parent material in the Summit-Eram-Balltown association.

moderately deep and well drained. They are on narrow ridgetops and side slopes. Coweta soils are shallow and well drained. They are on sandstone ridgetops. Newtonia soils are very deep. They are on the broader ridgetops. They have less clay than the major soils. Verdigris soils are silty throughout. They are on narrow flood plains.

About 60 percent of the acreage in this association is used for pasture and hay. Cultivated crops, such as wheat, grain sorghum, corn, and soybeans, are grown in some areas of the gently sloping Summit and Eram soils. The remaining acreage is moderately steep, uneven areas that support native grasses and scattered mixed hardwoods.

This association is suited to grasses. The hazard of erosion during seedbed preparation and overgrazing are management concerns. Droughtiness is a hazard in areas of the Balltown and Eram soils during the hot summer months.

Summit and Eram soils are suited to cultivated crops, grasses, and legumes. Balltown soils are best suited to native grasses. The main management concerns are controlling water erosion and improving and maintaining fertility and tilth. Gullies are a problem in some areas.

Summit and Eram soils are suited to building site development and sanitary facilities. Wetness, the shrink-swell potential in the clayey subsoil, and the restricted permeability are management concerns. The depth to bedrock is a limitation in areas of the Eram soils. Balltown soils are unsuited to building site development and sanitary facilities because of the shallow depth to bedrock.

2. Kenoma-Hartwell-Deepwater Association

Very deep, nearly level to gently sloping, moderately well drained and somewhat poorly drained soils that formed in material weathered from shale; on uplands

This association is on broad, smooth ridgetops and side slopes that separate the watersheds in the county (fig. 3). Minor acreages are adjacent to the flood plains and terraces of major streams. Slopes range from 0 to 5 percent.

This association makes up about 60 percent of the county. It is about 60 percent Kenoma soils, 12 percent Hartwell soils, 8 percent Deepwater soils, and 20 percent minor soils.

Kenoma soils are very gently sloping and gently sloping and are moderately well drained. They are on broad, convex ridgetops and side slopes in the uplands.

The typical sequence, depth, and composition of the layers of the Kenoma soils are as follows—

Surface layer:

0 to 9 inches, very dark grayish brown, friable silt loam

Subsoil:

9 to 16 inches, very dark grayish brown, mottled, very firm silty clay

16 to 60 inches, dark yellowish brown, mottled, very firm and firm silty clay

Hartwell soils are nearly level and somewhat poorly drained. They are on broad, smooth divides in the uplands.

The typical sequence, depth, and composition of the layers of the Hartwell soils are as follows—

Surface layer:

0 to 9 inches, very dark grayish brown, very friable silt loam

Subsurface layer:

9 to 14 inches, grayish brown, very friable silt loam

Subsoil:

14 to 48 inches, very dark gray, dark grayish brown, and grayish brown, mottled, firm silty clay and silty clay loam

48 to 60 inches, mottled dark yellowish brown, gray, and yellowish red, firm silty clay loam

Deepwater soils are gently sloping and moderately well drained. They are on side slopes in the uplands.

The typical sequence, depth, and composition of the layers of the Deepwater soils are as follows—

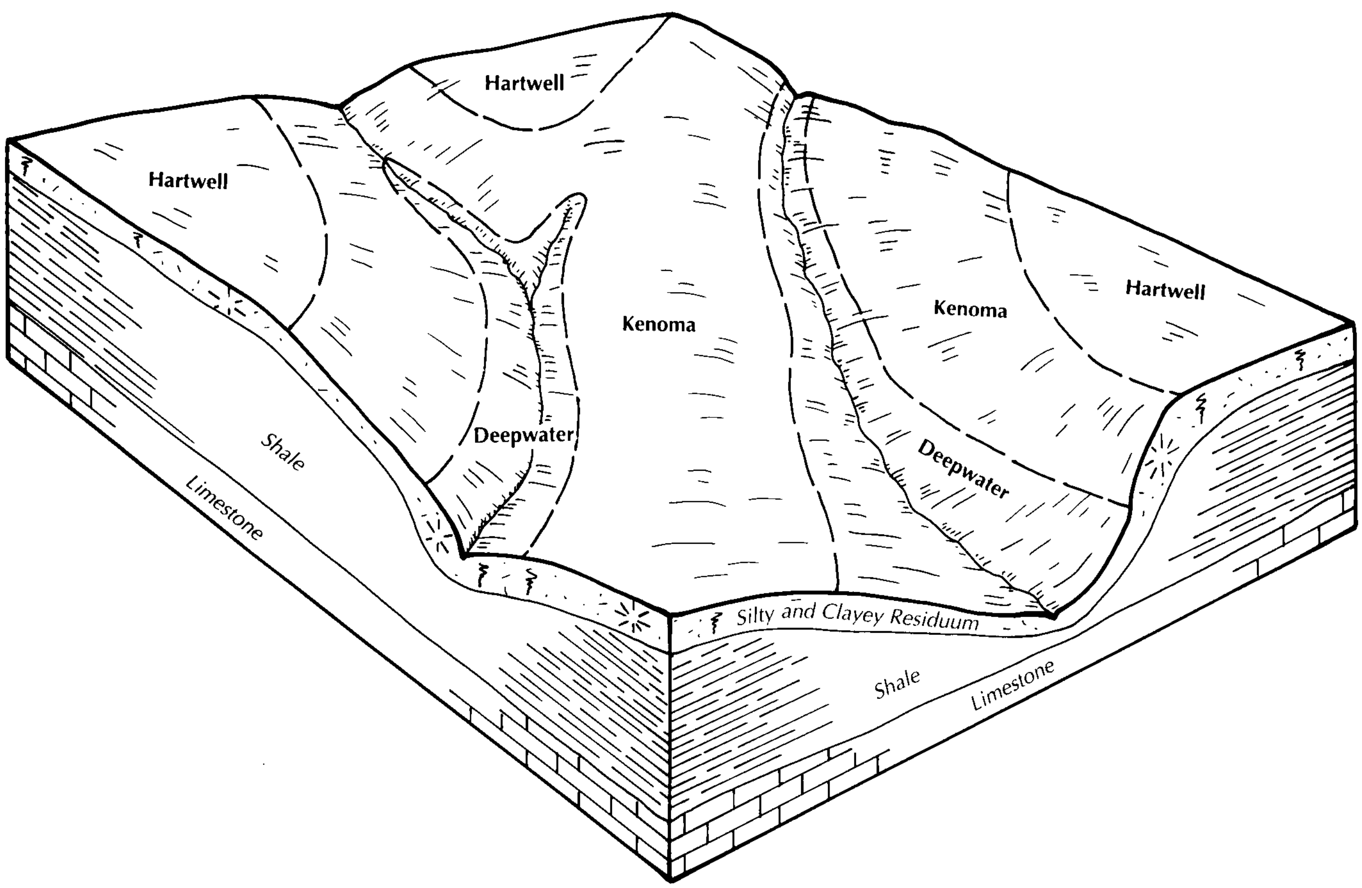

Figure 3.—Typical pattern of soils and parent material in the Kenoma-Hartwell-Deepwater association.

Surface layer:
0 to 7 inches, very dark grayish brown, friable silt loam

Subsoil:
7 to 13 inches, dark brown, friable silt loam
13 to 37 inches, brown and dark brown, mottled, friable and firm silty clay loam
37 to 60 inches, multicolored, firm silty clay loam

Of minor extent in this association are Bates, Brazilton, Coweta, Eram, Hepler, Kanima, and Verdigris soils. The moderately deep Bates and Eram soils and the shallow Coweta soils are on ridgetops and side slopes. Brazilton soils are in excavated material that has been reconstructed. The strongly sloping to steep Kanima soils are excavated coal pits. The moderately slowly permeable Hepler soils and the well drained Verdigris soils are on flood plains.

About 90 percent of the acreage in this association is used for cultivated crops, such as corn, soybeans, wheat, and grain sorghum. Some areas are used for pasture and hay. The remaining acreage is uneven, moderately steep or steep areas that generally support native grasses and scattered mixed hardwoods.

This association is suited to cultivated crops, small grain, and grasses and legumes. Controlling water erosion and improving and maintaining fertility and tilth are the main management concerns in areas used for cultivated crops. Wetness is a limitation in areas of the Hartwell soils.

The main management concerns in areas used for pasture are the hazard of erosion during seedbed preparation, overgrazing, and the seasonal wetness.

These soils are suited to building site development and sanitary facilities. The wetness and the high shrink-swell potential in the clayey subsoil are limitations on sites for dwellings and septic tank absorption fields. The moderate to very slow permeability is a major concern. The soils are better suited to sewage lagoons for waste disposal than to septic tank absorption fields.

3. Bates-Coweta-Kenoma Association

Moderately deep, shallow, and very deep, very gently sloping to strongly sloping, moderately well drained and well drained soils that formed in material weathered from sandstone and shale; on uplands

This association is on ridgetops and side slopes and in the steeper areas along drainageways (fig. 4). Slopes range from 1 to 14 percent.

This association makes up about 5 percent of the county. It is about 42 percent Bates soils, 26 percent Coweta soils, 19 percent Kenoma soils, and 13 percent minor soils.

Bates soils are moderately deep, gently sloping and moderately sloping, and well drained. They are on ridgetops and side slopes in the uplands.

The typical sequence, depth, and composition of the layers of the Bates soils are as follows—

Surface layer:
0 to 8 inches, very dark grayish brown, very friable loam

Subsurface layer:
8 to 16 inches, very dark grayish brown, friable loam

Subsoil:
16 to 24 inches, dark yellowish brown, friable sandy clay loam
24 to 34 inches, strong brown, firm sandy clay loam

Bedrock:
34 inches, soft, weathered sandstone

Coweta soils are shallow, moderately sloping and strongly sloping, and well drained. They are on ridgetops and side slopes and in the steeper areas along drainageways in the uplands.

The typical sequence, depth, and composition of the layers of the Coweta soils are as follows—

Surface layer:
0 to 6 inches, very dark grayish brown, friable loam

Subsoil:
6 to 12 inches, dark brown, friable gravelly fine sandy loam

Bedrock:
12 inches, weathered sandstone

Kenoma soils are very deep, very gently sloping and gently sloping, and moderately well drained. They are on ridgetops and side slopes in the uplands.

The typical sequence, depth, and composition of the layers of the Kenoma soils are as follows—

Surface layer:
0 to 9 inches, very dark grayish brown, friable silt loam

Subsoil:
9 to 16 inches, very dark grayish brown, mottled, very firm silty clay
16 to 60 inches, dark yellowish brown, mottled, firm and very firm silty clay

Of minor extent in this association are Deepwater, Eram, and Verdigris soils. The moderately well drained Deepwater soils have less clay in the subsoil than the Kenoma soils. They are on ridgetops and side slopes. The moderately deep Eram soils have more clay than

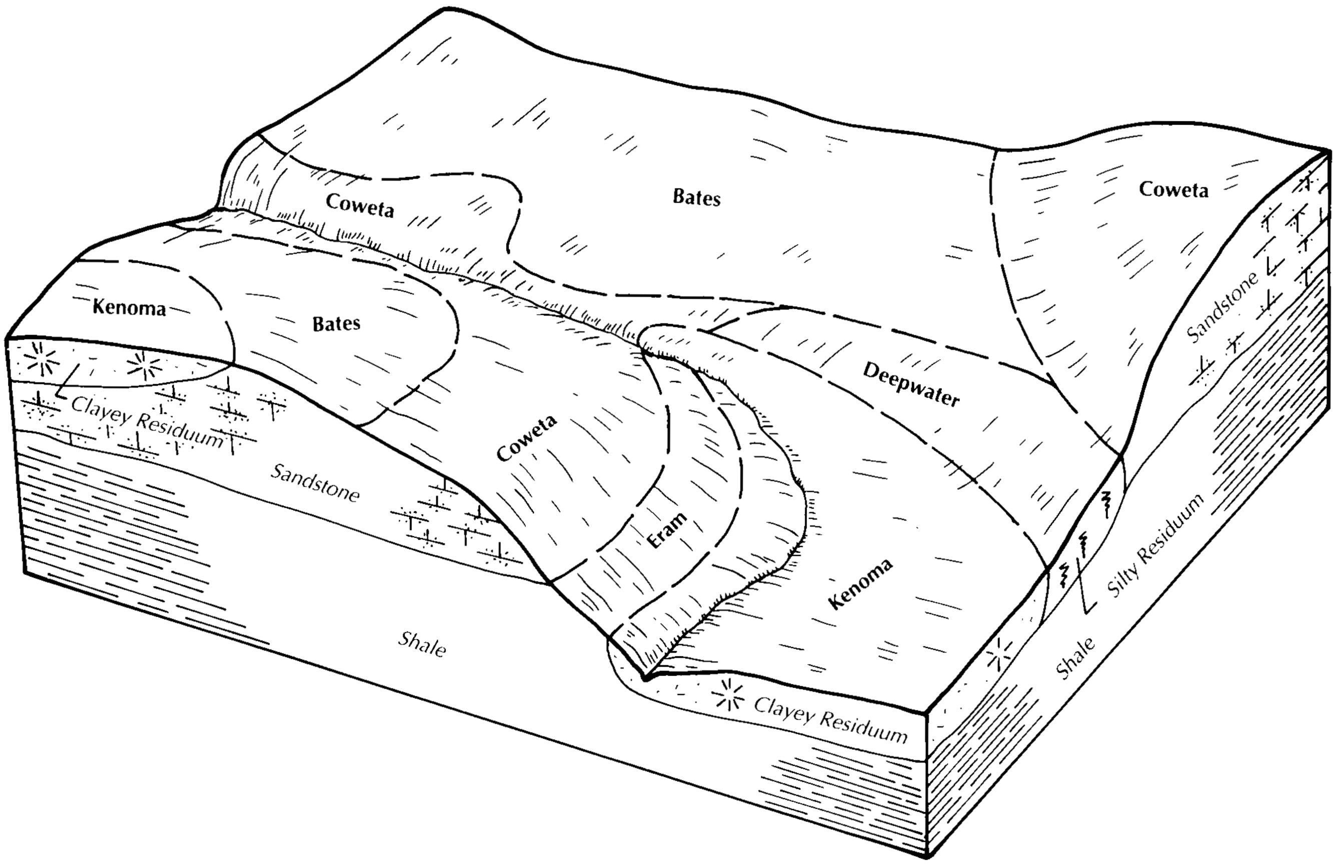

Figure 4.—Typical pattern of soils and parent material in the Bates-Coweta-Kenoma association.

the Bates and Coweta soils. They are on side slopes and in the steeper areas along drainageways. Verdigris soils are very deep and have less clay in the subsoil than the Kenoma soils. They are on narrow flood plains.

About 70 percent of the acreage in this association is used for pasture, hay, or small grain. Grain sorghum and soybeans are grown in some of the very gently sloping and gently sloping areas. The remaining acreage is strongly sloping, uneven areas that support native grasses.

Bates and Kenoma soils are suited to cultivated crops. Coweta soils are best suited to warm-season grasses. Controlling water erosion and improving and maintaining fertility and tilth are the main management concerns in areas used for cultivated crops. Gullies are a problem in some areas.

The major soils are suited to grasses and legumes. The hazard of erosion during seedbed preparation and overgrazing are management concerns. Droughtiness is a hazard in areas of the Bates and Coweta soils during the hot summer months.

Bates and Kenoma soils are suited to building site development and sanitary facilities. The shrink-swell potential in areas of the Kenoma soils and the moderate depth to bedrock in areas of the Bates soils are limitations. Coweta soils are generally unsuited to building site development because of the shallow depth to bedrock.

4. Osage-Verdigris Association

Very deep, nearly level, poorly drained and well drained soils that formed in alluvium; on flood plains

This association is on flood plains along medium and large streams throughout the county (fig. 5). The width of the flood plain ranges from about 200 feet to more than 3 miles. Slopes range from 0 to 2 percent.

This association makes up about 13 percent of the county. It is about 50 percent Osage soils, 40 percent Verdigris soils, and 10 percent minor soils.

Osage soils are nearly level and poorly drained. They are on wide flood plains.

The typical sequence, depth, and composition of the layers of the Osage soils are as follows—

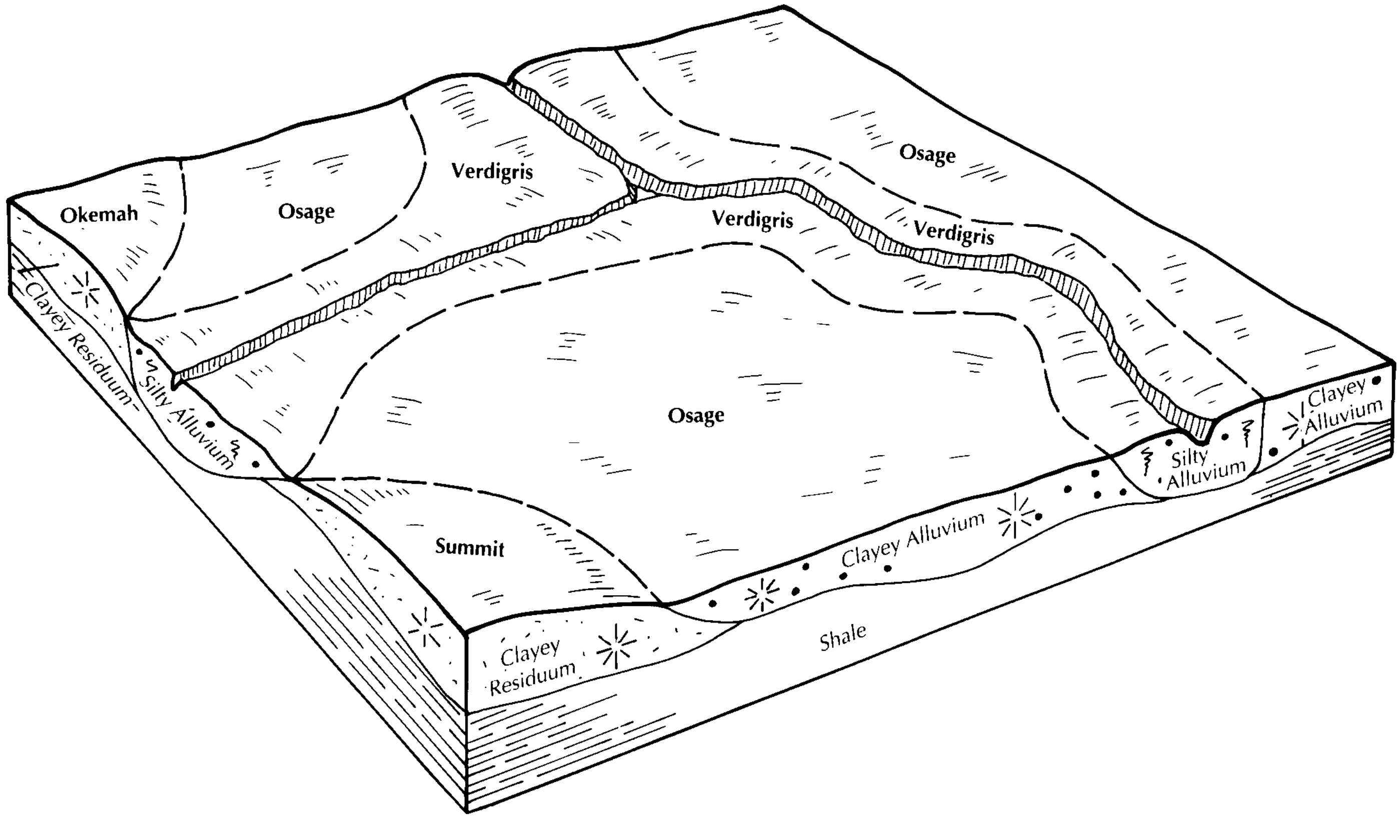

Figure 5.—Typical pattern of soils and parent material in the Osage-Verdigris association.

Surface layer:
0 to 7 inches, black, firm silty clay

Subsurface layer:
7 to 15 inches, black, firm silty clay

Subsoil:
15 to 60 inches, black, mottled, firm and very firm silty clay

Verdigris soils are nearly level and well drained. They are on low flood plains adjacent to streams.

The typical sequence, depth, and composition of the layers of the Verdigris soils are as follows—

Surface layer:
0 to 12 inches, very dark grayish brown, friable silt loam

Subsurface layer:
12 to 39 inches, dark brown, friable silt loam

Substratum:
39 to 60 inches, dark yellowish brown, friable silty clay loam

Of minor extent in this association are Hepler, Okemah, and Summit soils. The somewhat poorly drained Hepler soils are in landscape positions similar to those of the major soils and on the higher flood plains along medium-sized streams. The moderately well drained Okemah and Summit soils are mainly on adjacent terraces and foot slopes. Some areas of the Summit soils are on upland side slopes.

This association is used mainly for cultivated crops, pasture, or hay. The soils are suited to small grain, soybeans, grain sorghum, and grasses and legumes.

Frequent flooding, wetness, and the deterioration of tilth and fertility are the main management concerns in areas used for cultivated crops. Overgrazing and the wetness are the main management concerns in areas used for pasture.

This association is suited to trees. Many areas that are too small for cultivated crops are used as woodland. Existing stands are predominantly oak, hickory, and pecan. The main management concerns are the equipment limitation, seedling mortality, and the windthrow hazard, which is caused by wetness.

This association is unsuited to building site development and sanitary facilities. The wetness and the flooding are difficult to overcome.

Detailed Soil Map Units

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under the heading "Use and Management of the Soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the substratum, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the substratum. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Bates loam, 3 to 8 percent slopes, eroded, is a phase of the Bates series.

Some map units are made up of two or more major soils. These map units are called soil complexes. A *soil complex* consists of two or more soils, or one or more soils and a miscellaneous area, in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Eram-Balltown complex, 5 to 20 percent slopes, is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. The included soils are identified in each map unit description. Some small areas of strongly contrasting soils are identified by a special symbol on the soil maps.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Pits, quarries, is an example. Miscellaneous areas are shown on the soil maps. Some that are too small to be shown are identified by a special symbol on the soil maps.

The descriptions, names, and delineations of the soils identified on the detailed soil maps of this survey do not fully agree with those of the soils identified on the maps of adjacent counties published at a different date. Differences are the result of additional soil data, variations in the intensity of mapping, and correlation decisions that reflect local conditions.

Table 4 gives the acreage and proportionate extent of each map unit. Other tables (see "Summary of Tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The "Glossary" defines many of the terms used in describing the soils.

Soil Descriptions

10—Verdigris silt loam, channeled. This very deep, nearly level, well drained soil is on low, narrow flood plains. It is frequently flooded. Individual areas are long and narrow or irregular in shape. They range from about 10 to more than 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 7 inches, dark brown, friable silt loam

Subsurface layer:
7 to 50 inches, very dark brown and brown, friable silt loam

Substratum:
50 to 60 inches, brown, friable silt loam

In some areas the surface layer has an overwash of fine loam. In other areas limestone is exposed in the streambed.

Included with this soil in mapping are small areas of Hepler soils. These soils are somewhat poorly drained and are in the higher positions on the landscape. They make up less than 10 percent of the unit.

Important properties of the Verdigris soil—

Permeability: Moderate
Surface runoff: Slow
Available water capacity: Very high
Organic matter content: Moderate
Shrink-swell potential: Moderate

Most areas are used for pasture or hay. A few areas are used as woodland. Many areas are dissected by meandering stream channels, which divide fields into small, irregularly shaped areas. These dissected areas are suited to legumes and grasses.

This soil is well suited to cool-season grasses, such as tall fescue and orchardgrass, and to legumes, such as ladino clover. It is moderately well suited to lespedeza. It is well suited to warm-season grasses, such as switchgrass, and moderately well suited to indiangrass and big bluestem. Frequent flooding is the main management concern. Species that can tolerate the flooding grow best. Grazing schedules can be designed to avoid periods of flooding.

This soil is suited to trees. A few areas support native hardwoods. No major limitations affect planting or harvesting.

This soil is not suited to building site development or onsite waste disposal because of the flooding.

The land capability classification is Vw. The woodland ordination symbol is 4A.

11—Verdigris silt loam. This very deep, nearly level, well drained soil is on flood plains adjacent to stream channels and along the major streams. It is frequently flooded. Individual areas are long and narrow adjacent to intermittent streams but are wide along major tributaries. They range from about 20 to more than 300 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 12 inches, very dark grayish brown, friable silt loam

Subsurface layer:
12 to 39 inches, dark brown, friable silt loam

Substratum:
39 to 60 inches, dark yellowish brown, friable silty clay loam

In some areas the surface layer has an overwash of fine sandy loam or loam. Other areas are dissected by narrow stream channels.

Included with this soil in mapping are small areas of Hepler and Osage soils. Hepler soils are somewhat poorly drained. They are in the higher areas on bottom land. Osage soils have more clay in the surface layer and the subsoil than the Verdigris soil. They are in the lower positions on the landscape. Included soils make up less than 10 percent of the unit.

Important properties of the Verdigris soil—

Permeability: Moderate
Surface runoff: Slow
Available water capacity: Very high
Organic matter content: Moderate
Shrink-swell potential: Moderate

Most areas are used for cultivated crops, pasture, or hay. A few areas are used as woodland. This soil generally is suited to corn, soybeans, and small grain. Some areas are dissected by meandering stream channels, which divide fields into small, irregularly shaped areas that are not well suited to cultivated crops.

This soil is well suited to cool-season grasses, such as tall fescue and orchardgrass, and to legumes, such as alfalfa and red clover. It is well suited to warm-season grasses, such as switchgrass, and moderately well suited to indiangrass and big bluestem. Frequent flooding is the main management concern. Species that can tolerate the flooding grow best. Grazing schedules can be designed to avoid periods of flooding.

This soil is suited to trees. A few areas support native hardwoods. No major limitations affect planting or harvesting.

This soil is not suited to building site development or onsite waste disposal because of the flooding.

The land capability classification is IVw. The woodland ordination symbol is 4A.

13—Okemah silt loam. This very deep, nearly level, moderately well drained soil is on high stream terraces and foot slopes. Individual areas are irregular in shape and range from about 20 to more than 200 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 8 inches, very dark grayish brown, friable silt loam

Subsoil:
8 to 16 inches, very dark grayish brown, friable silty clay loam
16 to 26 inches, very dark gray, mottled, firm silty clay loam
26 to 37 inches, dark gray, mottled, firm silty clay
37 to 52 inches, mottled strong brown and dark grayish brown, firm silty clay
52 to 60 inches, multicolored, firm silty clay

Included with this soil in mapping are small areas of Kenoma and Summit soils. Kenoma soils are less than 60 inches thick. They are in the higher positions on the landscape. Summit soils have more clay in the surface layer than the Okemah soil. They are in landscape positions similar to those of the Okemah soil. Included soils make up about 10 to 15 percent of the unit.

Important properties of the Okemah soil—

Permeability: Slow
Surface runoff: Slow
Available water capacity: High
Organic matter content: Moderate
Water table: Perched at a depth of 2 to 3 feet from November through April
Shrink-swell potential: High

Most areas are used for cultivated crops, pasture, or hay.

This soil is suited to corn, soybeans, and small grain. A system of conservation tillage, such as no-till or ridge till, that leaves large amounts of crop residue on the surface, winter cover crops, contour farming, and a conservation cropping system that includes close-growing pasture and hay crops help to prevent excessive soil loss. Returning crop residue to the soil improves fertility, minimizes crusting, and increases the rate of water infiltration.

Growing pasture and hay crops helps to control erosion on this soil. The soil is well suited to ladino clover. It is moderately well suited to reed canarygrass, switchgrass, big bluestem, and indiangrass. It is moderately suited to tall fescue and orchardgrass. It is not suited to deep-rooted plants. Wetness is a limitation affecting grazing. Grazing should be avoided when the soil is wet. Erosion during seedbed preparation is a management concern. Timely tillage and a quickly established ground cover minimize erosion.

This soil is suited to building site development and onsite waste disposal if proper design and installation procedures are used. Constructing footings, foundations, and basement walls with adequately reinforced concrete and backfilling with sand or gravel help to prevent the damage caused by shrinking and swelling. Installing tile drains around footings helps to prevent the damage caused by excessive wetness. The soil is not suited to septic tank absorption fields because of the wetness and the restricted permeability. It is well suited to sewage lagoons.

This soil is suited to local roads and streets. Low strength, the shrink-swell potential, and the potential for frost action are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by wetness, shrinking and swelling, and frost action.

The land capability classification is IIe. No woodland ordination symbol is assigned.

14—Osage silty clay loam. This very deep, nearly level, poorly drained soil typically is on wide flood plains along the major streams. It is frequently flooded. Individual areas are irregular in shape and range from about 10 to more than 200 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 7 inches, black, firm silty clay loam

Subsurface layer:
7 to 15 inches, black, firm silty clay

Subsoil:
15 to 60 inches, black and very dark gray, mottled, very firm silty clay

In some areas the surface layer is silt loam or silty clay. A few small areas are on narrow flood plains along intermittent streams.

Included with this soil in mapping are areas of the well drained Verdigris soils. These soils have less clay than the Osage soil. They are adjacent to meandering stream channels. They make up about 5 to 10 percent of the unit.

Important properties of the Osage soil—

Permeability: Very slow
Surface runoff: Very slow
Available water capacity: Moderate
Organic matter content: Moderate
Water table: At the surface to 1 foot below the surface from November through May
Shrink-swell potential: Very high

Most areas are used for cultivated crops. A small acreage is used for pasture or hay. A few areas are used as woodland.

Wetness and frequent flooding are major management concerns in areas used for cultivated crops. Returning crop residue to the soil, tilling only under optimum moisture conditions, and deep plowing in the fall improve tilth and the chances of early planting in the spring. Summer crops that have a short growing season should be selected.

This soil is best suited to species that can tolerate the wetness, such as reed canarygrass and alsike clover. The wetness and the flooding are the main management concerns. The soil is poorly suited to hay. Grazing schedules can be designed to avoid periods of flooding. Maintaining stands of desirable species is difficult in depressional areas. Surface drainage systems can be used for the deeper rooted species.

This soil is suited to trees. The equipment limitation, seedling mortality, and the windthrow hazard are management concerns. Equipment should be used during periods when the soil is dry or frozen. Ridging the soil and planting on the ridges increase the seedling survival rate. Thinning the stands less intensively and more frequently reduces the windthrow hazard.

This soil is not suited to building site development or onsite waste disposal because of the wetness, the shrink-swell potential, and the flooding.

The land capability classification is IVw. The woodland ordination symbol is 4W.

21—Osage silty clay. This very deep, nearly level, poorly drained soil typically is on wide flood plains along the major streams. It is frequently flooded. Individual areas are irregular in shape and range from about 10 to more than 200 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 7 inches, black, firm silty clay

Subsurface layer:
7 to 15 inches, black, firm silty clay

Subsoil:
15 to 60 inches, black, mottled, firm and very firm silty clay

In some areas the surface layer is silty clay loam.

Included with this soil in mapping are areas of the well drained Verdigris soils. These soils have less clay than the Osage soil. They are adjacent to meandering stream channels. They make up about 10 to 15 percent of the unit.

Important properties of the Osage soil—

Permeability: Very slow
Surface runoff: Very slow
Available water capacity: Moderate
Organic matter content: Moderate
Water table: At the surface to 1 foot below the surface from November through May
Shrink-swell potential: Very high

Most areas are used for cultivated crops. A small acreage is used for pasture or hay. A few areas are used as woodland.

Wetness, flooding, ponding, and poor surface drainage are the major management concerns in areas used for cultivated crops. Land smoothing and properly designed and constructed surface ditches improve surface drainage. Returning crop residue to the soil, tilling only under optimum moisture conditions, and deep plowing in the fall improve tilth and the chances of early planting in spring. Summer crops that have a short growing season should be selected. The flooding can cause major crop damage in some years.

This soil is best suited to species that can tolerate the wetness, such as reed canarygrass and alsike clover. The wetness and the flooding are the main management concerns. The soil is poorly suited to hay. Grazing schedules can be designed to avoid periods of flooding. Maintaining stands of desirable species is difficult in depressional areas. Surface drainage systems can be used for the deeper rooted species.

This soil is suited to trees. The equipment limitation, seedling mortality, and the windthrow hazard are management concerns. Equipment should be used during periods when the soil is dry or frozen. Ridging the soil and planting on the ridges increase the seedling survival rate. Thinning the stands less intensively and more frequently reduces the windthrow hazard.

This soil is not suited to building site development or onsite waste disposal because of the wetness, the shrink-swell potential, and the flooding.

The land capability classification is IVw. The woodland ordination symbol is 4W.

51B2—Deepwater silt loam, 2 to 5 percent slopes, eroded. This very deep, gently sloping, moderately well drained soil is on side slopes in the uplands. Typically, water erosion has removed 25 to 75 percent of the original surface layer. In some areas the surface soil has been mixed with the upper part of the subsoil. Individual areas are irregular in shape and range from about 10 to more than 150 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 7 inches, very dark grayish brown, friable silt loam

Subsoil:
7 to 13 inches, dark brown, friable silt loam

13 to 37 inches, brown or dark brown, mottled, friable and firm silty clay loam
37 to 60 inches, multicolored, firm silty clay loam

In some areas the surface layer is uneroded. Some small areas are severely eroded. In some places the depth to shale bedrock is less than 48 inches.

Included with this soil in mapping are some small areas of Bates, Eram, and Kenoma soils. Bates soils are moderately deep over sandstone bedrock. They are in landscape positions similar to those of the Deepwater soil and in the higher, mounded areas. Eram soils have more clay than the Deepwater soil and are less than 40 inches deep over shale bedrock. They are in landscape positions similar to those of the Deepwater soil. Kenoma soils have more clay in the subsoil than the Deepwater soil. They are in the higher positions on the landscape. Included soils make up about 15 percent of the unit.

Important properties of the Deepwater soil—

Permeability: Moderate
Surface runoff: Medium
Available water capacity: High
Organic matter content: Moderate
Water table: Perched at a depth of 3.0 to 4.5 feet from November through March
Shrink-swell potential: Moderate

Most areas are used for cultivated crops, pasture, or hay.

This soil is suited to corn, soybeans, grain sorghum, and small grain. If cultivated crops are grown, the hazard of further erosion is severe. A system of conservation tillage, such as no-till (fig. 6) or ridge till, that leaves a protective cover of crop residue on the surface, winter cover crops, a combination of terraces and grassed waterways, contour farming, and a conservation cropping system that includes pasture, hay, and winter wheat in the rotation help to control erosion. These measures also help to maintain the organic matter content and fertility, improve tilth, and increase the rate of water infiltration.

Growing pasture and hay crops helps to control erosion on this soil. The soil is well suited to the commonly grown cool-season grasses, such as tall fescue, orchardgrass, and timothy; to legumes, such as lespedeza and red clover; and to warm-season grasses, such as switchgrass, indiangrass, and big bluestem. No serious limitations affect the areas used as pasture or hayland. Erosion is a hazard in newly seeded areas. Timely seedbed preparation helps to ensure a good ground cover.

This soil is suited to building site development and onsite waste disposal if proper design and installation procedures are used. Constructing foundations and footings with adequately reinforced concrete and backfilling with sand or gravel help to prevent the damage caused by shrinking and swelling. Installing tile drains around footings helps to prevent the damage caused by excessive wetness. Unless drains are installed to lower the water table, this soil is not suited to septic tank absorption fields or sewage lagoons because of the wetness. Sewage lagoons can function adequately if the bottom of the lagoon is sealed to prevent the contamination of ground water. Alternative sites that are better suited can be selected for onsite waste disposal.

This soil is suited to local roads and streets. Low strength and the potential for frost action are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by low strength and by frost action.

The land capability classification is IIe. No woodland ordination symbol is assigned.

52—Hepler silt loam, occasionally flooded. This very deep, nearly level, somewhat poorly drained soil is on broad, high flood plains. It is occasionally flooded. Individual areas are elongated and wide and range from about 15 to more than 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 9 inches, very dark grayish brown, friable silt loam

Subsurface layer:
9 to 19 inches, grayish brown, mottled, friable silt loam

Subsoil:
19 to 31 inches, dark gray, mottled, firm silty clay loam
31 to 60 inches, dark grayish brown, mottled, firm silty clay loam

In some areas the dark surface layer is more than 10 inches thick.

Included with this soil in mapping are areas of the well drained Verdigris soils. These soils have less clay in the subsoil than the Hepler soil. They are on the lower flood plains. They make up about 5 to 15 percent of the unit.

Important properties of the Hepler soil—

Permeability: Moderately slow
Surface runoff: Slow

Figure 6.—No-till soybeans planted in the stubble of winter wheat in an area of Deepwater silt loam, 2 to 5 percent slopes, eroded.

Available water capacity: High
Organic matter content: Low
Depth to the water table: 1 to 3 feet from November through April
Shrink-swell potential: Moderate

Most areas are used for cultivated crops, pasture, or hay. A few areas are wooded.

This soil is suited to corn and soybeans. Wetness is a major management concern in areas used for cultivated crops. Land grading and shallow surface ditches can improve surface drainage. Returning crop residue to the soil helps to maintain the content of organic matter, improves tilth, and increases the rate of water infiltration. The flooding can result in crop damage.

Some areas along small, narrow, upland drainageways are used for pasture or hay. This soil is moderately well suited to the commonly grown cool-season grasses, such as tall fescue and timothy; to legumes, such as red clover, ladino clover, and lespedeza; and to warm-season grasses, such as switchgrass. It is moderately suited to other warm-season grasses, such as indiangrass and big bluestem. Wetness caused by the seasonal high water table is the main management concern. Grazing schedules can be designed to avoid periods of flooding. Maintaining stands of desirable species is difficult in depressional areas. Plants should be selected accordingly.

This soil is suited to trees. A few areas support native hardwoods. No major limitations affect planting or harvesting.

This soil is not suited to building site development or onsite waste disposal because of the flooding and the wetness.

The land capability classification is IIw. The woodland ordination symbol is 3A.

53—Hepler silt loam. This very deep, nearly level, somewhat poorly drained soil is on high flood plains. It is subject to rare flooding. Individual areas are irregular in shape and range from about 10 to more than 80 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:

0 to 9 inches, very dark grayish brown, friable silt loam

Subsurface layer:

9 to 18 inches, grayish brown, very friable silt loam

Subsoil:

18 to 26 inches, grayish brown, friable silt loam

26 to 60 inches, dark gray, gray, and dark yellowish brown, mottled, firm silty clay loam

In some areas the surface layer is lighter colored. In other areas the subsoil has a higher content of clay.

Included with this soil in mapping are areas of the well drained Verdigris soils. These soils have less clay in the subsoil than the Hepler soil. They are on the lower flood plains. They make up about 5 to 10 percent of the unit.

Important properties of the Hepler soil—

Permeability: Moderately slow
Surface runoff: Slow
Available water capacity: High
Organic matter content: Low
Depth to the water table: 1 to 3 feet from November through April
Shrink-swell potential: Moderate

Most areas are used for cultivated crops. Some areas are used for pasture or hay. A few small areas are wooded.

This soil is suited to corn, soybeans, and small grain. Wetness is the main limitation affecting cultivated crops. Proper management of crop residue helps to maintain the organic matter content, improves tilth, and increases the rate of water infiltration. A system of conservation tillage, such as no-till or ridge till, that leaves large amounts of crop residue on the surface, winter cover crops, and grassed waterways help to prevent soil loss.

This soil is best suited to shallow-rooted cool-season grasses that can tolerate wetness, such as reed canarygrass. Switchgrass is the best suited warm-season grass. The wetness is the main management concern. The soil is poorly suited to hay. Grazing schedules can be designed to avoid periods of flooding. Maintaining stands of desirable species is difficult in depressional areas. Surface drainage systems can be used for the deeper rooted species.

This soil is suited to trees. A few areas support native hardwoods. No major limitations affect planting or harvesting.

This soil is not suited to building site development or onsite waste disposal because of the flooding, the shrink-swell potential, and the wetness.

The land capability classification is IIw. The woodland ordination symbol is 4A.

54B—Newtonia silt loam, 2 to 5 percent slopes. This very deep, gently sloping, well drained soil is on ridgetops and side slopes in the uplands. Individual areas are irregular in shape and range from about 10 to more than 150 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:

0 to 15 inches, very dark brown, friable silt loam

Subsurface layer:

15 to 22 inches, dark brown, friable silty clay loam

Subsoil:

22 to 34 inches, reddish brown, friable silty clay loam

34 to 60 inches, red, mottled, firm silty clay

In some areas the dark surface layer is less than 10 inches thick. In other areas the depth to hard bedrock is less than 60 inches.

Included with this soil in mapping are areas of Catoosa soils. These soils are less than 40 inches deep over hard bedrock. They are in landscape positions similar to those of the Newtonia soil. They make up about 5 to 10 percent of the unit.

Important properties of the Newtonia soil—

Permeability: Moderate
Surface runoff: Medium
Available water capacity: High
Organic matter content: Moderate
Shrink-swell potential: Moderate

Most areas are used for cultivated crops, pasture, or hay.

This soil is suited to corn, grain sorghum, soybeans, and winter wheat. Erosion is a management concern in areas used for cultivated crops. A system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface, winter cover crops, contour farming, a combination of terraces and grassed waterways, and a conservation cropping system that includes close-growing pasture and hay crops help to control erosion. Returning crop residue to the soil improves fertility and increases the rate of water infiltration.

Growing grasses and legumes for pasture and hay helps to control erosion. This soil is well suited to the commonly grown cool-season grasses, such as tall fescue, orchardgrass, and timothy; to legumes, such as ladino clover and lespedeza; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. Erosion is a hazard in newly seeded areas. No serious limitations affect the areas used as pasture or hayland after the plants are established.

This soil is suited to building site development if proper design and installation procedures are used. The shrink-swell potential is a limitation. Constructing foundations, footings, and basement walls with adequately reinforced concrete helps to prevent the structural damage caused by shrinking and swelling. Enlarging septic tank absorption fields helps to overcome the restricted permeability.

This soil is suited to local roads and streets. Low strength and the potential for frost action are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by frost action.

The land capability classification is IIIe. No woodland ordination symbol is assigned.

55B—Catoosa silt loam, 2 to 5 percent slopes. This moderately deep, gently sloping, well drained soil is on convex ridgetops and side slopes in the uplands. Individual areas are irregular in shape and range from about 10 to more than 150 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 9 inches, very dark grayish brown, friable silt loam

Subsoil:
9 to 29 inches, dark reddish brown, firm silty clay loam

Bedrock:
29 inches, hard limestone

In some areas the depth to limestone bedrock is more than 40 inches.

Included with this soil in mapping are small areas of rock outcrop and Clareson, Eram, Newtonia, and Summit soils. Clareson soils have a subsoil of flaggy silty clay. They are in narrow bands in mid positions on side slopes. The moderately well drained Eram and Summit soils are on foot slopes. The very deep Newtonia soils are in landscape positions similar to those of the Catoosa soil. The rock outcrop is in isolated areas. Included areas make up about 15 percent of the map unit.

Important properties of the Catoosa soil—

Permeability: Moderate
Surface runoff: Medium
Available water capacity: Low
Organic matter content: Moderately low
Shrink-swell potential: Moderate

Most areas are used for cultivated crops, pasture, or hay.

This soil is suited to small grain, grain sorghum, soybeans, and grasses for hay or pasture. It is poorly suited to corn and alfalfa because of seasonal droughtiness. Erosion is a hazard in areas used for cultivated crops. A system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface, winter cover crops, contour farming, and a combination of terraces and grassed waterways help to prevent excessive soil loss. Returning crop residue to the soil or regularly adding other organic material improves fertility, minimizes crusting, and increases the rate of water infiltration.

Growing pasture and hay crops helps to control erosion on this soil. The soil is well suited to cool-season grasses, such as tall fescue, orchardgrass, and timothy; to legumes, such as ladino clover, red clover, and lespedeza; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. Proper stocking rates, applications of fertilizer, pasture rotation, and timely deferment of grazing help to keep the grassland in good condition. In many areas controlling brush and resting or reseeding pastures can improve the condition of the grassland.

If this soil is used as a site for dwellings without basements, the depth to bedrock and the shrink-swell potential are moderate limitations. Constructing footings and foundations with adequately reinforced concrete and backfilling with sand and gravel help to prevent the damage caused by shrinking and swelling. The soil generally is not suited to septic tank absorption fields or sewage lagoons because of the depth to bedrock. A properly constructed mound system will function if adequate soil material is available in adjacent areas.

This soil is suited to local roads and streets. Low strength, the depth to bedrock, the shrink-swell potential, and the potential for frost action are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. The bedrock can be ripped in most places. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by shrinking and swelling and by frost action.

The land capability classification is IIIe. No woodland ordination symbol is assigned.

56B—Bates loam, 2 to 5 percent slopes. This moderately deep, gently sloping, well drained soil is on ridgetops and some adjoining side slopes in the uplands. Individual areas are irregular in shape and range from about 5 to more than 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 8 inches, very dark grayish brown, very friable loam

Subsurface layer:
8 to 16 inches, very dark grayish brown, friable loam

Subsoil:
16 to 24 inches, dark yellowish brown, friable sandy clay loam
24 to 34 inches, strong brown, firm sandy clay loam

Bedrock:
34 inches, soft, weathered sandstone

In some areas the dark surface layer is less than 7 inches thick. In other areas the surface layer is fine sandy loam. In places the depth to soft sandstone bedrock is more than 40 inches.

Included with this soil in mapping are small areas of Coweta, Deepwater, and Eram soils. Coweta soils are less than 20 inches deep over fractured bedrock. They are on ridgetops or steep side slopes. Deepwater soils are more than 60 inches deep over bedrock. They are in landscape positions similar to those of the Bates soil. Eram soils are slowly permeable. They are in landscape positions similar to those of the Bates soil. Included soils make up about 10 to 15 percent of the unit.

Important properties of the Bates soil—

Permeability: Moderate
Surface runoff: Medium
Available water capacity: Low
Organic matter content: Moderately low
Shrink-swell potential: Low

Most areas are used for cultivated crops, pasture, or hay.

This soil is suited to corn, soybeans, and small grain. Erosion is a management concern in areas used for cultivated crops. A system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface, winter cover crops, contour farming, a combination of terraces and grassed waterways, and a conservation cropping system that includes close-growing pasture and hay crops help to control erosion. Returning crop residue to the soil improves fertility and increases the rate of water infiltration.

Growing grasses and legumes for pasture and hay helps to control erosion. This soil is moderately well suited to the commonly grown cool-season grasses, such as tall fescue and orchardgrass; to legumes, such as lespedeza; and to warm-season grasses, such as big bluestem and indiangrass. Erosion is a hazard in newly seeded areas. No serious limitations affect the areas used as pasture or hayland after the plants are established.

This soil is suited to dwellings without basements if proper design and installation procedures are used. It may be necessary to excavate the rock, or the dwelling can be designed according to the depth to bedrock. In some areas special design and extra excavation may be needed if dwellings with basements are constructed. The soil is suited to septic tank absorption fields if additional soil material is used to increase the depth to bedrock and thus prevent the surfacing of the effluent. The field also can be designed so that it conforms to the natural slope of the land. The restricted permeability can be overcome by extending the length of the laterals and by shaping the area. The soil also is suited to sewage lagoons if the berms are built up with extra soil material. Sealing the bottom of the lagoon with slowly permeable material helps to prevent seepage.

This soil is suited to local roads and streets. There are no major limitations.

The land capability classification is IIe. No woodland ordination symbol is assigned.

56C2—Bates loam, 3 to 8 percent slopes, eroded. This moderately deep, gently sloping and moderately sloping, well drained soil is on ridgetops and side slopes in the uplands. Erosion has removed 25 to 75 percent of the original surface layer. The remaining surface layer is a mixture of the original surface layer, a former subsurface layer, and the upper part of the subsoil. Individual areas are irregular in shape and range from about 10 to more than 80 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 6 inches, dark brown, very friable loam

Subsoil:
6 to 19 inches, dark yellowish brown, friable clay loam
19 to 28 inches, yellowish brown, friable sandy clay loam

Bedrock:
28 inches, soft, weathered sandstone

In some areas the surface layer is fine sandy loam. In other areas the depth to soft sandstone bedrock is more than 40 inches.

Included with this soil in mapping are small areas of Coweta, Deepwater, and Eram soils. Coweta soils are less than 20 inches deep over bedrock. They are on ridgetops or the steeper side slopes. Deepwater soils are more than 60 inches deep over bedrock. They are in landscape positions similar to those of the Bates soil. Eram soils are slowly permeable. They are on the lower side slopes. Included soils make up about 10 to 15 percent of the unit.

Important properties of the Bates soil—

Permeability: Moderate
Surface runoff: Medium
Available water capacity: Low
Organic matter content: Moderately low
Shrink-swell potential: Low

In most areas this soil is used for cultivated crops, pasture, or hay. It is best suited to small grain crops. It is poorly suited to corn, grain sorghum, and soybeans.

If this soil is used for cultivated crops, the hazard of erosion is severe. A system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface, winter cover crops, a conservation cropping system that includes close-growing pasture and hay crops, contour farming, and a combination of terraces and grassed waterways help to prevent excessive soil loss. Returning crop residue to the soil improves fertility and increases the rate of water infiltration.

Growing grasses and legumes for pasture and hay helps to control erosion. This soil is moderately well suited to the commonly grown cool-season grasses, such as tall fescue and orchardgrass; to legumes, such as lespedeza; and to warm-season grasses, such as big bluestem and indiangrass. Erosion is a hazard in newly seeded areas. No serious limitations affect the areas used as pasture or hayland after the plants are established.

This soil is suited to dwellings without basements if proper design and installation procedures are used. It may be necessary to excavate the rock, or the dwelling can be designed according to the depth to bedrock. In some areas special design and extra excavation may be needed if dwellings with basements are constructed. The soil is suited to septic tank absorption fields if additional soil material is used to increase the depth to bedrock and thus prevent the surfacing of the effluent. The field also can be designed so that it conforms to the natural slope of the land. The restricted permeability can be overcome by extending the length of the laterals and by shaping the area. The soil also is suited to sewage lagoons if the berms are built up with extra soil material. Sealing the bottom of the lagoon with slowly permeable material helps to prevent seepage.

This soil is suited to local roads and streets. There are no major limitations.

The land capability classification is IVe. No woodland ordination symbol is assigned.

58—Hartwell silt loam. This very deep, nearly level, somewhat poorly drained soil is on broad upland divides. Individual areas are irregular in shape and range from about 30 to more than 200 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 9 inches, very dark grayish brown, very friable silt loam

Subsurface layer:
9 to 14 inches, grayish brown, very friable silt loam

Subsoil:
14 to 48 inches, very dark gray, dark grayish brown, and grayish brown, mottled, firm silty clay and silty clay loam
48 to 60 inches, mottled dark yellowish brown, gray, and yellowish red, firm silty clay loam

Included with this soil in mapping are areas of Deepwater and Kenoma soils. These soils are in the lower positions on the landscape. Deepwater soils have less clay in the subsoil than the Hartwell soil. Kenoma soils do not have a light-colored subsurface layer. Included soils make up about 5 to 10 percent of the unit.

Important properties of the Hartwell soil—

Permeability: Slow
Surface runoff: Slow
Available water capacity: High
Organic matter content: Moderate
Water table: Perched at a depth of 0.5 foot to 1.5 feet from November through April
Shrink-swell potential: High

Most areas are used for row crops. A few areas are used for pasture or hay.

This soil is suited to corn, soybeans, small grain, and grain sorghum. Wetness during spring and fall is the major limitation in areas used for cultivated crops. Erosion is a hazard on long slopes. Land smoothing, shallow surface ditches, and timely tillage can reduce the wetness. In areas that have long slopes and good surface drainage, a system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface, cross-slope terraces, and grassed waterways help to prevent excessive soil loss. Returning crop residue to the soil improves fertility, minimizes crusting, and increases the rate of water infiltration.

This soil is suited to cool-season grasses, such as reed canarygrass, tall fescue, and orchardgrass; to legumes, such as ladino clover; and to warm-season grasses, such as switchgrass, big bluestem, and indiangrass. Wetness is the main limitation. Grazing should be avoided when the soil is wet.

This soil is suited to building site development if proper design and installation procedures are used. Constructing footings, foundations, and basement walls with adequately reinforced concrete helps to prevent the damage caused by shrinking and swelling. Installing tile drains around footings helps to prevent the damage caused by excessive wetness. The soil is unsuited to septic tank absorption fields because of the wetness and the restricted permeability. Properly designed sewage lagoons will function adequately.

This soil is suited to local roads and streets. Low strength, the potential for frost action, the shrink-swell potential, and the wetness are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by shrinking and swelling, frost action, and wetness.

The land capability classification is IIw. No woodland ordination symbol is assigned.

60B—Kenoma silt loam, 1 to 4 percent slopes. This very deep, very gently sloping and gently sloping, moderately well drained soil is on convex ridgetops and side slopes. Individual areas are irregular in shape and range from about 10 to more than 400 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
- 0 to 9 inches, very dark grayish brown, friable silt loam

Subsoil:
- 9 to 16 inches, very dark grayish brown, mottled, very firm silty clay
- 16 to 60 inches, dark yellowish brown, mottled, firm and very firm silty clay

In some areas the surface layer is thicker.

Included with this soil in mapping are small areas of Deepwater, Eram, and Hartwell soils. Deepwater soils have less clay in the subsoil than the Kenoma soil. They are in landscape positions similar to those of the Kenoma soil. Eram soils are on the steeper shoulders and side slopes along drainageways. They are less than 40 inches deep over weathered shale bedrock. The somewhat poorly drained Hartwell soils are in broad, nearly level areas. Included soils make up about 10 to 15 percent of the unit.

Important properties of the Kenoma soil—

Permeability: Very slow
Surface runoff: Medium
Available water capacity: Moderate
Organic matter content: Moderate
Shrink-swell potential: High

Most areas are used for cultivated crops, pasture, or hay (fig. 7).

This soil is suited to corn, soybeans, and small grain. Erosion is a hazard in areas used for cultivated crops. A system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface, winter cover crops, and contour farming help to prevent excessive soil loss. Most areas have long slopes that should be terraced and farmed on the contour. Returning crop residue to the soil improves fertility and increases the rate of water infiltration.

Growing pasture and hay crops helps to control erosion on this soil. The soil is well suited to legumes, such as ladino clover. It is moderately well suited to most of the commonly grown cool-season grasses, such as tall fescue and timothy, and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. Overgrazing or grazing when the soil is wet causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, pasture rotation, applications of fertilizer, timely deferment of grazing, and restricted use during wet periods help to keep the grassland in good condition. Erosion during seedbed preparation is a management concern. Timely tillage and a quickly established ground cover minimize erosion.

This soil is suited to building site development and onsite waste disposal if proper design and installation procedures are used. The high shrink-swell potential is a limitation on sites for dwellings. Constructing footings,

Figure 7.—Hay in an area of Kenoma silt loam, 1 to 4 percent slopes.

foundations, and basement walls with adequately reinforced concrete and backfilling with sand or gravel help to prevent the damage caused by shrinking and swelling. The soil is unsuited to septic tank absorption fields because of the restricted permeability. It is suited to sewage lagoons. The slope is a moderate limitation, but it can be overcome by leveling.

This soil is suited to local roads and streets. Low strength, the shrink-swell potential, and the potential for frost action are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by shrinking and swelling and by frost action.

The land capability classification is IIIe. No woodland ordination symbol is assigned.

61B—Summit silty clay loam, 1 to 5 percent slopes. This very deep, gently sloping, moderately well drained soil is on foot slopes and side slopes in the uplands. Individual areas are irregular in shape and range from about 10 to more than 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 8 inches, black, firm silty clay loam

Subsurface layer:
8 to 14 inches, very dark gray, firm silty clay loam

Subsoil:
14 to 60 inches, very dark gray, very dark grayish brown, and dark grayish brown, mottled, very firm silty clay

In places the surface layer is silt loam.

Included with this soil in mapping are areas of the moderately deep Eram soils. These soils have less clay in the surface layer than the Summit soil. They are on side slopes along drainageways. They make up about 5 percent of the unit.

Important properties of the Summit soil—

Permeability: Slow
Surface runoff: Medium

Available water capacity: Moderate
Organic matter content: Moderate
Water table: Perched at a depth of 2 to 3 feet from November through April
Shrink-swell potential: High

Most areas are used for cultivated crops, pasture, or hay.

This soil is suited to corn, soybeans, grain sorghum, and small grain. Erosion is a hazard in areas used for cultivated crops. A combination of terraces and grassed waterways, contour farming, and a system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface help to control erosion, maintain the content of organic matter, and improve tilth.

This soil is well suited to most of the commonly grown cool-season grasses, such as tall fescue, orchardgrass, and timothy; to legumes, such as ladino clover and lespedeza; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. Growing pasture and hay crops helps to control erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, applications of fertilizer, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the pasture in good condition. Erosion is a hazard in newly seeded areas. Timely seedbed preparation helps to ensure a good ground cover.

This soil is suited to building site development if proper design and installation procedures are used. Constructing footings, foundations, and basement walls with adequately reinforced concrete and backfilling with sand or gravel help to prevent the damage caused by shrinking and swelling. Installing tile drains around footings helps to prevent the damage caused by excessive wetness. The soil is unsuited to septic tank absorption fields because of the wetness and the restricted permeability. Sewage lagoons can function adequately if the bottom of the lagoon is sealed to prevent the contamination of ground water. Drains can be installed to lower the water table.

This soil is suited to local roads and streets. Low strength, the shrink-swell potential, and the potential for frost action are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by shrinking and swelling and by frost action.

The land capability classification is IIIe. No woodland ordination symbol is assigned.

61C2—Summit silty clay loam, 5 to 9 percent slopes, eroded. This very deep, moderately sloping, moderately well drained soil is on foot slopes and side slopes in the uplands. Erosion has removed 25 to 75 percent of the original surface layer. The remaining surface layer has been mixed with the subsurface layer and the upper part of the subsoil. Individual areas are irregular in shape and range from about 10 to more than 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 6 inches, black, firm silty clay loam

Subsoil:
6 to 12 inches, black, mottled, firm silty clay loam
12 to 60 inches, very dark grayish brown and dark grayish brown, mottled, very firm silty clay

Included with this soil in mapping are areas of the moderately deep Eram soils. These soils have less clay in the surface layer than the Summit soil. They are on side slopes along drainageways. They make up about 5 percent of the unit.

Important properties of the Summit soil—

Permeability: Slow
Surface runoff: Medium
Available water capacity: Moderate
Organic matter content: Moderate
Water table: Perched at a depth of 2 to 3 feet from November through April
Shrink-swell potential: High

Most areas are used for pasture or hay. A few areas are used for cultivated crops.

This soil is well suited to most of the commonly grown cool-season grasses, such as tall fescue and bromegrass; to legumes, such as ladino clover and lespedeza; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. Growing pasture and hay crops helps to control erosion. Overgrazing or grazing when the soil is too wet causes surface compaction, excessive runoff, and poor tilth. Proper stocking rates, applications of fertilizer, pasture rotation, deferred grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is suited to small grain and grain sorghum. If cultivated crops are grown, continued erosion is a major management concern. Minimum tillage, contour farming, a combination of terraces and grassed waterways, and a system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface help to prevent excessive soil loss. Diversions help to control surface runoff from adjacent soils.

This soil is suited to building site development if proper design and installation procedures are used. Constructing footings, foundations, and basement walls with adequately reinforced concrete and backfilling with sand or gravel help to prevent the damage caused by shrinking and swelling. Installing tile drains around footings helps to prevent the damage caused by excessive wetness. The soil is unsuited to septic tank absorption fields because of wetness and the restricted permeability. Sewage lagoons can function adequately if the bottom of the lagoon is sealed to prevent the contamination of ground water. Drains can be installed to lower the water table. Also, the lagoons can be constructed in the less sloping areas, or the areas may be leveled.

This soil is suited to local roads and streets. Low strength, the shrink-swell potential, and the potential for frost action are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by shrinking and swelling and by frost action.

The land capability classification is IVe. No woodland ordination symbol is assigned.

63B2—Eram silt loam, 2 to 5 percent slopes, eroded. This gently sloping, moderately deep, moderately well drained soil is on convex ridgetops and side slopes in the uplands. Erosion has removed 25 to 75 percent of the original surface layer. In many areas the surface layer has been mixed with the upper part of the subsoil. Individual areas are irregular in shape and range from about 10 to more than 75 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 8 inches, very dark grayish brown, friable silt loam

Subsoil:
8 to 19 inches, brown, mottled, firm clay loam
19 to 28 inches, grayish brown, mottled, firm clay

Bedrock:
28 inches, soft, weathered shale and sandstone

In places the soil is more than 40 inches deep over bedrock. In some small areas cobbles are on the surface. In other areas the surface layer is silty clay loam or clay loam.

Included with this soil in mapping are small areas of Coweta and Deepwater soils. Coweta soils are shallow over sandstone. They are on the highest points of ridgetops. Deepwater soils have less clay than the Eram soil. They are more than 40 inches deep over bedrock. They are higher on the side slopes than the Eram soil. Included soils make up less than 5 percent of the unit.

Important properties of the Eram soil—

Permeability: Slow
Surface runoff: Medium
Available water capacity: Low
Organic matter content: Moderate
Water table: Perched at a depth of 1 to 2 feet from November through April
Shrink-swell potential: High

Most areas are used for cultivated crops, pasture, or hay.

This soil is suited to soybeans and small grain. If cultivated crops are grown, further erosion is a hazard. A system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface, winter cover crops, a combination of terraces and grassed waterways, and a conservation cropping system that includes close-growing pasture and hay crops help to prevent excessive soil loss. A few areas have slopes that are long enough and smooth enough to be terraced and farmed on the contour. Returning crop residue to the soil improves fertility and increases the rate of water infiltration.

Growing pasture and hay crops helps to control erosion on this soil. The soil is well suited to legumes, such as ladino clover. It is moderately well suited to cool-season grasses, such as tall fescue and timothy; to legumes, such as lespedeza; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. Erosion during seedbed preparation is the main management concern. Timely tillage and a quickly established ground cover minimize erosion.

This soil is suited to building site development if proper design and installation procedures are used. Constructing foundations and footings with adequately reinforced concrete and backfilling with sand or gravel help to prevent the structural damage caused by shrinking and swelling. Installing tile drains around footings helps to prevent the damage caused by excessive wetness. The soil is unsuited to septic tank absorption fields because of the wetness, the depth to bedrock, and the restricted permeability. Properly designed sewage lagoons can function adequately. Because of the moderate depth to bedrock, it may be necessary to seal the bottom of the lagoon to prevent the contamination of ground water.

This soil is suited to local roads and streets. Low strength, the shrink-swell potential, and the potential for frost action are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by shrinking and swelling and by frost action.

The land capability classification is IVe. No woodland ordination symbol is assigned.

63C—Eram silt loam, 5 to 9 percent slopes. This moderately deep, moderately sloping, moderately well drained soil is on side slopes in the uplands. Individual areas are irregular in shape and range from about 10 to more than 50 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 10 inches, dark brown, friable silt loam

Subsoil:
10 to 21 inches, brown, mottled, firm silty clay
21 to 31 inches, yellowish brown, mottled, firm silty clay

Bedrock:
31 inches, weathered shale

In some areas the slope is more than 9 percent. In other areas the depth to bedrock is 40 inches or more. In small areas cobbles are on the surface.

Included with this soil in mapping are small areas of Coweta and Deepwater soils. Coweta soils are less than 20 inches deep over sandstone. They are on the highest points of ridgetops. Deepwater soils have less clay than the Eram soil. They are more than 40 inches deep over bedrock. They are higher on the side slopes than the Eram soil. Included soils make up less than 5 percent of the unit.

Important properties of the Eram soil—

Permeability: Slow
Surface runoff: Medium
Available water capacity: Low
Organic matter content: Moderate
Water table: Perched at a depth of 1 to 2 feet from November through April
Shrink-swell potential: High

Most areas are used for pasture or hay.

Growing pasture and hay crops helps to control erosion. This soil is well suited to legumes, such as ladino clover. It is moderately well suited to other legumes, such as lespedeza; to cool-season grasses, such as tall fescue and timothy; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. Erosion during seedbed preparation is the main management concern. Timely tillage and a quickly established ground cover minimize erosion.

This soil is suited to some small grain crops. If cultivated crops are grown, erosion is a major management concern. A system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface helps to prevent excessive soil loss. Returning crop residue to the soil improves fertility and increases the rate of water infiltration.

This soil is suited to building site development, but wetness and the shrink-swell potential are limitations on sites for dwellings. Constructing foundations and footings with adequately reinforced concrete and backfilling with sand or gravel help to prevent the structural damage caused by shrinking and swelling. Installing tile drains around footings helps to prevent the damage caused by excessive wetness. The soil is unsuited to septic tank absorption fields because of the wetness and the restricted permeability. The depth to bedrock and the slope are limitations on sites for sewage lagoons. Alternative sites in adjacent areas that are better suited can be selected for onsite waste disposal.

This soil is suited to local roads and streets. Low strength, the shrink-swell potential, and the potential for frost action are limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by shrinking and swelling and by frost action.

The land capability classification is VIe. No woodland ordination symbol is assigned.

65B—Clareson silty clay loam, 2 to 5 percent slopes. This moderately deep, gently sloping, well drained soil is on ridgetops and side slopes in the uplands. Individual areas range from about 5 to more than 70 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 5 inches, very dark grayish brown, friable silty clay loam

Subsoil:
5 to 10 inches, dark brown, firm silty clay loam
10 to 28 inches, dark reddish brown and reddish brown, very firm flaggy and very flaggy silty clay

Bedrock:
28 inches, hard limestone

Included with this soil in mapping are areas of soils that are more than 40 inches deep over limestone bedrock. Also included are areas of Balltown, Catoosa, and Eram soils. Balltown soils are less than 20 inches deep over bedrock. They are on the lower side slopes. Catoosa soils have less clay and rock in the subsoil than the Clareson soil. They are in the slightly higher positions on the landscape. Eram soils have a lower content of coarse fragments than the Clareson soil. They are on foot slopes. Included areas make up about 10 to 15 percent of the unit.

Important properties of the Clareson soil—

Permeability: Moderately slow
Surface runoff: Medium
Available water capacity: Low
Organic matter content: Moderate
Shrink-swell potential: Moderate

Most areas are used for pasture or hay. Some areas are used for cultivated crops.

Growing grasses for pasture and hay helps to control erosion. This soil is moderately well suited to most cool-season grasses, such as tall fescue and orchardgrass; to legumes, such as lespedeza; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion during seedbed preparation is a management concern. Timely tillage and a quickly established ground cover minimize erosion.

This soil is suited to cultivated crops only on a limited basis because of the content of coarse fragments and the susceptibility to erosion. Also, the hazard of erosion limits the choice of crops. A combination of grassed waterways and terraces, a system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface, and a conservation cropping system that includes close-growing pasture or hay crops help to prevent excessive soil loss.

This soil is suited to dwellings without basements. Large stones and the depth to bedrock are limitations. If this soil is used for building site development, dwellings without basements can be designed so that they conform to the natural slope of the land and to allow for the depth to bedrock. The bedrock can be ripped in most places. The soil is unsuited to onsite waste disposal systems because of the depth to bedrock. Alternative sites in adjacent areas that are better suited can be selected for onsite waste disposal. Onsite investigation is essential.

If this soil is used as a site for local roads and streets, low strength, large stones, and the potential for frost action are severe limitations. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by low strength. Large stones should be removed. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by frost action.

The land capability classification is IVe. No woodland ordination symbol is assigned.

66B—Olpe gravelly silt loam, 2 to 5 percent slopes. This very deep, gently sloping, well drained soil is on ridgetops and sides of ridges in the uplands. Individual areas are irregular in shape and range from about 15 to more than 50 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 11 inches, dark brown, very friable gravelly silt loam

Subsurface layer:
11 to 19 inches, reddish brown, friable very gravelly silty clay loam

Subsoil:
19 to 31 inches, yellowish red, firm very gravelly silty clay
31 to 38 inches, dark brown, mottled, firm extremely gravelly silty clay
38 to 49 inches, yellowish red, mottled, firm very gravelly silty clay
49 to 60 inches, multicolored, firm very gravelly silty clay

In some areas the surface layer is brown or reddish brown. In other areas the dark surface layer is less than 10 inches thick.

Included with this soil in mapping are areas of Kenoma and Summit soils. These soils do not have gravel in the solum. They are adjacent to and slightly below the Olpe soil. Also included are areas from which the gravel has been removed for use as road material. Included areas make up about 10 to 25 percent of the unit.

Important properties of the Olpe soil—

Permeability: Slow
Surface runoff: Medium
Available water capacity: Low
Organic matter content: Moderately low
Shrink-swell potential: Moderate

Most areas are used for pasture or hay. Some areas are used for cultivated crops.

This soil is not suited to cultivated crops because of the hazard of erosion and the high content of chert. Growing grasses for pasture and hay helps to control erosion. The soil is moderately well suited to most cool-season grasses, such as tall fescue and orchardgrass; to legumes, such as lespedeza; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. No serious limitations affect the areas used as pasture or hayland. Erosion during seedbed preparation is a management concern. Timely tillage and a quickly established ground cover minimize erosion.

This soil is suited to building site development if proper design and installation procedures are used. Constructing foundations, footings, and basement walls with adequately reinforced concrete helps to prevent the structural damage caused by shrinking and swelling. The soil is unsuited to septic tank absorption fields because of the restricted permeability. Sewage can be treated in a properly designed lagoon.

This soil is suited to local roads and streets. The shrink-swell potential and the potential for frost action are limitations. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by shrinking and swelling and by frost action.

The land capability classification is VIe. No woodland ordination symbol is assigned.

68D—Coweta loam, 5 to 14 percent slopes. This shallow, moderately sloping and strongly sloping, well drained soil is on ridgetops and side slopes and in the steeper areas along drainageways in the uplands. Individual areas are irregular in shape and range from about 5 to more than 100 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 6 inches, very dark grayish brown, friable loam

Subsoil:
6 to 12 inches, dark brown, friable gravelly fine sandy loam

Bedrock:
12 inches, weathered sandstone

In some areas the surface layer is thinner and lighter colored. In other areas the surface layer is fine sandy loam.

Included with this soil in mapping are small areas of Bates and Eram soils. Bates soils are deeper over soft sandstone bedrock than the Coweta soil. They are in the higher positions on the landscape. Eram soils are deeper than the Coweta soil and have more clay in the subsoil. They formed over shale. They are on the lower side slopes. Also included are areas of sandstone rock outcrop. Included areas make up about 10 to 15 percent of the unit.

Important properties of the Coweta soil—

Permeability: Moderate
Surface runoff: Medium
Available water capacity: Very low
Organic matter content: Moderately low
Shrink-swell potential: Low

Most areas are used for native pasture. This soil is best suited to shallow-rooted plants. It is moderately suited to big bluestem, indiangrass, and switchgrass. In places it is nearly impossible to till. Broadcast seeding may be necessary. The slope and the rock outcrop can hinder mowing in places. The stands of native grass can be improved by proper grazing, weed control, and timely controlled burning.

This soil is fairly suited to habitat for most types of upland wildlife. Sumac and native grasses provide most of the cover. They provide an edge type of wildlife habitat.

This soil is suited to dwellings without basements. The depth to bedrock and the slope are limitations. If the soil is used for building site development, dwellings without basements can be designed so that they conform to the natural slope of the land and to allow for the shallow depth to sandstone bedrock. The bedrock can be ripped in most places. The soil is unsuited to onsite waste disposal systems because of the shallow depth to bedrock. Alternative sites in adjacent areas that are better suited can be selected for onsite waste disposal. Onsite investigation is essential.

If this soil is used as a site for local roads and streets, the depth to bedrock, the slope, and the potential for frost action are limitations. Roads can be designed so that they conform to the natural slope of the land and to allow for the shallow depth to sandstone bedrock. The bedrock can be ripped in most places. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by frost action.

The land capability classification is VIe. No woodland ordination symbol is assigned.

72E—Balltown very flaggy silt loam, 5 to 20 percent slopes. This shallow, moderately sloping to moderately steep, somewhat excessively drained soil is on side slopes and ridgetops in the uplands. Individual areas are irregular in shape and range from about 10 to more than 200 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 8 inches, black, friable very flaggy silt loam

Substratum:
8 to 15 inches, very dark grayish brown, friable very flaggy silt loam

Bedrock:
15 inches, hard limestone

Included with this soil in mapping are areas of Catoosa, Clareson, and Eram soils. These soils are moderately deep and are less sloping than the Balltown soil. They are in the slightly higher positions on the landscape. Eram soils are at the lower edge of the mapped areas. Also included are intermingled areas of limestone rock outcrop. Included areas make up about 10 to 15 percent of the unit.

Important properties of the Balltown soil—

Permeability: Moderate
Surface runoff: Rapid
Available water capacity: Very low
Organic matter content: Moderate
Shrink-swell potential: Moderate

Most areas support native grasses. This soil is best suited to shallow-rooted pasture plants. The grasses that grow best on this soil are lespedeza, tall fescue, big bluestem, indiangrass, and grama. The areas of rock outcrop limit the use of equipment. Broadcast seeding may be necessary.

This soil is fairly suited to habitat for most types of upland wildlife. Redcedar and native grasses provide most of the cover. They provide an edge type of wildlife habitat.

This soil is generally not suited to building site development or sewage disposal because of the slope and the shallow depth to bedrock. Onsite investigation is essential.

If this soil is used as a site for local roads and streets, the depth to bedrock, the slope, low strength, and the potential for frost action are severe limitations. Roads can be designed so that they conform to the natural slope of the land and to allow for the shallow depth to limestone bedrock. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by low strength and by frost action.

The land capability classification is VIIs. No woodland ordination symbol is assigned.

73E—Eram-Balltown complex, 5 to 20 percent slopes. These moderately sloping to moderately steep soils are on uplands. The moderately deep, moderately well drained Eram soil is on side slopes. The shallow, somewhat excessively drained Balltown soil is on ridgetops. Individual areas are irregular in shape and range from about 25 to more than 300 acres in size. They typically are about 45 percent Eram soil and 40 percent Balltown soil. The two soils occur as areas so intricately mixed or so small that mapping them separately was not practical.

The typical sequence, depth, and composition of the layers of the Eram soil are as follows—

Surface layer:
0 to 6 inches, very dark brown, friable silt loam

Subsoil:
6 to 21 inches, dark brown and dark grayish brown, firm clay

Bedrock:
21 inches, weathered shale

In some areas the surface layer is thinner. In other areas the surface layer is silty clay loam or clay loam.

Important properties of the Eram soil—

Permeability: Slow
Surface runoff: Rapid
Available water capacity: Low
Organic matter content: Moderate
Water table: Perched at a depth of 1 to 2 feet from November through April
Shrink-swell potential: High

The typical sequence, depth, and composition of the layers of the Balltown soil are as follows—

Surface layer:
0 to 8 inches, black, friable very flaggy silt loam

Substratum:
8 to 15 inches, very dark grayish brown, friable very flaggy silt loam

Bedrock:
15 inches, hard limestone

Important properties of the Balltown soil—

Permeability: Moderate
Surface runoff: Rapid
Available water capacity: Very low
Organic matter content: Moderate
Shrink-swell potential: Moderate

Included with these soils in mapping are areas of Catoosa and Clareson soils. These included soils are moderately deep and well drained. They are in the slightly higher positions on the landscape. They are intermingled within the mapped areas. Also included are intermingled areas of limestone rock outcrop and seepy spots. Included areas make up about 15 percent of the unit.

Most areas of this unit support native grasses. Some areas are used for pasture. Some of the less rocky areas have been cleared of brush and are seeded to cool-season grasses, mainly tall fescue.

These soils are best suited to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. These grasses grow better in areas of the Eram soil than in other areas of the unit. Many areas have been invaded by brush and trees. Proper stocking rates, uniform grazing, timely deferment of grazing, controlled burning, and brush management help to keep the grassland in good condition.

These soils are fairly suited to habitat for most types of upland wildlife. Redcedar and native grasses provide most of the cover. They provide an edge type of wildlife habitat.

These soils are suited to dwellings without basements. The shrink-swell potential, wetness, and the slope are limitations in areas of the Eram soil, and the depth to bedrock and the slope are limitations in areas of the Balltown soil. If the soils are used for building site development, dwellings without basements can be designed so that they conform to the natural slope of the land and to allow for the depth to limestone bedrock in areas of the Balltown soil. The bedrock can be ripped in most places. The soils are not suited to onsite waste disposal systems because of the restricted permeability, the wetness, and the depth to bedrock in areas of the Eram soil and the depth to bedrock, seepage, and the slope in areas of the Balltown soil. Alternative sites that are better suited can be selected for waste disposal systems. Onsite investigation is essential.

These soils are severely limited as sites for local roads and streets because of the shrink-swell potential in areas of the Eram soil and the depth to bedrock in areas of the Balltown soil. Low strength, the slope, and the potential for frost action are limitations in areas of both soils. Strengthening the subgrade with crushed rock or other suitable material helps to prevent the damage caused by shrinking and swelling and low strength. Grading the roads so that they shed water, constructing side ditches, and installing culverts for drainage help to prevent the damage caused by the slope and by frost action.

The land capability classification is VIIs. No woodland ordination symbol is assigned.

94F—Kanima very channery silty clay loam, 5 to 50 percent slopes. This very deep, moderately sloping to very steep, well drained soil is in areas of mine spoil on uplands. Individual areas are irregular in shape and range from about 10 to more than 400 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
0 to 6 inches, dark grayish brown, friable very channery silty clay loam

Substratum:
6 to 60 inches, light olive brown, friable extremely channery silty clay loam

The end escarpments have slopes of 50 percent or more. In some areas the soil and underlying shale are very strongly acid. In other areas the surface layer is fine sandy loam because of the excavated sandstone bedrock. In places the surface layer is the channery or extremely channery analogs of clay loam or silty clay.

Included with this soil in mapping are long, narrow bodies of water that vary in depth. Also included are areas that have scattered fragments of coal, limestone, sandstone, and shale. Included areas make up about 10 percent of the unit.

Important properties of the Kanima soil—

Permeability: Moderate
Surface runoff: Rapid
Available water capacity: Low
Organic matter content: Low
Shrink-swell potential: Low

This soil is used mostly for wildlife habitat or recreation. Fishing is excellent in the areas where water is impounded. Some areas are suited to pasture if they are shaped and if the scattered acid-producing materials are covered with nonacid soil. The hazard of erosion is severe because of the slope and the scarcity of vegetation. Establishing a good cover of grass helps to control erosion.

This soil is moderately suited to legumes, such as crownvetch and lespedeza; to cool-season grasses, such as tall fescue; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. Seedbed preparation is very difficult because of the slope.

This soil generally is not used for building site development or sewage disposal because of the slope. Onsite investigation is essential.

The land capability classification is VIIs. No woodland ordination symbol is assigned.

95B—Brazilton silt loam, 1 to 5 percent slopes. This very deep, very gently sloping and gently sloping, moderately well drained soil is on reclaimed, mined uplands and stream terraces. Individual areas are irregular in shape and range from about 60 to more than 640 acres in size.

The typical sequence, depth, and composition of the layers of this soil are as follows—

Surface layer:
- 0 to 10 inches, very dark grayish brown, friable silt loam

Substratum:
- 10 to 40 inches, mixed dark grayish brown, yellowish brown, very dark gray, and strong brown, very firm silty clay
- 40 to 60 inches, mixed gray and olive brown very channery silty clay

In some areas the end escarpments adjacent to bodies of water have slopes that are more than 5 percent.

Included with this soil in mapping are long, narrow bodies of water. Included areas make up less than 10 percent of the unit.

Important properties of the Brazilton soil—

Permeability: Very slow
Surface runoff: Medium
Available water capacity: Low
Organic matter content: Moderately low
Shrink-swell potential: High

Most areas are used for pasture or hay. Some areas are used for cultivated crops.

Growing pasture and hay crops helps to control erosion on this soil. The soil is moderately well suited to cool-season grasses, such as tall fescue and timothy; to legumes, such as lespedeza; and to warm-season grasses, such as big bluestem, indiangrass, and switchgrass. Erosion during seedbed preparation is the main management concern. Timely tillage and a quickly established ground cover minimize erosion.

This soil is suited to most small grain crops. Erosion is a moderate hazard in areas used for cultivated crops. A system of conservation tillage, such as no-till or ridge till, that leaves a protective cover of crop residue on the surface, winter cover crops, a combination of terraces and grassed waterways, and a conservation cropping system that includes close-growing pasture and hay crops help to prevent excessive soil loss. Returning crop residue to the soil improves fertility and increases the rate of water infiltration.

This soil is not used for building site development or onsite waste disposal because of coal-mining activity. The shrink-swell potential and the restricted permeability are limitations if the soil is used for building site development.

The land capability classification is IIIe. No woodland ordination symbol is assigned.

96—Pits, quarries. This unit consists mainly of open excavations and piles of rock in areas where the soil material has been removed. Some of the pits are filled with water during all or part of the year. Individual areas range from 5 to 40 acres in size.

Included in mapping are areas of dumps. Dumps are accumulations of limestone aggregates that have been mixed with some excavated soil material.

The slope, large stones, and exposed rock restrict the use of this unit. Virtually no vegetation can be produced in the pits. Many of the pits can be developed into a source of water for wildlife, irrigation, or livestock. Some quarries typically are open at one end and do not contain enough water to make reclamation economically feasible. The smaller quarries could be reclaimed at a minimum cost so that an adequate vegetative cover could be produced. As the size of the quarries and the intensity of mining activities increase, the difficulty of reclamation also increases. The dumps are suited to grasses and legumes if leveled and shaped prior to seeding.

Pits and quarries are not suited to building site development or sanitary facilities. Onsite investigation is needed to determine the suitability for other anticipated land uses.

No land capability classification or woodland ordination symbol is assigned.

Prime Farmland

Prime farmland is one of several kinds of important farmland defined by the U.S. Department of Agriculture. It is of major importance in meeting the Nation's short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is the land that is best suited to food, feed, forage, fiber, and oilseed crops. It may be cultivated land, pasture, woodland, or other land, but it is not urban or built-up land or water areas. It either is used for food or fiber crops or is available for those crops. The soil qualities, growing season, and moisture supply are those needed for a well managed soil to produce a sustained high yield of crops in an economic manner. Prime farmland produces the highest yields with minimal expenditure of energy and economic resources, and farming it results in the least damage to the environment.

Prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The level of acidity or alkalinity is acceptable. Prime farmland has few or no rocks and is permeable to water and air. It is not excessively erodible or saturated with water for long periods and is not frequently flooded during the growing season. The slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Soil Conservation Service.

About 326,780 acres in the survey area, or about 60 percent of the total acreage, meets the requirements for prime farmland. An additional 118,425 acres meets the requirements if the soil is drained or protected from flooding. The prime farmland is mainly in areas of associations 2, 3, and 4, which are described under the heading "General Soil Map Units." Most of the prime farmland is used for cultivated crops, pasture, or hay.

The map units in the survey area that are considered prime farmland are listed in table 5. This list does not constitute a recommendation for a particular land use. The extent of each listed map unit is shown in table 4. The location is shown on the detailed soil maps at the back of this publication. The soil qualities that affect use and management are described under the heading "Detailed Soil Map Units."

Some soils that have a seasonal high water table and all soils that are frequently flooded during the growing season qualify as prime farmland only in areas where these limitations have been overcome by drainage measures or flood control. The need for these measures is indicated after the map unit name in table 5. Onsite evaluation is needed to determine whether or not these limitations have been overcome by corrective measures.

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help to prevent soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavioral characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreational facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

Crops and Pasture

Raleigh L. Redman, district conservationist, Soil Conservation Service, helped prepare this section.

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils, including some not commonly grown in the survey area, are identified; 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 listed for each soil.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under the heading "Detailed Soil Map Units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

In 1988, about 457,900 acres in Bates County was used for crops and pasture. Of this total, about 140,000 acres was used for row crops and 45,000 acres for close-growing crops, mainly wheat *(6)*. The remaining acreage, mainly permanent pasture and hayland, was used for conservation purposes or was idle cropland.

The potential for the sustained production of crops in the county is good. About 60 percent of the acreage is prime farmland. Approximately 22 percent can be considered prime farmland if it is drained or protected from flooding. About 63 percent of the cropland and pasture is adequately treated to meet conservation needs. Much of the cropland is on uplands, where erosion is a hazard. Some of the marginal cropland that is used for row crops should be converted to pasture or hayland.

The main management concerns affecting crops and pasture in the county are the hazard of water erosion, drainage and flood control, fertility, tilth, and the need for irrigation.

Water erosion is a major problem on nearly all of the sloping cropland and overgrazed pasture in Bates County. It is a hazard in areas where slopes are more than 2 percent. Soils that have slopes of 2 percent or less, such as Hartwell soils, are susceptible to severe erosion during intense spring rains if tillage is excessive and all crop residue is removed.

Loss of the surface layer through erosion is damaging for several reasons. Productivity is reduced as the surface layer is lost and part of the subsoil is incorporated into the plow layer. Loss of the surface layer is especially damaging on soils that have a clayey subsoil, such as Hartwell and Kenoma soils. Erosion also reduces the productivity of soils that are droughty because they are shallow over bedrock. Examples are Balltown and Coweta soils. Erosion on farmland results in the sedimentation of streams, lakes, and ponds. Erosion control minimizes this pollution and improves the quality of water for municipal and recreational uses and for fish and wildlife.

Erosion-control practices protect the surface layer, help to control runoff, and increase the rate of water infiltration. A cropping system that keeps vegetation or crop residue on the surface helps to control erosion and preserves the productive capacity of the soil. Growing grasses and legumes for pasture and hay helps to control erosion. Including legumes, such as clover and alfalfa, in the cropping sequence improves tilth and provides nitrogen for the subsequent crop.

Terraces reduce the length of slopes and thus help to control runoff and erosion. Conventional terraces are practical on the uneroded upland soils that have long, smooth slopes of less than 8 percent. Minimizing tillage on sloping soils and leaving large quantities of crop residue on the surface increase the rate of water infiltration and help to control runoff and erosion. These practices can be adapted to many of the soils in the county, but they are less successful on eroded soils that have a clayey surface layer. Special management techniques may be needed in areas of Kenoma and Summit soils if terracing exposes the clayey subsoil.

If the soil is not suitable for terracing or if farmers do not choose to construct terraces, other conservation practices can be used. Contour stripcropping, for example, helps to control erosion by alternating contoured strips of close-growing crops with clean-tilled crops. Strips of grasses or of grasses and legumes are generally used for hay. The areas between the strips are cultivated and planted to row crops, which are grown on the contour. Conservation tillage is effective in controlling erosion on sloping soils. It can be used on many of the soils in Bates County, but special management is needed in eroded areas.

Soil drainage and flood control are management concerns on about 15 percent of the acreage used for crops and pasture. Osage soils are naturally so wet that crop production is reduced during some part of the year. Frequent flooding can prevent crop production on Hepler, Verdigris, and Osage soils. The flooding on these soils commonly occurs during the period from November through May.

Soil fertility is naturally lower in most of the eroded or shallow soils than in other soils. Additional plant nutrients are needed on all soils, however, before maximum production can be achieved. Most of the soils in the county are naturally acid in the upper part of the root zone. As a result, applications of ground limestone are needed to raise the pH and calcium levels sufficiently for the optimum growth of legumes. Additions of lime and fertilizer should be based on the results of soil tests, on the needs of the crop, and on the desired level of yields. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer and lime to be applied.

Soil tilth is affected by the texture and organic matter content of the surface layer. Most of the uneroded upland soils used for crops in the county have a surface layer of silt loam that is dark and has a moderate content of organic matter. Generally, the structure of these soils is weakened by tillage and compaction. Under these conditions, intense rainfall causes the formation of a crust on the surface. Because the crust is hard when dry, it reduces the rate of water infiltration and increases the runoff rate. Regular additions of crop residue, manure, or other organic material improve soil structure and tilth.

The eroded upland soils have a higher content of clay in the surface layer than the corresponding uneroded soils. As a result, tilth is poorer, the infiltration rate is slower, and the runoff rate is more rapid. Conservation practices are needed to control further erosion.

Several irrigation systems are used in the county (fig. 8). These systems increase yields by providing supplemental water during critical periods of crop growth. Double-cropping is possible on irrigated soils. Soybeans, for example, can be planted directly into wheat stubble if an irrigation system supplies enough water to ensure germination and crop growth. The large amount of crop residue on the surface helps to protect the soil against erosion.

If an irrigation system is used, soil and water conservation practices are needed. Immediately after irrigation, the saturated topsoil is extremely vulnerable to erosion if intense rainfall occurs. Such accelerated erosion can drastically reduce natural fertility and can cause rapid sedimentation of downstream bodies of water. Since most systems are supplied by reservoirs in the irrigated watershed, this sedimentation reduces the irrigation capacity. Therefore, protection of the topsoil against erosion is especially crucial. Another management concern in irrigated areas is the careful maintenance of terraces. Allowing ruts to form where the wheels of the irrigation equipment pass over the saturated terrace berm can reduce the effectiveness of the terrace.

The pasture and hay crops that are suitable for planting in Bates County include legumes, cool-season grasses, and warm-season native grasses. Overgrazing and erosion are the major management concerns in

Figure 8.—Irrigated corn in an area of Kenoma silt loam, 1 to 4 percent slopes.

most of the pastured areas. Droughtiness is a limitation affecting the moderately deep or shallow soils. Controlled grazing is needed. Also, keeping grasses at a desirable height reduces runoff and helps to control erosion.

Many good stands of grass-legume pasture have been established in the survey area. More pasture renovation is needed to improve forage quality and prevent excessive erosion.

Establishing a good pasture is generally successful if management practices include applying limestone and fertilizer as recommended by a current soil test, preparing firm seedbeds, planting the recommended amounts of pure live seed and covering the seed with ¼ to ½ inch of soil, inoculating all legume seeds with the proper bacteria within 24 hours of planting, controlling weeds until new seedlings are well established, and deferring grazing until root systems are well established. Only adapted species of grasses and legumes should be planted. The seeding dates vary for different species.

Good pasture management results in greater forage yields and more pounds of livestock produced. In order to obtain good yields, generally several factors should be considered. Using a system of rotation grazing helps to prevent overgrazing. Allowing the livestock to graze until pasture plants are too short weakens the stand and increases competition from weeds and brush. Cross-fencing and providing an adequate supply of livestock water also help to prevent overgrazing.

The most common cool-season grasses are tall fescue, bromegrass, timothy, and orchardgrass. These species grow in the spring and fall. Common legumes include alfalfa, red clover, ladino clover, and lespedeza. These species are grown in mixed stands with cool-season grasses.

Most warm-season grasses, such as big bluestem, little bluestem, Caucasian bluestem, indiangrass, and switchgrass, can be planted. These grasses grow well during the hot summer months and can provide high-quality forage when cool-season plants are dormant. Prescribed burning may be needed to control undesirable vegetation and improve forage quality and quantity in areas of warm-season grasses. Burning is needed no more than once every 3 to 5 years. Before proper grazing management can be applied, fields of warm-season grasses should be separated from fields of cool-season grasses.

A well planned and managed grazing system generally includes a mixture of cool-season grasses and legumes for spring and fall grazing and warm-season grasses for summer pasture or stockpiled cool-season grasses for summer use. Regular applications of limestone and fertilizer are needed. Pastures should be stocked with the appropriate number of livestock. A system of pasture rotation helps to prevent overgrazing.

Specialty crops, such as apples, peaches, melons, and Christmas trees, are grown on a small acreage in the county. These crops generally require special equipment, management, and propagation techniques. Onsite investigation and feasibility information are needed.

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 6. 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. The land capability classification also is shown in the table.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; 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 residue, barnyard manure, and green manure crops; and harvesting that ensures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil 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 6 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils for those crops.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for woodland and for engineering purposes.

In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit *(10)*. Only class and subclass are used in this survey.

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 miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

There are no class I or class VIII soils in Bates County.

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 hazard is the 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 very cold or very 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* or *s* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, woodland, wildlife habitat, or recreation.

The capability classification of each map unit is given in the section "Detailed Soil Map Units" and in the yields table.

Woodland Management and Productivity

Douglas C. Wallace, forester, Soil Conservation Service, helped prepare this section.

In 1986, approximately 11 percent of Bates County, or 57,192 acres, was forested *(5).* Woodland tracts in the county are primarily small, private holdings of 10 to 50 acres and are essentially unmanaged. On the flood plains, forests are restricted to long, narrow bands bordering streams and rivers. Tree species and growth rates vary, depending upon site conditions, soil types, and past management practices.

The soil serves as a reservoir for moisture, provides an anchor for roots, and supplies essential plant nutrients. Trees grow best on soils whose properties are not in the extreme range and that have an effective rooting depth of more than 40 inches.

Site characteristics that affect tree growth include aspect and topographic position. These site characteristics influence the amount of available sunlight, air drainage, soil temperature, soil moisture, and relative humidity. North- and east-facing slopes and low positions on the slope are generally the best upland sites for tree growth because they are cooler and have better moisture conditions than south- and west-facing slopes.

Management practices can influence woodland productivity. They can minimize the factors that reduce productivity. These practices include thinning young stands, harvesting mature trees, preventing fire, and eliminating the use of woodland for grazing. Fire and grazing have a very negative impact on forest growth and quality. Forest fires are no longer a major problem in the county, but about 46 percent of the woodland is used for grazing. Grazing destroys the leaf layer, compacts the soil, and destroys or damages seedlings. Woodland sites that are not used for grazing and that are protected from fire have the highest potential for production.

Along the major watercourses, Osage, Hepler, and Verdigris soils support bottom-land hardwoods that are adapted to the poorly drained soil conditions. Most areas of these soils have been leveed and cleared for crop production. In wooded areas, typical species include silver maple, hackberry, American elm, sycamore, cottonwood, and pin oak. Bur oak, shellbark hickory, and walnut are common along the smaller stream bottoms and the higher terraces of the major streams. A high potential for excellent forest growth exists on these sites.

Soils in the uplands formed primarily under prairie vegetation. Successfully establishing trees on these soils requires extra care and maintenance. Specialty trees, such as Christmas trees, nut trees, and fuelwood trees, can be produced very successfully.

Christmas trees can be established on soils that are not poorly drained or very poorly drained. The tree species best adapted to the soils in Bates County are Scotch pine, Austrian pine, red pine, and white pine. Deep, medium textured, moderately well drained or well drained soils, such as Hepler and Verdigris soils, are best suited to nut trees, such as black walnut and pecan. Other soils are suited, but they may be less productive. The soils in Bates County have potential for supporting fuelwood plantations of fast-growing trees. The best species are green ash, black locust, sycamore, and silver maple.

Table 7 can be used by woodland owners or forest managers in planning the use of soils for wood crops. Only those soils suitable for wood crops are listed. The table lists the ordination symbol for each soil. Soils assigned the same ordination symbol require the same general management and have about the same potential productivity.

The first part of the *ordination symbol,* a number, indicates the potential productivity of the soils for an indicator tree species. The number indicates the volume, in cubic meters per hectare per year, which the indicator species can produce. The number 1 indicates low potential productivity; 2 and 3, moderate; 4 and 5, moderately high; 6 to 8, high; 9 to 11, very high; and 12 to 39, extremely high. The second part of the symbol, a letter, indicates the major kind of soil limitation. The letter *R* indicates steep slopes; *X,* stoniness or rockiness; *W*, excess water in or on the soil; *T*, toxic substances in the soil; *D*, restricted rooting depth; *C*, clay in the upper part of the soil; *S*, sandy texture; *F*, a high content of rock fragments in the soil; and *N*, snowpack. The letter *A* indicates that limitations or restrictions are insignificant. If a soil has more than one limitation, the priority is as follows: R, X, W, T, D, C, S, F, and N.

In table 7, *slight, moderate,* and *severe* indicate the degree of the major soil limitations to be considered in management.

Erosion hazard is the probability that damage will occur as a result of site preparation and cutting where the soil is exposed along roads, skid trails, and fire lanes and in log-handling areas. Forests that have been burned or overgrazed are also subject to erosion. Ratings of the erosion hazard are based on the percent of the slope. A rating of *slight* indicates that no particular prevention measures are needed under ordinary conditions. A rating of *moderate* indicates that erosion-control measures are needed in certain silvicultural activities. A rating of *severe* indicates that special precautions are needed to control erosion in most silvicultural activities.

Equipment limitation reflects the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. The chief characteristics and conditions considered in the ratings are slope, stones on the surface, rock outcrops, soil wetness, and texture of the surface layer. A rating of *slight* indicates that under normal conditions the kind of equipment and season of use are not significantly restricted by soil factors. Soil wetness can restrict equipment use, but the wet period does not exceed 1 month. A rating of *moderate* indicates that equipment use is moderately restricted because of one or more soil factors. If the soil is wet, the wetness restricts equipment use for a period of 1 to 3 months. A rating of *severe* indicates that equipment use is severely restricted either as to the kind of equipment that can be used or the season of use. If the soil is wet, the wetness restricts equipment use for more than 3 months.

Seedling mortality refers to the death of naturally occurring or planted tree seedlings, as influenced by the kinds of soil, soil wetness, or topographic conditions. The factors used in rating the soils for seedling mortality are texture of the surface layer, depth to a seasonal high water table and the length of the period when the water table is high, rock fragments in the surface layer, effective rooting depth, and slope aspect. A rating of *slight* indicates that seedling mortality is not likely to be a problem under normal conditions. Expected mortality is less than 25 percent. A rating of *moderate* indicates that some problems from seedling mortality can be expected. Extra precautions are advisable. Expected mortality is 25 to 50 percent. A rating of *severe* indicates that seedling mortality is a serious problem. Extra precautions are important. Replanting may be necessary. Expected mortality is more than 50 percent.

Windthrow hazard is the likelihood that trees will be uprooted by the wind because the soil is not deep enough for adequate root anchorage. The main restrictions that affect rooting are a seasonal high water table and the depth to bedrock, a fragipan, or other limiting layers. A rating of *slight* indicates that under normal conditions no trees are blown down by the wind. Strong winds may damage trees, but they do not uproot them. A rating of *moderate* indicates that some trees can be blown down during periods when the soil is wet and winds are moderate or strong. A rating of *severe* indicates that many trees can be blown down during these periods.

The *potential productivity* of merchantable or *common trees* on a soil is expressed as a *site index* and as a *volume* number. The site 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. Commonly grown 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.

The *volume*, a number, is the yield likely to be produced by the most important trees. This number, expressed as cubic feet per acre per year, indicates the amount of fiber produced in a fully stocked, even-aged, unmanaged stand.

The first species listed under *common trees* for a soil is the indicator species for that soil. It generally is the most common species on the soil and is the one that determines the ordination class.

Trees to plant are those that are suitable for commercial wood production.

Windbreaks and Environmental Plantings

Douglas C. Wallace, forester, Soil Conservation Service, helped prepare this section.

Living plants play an important role in supporting and improving human life. If they are properly used and maintained, plants help to provide positive solutions to many environmental problems. In Bates County, windbreaks and environmental plantings can be grown for a variety of engineering, climatological, and esthetic purposes.

Windbreaks can be grown successfully in most areas of Bates County. Successful management of farmstead and field windbreaks includes the consideration of design and layout, species selection, site preparation, seedling handling, weed control, irrigation, and protection from diseases, insects, and livestock.

Farmstead windbreaks make the farmstead area a more comfortable place. They reduce energy costs, increase garden and fruit tree yields, enhance wildlife populations, provide a buffer against noise, and increase property values *(9)*. Feedlot windbreaks protect livestock from wind and snow. They significantly reduce calf losses, make feeding operations easier, and enable livestock to maintain better weight with less feed.

Farmstead and feedlot windbreaks are generally three or more rows in width and depth. At least two of the rows are a conifer type species. The windbreaks should be located on the windward side of the area, perpendicular to the prevailing wind. Well designed farmstead and feedlot windbreaks are needed throughout Bates County, but especially in the former open prairie areas of the Kenoma-Hartwell-Deepwater association.

Field windbreaks or shelterbelts are designed to protect field crops and bare soil from strong winds. Field windbreaks reduce soil losses, increase crop yields, retard the spread of weeds between fields, and enhance wildlife populations *(4)*. They should be carefully planned. Field boundaries, irrigation systems, power lines, and roads should be considered in determining the location of field windbreaks. Windbreaks should be oriented at right angles to the prevailing wind. The typical field windbreak system consists of a series of single rows of trees or shrubs. As with many farmstead windbreaks, field windbreaks are adaptable to many locations throughout Bates County but are most beneficial in areas of the Kenoma-Hartwell-Deepwater association.

Environmental plantings help to beautify and screen houses and other buildings and to abate noise. Species used for environmental plantings should be the proper height, shape, color, and texture in order to be compatible with the surrounding area and structures and the desired use *(8)*. Trees and shrubs are easily established in most areas of Bates County as long as the site is adequately prepared before planting and weeds and other competing vegetation are controlled after planting.

Table 8 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 8 are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens. Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from local offices of the Soil Conservation Service or the Cooperative Extension Service or from a commercial nursery.

Recreation

Kenneth V. Kriewitz, wildlife biologist, Missouri Department of Conservation, helped prepare this section.

Outdoor recreational opportunities, especially fishing, are relatively abundant in Bates County. The Missouri Department of Conservation owns and manages several public recreational areas in the county. These include the Settles Ford Wildlife Area, the Harmony Mission Wildlife Area, the Peabody Wildlife Area, the Old Town Access, and the Four Rivers Wildlife Area.

The Settles Ford Wildlife Area is 6,056 acres in size. It is 1 mile south of Dayton on the South Grand River. Along with fishing, hunting for waterfowl, upland game, deer, and turkey is the main outdoor pursuit in this area.

The Harmony Mission Wildlife Area offers 1,080 acres for fishing and hunting. It is 3 miles southwest of Rich Hill off Highway PP. A 96-acre lake provides fishing opportunities.

The Peabody Wildlife Area is 299 acres in size. It is open to fishing and hunting. It has three lakes, the largest of which is 35 acres in size. It is 4 miles west of Rich Hill on Highway A.

The Old Town Access provides access to the Marais des Cygnes River and the Bates County Drainage Ditch. It is 310 acres in size and provides public fishing and hunting opportunities. It is 3 miles north of Rich Hill off Highway 71. It has a boat ramp and two ponds, the largest of which is 5 acres in size.

The Four Rivers Wildlife Area is 6,218 acres in size. Fishing and hunting are allowed. The area is 5 miles southeast of Rich Hill on the Osage and Little Osage Rivers.

Primitive camping, picnicking, nature study, hiking, and other activities are allowed in these public recreational areas. Prior to visiting a specific area, visitors should check on the activities that are allowed.

Butler City Lake provides fishing and picnicking opportunities. The lake is 48 acres in size and is 5 miles west of Butler off Highway 52. Adrian City Lake also is open to public fishing and picnicking. This 42-acre lake is about one-fourth mile southeast of Adrian just off Highway 18.

Drexel City Lake and Appleton City Lake also provide fishing opportunities. Each of these lakes is about 40 acres in size. Drexel City Lake is about one-half mile southwest of Drexel. Appleton City Lake is approximately 9 miles southwest of Appleton City.

Numerous private farm ponds and abandoned strip pits, especially in the west-central and southern parts of the county, also provide fishing opportunities.

The soils of the survey area are rated in table 9 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation also are important. Soils subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 9, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that 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 9 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 12 and interpretations for dwellings without basements and for local roads and streets in table 11.

Camp areas require site preparation, such as shaping and leveling the 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 have gentle 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 campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for 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 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 and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

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

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

Wildlife Habitat

Kenneth V. Kriewitz, wildlife biologist, Missouri Department of Conservation, helped prepare this section.

Bates County is one of 13 counties in Missouri that make up the West Prairie Zoogeographic Region *(7)*. The native vegetation was a mosaic of tall grass prairies and oak-hickory forests. As the area was settled and cultivated, the extent of forested land rapidly decreased. Much of the prairie was plowed for crop production. Currently, only scattered areas of prairie remnants remain. Woodland is scarce and is generally along streams and in other areas that are not suitable for agriculture.

The major game species in Bates County are white-tailed deer, eastern wild turkey, bobwhite quail, cottontail rabbit, fox squirrel, and several species of waterfowl. Two river systems, several smaller streams, and the Peabody and Harmony Mission Wildlife Areas contribute to good waterfowl populations.

Nongame species include the greater prairie chicken, which is currently listed as rare in Missouri. Prairie chickens are seen occasionally, usually in the eastern and southeastern parts of the county. Land management trends have been generally unfavorable for prairie chickens. It is hoped that the population of prairie chickens will increase as a result of recent government programs, in which many acres have been set aside for their habitat, and of the prairie chicken management program established by the Missouri Department of Conservation.

Furbearers, such as mink, raccoon, beaver, and muskrat, are fairly common in areas around the rivers, streams, and tributaries in the county. Although trapping is not widespread, several residents of the county participate in this sport and annually harvest pelts worth several thousand dollars.

Woodland and upland furbearers, such as red fox, coyote, opossum, and striped skunk, are relatively numerous in areas that are suited to their habitat. These species also are hunted and trapped.

White-tailed deer are relatively plentiful in Bates County because they prefer the edge growth, which has different habitat types that overlap. About 50 percent of the county is used as cropland, which adds to the diversity of habitat and thus favors this wildlife species.

Eastern wild turkey populations are increasing in the county. Although they are primarily a woodland species, turkeys can find suitable habitat in the ample timber, brushy fence rows, woody draws, and other areas. Currently the habitat for wild turkeys is limited, but some turkeys are harvested each year. As the turkey population continues to increase, Bates County has the potential to supply more and more of the state's annual turkey harvest.

The Marais des Cygnes River and Miami Creek traverse the county from northwest to southeast. The Grand River makes up the eastern half of the county's northern boundary, and the Osage River makes up the eastern part of the southern boundary. These streams and numerous farm ponds of various sizes provide good fishing opportunities.

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 10, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in 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* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

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

Grain and seed crops are domestic grains and seed-producing herbaceous plants. Soil properties and features 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 flooding. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are corn, winter wheat, oats, and soybeans.

Grasses and legumes are domestic perennial grasses and herbaceous legumes. Soil properties and features 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, flooding, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, bromegrass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features 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 flooding. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, goldenrod, beggarweed, wheatgrass, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness. Examples of these plants are oak, poplar, cherry, sweetgum, apple, hawthorn, dogwood, hickory, blackberry, and blueberry. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, autumn-olive, and crabapple.

Coniferous plants furnish browse and seeds. Soil properties and features that affect the growth of coniferous trees, shrubs, and ground cover are depth of the root zone, available water capacity, and wetness.

Examples of coniferous plants are pine, spruce, fir, cedar, and juniper.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, wild millet, cordgrass, rushes, sedges, and reeds.

Shallow water areas have an average depth of less than 5 feet. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife 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. Wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, cottontail, and red fox.

Habitat for woodland wildlife consists of areas of deciduous plants or coniferous plants or both and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include wild turkey, ruffed grouse, woodcock, thrushes, woodpeckers, squirrels, gray fox, raccoon, and deer.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, muskrat, mink, and beaver.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given for building site development, sanitary facilities, construction materials, and water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 or 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kinds of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to evaluate the potential of areas for residential, commercial, industrial, and recreational uses; make preliminary estimates of construction conditions; evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; plan detailed onsite investigations of soils and geology; locate potential sources of gravel, sand, earthfill, and topsoil; plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations.

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

Building Site Development

Table 11 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and depth to the water table.

Dwellings and *small commercial buildings* are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrinking and swelling, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, slope, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 or 6 feet are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or stabilized soil material; and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic-supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 40 inches, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Sanitary Facilities

Table 12 shows the degree and kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 12 also shows the suitability of the soils for use as daily cover for landfill. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the 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.

Table 12 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage resulting from rapid permeability in the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground-water pollution. Ease of excavation and revegetation should be considered.

The ratings in table 12 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to wind erosion.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

Table 13 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a *probable* or *improbable* source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help to determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, a low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have a moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet and have a water table at a depth of less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and *gravel* are natural aggregates suitable for commercial use with a minimum of processing. They are used in many kinds of construction. Specifications for each use vary widely. In table 13, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 3 feet thick and less than 50 percent, by weight, large stones. All other soils are rated as an improbable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable, loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal high water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Water Management

Table 14 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and for embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage, irrigation, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and the potential for frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, or sulfur. Availability of drainage outlets is not considered in the ratings.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock or to a cemented pan. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to control erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind erosion or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances such as salts and sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help to characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classification, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

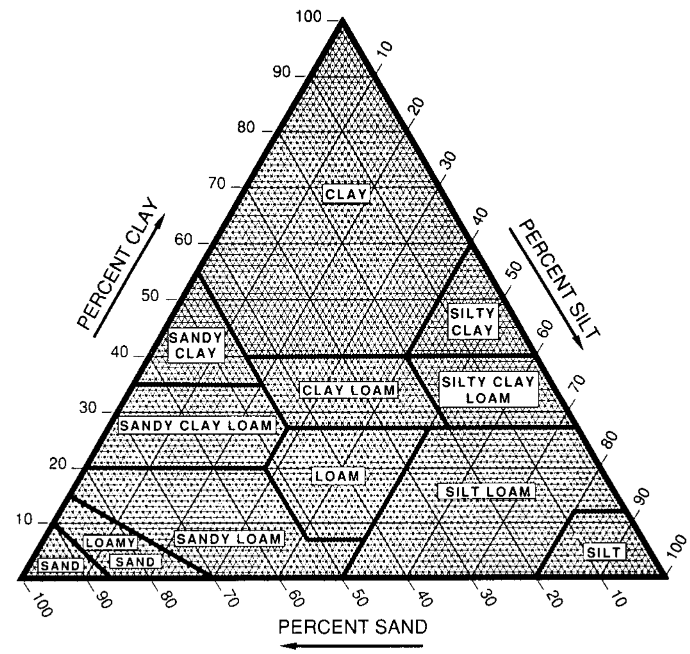

Figure 9.—Percentages of clay, silt, and sand in the basic USDA soil textural classes.

Engineering Index Properties

Table 15 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under the heading "Soil Series and Their Morphology."

Texture is given 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 the fraction of the soil that is less than 2 millimeters in diameter (fig. 9). "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as about 15 percent, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the "Glossary."

Classification of the soils is determined according to the Unified soil classification system *(2)* and the system adopted by the American Association of State Highway and Transportation Officials *(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 and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups 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 (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

The estimates of grain-size distribution, liquid limit, and plasticity index are generally rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is omitted in the table.

Physical and Chemical Properties

Table 16 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at ⅓-bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

The shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion. Soils are grouped according to the following distinctions:

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

2. Loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, and sapric soil material. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Coarse sandy loams, sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

4L. Calcareous loams, silt loams, clay loams, and silty clay loams. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, noncalcareous clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion are used.

5. Noncalcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.

6. Noncalcareous loams and silt loams that are more than 20 percent clay and noncalcareous clay loams that are less than 35 percent clay. These soils are very slightly erodible. Crops can be grown if ordinary measures to control wind erosion are used.

7. Silts, noncalcareous silty clay loams that are less than 35 percent clay, and fibric soil material. These soils are very slightly erodible. Crops can be grown if ordinary measures to control wind erosion are used.

8. Soils that are not subject to wind erosion because of coarse fragments on the surface or because of surface wetness.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In table 16, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter in a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

Soil and Water Features

Table 17 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the infiltration of water when the soils are thoroughly wet and receive 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 mainly of deep, well drained to excessively drained sands or gravelly sands. 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 having a layer that impedes the downward movement of water or soils of 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 clays 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, the temporary inundation of an area, is caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, nor is water in swamps and marshes.

Table 17 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); and *frequent* that it occurs often under normal weather conditions (the chance of flooding is more than 50 percent in any year). Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 days to 1 month, and *very long* if more than 1 month. Probable dates are expressed in months. About two-thirds to three-fourths of all flooding occurs during the stated period.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 17 are depth to the seasonal high water table; the kind of water table—that is, perched or apparent; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 17. Only saturated zones within a depth of about 6 feet are indicated.

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. A *perched* water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

Depth to bedrock is given if bedrock is within a depth of 5 feet. The depth is based on many soil borings and on observations during soil mapping. The rock is either soft or hard. If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment is needed for excavation.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low, moderate,* or *high,* is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as *low, moderate,* or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories *(11)*. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 18 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Eleven soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol.* An example is Mollisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that 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 humid, 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 development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Paleudolls (*Pale,* meaning old, plus *udolls,* the suborder of the Mollisols that has a udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group 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 typifies the great group. An example is Typic Paleudolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-silty, mixed, thermic Typic Paleudolls.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

Soil Series and Their Morphology

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

Characteristics of the soil and the material in which it formed are identified for each series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the "Soil Survey Manual" *(12)*. Many of the technical terms used in the descriptions are defined in "Soil Taxonomy" *(11)*. Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed Soil Map Units."

Balltown Series

The Balltown series consists of shallow, somewhat excessively drained, moderately permeable soils on uplands. These soils formed in material weathered from limestone. Slopes range from 5 to 20 percent. The soils are loamy-skeletal, mixed, thermic Lithic Hapludolls.

Typical pedon of Balltown very flaggy silt loam, 5 to 20 percent slopes, 700 feet east and 1,400 feet south of the northwest corner of sec. 24, T. 42 N., R. 33 W.

A—0 to 8 inches; black (10YR 2/1) very flaggy silt loam, very dark gray (10YR 3/1) dry; moderate fine granular structure; friable; about 40 percent limestone fragments; neutral; clear smooth boundary.

C—8 to 15 inches; very dark grayish brown (10YR 3/2) very flaggy silt loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; friable; about 50 percent limestone fragments; neutral; clear irregular boundary.

R—15 inches; limestone bedrock.

The depth to bedrock ranges from 10 to 20 inches. The content of coarse fragments ranges from 35 to 75 percent. The A and C horizons have chroma of 1 to 3. They are the very flaggy or extremely flaggy analogs of silt loam or silty clay loam.

Bates Series

The Bates series consists of moderately deep, well drained, moderately permeable soils on uplands. These soils formed in material weathered from sandstone that contains thin beds of silty and sandy shale. Slopes range from 2 to 8 percent. The soils are fine-loamy, siliceous, thermic Typic Argiudolls.

Typical pedon of Bates loam, 2 to 5 percent slopes, 2,220 feet west and 660 feet south of the northeast corner of sec. 10, T. 40 N., R. 29 W.

A—0 to 8 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; weak fine granular structure; very friable; many fine roots; slightly acid; clear smooth boundary.

AB—8 to 16 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; friable; few fine roots; moderately acid; gradual smooth boundary.

Bt1—16 to 24 inches; dark yellowish brown (10YR 4/4) sandy clay loam; moderate medium subangular blocky structure; friable; few faint clay films on faces of peds; few fine roots; strongly acid; gradual smooth boundary.

Bt2—24 to 34 inches; strong brown (7.5YR 4/6) sandy clay loam; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; strongly acid; clear smooth boundary.

Cr—34 inches; weathered sandstone bedrock.

The depth to soft sandstone bedrock ranges from 20 to 40 inches. The A horizon has hue of 10YR or 7.5YR and value and chroma of 2 or 3. The B horizon has value of 3 to 5 and chroma of 3 to 6. It is loam, sandy clay loam, or clay loam. In the lower part of the B horizon, the content of sandstone fragments less than 3 inches in diameter ranges from 0 to 15 percent, by volume. The BC horizon, if it occurs, has mottles with value of 4 or more and chroma of 2 or less.

Bates loam, 3 to 8 percent slopes, eroded, has a dark surface layer that is thinner than is defined as the range for the series. This difference, however, does not significantly affect the use and management of the soils.

Brazilton Series

The Brazilton series consists of very deep, moderately well drained, very slowly permeable soils on uplands. These soils are in excavated material that has been reconstructed to resemble the original major horizons. Slopes range from 1 to 5 percent. The soils are fine, mixed, nonacid, thermic Mollic Udarents.

Typical pedon of Brazilton silt loam, 1 to 5 percent slopes, 2,000 feet south and 400 feet east of the northwest corner of sec. 28, T. 41 N., R. 33 W.

A—0 to 10 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; neutral; abrupt wavy boundary.

C1—10 to 40 inches; mixed dark grayish brown (2.5Y 4/2), light yellowish brown (2.5Y 6/4), very dark gray (10YR 3/1), and strong brown (7.5YR 5/6) silty clay; weak medium platy structure; very firm; common medium concretions of iron and manganese oxide; neutral; clear wavy boundary.

2C2—40 to 60 inches; mixed gray (5Y 5/1), olive brown (2.5Y 4/4), and gray (N 5/0) very channery silty clay; massive; very firm; about 35 percent shale and slate fragments; few limestone fragments; calcareous; moderately alkaline.

The depth to channery material ranges from 40 to more than 60 inches. The content of coarse fragments ranges from 0 to 15 percent in the A and C horizons. The channery material includes shale, limestone, coal, and sandstone. The A and C horizons have value of 2 to 4 and chroma of 1 to 3. The C horizon is silty clay, clay, or silty clay loam. Its colors vary widely, reflecting the soil before it was disturbed. It has hue of 7.5YR to 2.5Y, value of 2 to 5, and chroma of 1 to 4.

The 2C2 horizon consists of mine spoils. The content of shale fragments ranges from 35 to 90 percent. This horizon ranges from strongly acid to moderately alkaline. It has hue of 7.5YR to 5Y, value of 2 to 6, and chroma of 1 to 6. It is silty clay or silty clay loam in the fine-earth fraction. In some pedons it contains limestone and coal fragments.

Catoosa Series

The Catoosa series consists of moderately deep, well drained, moderately permeable soils on uplands. These soils formed in material weathered from limestone. Slopes range from 2 to 5 percent. The soils are fine-silty, mixed, thermic Typic Argiudolls.

The Catoosa soils in this county have a higher content of clay in the subsoil than is defined as the range for the series. This difference, however, does not significantly affect the use and management of the soils.

Typical pedon of Catoosa silt loam, 2 to 5 percent slopes, 900 feet north and 1,250 feet west of the southeast corner of sec. 16, T. 40 N., R. 30 W.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, brown (7.5YR 5/2) dry; moderate fine granular structure; friable; slightly acid; gradual smooth boundary.

BA—9 to 15 inches; dark reddish brown (5YR 3/3) silty clay loam, reddish brown (5YR 4/3) dry; few faint reddish brown (5YR 4/4) mottles; weak fine granular structure; firm; moderately acid; gradual smooth boundary.

Bt—15 to 29 inches; dark reddish brown (5YR 3/4) silty clay loam; weak medium subangular blocky structure; firm; common distinct clay films on faces of peds; moderately acid; abrupt wavy boundary.

R—29 inches; limestone bedrock.

The depth to limestone bedrock ranges from 20 to 40 inches. The thickness of the mollic epipedon ranges from 10 to 20 inches.

The A horizon has hue of 10YR or 7.5YR and value and chroma of 2 or 3. The BA and Bt horizons have hue of 7.5YR to 2.5YR and value and chroma of 2 to 4. They are silty clay loam or clay loam. The content of chert and limestone fragments in the lower part of the solum is less than 10 percent, by volume.

Clareson Series

The Clareson series consists of moderately deep, well drained, moderately slowly permeable soils on uplands. These soils formed in material weathered from limestone. Slopes range from 2 to 5 percent. The soils are clayey-skeletal, mixed, thermic Typic Argiudolls.

Typical pedon of Clareson silty clay loam, 2 to 5 percent slopes, 1,300 feet east and 2,400 feet south of the northwest corner of sec. 14, T. 40 N., R. 32 W.

A—0 to 5 inches; very dark grayish brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; friable; about 5 percent limestone fragments; slightly acid; clear smooth boundary.

BA—5 to 10 inches; dark brown (7.5YR 3/2) silty clay loam, brown (7.5YR 4/4) dry; weak fine subangular blocky structure; firm; about 5 percent limestone fragments; moderately acid; clear smooth boundary.

Bt1—10 to 18 inches; dark reddish brown (5YR 3/3) flaggy silty clay; weak fine subangular blocky structure; very firm; about 35 percent limestone fragments; common faint clay films on faces of peds; slightly acid; clear smooth boundary.

Bt2—18 to 28 inches; reddish brown (5YR 4/3) very flaggy silty clay; moderate medium subangular blocky structure; very firm; about 50 percent limestone fragments; common faint clay films on faces of peds; neutral; abrupt wavy boundary.

R—28 inches; limestone bedrock.

The depth to limestone bedrock ranges from 20 to 40 inches. The A horizon has hue of 10YR or 7.5YR and value and chroma of 2 or 3. It is silty clay loam or silt loam or the flaggy analogs of those textures. The Bt horizon has hue of 2.5YR to 7.5YR, value of 3 or 4, and chroma of 2 to 6. It is flaggy silty clay, very flaggy silty clay, or extremely flaggy silty clay.

Coweta Series

The Coweta series consists of shallow, well drained, moderately permeable soils on uplands. These soils formed in material weathered from sandstone interbedded with shale. Slopes range from 5 to 14 percent. The soils are loamy, siliceous, thermic, shallow Typic Hapludolls.

Typical pedon of Coweta loam, 5 to 14 percent slopes, 2,050 feet west and 100 feet south of the northeast corner of sec. 10, T. 40 N., R. 29 W.

A—0 to 6 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; weak fine granular structure; friable; about 10 percent sandstone fragments less than 3 inches in diameter; moderately acid; clear smooth boundary.

Bw—6 to 12 inches; dark brown (7.5YR 3/2) gravelly fine sandy loam, brown (7.5YR 5/2) dry; weak fine granular structure; friable; about 15 percent sandstone fragments less than 3 inches in diameter; moderately acid; abrupt wavy boundary.

Cr—12 inches; weathered sandstone bedrock.

The depth to soft sandstone bedrock ranges from 10 to 20 inches. The A horizon has chroma of 2 or 3. In some pedons it contains as much as 15 percent sandstone fragments. The B horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 to 6. It is fine sandy loam, loam, or the gravelly analogs of those textures. It has as much as 30 percent sandstone fragments less than 3 inches in diameter. In some pedons hard sandstone is between depths of 24 and 60 inches.

Deepwater Series

The Deepwater series consists of very deep, moderately well drained, moderately permeable soils on uplands. These soils formed in material weathered from shale. Slopes range from 2 to 5 percent. The soils are fine-silty, mixed, thermic Typic Argiudolls.

The Deepwater soils in this county have a thinner dark surface layer than is defined as the range for the series. This difference, however, does not significantly affect the use and management of the soils.

Typical pedon of Deepwater silt loam, 2 to 5 percent slopes, eroded, 500 feet west and 20 feet south of the northeast corner of sec. 33, T. 41 N., R. 32 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate medium granular structure; friable; neutral; clear smooth boundary.

BA—7 to 13 inches; dark brown (10YR 4/3) silt loam, brown (10YR 5/3) dry; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

Bt1—13 to 24 inches; brown (10YR 5/3) silty clay loam; common medium faint dark yellowish brown (10YR 4/4) and common medium prominent red (2.5YR 4/6) mottles; moderate medium subangular blocky structure; friable; common distinct clay films on faces of peds; moderately acid; gradual smooth boundary.

Bt2—24 to 37 inches; dark brown (10YR 4/3) silty clay loam; common medium prominent strong brown (7.5YR 5/6) and few fine prominent red (2.5YR 4/6) mottles; moderate medium subangular blocky structure; firm; many distinct clay films on faces of peds; moderately acid; gradual smooth boundary.

Bt3—37 to 50 inches; mixed yellowish brown (10YR 5/6), dark brown (10YR 4/3), and yellowish red (5YR 5/6) silty clay loam; moderate medium subangular blocky structure; firm; common distinct clay films on faces of peds; slightly acid; gradual smooth boundary.

BC—50 to 60 inches; mixed strong brown (7.5YR 5/6), light brownish gray (10YR 6/2), and dark grayish brown (10YR 4/2) silty clay loam; weak fine subangular blocky structure; firm; slightly acid.

The Ap horizon and the A horizon, if it occurs, have value of 2 or 3 and chroma of 1 to 3. The BA horizon has value of 3 or 4 and chroma of 2 or 3. The Bt and BC horizons have chroma of 3 to 6.

Eram Series

The Eram series consists of moderately deep, moderately well drained, slowly permeable soils on uplands. These soils formed in material weathered from shale. Slopes range from 2 to 20 percent. The soils are fine, mixed, thermic Aquic Argiudolls.

Typical pedon of Eram silt loam, 5 to 9 percent slopes, 250 feet west and 1,250 feet south of the northeast corner of sec. 31, T. 41 N., R. 30 W.

Ap—0 to 10 inches; dark brown (10YR 3/3) silt loam, brown (10YR 4/3) dry; moderate medium granular structure; friable; moderately acid; clear smooth boundary.

Bt—10 to 21 inches; brown (10YR 4/3) silty clay; common fine faint yellowish brown (10YR 5/4) and few fine prominent red (2.5YR 4/8) mottles; moderate medium subangular blocky structure; firm; common distinct clay films on faces of peds; slightly acid; gradual smooth boundary.

BC—21 to 31 inches; yellowish brown (10YR 5/4) silty clay; common medium distinct gray (10YR 6/1) and many coarse prominent yellowish brown (10YR 5/8) mottles; weak medium platy structure; firm; neutral; clear smooth boundary.

Cr—31 inches; weathered shale bedrock.

The depth to shale bedrock ranges from 20 to 40 inches. The A horizon has hue of 7.5YR or 10YR and value and chroma of 2 or 3. The B horizon has hue of 7.5YR or 10YR, value of 3 to 5, and chroma of 2 to 4. It is clay loam, silty clay loam, silty clay, or clay.

Eram silt loam, 2 to 5 percent slopes, eroded, and the Eram component of the Eram-Balltown complex, 5 to 20 percent slopes, have a dark surface layer that is thinner than is defined as the range for the series. This difference, however, does not significantly affect the use and management of the soils.

Hartwell Series

The Hartwell series consists of very deep, somewhat poorly drained, slowly permeable soils on broad upland divides. These soils formed in material weathered from shale. Slopes range from 0 to 2 percent. The soils are fine, mixed, thermic Typic Argialbolls.

Typical pedon of Hartwell silt loam, 150 feet north and 1,300 feet east of the southwest corner of sec. 15, T. 41 N., R. 33 W.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, gray (10YR 5/1) dry; weak fine granular structure; very friable; slightly acid; abrupt smooth boundary.

E—9 to 14 inches; grayish brown (10YR 5/2) silt loam, light gray (10YR 6/1) dry; weak fine granular structure; very friable; moderately acid; abrupt smooth boundary.

Bt—14 to 24 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; common fine prominent dark yellowish brown (10YR 4/6) mottles; moderate fine subangular blocky structure; firm; few faint clay films on faces of peds; strongly acid; gradual smooth boundary.

Btg1—24 to 37 inches; dark grayish brown (10YR 4/2) silty clay; common fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium subangular blocky structure; firm; common distinct clay films on faces of peds; strongly acid; gradual smooth boundary.

Btg2—37 to 48 inches; grayish brown (10YR 5/2) silty clay loam; common medium prominent dark yellowish brown (10YR 4/6) and many medium distinct light gray (10YR 6/1) mottles; weak medium subangular blocky structure; firm; few faint clay films on faces of peds; strongly acid; gradual smooth boundary.

BC—48 to 60 inches; mottled dark yellowish brown (10YR 4/4), light gray (10YR 6/1), and yellowish red (5YR 5/6) silty clay loam; weak medium subangular blocky structure; firm; strongly acid.

The A horizon has value of 2 or 3 and chroma of 1 or 2. The E horizon has value of 5 or 6 and chroma of 1 or 2. The upper part of the Bt horizon has value of 2 or 3 and chroma of 1 or 2. The lower part has value of 4 to 7 and chroma of 2 to 8. It is clay, silty clay, or silty clay loam. The BC horizon is mottled in shades of gray, brown, and red.

Hepler Series

The Hepler series consists of very deep, somewhat poorly drained, moderately slowly permeable soils on high flood plains. These soils formed in silty alluvium. Slopes range from 0 to 2 percent. The soils are fine-silty, mixed, thermic Udollic Ochraqualfs.

Typical pedon of Hepler silt loam, occasionally flooded, 2,350 feet east and 650 feet south of the northwest corner of sec. 14, T. 39 N., R. 29 W.

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; friable; slightly acid; clear smooth boundary.

E—9 to 19 inches; grayish brown (10YR 5/2) silt loam; many medium faint dark grayish brown (10YR 4/2) and few fine prominent dark yellowish brown (10YR 4/6) mottles; weak fine granular structure; friable; moderately acid; clear smooth boundary.

Btg1—19 to 31 inches; dark gray (10YR 4/1) silty clay loam; few fine prominent strong brown (7.5YR 4/6) mottles; moderate medium subangular blocky structure; firm; common faint clay films on faces of peds; strongly acid; gradual smooth boundary.

Btg2—31 to 45 inches; dark grayish brown (10YR 4/2) silty clay loam; common medium prominent strong brown (7.5YR 5/6) mottles; moderate medium subangular blocky structure; firm; common faint clay films on faces of peds; strongly acid; gradual smooth boundary.

Btg3—45 to 60 inches; dark grayish brown (10YR 4/2) silty clay loam; common medium prominent strong brown (7.5YR 5/6) mottles; weak medium subangular blocky structure; firm; common faint clay films on faces of peds; few fine concretions of iron and manganese oxide; strongly acid.

The Ap horizon has value of 2 or 3 and chroma of 1 or 2. The E horizon has value of 4 or 5 and chroma of 2 or 3. The Bt horizon has value of 3 to 5. It is silty clay loam or silty clay in the lower part.

Kanima Series

The Kanima series consists of very deep, well drained, moderately permeable soils on uplands. These soils formed in spoil banks that remain after stripmining activities. Slopes range from 5 to 50 percent. The soils are loamy-skeletal, mixed, nonacid, thermic Alfic Udarents.

Typical pedon of Kanima very channery silty clay loam, 5 to 50 percent slopes, 1,850 feet west and 650 south of the northeast corner of sec. 9, T. 38 N., R. 32 W.

A—0 to 6 inches; dark grayish brown (2.5Y 4/2) very channery silty clay loam, grayish brown (2.5Y 5/2) dry; massive; friable; about 40 percent shale channers; moderately alkaline; diffuse wavy boundary.

C—6 to 60 inches; light olive brown (2.5Y 5/4) extremely channery silty clay loam; massive; friable; about 65 percent shale channers; weak effervescence; moderately alkaline.

The A horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 2 or 3. The content of shale or sandstone channers less than 3 inches in diameter ranges from 15 to 85 percent. The content of channers more than 3 inches in diameter is less than 5 percent, by volume.

The C horizon has hue of 10YR to 5Y, value of 3 to 5, and chroma of 2 to 4. It has the same textural range as that of the A horizon. The content of shale, coal, or sandstone channers less than 3 inches in diameter ranges from 25 to 85 percent, by volume. The content of channers more than 3 inches in diameter ranges from 5 to 20 percent, by volume. In some pedons the C horizon has pockets of undisturbed B horizon material similar to that in associated soils.

Kenoma Series

The Kenoma series consists of very deep, moderately well drained, very slowly permeable soils on uplands. These soils formed in material weathered from shale. Slopes range from 1 to 4 percent. The soils are fine, montmorillonitic, thermic Vertic Argiudolls.

Typical pedon of Kenoma silt loam, 1 to 4 percent slopes, 2,550 feet west and 1,250 feet south of the northeast corner of sec. 19, T. 42 N., R. 30 W.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; friable; slightly acid; abrupt smooth boundary.

Bt1—9 to 16 inches; very dark grayish brown (10YR 3/2) silty clay, grayish brown (10YR 5/2) dry; common fine prominent reddish brown (2.5YR 4/4) mottles; weak fine subangular blocky structure; few faint clay films on faces of peds; very firm; moderately acid; clear smooth boundary.

Bt2—16 to 26 inches; dark yellowish brown (10YR 4/4) silty clay; common fine distinct brown (7.5YR 4/4) mottles; moderate medium subangular blocky structure; common distinct clay films on faces of peds; very firm; common nonintersecting slickensides; moderately acid; gradual wavy boundary.

BC—26 to 45 inches; dark yellowish brown (10YR 4/6) silty clay; common medium prominent light brownish gray (10YR 6/2) mottles; weak coarse subangular blocky structure; common distinct clay films on faces of peds; firm; many nonintersecting slickensides; slightly acid; gradual smooth boundary.

C—45 to 60 inches; dark yellowish brown (10YR 4/6) silty clay; common medium prominent light brownish gray (10YR 6/2) and yellowish red (5YR 4/6) mottles; massive; firm; neutral.

The A horizon has value of 2 or 3 and chroma of 1 to 3. The upper part of the Bt horizon has hue of 10YR or 7.5YR and value and chroma of 2 or 3. The lower part has hue of 10YR to 5YR, value of 3 to 6, and chroma of 2 to 6. It is silty clay loam, silty clay, or clay. The C horizon has hue of 5YR to 5Y, value of 4 to 6, and chroma of 2 to 6. It is silty clay loam or silty clay.

Newtonia Series

The Newtonia series consists of very deep, well drained, moderately permeable soils on uplands. These soils formed in loamy and clayey sediments. Slopes range from 2 to 5 percent. The soils are fine-silty, mixed, thermic Typic Paleudolls.

Typical pedon of Newtonia silt loam, 2 to 5 percent slopes, 700 feet north and 100 feet west of the southeast corner of sec. 15, T. 40 N., R. 30 W.

Ap—0 to 6 inches; very dark brown (10YR 2/2) silt loam, dark brown (10YR 3/3) dry; weak fine granular structure; friable; slightly acid; abrupt smooth boundary.

A—6 to 15 inches; very dark brown (10YR 2/2) silt loam, dark brown (10YR 3/3) dry; moderate coarse granular structure; friable; slightly acid; gradual smooth boundary.

BA—15 to 22 inches; dark brown (7.5YR 3/2) silty clay loam, brown (7.5YR 5/2) dry; weak fine subangular blocky structure; friable; moderately acid; gradual smooth boundary.

Bt1—22 to 34 inches; reddish brown (5YR 4/4) silty clay loam; weak fine subangular blocky structure; friable; common distinct clay films; many fine concretions of iron and manganese oxide; moderately acid; clear smooth boundary.

Bt2—34 to 47 inches; red (2.5YR 4/6) silty clay; many medium prominent brown (10YR 4/3) mottles; moderate medium subangular blocky structure; firm; common distinct clay films; many medium concretions of iron and manganese oxide; moderately acid; clear smooth boundary.

Bt3—47 to 60 inches; red (2.5YR 4/6) silty clay; many medium prominent brown (10YR 4/3) mottles; strong medium subangular blocky structure; firm; many distinct clay films; many medium concretions of iron and manganese oxide; moderately acid.

The thickness of the mollic epipedon ranges from 10 to 24 inches. The Ap, A, and BA horizons have hue of 5YR to 10YR and chroma of 2 or 3. The Bt horizon has value of 3 or 4 and chroma of 4 to 8. It is silty clay loam or silty clay in the lower part. In some pedons the content of coarse fragments less than 3 inches in diameter is as much as 15 percent, by volume, in the BC horizon.

Okemah Series

The Okemah series consists of very deep, moderately well drained, slowly permeable soils on high stream terraces and foot slopes. These soils formed in material weathered from shale or old alluvium. Slopes range from 0 to 2 percent. The soils are fine, mixed, thermic Aquic Paleudolls.

Typical pedon of Okemah silt loam, 300 feet west and 200 feet south of the northeast corner of sec. 12, T. 38 N., R. 33 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate medium granular structure; friable; moderately acid; clear smooth boundary.

BA—8 to 16 inches; very dark grayish brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; weak medium subangular blocky structure; friable; slightly acid; clear smooth boundary.

Bt1—16 to 26 inches; very dark gray (10YR 3/1) silty clay loam; many fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium subangular blocky structure; firm; common faint clay films on faces of peds; neutral; gradual smooth boundary.

Bt2—26 to 37 inches; dark gray (10YR 4/1) silty clay; many fine distinct dark brown (10YR 4/3) mottles; moderate medium subangular blocky structure; firm; common distinct clay films on faces of peds; neutral; gradual smooth boundary.

Bt3—37 to 52 inches; mottled strong brown (7.5YR 5/6) and dark grayish brown (10YR 4/2) silty clay; weak medium subangular blocky structure; firm; common distinct clay films on faces of peds; many medium concretions of iron and manganese oxide; neutral; gradual smooth boundary.

BC—52 to 60 inches; mottled reddish brown (5YR 5/4), yellowish brown (10YR 5/4), and dark brown (7.5YR 4/4) silty clay; weak fine angular blocky structure; firm; common medium concretions of iron and manganese oxide; neutral.

The thickness of the mollic epipedon ranges from 18 to 28 inches. The A horizon has value of 2 or 3 and chroma of 1 or 2. The BA and Bt horizons have hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 or 2. They have mottles in shades of gray to red. The lower part of the Bt horizon and the BC horizon have many coarse mottles with hue redder than 7.5YR or chroma of more than 5. They are silty clay or silty clay loam.

Olpe Series

The Olpe series consists of very deep, well drained, slowly permeable soils on ridges in the uplands. These soils formed in old gravelly sediments. Slopes range from 2 to 5 percent. The soils are clayey-skeletal, montmorillonitic, thermic Typic Paleudolls.

Typical pedon of Olpe gravelly silt loam, 2 to 5 percent slopes, 3,100 feet west and 400 feet north of the southeast corner of sec. 32, T. 40 N., R. 33 W.

A—0 to 11 inches; dark brown (10YR 3/3) gravelly silt loam, brown (10YR 4/3) dry; weak fine granular structure; very friable; about 15 percent rounded chert gravel; slightly acid; clear smooth boundary.

BA—11 to 19 inches; reddish brown (5YR 4/4) very gravelly silty clay loam; weak fine subangular blocky structure; friable; about 55 percent rounded chert gravel; moderately acid; gradual smooth boundary.

Bt1—19 to 31 inches; yellowish red (5YR 5/6) very gravelly silty clay; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; about 55 percent rounded chert gravel; moderately acid; gradual smooth boundary.

Bt2—31 to 38 inches; dark brown (7.5YR 4/4) extremely gravelly silty clay; many medium prominent grayish brown (10YR 5/2) mottles; moderate medium subangular blocky structure; firm; few faint clay films on faces of peds; about 65 percent rounded chert gravel; moderately acid; gradual smooth boundary.

Bt3—38 to 49 inches; yellowish red (5YR 5/6) very gravelly silty clay; many medium prominent grayish brown (10YR 5/2) and common fine distinct red (2.5YR 4/6) mottles; moderate medium subangular blocky structure; firm; common prominent clay films on faces of peds; about 55 percent rounded chert gravel; moderately acid; gradual smooth boundary.

Bt4—49 to 60 inches; mottled light brownish gray (10YR 6/2), strong brown (7.5YR 5/6), and red (2.5YR 4/6) very gravelly silty clay; moderate medium angular blocky structure; firm; common prominent clay films on faces of peds; about 55 percent rounded chert gravel; moderately acid.

The thickness of the mollic epipedon ranges from 10 to 20 inches. The A horizon has value of 2 or 3 and chroma of 1 to 3. The Bt horizon has value of 3 to 5 and chroma of 4 to 6. The content of gravel ranges from 35 to 80 percent.

Osage Series

The Osage series consists of very deep, poorly drained, very slowly permeable soils on flood plains. These soils formed in thick, clayey alluvium. Slopes range from 0 to 2 percent. The soils are fine, montmorillonitic, thermic Vertic Haplaquolls.

Typical pedon of Osage silty clay, 50 feet north and

150 feet east of the southwest corner of sec. 19, T. 39 N., R. 31 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; moderate medium granular structure; firm; slightly acid; clear smooth boundary.
A—7 to 15 inches; black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; common fine distinct brown (10YR 4/3) mottles; moderate fine angular blocky structure; firm; slightly acid; clear smooth boundary.
Bg1—15 to 35 inches; black (N 2/0) silty clay, dark gray (5Y 4/1) dry; common fine prominent strong brown (7.5YR 4/6) mottles; weak medium angular blocky structure; firm; few slickensides; slightly acid; gradual smooth boundary.
Bg2—35 to 60 inches; black (N 2/0) silty clay, dark gray (5Y 4/1) dry; common fine prominent dark yellowish brown (10YR 4/4) mottles; moderate fine angular blocky structure; very firm; common slickensides; slightly acid.

The thickness of the mollic epipedon is 24 inches or more. The A horizon has value of 2 or 3 and chroma of 1 or 2. It is silty clay loam or silty clay. The upper part of the B horizon has hue of 10YR to 5Y or is neutral in hue. It has value of 2 or 3 and chroma of 0 to 2. The lower part has hue of 10YR to 5Y or is neutral in hue. It has value of 3 to 6 and chroma of 0 or 1. It is silty clay loam, silty clay, or clay.

Summit Series

The Summit series consists of very deep, moderately well drained, slowly permeable soils on uplands and foot slopes. These soils formed in material weathered from shale. Slopes range from 1 to 9 percent. The soils are fine, montmorillonitic, thermic Vertic Argiudolls.

Typical pedon of Summit silty clay loam, 1 to 5 percent slopes, 1,500 feet south and 75 feet east of the northwest corner of sec. 18, T. 41 N., R. 33 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate medium granular structure; firm; moderately acid; clear smooth boundary.
BA—8 to 14 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; few fine distinct dark yellowish brown (10YR 4/4) mottles; weak fine subangular blocky structure; firm; moderately acid; clear smooth boundary.
Btg1—14 to 21 inches; very dark gray (10YR 3/1) silty clay; few fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium subangular blocky structure; very firm; few distinct clay films on faces of peds; moderately acid; clear smooth boundary.
Btg2—21 to 41 inches; very dark grayish brown (2.5Y 3/2) silty clay; few fine distinct dark yellowish brown (10YR 4/4) mottles; moderate medium angular blocky structure; very firm; common distinct clay films on faces of peds; moderately acid; gradual smooth boundary.
Btg3—41 to 60 inches; dark grayish brown (2.5Y 4/2) silty clay; common fine prominent dark yellowish brown (10YR 4/4) mottles; moderate fine angular blocky structure; very firm; common distinct clay films on faces of peds; moderately acid.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is silty clay loam or silty clay. The upper part of the Bt horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1 to 4. The lower part has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 6. It is silty clay or clay.

Verdigris Series

The Verdigris series consists of very deep, well drained, moderately permeable soils on flood plains. These soils formed in silty alluvium. Slopes range from 0 to 2 percent. The soils are fine-silty, mixed, thermic Cumulic Hapludolls.

Typical pedon of Verdigris silt loam, 800 feet west and 100 feet south of the northeast corner of sec. 5, T. 39 N., R. 31 W.

Ap—0 to 12 inches; very dark grayish brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; friable; slightly acid; clear smooth boundary.
A—12 to 28 inches; dark brown (10YR 3/3) silt loam, brown (10YR 4/3) dry; weak medium granular structure; friable; moderately acid; gradual smooth boundary.
AC—28 to 39 inches; dark brown (10YR 3/3) silt loam, brown (10YR 4/3) dry; weak medium granular structure; friable; moderately acid; gradual smooth boundary.
C—39 to 60 inches; dark yellowish brown (10YR 4/4) silty clay loam; massive; friable; moderately acid.

The thickness of the mollic epipedon ranges from 24 to 50 inches. The A horizon has hue of 7.5YR or 10YR, value of 2 or 3, and chroma of 1 to 3. The C horizon has hue of 7.5YR or 10YR, value of 3 to 6, and chroma of 2 to 4. It is silt loam or silty clay loam.

Formation of the Soils

Soils are continually changing. The characteristics of a soil at any given point are determined by the physical and mineralogical composition of the parent material; the living organisms on and in the soil; the climate under which the soil material accumulated and has existed since accumulation; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

The parent material affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Plant and animal life, chiefly plants, are active in soil formation. The climate determines the amount of water available for leaching and the amount of heat available for physical and chemical changes. Together, climate and plant and animal life 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. Relief often modifies these other factors. Finally, time is required for the parent material to become a soil. Generally, a long time is required for the development of distinct soil horizons.

These factors of soil formation are all so closely interrelated that few generalizations can be made about the effect of any one factor unless conditions are specified for the other four. Soil formation is complex, and many processes of soil development are still unknown.

Parent Material

Parent material is the unconsolidated mass in which a soil forms. It determines the limits of the chemical and mineral composition of the soil. The soils in Bates County formed mainly in residual material of Pennsylvanian age, in alluvium, or in a combination of these materials. Some of the soils formed in recent alluvium of the Quaternary and Tertiary systems.

Residual material in Bates County consists primarily of material that weathered from limestone, sandstone, or old alluvium and shale. Eram, Hartwell, Kenoma, Okemah, and Summit soils formed in material weathered from old alluvium and shale. Bates and Coweta soils formed in residuum derived from sandstone and silty shale. Balltown, Catoosa, Clareson, and Newtonia soils formed in material weathered from limestone.

The recent alluvium is soil material that was transported by water and deposited on the nearly level flood plains along streams. The major streams in Bates County are the South Grand River in the northeastern part of the county and the Marais des Cygnes River, which flows from the west-central part of the county into the Osage River system in the southeast corner of the county. The alluvium ranges from silt to clay. Hepler and Verdigris soils formed in the silty material, and Osage soils formed in the clayey material.

Living Organisms

Living organisms on and in the soil contribute to the alteration of parent material and influence soil properties. Plants, bacteria, fungi, burrowing animals, and humans have had varying impacts on soil formation. They have influenced organic matter content, nitrogen content, reaction, color, the thickness and kinds of horizons, structure, aeration, and other properties of the soil.

Plants greatly influence soil formation. Throughout time, plant communities have varied according to the soil's fertility, available water capacity, drainage, and depth. Most of the soils in the survey area formed under prairie vegetation. They accumulated a large amount of organic matter and thus have a thick, dark surface layer. Bates, Deepwater, Kenoma, Okemah, and Summit soils formed under this kind of vegetation.

Worms, insects, burrowing animals, and large animals affect and disturb the soil. Bacteria and fungi influence soil formation more significantly than do animals. Bacteria and fungi decompose organic material, improve tilth, and fix nitrogen in the soil. The population of soil organisms is directly related to the rate of decomposition of the organic material in the soil. The kinds of organisms in a given area and their activity are determined by differences in vegetation.

Intensive cultivation and other human activities also influence soil formation. In places cultivation has mixed the surface layer with the subsurface layer, lowered the organic matter content, reduced biological activity in the soil, and decreased the stability of soil structure. In many places it has increased the runoff rate and the hazard of erosion. Bates, Deepwater, Eram, and Summit soils are examples of soils in which the surface layer has been mixed with the subsurface layer. In some areas erosion has completely removed the original surface layer, thereby reducing fertility and the productivity of the soil. By introducing new crops and by adding chemicals, such as fertilizer and lime, humans continue to affect soil formation.

Climate

Climate is an important factor in the formation of the soils in the survey area. Rainfall and temperature have an ongoing influence on soil formation. The rate of geologic erosion varies with the climate and influences the shape and character of the landforms in the area. Changes in the relative abundance and species composition of plant and animal life are directed by climatic change.

High temperatures and large amounts of rainfall encourage rapid chemical change and physical disintegration of the soil. When calcium carbonate and other soluble salts are removed by leaching, soil fertility declines. A warm, moist climate also contributes to the rapid breakdown of minerals, which results in the formation of clay within the soil. The clay is moved downward within the soil profile into the subsoil. This process is known as illuviation. Nearly all of the soils in the uplands, such as Bates, Deepwater, Hartwell, and Kenoma soils, show the effects of this process.

Relief

Relief, or lay of the land, is characterized by gradient, length, shape, aspect, and uniformity of slopes that make up a landscape. It influences soil formation mostly through its effect on drainage, runoff, and erosion.

The steepness of slope influences the amount of runoff, the rate of water infiltration, the rate of leaching, the movement of clay within the profile, and the thickness of the solum. Soil temperature is directly related to aspect and steepness of slope. Position on the landscape affects water movement and water balance. Gentle uplands absorb a considerable amount of moisture; steep side slopes are characterized by a rapid runoff rate; and low side slopes receive runoff from adjoining areas in addition to direct rainfall. Length, shape, and gradient of slope affect soil and water relationships.

Time

Time is needed to allow living organisms, climate, and relief to influence the parent material. The degree to which the soil-forming processes have changed the parent material determines the age of a soil.

Osage and Verdigris soils formed in alluvium deposited by floodwater receding from the major streams. They are examples of the youngest soils in the survey area. The oldest soils formed in nearly level, very gently sloping or gently sloping areas at the highest elevations in the county. Hartwell and Kenoma soils are examples. They have well developed, distinct horizons. In these soils, the carbonates that were originally in the parent material have been leached to a great depth, leaving the soils acid throughout. Clay has been concentrated in distinct subsoil horizons through translocation by water. It is clear that some time is required for these processes to take place.

The age of a soil, as expressed in profile characteristics, is not necessarily a reflection of time in years but is rather a result of the interaction of various soil-forming factors over periods of time. Time, or age, is influenced by relief and climate. Age is determined by the degree of development of a given soil profile and not by the years that the soil material has existed.

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Glossary

ABC soil. A soil having an A, a B, and a C horizon.

AC soil. A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

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

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

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:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation-exchange capacity.

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 flooding.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Channery soil. A soil that is, by volume, more than 15 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches along the longest axis. A single piece is called a channer.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

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 coating, clay skin.

Climax vegetation. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

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.

Conservation tillage. A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

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. 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.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

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.

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

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 they are wet 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.

Drainage, surface. Runoff, or surface flow of water, from an area.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Erosion. The wearing away of the land surface by 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 human or animal activities or of a catastrophe in nature, for example, fire, that exposes the surface.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Fine textured soil. Sandy clay, silty clay, or clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flagstone. A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist, 6 to 15 inches (15 to 38 centimeters) long.

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

Foot slope. The inclined surface at the base of a hill.

Forb. Any herbaceous plant not a grass or a sedge.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.6 centimeters) in diameter.

Green manure crop (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 the material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, any plowed or disturbed surface layer.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) granular, prismatic, or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

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 overlying horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Hard, consolidated bedrock beneath the soil. The bedrock 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.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

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.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Karst (topography). The relief of an area underlain by limestone that dissolves in differing degrees, thus forming numerous depressions or small basins.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Large stones (in tables). Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

Limestone. A shaly or sandy sedimentary rock, chiefly calcium carbonate, containing variable quantities of magnesium carbonate and quartz.

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 the wind.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

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

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, or silty clay loam.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent.* The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Munsell notation. A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan.*

Parent material. The unconsolidated organic and mineral material in which soil forms.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil, adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

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 semisolid to plastic.

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

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

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

Reaction, soil. A measure 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 degrees of acidity or alkalinity, expressed as pH values, are:

Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Moderately acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Slightly 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

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock.

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep-sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rippable. Bedrock or a hardpan can be excavated using a single-tooth ripping attachment mounted on a tractor with a 200-300 drawbar horsepower rating.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

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.

Sandstone. Sedimentary rock containing dominantly sand-sized particles.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the substratum. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

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.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Site index. A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75 feet.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

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. In this survey the following slope classes are recognized:

Nearly level	0 to 2 percent
Very gently sloping	1 to 4 percent
Gently sloping	2 to 5 percent
Moderately sloping	5 to 9 percent
Strongly sloping	9 to 14 percent
Moderately steep	14 to 20 percent
Steep	20 to 35 percent
Very steep	35 to 100 percent

Slope (in tables). Slope is great enough that special practices are required to ensure satisfactory performance of the soil for a specific use.

Slow intake (in tables). The slow movement of water into the soil.

Small stones (in tables). Rock fragments less than 3 inches (7.6 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It 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.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

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

Stone line. A concentration of coarse fragments in a soil. Generally, it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stripcropping. Growing crops in a systematic arrangement of strips or bands which provide vegetative barriers to wind erosion and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or 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. It protects the soil from wind erosion 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.

Subsoiling. Breaking up a compact subsoil by pulling a special chisel through the soil.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

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

Surface soil. The A, E, AB, and EB horizons. It includes all subdivisions of these horizons.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

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

Thin layer (in tables). Otherwise suitable soil material that is too thin for the specified use.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

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

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

(Recorded in the period 1951-87 at Appleton City, Missouri)

Month	Temperature: Average daily maximum	Temperature: Average daily minimum	Temperature: Average daily	Temperature: 2 years in 10 will have-- Maximum temperature higher than--	Temperature: 2 years in 10 will have-- Minimum temperature lower than--	Temperature: Average number of growing degree days*	Precipitation: Average	Precipitation: 2 years in 10 will have-- Less than--	Precipitation: 2 years in 10 will have-- More than--	Precipitation: Average number of days with 0.10 inch or more	Precipitation: Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January-----	40.9	19.5	30.2	68	-9	9	1.39	0.43	2.16	3	5.5
February----	47.1	24.9	36.0	73	-4	18	1.68	.63	2.56	4	3.7
March-------	57.4	33.3	45.4	83	8	87	2.99	1.43	4.32	6	2.9
April-------	69.7	44.6	57.2	89	23	244	3.57	1.70	5.17	6	.2
May---------	78.2	54.0	66.1	91	34	499	4.78	2.94	6.43	7	.0
June--------	86.4	62.6	74.5	98	47	735	4.87	2.10	7.22	7	.0
July--------	91.8	66.7	79.3	104	52	908	3.64	1.09	5.71	5	.0
August------	91.1	64.6	77.9	104	50	865	3.72	1.72	5.42	6	.0
September---	83.3	57.3	70.3	100	38	609	4.57	1.77	6.92	6	.0
October-----	72.0	46.0	59.0	92	26	298	4.12	1.24	6.45	6	.0
November----	56.7	34.2	45.5	79	11	45	2.50	.75	3.94	4	1.2
December----	44.9	24.7	34.8	70	-4	16	2.03	.82	3.03	4	3.9
Yearly:											
Average---	68.3	44.4	56.4	---	---	---	---	---	---	---	---
Extreme---	---	---	---	106	-10	---	---	---	---	---	---
Total-----	---	---	---	---	---	4,333	39.86	30.60	47.64	64	17.4

* A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (50 degrees F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

(Recorded in the period 1951-87 at Appleton City, Missouri)

Probability	Temperature		
	24 °F or lower	28 °F or lower	32 °F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	Apr. 9	Apr. 21	May 1
2 years in 10 later than--	Apr. 4	Apr. 17	Apr. 26
5 years in 10 later than--	Mar. 25	Apr. 9	Apr. 16
First freezing temperature in fall:			
1 year in 10 earlier than--	Oct. 27	Oct. 19	Oct. 11
2 years in 10 earlier than--	Oct. 31	Oct. 24	Oct. 15
5 years in 10 earlier than--	Nov. 8	Nov. 1	Oct. 22

TABLE 3.--GROWING SEASON

(Recorded in the period 1951-87 at Appleton City, Missouri)

Probability	Daily minimum temperature during growing season		
	Higher than 24 °F	Higher than 28 °F	Higher than 32 °F
	Days	Days	Days
9 years in 10	207	186	172
8 years in 10	214	193	177
5 years in 10	227	206	188
2 years in 10	241	219	199
1 year in 10	248	225	205

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
10	Verdigris silt loam, channeled	8,330	1.5
11	Verdigris silt loam	33,070	6.1
13	Okemah silt loam	7,830	1.4
14	Osage silty clay loam	12,360	2.3
21	Osage silty clay	21,850	4.0
51B2	Deepwater silt loam, 2 to 5 percent slopes, eroded	28,360	5.2
52	Hepler silt loam, occasionally flooded	5,475	1.0
53	Hepler silt loam	5,860	1.1
54B	Newtonia silt loam, 2 to 5 percent slopes	10,135	1.9
55B	Catoosa silt loam, 2 to 5 percent slopes	4,640	0.9
56B	Bates loam, 2 to 5 percent slopes	14,065	2.6
56C2	Bates loam, 3 to 8 percent slopes, eroded	6,530	1.2
58	Hartwell silt loam	39,810	7.3
60B	Kenoma silt loam, 1 to 4 percent slopes	195,780	36.0
61B	Summit silty clay loam, 1 to 5 percent slopes	45,600	8.4
61C2	Summit silty clay loam, 5 to 9 percent slopes, eroded	4,205	0.8
63B2	Eram silt loam, 2 to 5 percent slopes, eroded	15,450	2.8
63C	Eram silt loam, 5 to 9 percent slopes	8,850	1.6
65B	Clareson silty clay loam, 2 to 5 percent slopes	4,345	0.8
66B	Olpe gravelly silt loam, 2 to 5 percent slopes	2,945	0.5
68D	Coweta loam, 5 to 14 percent slopes	18,505	3.4
72E	Balltown very flaggy silt loam, 5 to 20 percent slopes	6,970	1.3
73E	Eram-Balltown complex, 5 to 20 percent slopes	28,517	5.2
94F	Kanima very channery silty clay loam, 5 to 50 percent slopes	8,850	1.6
95B	Brazilton silt loam, 1 to 5 percent slopes	4,920	0.9
96	Pits, quarries	415	0.1
	Water	698	0.1
	Total	544,365	100.0

TABLE 5.--PRIME FARMLAND

(Only the soils considered prime farmland are listed. Urban or built-up areas of the soils listed are not considered prime farmland. If a soil is prime farmland only under certain conditions, the conditions are specified in parentheses after the soil name)

Map symbol	Soil name
11	Verdigris silt loam (where protected from flooding or not frequently flooded during the growing season)
13	Okemah silt loam
14	Osage silty clay loam (where drained and either protected from flooding or not frequently flooded during the growing season)
21	Osage silty clay (where drained and either protected from flooding or not frequently flooded during the growing season)
51B2	Deepwater silt loam, 2 to 5 percent slopes, eroded
52	Hepler silt loam, occasionally flooded (where drained)
53	Hepler silt loam (where drained)
54B	Newtonia silt loam, 2 to 5 percent slopes
55B	Catoosa silt loam, 2 to 5 percent slopes
56B	Bates loam, 2 to 5 percent slopes
58	Hartwell silt loam (where drained)
60B	Kenoma silt loam, 1 to 4 percent slopes
61B	Summit silty clay loam, 1 to 5 percent slopes
63B2	Eram silt loam, 2 to 5 percent slopes, eroded
95B	Brazilton silt loam, 1 to 5 percent slopes

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE

(Yields are those that can be expected under a high level of management. 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	Land capability	Corn	Soybeans	Grain sorghum	Winter wheat	Tall fescue-red clover hay	Alfalfa hay	Tall fescue
		Bu	Bu	Bu	Bu	Tons	Tons	AUM*
10-------------- Verdigris	Vw	---	---	---	---	---	---	---
11-------------- Verdigris	IVw	96	35	85	42	3.5	5.0	7.0
13-------------- Okemah	IIe	110	40	95	48	4.2	5.8	8.5
14, 21---------- Osage	IVw	60	25	60	30	2.0	---	5.6
51B2------------ Deepwater	IIe	120	45	105	50	4.5	6.0	9.0
52-------------- Hepler	IIw	120	45	105	50	4.5	6.0	9.0
53-------------- Hepler	IIw	128	47	112	52	4.8	6.3	9.5
54B------------- Newtonia	IIIe	115	42	100	49	4.5	6.0	9.0
55B------------- Catoosa	IIIe	85	30	75	34	3.2	4.7	6.3
56B------------- Bates	IIe	88	32	78	36	3.4	4.9	6.8
56C2------------ Bates	IVe	74	27	65	30	2.6	4.0	5.2
58-------------- Hartwell	IIw	108	40	94	44	4.0	5.5	8.0
60B------------- Kenoma	IIIe	102	38	89	42	3.9	5.3	7.8
61B------------- Summit	IIIe	97	37	85	40	3.6	5.1	7.2
61C2------------ Summit	IVe	83	32	72	34	3.0	4.0	6.0
63B2------------ Eram	IVe	80	30	70	32	2.5	3.5	5.0
63C------------- Eram	VIe	---	---	---	25	2.3	3.3	4.5
65B------------- Clareson	IVe	---	---	---	20	1.6	2.5	3.2
66B------------- Olpe	VIe	---	---	---	---	2.0	2.8	4.0

See footnote at end of table.

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn	Soybeans	Grain sorghum	Winter wheat	Tall fescue-red clover hay	Alfalfa hay	Tall fescue
		Bu	Bu	Bu	Bu	Tons	Tons	AUM*
68D------------- Coweta	VIe	---	---	---	---	1.5	---	3.0
72E------------- Balltown	VIIs	---	---	---	---	---	---	1.0
73E------------- Eram-Balltown	VIIs	---	---	---	---	---	---	2.0
94F------------- Kanima	VIIs	---	---	---	---	---	---	2.5
95B------------- Brazilton	IIIe	80	30	70	33	3.0	3.8	6.0
96. Pits								

* 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 30 days.

TABLE 7.--WOODLAND MANAGEMENT AND PRODUCTIVITY

(Only the soils suitable for production of commercial trees are listed. Absence of an entry indicates that information was not available)

Soil name and map symbol	Ordi- nation symbol	Management concerns: Erosion hazard	Management concerns: Equip- ment limita- tion	Management concerns: Seedling mortal- ity	Management concerns: Wind- throw hazard	Potential productivity: Common trees	Potential productivity: Site index	Potential productivity: Volume*	Trees to plant
10, 11: Verdigris	4A	Slight	Slight	Slight	Slight	Pin oak	75	57	Eastern cottonwood, American sycamore, pin oak, black walnut, green ash.
						Eastern cottonwood	87	95	
						Hackberry	69	---	
						Black walnut	69	---	
						Green ash	69	32	
14: Osage	4W	Slight	Moderate	Moderate	Moderate	Pin oak	75	57	Pin oak, pecan.
						Pecan	50	---	
						Eastern cottonwood	80	88	
						Bur oak	---	---	
21: Osage	4W	Slight	Moderate	Severe	Moderate	Pin oak	75	57	Pin oak, pecan.
						Pecan	50	---	
						Eastern cottonwood	80	88	
						Bur oak	---	---	
52: Hepler	3A	Slight	Slight	Slight	Slight	Northern red oak	67	3	Pecan, green ash, American sycamore.
						Eastern cottonwood	90	7	
						Hackberry	76	---	
						Green ash	73	3	
						Pin oak	80	4	
53: Hepler	4A	Slight	Slight	Slight	Slight	Pin oak	80	4	Pecan, green ash, eastern cottonwood.
						Eastern cottonwood	90	7	
						Hackberry	76	---	
						Green ash	73	3	

* Volume is the yield in cubic feet per acre per year calculated at the age of culmination of mean annual increment for fully stocked natural stands.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

(The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil)

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
10, 11. Verdigris	---	Lilac, Amur honeysuckle, Amur maple, autumn-olive.	Eastern redcedar	Austrian pine, green ash, hackberry, pin oak, honeylocust, eastern white pine.	Eastern cottonwood.
13. Okemah	Lilac, skunkbush sumac.	Amur honeysuckle, Austrian pine, redbud.	Lacebark elm, honeylocust, eastern redcedar, hackberry, oriental arborvitae, silver maple.	---	---
14, 21. Osage	Redosier dogwood	American plum, common chokecherry.	Eastern redcedar, hackberry.	Norway spruce, honeylocust, green ash, silver maple, golden willow, northern red oak.	Eastern cottonwood.
51B2. Deepwater	---	Amur honeysuckle, autumn-olive, Amur maple, lilac.	Hackberry, Russian-olive, eastern redcedar.	Norway spruce, pin oak, honeylocust, green ash, eastern white pine.	---
52. Hepler	---	Peking cotoneaster, Amur honeysuckle, lilac, American plum.	Eastern redcedar	Austrian pine, eastern white pine, honeylocust, hackberry, green ash, bur oak.	Eastern cottonwood.
53. Hepler	---	Peking cotoneaster, silky dogwood, lilac, American plum.	Eastern redcedar	Austrian pine, eastern white pine, honeylocust, hackberry, green ash, bur oak.	Eastern cottonwood.
54B. Newtonia	Peking cotoneaster	Lilac, Amur honeysuckle, fragrant sumac.	Eastern redcedar, hackberry, green ash, bur oak, Russian-olive.	Austrian pine, Scotch pine, honeylocust.	---
55B. Catoosa	Amur honeysuckle, fragrant sumac, Peking cotoneaster, lilac.	---	Bur oak, Russian-olive, hackberry, eastern redcedar, green ash, Austrian pine.	Honeylocust, Siberian elm.	---

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of-- <8	8-15	16-25	26-35	>35
56B, 56C2: Bates	Lilac, Peking cotoneaster, Amur honeysuckle, fragrant sumac.	---	Eastern redcedar, green ash, Austrian pine, bur oak, hackberry, Russian-olive.	Siberian elm, honeylocust.	---
58: Hartwell	Lilac	Amur maple, Amur honeysuckle, autumn-olive, Manchurian crabapple.	Eastern redcedar, hackberry, jack pine, Austrian pine, green ash, Russian-olive.	Honeylocust	---
60B: Kenoma	Peking cotoneaster, lilac, fragrant sumac.	Amur honeysuckle, Manchurian crabapple.	Green ash, hackberry, Austrian pine, Russian-olive, eastern redcedar.	Siberian elm, honeylocust.	---
61B, 61C2: Summit	Lilac	Amur honeysuckle, autumn-olive, Amur maple, Manchurian crabapple.	Eastern redcedar, Russian-olive, hackberry, green ash, Austrian pine, jack pine.	Honeylocust	---
63B2, 63C: Eram	Lilac, Peking cotoneaster.	Manchurian crabapple, Amur honeysuckle, Siberian peashrub.	Eastern redcedar, hackberry, green ash, Austrian pine, Russian-olive.	Siberian elm, honeylocust.	---
65B: Clareson	Peking cotoneaster, Amur honeysuckle, lilac, fragrant sumac.	---	Austrian pine, eastern redcedar, green ash, Russian-olive, hackberry, bur oak.	Siberian elm, honeylocust.	---
66B: Olpe	Fragrant sumac, Amur honeysuckle, lilac.	Autumn-olive	Bur oak, eastern redcedar, Russian-olive, hackberry, Austrian pine, green ash, honeylocust.	Siberian elm	---
68D: Coweta	Skunkbush sumac, lilac, Amur honeysuckle.	Redbud, Rocky Mountain juniper.	Eastern redcedar, oriental arborvitae.	---	---
72E. Balltown					
73E:					
Eram	Lilac, Peking cotoneaster.	Manchurian crabapple, Amur honeysuckle, Siberian peashrub.	Eastern redcedar, hackberry, green ash, Austrian pine, Russian-olive.	Siberian elm, honeylocust.	---

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
73E: Balltown.					
94F: Kanima	Skunkbush sumac	Lilac, American plum, Amur honeysuckle.	Austrian pine, eastern redcedar, redbud.	Black locust, honeylocust, lacebark elm, hackberry.	---
95B: Brazilton	Lilac, Peking cotoneaster.	Siberian peashrub, Manchurian crabapple, Amur honeysuckle.	Eastern redcedar, hackberry, Russian-olive, Austrian pine, green ash.	Honeylocust, Siberian elm.	---
96. Pits					

TABLE 9.--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	Golf fairways
10 Verdigris	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
11 Verdigris	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
13 Okemah	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Slight	Slight.
14 Osage	Severe: flooding, wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness, flooding.	Severe: wetness.	Severe: wetness, flooding.
21 Osage	Severe: flooding, wetness, percs slowly.	Severe: wetness, too clayey, percs slowly.	Severe: too clayey, wetness, flooding.	Severe: wetness, too clayey.	Severe: wetness, flooding, too clayey.
51B2 Deepwater	Slight	Slight	Moderate: slope.	Slight	Slight.
52 Hepler	Severe: flooding, wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
53 Hepler	Severe: flooding, wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
54B Newtonia	Slight	Slight	Moderate: slope.	Slight	Slight.
55B Catoosa	Slight	Slight	Moderate: slope, depth to rock.	Severe: erodes easily.	Moderate: thin layer.
56B, 56C2 Bates	Slight	Slight	Moderate: slope, small stones, thin layer.	Slight	Moderate: thin layer, area reclaim.
58 Hartwell	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
60B Kenoma	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.
61B Summit	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Moderate: slope, wetness.	Slight	Slight.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
61C2------------------ Summit	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Severe: slope.	Slight----------	Slight.
63B2------------------ Eram	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
63C------------------- Eram	Severe: wetness.	Moderate: wetness.	Severe: slope, wetness.	Moderate: wetness.	Moderate: wetness.
65B------------------- Clareson	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: percs slowly.	Slight----------	Moderate: large stones, droughty.
66B------------------- Olpe	Moderate: small stones, percs slowly.	Moderate: small stones, percs slowly.	Severe: small stones.	Slight----------	Severe: droughty.
68D------------------- Coweta	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: erodes easily.	Severe: depth to rock.
72E------------------- Balltown	Severe: large stones, thin layer.	Severe: large stones, thin layer.	Severe: large stones, slope, thin layer.	Severe: large stones.	Severe: large stones, thin layer.
73E:					
Eram-----------------	Severe: wetness.	Moderate: wetness.	Severe: slope, wetness.	Moderate: wetness.	Moderate: wetness.
Balltown-------------	Severe: large stones, thin layer.	Severe: large stones, thin layer.	Severe: large stones, slope, thin layer.	Severe: large stones.	Severe: large stones, thin layer.
94F------------------- Kanima	Severe: slope.	Severe: slope.	Severe: slope, small stones.	Severe: slope.	Severe: droughty, slope.
95B------------------- Brazilton	Severe: percs slowly.	Severe: percs slowly.	Severe: percs slowly.	Slight----------	Slight.
96. Pits					

TABLE 10.--WILDLIFE HABITAT

(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	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
10: Verdigris	Poor	Fair	Fair	Good	Good	Poor	Fair	Fair	Good	Poor.
11: Verdigris	Poor	Fair	Fair	Good	Good	Poor	Fair	Fair	Good	Poor.
13: Okemah	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
14: Osage	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
21: Osage	Fair	Fair	Fair	Fair	Fair	Poor	Good	Fair	Fair	Fair.
51B2: Deepwater	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
52, 53: Hepler	Fair	Good	Good	Good	Good	Good	Fair	Good	Good	Fair.
54B: Newtonia	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
55B: Catoosa	Fair	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
56B, 56C2: Bates	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
58: Hartwell	Fair	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
60B: Kenoma	Good	Good	Fair	Fair	Fair	Poor	Fair	Good	Fair	Poor.
61B, 61C2: Summit	Fair	Good	Fair	Good	Good	Poor	Very poor.	Fair	Good	Very poor.
63B2: Eram	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
63C: Eram	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
65B: Clareson	Fair	Good	Good	Fair	Fair	Very poor.	Very poor.	Good	Fair	Very poor.
66B: Olpe	Fair	Good	Good	Fair	Fair	Poor	Very poor.	Good	Fair	Very poor.
68D: Coweta	Very poor.	Poor	Poor	Very poor.	Very poor.	Very poor.	Very poor.	Poor	Very poor.	Very poor.
72E: Balltown	Very poor.	Very poor.	Poor	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.

TABLE 10.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hardwood trees	Conif- erous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
73E:										
Eram	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Balltown	Very poor.	Very poor.	Poor	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.
94F: Kanima	Very poor.	Poor	Fair	Fair	Poor	Very poor.	Very poor.	Poor	Fair	Very poor.
95B: Brazilton	Fair	Good	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor.
96. Pits										

TABLE 11.--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. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
10: Verdigris	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.
11: Verdigris	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.
13: Okemah	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.	Slight.
14: Osage	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: shrink-swell, low strength, wetness.	Severe: wetness, flooding.
21: Osage	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: shrink-swell, low strength, wetness.	Severe: wetness, flooding, too clayey.
51B2: Deepwater	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
52: Hepler	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding.	Moderate: wetness, flooding.
53: Hepler	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding.	Moderate: wetness, flooding.
54B: Newtonia	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
55B: Catoosa	Severe: depth to rock.	Moderate: shrink-swell, depth to rock.	Severe: depth to rock.	Moderate: shrink-swell, depth to rock.	Moderate: shrink-swell, depth to rock.	Moderate: thin layer.
56B: Bates	Slight	Slight	Slight	Slight	Slight	Moderate: thin layer, area reclaim.
56C2: Bates	Slight	Slight	Slight	Moderate: slope.	Slight	Moderate: thin layer, area reclaim.
58: Hartwell	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: low strength, wetness, shrink-swell.	Severe: wetness.
60B: Kenoma	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, low strength, wetness.	Severe: wetness.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
61B, 61C2 Summit	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.	Slight.
63B2, 63C Eram	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, wetness.	Severe: low strength, shrink-swell.	Moderate: wetness.
65B Clareson	Severe: depth to rock, large stones.	Severe: large stones.	Severe: depth to rock, large stones.	Severe: large stones.	Severe: low strength, large stones.	Moderate: large stones, droughty.
66B Olpe	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: droughty.
68D Coweta	Severe: depth to rock.	Moderate: slope, depth to rock.	Severe: depth to rock.	Severe: slope.	Moderate: depth to rock, slope.	Severe: depth to rock.
72E Balltown	Severe: depth to rock, large stones.	Severe: depth to rock, large stones.	Severe: depth to rock, large stones.	Severe: slope, depth to rock, large stones.	Severe: depth to rock, low strength.	Severe: large stones, thin layer.
73E:						
Eram	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell, wetness.	Severe: low strength, shrink-swell.	Moderate: wetness.
Balltown	Severe: depth to rock, large stones.	Severe: depth to rock, large stones.	Severe: depth to rock, large stones.	Severe: slope, depth to rock, large stones.	Severe: depth to rock, low strength.	Severe: large stones, thin layer.
94F Kanima	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: droughty, slope.
95B Brazilton	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.	Slight.
96. Pits						

TABLE 12.--SANITARY FACILITIES

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "slight," "good," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
10, 11-------------- Verdigris	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Fair: too clayey.
13------------------ Okemah	Severe: wetness, percs slowly.	Slight-----------	Severe: too clayey.	Moderate: wetness.	Poor: too clayey, hard to pack.
14, 21-------------- Osage	Severe: flooding, wetness, percs slowly.	Severe: flooding.	Severe: flooding, wetness, too clayey.	Severe: flooding, wetness.	Poor: too clayey, hard to pack, wetness.
51B2---------------- Deepwater	Severe: wetness.	Severe: wetness.	Moderate: wetness, too clayey.	Slight-----------	Fair: too clayey, wetness.
52, 53-------------- Hepler	Severe: flooding, wetness, percs slowly.	Severe: flooding, wetness.	Severe: flooding, wetness, too clayey.	Severe: flooding, wetness.	Poor: too clayey, wetness.
54B----------------- Newtonia	Moderate: percs slowly.	Moderate: seepage, slope.	Severe: too clayey.	Slight-----------	Poor: too clayey, hard to pack.
55B----------------- Catoosa	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim, thin layer.
56B, 56C2----------- Bates	Severe: thin layer, seepage.	Severe: seepage.	Severe: seepage.	Moderate: seepage.	Poor: area reclaim, thin layer.
58------------------ Hartwell	Severe: wetness, percs slowly.	Slight-----------	Severe: wetness.	Severe: wetness.	Poor: wetness.
60B----------------- Kenoma	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
61B----------------- Summit	Severe: wetness, percs slowly.	Severe: wetness.	Severe: too clayey.	Moderate: wetness.	Poor: too clayey, hard to pack.
61C2---------------- Summit	Severe: wetness, percs slowly.	Severe: slope, wetness, slippage.	Severe: too clayey.	Moderate: wetness.	Poor: too clayey, hard to pack.
63B2---------------- Eram	Severe: depth to rock, wetness, percs slowly.	Severe: depth to rock.	Severe: depth to rock, wetness, too clayey.	Severe: depth to rock, wetness.	Poor: depth to rock, too clayey, hard to pack.

TABLE 12.--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
63C Eram	Severe: depth to rock, wetness, percs slowly.	Severe: depth to rock, slope.	Severe: depth to rock, wetness, too clayey.	Severe: depth to rock, wetness.	Poor: depth to rock, too clayey, hard to pack.
65B Clareson	Severe: thin layer, seepage, percs slowly.	Severe: depth to rock, seepage.	Severe: depth to rock, seepage, too clayey.	Moderate: seepage.	Poor: area reclaim, too clayey, hard to pack.
66B Olpe	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: too clayey, small stones.
68D Coweta	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Severe: depth to rock.	Poor: depth to rock, small stones.
72E Balltown	Severe: thin layer, seepage.	Severe: depth to rock, seepage, slope.	Severe: depth to rock, seepage.	Severe: seepage.	Poor: area reclaim, large stones.
73E:					
Eram	Severe: depth to rock, wetness, percs slowly.	Severe: depth to rock, slope.	Severe: depth to rock, wetness, too clayey.	Severe: depth to rock, wetness.	Poor: depth to rock, too clayey, hard to pack.
Balltown	Severe: thin layer, seepage.	Severe: depth to rock, seepage, slope.	Severe: depth to rock, seepage.	Severe: seepage.	Poor: area reclaim, large stones.
94F Kanima	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: small stones, slope.
95B Brazilton	Severe: percs slowly.	Moderate: seepage, slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
96. Pits					

TABLE 13.--CONSTRUCTION MATERIALS

(Some terms that describe restrictive soil features are defined in the "Glossary." See text for definitions of "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
10, 11 Verdigris	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
13 Okemah	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
14, 21 Osage	Poor: shrink-swell, low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.
51B2 Deepwater	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
52, 53 Hepler	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
54B Newtonia	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
55B Catoosa	Poor: area reclaim, thin layer.	Improbable: excess fines.	Improbable: excess fines.	Fair: area reclaim, thin layer, too clayey.
56B, 56C2 Bates	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: area reclaim, small stones.
58 Hartwell	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
60B Kenoma	Poor: shrink-swell, low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
61B, 61C2 Summit	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
63B2, 63C Eram	Poor: depth to rock, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
65B Clareson	Poor: area reclaim, low strength, large stones.	Improbable: excess fines, large stones.	Improbable: excess fines, large stones.	Poor: large stones.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
66B------------------- Olpe	Fair: shrink-swell, thin layer.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, small stones, area reclaim.
68D------------------- Coweta	Poor: depth to rock.	Improbable: excess fines.	Improbable: excess fines.	Poor: depth to rock, small stones.
72E------------------- Balltown	Poor: area reclaim, low strength, large stones.	Improbable: excess fines, large stones.	Improbable: excess fines, large stones.	Poor: area reclaim, large stones, thin layer.
73E:				
Eram-----------------	Poor: depth to rock, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Balltown-------------	Poor: area reclaim, low strength, large stones.	Improbable: excess fines, large stones.	Improbable: excess fines, large stones.	Poor: area reclaim, large stones, thin layer.
94F------------------- Kanima	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, area reclaim, slope.
95B------------------- Brazilton	Good-----------------	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim.
96. Pits				

TABLE 14.--WATER MANAGEMENT

(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 evaluated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation)

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
10, 11------------ Verdigris	Moderate: seepage.	Moderate: piping.	Deep to water	Flooding-------	Favorable------	Favorable.
13---------------- Okemah	Slight---------	Moderate: hard to pack, wetness.	Percs slowly---	Percs slowly, erodes easily.	Wetness, percs slowly, erodes easily.	Percs slowly, erodes easily.
14---------------- Osage	Slight---------	Severe: hard to pack, wetness.	Percs slowly, flooding.	Wetness--------	Wetness, percs slowly.	Wetness, percs slowly.
21---------------- Osage	Slight---------	Severe: hard to pack, wetness.	Percs slowly, flooding.	Wetness, droughty, slow intake.	Wetness, percs slowly.	Wetness, droughty, percs slowly.
51B2-------------- Deepwater	Moderate: seepage, slope.	Slight---------	Deep to water	Slope----------	Erodes easily	Erodes easily.
52, 53------------ Hepler	Moderate: seepage.	Severe: wetness.	Flooding-------	Wetness, erodes easily, flooding.	Erodes easily, wetness.	Wetness, erodes easily.
54B--------------- Newtonia	Moderate: seepage, slope.	Moderate: hard to pack.	Deep to water	Slope, erodes easily.	Erodes easily	Erodes easily.
55B--------------- Catoosa	Moderate: seepage, depth to rock, slope.	Severe: thin layer.	Deep to water	Depth to rock, rooting depth, slope.	Depth to rock, erodes easily.	Erodes easily, depth to rock.
56B, 56C2--------- Bates	Moderate: seepage, slope.	Severe: thin layer.	Deep to water	Thin layer, slope.	Area reclaim---	Area reclaim.
58---------------- Hartwell	Slight---------	Severe: wetness.	Percs slowly---	Wetness, percs slowly.	Erodes easily, wetness.	Wetness, erodes easily, percs slowly.
60B--------------- Kenoma	Slight---------	Severe: hard to pack, wetness.	Percs slowly---	Wetness, percs slowly.	Erodes easily, wetness, percs slowly.	Wetness, erodes easily, percs slowly.
61B, 61C2--------- Summit	Moderate: slope.	Moderate: hard to pack, wetness.	Percs slowly, slope.	Percs slowly, slope.	Wetness, percs slowly, erodes easily.	Erodes easily, percs slowly.
63B2, 63C--------- Eram	Moderate: depth to rock, slope.	Moderate: thin layer, hard to pack, wetness.	Percs slowly, depth to rock, slope.	Percs slowly, depth to rock, slope.	Depth to rock, erodes easily, wetness.	Wetness, erodes easily, depth to rock.
65B--------------- Clareson	Moderate: depth to rock, seepage, slope.	Severe: large stones.	Deep to water	Slope, large stones, droughty.	Large stones, depth to rock.	Large stones, droughty.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
66B--------------- Olpe	Moderate: slope.	Slight---------	Deep to water	Slope, droughty, percs slowly.	Percs slowly---	Droughty.
68D--------------- Coweta	Severe: depth to rock, slope.	Severe: piping, thin layer.	Deep to water	Depth to rock, slope, erodes easily.	Large stones, slope, depth to rock.	Large stones, slope, depth to rock.
72E--------------- Balltown	Severe: depth to rock, seepage, slope.	Severe: large stones, thin layer.	Deep to water	Slope, large stones, droughty.	Slope, large stones, depth to rock.	Large stones, slope, droughty.
73E:						
Eram-------------	Moderate: depth to rock, slope.	Moderate: thin layer, hard to pack, wetness.	Percs slowly, depth to rock, slope.	Percs slowly, depth to rock, slope.	Depth to rock, erodes easily, wetness.	Wetness, erodes easily, depth to rock.
Balltown---------	Severe: depth to rock, seepage, slope.	Severe: large stones, thin layer.	Deep to water	Slope, large stones, droughty.	Slope, large stones, depth to rock.	Large stones, slope, droughty.
94F--------------- Kanima	Severe: slope.	Slight---------	Deep to water	Droughty, slope.	Slope----------	Slope, droughty.
95B--------------- Brazilton	Moderate: seepage, slope.	Moderate: hard to pack.	Deep to water	Percs slowly, slope.	Erodes easily, percs slowly.	Erodes easily, percs slowly.
96. Pits						

TABLE 15.--ENGINEERING INDEX PROPERTIES

(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		Frag- ments > 10 inches	Frag- ments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO			4	10	40	200		
	In				Pct	Pct					Pct	
10------------ Verdigris	0-50	Silt loam-----	CL, CL-ML, ML	A-4, A-6	0	0	100	100	95-100	65-100	22-35	2-13
	50-60	Silt loam, silty clay loam.	CL	A-4, A-6, A-7	0	0	100	100	95-100	80-100	30-45	8-23
11------------ Verdigris	0-39	Silt loam-----	CL, CL-ML, ML	A-4, A-6	0	0	100	100	95-100	65-100	22-35	2-13
	39-60	Silt loam, silty clay loam.	CL	A-4, A-6, A-7	0	0	100	100	95-100	80-100	30-45	8-23
13------------ Okemah	0-8	Silt loam-----	CL	A-4, A-6	0	0	98-100	98-100	96-100	80-98	30-37	8-13
	8-37	Silty clay, clay, silty clay loam.	CL, CH	A-7	0	0	98-100	98-100	96-100	90-99	41-60	18-34
	37-60	Silty clay, clay, silty clay loam.	CL, CH	A-7	0	0	98-100	98-100	96-100	90-99	41-60	18-34
14------------ Osage	0-7	Silty clay loam.	CL	A-7	0	0	100	100	100	95-100	40-50	20-30
	7-60	Silty clay, clay, silty clay loam.	CH, CL	A-7	0	0	100	100	100	95-100	40-80	20-50
21------------ Osage	0-15	Silty clay----	CH	A-7	0	0	100	100	100	95-100	50-75	30-55
	15-60	Silty clay, clay, silty clay loam.	CH, CL	A-7	0	0	100	100	100	95-100	40-80	20-50
51B2---------- Deepwater	0-7	Silt loam-----	CL	A-4, A-6	0	0	100	100	90-100	70-95	25-40	7-15
	7-13	Silt loam, silty clay loam, loam.	CL	A-6, A-7	0	0	100	100	90-100	70-95	25-45	10-22
	13-60	Silty clay loam, clay loam.	CL	A-6, A-7	0	0	100	85-100	80-100	75-95	35-50	15-26
52------------ Hepler	0-9	Silt loam-----	CL, CL-ML	A-4, A-6	0	0	100	100	90-100	70-90	20-35	5-15
	9-19	Silt loam-----	CL, CL-ML	A-4, A-6	0	0	100	100	90-100	70-90	20-35	5-15
	19-60	Silty clay loam.	CL	A-6, A-7	0	0	100	100	95-100	85-95	35-45	15-20
53------------ Hepler	0-9	Silt loam-----	CL, CL-ML	A-4, A-6	0	0	100	100	90-100	75-95	20-35	5-15
	9-18	Silt loam-----	CL, CL-ML	A-4, A-6	0	0	100	100	90-100	75-95	20-35	5-15
	18-26	Silt loam-----	CL	A-6, A-7	0	0	100	100	95-100	85-95	35-45	15-20
	26-60	Silty clay loam, silty clay.	CL	A-6, A-7	0	0	100	100	95-100	85-95	35-50	15-25

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 10 inches	Fragments 3-10 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plasticity index
	In				Pct	Pct					Pct	
54B----------- Newtonia	0-15	Silt loam-----	CL	A-4, A-6	0	0	100	100	96-100	65-97	30-37	9-14
	15-22	Silt loam, silty clay loam.	CL	A-4, A-6	0	0	100	100	96-100	80-98	30-40	9-16
	22-34	Silty clay loam.	CL	A-6, A-7	0	0	100	100	98-100	90-98	33-42	12-19
	34-60	Silty clay loam, silty clay, clay.	CL, CH	A-6, A-7	0	0	100	100	96-100	90-98	37-60	15-34
55B----------- Catoosa	0-9	Silt loam-----	CL	A-4, A-6	0	0	100	100	96-100	65-97	30-37	8-14
	9-15	Silt loam, loam, clay loam.	CL	A-4, A-6, A-7	0	0	100	100	96-100	65-98	30-43	8-20
	15-29	Silty clay loam, clay loam.	CL	A-6, A-7	0	0	85-100	85-100	85-100	70-98	33-48	12-22
	29	Unweathered bedrock.	---	---	---	---	---	---	---	---	---	---
56B----------- Bates	0-16	Loam----------	ML, CL, CL-ML	A-4, A-6	0	0	90-100	85-100	75-95	55-75	20-40	3-15
	16-34	Loam, clay loam, sandy clay loam.	ML, CL, SC, SM	A-4, A-6, A-7	0	0	85-100	85-100	70-95	35-80	25-45	3-20
	34	Weathered bedrock.	---	---	---	---	---	---	---	---	---	---
56C2---------- Bates	0-6	Loam----------	ML, CL, CL-ML	A-4, A-6	0	0	90-100	85-100	75-95	55-75	20-40	3-15
	6-28	Loam, clay loam, sandy clay loam.	ML, CL, SC, SM	A-4, A-6, A-7	0	0	85-100	85-100	70-95	35-80	25-45	3-20
	28	Weathered bedrock.	---	---	---	---	---	---	---	---	---	---
58------------ Hartwell	0-9	Silt loam-----	CL-ML, CL	A-4, A-6	0	0	100	100	95-100	80-100	20-35	5-15
	9-14	Silty clay loam, silt loam.	CL	A-6	0	0	100	100	95-100	90-100	30-40	15-20
	14-37	Clay, silty clay.	CH	A-7	0	0	100	100	95-100	90-100	50-65	30-40
	37-60	Silt loam, silty clay loam, silty clay.	CL	A-6, A-7	0	0	100	100	95-100	90-100	35-45	20-25
60B----------- Kenoma	0-9	Silt loam-----	CL, CL-ML, ML	A-4, A-6	0	0	85-100	85-100	85-100	85-100	25-40	3-18
	9-45	Silty clay, clay.	CH	A-7	0	0	85-100	85-100	85-100	85-100	50-75	30-48
	45-60	Silty clay, silty clay loam.	CL, CH	A-7	0	0	85-100	85-100	75-100	75-95	45-65	25-44
61B, 61C2----- Summit	0-8	Silty clay loam.	CL, CH	A-6, A-7	0	0	90-100	85-100	80-100	70-99	35-60	11-30
	8-14	Silty clay, silty clay loam, clay.	CL, CH	A-7, A-6	0	0	85-100	85-100	75-100	60-99	37-65	15-35
	14-60	Clay, silty clay.	CH, CL	A-7	0	0	85-100	75-100	70-100	55-98	41-70	18-40

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 10 inches	Frag- ments 3-10 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO			4	10	40	200		
	In				Pct	Pct					Pct	
63B2, 63C----- Eram	0-10	Silt loam-----	CL	A-4, A-6	0	0	85-100	85-100	85-100	70-95	30-37	8-14
	10-31	Clay, silty clay, clay loam.	CL, CH	A-7, A-6	0	0	95-100	95-100	90-100	80-98	37-65	15-35
	31	Weathered bedrock.	---	---	---	---	---	---	---	---	---	---
65B----------- Clareson	0-5	Silty clay loam.	CL	A-4, A-6	0-5	0-25	90-100	90-100	85-95	85-95	30-40	8-18
	5-10	Silty clay loam, flaggy silty clay loam.	CL	A-6, A-7	0-5	0-65	90-100	90-100	85-95	85-95	35-45	11-20
	10-28	Flaggy silty clay, very flaggy silty clay.	CL, CH	A-7	5-15	50-85	85-100	85-100	80-95	80-95	41-60	18-35
	28	Unweathered bedrock.	---	---	---	---	---	---	---	---	---	---
66B----------- Olpe	0-11	Gravelly silt loam.	GC, CL, SC	A-2, A-4, A-6	0	0	60-80	50-75	40-75	30-70	20-40	7-20
	11-19	Very gravelly silty clay loam, gravelly silty clay loam.	GC, CL, SC, CH	A-2, A-6, A-7	0	0	20-80	10-75	10-75	10-70	35-55	15-30
	19-60	Very gravelly silty clay, very gravelly clay, extremely gravelly silty clay.	GC, GP-GC	A-2, A-7	0	0	20-60	10-50	10-45	10-40	40-65	25-40
68D----------- Coweta	0-6	Loam----------	ML, CL, CL-ML	A-4	0	0-15	90-100	85-100	80-90	55-85	<31	NP-10
	6-12	Gravelly fine sandy loam, gravelly clay loam, gravelly loam.	ML, CL, SM, SC	A-2, A-4, A-6	0	0-25	60-95	55-90	50-90	20-80	15-35	2-15
	12	Weathered bedrock.	---	---	---	---	---	---	---	---	---	---
72E----------- Balltown	0-15	Very flaggy silt loam.	CL	A-6	5-10	50-75	85-100	70-90	65-85	55-75	30-40	15-25
	15	Unweathered bedrock.	---	---	---	---	---	---	---	---	---	---
73E:												
Eram---------	0-6	Silt loam-----	CL	A-4, A-6	0	0	85-100	85-100	85-100	70-95	30-37	8-14
	6-21	Clay, silty clay, clay loam.	CL, CH	A-7, A-6	0	0	95-100	95-100	90-100	80-98	37-65	15-35
	21	Weathered bedrock.	---	---	---	---	---	---	---	---	---	---

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Frag-ments > 10 inches	Frag-ments 3-10 inches	Percentage passing sieve number-- 4	10	40	200	Liquid limit	Plas-ticity index
	In				Pct	Pct					Pct	
73E:												
Balltown-----	0-15	Very flaggy silt loam.	CL	A-6	5-10	50-75	85-100	70-90	65-85	55-75	30-40	15-25
	15	Unweathered bedrock.	---	---	---	---	---	---	---	---	---	---
94F----------- Kanima	0-6	Very channery silty clay loam.	GC, GP-GC	A-2, A-4, A-6	0	0-10	5-50	5-50	5-50	5-49	30-40	8-18
	6-60	Very channery clay loam, extremely channery silty clay loam, very channery loam.	GC, GP-GC	A-2, A-4, A-6	0	0-10	25-50	25-50	5-50	5-49	30-40	8-18
95B----------- Brazilton	0-10	Silt loam-----	CL	A-4, A-6	0	0-5	95-100	90-100	85-100	70-95	25-35	7-15
	10-40	Silty clay loam, silty clay, clay loam.	CL, CH	A-7	0	0-5	95-100	90-100	85-100	70-95	45-60	20-35
	40-60	Silty clay loam, silty clay.	CL, CH	A-6, A-7	0	0-5	95-100	90-100	85-100	70-95	35-55	15-30
96. Pits												

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

(The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" 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	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	g/cc	In/hr	In/in	pH					Pct
10---------------- Verdigris	0-50	15-27	1.30-1.40	0.6-2.0	0.20-0.24	5.6-7.3	Low-----------	0.32	5	6	2-4
	50-60	18-35	1.40-1.65	0.6-2.0	0.17-0.22	5.6-7.3	Moderate-----	0.32			
11---------------- Verdigris	0-39	15-27	1.30-1.40	0.6-2.0	0.20-0.24	5.6-7.3	Low-----------	0.32	5	6	2-4
	39-60	18-35	1.40-1.65	0.6-2.0	0.17-0.22	5.6-7.3	Moderate-----	0.32			
13---------------- Okemah	0-8	20-27	1.30-1.50	0.2-2.0	0.16-0.24	5.6-7.3	Low-----------	0.43	5	6	1-3
	8-37	35-55	1.40-1.65	0.06-0.2	0.10-0.18	5.6-7.8	High----------	0.43			
	37-60	35-55	1.40-1.65	0.06-0.2	0.10-0.18	6.6-8.4	High----------	0.43			
14---------------- Osage	0-7	35-40	1.25-1.45	<0.06	0.21-0.23	5.1-7.3	High----------	0.28	5	4	1-4
	7-60	35-60	1.50-1.70	<0.06	0.08-0.12	5.6-7.8	Very high----	0.28			
21---------------- Osage	0-15	40-50	1.40-1.60	<0.06	0.12-0.14	5.1-7.8	Very high----	0.28	5	4	1-4
	15-60	35-60	1.50-1.70	<0.06	0.08-0.12	5.6-7.8	Very high----	0.28			
51B2-------------- Deepwater	0-7	15-27	1.20-1.40	0.6-2.0	0.21-0.24	5.1-7.3	Low-----------	0.32	5	6	2-5
	7-13	18-32	1.25-1.45	0.6-2.0	0.18-0.22	5.1-7.3	Low-----------	0.32			
	13-60	27-35	1.40-1.60	0.6-2.0	0.18-0.20	5.1-6.5	Moderate-----	0.43			
52---------------- Hepler	0-9	12-27	1.25-1.35	0.6-2.0	0.22-0.24	4.5-6.5	Low-----------	0.37	5	6	.5-1
	9-19	12-27	1.25-1.35	0.6-2.0	0.22-0.24	4.5-6.0	Low-----------	0.37			
	19-60	27-35	1.35-1.45	0.6-2.0	0.18-0.20	4.5-6.5	Moderate-----	0.37			
53---------------- Hepler	0-9	15-27	1.25-1.35	0.6-2.0	0.22-0.24	4.5-6.5	Low-----------	0.37	5	6	2-4
	9-18	15-27	1.25-1.35	0.6-2.0	0.20-0.22	4.5-6.5	Low-----------	0.37			
	18-26	18-35	1.30-1.45	0.6-2.0	0.18-0.20	4.5-6.5	Moderate-----	0.37			
	26-60	27-42	1.35-1.45	0.2-0.6	0.14-0.17	4.5-6.5	Moderate-----	0.37			
54B--------------- Newtonia	0-15	10-24	1.30-1.55	0.6-2.0	0.15-0.24	5.6-6.5	Low-----------	0.37	5	6	1-3
	15-22	20-35	1.40-1.70	0.6-2.0	0.16-0.22	5.1-6.5	Moderate-----	0.37			
	22-34	27-35	1.45-1.70	0.6-2.0	0.18-0.22	5.1-6.0	Moderate-----	0.32			
	34-60	32-45	1.35-1.65	0.6-2.0	0.12-0.20	5.1-6.0	Moderate-----	0.32			
55B--------------- Catoosa	0-9	15-26	1.30-1.55	0.6-2.0	0.15-0.24	5.6-6.5	Low-----------	0.37	2	6	1-3
	9-15	18-30	1.40-1.70	0.6-2.0	0.15-0.24	5.6-6.5	Moderate-----	0.37			
	15-29	27-39	1.45-1.70	0.6-2.0	0.15-0.22	5.1-7.3	Moderate-----	0.32			
	29	---	---	---	---	---	-------------	----			
56B--------------- Bates	0-16	15-27	1.40-1.50	0.6-2.0	0.20-0.22	5.1-6.5	Low-----------	0.28	3	5	1-4
	16-34	18-35	1.30-1.45	0.6-2.0	0.15-0.19	5.1-6.5	Low-----------	0.28			
	34	---	---	0.2-0.6	---	---	-------------	----			
56C2-------------- Bates	0-6	15-27	1.40-1.50	0.6-2.0	0.20-0.22	5.1-6.5	Low-----------	0.28	3	5	1-4
	6-28	18-35	1.30-1.45	0.6-2.0	0.15-0.19	5.1-6.5	Low-----------	0.28			
	28	---	---	0.2-0.6	---	---	-------------	----			
58---------------- Hartwell	0-9	15-27	1.30-1.40	0.6-2.0	0.22-0.24	5.1-7.3	Low-----------	0.43	3	6	2-4
	9-14	15-32	1.30-1.40	0.2-0.6	0.18-0.20	5.1-7.3	Moderate-----	0.43			
	14-37	40-55	1.30-1.40	0.06-0.2	0.09-0.13	5.1-7.3	High----------	0.32			
	37-60	25-45	1.30-1.40	0.06-0.2	0.18-0.20	5.1-7.3	Moderate-----	0.43			
60B--------------- Kenoma	0-9	18-27	1.35-1.45	0.2-0.6	0.22-0.24	5.1-6.5	Low-----------	0.43	4	6	2-4
	9-45	40-60	1.40-1.50	<0.06	0.10-0.15	5.1-7.8	High----------	0.32			
	45-60	30-50	1.35-1.45	0.06-0.2	0.18-0.20	6.1-8.4	High----------	0.32			

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group	Organic matter
	In	Pct	g/cc	In/hr	In/in	pH					Pct
61B, 61C2-------- Summit	0-8	27-45	1.25-1.50	0.2-0.6	0.16-0.20	5.6-7.3	Moderate-----	0.37	5	4	1-4
	8-14	32-45	1.35-1.65	0.2-0.6	0.10-0.18	5.6-7.3	High---------	0.37			
	14-60	40-60	1.35-1.60	0.06-0.2	0.10-0.18	5.6-8.4	High---------	0.32			
63B2, 63C-------- Eram	0-10	18-26	1.30-1.60	0.2-2.0	0.15-0.20	5.6-6.5	Low----------	0.43	3	6	1-3
	10-31	35-55	1.35-1.65	0.06-0.2	0.10-0.18	5.1-7.3	High---------	0.37			
	31	---	---	---	---	---	-------------	----			
65B-------------- Clareson	0-5	15-30	1.25-1.35	0.6-2.0	0.16-0.22	5.6-7.3	Moderate-----	0.32	2	7	1-4
	5-10	27-40	1.30-1.40	0.2-2.0	0.09-0.21	5.6-7.3	Moderate-----	0.24			
	10-28	35-50	1.35-1.45	0.02-0.6	0.04-0.07	5.6-7.3	Moderate-----	0.24			
	28	---	---	---	---	---	-------------	----			
66B-------------- Olpe	0-11	15-30	1.20-1.30	0.6-2.0	0.03-0.06	5.1-6.5	Low----------	0.24	3	8	1-2
	11-19	27-40	1.30-1.40	0.2-0.6	0.02-0.04	5.1-6.5	Moderate-----	0.24			
	19-60	35-50	1.35-1.45	0.06-0.2	0.01-0.03	5.6-7.3	Moderate-----	0.24			
68D-------------- Coweta	0-6	15-26	1.30-1.55	2.0-6.0	0.13-0.20	5.1-6.5	Low----------	0.37	2	6	1-3
	6-12	10-30	1.45-1.70	0.6-2.0	0.09-0.18	5.1-6.5	Low----------	0.28			
	12	---	---	---	---	---	-------------	----			
72E-------------- Balltown	0-15	18-35	1.30-1.45	0.6-2.0	0.08-0.13	6.1-8.4	Moderate-----	0.24	2	8	2-4
	15	---	---	0.01-0.06	---	---	-------------	----			
73E:											
Eram------------	0-6	18-26	1.30-1.60	0.2-2.0	0.15-0.20	5.6-6.5	Low----------	0.43	3	6	1-3
	6-21	35-55	1.35-1.65	0.06-0.2	0.10-0.18	5.1-7.3	High---------	0.37			
	21	---	---	---	---	---	-------------	----			
Balltown--------	0-15	18-35	1.30-1.45	0.6-2.0	0.08-0.13	6.1-8.4	Moderate-----	0.24	2	8	2-4
	15	---	---	0.01-0.06	---	---	-------------	----			
94F-------------- Kanima	0-6	27-35	1.40-1.60	0.6-2.0	0.05-0.12	5.6-8.4	Low----------	0.15	2	8	.5-2
	6-60	18-35	1.40-1.70	0.6-2.0	0.02-0.12	5.6-8.4	Low----------	0.15			
95B-------------- Brazilton	0-10	18-27	1.40-1.60	0.2-0.6	0.18-0.20	5.1-7.3	Low----------	0.37	4	6	1-4
	10-40	35-55	1.50-1.70	<0.06	0.10-0.15	5.1-7.3	High---------	0.37			
	40-60	28-45	1.45-1.65	0.6-2.0	0.15-0.18	5.1-8.4	Moderate-----	0.32			
96. Pits											

TABLE 17.--SOIL AND WATER FEATURES

("Flooding" and "water table" and terms such as "rare," "brief," "apparent," and "perched" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated)

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard-ness	Uncoated steel	Concrete
					Ft			In			
10----------------- Verdigris	B	Frequent----	Very brief	Nov-May	>6.0	---	---	>60	---	Low------	Low.
11----------------- Verdigris	B	Frequent----	Very brief	Nov-May	>6.0	---	---	>60	---	Low------	Low.
13----------------- Okemah	C	None--------	---	---	2.0-3.0	Perched	Nov-Apr	>60	---	High-----	Moderate.
14, 21------------ Osage	D	Frequent----	Very brief to long.	Nov-May	0-1.0	Apparent	Nov-May	>60	---	High-----	Moderate.
51B2-------------- Deepwater	B	None--------	---	---	3.0-4.5	Perched	Nov-Mar	>60	---	High-----	Moderate.
52----------------- Hepler	C	Occasional	Brief-----	Nov-May	1.0-3.0	Apparent	Nov-Apr	>60	---	High-----	Moderate.
53----------------- Hepler	C	Rare--------	---	---	1.0-3.0	Apparent	Nov-Apr	>60	---	High-----	Moderate.
54B--------------- Newtonia	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	Moderate.
55B--------------- Catoosa	B	None--------	---	---	>6.0	---	---	20-40	Hard	Moderate	Moderate.
56B, 56C2--------- Bates	B	None--------	---	---	>6.0	---	---	20-40	Soft	Low------	Moderate.
58----------------- Hartwell	D	None--------	---	---	0.5-1.5	Perched	Nov-Apr	>60	---	High-----	Moderate.
60B--------------- Kenoma	D	None--------	---	---	0.5-1.5	Perched	Nov-Mar	>60	---	High-----	Moderate.
61B, 61C2--------- Summit	C	None--------	---	---	2.0-3.0	Perched	Nov-Apr	>60	---	High-----	Low.
63B2, 63C--------- Eram	C	None--------	---	---	1.0-2.0	Perched	Nov-Apr	20-40	Soft	High-----	Moderate.
65B--------------- Clareson	C	None--------	---	---	>6.0	---	---	20-40	Hard	High-----	Moderate.
66B--------------- Olpe	C	None--------	---	---	>6.0	---	---	>60	---	High-----	Moderate.
68D--------------- Coweta	C	None--------	---	---	>6.0	---	---	10-20	Soft	Low------	Moderate.
72E--------------- Balltown	D	None--------	---	---	>6.0	---	---	10-20	Hard	Moderate	Low.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro- logic group	Flooding			High water table			Bedrock		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard- ness	Uncoated steel	Concrete
					Ft			In			
73E:											
Eram-------------	C	None--------	---	---	1.0-2.0	Perched	Nov-Apr	20-40	Soft	High-----	Moderate.
Balltown---------	D	None--------	---	---	>6.0	---	---	10-20	Hard	Moderate	Low.
94F--------------- Kanima	C	None--------	---	---	>6.0	---	---	>60	---	Moderate	Low.
95B--------------- Brazilton	D	None--------	---	---	>6.0	---	---	>60	---	High-----	Moderate.
96. Pits											

TABLE 18.--CLASSIFICATION OF THE SOILS

(An asterisk in the first column indicates that the soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series)

Soil name	Family or higher taxonomic class
Balltown	Loamy-skeletal, mixed, thermic Lithic Hapludolls
Bates	Fine-loamy, siliceous, thermic Typic Argiudolls
Brazilton	Fine, mixed, nonacid, thermic Mollic Udarents
*Catoosa	Fine-silty, mixed, thermic Typic Argiudolls
Clareson	Clayey-skeletal, mixed, thermic Typic Argiudolls
Coweta	Loamy, siliceous, thermic, shallow Typic Hapludolls
*Deepwater	Fine-silty, mixed, thermic Typic Argiudolls
Eram	Fine, mixed, thermic Aquic Argiudolls
Hartwell	Fine, mixed, thermic Typic Argialbolls
Hepler	Fine-silty, mixed, thermic Udollic Ochraqualfs
Kanima	Loamy-skeletal, mixed, nonacid, thermic Alfic Udarents
Kenoma	Fine, montmorillonitic, thermic Vertic Argiudolls
Newtonia	Fine-silty, mixed, thermic Typic Paleudolls
Okemah	Fine, mixed, thermic Aquic Paleudolls
Olpe	Clayey-skeletal, montmorillonitic, thermic Typic Paleudolls
Osage	Fine, montmorillonitic, thermic Vertic Haplaquolls
Summit	Fine, montmorillonitic, thermic Vertic Argiudolls
Verdigris	Fine-silty, mixed, thermic Cumulic Hapludolls

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